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Biosemiotic Questions

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Abstract This paper examines the biosemiotic approach to the study of life processes by fashioning a series of questions that any worthwhile *semiotic* study of life should ask. These questions can be understood simultaneously as: (1) questions that distinguish a semiotic biology from a non-semiotic (i.e., reductionist–physicalist) one; (2) questions that any student in biosemiotics should ask when doing a case study; and (3) still currently unanswered questions of biosemiotics. In addition, some examples of previously undertaken biosemiotic case studies are examined so as to suggest a broad picture of how such a biosemiotic approach to biology might be done.

Keywords Semiotic life science · *Umwelten* · Function · Thresholds and attributes of semiosis · Sebeok's thesis · Uexküllian question · Qualitative methods in biology · Biosemiotic case studies

Introduction

"What are the fundamental questions in biology?' is itself a question that remains a pertinent one in the examination into any given lineage of biological study[1]. "*What*

[1]See, e.g., the examination of the primarily mechano-physicalist lineage in Hacking (1983), Keller (2002), Levins and Lewontin (2006); etc.

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are the fundamental questions in biology, if biology is seen as biosemiotics?"—i.e., as the study of sign processes that are essentially life processes—is the question that we wish to examine in some detail here.

Paradigmatic differences between the major approaches to biological investigation include differences in the questions that the respective types of inquiries will ask. Assuming that the semiotic approach in biology is, in fact, paradigmatically different from the reductionist and biophysical approaches that have been prevalent in biology since at least the Modern Synthesis of the 1930s, it will be fruitful to distinguish what we take to be the major differences between a *semiotic* and (what we will call for the purposes of this article) "non-semiotic" formulations of biological research questions. The successful framing of the relevant kind of biosemiotic questions, we will argue, may allow us to understand some aspects of life that a non-semiotic biology does not even inquire into (and therefore would never be able to successfully explain or describe).

We must mention at the outset, however, that while the purposes of this article are to contrast a semiotic approach to biology with a non-semiotic one, we see these not as alternative, but as complementary, approaches instead. Only by using both can we reach a more complete understanding of the phenomena and processes of life. Thus, since the principles and methodologies of the non-semiotic approach can be assumed to be well known to contemporary life scientists, the aim of this text will be to describe the *biosemiotic approach* by considering a series of questions that we feel that any worthwhile *semiotic study of life* should ask. These questions can be understood simultaneously as: (1) the questions that distinguish a semiotic biology from a non-semiotic (i.e., reductionist–physicalist) one; (2) the questions that any student in biosemiotics should ask when doing a case study; and (3) still currently unanswered questions of biosemiotics.

Semiotic Versus Non-semiotic Life Science

Semiosis, or true *sign* activity, occurs via a process of self-organisation. Taking place in self-organising systems, sign processes appear as emergent processes (or second-order self-organising processes—which means the 'organising self') of signification and interpretation that co-ordinate the biochemical self-organisation of living systems. In this sense, such activity might truly be thought of as being at the heart of the ongoing and interactive organising of physical constituents into biological agents, or 'selves'.[2] Accordingly, such processes are not only upwardly causal (emergent) in their physical effects, but are also the result of downwardly causal or informational (semiotic) constraints upon the activity of the system as a whole.[3] It is the addition of this latter mode of self-organization to the former that distinguishes biotic from abiotic self-organizing systems. For *semiosis*—or the ability to create and take part in meaning-generating processes—is the one of the distinguishing marks of

[2]This view is compatible with, and in some senses generalizes, the idea of Polanyi (1968) that the information in the DNA acts as a *boundary condition* for the physical processes in the cell.

[3]See, e.g., Andersen et al. (2000), Pattee (2007).

a system that is *alive*. Many biosemioticians (e.g., Hoffmeyer 1997; Emmeche 2002; Kull 2000b) would go so far as to assert that it is not just "one of many," but is, in fact, *the* central distinguishing mark of any truly "living" system. Repeatedly formulated by Thomas A. Sebeok (1996, 2001) over the course of many decades, the concept that *life and semiosis* are coextensive, we officially christen here as *Sebeok's Thesis*—and it is one of the basic positions held in contemporary biosemiotics.[4]

As this Thesis is at the heart of the entire "biosemiotic project" as we understand it, a few of Sebeok's more memorable formulations of the Thesis follows: "The process of message exchanges, or semiosis, is an indispensable characteristic of all terrestrial life forms. It is this capacity for containing, replicating, and expressing messages, of extracting their signification, that, in fact, distinguishes them more from the nonliving" (Sebeok 1991: 22). "All, and only, living entities incorporate a species-specific model (umwelt) of their universe; signify; and communicate by […] signs" (Sebeok 1996: 102). "Because there can be no semiosis without interpretability—surely life's cardinal propensity—semiosis presupposes the axiomatic identity of the semiosphere with the biosphere" (Sebeok 2001: 68). "The life sciences and the sign sciences thus mutually imply one another" (Sebeok 1994: 114).

Taking this last formulation, especially, to heart, the first of our 'meta-questions' becomes: "How, precisely, should a semiotic life science (or biological sign science) proceed in its investigations?" Certainly, some of the organizing principles and methodologies of life sciences that are already in place—such as naturalistic observation, *in vivo* experiments, qualitative reproducibility of findings, qualitative methods of study, etc.—can and will be made part of the daily work of the semiotic life scientist. But as the non-semiotic life sciences *de facto* rule out the viability of investigating such fundamentally semiotic phenomena as meaning, interpretation, subjective experience and sign relations, they can and do offer us no guidance on how to go about investigating such *semiotic* phenomena *scientifically*. The task is left to us, then—and in the short discussion that follows, we lay out a few of what we consider to be the most basic questions that a science studying semiotic phenomena in living systems will have to concern itself with.

Questions About the Biosemiotics of Subjective Experience and Distinctions in *Umwelten*

One such major question–i.e., "How does the world in which any individual organism finds itself appear to that organism?"–has been often perceived as inaccessible to scientific investigation and has therefore been left unresolved by reductionist biology. But in our opinion, scientific knowledge of other species' phenomenological experience need not be seen as any more *a priori* inaccessible than any other of science's previously "unsolvable mysteries." Rather, we feel that one of the main reasons why the question of organisms' subjective experience has been perceived as an "unscientific" question to begin with is simply because of the

[4]See also Anderson et al. (1984), Hoffmeyer (1997); also, "Thesis 1" in Emmeche et al. (2002: 14).

fact that "the scientific method" has been prematurely codified (and perhaps has subsequently become petrified) in a too narrow and restricted sense, reflecting its origins in seventeenth and eighteenth century mechanistic reductionism.

For while it is trivially true that we do not have a direct access to other organisms' (or even other human beings') phenomenological experience, it is important to take note that scientific knowledge is *always* "indirect" in some sense. Neither physical *nor* semiotic knowledge can ever be 'direct' or 'immediate'—which is why it has been necessary to develop the many methodological apparatuses that enable traditional, non-semiotic science to work at all (these include the development of the rules of *mediation* between scientists and the objects of their inquiry, such as: the rules governing how to design an experiment, how to take measurements, how to analyse data, and how to draw conclusions about the mechanisms of the world, along with the more obvious technological apparatuses necessary for mediating the relation of observer to observed). In an analogous way, semiotic life science (or "biosemiotics") will likewise have to develop the proper mediating apparatuses—apparatuses of both technology *and* of interpretation—proper to the successful examination, understanding, and explanation of the objects of its inquiry, accordingly.

Indeed, as far back as 45 years ago, Rothschild (1962) had already realized that one of the main distinctions between biosemiotics and biophysics would lie in the difference of their adopted methods. Therefore the question: "What are the specific methods of biosemiotics?" when applied to the investigation of species-specific experience, becomes: "What are the methods that allow the study of subjective worlds (the umwelten)?" Developing a biosemiotic approach thus means developing *both* quantitative *and qualitative* methods for biological research and analysis (Kull 2007a, b). Via these methods, genuine scientific knowledge regarding both the ubiquitously observed semiotic phenomena (i.e., the sign relations *qua* "sign" relations) of organisms—*as well as* knowledge regarding the physical, material and biological substrates upon which such relations must necessarily take place—can, ideally, be obtained. But again: this will necessitate the introduction into science of something that non-semiotic science has generally resisted: an investigation into the qualities (or *qualia*) of experience and into the organization of subjective states *per se*.

Thus, bio-semiotics can be generally defined as the study of *qualitative* diversity found in and by living systems. And in order to study such diversity, we will need to develop certain new methods—specifically biosemiotic methods—of research. Seen thusly, the major task of any biosemiotic "case study" will be to ascertain the particulars of that available set of qualitative diversity that literally *makes* 'sense' (i.e., that makes a 'difference') *for the organism or biosystem* under study. In other words: the first task must be to describe the *umwelt* (or the entire network of experiential sign processes) proper to that organism. Thus we arrive at what we will call biosemiotics' *Uexküllian Question*: "How is the subjective experiential world (or *umwelt*) of an organism organised?" Or: "In what does the subjective world experienced by an organism (*umwelt*) consist?"

With Charles S. Peirce, many of us in biosemiotics would reply to the second question: "in sign relations." And in this way, the general formulation of the Uexküllian question can also be considerably specified, both by Peircean semeiotic

(logic of sign relations) and by Uexküllian *Umweltlehre* (see, for example, Deely 1994, 2002; Emmeche 2002; Favareau 2007; Hoffmeyer 1996b; Kull 2003; among many others). From that foundation, we can then fruitfully next ask: *What would be a good general model to which most sign processes in living systems conform*?

One good proposal for such a model is the functional cycle (*Funktionskreis*) as described by Jakob von Uexküll in 1928. This model effectively conjoins an animal's sensing of the world with its subsequent actions upon the world—actions whose consequences for the organism are then fed back into the system cybernetically (in the semiotic, and not in the mechanical sense) in a recursively knowledge-generating loop. This is a *feed-forward* loop, according to Robert Rosen (1991, 1999), engendering *anticipating agency* into the physiology of the organism. We suggest, therefore, that the model of functional cycle can serve as a usable initial general "working model" of *semiosis* in general and, of *umwelt* in particular. And, indeed, it has often been applied as such in the biosemiotic "case studies" that we will be considering at the end of this article.

Once adopted as a *initial* "working model" for the investigation into the varieties of naturally occurring biosemiosis, it is next worthwhile to ask: "In what ways it is possible to improve upon the initial Uexküllian model?" Happily, for it is a sign of a young science progressing, recent years have seen the proposal of several more detailed models of semiosis–many but not all of which use as their point of departure Jakob von Uexküll's original model (for an excellent review of these, please see Krampen 1997). Particularly, and as it has often been noted at biosemiotic conferences and informal gatherings, it will be important for the continual development of our field to let our research guide us in developing the necessary amendments and alternatives to the Uexküllian *Funktionskreis* model for the experientially distinctive modes of iconic, indexical, and symbolic semiosis.

Questions About the Biosemiotics of Biological Function

Umwelten—the experiential worlds within which organisms live and must choose their actions—are *qualitative* by their very nature. Accordingly, we need to develop an approach that can investigate such qualitative changes and differences in detail. For once the reality of "qualitative" difference *as such* is accepted, as it is in biosemiotics, we then are faced with the *scientific* problems of determining the specific what, where, why, how, and when such qualitative differences actualize within and between organisms.

For again: a non-semiotic life science approach generally will not deign such qualitative phenomena susceptible to scientific study, and can therefore offer little guidance or insight in this regard. Rather, such approaches will often go to quite extraordinary lengths to provide explanations of qualitative phenomena as being quantitative phenomena "in disguise".

To wit: In behavioural ecology, the communicative behaviour of animals is considered to be fully explained when its *function* for "the increase of the individual's fitness" has been substantiated in terms of the theory of natural selection. Thus Krebs and Dawkins (1984) use the word "mind-reading" (e.g.: "a bird may mind-read a sneaking cat") as a 'nakedly metaphorical' euphemism for

those "underlying statistical laws" that they believe will predict what an animal will do as a consequence of its observation of another animal's behaviour. The "mind reader" *function*, they argue, is a Darwinian biological endowment that allows an organism to "optimise its own behavioral choices in the light of the probable future responses of its victim. A dog with its teeth bared is statistically more likely to bite than a dog with its teeth covered. This being a fact, natural selection or learning will shape the behaviour of other dogs in such a way as to take advantage of future probabilities, for example by fleeing from rivals with bared teeth" (Krebs and Dawkins 1984: 387).

Such statistical analysis reveals a major scheme of thought in contemporary behavioural ecology (as well as in the "classical ethologist view") that there are two principal causes of behaviour: the environmental and the genetic—and that these causes correspond to the two main types of manifest behaviour, learned and innate. A major contribution of biosemiotics in improving upon this scheme would be the provision of scientific explanations that would *also* account for cognitive-semiotic mechanisms of "qualitative difference" processing and negotiation in animal *umwelten*—an explanation (or, more likely, a coherent *set* of explanations) that would turn the frequently observed phenomena of "mind-reading" from a deliberately empty metaphor into a full-blown explanatory scientific concept (Kull and Torop 2003).

Relatedly, another one of our overarching biosemiotic questions has to be: "What are the general biological functions that are *made possible* through the phenomenon of semiosis?" Minimally, these would seem to include: recognition, action choice, memory, code relations, categorization, and communication. A particularly fascinating question, moreover, concerns the nature of *intentionality* as a general feature of semiosic processes.[5] Deacon and Sherman (2008) have argued that such intentionality may start from the ability of living systems to recognize an absence—i.e., that the recognition of absence is what makes *intention* ('toward-ness') possible.[6] This, then, turns our attention to the empirical question: *What sets of relations must necessarily be in place in order for an 'absence' to be recognised*?

No less general than *intentionality* is the ability, in living systems, for *categorization*. As Lakoff and Johnson have noted, "every living being categorizes" (1999: 17). Thus, yet another empirical biosemiotic question then becomes: "*What are the processes by which organisms 'categorise'?*" [7] And because the ability to categorize presupposes the ability to make distinctions: "*How are distinctions made by organisms and in organisms?*" Again, the wealth of scientific questions that have been left unanswered—primarily because they have been left unasked—by the non-semiotic life science approach has truly left "an embarrassment of riches" for twenty-first century semiotic life sciences to investigate.

[5]Cf. Short (1981), Searle (1993), Deely (2007), Hoffmeyer (1996a).

[6]On the relatedness between intentionality, biological needs, and the recognition of absence, see also Kull (2000a).

[7]The fundamental role of the processes of *categorization* by organisms can be demonstrated via the view of a species as a 'communicative category' that has been developed in studies examining the evolutionary role of various forms of *recognition* between organisms and species (e.g., the 'recognition concept of species' as developed by Paterson (1993), Lambert and Spencer (1995).

Doing so, however, will entail grappling with some long-neglected fundamental questions right at the very start. An example of such a fundamental question is this: "How can anything (e.g., molecule x) that initially does not have a function, obtain a function?" Emmeche (2002) has argued that "obtaining a function" refers to the re-setting of internal relations that occurs when a molecule (or some other structure) is taken in and made an integral part of a functional cycle or semiosis.[8] Questions that then arise from this most general formulation will then include: "What are the primary biological functions?" "How do these biological functions relate to specifically semiotic functions?" and "How may one kind of function turn into the other?" And perhaps all of these last three questions may fall under the larger question: "What are the major modes of biosemiosis?"

For again: it is important to notice that the kind of semiotic incorporation of *qualitative* change discussed by Emmeche (2002) is not fully reducible to the mere *quantitative* change that is also introduced with the inclusion of some new element (a molecule, etc.) into the operations of the body structure. For most such bioprocesses attain their particularly bio-*semiotic* status from the dynamic feed-forward loop that they establish between *both* the organism's set of internal relations *and* the set of existing environmental relations "external" to the organism/environment interface (e.g., its membrane, skin or other boundary condition).[9] The model of the functional cycle demonstrates well the necessary node of the triadic sign relation that often lies outside of an organism's body.[10] Acknowledging the necessity of this agent-environment interdependence for the successful setting up and negotiation of sign relations makes it particularly interesting to ask: "How is a particular semiosic process (meaning both any particular given "sign" as well as the several different *types* of signs) extended spatially and temporally?" and "Which (physiological, ecological, and communicational) processes and structures are involved in this?"

Perhaps, then, we spoke to soon when we noted earlier that such biosemiotic investigation would occupy 21st century science. For as the empirically examinable and scientifically testable questions multiply exponentially—once one takes the relatively simple first step of refusing to believe *a priori* that all semiotic phenomena *must* be fully reducible to non-semiotic phenomena—several more centuries worth of productive scientific inquiry appear on the horizon.

Accordingly, we too realize that we have yet but scratched the surface in our examination into the "questions" raised by and for a biosemiotic life science. So in the interest of brevity, let us just use what little remaining space we have at our disposal here to sketch out a few of the more pressing "big picture" questions that "taking the biosemiotic turn" engenders.

[8] On the biosemiotic concept of *function*, see Emmeche (2002).

[9] See Palmer (2004).

[10] Similarly to the concept of the 'extended mind' in cognitive approaches (Clark and Chalmers 1998).

Questions About the Attributes and Boundary Levels of Biosemiosis

The biosemiotic approach to investigating life processes can in many ways be characterised as a *relational approach*, because its primary area of inquiry regards biological creatures' sign relations and the sign-relational aspects of those creatures' worlds. It is too, then—and perhaps on the most obvious level—an inquiry into many of the *communicative* aspects of living organization, both within and between organisms. A fundamental question in "biosemiotic ethology" then will concern: "How should science theoretically characterise the communication between (and within) organisms?" Relatedly: A principled method for capturing and accounting for the *translatability between sign systems* occurring both between different species, as well as between different types, of semiosis (including human–animal communication) will certainly prove to be a pressing need once biosemiotic research advances to that point.[11]

Thus, the questions of *development*, from the biosemiotic point of view, turn out to be a deeply interconnected set of questions about the ways of categorization and *re*-categorization, as the introduction of new elements and the change or removal of old ones effect both local and global changes in the system's network of *meaning* (i.e., the relations between "instruction" and "appropriate response"), as such interdependent elements obtain new meanings (and new functions), and result (and become subjected to) different *types* of emergent sign processes. Perhaps the overarching question for semiotic life science here is: "How to analyse living structures and organic forms themselves as 'communicative' structures?"

Framed thusly, the questions of *evolution* can then be seen simply as an inquiry into the fixation of these developmental changes, making these both irreversible for the species, as well and part of the now-existing substrate upon which subsequent developmental change must take place (Hoffmeyer and Kull 2003; Kull 2000b). Such questions, when biosemiotically unpacked and related in detail to the rich spectrum of debates in contemporary evolutionary theory—including Evo-Devo and Developmental Systems Theory—should yield rich rewards in our understanding of the deep relations between life and change—an understanding that we can but gesture towards here.

It is hoped that a more biosemiotically informed approach to evolution will also throw some light on the questions regarding *semiotic thresholds*, or the major qualitative differences between the types of semiosis available to different organisms. The concept of a 'semiotic threshold' was introduced originally by Umberto Eco (1979), who used that term to speak about the boundary between the semiotic and non-semiotic world.[12] Later, Terrence Deacon (1997) used the term "symbolic threshold" to differentiate between what he sees as the human-specific culture of thirdness relations (or "symbolic reference") that is *language* and the

[11] See Kull and Torop (2003).

[12] Eco (1979: 6) writes: 'By *natural boundaries* I mean principally those beyond which a semiotic approach cannot go; for there is non-semiotic territory since there are phenomena that cannot be taken as sign-functions'. On multiple approaches to such a semiotic threshold, see Stjernfelt (2003, 2007).

manifold number of other (iconic and indexical) sign systems used by all species (including humans) to gain knowledge about the world and (in some cases) to communicate to one another. The pressing question for this research agenda would then be *to determine the indexical threshold, and to describe the iconic and symbolic thresholds in further detail*.

Tackling the question from a more 'categorical' perspective, we may reformulate the question in its "biggest picture" sense as: "What are the main types and levels of semiosis?" Kull and others have argued that the main three types of semiosis are, somewhat in the Aristotelian sense: the vegetative, the animal, and the rational (or propositional and lingual).[13] Here, we would hypothesise that the indexical threshold concerns the difference between vegetative and animal semiosis, though the more detailed reasoning behind this hypothesis must wait for another time. Obviously, there is work for biologically informed *philosophers* in the coming age of biosemiotic inquiry, as well!

And finally, an ultimate—and perhaps the most immediately pressing and 'practical' problem to be addressed by biosemiotics (and maybe by science and by human culture in general)—is *the problem of (bio)semiotic balance*. The organic balance, the balance of life, by its very nature is a semiotic balance. This means that the problem of the ecological balance may converge with the problems of the balance of cultures and the problems of human health; thus the protection of biodiversity and protection of cultural diversity turn out to be parts of the same general problem—the protection of diversity, or quality as such (cf. Keskpaik 2001; Petrilli and Ponzio 2005).

Biosemiotic Case Studies

Many of the above questions have already begun to be addressed to some extent in a series of biosemiotic case studies undertaken during the past decade. We will not give a detailed review of all such studies here, but will only provide a short list that we think indicates some of the more important lines of research wherein contemporary empirical biology is interpreted biosemiotically, or where the biosemiotic approach is used as a major guide in understanding basic meaning-making mechanisms and/or significant patterns of sign relations in biosystems across many scales of integration.

1. *The biosemiotics of animal communication* (e.g., Sebeok 1972, 1977; Lestel 1995; Martinelli 2007a). Such study includes research into the sign behaviour of particular species (e.g., Sebeok 1994; Pain 2005). Of particular note here is a semiotic analysis of the vocal signs used by vervet monkeys that seeks to classify them according to the fundamental kinds of signs, infer minimum brain organizational constraints for their interpretation, hypothesize possible neuro-anatomical substrates able to satisfy these constraints, and propose an experiment based on the interpretation of signs in these monkeys in order to test these hypotheses (Queiroz and Ribeiro 2002).

[13] von Uexküll (1986a, b); Emmeche (1984, 2004); cf. Clarke (2003).

2. *Biosemiotic processes in ecosystems* are crucial to proper ecosystem function. S. N. Nielsen (2007: 99) writes: "where would ecosystems be without insects to pollinate flowers? Bees could hypothetically be flying around in a random manner—which indeed would most likely lead to the result that some flowers would be fertilised. But adding their ability to smell flowers, see them at distance, possibly remembering a good spot and for sure to communicate it to the other workers of the beehive would increase the probability for this. These semiotic processes are crucial not only to the beehive but also to the ecosystem as such". Similarly, the abiding concern with the deep interrelations between ecosystems and organisms that was initiated in biosemiotics by its "precursors" such as Bateson (1979, 2000) and von Uexküll (1928) has been carried on today by such "eco-biosemioticians" as Peter Harries-Jones and Myrdene Anderson. Additionally, Krampen (2001) has described the functional differentiation in ecosystems as a semiosic relationship, and Farina et al. (2007) have investigated the relationships of umwelten within a ecological landscape. The studies on the semiotics of plant and animal mimicry by Maran (2007) are also extremely worthwhile contributions to this field.
3. *The biosemiotics of the immune system* (Sercarz et al. 1988). Of recent note here is El-Hani et al.'s (2007) semiotic model of signalling pathways in the B-cells of the immune system. This study substantiates the notion that semiotic modelling is required in order for the *referential* aspect of signalling processes to be analyzed and explicated. Hoffmeyer's extended discussion of the immune system's role in the creation of a self-nonself distinction in organisms is also relevant in this regard (Hoffmeyer 1996b).
4. *The biosemiotics of signal transduction*. A crucial part of comprehending the regulation processes within eukaryoric cells is the attempt to understand how *specificity* is determined (e.g., by the categorical sensing of the Ca^{2+} code), how and why ubiquitous messengers convey specific information, how the cell avoids undesired 'cross-talk', and the role of redundancy for systemic integration. Bruni (2007) is particularly instructive in addressing all of these important issues.
5. *Neurosemiotic* approaches to brain research and consciousness studies have been proposed by Deacon (1997), Favareau (2002), Neuman (2003), Roepstorff (2004) and Villa (2005); while a biosemiotically informed approach to cognitive robotics has been undertaken by Ziemke and Sharkey (2001), Sharkey (1999, 2002), and Emmeche (2001).
6. *A biosemiotic model of the genetic information system of the cell*. Reconceptualizing the standard models of molecular biology for conceptualizing protein synthesis (including transcription, RNA processing, translation, etc.) several studies (Queiroz et al. 2005; El-Hani et al. 2006, 2008) adopt a Peircean model to explain such sign process; Barbieri (2003, 2007) adopts an "organic code" model to explain the same. In both cases, the goal is to move away from reliance on the sterile and unhelpful use of the term 'information' as a placeholder or mere metaphor in explaining genetic processes, and to replace it with a fully useable and genuinely bio-semiotic *definition* of what 'information' for a living system consists in.

7. *A biosemiotic taxonomy* of systematic, compositional, sign-dependent relations in the living realm has been begun by Barbieri (2003, 2007) in his delineation of "the organic codes" of genetics—e.g., sequence codes, signal transduction codes, splicing codes, etc. The recently published *Codes of Life* (2008) features 18 different authors contributing to the development of this taxonomy, and building on this work, too, is Faria's (2007) study of how a major evolutionary change—in this case, the appearance of vertebrates—requires the development and fixation of new codes for the immune system.
8. Using Krampen's (1997) *semiosic matrix*, Huber and Schmid-Tannwald (2007) have devised a compelling reinterpretation of the process of oocyte-to-embryo transition in development by showing in detail how and in which sense the zygote acts as an 'situated interpreter' not only of the inert nucleotides of the genome, but also of its specific context-dependant and context-constructing constructing *umwelt*.
9. *Comparative studies* of sensorimotor interactions and inner representations in vertebrates (turtles, canids) and invertebrates (jellyfish, earthworms) discussing also qualitative aspects of sensation (such as pain) have been surveyed from a general biosemiotic perspective in an fascinating study by Stephen Pain (2007).
10. *Studies of vegetative semiosis*, particularly in plants (Krampen 1981; Kull 2000a, b; Baluška et al. 2006; Barlow and Lück 2007) have demonstrated the existence of genuine sign processes in the vegetative realm of life.
11. *The role of sign types at various biosemiotic levels for the emergence of the human linguistic animal*, and in particular differences and similarities between human language and animal communication have been suggestively studied and biosemiotically analysed by Terrence Deacon (1997); Donald Favareau (2008) and Dario Martinelli (2007b). John Deely's seminal *What Distinguishes Human Understanding?* (2002) and more recent *Intentionality and Semiotics* (2007) should also be noted in this regard.

Conclusion

Having in this article only briefly gestured towards just some of the major questions facing biosemiotic inquiry at this stage of its development, we hope we have yet been able to demonstrate some of the fundamental differences entailed between taking a semiotic approach to life science and the approach taken by non-semiotic biology, where such questions are provided no conceptual space in which to be asked. That said, one should not ignore the fact that from within that very successful tradition of non-semiotic biology, there have recently (and, indeed, increasingly) emerged new trends in genetics and in cellular and molecular biology that aim at more systemic and holistic understandings than had previously been attempted in the atomistic–reductionist phase of their sciences.

The search for such "higher-order understandings" is expressed not only by the increasing prevalence of key terms such as *systems biology* (Ideker et al. 2001), and the big-*omics* or mapping projects (e.g., genomics, transcriptomics, proteomics, cellomics, etc.)—but also by the increasingly acknowledged necessity for integrating

the many current findings across disciplines in order to model the complex dynamics of life processes such as regulation, morphogenesis, communication, cell death, cell differentiation, the epigenetic processes, and in general, the massively interconnected processes that are biocomplexity and biodiversity.

Biosemiotics as a nascent scientific paradigm-shift welcomes these trends towards a more organicist biology (cf. Gilbert and Sarkar 2000) but also criticizes a tendency among some of them to remain mired in a self-defeating metaphysics wherein only the dyadism of brute physical interactions, as established within the study of physics and chemistry and as interpreted atomistically, are taken as explanatorily exhaustive of what is 'real'. For in order to *explain* such undeniably present phenomena in the biological world as: subjective sensation, feeling, anticipation, awareness, meaning communication, and 'mindedness', what is needed is a wider diversity of scientifically grounded concepts dealing with emergent *qualitative* novelties at different levels of biological integration. But this is precisely, of course, what a non-semiotic approach to biology, by definition, rules out the possibility of ever developing.

It is precisely in this domain of the life sciences, we believe, that biosemiotics can contribute to a better understanding of the interdependently *relational* and *semiosic* nature of living being, and of the contextual settings determining the interpretations of intrinsic signs processes in complex biosystems. In this sense, a more qualitative form of the 'organicist' framework is achieved, integrating the rich findings of non-semiotic research within an expanded (or extended) biology that can and will undertake the inquiry into the underlying "science of signs". For only within such a new biology can phenomena such as organic 'qualia' be comprehended, including the qualitative organic relations characteristic of the human species.

This is so because, in the Modern epoch of scientific research, the human species has been considered as, on the one hand, a strangely unique creature in the sense of having special access to reality through language and science, and of being capable of making objective descriptions of the world—and, on the other hand, as simply one species among others within the long and continuous history of evolution. As we see it, biosemiotics is an approach to the life sciences that makes it possible to unify these two apparently contradictory images of human beings and their place in nature. Our articulation of some of the preliminary biosemiotic 'questions' that we have presented here will, we hope, help aid in the development of a focused set of conceptual tools that may eventually allows us to model the *realities* (*both* semiotic *and* non-semiotic) of not only the human experience of living being, but also the sphere of objectively significant organismal relations as categorised by other species, as well.

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