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Creation of the relevant next: How living systems capture the power of the adjacent possible through sign use

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ABSTRACT

Stuart Kauffman's revolutionary notion of the Adjacent Possible as an organizing principle in nature shares much in common with logician Charles S. Peirce's understanding of the universe as an ever-unfolding 'process ontology' of possibility space that is brought about through the recursive interaction of genuine possibility, transiently actualized order, and emergent (but never fully deterministic) lawfulness. Proceeding from these three fundamental categories of becoming-as-being, Peirce developed a complimentary logic of sign relations that, along with Estonian biologist Jakob von Uexküll's action-as-meaning-imprinting *Umwelt* theory, informs the work that is currently being undertaken under the aegis of Biosemiotics.

In this paper, I will highlight the deep affinities between Kauffman's notion of the Adjacent Possible and Biosemiotics' hybrid Peircean/Uexküllian "sign" concept, by which living systems – both as individuals and in the aggregate (i.e., as co-actors, communities and lineages) – "capture" relevant aspects of their relations with the immediately given Adjacent Possible and preserve those recipes for future interaction possibilities as biologically instantiated *signs*.

By so doing, living systems move into the Adjacent Possible by "collapsing the wave function" of possibility not just probabilistically, but guided by system-internal *values* arising from previously captured sign relations that are biologically instantiated as replicable system biases and generative constraints. The influence of such valenced and end-directed action in the world introduces into the universe the phenomenon of the Relevant (and not just deterministic, or even stochastic) Next.

My argument in this paper is that organisms live out their lives perpetually confronted with negotiating the omnipresent Relevant Next, and are informed by the biological capture of their (and their lineage's) previous engagements in doing so. And because that "capture" of previous agent-object-action relationships are instantiated as biological *signs* for the guidance of the organism, not only are "successful survival strategies" within a given possibility space captured (as in traditional accounts of Natural Selection), but captured as well within those signs are the entire complement of previously untaken but still veridical real-world possibility spaces that are inseparably 'entangled' with that sign, and just awaiting exploration by the organism.

Thus, while all action in the universe is both current-context dependant and next-context creating, the emergence of ever-more complex semiotic capabilities in organisms has expanded the possibility space of immediate-next-action in the world exponentially, and has brought into being not a pre-given, singly end-directed ordered world, but an emergent, many ends-directed world of promiscuous, unforeseeable and interacting *telos*. The goal of Biosemiotics is to understand and to explore this world.

1. Introduction: making space for the role of signs in moving into the adjacent posible

In the article that opens this Special Issue, Stuart Kauffman and Arran Gare write that

> the 'interpolation' of new constraints is central both to evolution and the development of particular organisms, and are not entailed by their antecedent conditions (Salthe, 1985, 145; 1993, ch.2; 2012). Among the most important of these are the various facilitative constraints that transform physical structures or

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events into *signs* through which organisms are able to remember and anticipate, and communicate" (Kauffman and Gare, this issue).

To set the ground for this exploration of these processes, Kauffman and Gare explore deeply the implications of a concept that Kauffman has been working on for some time now that he calls the Adjacent Possible (Kauffman, 2000; Kauffman et al., 2008; Kauffman and Gare, this issue). Inspired in equal measures by the considerations of quantum phenomena and the coming-into-being of novel forms of organization in the biosphere, Kauffman's notion of the Adjacent Possible may be simplified schematically as follows:

Depicting a time series in *media res*, we see in Frame A of Fig. 1, a number of mutually exclusive possible next states that a system might move into at Time 1. Such states range from the extremely likely to the extremely unlikely, and states that it would be absolutely impossible for the system to move into earn no depiction here. Frame B illustrates the actualization of just one of those possibilities at Time 2, at which point the unactualized possibilities for all intents and purposes immediately disappear, as shown in Frame C. Frame D shows that simultaneously with the actualization of possibility [c] at Time 2, the set of "next" possible states is made actualizable … of which only one will become actualized at Time 3 (Frame E), "collapsing the wave function of possibility" again, and bring into being the *next* set of manifold but not unlimited possibilities (to which Kauffman and Gare assign the ontological status of *res potentia*, given these "possibilities" origin in real-world material processes, and their ability to exert real-world material effects, once actualized) – and so on until the end of the series (if any).

I have long used this series of simple diagrams to illustrate to my students not just the concepts of Prigoginean (1969, 1984) "irreversibility" and the Eddingtonian (1928) "arrow of time", but also the reality that themselves are situated in as agents in the social world. For human interaction, too – and especially human face-to-face interaction – consists in the moment-to-moment collapsing of the wave function of immediate-next possibility into actuality, which in turn brings forth the next set of context-dependant and context-creating possibilities to be acted upon, *ad infinitum*.

And, in fact, the realization of such ineliminable, generative and un-pre-stateable contingent responsivity was brought to my attention first, not by a consideration of quantum indeterminacy or by the puzzle of emergent dissipative structure, but by the empirical studies of moment-to-moment everyday talk, where it has been discovered that all of our face-to-face verbal interactions with one another, too, obey the exact same principles illustrated in the time series above.

The following contribution is an attempt to apply some of the insights gained from an understanding of Peircean semiotics to the questions now being explored in the fields of biology and naturalized phenomenology, and in particular the one being posed by Kauffman and Gare at the end of the quotation that appears above: *How do organisms transform physical structures and events into signs?*

The question, of course, requires at least a two-part answer: one, what are the precise physical mechanisms at work in the case of any such given transformation; and two, what is the nature of this organismic "transformation product" that we are calling here a "sign"? Without a good, solid answer to the latter, we cannot begin to work profitably on the former. My contention is that the sign logic worked out by the late 19th and early 20th century philosopher and scientist Charles Sanders Peirce (1839–1914) can provide researchers with a much needed set of conceptual tools with which to begin working on discovering the empirical answers to these puzzling and profound questions.

But since that discussion will involve a good deal of technical terminology seemingly far removed from the concerns of our everyday experience, I will begin this essay with a consideration of the urgency of the Adjacent Possible that, I feel, cannot not resonate with the lived experience of all my readers, and that I think well reflects the unique *biological* phenomenon that this paper is concerning itself with. I beg the reader's indulgence, then, and ask even those wishing to get right into the semiotic theory, to pause instead and to consider the 'big picture' issues that are foreshadowed by this prelude.

1.1. A sociological prelude: introducing the concept of the relevant next

Day to day I have to make all sorts of choices about what is good and important and fun, and then I have to live with the forfeiture of all the other options those choices foreclose. And I'm starting

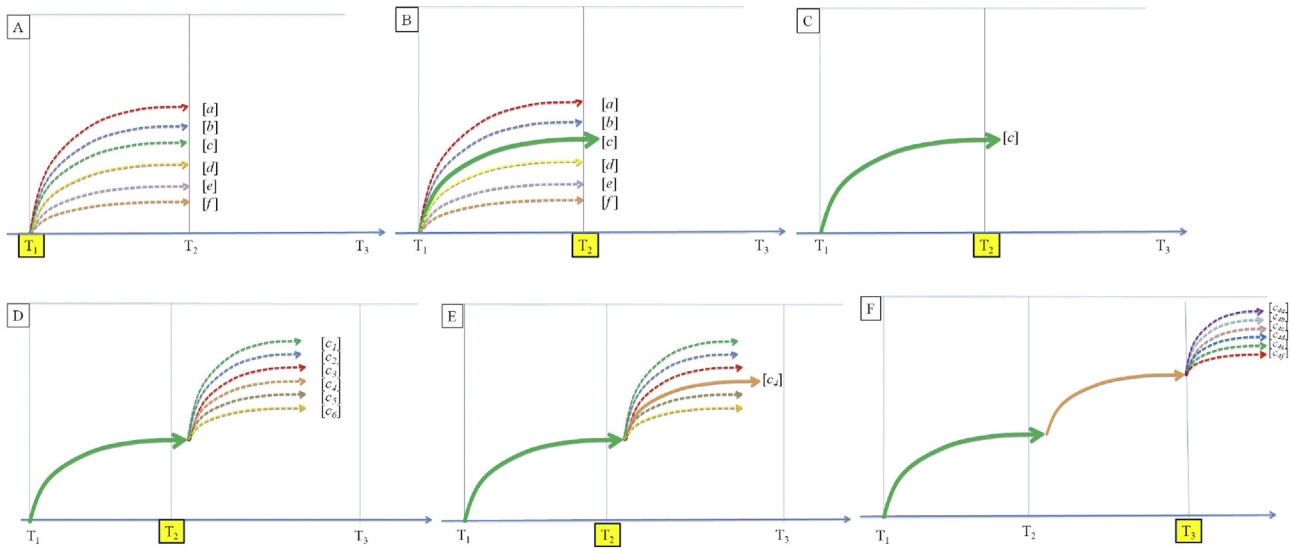

Fig. 1. An extremely simplified depiction of the relations between possibility and actuality in the world of the Adjacent Possible.

> to see how as time gains momentum my choices will narrow and their foreclosures multiply exponentially until I arrive at some point on some branch of all life's sumptuous branching complexity at which I am finally locked in and stuck on one path and time speeds me through stages of stasis and atrophy and decay until I go down for the third time, all struggle for naught, drowned by time. It is dreadful. But since it's my own choices that'll lock me in, it seems unavoidable – if I want to be any kind of grownup, I have to make choices and regret foreclosures and try to live with them.
>
> – David Foster Wallace (1997), *A Supposedly Fun Thing I'll Never Do Again*

I have noted that my early studies in Conversation Analysis presented me with an overwhelming amount of empirical evidence that the moment to moment unfolding of everyday communication exhibits the exact same principles as depicted in the illustration of Kauffman's Adjacent Possible. Consider, for example, what actually happens when one person asks another the apparently mundane, apparently unproblematic question "Are we going to the beach tomorrow?" Were one to try to formalize this interaction into a computer program, one would create a dyadic flow-chart architecture, such that "if person B's answer to person A's question is "yes" (Y), do *x*; if it is "no" (N), do *y*" and so on and so on for all subsequent questions and answers. Yet real-life interaction rarely works like this.

Far more frequently, such an exchange may begin like this: "Are we going to the beach tomorrow?", as a question that has been actualized – meaning that it is now *this* question (Q_1) and not an infinity of possible others that could have been asked at this moment but haven't – that the receiver of the question has now been put into the boundary-conditioned spot of answering from among the un-pre-stateable number of possibilities that have now opened up to her.

But instead of a dyadic "yes" or "no" answer, it is far more commonly the case that our interlocutor does something else entirely. They may, for example, reply puzzledly: "Didn't you say you wanted to stay home and work?" (Q_{1a}), or reply cryptically [from the viewpoint of a Y/N computer] "The TV says that it's going to rain" (Q_{1b}), or reply angrily "After what you said to me yesterday?" (Q_{1c}), or … any of a vast number of possible yet still relevant responses – each of which sets off a whole new trajectory of un-pre-stateable "branching" and step-wise transitions to that often take one far into other topics and other concerns that were *not* fore-visioned by either party – and that not uncommonly branch their way back, although sometimes only after many, many minutes, to a definitive yes/no 'type' answer to the original query – whose "relevant absence" of an answer to date looms over the whole interaction for its required foreclosure.

Kauffman and Gare compare such recursive re-shapings of the immediate-next adjacent possible to that of improvisational comedy – but all of our conversations, when one comes to examine them empirically, appear to partake of this exact same "collaboratively improvisational" nature. Clearly, the dyadic logic of the computer circuit cannot gain us any purchase here, for the ever-coming-into-being of naturally occurring conversation can never be reduced to a prediction-bearing algorithm. Rather, the moment-to-moment unfolding of the process in real-time *is* "its own shortest algorithm", as Stuart Kauffman has written earlier of the evolutionary unfolding of life on earth: "we can have no compact theory that predicts all the details of the unfolding. We must instead simply stand back and watch the pageant" (1995:23).

Researchers in the field of Conversation Analysis (from whom I have inherited the widely discipline-used concepts of the "relevant next" as well as the "relevantly absent") have taken Kauffman's advice to heart and have, over the course of over 40 years now, empirically documented the millisecond-to-millisecond choreographies of spontaneous human interaction – discovering, in the process, and just as Kauffman predicted, "powerful laws [or, in this case, orientations and social norms] that predict and explain their general shape" (Kauffman, 1995:23).

They have, moreover – and independent of any contact with the fields of dynamic systems theory and its emphasis on self-organizing processes – discovered that the *generative*, *emergent orderliness* that they observe "at all points" in human interaction is brought into being, oriented to, sustained and perpetuated entirely by the actions of the agents themselves in real-time (and contexulaized, of course, by the personal and extra-personal histories of such interactions over time). And the reason this system is sustained is because all participants in face-to-face interaction have an "intrinsic motivation" to attend to on the micro-level and to track the unfolding trajectory of the ongoing activity of which they are a part, given that the just-actualized state of affairs at any given moment demands of them to choose from a newly instantiated set of possibilities for immediate next action that will, itself, open up and foreclose the "possibility space" of what comes next.

Accordingly, writes Conversation Analysis co-founder Emmanuel Schegloff, "one basic and omnirelevant issue for the participants for any bit of talk-in-interaction is *"why that now?"* (Schegloff and Sacks, 1973:299; Schegloff, 2007:2) And in this concern, the human beings that conversation analysts study as they rely on talk to help build their social worlds together, display their existential continuity with all living creatures, for whom the un-worded but omnipresent survival question of "*what to do now, given this?*" is the one that nature forces every organism – including us – to confront and answer, by our actions, at every moment of our existence.[1]

In Kauffmanian terms, that experiential reality might be rephrased as: "What action possibilities and demands have just come into being right here before me now, given what has just actualized in this particular moment?" And it is here that we need to raise the question of how living beings both recognize and act on *res potentia*, as opposed to how the *res potentia* becomes actualized in the non-living world – and it is precisely here where the work done over the last few decades under the aegis of Biosemiotics can help us as we piece-by-piece attempt to reconstruct the "middle section" of explanatory bridge between non-living nature on the one hand and human phenomenology on the other, as I hope to show.

1.2. Biosemiotics: searching for the natural history of signs

Biosemiotics is the study of sign processes in life processes [2] and the model of the sign relation that it employs most commonly in its analyses and conjectures is that of the logician and philosopher Charles Sanders Peirce (1839–1914). Undoubtedly a genius and a polymath, Peirce was a difficult man in his personal life, and the

[1] The parallels between the work done in Conversation Analysis and Stuart Kauffman's notion of the "adjacent possible" – as well as Terrence Deacon's notion of "absential properties" – are many and profound, though it is beyond the scope of the current paper to go into them here. Readers wishing an excellent brief overview of the field and its findings are directed to Goodwin and Heritage 1990. Longer introductory texts include the relevant chapters in Heritage (1984) and Levinson (1983), as well as all of Schegloff 2007. "Collapsing the Wave Function of Meaning" is my own attempt to incorporate Conversation Analytic findings within the perspective of Biosemiotics (Favareau, 2008).

[2] As detailed historically in Favareau 2010, and theoretically most concisely in Hoffmeyer 1997, 2008. An excellent portal into biosemiotic work and its ongoing history is here: http://www.biosemiotics.net/.

corpus of writing that he left behind – over 80,000 manuscript pages accounted for so far, a great deal of which is devoted to the development of a grand 'architectonic' of sign logic – are likewise difficult and by no means easily synthesized … not even by Peirce, who left much of this study a work in progress at the time of his death.[3]

For Peirce, the central question of such study was to discover the internal logic whereby following a train of signs (which is the totality of what Peirce believed that we are doing when we are "thinking" [CP 5:253] [4]) could lead a human being (or what he later characterized as any kind of "intelligence capable of learning by experience" [CP 2.227]) to be able to come to true knowledge about that which is not yet itself a sign – i.e., extra-mental reality. For biosemiotics, a central question needing resolution is: "How has it come about that there can even *be* such things as "sign" relations – i.e., things "standing for" or "meaning" something *other than themselves* – in a universe that, according to the standard interpretation, is composed entirely of force and matter, all of which is only what it is *in itself*, and nothing else?"

The biosemiotician Claus Emmeche puts the question very well when he states that the goal of the project of biosemiotics is to be able to intelligibly explain how "all the phenomena of inherent meaning and signification in living nature – from the lowest level of sign processes in unicellular organisms to the cognitive and social behavior of animals – can emerge from a universe that was not [so] organized and meaningful from the very beginning" (Emmeche et al., 2002:41). From where in the world of pure physical interactions comes this "natural history of 'signs' and 'meanings'"? And what do we *mean* by "meaning" in the non-human, non-linguistic biological sense? Or even in the human sense, if we think about the problem carefully enough?

Two elements of Peirce's architectonic of sign logic have been indispensible in helping biosemioticians posit some answers to these still fundamental questions that are still very much understudied in biological science. The first is what Peirce scholar David Savan (1976 [1989]) first christened as Peirce's doctrine of "Semiotic Realism" and the second, dependant on the first, is what Peirce himself referred to as "Pragmatism's Maxim". It will take a little bit of unpacking to understand these two critically important ideas, but fortunately, an understanding of Kauffman's notion of the Adjacent Possible provides a firm foundation for understanding Peirce's own evolutionary cosmology, which in turn grounds his semiotic realism and his pragmatic maxim.

1.3. Charles S. Peirce and the universe of becoming: "Law is par excellence the thing that requires an explanation" [CP 6.612]

Peirce was, as noted, a scientist (in geodesy and chemistry) as well as a logician, and it was from his practical work as a scientist that he came to the conclusion that what scientists' measurements reveal is not a world of rigid determinism, operating under the iron rule of laws which seemingly could not have been otherwise, but instead a world of ongoing possibility that has been sculpted into its present state by its history of prior actualizations upon that possibility (in the manner of Kauffman's evolution of the adjacent possible, and as illustrated in Fig. 1 above). And while the cumulative effect of those actualizations exert a strong biasing tendency to canalize immediate-next-possibility into this state or that, there always remains an element of pure chance, or *tyche*, such that the universe resists manifesting complete unvarying non-statistical regularity at every moment.

What we see instead, felt Peirce, was instead a continuum (*synechism*) of emergent lawfulness, ranging from the extremely regular, seemingly all but "eternal and invariant" biases and constraints governing the motion of macroscopic bodies, to the fluid and all but "infinitely open-ended" possibility space explored by human thought. Neither of these extremes, however, were ontologically discrete from the other, claimed Peirce, and both were, in fact, the products solely of historical interaction within the system (that is, the universe) over time. It is for this reason that Peirce preferred to call such regularity-producing tendencies "habits" instead of "laws" [CP 1.409].

Like Kauffman, Peirce posited a universe that was always coming further into being – all but deterministically in some places, all but absolutely unconstrained and free in others. But, like Kauffman, he believed that despite its ever coming-into-being structure, "we may yet find deep and beautiful laws governing that unpredictable flow" (1995:23). For Peirce, that flow comes about through the ever-generative interplay of what he called the ontological relations of *firstness*, *secondness and thirdness* – which we may simplify for our purposes here as the endlessly dynamic interaction of *possibility*, *actuality* and *lawfulness*.

An entire literature is devoted to understanding and explicating Peirce's notions of *firstness*, *secondness and thirdness*, But for our purposes here, the shorthand heuristic that is Fig. 2 below illustrates the simultaneously emergent, downwardly causal and recursive nature of Peirce's process ontology of material being.

Within this ever-unfolding universe, writes Peirce scholar Menlo Hulswit:

> modal distinctions correspond to temporal ones; thus *possibility, actuality,* and *conditional necessity* [as the result of established habit, or lawfulness] are the modes of, respectively, present, past, and future (CP 5.459, 1905). Accordingly, it would appear that in each Peircean event three distinct temporal phases may be recognized: (1) reception of causal influence from the past, (2) (present) self-determining activity, and (3) influence upon subsequent events. Thus, every *present event* is conditioned by the past while it conditions the future. Though the present event conforms to *the past,* it nevertheless contains an element of irreducible novelty, for causal conditioning always leaves a range of open possibilities, however small it may often be (e.g. in so-called mechanical processes). Though future events are not necessitated in their full particularity, certain abstract, more or less *general,* features are determined in advance. (Hulswit, 2001: online)

"Reality" writes Peirce, is itself "an affair of Thirdness as Thirdness, that is, in its mediation between [the open possibilities of] Firstness and the [actualized current brute state of affairs of] Secondness" (EP 2:197, 1903). And this "thirdness" itself, we can see, is not some Universal Law from outside the system that imposes its efficacy with invariant force. Rather, it is itself the emergent *product*

[3] Brent's (1993) biography of Peirce, as well as the Introductions by Nathan Houser appearing *The Essential Peirce, Volumes 1 and 2* and by Favareau in the *Essential Readings in Biosemiotics* (Favareau, 2010) offer good introductory overviews of the man and his thought, whereas to explore the exponentially growing body of work on Peirce and his architectonic, as well as much of the primary source material, interested readers may want to start with *Arisbe: The Peirce Gateway*, hosted by Indiana University and *The Peirce Edition Project* here: http://www.iupui.edu/~arisbe/.

[4] I follow here the standard citation practices of Peirce scholarship whereby [CP: #] refers to the eight volumes of *The Collected Papers of Charles Sanders Peirce* (1866–1913 [1931–1935; 1958]), followed by the paragraph number in which the passage appears; [EP: #] refers to the two volumes of *The Essential Peirce* (1867–1913 [1992–1998]), followed by the volume and the page number where the passage appears; and [MS [R]: #] refers to the numbering assigned by Richard Robin to as the yet unpublished manuscripts of Peirce's that are held at the rare book and manuscript library at Harvard University, many facsimiles of which are available online at: http://www.iupui.edu/~arisbe/digitized.HTM.

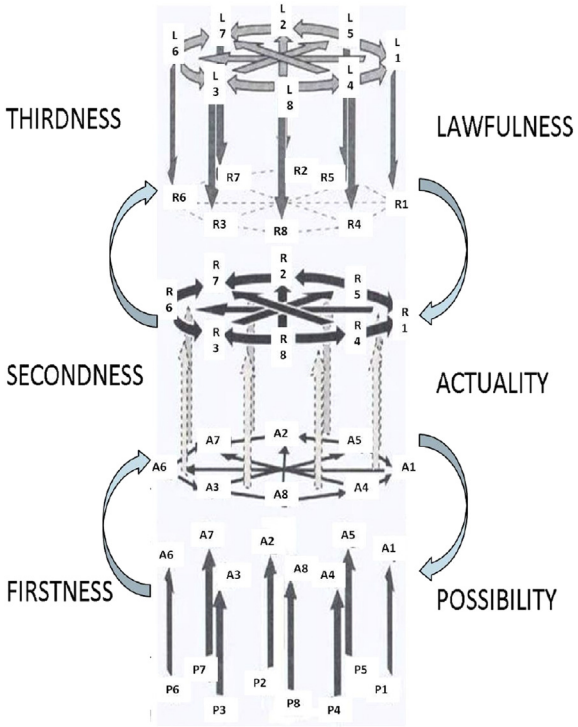

Fig. 2. A highly simplified, bare-bones schematic depicting the Peircean understanding of how the causal efficacy of bottom-up organization via the biasing and constraints imposed by actualized (A) possibility (P), and their resulting regular interactions (R) (e.g. combination, annihilation, contact force, etc.), give rise to a higher-order set of relational biases and constraints (L, for lawfulness) that, in turn, exert downwardly causal biasing and constraints of the possibilities to be actualized subsequently, and the endlessly recursive nature of all such organization that results.[5]

[5] I have adapted this diagram with considerable modification (e.g. changing the direction of the arrows) from a diagram illustrating the bottom-up and top-down nature of the emergence of symbolic reference within a Peircean framework that appears in Terrence Deacon's (1997) *The Symbolic Species*. I thank Professor Deacon for his permission for me to do so.

of actualizations interacting at a lower level. Terrance Deacon characterize this kind of emergence well when he defines it as the phenomenon whereby "unprecedented global regularity generated within a composite system by virtue of the higher-order consequences of the interactions of its composite parts … [and wherein] it is the *relational* properties of the constituents (as opposed to their primary or intrinsic properties) that constitute the highest order" (Deacon, 2006:122).

Accordingly, what these arrows are depicting and putting into relation with one another are *not*, in the first instance, 'entities' and 'things' (though entities and things may and indeed do arise from their interaction). Rather, what is being depicted by the arrows that form the vertical bars and horizontal beams constituting these scaffolds are precisely those sets of possibility biases, constraints and openness that have been brought into being in the moment that this 'snapshot of fluent, open-ended relational dynamics' (Hoffmeyer, 2014a: 103) is depicting. These specific sets of possibility conditions were actualized out of the immediately prior set of given possibility states, and will, in turn, set the biases, constraints and openness boundary conditions for the moment of ontological actualization that will happen next.

As such, we see clearly that Peirce's ontology, like Kauffman's, is one of generatively *enabling* but not deterministically *entailing* laws (or habits), in which, in addition to the propagation of consistent regularity by relations that have become all but irreversibly canalized (such as those relations that are studied in classical physics), the ineliminable interplay of what Kauffman calls *res extensa* (actualized material being) and *res potentia* (the real possibilities enabled by actualized being) in the universe has resulted also in the creation of a biosphere populated by populated by beings who have learned not only how to operate within such generatively recursive universe-of-becoming, but to actually recognize *res potentia* as *res potentia*. It is to an examination of that biosphere, and those creatures within it, that we must now turn.

1.4. Semiotic realism and the pragmatic maxim

The continuity between the way that the physical world is structured and the way that our minds, which are products arising from our interactions with that world, are structured such that we could reliably know that world in some veridically "good enough" sense, is a central tenet of Peirce's semiotic logic, as well as his cosmology. "The very being of law, general truth and reason", wrote Peirce, "consists in its expressing itself in a cosmos and in the intellects which reflect it" [CP 8:136]. But what Peirce is arguing for here is not a kind of "naïve realism", much less a "naïve representationalism", both of which his writings strongly abjure.

Instead, informed by his reading of the medieval scholastics who anticipated modern cognitive science with the observation that sign relations by definition are composed in equal parts by the structure of what is being perceived and the structure of the perceiver,[6] Peirce posited that our understandings were informed by a kind of semiotic realism (or "objective idealism") such that, beginning with even the tiniest sliver of correspondence between our organismic experience of the world – which is mediated entirely throughout by signs – and the way that extra-mentally existing reality actually is, we could build on that correspondence over the course of evolutionary time, modifying it and honing it both through natural selection and by the discoveries of our own experiments, such that "the *real*, then, is that which, sooner or later, information and reasoning would finally result in, and which is therefore independent of the vagaries of me and you" [CP 5.311].

One key component of this process, Peirce felt, was its *falliblism*, given that if truth is "that concordance of an abstract statement with the ideal limit towards which endless investigation would tend to bring scientific belief", then on the way to that ideal limit, whatever "concordance the abstract statement may possess by virtue of the confession of its inaccuracy and one-sidedness, this confession is an essential ingredient of truth" [CP 5.565]. To the extent that reality "pushes back" against our expectations during the course of our investigations of it, such pushback itself can be veridically informative. In more colloquial terms, we may summarize Peirce's view of semiotic realism as one that proceeds from the position put forth 100 years later by Francois Jacob to the extent that: "if the image that a bird gets of the insects it needs to feed its progeny does not reflect at least some aspects of reality, there are no more progeny. If the representation that a monkey builds of the branch it wants to leap to has nothing to do with reality, then there is no more monkey" (Jacob, 1982:56). The falliblism of animal action here drives natural selection, at least up to the point of necessary sufficiency, if no farther.

Again, though, Peirce is no naïve representationalist. Peirce's understanding, rather, echoes that of his contemporary, the physicist Heinrich Hertz (1857–1894), who writes:

[6] Cf my earlier paraphrase of Thomas Aquinas: "Sign relations partake of a dual being: One in singular things, another in the soul, and both [contribute their respective] accidents to it" (1252 [1965] in Favareau, 2006:17).

> We form for ourselves images or symbols of external objects; and the form that we give them is such that the *logically necessary consequents* of the images in thought are always the images of the necessary natural consequents of the thing pictured. … For our purpose it is not necessary that the images should be in conformity with the things in any other respect whatever. As a matter of fact, we do not know, nor have we any means of knowing, whether our conception of things are in conformity with them in any other than this one fundamental respect." (Hertz, 1894:323–324 [1956:1–2]).

What Peirce importantly adds to this characterization is the corollary idea that through the communal investigation and testing of *"this one fundamental respect"* of *logical consequence* and over time, our conceptions can, in fact, come to conform closer and closer to the object of our investigations. Understood in this light, one can better appreciate the "meaning of meaning" as defined by Peirce's Pragmatic Maxim, which asks us to: "consider what effects, that might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" [CP: 5.402].

Importantly, what Peirce is *not* saying here is that a sign's meaning is "whatever works for us in the world" and that such utilitarianism delimits all what we can really know about reality. This nominalistic notion – misguidedly adopted by some of his contemporaries – was so contrary to Peirce's own world outlook and intended meaning of his maxim, that he henceforth re-christened his own philosophy with the deliberately ugly-sounding term "pragmaticism" so as to distinguish it from this more relativistic kind of "pragmatism" [CP 5.414].

Instead, when Peirce talks here about a concept's (or sign's) "*conceivably* practical bearings" he is laying emphasis on *both* its already actualized and discovered relations *and* the yet-to-be-discovered, potential and (in Kauffman's terms) un-pre-stateable relations belonging to the object of our inquiry in its own right. These latter are what are progressively discovered through our interactions (and, especially, for Peirce, our scientific examinations and experimentations upon) the objects of our inquiry, and it is for this reason that Peirce asserts that "the opinion which is fated to be *ultimately* agreed to by all who investigate, is what we mean by the truth, and the object represented in this opinion is *the real*. That is the way I would explain reality" [CP 5.407].

Such inquiry, noted Peirce, demands the work of a community of inquirers purposively exploring these possibility spaces over time – and, again, as in the Kauffmanian picture, creating ever new possibility spaces as they do so. He did not, I imagine, believe that we had actually reached this ultimate end-point in *any* of our species-long investigations of the natural world – and if the world is ever-coming-into-being as he says it is, it's not clear that, in fact, we ever actually could, even in theory. But his semiotic realism is a genuine endorsement of realism nonetheless, and is a direct refutation of the skeptics' and the postmodernists' claims that because we can never have *absolute certainty* that the signs we fashion to know the world by are veridical, then all our so-called knowledge is just solipsistic sign play and a will to power.[7]

Peirce's semiotic, by contrast, recognizes the very real value that even *partial certainty* – the quantum of verticality that enables "good enough" veridicality – has to an organism whose perceptual capacities cannot access the whole of existing reality – as, of course, no organism can, including us. It does not, like Descartes and the postmodernists, demand "all or nothing at all" out of our certainty regarding our knowledge of the world. It insists, rather, that all knowledge always must be *both* mediated by a knower, *and by the object of that knower's inquiry*, in order to come into existence *as* knowledge at all. The process that brings this mediation about is called *semiosis*, and it bears some brief explication here, if we are to better understand how the affordances of *res potentia* come to be apprehended as such and acted on by the creatures of the living world.

1.5. Jakob von Uexküll and the active imprintation of meaning

The problems in philosophy to which Peirce's semiotic are devoted, according to Peirce scholar T.L Short are: firstly, "to construct a naturalistic but non-reductive account of the human mind" and secondly, "to explain and defend the claim that the sciences are objective in their mode of inquiry and, in fact, yield knowledge of an independently existing reality" (2007: *ix*). Accordingly, although Peirce insists in many places throughout his work that his references to "mind" are not limited to those of human beings, he writes very little explicitly about how animals other than human beings create, understand, act upon, exchange and, ultimately, know the world and make their livings in it through the use of signs.

One of the great projects of biosemiotics is to discover and detail this knowledge, which is why the pioneering work of the Estonian physiologist Jakob von Uexküll (1864–1944) plays a role equal to that of Peirce in the biosemiotic attempt to conceptualize a naturalistic understanding of sign relations. Sign relations, observed Uexküll, comprise the entirety of the experiential domain of any living creature's being – what Uexküll calls its *Umwelt*. And it is in accordance with the relations of this experiential world – and *not* the entirety of the whole unseen but physically existing world – that the creature must rely on in order to coordinate its actions to eat, flee, forage, mate and sustain itself.

For Uexküll, organisms "imprint" meaning on the inputs that they receive from the world on the basis of how those inputs can be used in the activities that the organism is attempting to carry out (feeding, mating, avoiding danger). This imprintation of meaning is not a mental process, but a feedback-driven "functional circle" that arises between the actions of the organism upon the word and the results of those actions for the organism, resulting in sensori-motor couplings that take the biological form of *if/then* action programs.[8]

Just as Kull (this issue) and Stjernfelt and Hoffmeyer (2015) note, however, while Uexküll's analysis provides a strong naturalistic basis for understanding the role and emergence of meaning in the animal world, it cannot alone account for the manifold of situations that almost all organisms more complicated than a bacteria encounter when the situation that is before them in the present moment presents multiple and simultaneous, competing and often even contradictory *if/then* opportunities and demands. At that point, some sort of 'meta-level' sign process must be available that can mediate the various competing demands and "collapse the

[7] Semiotics scholar John Deely, who identifies the term "modernism" with the dualism of Descartes, makes a convincing argument that the positions that in the 20th century were associated with the term "post-modernism" were, in fact, merely the logical entailment of a self-unacknowledged acceptance of Cartesian dualism, and should therefore be re-christened with the term "*ultra*-modernism" of even "*hyper*-modernism" so as to distinguish them from the true post-Cartesian *post*-modernism introduced by Peirce, and now being advanced by biosemiotics (Deely, 2001a:685).

[8] Excellent explications of Uexküll's *Umwelt* theory of meaning may be found at Deely 2001b, Kull 1998, and in the 2001 *Semiotica* Special Issue on Jakob von Uexküll (Volume 134, edited by Kalevi Kull), while English translations of Uexküll's own writings are available as Uexküll 1926[1928], 1934[1992] and 1940[1982] and reprinted, with an extensive historical preface, in Favareau 2010.

wave function" of immediately presented possibilities, by 'deciding' to actualize action A over action B (or to deploy a brand new action, C, instead of either of them).

Such a 'decision' – and again, we are not talking about anything mental or even conscious here, much less anything restricted to only to the human animal – reflects and is informed by system-specific *values* that have likewise arisen over time as biological biases, thresholds, and "facilitative constraints" that make the system's actualization of one given possibility more likely than the actualization of another.

Indeed, Stjernfelt and Hoffmeyer (2015) posit that the development of a specifically tertiary processing organ for mediating input–output processes – i.e., the coordinative brain – may have been driven precisely by the appearance of potentially contradictory impulses that could arise in the life of bilateral animals. For Kull (this issue), the entire existence of the "phenomenal present" in organisms (and all of the biology that underlies it) has evolved for the negotiation of such simultaneous yet mutually exclusive action-taking.

In either case, such higher-order mediation resulting in lower-order "possibility wave collapse" might be seen as case of 'downward causation' dynamic systems theory terms – i.e., a case where a higher-order system dynamic that itself has arisen from the emergent lawfulness of its bottom-up interactions, comes to exert its own top-down lawful organizing influence upon the interactions of its lower-order constituents. And, indeed, this is precisely the way that Peirce saw both material interaction and the organization of sign relations within cognition, one hundred years before the advent of complex adaptive systems theory.

1.6. The Peircean relation between ontology and semiotic

For Peirce, the continuity between the organizing relations of the external world and the organizing relations of the creatures who have emerged as products of that world (including, especially, their processes of perceiving it) is a fundamental axiom of his semiotic logic.[9] Accordingly, Peirce argued that his three fundamental categories of becoming-as-being, *firstness*, *secondness* and *thirdness* (possibility, actuality and habit, or law) likewise structure the sign relations that living systems can and do create in order to know of the external world and to successfully act in it.

And while the full scope of Peirce's complex semiotic cannot be captured in a single article, much less in a single illustration, Fig. 3 depicts at least one central aspect of its generatively recursive nature:

To explain the diagram on the right as schematically as the process has been depicted here: The diagram depicts the internal relations of the sign processes involved in human cognition. Peirce characterized these experiential phenomena as derived from the nested ontological relations of *firstness*, *secondness* and *thirdness* – with the characteristic sign types corresponding to each of these respective categories being *icons*, *indexes*, and *symbols*. Thus, to the extent that a sign is a property of, or "partakes in the *character* [likeness] of its object," it is an *icon* of that object; to the extent that a sign is "really and in its individual existence *connected* with its individual object," it is an *index* of that latter object; and to the extent that a sign "will be interpreted as denoting the object, in consequence of a *habit*," convention or law, it is a *symbol* – all of these characteristics not being self-subsisting properties of a sign, but are so only in their being as relations *for* the agent to whom the object *is being used as* a sign of something other than itself [CP 4.531].

Note here, especially, the necessarily recursive bottom-up and top-down nature of the resulting sign system. At the bottom is the *firstness* of immediate brute sensation, *qualia*, or the apprehension of an object at the moment such that one is forced to categorize it (as 'black' or 'white', 'an apron' or 'a hammer', 'predator' or 'prey') within one's existing system of sign relationships in order to be able to act towards it intelligently. Once so categorized as sign of *x*, all of one's *causal* (secondness) associations with *x* ('smoke' with 'fire', 'buzzer' with 'food') become semiotically available, bringing about, in turn, all one's virtual, or *acausal*, 'associations between associations' that constitute the higher-order emergent logic, or *thirdness*, of the sign system itself (as embodied in an organism that is embedded in a world of ineliminable action and consequence cycles). The result is that perception gives rise to association that gives rise to ideation – at which point, said ideation re-structures subsequent association, which re-structures subsequent perception, generatively and recursively, allowing for the canalization of preferred and dispreferred sign pathways that Peirce calls an intelligent creature's *habits*.

Again, this is but the roughest of sketches of just one element of Peirce's sign logic, and one may substitute terms like *detection*, *reaction* and *meaning* – which map onto the elements of Uexküll's "functional cycle" – to apply Peirce's system to the analysis of non-human semiosis. We will need to keep the above 'bigger picture' diagrams in mind, however, as we next magnify the resolution of the arrows within the schematic, so as to see to see what, in fact, these "sign relations" *are* for Peirce – and what they can be for a future science of naturalized signs.

1.7. Elements in the construction of meaning: sign, object, interpretant

One concise way to talk about Peirce's complex understanding of a sign relationship is to say that, for Peirce, an act of *sign* creation consists in the using of one element of a system of existing relations as a *sign vehicle* (or *representamen*) to represent something other than just itself (the *object* of the sign) to that same system of relations, and effecting a change in the system (the *interpretant* of the sign) thereby.

"Only when such an interpretant is formed (in a cell, in a tissue and, of course, in a brain) does 'information' acquire biological meaning" writes biosemiotician Jesper Hoffmeyer, adding importantly that:

> since an interpretant is always formed as a *context sensitive response to an event* (e.g. an electrochemical change of a cellular membrane) the interpretant is never a given once and for all *but always a result of the specific history that the involved entity* (e.g. a nerve cell) has gone through, so that former experiences will come to influence the interpretative process already at the earliest stages (e.g., ganglia in the eye). (Hoffmeyer, 2014a: 104, italics mine)

In Kauffmanian terms, the reception of any signal that is functioning as a *sign-vehicle* within a system is a change that sets up a number of immediate future possibilities for system states that the system can move into next. Peirce's *interpretant* is precisely that moment of effective 'measurement' within the system that "collapses the wave function" of possibility, resulting in the actualization of just one of those possibilities … and in so doing, providing the change in the system state that can be likewise acted upon as the sign-vehicle for the subsequent act of semiosis (setting its initial conditions and delimiting the set of possibilities that can be

[9] In yet another tantalizing concrescence between the ideas of Kauffman and Peirce, Peirce thought of the elements of which a continuum are composed "not as actual individuals, but as *possibilia*" (Lane, 2011:248; Zalamea, 2012).

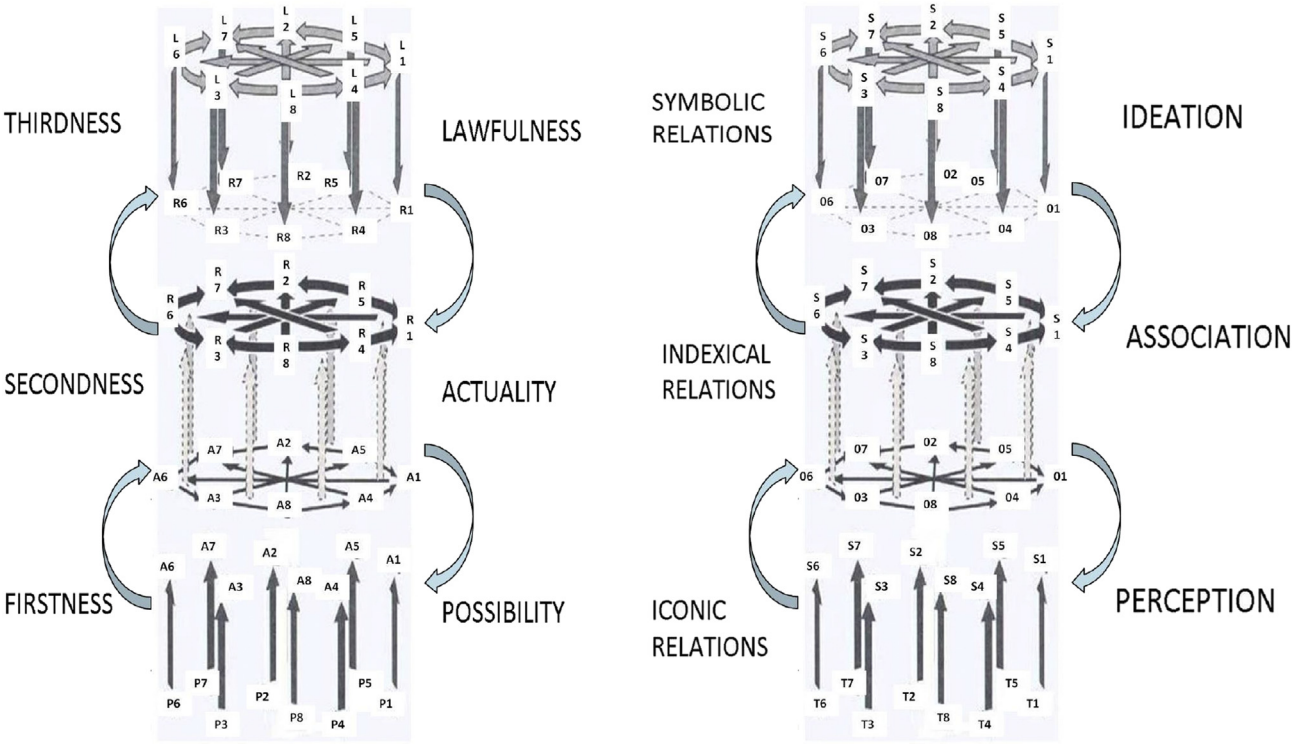

Fig. 3. Left: A schematic of Peirce's process ontology of possibility (P) actuality (A) and lawfulness (L), as discussed earlier in this paper. Right: An equally schematic outline depiction of experiential and cognitive relations in human experience, as suggested by the processural interrelations of Peirce's semiotic logic, in which Iconic relations, i.e., the things of the external world (T), experienced by the knower as signs (S), become associated within the system as signs that reliably Index one another (e.g.,'smoke':'fire'; 'buzzer':'food pellet') based on real-world tested 'constant conjunction', and whose internal relations, taken *qua* "relation" *per se*, constitute the emergent lawfulness that then downwardly organizes the structural relations within which subsequent iconic and indexical relations are understood. Note, here, too "each subsequent representation in the semiotic chain [of interpretants] represents the *prior* object-sign relation (0), *taken itself* as a higher-level semiotic object"(1994:5). (*Diagram, again, rearranged and repurposed from* Deacon 1997:86).

actualized next).

It is for this reason that Peirce posits that the interpretant of every sign process – the change in the system effected in response to the detection of a sign – itself functions "an equivalent sign, or perhaps a more developed sign" for the next change in the system [CP 2.228], such that "each subsequent representation in the semiotic chain [of interpretants] represents the *prior* object-sign relation, *taken itself* as a higher-level semiotic object" (Parmentier, 1994:5). This process, too, is illustrated schematically in Fig. 4.

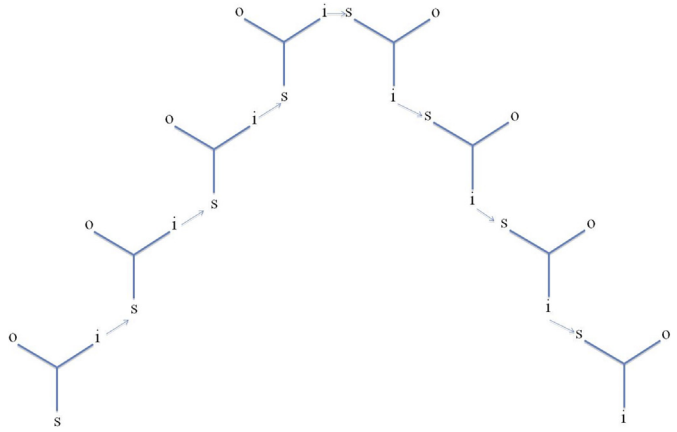

Fig. 4. A schematic depiction of the chaining of Peircean sign triads, wherein the interpretant produced by one sign relation becomes the sign-vehicle for the next.

Observing these relations diagrammatically (as Peirce often advises his readers to do) brings to light a number of important phenomena. First, we see from Fig. 4 that the Peircean "interpretant" is a last context-formed and next context-creating *response* that can then be embedded into upwardly ascending and downwardly causal chains such that organism can both obtain reliable knowledge about the world, *as that knowledge relates to their own situation in the moment*, (which is enabled by the progressive semiotic lamination as the initial sensory sign relation 'travels' up the neuraxis), and can then "act upon" the world accordingly as the (proximally) 'final' interpretant of the ascending chain actualizes the 'downwardly directed' sign cascade that constitutes the motor response.

Now clearly, this simple 'upward then downward' picture is as bare bones a schematic as possible, for as Bruni points out (*this issue*), biological organization is dependant as much on heterarchial relations, as on hierarchical ones – which is why the above 'microscopic' pictures must be embedded in the more overall systemic processes depicted in the semiotic matrix discussed and illustrated by Fig. 3.

Before leaving these current diagrams, however, we should note that the illustration of an immune response depicted in Fig. 5 reveals another important aspect of Peircean semiotic that should be of great interest to biologists (as well as to philosophers of mind). Like the diagram on the left, it shows how interpretant response of

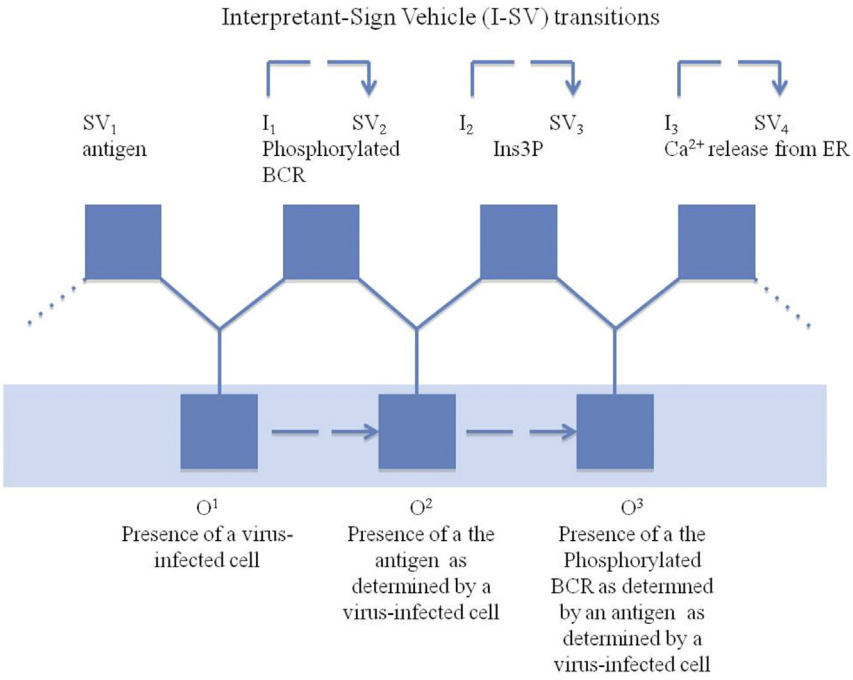

Fig. 5. A more fine-grained illustration, taking an immune response as a biological example of Parmentier's observation that "each subsequent representation in the semiotic chain [of interpretants] represents the *prior* object-sign relation, *taken itself* as a higher-level semiotic object" (1994:5). (Diagram adopted, with revisions, from El-Hani et al., 2007:33).

one sign process serves as the sign-vehicle (denoting "the *prior* object-sign relation, *taken itself* as a higher-level semiotic object") for the next cellular response. Note though that throughout all the transformations of sign-vehicles and interpretants – which we may also think of as the series of "adjacent possibles and their actualizations" in Kauffmanian terms – some aspect of the sign's original Object survives through all the Heraclitan transformations.

"What is maintained," as Terrence Deacon writes about a similar process, "is not any specific collection of molecules but rather, in Shannonian terms it is a *constraint* (or pattern) that is transferred from substrate to substrate over time, but in addition maintains reference" (Deacon, 2015) to the original "object" in the external world (here, a virus) whose detection initiated the sign cascade initially. Some real and fundamental reference to reality is preserved throughout all our variegated semiotic transformation, and, contra Kant, we are not cut off from the world of extra-mental being. Rather, our very sign-use – "with one foot in the world, and the other in the agent" – ensures we are connected.

This should be a perspective of some interest for philosophers of mind, and for the disillusioned post – (or hyper) modernists of the 20th century. "Human beings and animals are not tucked away behind some screen through which they gain an impression of the external reality on the other side" in the words of Jesper Hoffmeyer (1997:115), and adopting the view of sign relations offered by Peircean biosemiotics "points out the direction for the overdue reintegration of the human and the natural sciences at a level of synthesis beyond the false dichotomy … of realism and idealism, as though this dichotomy was exhaustive of the possibilities for interpreting experience" (Anderson et al., 1984: 35, 7).

To really see why this is so, however, we need to zoom in just one more level of detail, before zooming back out to embed Peirce's insights about semiotic logic with the work being done by people like Stuart Kauffman and Terrence Deacon. This level asks us to consider the fundamental phenomenon alluded to above: the relation of the agent to the object in the world that initiates the sign process. Here we will discover that it is precisely what is apparently "absent" in that relationship – what at that point does not yet exist in the world except as *res potentia* – that endows the sign relation with the ability not only to veridically inform the agent, but also to provide it with a 'more than can be currently known' kind of information that it can literally grow into in the future.

1.8. Ensuring veridicality: the Peircean object as facilitative constraint

Peirce scholars – and even biosemioticians – focus quite intently on Peirce's by no means simple nor intuitive notion of the interpretant, while the word 'sign' – which for Peirce denotes the whole triadic relation of representamen, object and interpretant – is conflated in everyday discourse with just the *sign-vehicle*, or representamen, itself (e.g., "those red (in the web version) spots are a sign"), one result of which is the misguided assumption throughout much of contemporary science that "information" is something that self-subsists in its own right *per se*.

Here, though, to make our discussion complete, we need to pay closer attention than perhaps is usual to the unique properties of the Peircean 'Object' within the processural mode of being proper to semiosis, so as to make finally intelligible how Peirce's late 19th and early 20th century analyses may be uniquely applicable to the 21st century project of understanding 'meaning' naturalistically and examining it scientifically.

We said earlier that Peirce's *interpretant* is precisely that moment of effective 'measurement' within the system that "collapses the wave function" of possibility, resulting in the actualization of just one of those possibilities … and in so doing, providing the change in the system state that can be likewise acted upon as the sign-vehicle for the subsequent act of semiosis (setting its initial conditions and delimiting the set of possibilities that can be

actualized next). But what do we really mean by this notion of 'measurement' (or 'decision making' or whatever else that happens that leads to the actualization of one possibility from the set of presented others)? And in what sense are these not-yet-physically present "possibilities" 'presented' – and to whom? We can get some way in answering these questions by examining what Peirce himself had to say about the nature of a semiotic Object.

Remember that when we use the words 'sign vehicle', 'sign interpretant' and 'sign object' here, we are referring to relationships within a process that derive their status (*as* a 'sign vehicle', 'sign object', etc) wholly from within that particular relationship. Butyric acid is a *sign-vehicle* of food for the tick, but not for us. Likewise, the sign-vehicle composed of the letters "tick" may have as its *sign-object* a small arachnid of the order *Parasitiformes* for us, but not for the arachnids themselves (nor even for a non-English speaker). This being the case, how do we genuinely escape solipsism, if even the sign *object*, which persists in some non-trivial sense, as we saw in Figs. 4 and 5 above, appears to get its status as such only within this triadic relationship?

Semiotician John Deely (1994, 2003, 2007, 2009) argues that this confusion arises from a terminological misunderstanding, clarifying that while all "sign objects" are indeed so only because they are the result of some living agent's action in constructing a sign relation, said construction is first and foremost in and towards a world of real *things* – some of which become the objects or our signs (and, more broadly, the objects of our experience), and some of which do not. We are not back to the notion of the Kantian *noumena* here, however, due to the fact that just because some extra-mentally existing things (such as might be found only on the ocean floor or on the surface of other as-yet-undiscovered planets) have not become the objects of any person's sign-relations *yet*, does not mean that they must forever remain unknowable. These 'things', if they exist, may become 'objects' of our experience someday – just as did a world of billions of years of pre-existing reality everywhere surrounding us that we had no perceptual access to prior to Leeuwenhoek's modification of the microscope in the late 17th century – with more 'things' becoming (also) the 'objects' of our experience with each subsequent modification.[10]

Most importantly, Peirce realized that what is true about the nature of 'whole' things that actually exist but have not yet become known to us (such as were single celled organisms and the vacuole of the cell, pre-Leeuwenhoek), is true as well for the potential (indeed, the probable) partiality of the 'sign objects' (or conceptions) that we have of the things that we do now 'know.' As per Peirce's pragmatic maxim, everything we think we know about those things, taken in its totality, exhausts what those things "are" for us. But if the scientific endeavor shows us anything – and Peirce himself was first and foremost a scientist in his thinking – it is that what we know about *x* today may indeed be only a fraction of all that there really is to know about *x*. And we gain this knowledge – slowly, over time, and as a community – solely through our continued inquiry – which is *sign*-based every step of the way, from perception to conception.

What makes veridicality possible here are the genuine real-world properties inherent in things-in-themselves, which we come to know – first grossly perhaps, but also perhaps later in finer and finer grained detail – through the sign relations we set up with them and our subsequent interactions with them through such sign use. I term

> "A Sign is a Cognizable", writes Peirce, "that, on the one hand, is so determined (i.e., specialized, *bestimmt*) by something other than itself, called its Object […] while, on the other hand, it so determines some actual or potential Mind, the determination whereof I term the Interpretant created by the Sign, that that Interpreting Mind is therein determined mediately by the Object" [EP 2:492].

Peirce himself despaired of using the misleading term "determine" here, for what he is telling us here in more contemporary parlance is that the actual properties an *Object* delimit or 'specializes' – i.e., provides the substrate of possible and impossible *facilitative constraints* that delimit (within a range, and not deterministically) the properties of the kind of *Sign vehicle* that can represent it – which in turn likewise "delimits" (i.e., provides the substrate of possible and impossible facilitative constraints for) the resulting action that is the *Interpretant*.

Again, we see here that extra-mental reality functions as a constraint on the kinds of iconic and indexical sign vehicles we can have for it – with the nature of those signs vehicles, in turn, providing the constraint conditions on the kind of higher-order sign relations (genuine triadic signs) and responses (interpretants) that they recursively generate. Let us take a simple example here to see how this is so. And in honor of Jacob's existentially important (for a monkey) "tree branch" – let's take that branch as an example. Given that our foundational awareness of the branch is solely through our sensations, and that our sensations are by their nature mediated, subjective, limited, perspectival, fallible – all the things that Descartes said they are, and to which the Peircean would, in fact, agree: How do we know that the branch really "is" in any way at all as we think it is (brown, crooked, wooden, an oak and not a maple, etc.)?

The first thing that a Peircean would reply here is that when we say those sensations come to us as signs that are 'mediated' by us, what we, unlike Descartes, are referring to on *both* sides of the mediation are absolutely real-world *natural* processes. These are the processes of (1) our body's biology (2) the surrounding natural world. The former is a *product* of the latter, and has evolved to survive in an environment made of *its* laws and regularities, and none other. For example, despite the huge variety of eyes that populate the animal kingdom and the huge variety of incommensurable subjective experience they enable, all evolved in accordance with the real-world regularity that light travels in a straight line at *c*. As Colombian neuroscientist Rudolfo Llinás notes in his elegant discussion of the topic (2001: 93–109), it is this invariant regularity that, no matter how transformed by the organism experientially, maintains the connection with exterior reality and in so doing constitutes the reference signal against which all the organism's actions will either ultimately accord – or fail. The animals in the world that we see today are the ones whose development in accordance with this real-world regularity did not fail.

Gravity, temperature, the properties of soundwaves, and, in fact, all the mind-external regularities in nature not only act as constraints on the direction of the evolution of teleception in animals – they also provide the stability needed for orientation, proprioception, prediction, decision making and practical inference in real-

[10] Peirce, too, made the distinction that Deely is making here, although he used the term Real Object (and later, the Dynamoid or Dynamical Object) instead of "thing", and the tern Immediate Object to denote the role of the "sign object" with respect to its sign vehicle and sign interpretant. Peirce notes that "One must distinguish the Object as it is represented, which is called the Immediate Object, from the Object as it is in itself. The latter is purely active in the representation. That is, it remains in all respects exactly as it was before it was represented. It is true that the purpose of representing an Object is usually, if not always, to modify it in some respect. But by the Object Itself, or the Real Object, we mean the Object insofar as it is not modified by being represented" [MS [R] 793:14]. But again, for Peirce these Objects are in a continuum, not a Kantian dualism: he calls "the *Object* of the sign, the *Immediate* Object, if it be the idea which the sign is built upon [and] the *Real* Object, if it be that real thing or circumstance upon which that idea is founded, as on bedrock". [EP 2:407].

time. Were this not the case, living systems would not only be unable to evolve in the world, they would be unable to even successfully sustain themselves in it. The 'circularity' here between sign and world is thus not a vicious or a vacuous circularity, but a virtuous one. For as Bateson notes: "The physical environment contains internal patterning or redundancy [such that] the perception of certain events or objects makes other events or objects predictable for the animals and/or for the observer. […] I would argue, [therefore], that the concept '*redundancy*' is at least a partial synonym of '*meaning*'" (1972:423, 421).

The organism must evolve to act upon and within the outside world's "internal redundancies" (i.e., regularities) and it is towards those external regularities that the organism orients its own internal regularities, in what Uexkull (1926 [1928]) calls the "functional circle". Here, again, we see a circularity that is complementary and generative instead of tautological and vacuous – the world is offering its half of the circle, to which the organism is bringing its half, in the manner of Aquinas' aphorism that we noted earlier. Likewise, and through this very process, some real regularity of the external world is being perceived similarly in each of our iconic experiences of what we will (much, much later) come to call "an oak branch" just as some real regularity – in this case, butyric acid – is common to all of the tick's un-named semiotic experience of "food source."

It is precisely for this reason, too, that Peirce asserts that a Real (i.e., extra-mentally existing) Object 'delimits' what can serve as an effective Sign Vehicle of it on the Iconic level, which is where all sign relations, as we have seen, must begin. Sign vehicles that fail to reliably map onto the regularities that are genuinely present in the objects of the external world will not be preserved evolutionarily. Accordingly, our representations of such regularities – whatever those regularities are in the incalculable fullness of themselves – constitute the atomic, fundamental (i.e., iconic) objects of our experience of the world.

And as our experiences with this as yet un-named thing are grounded in this most fundamental sign-object redundancy that is constrained (in at least some minimal but very real sense) by the nature of the real world thing that our iconic sign is a sign *of*, claims Peirce, we next come to learn more about the reality of that thing's intrinsic and relational properties by performing physical operations upon it (e.g., breaking it, eating it, digging with it, etc). It is through these operations that our sign's *indexical* veridicality is assured by the "persistent regularity" of the *consequences* of our doing *x* to *y*. Such knowledge, just as Hertz reminded us earlier, is *sufficient* for the real-world practical purposes of organisms. Indeed, the non-verbal, non-self-conscious disposition or biological orientation to "treat all input along the range of x_1 to x_n as *x* and in the presence of *x*, do *y*" is all the real-world sign-object-action (i.e., interpretant) organization that a species or a lineage needs for a successful multi-millenia run in life's earthly pageant.

Note here, too, that both these fundamental iconic ("all instances of input within the range x_1 to x_n] count equally as x") and these fundamental indexical ("when x, do y") sign relations are manifested biologically. And in both cases, the nature of Real Object delimits and, in Peirce's terms "specializes" (as tested in real-world interaction) what can be an effective Iconic Sign of it, while the nature of that Sign (as likewise tested in real-world interaction) delimits and "specializes" what can be an effective Interpretant, or response action to it. And as Peirce's Pragmatic Maxim reminds us, the ever-growing "sum total" of these practical consequences (of, in our oak branch example, several hundreds of thousands of years of interacting with the object of our inquiry as primates, and later our eventually formalizing and extending that knowledge within a test-based science of botany) thus constitutes an ongoing action-based investigation "constrained" by reality – in a positive sense – at every step.

Within Peircean sign logic, only Symbols – which allow us humans to break free, to an extent, of the constraints of externally-existing reality – can be "arbitrary" in the way that Saussure and the post-structuralists, looking to human language as their model sign system, mistakenly assumed all true "sign" relationships to be.[11]

Most importantly for our current discussion: The real-world 'constraints' that "specialize" the iconic and indexical relationships so as to align with external reality are themselves the product of the higher-order Thirdness relations depicted in Figs. 2 and 3. Accordingly, the organizing logic operative in those figures is operative too, for Peircean-inspired biosemioticians, in the very biological organization of those creatures whose bottom-up interactions give rise to a top-down causality of sensation-action coupling.

Such 'constraints', of course, are what theoretical biologists like Stanley Salthe and Terrance Deacon write about as *generative* or *facilitative* constraints – i.e, they not only foreclose a certain range of possibilities from coming into existence next, but they simultaneously *enable* a range of other possibilities for doing so. These sets of immediately made available possibilities are then 'collapsed' into single actualities by the over-arching *thirdness* (law-like) relations that constitute the structure of the self-sustaining (i.e., biological) system itself – sometimes all but invariantly (as in the moment to moment activity of the autonomous nervous system), sometimes in ways that are seemingly infinitely open-ended (as in the phenomenal experience of human thought).

In Fig. 5, El-Hani et al (2007) showed us how an organism's internal world of immediate sign objects and its external world of dynamical or real objects can and do have productive and veridical commerce via semiosis. There, the 'object' of the sign that is an activated B-cell antigen receptor at this moment of frozen time in semiosis is *immediately* the presence of antigen and *dynamically* the virus from the external world that has now entered the body and is infecting the cell. The resulting sign-object relationship is one of fundamental *realism*, regardless of the fact that the cell itself "knows" of the existence of extra-mental viruses not consciously or symbolically, as we do, but only in Hertz's criterial "one fundamental respect" – i.e., it has organized its own actions towards it accordingly, based on the principle of practical consequence, as honed over the course of evolutionary time.

Obeying the same logic, but on the far other side of the spectrum, in the cerebral cortex, such 'immediate objects' as those that structure cognition may not even have the ontological status of antigens, but are much more likely simply to be *patterns* of immediately present neuronal activity (what Edelman and

[11] Peirce's notion of the symbol is profound and sublime, and an even cursory discussion of it is beyond the scope of the present article. Suffice it for our purpose here to mere note that for Peirce, a *symbol* is a sign that is interpreted as such not because of its "likeness" to its object, as are icons; nor because of its "real connections" with its object, as are indices; but simply because conventions, "dispositions or factitious habits of their interpreters" have arisen and make themselves felt for interpreting it so [EP 2:460–461]. Accordingly, in the human world, the words we use to speak of things may indeed be "arbitrary", but it is the higher-order thirdness relations – i.e., the lawfulness that governs the set of conventions that is our particular "language" – that ensures reliable meaning-making and meaning-taking with these symbols, as in Fig. 3. Readers should consult Deacon's (1997) *The Symbolic Species* for a masterful explanation of the unique status of the Peircean "symbol" and its role in enabling and re-structuring human thought, and Schilhab et al.'s (2012) *The Symbolic Species Evolved*, for an informed discussion of the thirdness relations that qualify as "symbolic" – without being either linguistic or self-conscious – in the non-human biological world.

Tononi (2008) refer to as 'transient functional neuronal clusters') that would yet still be 'determinitive' for the subsequent patterned activity, such that the dynamic object in the world that initiated the cascade would be 'preserved' semiotically throughout all the heterarchial laminations added to the increasingly contextualized sign by the contributions of the affective, mnemonic, eidetic, linguistic and other bodily and cognitive sub-systems as it travels up the neuraxis and around the circuits of brain. In this way, all we humans can, indeed, see the exact same thing – and at the same time each see it differently and uniquely.

1.9. Collapsing the wave function of meaning: life in the adjacent possible

With all of these basics of Peircean semiotics now in mind, we can briefly build up the 'big picture' take-away of this analysis.

We have noted earlier Uexküll's observation, confirmed by evolution, that perceptual capacities develop as organisms mediate external and internal survival demands over time. The perceptual apparatuses generate *sign relations* that are based upon the organisms' successful and unsuccessful interactions with the world, and these sign relations are instantiated in any biological process or organizational structure such that *x* (an odor, a particular type of molecule, a sound pattern) has its function in the system as a *sign* of something that is very much not *x*, but *y* (an available mate, a breakdown in another part of the system, the presence of a nearby predator). Organisms live and die by such sign relations, and again, as pointed out earlier, it is in accordance with the relations of *this experiential world* that is grounded in, but not co-extensive with the agent-independent relations of physically existing world, that the creature has to coordinate its actions to eat, flee, forage, mate and sustain itself.

What evolution and the incredible variety of animal ways of surviving in this "all but unseen" world shows us is that living systems – both as individuals and in the aggregate (i.e., as co-actors, communities and lineages) – have evolved ways in which to collapse the ever-renewing wave function of possibility that constitutes the omnipresent "do what now?" of their existence through the establishment of biologically instantiated *sign* relations. Such signs are *doubly contextualized* for each instance of organism-environment coupling, given that they are set up within the biological context that is the organism, towards and within the larger context that is the organism's environment. This dynamic alone accounts for what Bateson called the sign's essentially veridical "pattern redundancy" – but it is the dual wave-collapsing properties of the Peircean sign relation that most genuinely "points out the direction for the overdue reintegration of the human and the natural sciences at a level of synthesis beyond the false dichotomy […] of realism and idealism" as noted earlier in this paper (Anderson et al., 1984: 35, 7).

For we have seen that the first of two such wave-collapses inherent in any sign is initiated by the *world*, as the real object of externality delimits, over the course of an organism's evolution, what can serve as an iconic or indexical sign of it in the transition (collapse) from the manifold of as yet untaken possibilities of Firstness to the singularized actuality of Secondness. Upon this world-collapsed sign, a second real-time collapse is effected by the *agent* in its action decision taking, which is guided by the emergent system biases and values unique to its evolution and development (or in other words, its Thirdness). I call this process *semiotic entanglement*.

Neither the kind of naïve realism one often encounters in scientism, nor the naïve idealism one often encounters in the contemporary humanities, can capture this essentially mediated way of being in, with, and through the world that is the hallmark of all living systems. For only living systems have evolved, by necessity, the ability to "capture" relevant aspects *of their own relations* with the immediately given Adjacent Possible and to preserve those recipes for future interaction possibilities as biologically instantiated *signs*.

By so doing, such living systems move into the Adjacent Possible by "collapsing the wave function" of possibility not just probabilistically, as inanimate systems appear to do, but guided by a dynamic that, in every instance, partakes of both the persistently conserved access to the reality of the outside world guaranteed by the feedback cycle of the Uexküllian *funktionskreis*, and by the emergent yet still evolutionarily flexible system-internal values arising from the organism's (and its lineage's) previously captured sign relations, which are biologically instantiated as *replicable facilitative system biases* and *generative constraints*. The influence of such valenced and end-directed action in the world introduces into the otherwise non-living universe the phenomenon of the system- and moment- *Relevant* (and not just deterministic, or even stochastic) Next.

We have seen how an orientation to ever-renewing urgency of the Relevant Next structures virtually every moment of human face-to-face interaction, and a moment's reflection will reveal that the lives of all non-human animals, as well, consist in an inescapable "collapsing of the wave function of possibility" in the face of an omnipresent and consequence-guaranteeing immediate-next-action space of the Adjacent Possible. The fact that evolution has equipped many of the simpler organisms with what look like a fully exhaustive set of "mechanisms" for doing so, should not blind us to the fact that these mechanisms themselves are the canalized products of those organisms' prior sign-based explorations in the search space over evolutionary time.

1.10. From biological relevance to semiotic reference

Clearly, even the kinds of much more explicit orientation to the open possibilities of the Adjacent Possible and the recursive consequentiality of action taking as we find in many of the so-called higher animals (including ourselves) must be enabled by an underlying biology of recognition, anticipation, course correction and prediction, as systems theorists such as Robert Rosen (1985) and Mark Bickhard (2001, 2013) have long argued. Until recently, however, few theorists other than biosemioticians have attempted to systematically incorporate Peircean sign logic in their modeling of anticipatory systems.

Of these attempts, Terrence Deacon's most recent work is among the most important. Although much of his work is explicitly inspired by Peircean sign logic, Deacon yet avoids using Peircean terminology when discussing the relations of living systems below the level of the whole organism. Nonetheless, his recent "autogen" experiments, as detailed in his 2011 treatise *Incomplete Nature* and elsewhere (Deacon and Cashman, 2013; Deacon and Koutroufinis, 2014) are an attempt to illustrate just how such "*relevant*" next actions can become so for any system with the ability to consistently re-generate within itself "constraints (or patterns) that are transferred from substrate to substrate over time, [and that] in addition maintain reference to the probable fit of this organization to its environment" (2015). The ability that Deacon refers to here is, if only in its most deliberately primitive form, the ability to first generate and then come to rely upon "reference". It is thus perforce a *sign* relationship.

Most important to a consideration of how such sign relationships could have ever emerged from non-living but self-constituting physical systems within an appropriate environment, however, is Deacon's demonstration that such "reference" to a

general and often not-yet-instantiated optimal system state may be *incarnate* not in any mind or brain, but in the very system of next-possibility allowing, denying and biasing "facilitative constraints" that are still general enough to allow the taking of slightly different system states, so long as they fall within a given range. This dynamic is exactly what Peirce characterizes as a system's *finiousity* and what Deacon's calls its *teleodynamic* form.[12]

Deacon's autogens, deliberately, are magnitudes simpler than a single living cell, but it is not hard to extrapolate that once such a dynamic between and an agent and its environment is instantiated in a biological being, the capacity for not only for primordial *reference*, but also for more and more fine-grained agent-specific *relevance* would multiply exponentially with the organism's internal complexity (and with the complexity of its external demands).

Hoffmeyer (2014a, 2014b) calls this phenomenon *semiotic scaffolding*, which his colleague in biosemiotican Claus Emmeche defines as the interlocking of a number of *enabling processes* of sign action unfolding at several levels of organization, 'focusing energy flow and agency of the system or subsystem upon a constrained repertoire of possibilities', thus guiding the system's behavior to follow a more definite sequence of events (Emmeche, 2015: 275). Such scaffolding "canalizes further behavior," writes Kull, and in so doing, becomes "the frame for habits" (Kull, 2012: 228). This phenomenon is well-represented by the Peircean recursive matrix of semiosis that I have depicted in Fig. 3.

What an understanding of Peircean semiotics gives us, then, is a way of thinking about all these processes not just in their complex system dynamics, but in their necessarily semiotic dynamics as structures that have come about through *enacted*, and not self-consciously reflective, *meaning-assignation* on the part of the organism – and that such meaning itself has its roots *entirely* in the processes and structures of natural world, with "one foot in the biological organization of the organism, and one foot in the physical organization of the external world" (which includes, of course, the equally sign-based doings of other organisms).

Via this dynamic, biological organisms *guide themselves* into the adjacent possible, in-formed (again, not necessarily in a "cognitive" sense) by the biological capture of their (and their lineage's) previous engagements in doing so. In this, they at each instant "collapse the wave function of possibility" not blindly, but based on *meaning* – as such meaning has become incarnate in a biology that has developed through the use of signs.

Moreover, Peirce's sublime analysis if the role of the Real Object in acting as a constraint in its own right in the establishment of any sign, insures that not only are "successful survival strategies" within a given possibility space captured (as in traditional accounts of Natural Selection) in semiosis, but that captured as well within those signs are the entire complement of previously untaken but still veridical real-world possibility spaces that are inseparably 'entangled' with that Object in the real world[13], and just awaiting exploration by the organism.

Thus, while all action in the universe is both current-context dependant and next-context creating, the emergence of ever-more complex semiotic capabilities in organisms has expanded the possibility space of immediate-next-action in the world exponentially, and has brought into being not a pre-given, singly end-directed ordered world, but an emergent, many ends-directed world of promiscuous, unforeseeable possibility and interacting *telos*. The goal of Biosemiotics is to understand and to explore this world.

[12] Peirce, writing in 1898, presciently defines the concept of *finiousity* as: "those non-conservative actions which seem to violate the law of energy, and which physics explains away as due to chance-action among trillions of molecules, are one and all marked by two characters. The first is that they act in one determinate direction and tend asymptotically toward bringing about an ultimate state of things. If teleological is too strong a word to apply to them, we might invent the word *finious*, to express their *tendency* toward a final state. The other character of non-conservative actions is that they are *irreversible*" [CP 7.471].

[13] And, for humans, in the cultural and symbolic ones, as I argue at some length in Favareau, 2015.

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