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On the Semiosphere, Revisited

Abstract

The semiosphere is frequently described as a topos of complexification, namely discontinuous or heterogeneous, recursive or self-reflexive, stochastic, radically subjective, and capable of simultaneous multiple perspectives. While the topos of complexification describes the gross morphology of a model, it is not a model adequate for explaining phenomena or making predictions. The ecological theory of dual hierarchies is proposed as a framework for developing models of the semiosphere that are appropriately limited in scope and scale. In particular the semiosphere is modeled as a dual hierarchy of semiotic spaces, the dual hierarchies corresponding to the semiosis that is occurring within the dual hierarchies of ecological organization. This framework immediately solves several theoretical problems, such as clearing up conceptual inconsistencies in Lotman's concept of semiosphere.

Keywords: semiotics, semiosphere, ecosystem, hierarchy theory, category theory, semiotic triad

Introduction

Juri Lotman's (2005) On the semiosphere, first published in 1984, introduced the concept of the semiosphere and attempted to describe its gross structural features in broad terms. The semiosphere is defined as the semiotic space outside of which semiosis cannot exist, where semiosis is any form of activity, conduct, or process that involves signs. On its face, the structure of Lotman's concept of semiosphere has difficulties, but by focusing on these difficulties one loses sight of the value of the concept. Lotman's conceives of the semiosphere as a space that carries an abstract character and possessing signs, which space he asserts is not metaphorical (therefore not abstract?) but specific (therefore material and not abstract?). Lotman's main theme was that the semiosphere is a unitary whole (all semiotic space may be regarded as a unified mechanism; Lotman 2005) having a unitary boundary, yet in his discussions of Russian history in terms of boundary and irregularity he suggests that boundary is in the eyes of the beholder and that one man's non-semiotic space is another man's semiotic space (the crossing point of the boundary of a given culture depends upon the position of the observer; Lotman 2005: 213).

Moreover, Lotman claimed that his semiosphere was motivated by and analogous to the biosphere of Vernadsky (1998). Kotov (2002: 44) showed that Lotman in fact did not adopt Vernadsky's definition of biosphere. Lotman's biosphere comprises space and living matter, whereas Vernadsky's concept comprises space, living matter and the physical environment. Vernadsky's biosphere contains ecological communities and their environment, but, it must be emphasized, it contains none of the functions of ecosystems (Kalevi Kull, personal communication). For example, he represented Suess' concept of the biosphere, on which he depended, as a specific, life-saturated envelope of the Earth's crust (Vernadsky 1998: 91, § 68). It is one of a series of envelopes, the geospheres (Vernadsky 1998: 95, § 78), which comprise *thermodynamic envelopes*, determined by values of temperature and pressure; *envelopes of states of matter*, characterized by material phases (sold, liquid, etc.); and *chemical envelopes*, distinguished by chemical composition (Vernadsky 1998: 97, § 81); but it is left out of this scheme (id.). Vernadsky acknowledged that living organisms bring solar energy into the physico-chemical processes of the crust (Vernadsky 1998: 97, § 82); he acknowledged that living organisms are special thermodynamic fields of the biosphere (Vernadsky 1998: 99, § 85); but he never acknowledged that the biogeochemical processes at play in the biosphere were part of the biosphere. Thus Vernadsky's concept of the biosphere does not match the current concept of the biosphere as the sum of all ecosystems. As a construct of purely structural elements, it makes for an impoverished model for the semiosphere.

After pointing out that Lotman did not strictly analogize with Vernadsky's concept of the biosphere, Kotov (2002: 48) elaborates on Lotman's concept. Citing Lotman, Kotov reasons that the environment is not part of the semiosphere, but the environment is subject to semiotization. In fact the semiosphere is *the main transformative device of the (human) environment* (Id.; italics in the original). This line of thought needs more subtlety. We should remember Lotman's statement that the crossing point of the boundary of a given culture depends upon the position of the observer (Lotman 2005: 213). What is non-semiotic to humans may be semiotic to non-humans. A more detailed theoretical model is needed to clarify these and other points.

Semiosphere as a Topos of Complexification

Semioticians currently conceive of the semiosphere a topos, an abstract world or a universe for [mathematical] discourse (Trifonov, 1995) in which the researcher's logic is conceptualized as part and parcel of what he is observing. Topos theory assumes that we view our world through filters, but it tells us that those filters are deeply related to reality.

Formally, topoi are mathematical categories in which the objects are set-like, the arrows are function-like, and there is a complex logic (Boolean or not) on the arrows (these indicate the direction of the morphism but do not include the morphism; the morphism itself is the operation on the arrow or the logic). It might be remembered that a category **C** is a collection **Ob**, the *objects* of **C** which satisfy the following conditions (Marquis, 2004, Easterbrook 1999) (Figure 1):

> For every pair *a*, *b* of objects, there is a collection **Mor**(*a*, *b*), namely, the morphisms from *a* to *b* in **C** (when **f** is a morphism from *a* to *b*, we

write **f**: *a* ->*b*);

For every triple *a*, *b* and *c* of objects, there is a partial operation from pairs of morphisms in **Mor**(*a*, *b*) X **Mor**(*b*, *c*) to morphisms in **Mor**(*a*, *c*), called the composition of morphisms in **C**

(when **f**: *a* ->*b* and **g**: *b* ->*c*, (**g** o **f**): *a* ->*c* is their composition);

For every object *a*, there is a morphism **id***a* in Mor(*a*, *a*), called the identity on *a*.

The morphisms must satisfy two axioms:

Associativity: if **f**: *a* ->*b*, **g**: *b* ->*c* and **h**: *c* ->*d*, then **h** o (**g** o **f**) = (**h** o **g**) o **f**

Identity: if **f**: *a* -> *b*, then (**id***b* o **f**) = **f** and (**f** o **id***a*) = **f**.

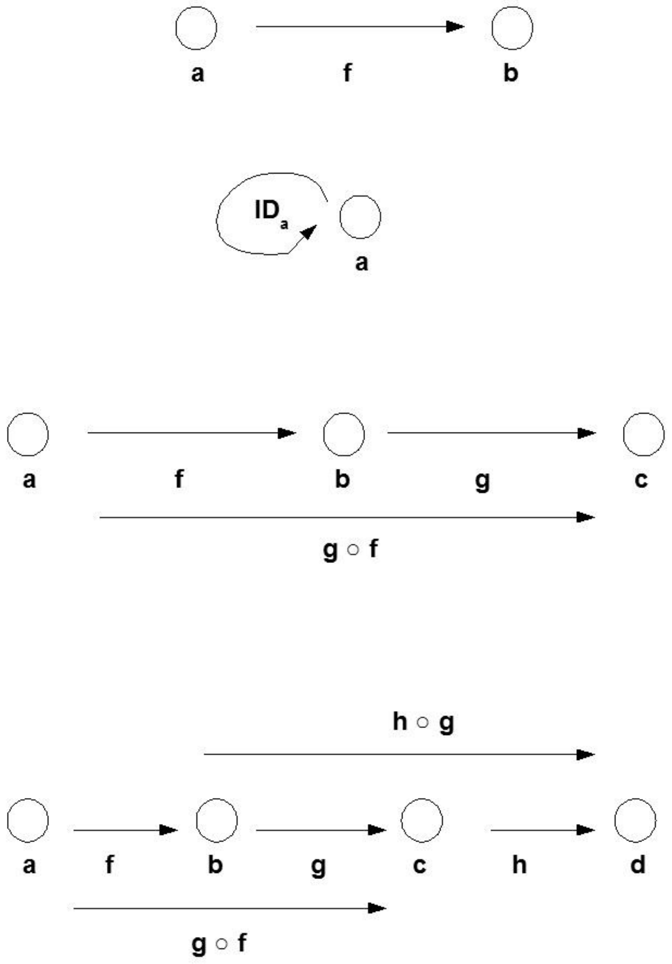

Figure 1. A category **C** is a collection **Ob**, the *objects* of **C** which satisfy certain conditions.

Category theory was developed between 1942 and 1945 by Eilenberg and Mac Lane (1942, 1945). Generally speaking, categories grow organically like living systems, in contrast to functional analysis that has only points, sequences, norms, spaces (Kainen 2005). We start with the morphism. We map a morphism to itself;

that is an object. We construct a (homeo)morphism that maps one category to another; that is a functor. We construct a morphism that maps one functor to another; that is a natural transformation. Thus category theory is hierarchical, having discrete or discontinuous levels of organization, and recursive or self-referential.

Though category theory is widely viewed as providing an alternative to set theory as a foundation to mathematics (e.g., Mac Lane 1996, Lawvere and Rosebrugh 2003, Lawvere and Schanuel 1996), the primary importance of category theory is turning out to be adjoint functors (e.g., Awodey 2006, Wood 2004: 6, Taylor 1999: 367), which apparently capture something very important that was missed by the rest of the entire body of mathematics. Adjoint functors are pairs of functors that are in a sense inverses of each other. A functor $F : C \to D$ is called right adjoint and a functor $G : C \leftarrow D$ is called left adjoint (C and D are categories). An adjunction between categories C and D comprises the functors F and G, and a natural isomorphism $\Phi_{X,Y}$: $\mathrm{hom}_C(FY,X) \to \mathrm{hom}_D(Y,GX)$. Rosen (1958) for example expressed his (M,R) systems theory using categories and depended heavily on adjoint functors, but his theory does not require categories (Letelier et al. 2006). He was apparently attracted to category theory in part by its similarity to natural language, in particular by its ability to talk about itself (self-referentiality) and by its scalable hierarchical nature (simultaneous multiple perspectives) (Rosen 1991: 54-55, 149). As a topos of complexification, category theory probably satisfied Rosen's postmodern aesthetic and sensibility. But more critically, Rosen's project was to produce a model in which every variable was a function of a variable that already existed in the model (Figure 2), and categories are closed systems (Rosen 1991: 127-8). Rosen probably liked category theory because it forced him to develop a self-entailed system. For example, Rosen distinguished between inner entailments and outer entailments. An inner entailment is of the form X entails Y which reciprocally entails X, where both X and Y are elements in the category. An outer entailment is the construction of mappings from mappings, for example through functional composition, which is outer because the resulting composition of functions is not in the category even though it is made up solely of functions in the category. Rosen's theory depends on one outer entailment in particular, namely the Cartesian product, which he uses to model the metabolic transformation of one element into another. Baianu subsequently developed Rosen's ideas in a theory of organismic supercategories (Baianu and Marinescu 1968, Baianu 1970, 1971), which enabled the development of models of various life processes (Baianu et al. 2006). Kainen (2005, 1990a,b) proposes a category theoretic approach to biology in which perception and action are adjoint functors. Haruna and Gunji (2007) formalize decomposition into functions and gluing functions as endofunctors on the category of directed graphs and prove that they constitute an adjunction.

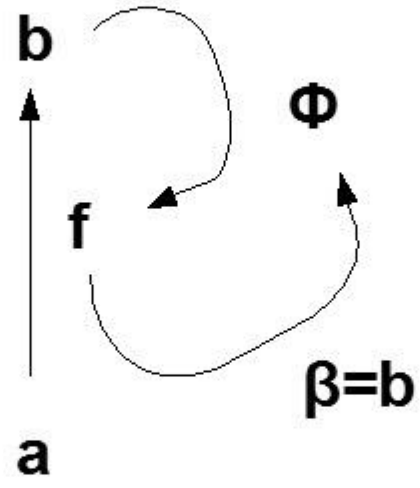

Figure 2. Schematic of Rosen's (M,R) system. Variables a and b are molecules, f is metabolism, ϕ is the replacement mechanism for f, ß is a procedure that given metabolism f produces ϕ. One may also treat the variables a, b f, ß and ϕ as objects and the arrows between them as morphisms, to construct a category.

Category theory has recently found its way into semiotics. It is used in the relatively new field of algebraic semiotics (the seminal paper is Goguen 1999). Joslyn (2001) uses category theory in his analysis of the semiotics of control systems. Thiopoulos (1992) uses category in his development of the logic of semiotic systems (for example, he defines a semiotic category).

Applying category theory to semiotics immediately provides useful results. Let **Sign** be a category with objects *r*, *i* and *o*, where *r* is the representamen (the form the sign takes), *i* is the interpretant (the sense made of the sign), and *o* is the object (to which the sign refers); and with morphisms **f**: *o* -> *r*, **g**: *r* -> *i,* **h**: *o* -> *i* , **j**: *i* -> *r*, **k**: *r* -> *o,* **l**: *i* -> *o* , along with the requisite identity operations and associativity (Figure 3). The category **Sign** is Peirce's (1955) semiotic triad.

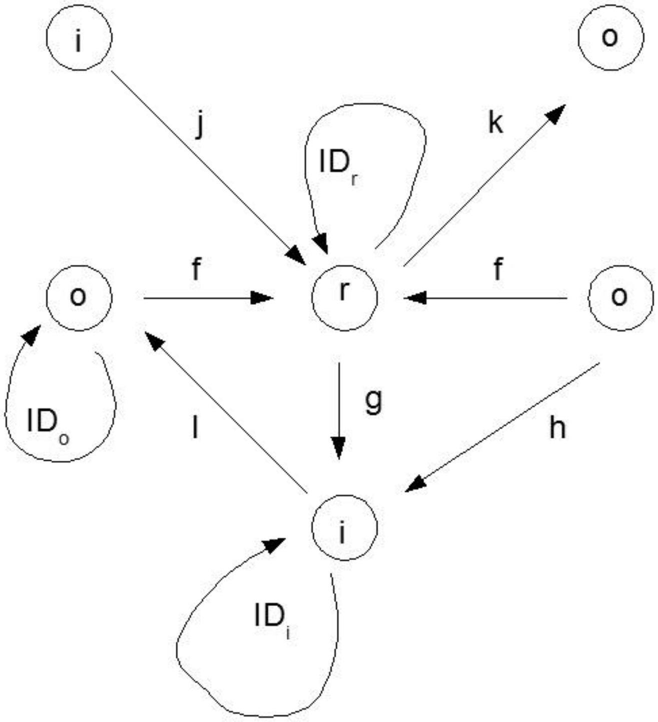

Figure 3. The category **Sign**. Not every arrow (morphism) is required.

It is possible that all signs, each of which itself is a category, are isomorphic to the category **Sign**. Two categories C and D are isomorphic if there exists a transformation $F : C \to D$ that maps every object and morphism in C to an object and morphism in D, respectively (Figure 4); formally, there exists $F : C \to D$ and $G : D \to C$ where F and G are mutually inverse to each other, i.e. $FG = 1_D$ and $GF = 1_C$. . As an example consider Kull's (1998b) Four Natures (Figure 5). **Sign**'s object *o* maps to Nature (both are *o* and Nature are objects in the colloquial sense), and **Sign**'s object *i* maps to Image (both *i* and Image are images in the colloquial sense). In Kull's Four Natures the correlates to object *r* and the correlates to the morphisms are unspecified. Kull's Four Natures is isomorphic to the category **Sign**. Colloquially, Kull's Four Natures is a Piercean sign.

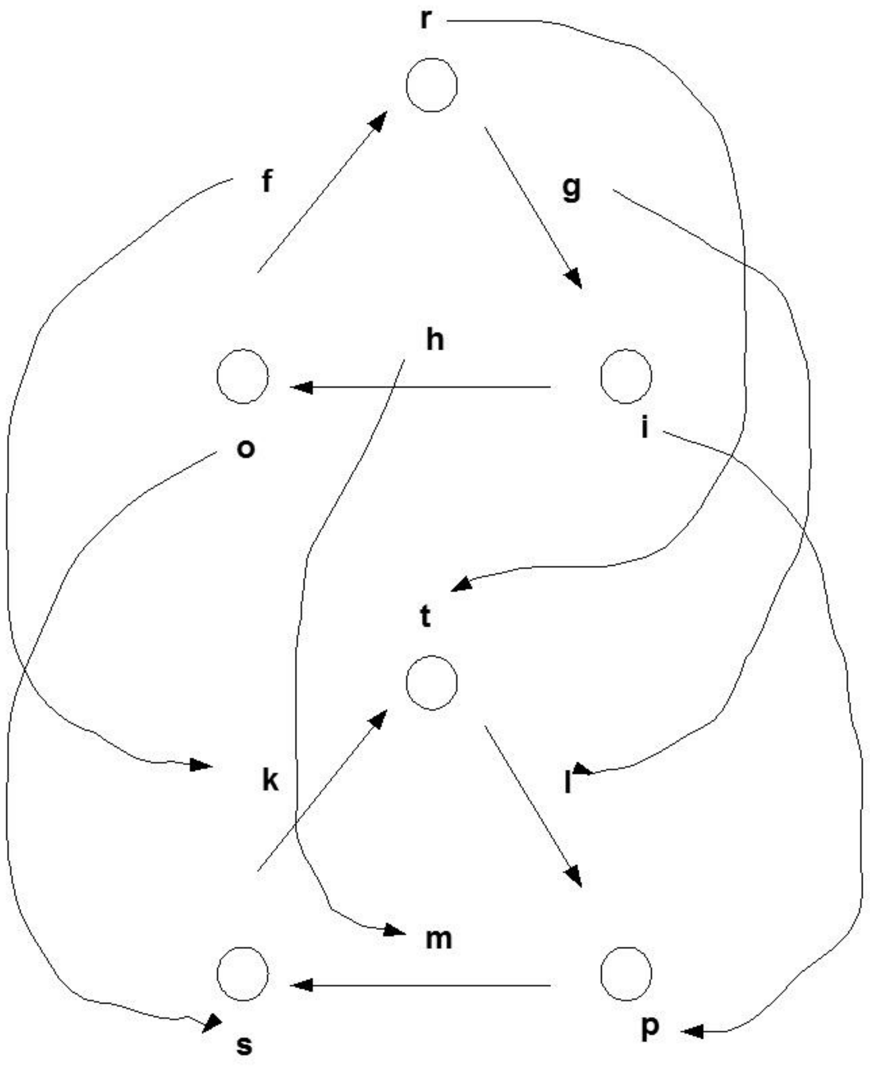

Figure 4. Isomorphic categories.

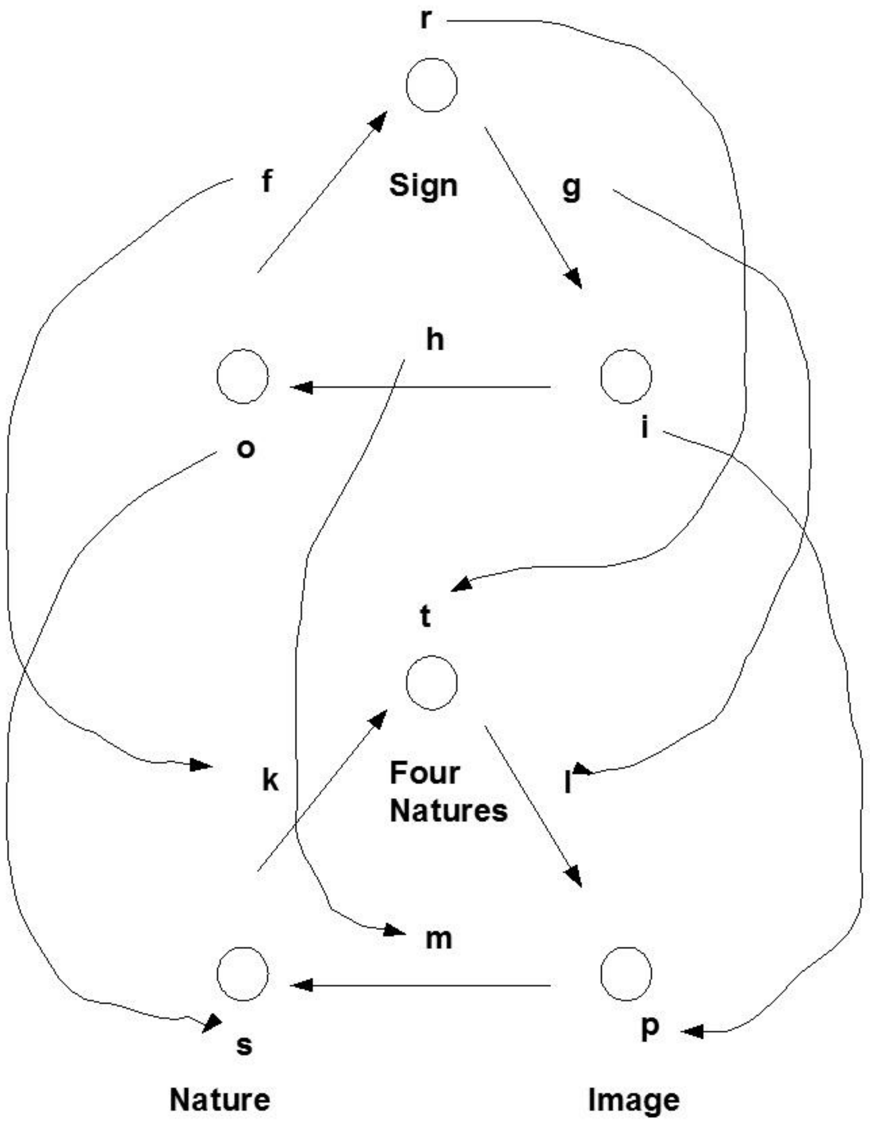

Figure 5. Kull's (1998) Four Natures as a category, which is isomorphic to the category Sign. The identity operations are not shown.

As another example consider Uexküll's (1928) functional circle or *Funktionskreis* (Figure 6). Uexküll (1997) claims that the model of the functional circle contains all the elements which are part of a sign process: the organism is the *subject*, environmental signals are *signs* (interpretanda), and the organism's biological condition determines the *behavioral disposition* (interpretant) (see also http://www.zbi.ee/~uexkull/cv.htm: [Uexküll's] concept of functional circle (*Funktionskreis*) can be interpreted as a general model of sign processes (semiosis)). Kull (1998b) points out that his *Funktionskreis* and his Four Natures (a Piercean sign) are almost isomorphic. Is Uexküll's *Funktionskreis* isomorphic to the category **Sign**? One semiotician sought to avoid a detailed Peircean re-interpretation of J. von Uexküll's functional circle (Emmeche 2001 note 16), but we shall do so here. To some extent Uexküll specified the morphisms, viz. **f**: *o* -> r is the *Merkwelt*, **k**: *r* -> o is the *Wirkwelt* (**f** and **k** are adjoint morphisms), the simultaneous operation of **f** and **g** is the *Umwelt*, the identity operator on object *i* is the *Innenwelt*, and the identity operator on object *o* is the Kantian *Ding an sich*. The arrows in my (our) category theoretic semiotic triad traditionally stand for environment, i.e., **f**: O-> R is the merkwelt or that part of the world to which an organism can pay attention (the reverse **k**: R-> O is wirkwelt or that part of the environment that an organism can effect/change); and **g**: O -> R -> I is the Umwelt or the environment as subjectively perceived by the organism. Sharov (2001) claims that the significant difference between Pierce's sign and Uexküll's *Funktionskreis* is that Uexküll holds that signs are interpreted as actions instead of as mental concepts or interpretants. If that is correct, both Peirce and Uexküll could be accomodated by the same category if object *i* is broadened to accommodate both action and interpretant, though it may eventually prove useful to keep the two distinct. Otherwise Uexküll's *Funktionskreis* is isomorphic to **Sign**.

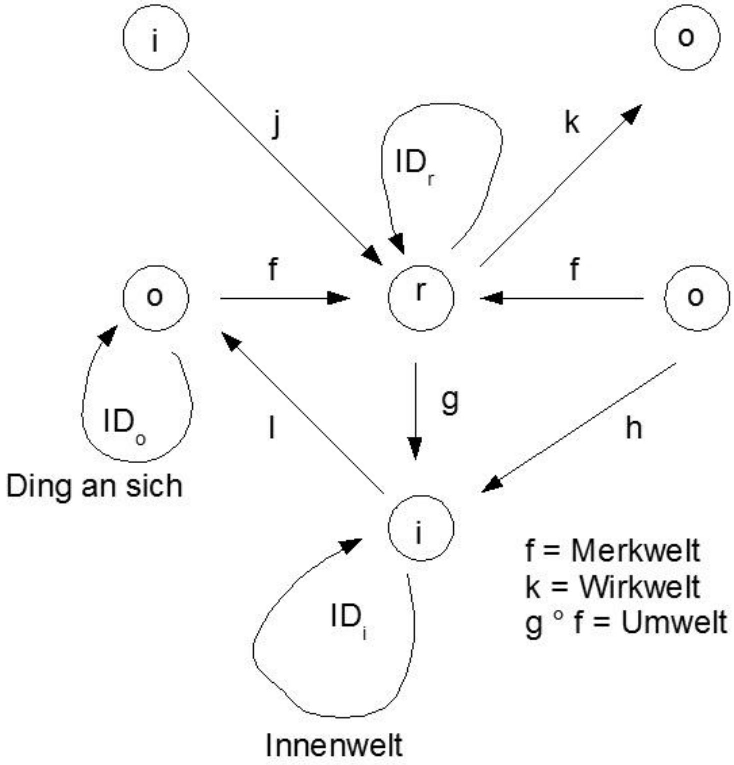

Figure 6. Uexküll's (1928) functional circle or *Funktionskreis* as a category.

Peirce's Firstness, Secondness and Thirdness also comprises a category (Figure 7). Peirce maintained that Thirdness mediates between Firstness and Secondness (Hartshorne and Weiss 1931-1958, volume 5 page 121). That makes Thirdness sound more like the morphisms **f** and **i** between objects Firstness and Secondness; however, we can achieve the same result using compositions of functions through Thirdness, i.e., $i = l \circ g$, and $f = j \circ h$. The morphisms in Figure 7 have all been discussed in trikonic vector analysis (e.g., Richmond 2005) but not in terms of category theory.

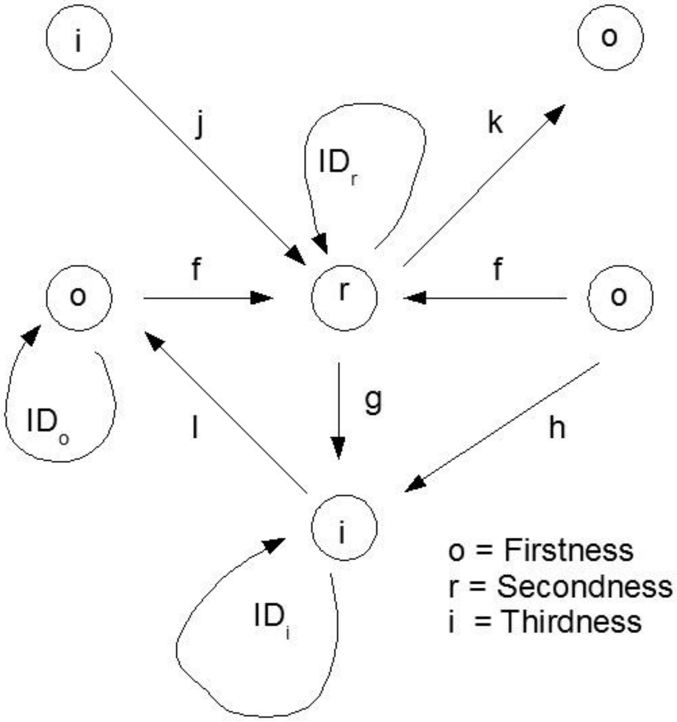

Figure 7. Peirce's Firstness, Secondness and Thirdness as a category.

Returning to topos, the primary benefit of topos theory is that it explicitly demonstrates that the logic of the observer is developed in his interaction with the environment. Trifonov (1995) refers to this as the principle of active comprehension. All the possible influences of a researcher (i.e., all of his possible actions) on the physical world or absolute universe define that researcher's interpretation of the absolute universe or his proper universe. His proper universe then defines his logic for him. Now a researcher acts and interprets his observations in accordance with his knowledge, which contains his logic, such that his logic determines his actions. In other words, all of his possible actions determine his logic, but his logic determines his possible actions (Figure 8). Thus the object level is unified with the subject level, and ontology and epistemology are placed on the same footing (Zimmermann 1999, 2002).

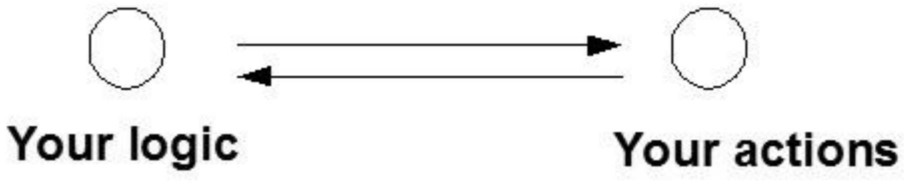

Figure 8. In a topos, your possible actions determine your logic, but your logic determines your possible actions.

The topos of complexification (Table 1) is a topos in which the objects are the physical world, and the arrows convey the logic of complexity, where the logic of complexity involves recursion (or self-reflexivity, or iteration), stochasticity, discontinuity, radical subjectivity, simultaneous multiple perspectives, and perhaps nonlocality. Recursive or self-reflexive means referring only to itself, such as non-representational (abstract, conceptual) art, or iterative mathematics, or any other type of self-reference or self-referential system (see e.g., Russell's Paradox). Stochastic means random through time; this might also manifest as heterogeneous in space. Discontinuous means mathematically or physically so. Radically subjective means such things as the unique vision of an individual (consider Picasso's work), or the phenomenon that what is observed depends on the scale of the observer. Simultaneous multiple perspectives means such things as nested hierarchies, or multiculturalism, or fuzzy logic. Nonlocality means correlation instantaneously across space, as in the nonlocality of the quantum. This is a worldview that complexifies one's perspective, that fragments the world. This topos captures the main characteristics of Modernism and arguable Postmodernism (e.g., Everdell 1997). The value of topos theory is that it assures us that we know the world as complex because the world really is complex, and that our complex models help us appreciate the complexity of the world.

Discontinuous
Stochastic
Radically subjective

Simultaneous multiple perspectives
Recursive
Non-local

Table 1. The topos of complexification (Marinakis 2008a, b).

It is easily demonstrated that semioticians conceive of the semiosphere as a topos of complexification. I begin with Lotman. Lotman's notion of border (pp. 208-213) and semiotic irregularity (213 ff.) satisfy the condition of discontinuity (209: The isolated nature of the semiosphere subsists in the fact that it cannot be contiguous to extra-semiotic texts or non-texts.). His idea that the crossing point of the boundary of a given culture depends upon the position of the observer satisfies the condition of radical subjectivity (213). Lotman's notions of hierarchy (213, 215) and dialogue (216) satisfy the condition of simultaneous multiple perspectives. Lotman's notions of self-description (214), self-knowledge (217) and self-reference (mirror symmetry, 220-225) satisfies the condition of recursion. Only stochasticity is missing, but Torop (2005) informs us that Lotman is interested in unpredictability.

Other semioticians have followed suit, describing the semiosphere as a topos of complexification. Hoffmeyer (1998a) discusses stochasticity (indeterminacy), heterogeneity, recursion (habit), discontinuity, and hierarchy (organisational levels); Merrell (2001) discusses heterogeneity; Kotov (2002) discusses heterogeneity (42), discontinuity (boundary, 42), recursion (Redi principle, 42; self-regulation, 44), multiple simultaneous perspectives (semiosphere as a semiotic space itself consisting of several semiospheric structures, 43), stochasticity (49); Lotman (2002) discusses recursion (dialogism); Kull (2005) discusses simultaneous multiple perspectives (177, 180; diversity, 179, 185), recursion (178); Torop (2005) discusses stochasticity (160), recursion (dialogism, 162-163) and hierarchy (164, 166).

The topos of complexification describes the gross morphology of a model, but it is not a model adequate for explaining phenomena or making predictions. Consider that Quantum Mechanics is a topos of complexification: the quantum is discrete or discontinuous, its state upon decohering is stochastic, its states are superposed (simultaneous multiple perspectives), the observer's consciousness affects reality (radical subjectivity), quantum states display nonlocality. But this description is far from Quantum Mechanics itself.

Semiosphere as Dual Hierarchies

If the topos of complexification does not provide an adequate model for the semiosphere, what does? One option begins with the hierarchy. I write purposefully that one option *begins* with the hierarchy. It is a framework model, useful for its own attributes and for hosting other models at the various levels of the hierarchy. Hierarchy theory provides a conceptual method for dealing with complexity of...systems by grouping factors of interest into separate levels characterized by process rates and their relationships with other levels (Smiley and Dibble 2005). In hierarchy theory, the higher levels of the hierarchies constrain the lower levels (Ratzé et al. 2007; Allen and Hoekstra 1992, Chapter 1; O'Neill et al. 1986; Allen and Starr 1982), but lower levels may also constrain the higher levels (O'Neill et al. 1989). Lower levels operate at smaller spatial scales and faster temporal scales. Each level is a holon, or something that is simultaneously a whole and a part (Koestler 1967). Hierarchy theory also makes predictions, namely that correlations will be observed between all levels, and that the entities within a given level will be more strongly linked together than they will be with entities at higher or lower levels (Smiley and Dibble 2005, Allen et al. 1987, O'Neill et al. 1986).

There is another good reason for adopting the hierarchy as a framework: a richness of communication occurs at the community and ecosystem levels. These are emergent properties, synergistic outcomes, where the total is greater than the sum. As such it is necessary to consider these levels of organization as more than aggregates of individuals.

It has been previously asserted that ecosystems are a topos of complexification (Marinakis 2008a,b), in part because their treatment as hierarchies is common. Ecologists describe actual physical ecosystems as discontinuous (e.g., Milne et al. 1996, conceptualizing the transitions between them or ecotones as spatial phase transitions), stochastic (e.g., Scheffer et al. 2001, arguing that ecosystems sometimes respond rapidly and irreversibly, and perhaps stochastically, to multiple driving forces), radically subjective (Haynes et al. 1996: 11, asserting that [e]cosystem descriptions...and ecosystem processes, structures, and functions are all defined by the observer...; Rauscher (1999), asserting that [e]cosystems are communities or organisms and their environment whose boundaries are defined by an observer to facilitate some human purpose such as research or management.), displaying multiple simultaneous perspectives (O'Neill et al. 1986; Smiley and Dibble 2005, using Hierarchy Theory to study the relationship between stream channel form, instream habitat, and stream communities; Yarrow and Marín 2007, using Hierarchy Theory to study the boundaries between ecosystems, or ecotones; Ratzé et al. 2007, using Hierarchy Theory as the foundation of dynamical systems models of ecosystems), and recursive (ecosystems are conceived of as something in or through which nutrients cycle and energy flows). Otherwise the explicit use of category theory in ecology is highly limited. Levich and Solov'yov (1990) use category theory to model an ecological community. There is some non-explicit use of category theory in ecology: the directed digraphs of food web loop analysis (e.g., Levins 1975) stripped of their equations can be interpreted as categories.

The hierarchy is not new to semiotics. Kull (1993) suggested that there are hierarchies of Umwelten (Biosystems are hierarchic systems in the sense that they consist of several SRSs of different levels. Consequently, there is a hierarchy of Umwelten, hierarchy of adaptations, and hierarchy of meanings.). But one must be careful how one applies the hierarchy. Alexandrov's (2000) criticizes Lotman's work mainly (if not entirely) on grounds of Lotman's assertion that hierarchy exists in human semiotic systems. Alexandrov's criticism of Lotman arises out of Lotman's imposition of a hierarchy within the human level of organization, which is that of population and of ecosystem (noosphere). That Vernadsky's model does not work as applied by Lotman does not necessarily mean that the model is inappropriate. It could mean that the model has not been correctly applied. The difference between Kull's hierarchy of Umwelten and Lotman's cultural hierarchy is that Kull's hierarchy has a basis in physical reality. We should take this as a first principle: all divisions or hierarchical levels of semiotic spaces must have a correlate in physical reality. Lotman's semiotic hierarchy based on cultural hierarchy has no physical correlate. Kull's Umwelt hierarchy has physical correlates.

The hierarchy I am suggesting to use to model the semiosphere is that of O'Neill et al. (1986), who presented a dual theory of ecosystems, or more precisely, of ecology. O'Neill et al. showed that ecologists had conflated two hierarchies of organization into one unworkable, untenable hierarchy (Figure 9), and accordingly they suggested two hierarchies of ecological organization: organism-population-community, and functional component-ecosystem-biosphere (Figure 10). O'Neill et al. read the term biosphere broadly, as encompassing the environment as well as space and living organisms, whereas Lotman limits the term to space and living organisms. For O'Neill et al., the biosphere is not the sum of organisms, it is the sum of ecosystems; and ecosystems are not the sum of individuals, they are the sum of functional groups, e.g., decomposers, primary producers (Figure 10). As the sum of ecosystems, biosphere sensu O'Neill et al. contains the physical environment along with the living organisms. Some call it the ecosphere, reserving biosphere for Lotman's usage. Given biosphere sensu O'Neill et al., Lotman's concept of the biosphere is more like the sum of ecological communities---the (eco)communosphere, if you will.

Biosphere sensu O'Neill et al.
|
Biosphere sensu Vernadsky
|
Ecosystems
|
Ecological Communities
|
Functional Groups
|
Populations
|
Individuals
|
Sub-individuals

Figure 9. Single ecological hierarchy.

Biosphere sensu O'Neill et al.

Biosphere sensu Lotman
|
Ecological Communities
|
Populations
|
Individuals
|
Infra-individuals (cells)

|
Ecosystems
|
Functional Groups
|
|
[Protocells?]
|
Molecules

Figure 10. Dual ecological hierarchies (from O'Neill et al. 1986; my addition in brackets “[]”).

It is warranted here to briefly clarify what is meant by ecosystem and what is meant by ecological community. An ecological community or biocoenosis (also known as biocoenose or biocenose), comprises all the interacting organisms living together in a specific habitat (or biotope). Intuitively, an ecosystem is an ecological community plus all the biogeochemical processes or functions that it participates in or that sustain it. More formally, an ecosystem is The whole system,… including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment (Tansley 1935). Ecosystem ecology abstracts the organisms from their functions or processes. It focuses on biogeochemical processes, especially the properties that emerge at the ecosystem level, namely nutrient cycling, primary production and energy flow.

My suggestion here is not an imposition of biological theory onto semiotics, or an example of theory reduction such as the attempted reduction of biological theories to physical theories (Alexandrov 2000: 348). In contrast my method for applying the hierarchy theory of ecology is to note that semiosis occurs between actual entities in the world. I then proceed to ask, what models do we have of actual entities in the world? What are the semiotic implications of those models? In this paper I chose one model, the hierarchical theory of ecology, because it is comprehensive and well-developed. This method avoids many of the objections that Alexandrov (2000) has for Lotman (2005). Lotman imposes hierarchies onto human semiotic systems, that is, into an aspect of human populations and ecosystems, whereas the hierarchy theory of ecology in contrast places populations in one hierarchy and ecosystems in another hierarchy (and it does not impose hierarchies within populations or within ecosystems). Hierarchy theory acknowledges the existence and the role of emergence (cited favorably by Alexandrov 2000: 346, By contrast, modern biologists claim that 'new properties and capacities *emerge* at higher hierarchical levels and can be explained only in terms of the constituents at those levels. Italics in the original.).

The Sign

I suggest that these two different levels of organization, organism-population-community, and functional component-ecosystem-biosphere, have their own types of semiotic signs and thus their own semiotic spaces, though there may be some overlap. Before elaborating on this, I would like to clarify what I mean by sign. Perice's triad requires the object, the sign/representamen and the interpretant to be three unique and different things.

De Cuypere (2008: 58) argues (in effect) that an object can be a sign/representamen of itself (…in perception signs are *self-representing* whereas in communication signs are *other-representing* (cf. Ransdell 1997 [1986]: 55)); and he asserts that Uexküll (1928) shared his view (2008: 58 n. 20: The view that perception of the environment is a semiotic process was most convincingly argued by Jacob von Uexküll (1928 [1920]), whose philosophical views are based on Kant (cf. Kull 2001: 8)...each life-form has nonetheless a distinct semiosphere or *Umwelt*, based on the physical constitutution of the organism. Thus each life-form constructs its environment differently according to its capacities.). De Cuypere reads too much into Uexküll. From the fact that the Umwelt of each individual or species is unique, it does not necessarily follow that the individual treats everything as a sign. It means only that each individual or each individual species has potentially different notions of what is a sign and what is not (and what is food and what is not), and they interpet them in their own species-specific ways. De Cuypere's definition of sign is self-consistent and interesting, but it is not consistent with Peirce's triadic Sign, as it collapses the object and the sign/representamen, if not also the interpretant, into one. A dyad or a monad cannot be said to be a triad. To be a Peircean Sign, the object, sign/representamen and the interpretant must all be unique and different from each other. Consider Magritte's painting of a pipe (Ceci n'est pas une pipe). It is a Peircean Sign only if the interpretant is not a pipe, because the object is a pipe (of course the painting is not a pipe, it is a drawing of a pipe). It would be a sign/representamen if the interpretant were Pipes for Sale or Here's a lesson in semiotics. Thus an improper interpretation can not only miss the point of the sign; it can also negate the sign's status as a sign.

A thing might also not be a sign/representamen until it passes a threshold concentration, flux or amount. It is well-known that some plants have phototropic thresholds (e.g., Galland and Russo 2008, Janoudi and Poff 1990). A typical example is the phototropic threshold for *Phycomyces* sporangiphores, which varied between fluence rates of 10^{-9} W m^2 to $2X10^{-7}$ W m^2 depending on growth conditions (Galland and Russo 1984). This situation is complicated by the co-existence of a photosynthetic threshold. Hermsmeier et al. (1991) report a photosynthetic threshold for the green alga Scenedesmus *obliquus* of about 1 W m^2. If an organism's photosynthetic threshold is lower than or equal to its phototropic threshold, it would be unwarranted to suggest that phototropic response is a sign response. If on the other hand an organism's photosynthetic threshold is higher than its phototropic threshold, then we might be warranted in calling the phototropic response a semiotic process. Armitage (2001: 128) for example discusses photoresponses of purplephotosynthetic bacteria below their photosynthetic threshold, and suggests they might be moving to maintain optimal positions within bacterial mats. Is this perception or interpretation? Consider pheromones. It is widely reported that in some cases detection of a single molecule is enough to trigger a response (UT Southwestern Medical Center 2008). In other cases the pheromone must reach its destination in a concentration above the detection limit of the recipient, otherwise it is not a sign. Is this perception or interpretation? In both cases, the organism perceives the input and then voluntarily acts on it. I suggest this is interpretation.

Whether a thing is a sign also depends on how the foraging animal interprets it, i.e., the actually-formed interpretant or dynamic[al] interpretant (Hartshorne and Weiss 1931-1958, volume 4 page 536). Consider a foraging animal that comes across a morsel of food. The animal perceives the morsel as food. The animal might also interpret the morsel as a sign of the possibility of additional food in the neighborhood. In the latter case of the sign, the morsel and the possible additional food are both food, but they are not the same physical items. The situation is very analogous to blood as a sign of wounded or dead prey. If the dynamic interpretant is that the morsel is just nutrition, then there is no sign/representamen (here it is not technically correct to refer to the interpretation of the morsel as a dynamic interpretant, because there is no Sign). If the dynamic interpretant is that the morsel is a sign of more food, then the morsel is a sign/representamen. *In this case it is just as plausible to assume that the dynamic interpretant is that the morsel is a sign of food, as it is to assume that the dynamic interpretant is that the morsel is just nutrition.* Therefore it is arbitrary to exclude either case.

These examples also suggest that a sign can be inherently part of the channel that carries it. A bird song or a musical note is a sign. The channel is the sound wave, but so is the sign. The sign is carried in the frequency and amplitude of the sound wave (two sets of thresholds). There is no such thing as a sound wave without a frequency and an amplitude, and there is no such thing as a frequency and amplitude without a sound wave. An amplitude or a frequency by itself, however, is not a sound wave, though it can be a sign/representamen. In addition, the frequency and amplitude must lie within the range of hearing of the recipient.

Now in the organism-population-community(-biosphere sensu Lotman) hierarchy, the signs in faunal communities include visual displays, color and structure, sound and vibration, and concentrations of chemicals and electricity, for purposes of attraction, alarm, repellent, defense, and habitat selection (e.g., Leveque 2003, citing Darnet and Tordjman 1992). Examples:

- Holley's hare-and-fox (Holley 1993, Hoffmeyer 1997c). Holley's proposes to explain why a hare stands up straight when he sees a fox. He suggests that the fox knows it will be outrun if it has been seen, so the hare lets it know to avoid having to expend energy on running. The standing hare (sign/representamen) points to the seen fox (object), which is intended to provoke the interpretation I see you (interpretant) (Table 2).
- The same analysis can apply to signs deployed by vegetation, as interpreted by pollinators (Table 2). The color of the flower is a sign. The non-functional structure of the flower is a sign (by non-functional I mean those structural aspects of the flower that serve attraction not pollination). Both signs point to the object of nectar. A proper interpretant is that there is nectar here.
- Bird calls.
- Pheromones.
- Bioluminescence.

The semiotic spaces in these cases are the communities and the signs they deploy, along with the environmental context. There is nothing abstract about these spaces, though it is possible to examine them in an abstract sense for example by computing their species diversity using varieties of the Shannon index and information theory (e.g., Rosenzweig 1995; McCowan et al. 1999; Suzuki et al. 2005). For a review of phytosemiotics, see Kull (2000). For a review of zoosemiotics, see Sebeok (1972) and Kull (2003).

Sign/ representamen	The standing hare	Flower color	Flower non-functional structure	Chemical concentration
Object	The “seen” fox	Nectar	Nectar	Chemical
Interpretant	“I see you”	Here is nectar	Here is nectar	Threat to existence

Table 2. The sign points at the object, intending the interpretant.

The signs in the functional group-ecosystem-biosphere hierarchy are more problematic. No one has yet suggested that functional groups be recognized as possessing or comprising semiotic systems. Nielsen (2007) suggests that ecosystems (not ecological communities) should be recognized as semiotic systems (Lotman considered his original concept of the semiosphere to be analogous to Vernadsky's biosphere, but as discussed above, Vernadsky's biosphere did not recognize ecosystems and their biogeochemical cycles. It recognized the existence of biota in a geosphere.). He points out that ecosystems have something that is homologous to the organism's world of perception, namely Patten's (1978, 1981, 1982) input environ, which Nielsen connects to thermodynamic information (Nielsen is also self-admittedly influenced by Ulanowicz 1986, 1997); and that it may be inferred that this input is semiotic in character, due to the prevalence of indirect effects, network amplification and synergism inside the ecosystem. If an ecosystem is a semiotic system, then it engages in something analogous to constructing meaning. But what does that mean, both to the ecosystem and to us? Does an ecosystem have an Umwelt? The situation is reminiscent of Hoffmeyer's (1995) question about molecules (how could intention and values possibly be said to exist in a purely dynamic biochemical system?) and Emmeche's (2001) regarding whether a robot has an Umwelt. In the latter case there is a significant difference: an ecosystem is a natural body (albeit unorganized) with an evolutionary history; a robot is not. What is a sign to an ecosystem, and how would an ecosystem interpret it? I will return to these questions below.

Because semiosphere has been used as an analogy to biosphere sensu Lotman, I suggest that we retain that association. The semiotic space of biosphere sensu O'Neill will have a different name, as I will discuss below. We can refer to the whole of the semiotic spaces of the dual hierarchies as the metasemiosphere (Figure 11).

	Aggregates of Proto-Umwelten
	(Proto-semiosphere)
Aggregates of Communities	|
of Umwelten (semiosphere)	|
|	Proto-Umwelten
Communities of Umwelten	|
|	Infra-Proto-Umwelten
Populations of Umwelten	|
|	|
Umwelten	|
|	|
Infra-Umwelten	|
|	|

Figure 11. The (meta-)semiosphere as dual semiotic hierarchies.

This framework model immediately provides us with at least three results:

1. We can now clearly define the semiosphere and put to rest the Vernadsky affair. The biosphere sensu Lotman sits atop the organism-population-community hierarchy; the biosphere sensu O'Neill et al. sits atop the functional component-ecosystem hierarchy; and they each have their own semiotic spaces. Vernadsky's biosphere corresponds neither to O'Neill et al.'s biosphere nor Lotman's biosphere, because as discussed above Vernadsky's conception of the biosphere contained ecological communities and their environment but none of the functions of ecosystems. The semiosphere is a dual hierarchy of semiotic spaces corresponding to the dual hierarchies of ecological organization. Lotman's semiosphere corresponds to the organism-population-community hierarchy.

2. We are now able to clearly distinguish the relationship between semiotics and the levels of ecological organization in which semiosis occurs. To wit, Hoffmeyer (1995) writes: Surprisingly then, from a biosemiotic point of view the biosphere appears as a reductionist category which will have to be understood in the light of the yet more comprehensive category of the semiosphere. The model of dual hierarchies places the biosphere at the top of the organism-population-community hierarchy, and each of these levels has its own corresponding semiotic space.

3. We can clear up an issue that Kull has with Hoffmeyer. Kull (1998a) defines the Unwelt as the semiotic world of the organism or the closed world of the organism, that is, the subjective universe of the organism; and the semiosphere is the set of all interconnected Unmwelts, and the semiosphere does not impose limitations on the Umwelt(s) of its resident populations. Apparently Kull conceives of the biosphere as comprising space and living matter, and not the physical environment. In other words, Kull is referring to the semiotic spaces that belong to the organism-population-community hierarchy (Figure 10). Now, citing Hoffmeyer (1996:59, ...the semiosphere imposes limitations on the Umwelt of its resident

populations in the sense that, to hold its own in the semiosphere, a population must occupy a semiotic niche.), Kull worries that Hoffmeyer conceives of the semiosphere as something that may be partially independent of Umwelten. But both Kull and Hoffmeyer are correct, once their assumptions are made explicit. Given the O'Neill et al. understanding of hierarchy where the higher levels of organization constrain the lower levels, Hoffmeyer can be read to be correctly asserting that the semiosphere constrains Umwelten (e.g., 1998b: 82, The semiosphere poses constraints or boundary conditions to the Umwelten of populations since these are forced to occupy specific *semiotic niches* i.e. they will have to master a set of signs of visual, acoustic, olfactory, tactile and chemical origin in order to survive in the semiosphere.). It may be more precise to say that the semiosphere comprises communities of Umwelten, and that signals from lower levels are considerably dampened as they move up the hierarchy (O'Neill et al. 1986). Ten years ago, to the last sentence I would have added individual Umwelten have little or no effect on populations of Umwelten, communities of Umwelten, or on the semiosphere itself; however contemporary ecologists have refined their ideas about niche construction (e.g., Laland et al. 1999, Gorshkov et al. 2004) and are more open to the possibilities of organisms and ecosystems affecting their environments (hence their Umwelten).

The (proto-)Umwelt of the Ecosystem

Hoffmeyer (1995) asserts that ecosystems contain semiotic networks, but from his discussion it is clear that he is actually referring to ecological communities. Hoffmeyer criticizes ecosystem ecologists for restricting their study to nutrient cycling and energy flow, and food chains, while neglecting the behavioral and communicative aspects of animal life. He notes that This bias towards the material and energetic aspects of ecosystem dynamics may well have blinded us to the importance of the semiotic web unfolding throughout ecosystems. But ecosystem ecologists do not study food chains. Community ecologists study food chains. And by definition, ecosystem ecology does not concern itself with animal life. Ecosystem ecologists are concerned with ecosystems, in which functions are abstracted from organisms. Community ecologists, not ecosystem ecologists, are concerned with food chains and the behavioral and communicative aspects of animal life. I know what Hoffmeyer means, but what he means is not what he says. His criticism is probably intended for community ecologists. His mistake is understandable, given that an ecosystem is an ecological community plus all the abiotic factors influencing it. We can now make sense of his further statement that Ecosystem dynamics, therefore, shall have to include a proper understanding of the semiotic networks operative in ecosystems. Hoffmeyer is not calling for a recognition of semiosis in ecosystems. Hoffmeyer is calling for a recognition of semiosis in ecological communities. That is certainly warranted.

Hoffmeyer (1995) provides an imaginative interpretation that may help us elaborate on how an ecosystem can construct meaning. Reformulating Peirce, Hoffmeyer suggests that the internal structure of the egg exhibits a historically established regularity or lawfulness which gives meaning to the answer provided by the position of the entering spermatozoon. By analogy, the internal structure of an ecosystem can give meaning to the answer provided by inputs of energy or nutrients. The internal structure of an ecosystem arguably is comparable in complexity to that of an egg, and the biochemical processes in ecosystems (the Phosphorus, Nitrogen and Carbon cycles) appear as intentional as any biochemical pathway in an organism (Hoffmeyer 1996, 1997b; in Hoffmeyer 1997b, the author cites Yates 1985, In biochemistry the emphasis is peculiar: reactions are treated as though they had 'intentions' other than going to equilibrium.). Here we must be careful how we tread. In the 1930's the ecosystem was called a quasi-organism (Tansley 1935), but it is no longer considered to be a quasi-organism or an organism (e.g., Adelson 2008:

378, ...ecology by the mid-twentieth century had abandoned the organism metaphor in favor of a less teleological ecosystem.).

One alternative approach for how ecosystems construct meaning follows the model of Fath et al. (2001), who describe the Innenwelt or inner world (Uexküll 1909, Nöth 1998) of the ecosystem. Derived from the work of Patten (also relied upon by Nielsen 2007, above), they assert that because ecosystems are far from thermodynamic equilibrium, they do not operate according to the second law of thermodynamics (that entropy increases and approaches a maximum at equilibrium), nor do they operate according to the rule for open systems (that entropy production decreases with time and approaches a minimum at steady state). Rather they conjecture that ecosystems operate according to ten principles, or orientors or goal functions (Table 3). They describe ecosystems as comprising scaled (nested) levels of organization. They then calculate the ten principles from summations (over the entire system) of combinations of these five variables (Table 3). They also represent the ten principles in terms of five stages or modes, which can also be derived from summations of combinations of the five network variables (Table 3), where mode 0 refers to boundary input into the system, mode 1 refers to energy that passes out of the system after its first passage through the system, mode 2 refers to cyclical energy flow, mode 3 to compartment-wise dissipative energy flow and mode four to boundary output. The ecosystem goal functions will populate the network (food web and remaining portions of the ecosystem) with links that satisfy the goal functions. Of the ten principles, only three do not involve cycling: maximize dissipation, maximize residence time and minimize empower to exergy ratio. I suggest that the cycling-related principles relate to ecosystem-level phenomena such as nutrient cycling, and that the other three principles relate to community structure. Maximizing dissipation is the principle of maximal efficiency. It holds that systems will seek to maximally degrade usable energy. Maximizing residence time is suggested as the principle behind the organization (structure) of ecological systems. The empower to exergy ratio measures the cost required to produce a unit of organization. Minimizing this ratio minimizes the cost of the structure. In these three principles we have the principle of organization (implying stable structures), the minimization of cost of building those structures, and the maximization of efficiency (implying an optimal balance between these two principles). Fath et al. suggest that the primary principle at work in the network is that of maximizing specific dissipation. As might be expected, the model of Fath et al. is a topos of complexification. It is recursive, comprises nested hierarchies (multiple perspectives, radically subjective) of networks which consist of discrete (discontinuous) nodes and links, and displays sensitivity to initial conditions (stochasticity). These features are of importance, but they are of secondary importance. What is of primary importance is the thermodynamics. My point here is that the ecosystem arguably has a complex internal structure, comparable to that of an organism, such that inputs to it give meaning to that structure. But is the input environ experienced by an ecosystem as an Umwelt? Or is it its Außenwelt (Nöth 1998)?

Principle	Network analysis formulation	Network parameter (system level)
Maximize power	$TST = \Sigma\Sigma(n_{ij})\, z_j$	$TST = f^{(0)} + f^{(1)} + f^{(2)}$
Maximize storage	$TSS = \Sigma\Sigma\, \tau_i\, (n_{ij})\, z_j$	$TSS = x^{(0)} + x^{(1)} + x^{(2)}$
Maximize empower	$EMP = \Sigma\Sigma(n^*_{ij})\, z_j$	$EMP = f^{(0)} + f^{(1)} + f^{(2)}$
Maximize emergy	$EMG = \Sigma\Sigma\, \tau_i\, (n^*_{ij})\, z_j$	$EMG = x^{(0)} + x^{(1)} + x^{(2)}$
Maximize ascendancy	$ASC = AMI^*\Sigma\Sigma(n_{ij})\, z_j$	ASC $= AMI^*[f^{(0)} + f^{(1)} + f^{(2)}]$

Maximize dissipation	$TSE = \Sigma\Sigma\varepsilon_i(n_{ij})\ z_j$	$TSE = f^{(4)}$
Maximize cycling	$TSC = \Sigma\Sigma(n_{ij}/ n_{ii})\ (n_{ii}-1)\ z_j$	$TSC = f^{(2)}$
Maximize residence time	$TSS/TST = \Sigma\Sigma\ \tau_i\ (n_{ij})\ z_j/ (n_{ij})\ z_j = \Sigma\Sigma\ \tau_i$	$TSS/TST = \tau$
Minimize specific dissipation	TSE/TSS $= \Sigma\Sigma\varepsilon_i\ (n_{ij})\ z_j/ \tau_i\ (n_{ij})\ z_j$ $= \Sigma\Sigma\varepsilon_i / \tau_i$	TSE/TSS $= f^{(4)} / (x^{(0)} + x^{(1)} + x^{(2)})$
Minimize empower to exergy ration	TSS/TST $= \Sigma\Sigma(n^{*}_{ij})\ z_j/ \tau_i\ (n_{ij})\ z_j$ $= \Sigma\Sigma(n^{*}_{ij}) / \tau_i\ (n_{ij})$	$TSS/TST = 1/\tau$

Table 3. The Innenwelt or inner world (Uexküll 1909, Nöth 1998) of the ecosystem, according to Fath et al. (2001).

It has been suggested that ecosystems may be a form of protolife, because they share the same general properties of the hypothetical protocell (the putative precursor to the living cell; Marinakis 2007). The hierarchy theory of ecosystems (Salthe 1985, O'Neill et al. 1986, Wu and David 2002), for example, hypothesizes that hierarchical levels are separated by rates of processes, which constitute virtual boundaries. Ecosystems also capture and transduce energy, sequester organic matter and ions from the environment, catalyze the synthesis of its components from the captured material, protect organic matter accumulated in its interior from dilution in the surrounding water, and self-replicate (as an alternative to genomic evolution, Morowitz et al. 1988). That is not to say that all things that share these properties are protolife. It is not necessary to take every idea to its logical extreme. The ecosystem is a good candidate for protolife because it is an organized natural entity with an evolutionary history. It is plausible that Das Vaterland is also a form of protolife, but that does not necessarily make the idea of protolife dangerous. Not every form of life is benign, so one should not expect every form of protolife to be benign. There is no reason that Das Vaterland is necessarily malignant. Modern Germany has little in common with Hitler's Germany. In any case, if the ecosystem is a form of protolife, and if it has an Umwelt homologue, I suggest we call it the proto-Umwelt (Figure 11), and the biosphere sensu O'Neill may be a proto-semiosphere (Figure 11).

But what is a proto-Umwelt, and what is proto-semiosis? What signs are carried by the photons and chemicals that enter the ecosystem? What does the ecosystem do with its interpretations of these signs? As a form of proto-life or not, the ecosystem is not a unified natural body. Rather it is a aggregate of unified natural bodies in which the individuals in the collection have co-evolved. A single unified organism never emerges from the concerted action of the constituents of the aggregate. From the aggregate we might observe some overall effect due to the concerted actions of the constituents, and that concerted action might demonstrate thermodynamic directedness, but this concerted action never rises above that which can be explained through co-evolution. The apparent unified identity and behavior of the ecosystem lies in the co-evolutionary histories of the individual species comprising the communities that make up the ecosystem (which emphasizes the need to preserve natural communities and ecosystems, and to preserve them in situ.). The proto-Umwelt is the ecosystem's model of its world. The ecosystem is the community and the biogeochemical cycles and energy flows that it is embedded in. Thus the ecosystem is more than just the community and its environment; it is the community as it chemically and energetically engages with its environment, in a way that as a sum total approaches the behavior of a unified organism. The proto-Umwelt is the sum of the Umwelten of the community as they engage in co-evolutionary functions. The proto-Umwelt differs from the sum of the Umwelten of the community, as the former considers the community as it chemically and energetically engages with its environment, but the latter does not.

As for proto-semiosis, the ecosystem might even have co-evolved to cooperate in biosphere construction and maintenance. That is, the ecosystem may read the concentrations of ambient chemicals as signs, and interpret them and act on those interpretations in a manner that constructs and maintains the biosphere. Gorshkov et al. (2004) propose such a model. They suggest that ecosystems (i.e., the constituent co-evolved organisms in the communities, engaging in their co-evolved functions) can sense concentrations of chemicals above a certain threshold. Once the concentrations exceed that threshold, the ecosystem takes action to immobilize the chemical. Below the threshold, the ecosystem cannot detect the chemical concentration and there is no sign. In this example the sign/representamen is the concentration, the object is the chemical (which is different from the concentration of the chemical), and the interpretant is threat to existence (Table 2). The semiosis under consideration in the Gorshkov et al. example differs from the semiosis that most community ecologists would consider, such as that relating to predator-prey interactions, or inter-specific competition. One idea that is important here is Kull's decontextualization (Kull 1998b: 353). Removing vegetation from the context in which they evolved deprives them, and the rest of us in the biosphere, of the benefits of their previous co-evolution. It is impossible to say how much decontextualization the biosphere can survive.

The co-evolved individuals in the community suggests an alternative to the protolife approach, namely the dichotomy of aggregate and organized natural body with an evolutionary history. This dichotomy was introduced by Charles Hartshorne in the context of the philosophy of panpsychism (Clarke 2002), but the dichotomy does not depend on panpsychism. I am using the dichotomy here without reference to panpsychism. An organized natural body with an evolutionary history exhibits a unity of organizing structure and behavior, typically through a central nervous system (or perhaps through a network in the cytoplasm). An aggregate does not. Amoebas are primitive, but they exhibit a unity of structure and behavior, if only for brief instances. They are organized bodies, as are quarks, atoms, molecules and macromolecules. Plants and trees have structure, but it is not a structure that enables unified organizing behavior. Thus they are aggregates. Ecosystems are aggregates and not individuals because although ecosystems are organized at least in the sense of statistical thermodynamics or information theory (Fath et al. 2001, Nielsen 2000), they do not exhibit a unity of organizing structure. The aggregates of ecosystems, or the biosphere sensu O'Neill, are also aggregates. Though the question whether ecological communities are non-randomly structured is a perennially hot topic, aggregates of organisms such as populations or communities generally do not display a unity of organizing structure. Now, just as the individual organisms in the ecological community have co-evolved to cooperate, plant cells have co-evolved to cooperate. But as in my phototropism example, it is the individual plant cell, not the plant, that interprets environmental signs and acts on those interpretations; just as it is the individual organism, not the community or ecosystem, that interprets and acts on environmental signs. The result manifests in the behavior or structure of the aggregate, but the action is not initiated by the aggregate, it is initiated by the constituent individuals comprising the aggregate. Thus the proto-Umwelt is the sum of Umwelten of individuals in an aggregate, where the individuals have co-evolved to cooperate; and proto-semiosis is semiosis by individuals in an aggregate, where the action taken by those individuals based on the interpretant benefits the aggregate.

Hartshorne's dichotomy does not map to O'Neill et al.'s dual hierarchies. Griffin et al. (1993: 206) report that Hartshorne suggests a hierarchy of compound individuals, comprising at least atoms, molecules, macromolecules, cells, multicelled animal, and the universe. It is important to note that this list contains multicelled animals, not multicelled organisms (i.e., it excludes vegetation). If we were to construct a companion hierarchy of aggregates, it would minimally comprise vegetation, ecosystems, and the biosphere. However, ecosystems also contain bacteria and animals, which lie in the other hierarchy.

Conclusion

The framework set out in this article allows us to clarify several points. The semiosphere is metaphorical and abstract in the same sense that mathematical spaces are metaphorical and abstract, but unlike mathematical spaces the semiosphere necessarily corresponds to the natural if not physical world. I have suggested using a particular model of the natural world, namely the dual hierarchies of ecological organization, on which to construct the model of the corresponding semiosphere. If having a hierarchical conceptual structure is specific, then the semiosphere is specific. The semiosphere does have concrete boundaries, but those boundaries depend on the scale or hierarchical level of the observer. The hierarchy is the concrete unitary whole, but this whole comprises hierarchical levels and is therefore discontinuous. Does the semiosphere include the environment? Yes, but only one of the dual hierarchies includes the environment. Is the environment subject to semiotization? Yes, from the perspective of a cognitive organism, but that does not mean that the environment is not part of the semiosphere. It just means that that particular cognitive organism doesn't have a complete understanding of the semiosphere. What of the ecosystem? It has a proto-Umwelt and it engages in proto-semiosis. The proto-Umwelt is the sum of Umwelten of individuals in an aggregate, where the individuals have co-evolved to cooperate. Proto-semiosis is semiosis by individuals in an aggregate, where the action taken by those individuals based on the interpretant benefits the aggregate. The individuals making up the community that comprises the ecosystem have individual Umwelten, but the community apparently lacks an Umwelt.

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