Journal of Mediterranean Ecology **vol. 9, 2008: 5-30**
© Firma Effe Publisher, Reggio Emilia, Italy

The Semiotic Niche

Jesper Hoffmeyer

Department of Molecular Biology - The Biosemiotics Group, Ole Maaløesvej 5 - room no. 1-2-16 - 2200 Copenhagen N - Denmark - hoffmeyer@mail.dk

Zoosemiotics

"Images on the retina are not eatable or dangerous. What the eye of a higher animal provides is a tool by which, aided by a memory, the animal can learn the symbolic significance of events" (Sebeok 1979, 266). This observation, one that Thomas A. Sebeok ascribes to the ethologist John Z. Young, hits the nerve of the zoosemiotic conception that Sebeok launched as early as 1963 (see Sebeok 1963; 1972; Sebeok, Ed. 1977). Sebeok goes on to say that "Cephalopod brains may not be able to elaborate complex programs - i.e., strings of signs, or what Young calls *mnemons* - such as guide our future feelings, thoughts, and actions, but they can symbolize at least simple operations crucial for their survival, such as appropriate increase or decrease in distance between them and environmental stimulus sources" (Sebeok 1979, 43).

That beauty is in the eye of the beholder is a truth that cannot be repeated too often. Actually, as we now know, it is the brain rather than the eye that does the seeing for us. Don Favareau (2002, 10-11) has stated it this way:

> Significantly, recent research in the neurobiology of vision, especially the groundbreaking work of Semir Zeki (1993, 1999) demonstrate conclusively that sensory percepts such as *visual images* are not so much "received" from incoming photon impulses as they are semiotically and co-constructively "built" across heterogeneous and massively intercommunicating brain areas. Thus we find that sensory signification per se is intimately bound up with motoric processes of bodily and environmental interaction in an ongoing process of semiosis that cuts across the sub-systemic distinctions of brain, body and world.

What beauty exactly a cephalopod is seeing is of course unknowable, but whatever it may be, it hardly bears much resemblance to anything we would see in the same situation. However, the cephalopod certainly sees something and this something very probably is precisely the thing it needs to see. Conceivably, one might object that the cephalopod doesn't really *know* what it sees, and that it just reacts to what appears in its field of vision, not having the faintest idea of what it is about to do. But since our knowledge of what it means to *know*, neurobiologically speaking, is rather limited, such an objection likewise carries limited weight. Conscious knowledge is, for all we know, the privilege of a few big-brained animals, but most knowledge is probably unconscious, like the many routines one performs without paying attention to them.

The phenomenon of *blindsight*, for example, offers some surprising insights into the hidden reserves of knowledge that we all apparently carry around in our minded bodies. Blindsight may be observed in patients that have damaged their primary visual center so that they have lost access to a part of their visual field. If they are asked whether or not they can see an object placed in the blind area, their answer is, of course, no. And yet, if such patients are asked to guess where

This is a slightly modified version of chapter 6 in the author's new book: "Biosemiotics. An Examination into the Signs of Life and the Life of Signs", Scranton University Press, Scranton PA, 2008.

an object that they report they cannot see is placed, they may often point very accurately to its position. The explanation for this phenomenon is thought to be that visual impulses are divided into several parallel pathways on their way from retina to the brain, and some of these do not lead to the visual cortex but end up elsewhere in the brain. Here they obviously cannot produce conscious visual experiences, but the codified information is nevertheless still accessible to the analytic machinery of the brain. So, the patients see without seeing. Their vision is not accompanied by an experience of seeing - nevertheless they do, to some extent, know what their eyes tell them.[1]

Furthermore, many kinds of *knowledge* are purely embodied, such as, for instance, the immune system's knowledge of past infections, or the proprioceptive calibrations in the motoric system that explain why you are still able to successfully bike or swim, even though you haven't practiced any of these skills for years.

If you remove the brain from an earthworm (and this "brain" is nothing to write home about, as many readers may remember from this evil deed of childhood), the worm may still move forward as if nothing had happened. But when the worm comes to an obstacle, it is no longer able to pass beyond it: it continues again and again to push into the obstacle. It seems that it is no longer able to let the obstacle become knowledge in the sense that it uses the obstacle as a cause for changing its course. Compared to worms, the cephalopods have impressively well-developed brains. The octopus may have as many as 168 million nerve cells, half of them in the visual cortex, and is capable of at least limited associative forms of learning. Judged on this background, it may perhaps be permissible to say that the octopus does indeed *see*.

Umwelt Theory

Early in the twentieth century, the Estonian-born German biologist Jakob von Uexküll saw, long before anybody else, that a biology that would be true to its subject matter would have to direct its searchlight explicitly on the perceptual worlds of organisms, their *Umwelts* as he called them.[2] The Umwelt, as Uexküll used the term, is the subjective or phenomenal world of the animal. The way Uexküll saw it, animals spend their lives locked up, so to speak, inside their own subjective worlds, each in its own Umwelt. Thus, while modern biology employs the objective term *ecological niche* (that is to say, the set of conditions - in the form of living space, food, temperature, etc. - under which a given species lives), one might say that the Umwelt is the ecological niche as the *animal itself* apprehends it.

One of Uexküll's prime examples was the tick, known to crawl up in branches only to wait, nearly lifelessly, for a warm-blooded animal eventually to pass by below. Only when this happens will the tick let go of the branch and land itself upon the animal, where it quickly burrows itself into a fixed position on the animal's skin. The one signal that awakens the tick is butyric acid, a compound secreted by all mammals, and thus the Umwelt of the tick consists mainly in the presence or absence of butyric acid.

In *Bedeutungslehre* (*The Theory of Meaning*), published in 1940, Uexküll writes, "If we stand before a meadow covered with flowers, full of buzzing bees, fluttering butterflies, darting dragonflies, grasshoppers jumping over blades of grass, mice scurrying and snails crawling about, we would instinctively tend to ask ourselves the question: Does the meadow present the same prospect to the eyes of all those different creatures as it does to ours?" (Uexküll 1982 (1940), 45). And to illustrate why the answer to this question is no, he uses the example of a meadow flower:

1) A little girl picks the flower and turns it into a decorative object in *her* Umwelt;

2) An ant climbs up its stalk to reach the petals and turns the flower into a natural ladder in *its* Umwelt;

3) A larva of the spittlebug bores its way into the stalk to obtain the material for building its "frothy home," thus turning the flower into building material in *its* Umwelt; and

4) A cow simply chews up the flower and turns it into fodder in its Umwelt.

Each of these acts, he says, "imprints its meaning on the meaningless object, thereby turning it into a conveyor of meaning in each respective Umwelt" (ibid., 131).

The species-specific Umwelt of the animal, the model it makes of its immediate surroundings, is for Uexküll the very point of departure for a biological analysis. As the two parts in a duet must be composed in harmony (tone for tone, bar for bar), thus, he says, the organism and its Umwelt must also be composed in a contrapuntal harmony with those objects that enter the animal's life as meaning-carriers (ibid., 68). It is this idea of contrapuntal harmony that lets Uexküll call the flower beelike and the bee flowerlike, or the spider flylike, and the tick mammallike.

Yet, poetic formulations like these probably are much responsible for the rejection of Uexküll's ideas among most biologists and philosophers as being suspiciously *vitalistic*. Term *vitalism* may cover a range of different conceptions, which makes it a difficult accusation to refute, once levelled. Uexküll, however, never *defined himself* as a vitalist, and whereas Driesch, in his attempt to capture the essence of the life-world, returned to the Aristotelian concept of *entelechy*, Uexküll used the much more commonsensical word plan (Kull

1999d). Now, there can be no doubt that the Uexküllian conception of evolution as a sort of overarching regularity (*Planmässigkeit*) or composition of a big symphony, goes against the ontological intuitions of most modern biologists, who see chance mutations as the ultimate source creativity in the organic world.

And true enough, the more nature is seen as a "perfect symphony" the more difficult it becomes to connect von Uexküll's Umwelt theory with the evolutionistic conceptions that hold that either (if everything is perfect now) the world wasn't perfect earlier (when it was different) or conversely, if everything was perfect in earlier times, it cannot be so now. If, however, one tries to fit the Umwelt theory into an evolutionary framework, there emerges, as Frederik Stjernfelt (2001, 88) has observed, an important finding: "There remains, namely, a gestaltist and hence non-irrational account of the organization of the life of an organism." For in describing the behavior of animals as being arranged according to distinctive *qualitative* categories, (that he termed *tones*), Uexküll is on the track of a phenomenon that was later in phonetics and psychology to be christened *categorial perception*. Stjernfelt says,

> The melody - arch-example for the Gestalt theorists from von Ehrenfels, Stumpf, and the early Husserl onwards to the Berlin and Graz school - articulates an organized structure disconnected from the here and now of physics and implying a teleological circle foreseeing the last note already by the intonation of the first. Thus - as Merleau-Ponty (1995 (1968), 233) remarks - this metaphor makes it possible to see the life of the individual as a realization, a variation of the theme, *requiring no outside vitalist goal* - a variation, we may add, which constitutes the condition of possibility of modification of the animal's system of functional circles and hence the acquiring of new habits, possibly to govern evolutionary selection in Baldwinian evolution, …Music may be perfect but it is far from always the case (Stjernfelt 2001, 87–88; italics added).

Interpreting Uexküll's work in this way, we can see that *Planmässigkeit* does not imply a deterministic unfolding of a preordained order. And although the *telos* involved in *Planmässigkeit* is of course very different from Peirce's vision of evolutionary cosmology, it is not necessarily antagonistic either to Peirce or to the modern-day biosemiotic understanding (see Sebeok 1979, chapter 10). Rather, Uexküll's *Planmässigkeit* may be understood in its *purely local* and *situated* context:

> The semiotics of corporeal life in any creature - ourselves included - does take part in the dance of ecosemiotic motifs, the *local Planmässigkeit*, which has been framing the evolutionary processes and has formed the particular form of the Umwelt of each species. The Umwelt must serve to guide the animal's activity in the semiotic niche, i.e., the world of cues around the animal (or species) which the animal must necessarily interpret wisely in order to enjoy life. The semiosphere, as I use the term, i.e., the totality of actual or potential cues in the world, is thus to be understood as an externalistic counterpart to the the totality of Umwelts. Together they form, in the term of Jakob von Uexküll, an unending set of "contrapuntal duets" (Hoffmeyer 2006, 94).

I shall not delve further into the details of Uexküll's ontological positions but simply conclude that, whether the deeper presuppositions that nourished the work of Uexküll[3] are deemed acceptable to a modern scientific sensitivity or not, his Umwelt theory was, in any case, a milestone on the way to the establishment of a biosemiotic understanding of nature.[4]

For a characteristic concept in the work of Uexküll is the word *hinausverlegen* - a word that I, in agreement with Thure von Uexküll (Jakob's son), will translate as "projected to the outside" (Uexküll 1982). What is projected to the outside is precisely the Umwelt:

> No matter what kind of quality it may be, all perceptual signs have always the form of a command or impulse… If I claim that the sky is blue, I am doing so because the perceptual signs projected by myself give the command to the farthest level: Be blue! …The sensations of the mind become, during the construction of our worlds, the qualities of the objects, or, as we can put it in other words, the subjective qualities are building up the objective world. If we, instead of sensation or subjective quality, say perceptual sign, we can also say: the perceptual signs of our attention become the perceptual cues (properties) of the world (Uexküll, 1973; quoted in Uexküll 1982 (1940), 14-15).

Animals unconditionally and throughout their lifetimes conjure up internal models of the outer reality that they have to cope with. And these virtual realities apparently may sometimes entail an interactive aspect, too, since it is known that almost all vertebrate animals do on occasion dream. The Umwelt theory of Jakob von Uexküll is presumably the first serious effort ever made to subject virtual reality to scientific investigation (Hoffmeyer 2001c).[5]

The idea that animals possess internally experienced or phenomenal worlds that they then project back upon the outside world, however, has never been well received by mainstream twentieth-century biology. Rather, as John Collier has observed, the "modern synthesis" of the 1930s and 1940s signified a pervasive turn towards *behaviorism* in biology (Collier 2000): Organisms began being treated as black boxes, operated upon by the external forces of mutation and environmental selection. What went on *inside* the black box (morphologically, physiologically, or psychologically) was no longer seen as part of the *generative dynamics of nature*, since only the consequences of such processes - i.e., the actual survival patterns and population differentials - needed to be taken into consideration, it was thought, in order to understand and explain the great scheme of natural selection. In this scheme, the eventual possession by animals of phenomenological worlds was at best considered to be an unnecessary complication - much in the same way that human consciousness for most of the twentieth century was a nonexistent subject in mainstream psychology, and for many of the same reasons. And worse yet, the idea of Umwelt was thought to signal a dangerous return of anthropomorphic or even animistic atavisms in a biological science priding itself on its potential to approach the scientific status of physics.

The automatic rejection by modern science of all theories carrying even the faintest trace of anthropomorphism (a rejection reminding one of the *horror vacui* of an earlier epoch) is itself deserving of critical study (see Favareau 2006). As Karl Popper once remarked, if we are talking about the *nose* of a dog, we are also anthropomorphizing the dog, but we are doing so for good reasons, because the nose of the dog and the nose of the human individual are homologous organs, i.e., their structural and functional similarities are accounted for by the well-established fact of common ancestry. Likewise, claimed Popper, we are well-justified in speaking about *knowledge* in animals to the extent that homology implies that animal brains and human brains are evolutionarily related organs performing related functions (Popper 1990, 30). In fact, any claim that human beings are the only animals to possess Umwelts (or perceptually experienced subjective states) would require additional theories to explain why other mammals should be so fundamentally different from us. No satisfactory theories pertaining to such an effect is known to this author.

Umwelt theory does not, of course, represent an atavistic revival of animism in biology. Quite to the contrary, one might say that modern science, in its obsessional rejection of animism has itself maintained a strange trace of that which it rejects, in that in its very fear of spiritualism, science has closed itself off from vast areas of the world which most of us would take to be very real even if *objectively* immaterial in some modest sense of this term. Or to state this differently (and using these terms as science understands them), materialist science *spirit-ualizes* and, consequently, denies that area of lived experience that is the *virtual reality* of all animal perception.

The realization that the human experience of reality is always a *virtual reality* (though not one to be confused with any supposed *supra-reality* existing *independently* of our human knowledge) has, of course, been known to philosophers for centuries. But in general, the scientific community has been little influenced by the obvious consequences of this insight, namely that scientific reality itself is a human, and therefore humanly limited, construction. Or, to put it in the famous quote from Einstein, "Scientific concepts are free creations of the human mind, and are not, however it may seem, uniquely determined by the external world" (Einstein and Infeld 1938).

Yet considering the heated debates - the so-called science wars - arising in the wake of the Sokal affair (Robbins and Ross 1996, see Brown 2001) it may be necessary to emphasize that the social construction of reality which we label as *scientific* is not, in my view, independent of the genuinely mind-independent reality which it purports to investigate. In fact, I believe that the particular strategy underlying the scientific endeavor assures a probably unequaled dependence of knowledge on reality. And yet, in some sense this project still must be a *construction*, and the virtuality of human understanding cannot be escaped as Jakob von Uexküll clearly saw. Moreover, the epistemological consequences of this fact must be confronted as Uexküll certainly did in his *Theory of Meaning* (Uexküll 1982 (1940)).[6]

Yet the widespread resistance of the scientific community towards an acceptance of this fact explains why scientists in general feel justified to neglect the whole idea of virtuality as anything *real* in the world. But this willful epistemological innocence may now have become challenged in a way which mainstream biology may find difficult to ignore. This challenge comes from research in what is called artificial life as envisioned by, among others, Christopher Langton (1989). For if organisms are not understood in the Uexküllian way as living systems which are inherently and irreducibly suspended in their own phenomenal worlds or Umwelts, then one might easily imagine that the algorithmic kinds of dynamic systems exhibited by computer simulations do, in fact, mirror the abstract fundamental principles of *life* - whereas, *life as we know it* (i.e., organic life) would then be just one particular *instantiation* of this abstract "life form." And this is, in fact, the idea implicit in Christopher Langton's distinction between *A-life* (for artificial life) and *B-life* (for biological life). What this approach presupposes is that A-life theory and biology are equally valid ways to study life, because both are just new kinds of simulacra of some evanescing general life form (see Emmeche

1994). Both are equally virtual realities, and biology cannot claim privileged access to the reality of life.

If biology maintains its rejection of virtuality as a real constituent of life, it is hard to see how one can escape the logic of Langton's approach. If, however, biology adopted a more Uexküllian and thus semiotic approach to the study of life, then virtuality would be seen as built into life from the very beginning, and one might easily dismiss artificial life as it is presently conceived as fundamentally nonliving (regardless of its physical biology, or lack thereof). This would not, however, necessarily exclude the possibility that computers might some day *in the future* be constructed to host semiotic kinds of *true* artificial life. But in our opinion, this would most likely presuppose that ways were devised to solve what is called the *qualia problem* (Searle 1992; Emmeche 2004 - discussed below).

Self-Organization, Semiosis, and Experience

In her fine analysis of the concept of intentional behavior as a property of complex systems, the American philosopher Alicia Juarrero reminds us that the modern idea of self-organizing systems runs counter to a philosophical tradition leading back to Aristotle and that, all the way through, is based on the assumption that *causes are external to their effects* (Juarrero 1999, 2). Aristotle claimed, writes Juarrero, that nothing can move, cause, or act on itself in the same respect - and this principle has remained unchallenged throughout the history of philosophy. That a chicken develops from an egg is not, in the Aristotelian conception, due to immanent causes in the egg as a substantial thing; it is due rather to formative determinations that characterize hens in general.

Likewise, Kant inherited and expanded on this idea of causes as being external to their effects. He certainly seems to have intuited the self-organizing properties of organisms as a characteristic trait of life, but for him this property became a reason for *not* counting life as a field for scientific understanding. Juarrero puts it this way:

> Organisms' purposive behavior resists explanation in terms of Newtonian mechanics and is likewise a major impediment to unifying science under one set of principles. These considerations convinced Kant that natural organisms cannot be understood according to mechanism in general or its version of causality in particular. Since only external forces can cause bodies to change, and since no "external forces" are involved in the self-organization of organisms, Kant reasoned that the self-organization of nature "has nothing analogous to any causality known to us." Kant thus upheld Aristotle: causes are external to their effects; self-cause, and therefore, self-organization, are phenomenally impossible (ibid., 47).

In this elegant but, as seen from the point of view of rationality, strangely powerless way, Kant escapes the obvious antinomy between a Newtonian understanding of nature and life's self-organizing finality (see also Stjernfelt 1999).

For better or worse, natural scientists rarely let themselves be impeded by such philosophical reflections on the permissibility or nonpermissibility of this or that theoretical construction. And by the end of the twentieth century, the idea of self-organization little by little begins to take hold in science, thanks to developments in a range of advanced studies inside physics, biology, cognitive science, economics, and elsewhere. Too, a relative consensus seems to have been reached in viewing complex systems as having dynamic properties that allow for self-organization to occur (Haken 1984; Yates 1987; Kauffman 1993; Kelso 1995; Port and van Gelder 1995). Self-organization is seen here as a process by which energetically open systems of many components "tend to reach a particular state, a set of cycling states, or a small volume of their state space (attractor basins), with no external interference. This attractor behavior is often recognized at a different level of observation as the spontaneous formation of well-organized structures, patterns, or behaviors, from random initial conditions (emergent behavior, order, etc.)" (Rocha 2001, 96).

Juarrero's book is a scientifically well-informed attempt to use the conceptual structure offered by the theory of complex adaptive systems as a resource for the establishment of a "different logic of explanation - one more suitable to all historical, contextually embedded processes, including action" (Juarrero 1999, 5). In complex adaptive systems, there occur such kinds of positive feedback loops whose products are themselves necessary for the process to continue and complete itself, thereby producing a *circular cause* or a *self-cause* (ibid.).[7] Such systems, furthermore, form dynamic wholes that are not just, as science so often assume, *epiphenomena*, but are capable, as systems, of exerting causal power over their own components, and of exhibiting both *formal* as well as *final* kinds of causality. Juarrero furthermore claims that causal connections between different levels in the hierarchical structure of these systems are best described as *constraints* - in the sense of restrictions in the space of possibilities for processes to be able to manifest or realize at any given particular level.

Juarrero's scenario for the formation of complex adaptive systems capable of intentional and meaningful action is an impressive *tour de force* and is, in any case, a decisive contribution to the understanding of the philosophy of self-organization. Nonetheless, her analyses omit the semiotic aspect of selfhood as one of its concerns. It therefore remains unexplained how the element of first-person perspective that necessarily clings to intentionality - i.e., the fact that intentionality always presupposes an intentional *subject* - might possibly have appeared out of sheer complexity. How, in other words, could a self-organizing system that - in principle at least - might be described algorithmically in terms of sequences of ones and zeroes ends up with intentionality in the first-person sense of this term?

Traditionally the argument has been that the reason why evolution - though based on a continuous stream of chance events - can nevertheless create strange phenomena such as people, is that we, in the words of Eugene Yates (1998, 447),

> are the result of a random variation blocked at the statistical "left wall" of simple organisms, by the fact of their minimal complexity. The thus-constrained drift through chance must be toward the right (increased complexity), but it has no special outcome or elaboration. By a concatenation of accidents encountered and avoided, we are here, along with Venus flytraps, humming birds, and crocodiles. But the *modal* (most frequent, widely distributed, and most totally massive) forms of life are the bacteria.

I concur with this argument as far as the appearance of complex organisms is concerned. But this kind of explanation fails to take seriously the fact that we are not just complex material aggregates, but also *subjects*. Every person is genuinely an "I" phenomenon, whereas complexity in principle can be exhaustively described as an "it" phenomenon. How "it"s can possibly become "I"s is the puzzle that must be explained - and not even dynamic systems theory does yet offer a solution to this puzzle. What is missing, I would argue, is the admission of a semiotic dimension of explanation.

When we are often bothered (or offended in our scientific taste) by the badly hidden anthropomorphisms in Uexküll's writings, it is because it is maintained through his whole work that animals are much more like us than science has so far been willing to accept. And this is exactly because the animals have an Umwelt, an internal model of the relevant parts of their environment (i.e., those parts of the environment that are relevant for them), and that this model has to be included in any fully explanatory analysis of their life.

We need to take care to express things correctly here, and it may be a problem that language simply does not readily provide us with the appropriately subtle words. A tick waiting for butyric acid to reach its sense organs hardly has any experiences (as this term is normally understood). In fact, my guess would be that it is about as interactive as a computer in standby position. But in the moment its receptors catch the signal *butyric acid* in intensities that exceed the lower threshold value, a reflex-like movement occurs in it, immediately causing it to drop down upon (what turns out to be) its prey below. Now, even in this very split second, the state of the tick probably does not rise to the level of what we might call an experience, but here one might perhaps imagine the presence of some glimpse-like state of feeling - a *let go* impulse. On one level, of course, it is pointless to discuss unanswerable questions such as this. I do mention it here, however, because the question of the evolutionary history of *experiential* existence has huge theoretical implications, and raises the natural-science question: What might be the *function* of an experiental world? In other words, what good is the having of experiences in a biological sense?

We shall suggest that experiences quite generally serve as *holistic markers, causing the brain machinery to focus its (our) attention upon one single track in the spatio-temporal continuity*. In animals that have admittance to the world of experiences, as for instance, the cephalopod (presuming it actually does *experience* its demonstrated *seeing*), the sensoric aparatus continuously processes the changing production of an astronomical number of impulses being sent to different parts of the brain that - equally continuously and in parallel - activate a number of physiological and/or motoric mechanisms. All of this might presumably proceed quite efficiently in the absence of any experiential dimension - without *qualia*, as the philosophers might say. But there is a reason why a holistic control must interfere, and this reason is that the organism is a *unitary* agent in its own life. Holistic control, then, is needed in order to track the finality of brain processes in accordance with an organism's ever shifting current needs and intentions.[8] Thus it is through our experiences that the brain becomes a tool for the survival project of the bodily unity.

As a tool for such holistic control, the body has at its disposal first its emotional equipment - as when young birds duck their heads at the sight of big-winged objects moving above the nest. Such emotional reactions are accompanied by measurable alterations in the physiological and biochemical preparedness of the body. Secondly, there must minimally be an ability to build up a favorable correlation (or *ontogenetic optimization*) between the patterns of emotional reactions on the one hand, and the brain's sensoro-motoric coordination schemas on the other. Here we are talking about a kind of correlation - or *calibration* - that is unique to the individual's life history and cannot, for that reason, be encoded in the "innate manual" of the genome. And this is precisely where and why experience enters the picture. *Experiences serve to focus brain processes according to bodily finality by the creation of an approximated isomorph or analog virtual reality, a single dominating "lead track" that, as in a computer simulation, extracts an iconic surface out of its deep cerebral activity*.

That experiences appear to us as iconic or analog codings of meaningful parts of our surroundings, so that we can, to some extent, justly project them out as Umwelt, is probably due to the fact that such codings establish the simplest possible functional mechanism. Since we are bodily creatures bound to operate by and in a world of space and time, the simplest - or safest - way to organize our calculatory imagination, also is also in time and space, or in other words iconically. Our muscles are not preprogrammed to their functions, but are calibrated in the course of our ongoing interactive life processes, and our muscles and our experienced worlds are tightly reciprocally calibrated. For these reasons, it would not be unlikely that experiences are iconically coded in all animals that have experiences at all. The holistic control function is an emotionally anchored focusing of our brain processes. It has nothing to do with directly *controlling* the processing of the infinite multiplicity of input that the brain receives, but only deals with *establishing an overarching directional perspective*. The experience is at each moment the superior, immediate, and unconditional *interpretant* in the ongoing biosemiosis of the organism.

Then what about an animal whose nervous system is not sophisticated enough to produce such higher-order interpretants in the form of analog-coded models? The need for some primitive version of a holistic marker is probably present in all forms of life, and I imagine a graded series of such markers that in the lowest end consisits in the patterns of attraction and repulsion characteristic to chemotactic behavior in bacteria. In other words, I suggest that the phenomenon of experience has primitive parallels all over the life world. Uexküll distinguished sharply between plants and animals. Only the former had nervous systems and, therefore, Umwelts. Plants instead possessed what he called a *wohnhülle* - a cover of live cells by which they select their stimuli. Like Anderson et al. (1984), I shall prefer to use *Umwelt* as a common concept for the phenomenal worlds of organisms, of whatever kind these might be. Although plants, fungi, and protists do not possess nervous systems, they do have receptors to guide their activities, and they all, in our view, possess some kind of semiotic freedom, however limited it might be.

The experiential component of life, *qualia*, is thus seen as an integral aspect of life as such - an aspect that has had its own evolutionary history from its most primitive forms in prokaryotic life to the sophisticated kinds of Umwelts that we find in big-brained animals. In this respect, our view is in line with the American philosopher Maxine Sheets-Johnstone, who has sketched a natural history of consciousness where especially proprioceptive senses play a central role for what she calls a *somatic consciousness*. The capacity for proprioception seems itself to have evolved in the metazoans, Sheets-Johnston (1998) claims, via an internalization of the simple receptors that were originally localized at the surfaces of our protistan ancestors.

Additionally, it turns out that our *holistic marker* hypothesis is also in agreement with the American philosopher John Dewey (1948, 91):

> The true stuff of experience is recognized to be adaptive courses of action, habits, active functions, connections of doing and undergoing sensory-motor coordinations. *Experience carries principles of connection and organization within itself*... These principles are none the worse because they are vital and practical rather than epistemological. Some degree of organization is indispensable to even the lowest grade of life. Even an amoeba must have some continuity in time in its activity and some adaptation to its environment in space. Its life and experience cannot possibly consist in momentary, atomic, and self-enclosed sensations. *Its activity has reference to its surroundings and to what goes before and what comes after. This organization intrinsic to life renders unnecessary a super-natural and super-empirical synthesis*. It affords the basis and material for a positive evolution of intelligence as an organizing factor within experience (italics added).

The Semiotic Niche

The claim that there is an internal or subjective aspect to biological phenomena, and that this aspect must be taken into account in our theoretical understandings, has been called *internalism* and has lately been advanced in boundary explorations of evolutionary systems (Matsuno 1989; Matsuno and Salthe 1995; Van de Vijver 1996; Van de Vijver, Salthe, and Delpos 1998; Chandler and Van de Vijver 2000). While traditional neo-Darwinism clearly is *externalistic* in this sense, the Uexküllian Umwelt theory potentially takes us directly into the area of internalism.[9] As the Japanese biophysicist Koichiro Matsuno has explained, internalism is concerned with situations where a system finds itself in a state that might be grammatically characterized as its *present progressive tense*: the state of being in the midpoint of action - going towards, changing, recognizing, etc. Science never deals with such states but only with states that belong to the *present* or *past tense*.[10] According to Matsuno (1996), this omission by science of considering the unique properties of states in their present progressive tense - states of *becoming*, rather than *being* - springs from the universalist and externalist ambitions of science.

Honoring such an ambition presupposes the synchronization of all parts under one single measure of time. Since, however, nothing can move faster than the speed of light, synchronization - and thus universalism - can, in principle, never be realized in the *midpoint* of acting, for no matter how small an entity might be, there are always, even inside the atom, distances between parts that must be overcome in shared action. The synchronized perspective only applies after the fact, i.e., not *while* something happens but *when* it happens.[11] This understanding seems to be in deep agreement with Peirce's thinking on continuity, as this is for instance expressed in "The Law of Mind" from *The Monist* 1892 (CP 6:102–63).

Now, I should point out very clearly here that I do not wish to contest the view that the inner side of subjectivity per se is beyond the reach of the objective methods of science. The qualitative differences between the pleasure of looking at paintings of Rembrandt and the pleasure of being on the receiving end of a baby's first smile, is rightly considered a topic for the humanities, and definitely not for science. But even though science might not need to concern itself with examining the inner side of subjectivity, it may and should be concerned with examining the external side of subjectivity, such as the question of how the possession of subjectivity affects the living systems under study. It is not the task of biology to say what animal experiences are like (considered *as experiences*), but it is the task of biology to deal with the fact that at least some animals *have* experiences, and to study how this affects their livelihood.

The most obvious way biology could do this is by directing more attention to what I have previously referred to as *the semiotic niche* (Hoffmeyer 1996b). For the niche concept has a long ancestry in ecology. In 1917, Joseph Grinnell defined the niche as the totality of places where organisms of a given species might live. Ten years later, Charles Elton gave the concept a functional turn - seeing the niche as a description of the ecological role of the species, its way of life, so to say. The resulting duplicity in the understanding of the concept of niche has clung to it to this day: On the one side, the niche is a kind of *address* (Grinnell) on the other hand it is a *profession* (Elton).

In 1957, G. Evelyn Hutchinson gave the niche concept its modern definition, namely as an imaginary *n-dimensional hypervolume*, whose axes would indicate the multiple ecological factors of significance for the welfare of the species (Hutchinson 1957). Thus, the niche of a plant might include the range of temperatures that it can tolerate, the intensity of light required for its photosynthesis, its specific humidity regimes, and the minimum quantities of essential soil nutrients needed for its survival. Hutchinson also in this context introduced the distinction between an organism's *fundamental niche* and its *realized niche*. The fundamental niche of a species includes the total range of environmental conditions that are suitable for existence without the influence of interspecific competition or predation from other species. The realized niche describes that part of the fundamental niche actually occupied by the species.

In the *Oxford Companion to Animal Behavior*, the following more down-to-earth explanation is offered: "Animals are commonly referred to in terms of their feeding habits; terms such as carnivore, herbivore, and insectivore being widely used. The concept of *niche* is simply an extension of this idea. For instance, there is the niche which is filled by birds of prey which eat small mammals, such as shrews (*Soricidea*) and wood and field mice (*Apodemus*). In an oak wood this niche is filled by tawny owls (*Strix aluco*), while in the open grassland it is occupied by the Old-World kestrel (*Falco tinnunculus*)" (McFarland 1987, 411–12). This latter conception of what constitutes a *niche* has the advantage that with it it becomes possible to pose a series of interesting questions - e.g., How many ecological niches are there in the world? Are there more niches in warm climates than in cold? Were there more (or fewer) ecological niches a hundred million years ago than there are today?

Yet the concept of the *ecological niche* has framed a controversy about whether it is possible for two species with identical ecological niches to coexist, or whether one of the species will always, in the end, outdo the other via *competitive exclusion*. The question is difficult to decide because the n-dimensional character of the ecological niche makes it impossible to definitively clarify whether the ecological niches of the two species are indeed identical in all respects. This problem, of course, will only become so much more insolvable, if one includes the semiotic dimensions of the niche concept, as we are going to do in a moment.

Traditionally, it has been assumed that natural selection would favor those individuals inside the competing populations that evade competition by entering into a partnership of reciprocal specialization in the choice of resources, what is called the strategy of *resource partitioning*. The result of resource partitioning is that niche overlap between different species is minimized. In tropical forests in South and Central America, for example, several hundreds of species of birds, monkeys, and bats all eat fruit as their primary food source - but the enormous diversity of available fruits there has allowed all of these species to specialize such that the overlap between their diets has become very slight. Similarly, in a now classic study, Robert MacArthur found that five species of song birds with nearly identical niches self-segregated in a surprising way. Not only did they each seek food in different zones of the fir, they also ate insects in different combinations and timed their nest building differently.

Since Hutchinson's niche concept is n-dimensional, it is in principle wide enough to also embrace the semiotic dimensions of an organism's need for a living place.[12] It is plain, nevertheless, that the niche concept - as currently used in ecology - is grounded in a de-semiotized understanding of the interplay between organisms in nature. Behavioral ecology may well have become a fashionable part of ecology, but the methodology of this approach is based upon a selectionist frame of understanding that leaves no space open for a semiotic perspective. It is therefore necessary to introduce a special concept to cover the semiotic dimension of the niche concept, and my suggestion of the term *semiotic niche* was intended to do precisely this.

The idea behind the concept of the semiotic niche was to construct a term that would embrace the totality of signs or cues in the surroundings of an organism - signs that it must be able to meaningfully interpret to ensure its survival and welfare. The semiotic niche includes all of the traditional ecological niche factors, but now the semiotic dimension of these factors is also strongly emphasized. The organism must *distinguish* relevant from irrelevant food items and threats, for example, and it must *identify* the necessary markers of the biotic and abiotic resources it needs: water, shelter, nest-building materials, mating partners, etc. The semiotic niche thus comprises all the *interpretive challenges* that the ecological niche forces upon a species. Here are the words I originally used when introducing this concept: In order to occupy a semiotic niche, an organism or species "has to master a set of signs of a visual, acoustic, olfactory, tactile, and chemical nature, by means of which it can control its survival in the semiosphere" (Hoffmeyer 1996b, 59). To these means of semiosis one ought to add, as I have now learned, ultraviolet, ultrasonic, magnetic, electrical, solar, lunar, and presumably a host of other communicative media (Hediger 1974, cited in Sebeok 2001b, 24).

The semiotic niche in this way may be seen as an *externalistic counterpart* to the Umwelt concept. It makes the Umwelt concept easier to handle in an evolutionary context, since now one may pose the question of whether the Umwelt of a species is up to the challenges posed by the available semiotic-niche conditions. *Magnetotactic* bacteria, for instance, are anaerobic organisms that find their livelihood in the border zone between water and sediments. Because these bacteria do not tolerate oxygen, they must by all means avoid surface water, and evolution solved this problem in an inventive way. Their cytoplasm contains a smart protein-based compass, a magnetosome that tells them, what is up and what is down. However, if by accident these bacteria shifted hemispheres from north to south (or vice versa), they would soon perish, because the magnetosome would lead them to swim to the surface where the oxygen would kill them. In this (admittedly speculative) case, their Umwelt would not fit the semiotic niche available to them.[13]

Semiotic Freedom

The so-called Cambrian explosion that took place in the Cambrian era, half a billion years ago, refers to fossil findings that were interpreted to show a dramatically rapid appearance of new types of animals at this point in life's history. It has been suggested that all (contemporary as well as extinct) major phyla (main groups) of animals were established in one big "moment" of creativity at that time - with not a single basic architectural form (*bauplan*) having been added since (Gould 1989). One theory - just for illustration - has it that the explosion was caused by rising oxygen content. Before the Cambrian era, oxygen concentrations were supposedly too low to support life of anything but the smallest animals. Algae in the oceans in these distant times may have produced more oxygen than bacteria and other primitive marine animals could consume. Accordingly, the oxygen content on the whole began increasing, in spite of much turbulence. At the start of the Cambrian era, a critical threshold might have been attained, however, allowing bigger (more oxygen-using) animals to survive. At that point in time, therefore, a whole new competitive parameter was introduced - i.e., that of being big, and this then gave birth to radical evolutionary experiments involving how to make the most of bigness. The Cambrian explosion, in this view, reflects the fact that it took evolution less than seventy million years to invent the approximately thirty-five fundamentally different ways (i.e., basic body plans) to be an efficient big animal (with *big* here meaning more than a few centimeters).[14]

Be this as it may, what interests us here is the question of whether the space of morphological possibilities for constructing animals (which apparently filled up at this time) would have simultaneously caused a filling up of the *possibility space* at the level of ecological niches. Were the fundamental ecological roles already established several hundred million years ago, and has evolution since then mostly been concerned merely with the finer adjustments of these basic settings? (As, for instance, when marsupials spread into many of the niches left open by the extinction of the dinosaurs only to find themselves replaced later, for the most part, by placental mammals).

The answer that I propose to this question is *no*. And the reason I feel confident in saying so is because the property that we have called *semiotic freedom* (Hoffmeyer 1992) has an inherent tendency to grow, as we shall see. Over time, this has occasioned the formation of a range of new semiotic niches - thereby also, according to Hutchinson's niche concept, a corresponding range of new ecological niches.

Semiotic freedom was defined as "the depth of meaning that an individual or species is capable of communicating" (ibid., 109). The use of the word *depth* in this connection is related to Charles Bennet's concept of *logical depth* - his attempt to supply the concept of *information* with a measure for the *meaningfulness* or *complexity* of the information, quantified as the number of calculatory steps spent upon producing it. I have no illusions as to the possibility of transferring this kind of calculation from the world of computers to the reality of nature, but intuitively it seems clear that the meaning of different messages may indeed have different depths.

Thus, the saturation degree of nutrient molecules upon bacterial receptors would be a message with a low depth of meaning, whereas the bird that pretends to have a broken wing in an attempt to lure the predator away from its nest might be said to have considerably more depth of meaning. In talking about semiotic freedom rather than semiotic depth, then, I try to avoid being misunderstood to be claiming that semiotic freedom should possess a quantitative measurability; it does not. But it should also be noted that the term refers to an activity that is indeed *free* in the sense of being underdetermined by the constraints of natural lawfulness. Human speech, for instance, has a very high semiotic freedom in this respect, while the semiotic freedom of a bacterium that chooses to swim away from other bacteria of the same species is of course extremely small.[15] The middle ground between these two extremes is the main arena of biosemiotics.

In biology it has been widely discussed whether evolution might be seen as having optimized certain specific parameters for organisms. A range of parameters have been suggested as candidates for such a role, but none of them have been generally accepted. Probably the most common assumption has been that evolution exhibits a trend towards the increased complexity of organisms. The problem is, however, that it is not exactly clear just what this complexity amounts to. According to the evolutionary biologist Daniel McShea, it is more or less agreed that the morphological complexity of a system is determined by the number of different parts of which it is comprised and the greater or lesser irregularity of their arrangement. A complex system is therefore "heterogeneous, detailed and lacking in any particular patterns" (McShea 1991; Hoffmeyer 1996b, 60–61). Accordingly, McShea (1991) concludes that despite what common knowledge would have us believe, there is hardly any empirical evidence to support the theory that complexity, in the above-mentioned sense, has grown greater in the course of evolution. And apropos of this, he quotes the distinguished paleontologist George Gaylord Simpson (1949, 252): "It would be a brave anatomist who would attempt to prove that Recent Man is more complicated than a Devonian ostracoderm" (the ostracoderm is a species of fish, to which the trunkfish belongs, that was in existence between three and four hundred million years ago).

From a biosemiotic point of view, however, the focus of this analysis is misdirected. I have nothing against the idea that the purely morphological complexity of organisms reached its upper limit already in the Devonian period, or even earlier for that matter. But it seems obvious that as evolution little by little created animals with central nervous systems to be players "in the ecological theater" (to borrow Hutchinson's famous phrase), the play itself changed character so that increasingly, evolutionary gains would turn upon the development of efficient mechanisms for social interaction and cooperation - as well as upon such misinformative practices as cheating and faking - and, in short, that evolutionary games would be expected to increasingly concern the acquiring of semiotic competence. Therefore, as I originally suggested, "the most pronounced feature of organic evolution was… not the creation of a multiplicity of amazing morphological structures, but the general expansion of 'semiotic freedom.' …The anatomical aspect of evolution may have controlled the earlier phases of life on Earth but my guess is that, little by little, as semiotic freedom grew, the purely anatomical side of development was circumscribed by semiotic development and was thus forced to obey the boundary conditions placed on it by the semiosphere" (Hoffmeyer 1996b, 61–62). And indeed, as soon as one puts on one's semiotic glasses, the evolutionary trend towards the creation of species with more and more semiotic freedom becomes so obvious that one may wonder how it can be that it was never suggested.[16] The main reason for this may well be that *anthropomorphism* is generally considered such a deadly sin of the first magnitude, that in setting up semiotic freedom, as I do here, as the pivotal point of evolution - at least in its later phases - we almost by definition must accord to human beings the status of being the foremost creatures in the natural history of the Earth. Perhaps this is also the reason why science in general is suspicious of the semiotization of nature implied by the biosemiotic approach. It is time to stop this farce[17].

Semethic Interaction

The growth in semiotic freedom through evolution is caused by the possession in living systems of an extreme semiogenic capacity, a capacity based on their ability to *read omens* in the broadest possible sense of this expression - in other words, to take advantage of any regularities they might come upon as signifying vehicles, or signs. And indeed, although the word is not often any longer used this way these days, I must stress at the outset that by the word omen I mean nothing at all mysterious or supernatural. Anything is an *omen* until we understand its true significance. Thus, whether this reading of omens occurs via genetic adjustments down through generations or occurs as an effect of the cognitive system of an individual organism, is, in this connection, virtually irrelevant. What happens in both cases is the same - seen from the standpoint of semiotics - although the time scales of events are, of course, widely different in the two cases. I have called this pattern of interaction *semethic interaction* (from the Greek, *semeion* = sign + *ethos* = habit) (Hoffmeyer 1994a; 1994b). Whenever a regular behavior or habit of an individual or species is interpreted as a sign by some other individuals (conspecific or alter-specific) and is reacted upon through the release of yet other regular behaviors or habits, we have a case of semethic interaction.

The bird that lures the predator away from the nest by pretending it has a broken wing - and then flies away as soon as the predator has been misled a sufficiently long way - is an obvious example of a partner in a game of semethic interaction. And, in fact, at least two cases of semethic interactions are involved here: first, the predator has perceived (genetically or by experience) that clumsy behavior signifies an easy catch. The bird's behavior is therefore (mis) interpreted as a sign for an easy catch. Here we have a very simple semiotic process, where a nearly lawlike (and clearly nonsemiotic) relation (of one certain physical state to another - i.e., clumsiness with vulnerability) serves as a signifying regularity, or sign for the predator (Hoffmeyer 2008a).

The bird, however, takes advantage of a much less safe relation, the relation between a sign and its interpretant. By pretending to have a broken wing, the bird can "count on" (and again, this may or may not be a genetically fixed interpretant) the predator to misjudge the situation. In other words, the success of this strategy counts on a false interpretive act in the predator. That the predator will misinterpret the bird's behavior may be a safe assumption - seen from our view - but it is hardly a lawlike necessity. Clearly the act of pretending in this case has to be well executed. In this way then, semethic-interaction patterns are built upon other semethic-interaction patterns in chains or webs of increasing sophistication.

Among biochemists, there is a rule of thumb saying that whenever nature keeps a store of energy (e.g., food) there will also always be a species that makes a living on consuming it. I shall suggest a quite similar rule of thumb by saying that there never occurs a regularity or a habit in nature that has not *become a sign* for some other organism or species. Admittedly, this rule may be less well investigated (so far!) than the biochemical rule, but it does catch an important semiotic aspect of the evolutionary process, and that is this: Due to the mechanism of semethic interactions, the species of this world have become woven into a fine-meshed global web of semiotic relations. And I shall claim, furthermore, that these semiotic relations, more than anything else, are responsible for the ongoing stability of Earth's ecological and biogeographical patterns.

Semethic interactions have been at play from the earliest steps of evolution. An example on this is the invention of light sensitivity in early heterotroph organisms.[18] Swenson and Turvey (1991, 340) give the following description:

> Photopigments were first used in photosynthesis, and in locating or moving toward or away from places where the wavelength of light was suitable or not suitable for photochemistry… At some point, when (photosynthesising) cyanobacteria are presumed to have constituted a major portion of the biomass on earth, they themselves represented a field potential on which heterotrophs… began to feed. The heterotrophs used the same photopigments for detecting light, but not to photosynthesise; instead the pigments were used to detect light that was specific to where the autotrophs (photosynthezising cyanobacteria) were feeding (on the light). Light distributions specifying not light as food itself, but *information about* the location of food, was evolutionarily instantiated in its modern sense.

These heterothroph organisms evolved light-sensitive receptors, not because they needed light, but because their prey needed it.

For instance the squid that survives through a mutualistic interaction with light emitting spirochetes, or the fungus that profits from the regularities inherent to the sexual schemata of the male fly. Semethic interactions are probably involved in most - if not all - interspecific relations. Both predator and prey must in their opposing projects necessarily be aware of those signs that tell them about the habits of the opponent. A funny case in this respect is the hare-fox interaction as described by Anthony Holley (1993). A brown hare can run almost 50 percent faster than a fox, but when it spots a fox approaching, it stands bolt upright and signals its presence (with ears erect and the ventral white fur clearly visible), instead of fleeing. After ten years and five thousand hours of observation, Holley concluded that this behavior is energy saving: if a fox knows it has been seen, it will not bother to give chase, so saving the hare the effort of running. Holley rejects the alternative explanation, that the hares just want to better monitor the movements of their predators, partly because the behavior does in fact not help them to see the fox more clearly, and partly because they do not react the same way to dogs. While a fox depends on stealth or ambush to catch a hare, the dog can run faster and it would therefore be counterproductive for a hare to signal its presence… The hare "knows" that the fox has the habit of not chasing it if spotted. Thus it develops the habit of showing the fox it has become spotted. Whether this habit has become fixed in the genomic setup of the hare or whether it is based mostly on experience is probably not known, but doesn't matter (Hoffmeyer 1997a).

The amazing semiogenic competence of many animals was perhaps most famously brought to the attention of the scientific community in 1907, when the German psychologist Oskar Pfungst disclosed the trick behind Clever Hans - the horse that surprised audiences all over Europe with its ability to do simple calculations. Recall this famous story: Hans's trainer would pose to it a simple arithmetic problem, such as 3 x 4, by writing with chalk on a blackboard, and Hans would then reply by tapping one foreleg twelve times. In spite of many attempts, nobody was able to disclose any cheating until Pfungst began his studies.

The horse, of course, did not possess any capacity to do mathematics or understand writings on a table, but it did an eminent job of reading the wishes of individuals from a foreign species. If the horse could not see the person posing the question, it could not then perform, and the explanation for its artful tapping was shown to reside in the horse's ability to notice an ever so slight - and obviously unconscious - body movement by the trainer, when the correct number of tappings was reached. At the point when the cue showed up, all Clever Hans needed to do was to stop tapping. Now, unfortunately, this famous story has probably contributed more to bring ethology into ridicule than anything else. And, indeed, a series of other clever-animal stories have appeared since then, perhaps the most notorious being the many experiments purporting to show that great apes had been taught to talk (Sebeok and Umiker-Sebeok 1980). Yet in a comment on the Clever Hans phenomenon, the Swiss pioneer in nonverbal communication studies, Hans Hediger (1974, 27–28) writes, "The apparent performance of these 'code-tapping' animals is only explainable by the continually repressed fact, that *the animal* - be it horse, monkey or planarian - *is generally more capable of interpreting the signals emanating from humans than is converse the case*. In other words, the animal is frequently the considerably better observer of the two, or is more sensitive than man; it can evaluate signals that remain hidden to man" (cited in Sebeok 2001b, 23). Hediger quotes Pfungst for the observation that horses are capable of perceiving movements "less than one-fifth of a millimeter" in the human face (Hediger 1974, 32).

Similarly, a fascinating example of semethic interaction between humans and birds concerns the African Boran people and a bird known as the black throated honey guide, *Indicator indicator* (Sebeok 1979, 14–18). Collecting honey is an ancient human practice as witnessed by 20,000-year-old cave paintings. The honey guide often accompanies the Boran people when they go out to collect honey. *Indicator indicator* guides them from tree to tree by characteristic call-outs. Thanks to this assistance, the time Borans expend finding the bees' nests (which is otherwise approximately three hours) is shortened by one third. The bees are smoked out, the hives are opened, and the honey collected. And while the honey guide birds cannot themselves open the hives, after the Borans have taken their honey, much valuable larvae and wax still remain in the hives for the birds to eat. The species designation *Indicator* bears witness to the spontaneous semiotic intuition that many biologists have upon discovering such interactions.

Too, semethic interactions may, in some cases, be very complex and involve several species. This is, for instance, often the case in *plant signaling*, where plants that have been damaged by insect attacks emit signals that are received by undamaged conspecifics. Undamaged fava beans (*Vicia fabea*), for instance, immediately started attracting aphid parasites (*Aphidus ervi*) after having been grown in a sterilized nutrient medium in which aphid-infected fava beans had previously grown (Bruin and Dicke 2001). The damaged beans thus had managed to signal their predicament through the medium to the undamaged beans, which then immediately started to attract aphid *parasites*, although no aphids were, of course, available for parasites to find.

Perhaps the best studied examples of this mechanism in plants concern cases where the sign vehicle is a volatile airborne compound (but soluble waterborne compounds that spread to neighboring plants through the earth also often function as messengers). The complexity of these relationships is further increased by the intervention of nonconspecific plants that may gain advantage from the density of freely available parasitoids (insects whose larvae lives as parasites that eventually kill their hosts)) and it is therefore conceivable that these nonconspecific plants themselves may develop sensitivity to the volatile signal molecules. Bruin and

Dicke, reviewing a series of examples on this kind of communication, also advance the speculation that signals might be transferred by direct contact between the roots of neighboring plants, or even through the fungal bridges (*ectomycorrhiza*) between them.

Parasitic wasps (*Cotesia marginiventris*) that lay their eggs in caterpillars offer another intriguing example of semethic interaction. When a caterpillar munches on the leaves of a corn seedling, a component present in the oral saliva of the larva induces the formation of a signal that spreads to the whole plant. This signal causes the corn seedling to emit a volatile compound, a terpenoid, which is carried off with the wind. Eventually, the terpenoid arrives at the antennae of female wasps and is interpreted as a sign for oviposition, prompting the wasps to fly upstream towards the source of the terpenoid. Upon detecting the caterpillars, the wasps lay their eggs in the young larvae, one egg in each, and a couple of days later the eggs hatch and the parasitoid starts eating up the interior of the caterpillar. Ten days after oviposition, the parasitoid emerges from the caterpillar and spins itself a silky cocoon, leaving the host larva to die.

Seen from outside, what happens here is that the wasp and the corn plant have common, if opposite, interests in the caterpillar and have each worked out a cooperative way of satisfying those interests by actively sharing a small part of the semiosphere. Or, more concretely, a habit (the emission of a terpenoid by the corn plant when leaves are munched upon by caterpillars) has become a sign for the wasp, leading it to a suitable opportunity for oviposition. But should this wasp have any natural enemies, this very same successful oviposition mechanism might yet serve as a perfect habit for that enemy to exploit, building up even more layers of semethic interaction upon semethic interaction.

And in fact, parasitic and mutualistic symbioses are more or less unthinkable without a subtly developed pattern of semethic interaction between the involved organisms - as we have already seen in the case of the squid and light-emitting bacteria, where a multiplicity of signals and signal receptors interact back and forth across the species barrier. Further examples include cellulose-degrading microorganisms in the intestinal tract of ruminants, pollination relations between flowering plants and insects, and the close cooperation between coral polyps and algae (usually dinoflagellates). The scheme is nearly inexhaustible, and if sufficiently broadly defined, every organism on Earth does, in some sense or other, enter into mutualistic symbiotic community with other species.

Semethic interaction is often involved in *intraspecific ritualization* - i.e., the development of stereotypic displays with communicative content that are intended for conspecific individuals. An interesting theme in this context is the iconic use of typically feeding-related items for mating purpose. For example, during courtship the water mite (*Neumannia papillator*) male will make a vibrating movement with its front four legs while wandering around the female - a behavior called *courtship trembling*. This trembling behavior is iconically indistinguishable from the vibration in the water surface that discloses the presence of the small animals that the mites feed upon. The water mite strikes a specific attitude while watching the vibrations in the water surface ready to seize the prey with its forelegs, and this is precisely the way the female seizes the male in the initial step in mating. It is, of course, particularly intriguing for the imagination that the hungrier females are more likely to gravitate towards the male and clutch him (Johnstone 1997, 161). Seen from the standpoint of semiotics, what goes on is that the male takes advantage of the female *foraging Umwelt* for the purpose of communicating his mating wish. Students of behavioral ecology aptly call this phenomenon *sensory exploitation* or even *sensory trap*.

And again, the same theme is repeated with many different variants in many different animals. For instance, it is well known that female birds will often, in a late phase of the mating ritual, strike an attitude that is otherwise only seen in very young birds when they are begging for food. This exclusively happens in a late state of the ritual, and the birds are not especially hungry. Wish for feeding has thus developed to become an icon for wish for mating. Sebeok discusses a more cruel case of courtship ritual in that of the balloon flies of the genus *Empididae*, where swarming males bring with them insects caught as "wedding gifts." "The male offers his gift to a female," writes Sebeok, (1979, 18), "which sits peaceably sucking it out while the male inseminates her. As soon as copulation is completed, the female drops her present, but if the empidid bride is still hungry, she may consume her amorous groom next."[19]

The normal case of semethic interaction concerns the interplay between two or more organisms, but abiotic regularities may also be used as a substrate for the semiogenic inventiveness of living systems, as we saw in the case of magnetotactic bacteria. Similar cases are found among the migratory birds that find their way across continents - or between them - by interpreting stellar configurations by night.[20]

Too, semethic interaction is by no means exclusive just to the organismic level but may also take place at levels other than the organismic. Thus, in the case of the eyeless mutant in salamanders, this very same principle of semethic interaction is also an important principle during embryonic development. The presence of a developing eye at a distinct stage of cerebral development is used as a semethic trigger for those tissues from whence the hypothalamus is supposed to develop - so that, in the absence of the eye, the hypothalamus and the gonadotropic hormones go missing as well.

The Ecosemiotic Perspective

Traditionally, ecology has had a hard job in trying to map the multiple physical and chemical interactions between organismic populations, as these are reflected through such things as trophic structure and nutrient cycles. But the task of unraveling the semethic-interaction patterns between such populations is, of course, magnitudes more complex. Probably we have only seen the beginning of such studies, and my guess would be that our present knowledge gives us only a small glimpse of a nearly inexhaustible stock of *intelligent* semiotic interaction patterns taking place at all levels of complexity from cells and tissues inside the bodies up to the level of ecosystems.

The situation, in other words, has a matrix-like structure with multiple interdependent relationships binding populations of many different species into a shared interpretive universe or motif. Against this background, it would be reasonable to suggest that evolution may be as much constrained by the existence of these *ecosemiotic interaction structures*, as it is by developmental constraints (Alberch 1982).[21] In an earlier paper (Hoffmeyer 1997a), I suggested the term *ecosemiotic discourse structures* with reference to Michel Foucault's exposition upon the *discourse concept*, which, very briefly stated, refers to the symbolic order relating human subjects to a common world (Foucault 1970, Cooper 1981). However, the term ecosemiotic *interactions* may be preferable to that of *discourse*, since there is no reason to associate this activity to the human sphere of symbolic minds here.

Thus, while most biologists suppose that *symbiotic mutualism* is an exceptional case of no general importance for evolutionary theory, I believe that *semiotic* mutualism involving a delicate balance of interactions between many species is widespread (see Margulis and Sagan 2003). And if this is indeed the case, it has significant consequences for our thinking about evolution, for it implies that the relative *fitness* of changed morphological or behavioral traits become dependent on the whole system of existing semiotic relations that the species finds itself a part of. Accordingly, the firm organism-versus-environment borderline will be dissolved, and a new integrative level intermediate between the species and the ecosystem would have to be considered - i.e., the level of the *ecosemiotic interaction structure*. Clearly, this possibility becomes most interesting in cases where experience and learning enters the interaction pattern, as will often be the case in mammals and birds. Such learning might on occasion even subsume the evolutionary process, as is the case in human culture. Conversely, one might wonder if a relatively autonomous ecosemiotic interaction structure is precisely what is needed for learning to evolve in the first place. In this way, eventual increases in semiotic freedom will be prone to feed back into the evolutionary process by strengthening the advantages of possessing semiotic freedom.

Thus, semiotic freedom is an emergent property and should always be analyzed in relation to its proper level. For example, the semiotic freedom of the free-living individual cell must have been severely diminished in the process that transformed unicellular organisms to multicellular organisms. The necessity for single cells to obey the *somatic ecology of the body*, as Buss (1987) termed it, must have constrained the freedom of each individual cell, but these constraints at the level of the cell made possible the enormous gain in semiotic freedom acquired at the higher level of the organism. Through the differentiation of its tissues, the multicellular organism obtained a much greater capacity for processing and communicating knowledge, in the sense that it could deal with larger parts of its environment both in space and time.

We shall thus suggest the term *interpretance* as a measure of the capacity of a system to respond to signs through the formation of *meaningful* interpretants. High interpretance allows a system to "read" many sorts of cues in the surroundings; such high-level interpretance means that the system will form interpretants in response to complex cues that might not be noticed, or even be noticeable, by low-level agents. Thus, a unicellular organism cannot interpret complex patterns such as animal tracks, and in this sense it has a low-level interpretance. Mammalian organisms, on the other hand, are capable of interpreting extremly complex cues - such as the individual behavioral patterns of conspecifics - accordingly, they may be said to have high-level interpretance.

All this indicates that there is an aspect of *play* in the evolutionary process, an aspect which has been more or less overshadowed (virtually to the point of invisibility) by the Cyclopsian focus on selection. For *play*, it is often said, is an activity which carries its purpose in itself. "What is characteristic of 'play,'" writes Gregory Bateson (1979, 139) "is that this is a name for contexts in which the constituent acts have a different sort of relevance or organization from that which they would have had in non-play." Bateson (1979, 151) also suggests the definition of play as "the establishment and exploration of relationship" as opposed to ritual - "the affirmation of relationship." Thus, to the extent that the living world is engaged in an open-ended and nonsettled exploration of relationships between systems at many levels of complexity, it can truly be said that nature does, in fact, exhibit play-like behavior. It therefore will be as legitimate to talk about *natural play* as a force in the evolution of life forms, as it is to talk about natural selection. Selection acts to settle things - i.e., to fix behaviors, morphologies, or genetic setups - thereby putting an end to some element of ongoing play in the system while simultaneously providing for the beginning of whole new kinds of play.

Thus it was, for example, that more than fifty million years ago a particular ant species began interacting with a particular kind of fungus and the processes of natural selection eventually settled this as a new ant habit for farming fungi (as discussed above). The counter-processes of natural play, however, continued exploring this newly created semethic-interaction pattern (or *ecosemiotic interaction structure*), since now all two hundred of the existing fungus-growing species have evolved from this single ant species, And with few exceptions they all grow fungi from the same family, *Lepiotaceae*. In fact, the higher forms of ants have now become so specialized that they cannot survive without exactly the right variety of fungus (*New Scientist* 17/12 1994, 15). So here, the long, slow, interactive processes of natural selection may finally have resulted in the total crystallization of the relations from the open form of *play* to the closed form of *ritual* (or as it has sometimes been called, instinct).

Obviously, an increase in semiotic freedom will tend to push the influence of selective forces to higher levels. Thus, the more there is of inter-species semiotic interaction, the more will the *selective aspect* of evolution be loosened at that level, and the more dominating will become the *play aspect*. This is because a rich semiotic interaction pattern produces *fitness ambiguity* - for when organisms are bound up in a web of complex semiotic relations, virtually any newly developed property or behavior can potentially be counteracted or integrated in many different ways. Thus, the number of possible solutions for *selection* to scrutinize - and the subtlety of the communicational interactions - will tend to produce a no-win situation. As a result, selection cannot really measure the stakes of single players (individuals, demes, or species) in the game, though it could still influence the *choice of the game* itself. Because ultimately, it is plays, not players, that are selected for. Accordingly, I have suggested that instead of the evolutionarily derivative concept of *genetic fitness*, evolutionary biology should try to develop a concept of the evolutionarily prior phenomenon of *semiotic fitness*.

The Biosemiotic Core of Evolution

If a morphological or behavioral trait has a relatively unambiguous genetic anchoring, and if, on the average,[22] it conveys an increased advantage, in survival or reproduction, to the organisms carrying it, then one would expect this trait to spread in the population, thanks to natural selection. And, indeed, we have no problems in ascribing such authority to natural selection. What I do question, however, is that this principle can be said to, even approximately, suffice as a explanation for evolution. For the problem is that this principle does not itself explain the establishment of the conditions under which it applies, i.e., under which it both operates and became possible in the first place.

Whether a trait conveys an *advantage* to its carrier or not depends on a complex, self-organizing context of semiotic relations that were gradually established through massively combinatorial trial and error events *at the lived ecosystemic level* and is therefore beyond the reach of genetic prespecification. This especially applies to later stages of evolution, where the *semiotic competences* of species are more unambiguously pronounced. Our implication is not, of course, that selection is no longer very important in later stages of evolution, but only that selection cannot be said to explain the evolutionary process *as such* - since this process to a great extent has been played out on premises given solely by the force of organisms' semiotic context.

The Scottish geneticist Conrad Waddington (1957; 1968–72) fought strongly to get recognition for the idea of embryogenesis as an autonomous factor in evolution. His idea of *developmental canalization* is still an important resource for our understanding of the developmental process. According to Waddington, the ontogenetic process may be seen as analogous to a ball running downhill through a branching system of valleys in an *epigenetic landscape*, the contours of which are determined as the effect of interplay between multiple individual genes.

This illustrative idea conveys an immediate understanding of why genes do not usually determine distinct traits, but rather, in a cooperative fashion, maintain the structuring of a developmental course. Even slight changes in the height of the floor of a valley in the epigenetic landscape might force the ball into a deviating route, and if this happened in early stages, it might have dramatic final effects. By supposing, furthermore, that the contextual situation in which development takes place influences the structure of the landscape, we get a picture of a true interactive dynamics involving both genetic *and* environmental influences upon the embryological process. By adding the epigenetic landscape as an interactive layer between genotype and phenotype, Waddington attempted to transcend the behaviorist black-box conception of the role of the organism and to gain some space within which to explore his own new ideas about genetic assimilation.

The crux of this latter idea proceeds from the well-known occurrence of *exogenous adaptation* (e.g., muscles that become thicker and stronger when continually and intensely used). Most organisms are, to some extent, ontogenetically adaptable to changing environmental conditions, which in Waddington's terminology means that the *canalization* of the respective property or trait is only partial, leaving open a range of optional phenotypic end products. There must however be limits to such flexibility: "If for instance, there was no canalization of the growth habit of a plant ecotype, every cold spring would convert the lowland forms into alpine types unable to take advantage of a succeeding warm summer" (Waddington 1957, 168). *Natural selection* would therefore be expected to tend towards some kind of *balance* between flexibility and genetic fixation of adaptable traits. Thus came the idea of *genetic assimilation*:

> It looks as though it must be too difficult for natural selection to produce organisms which *always* respond in a *perfectly adjusted* adaptive manner to fluctuating environmental circumstances, and that *faute de mieux* it tends to fix, by canalization, a type which is *reasonably well adapted* to the situation it will *most* frequently encounter. When this occurs in a population in an environment that remains relatively unchanged for considerable periods, it is the *process* that I have called *canalizing selection*. When it happens to a subpopulation which is carrying out exogenous adaptation to a *new* environment, it converts this into a pseudo-exogenous adaptation, and the "acquired character" becomes genetically *assimilated* (Waddington 1957, 68).

Thus, the overall effect of this mechanism is to create genotypes that reflect the conditions of life of the organisms concerned. In other words, the *actual life* of a population influences its evolutionary future. Waddington was even capable of showing that such a mechanism was, in fact, at work in *Drosophila melanogaster*, as he for many generations subjected the flies to straining conditions such as ether vapor (Waddington 1956).

Like the Baldwin effect that we are going to discuss later, Waddinton's theory of genetic assimilation was not well received at the time by leading figures of what was called the new synthesis (between Darwinism and genetics) (see Depew 2003).[23] What is important about Waddington's idea for our biosemiotic understanding is his insistence, via the image of the epigenetic landscape, upon the autonomy of an intermediate zone between the genotype and phenotype - for this is a zone where not only embryological but also semiotic influences are of the essence.

And in fact, perhaps the most crucial single aspect of the embryological process (after the attainment of brute viability) is the development of the Umwelt of an organism. The role of the Umwelt is to regulate behavior (or, in general, organismic activities), for if it happens that the Umwelt of an organism is not well tuned to the semiotic niche, the chances of this organism surviving, much less leaving healthy offspring,will be diminished. Thus, it follows that the establishment of a good fit between the Umwelt of an organism and the semiotic-niche conditions it must cope with, stands as a central theater for natural selection.

But this immediately raises the question of the genetic anchoring of the Umwelt - a problem that once again brings us to the question of canalization. There must be species-specific determinants behind the selection of a potential sign in the surroundings of an organism that the organism can become capable of interpreting with some success. A moth, for instance, is equipped with a totally silent Umwelt, apart from the narrow chink that is kept open for registering the bat's fateful frequencies of approximately 20,000 Hz. When the bat is far away, the moth naturally veers away from the sound, but when the bat comes up close, the moth instead makes sudden and unpredictable movements. The moth, in other words, displays Umwelt-controlled behavior.

Now, it is true that *individual variations* in moths regarding these senso-motoric couplings are, of course, extremely limited, and Waddington's landscape probably does not reveal to us its true value at this level. But as soon as we move on to more advanced behavioral schemata - involving, for example associative learning, as in the octopus - it becomes necessary to explain the occurrence of *individual calibrations* to the semiotic surround.

The concrete shaping of the nervous system of an individual is, as we have seen, dependent on the sensory inputs that the individual receives, as well as on the brain's own interpretive activities. As a consequence of this, it might clarify matters to provide an extra - largely independent - layer of interpretive processing, that we have called the *Umwelt landscape* (Hoffmeyer 2001c). The canalization process then consists of a ball at the same time tracing a route through both of these landscapes. One might, of course, depict this as an n-dimensional landscape, and the combinatorial output of these two under-determined canalization processes thus creates the individual as a morphological-physiological system (*modus* Waddington) with an Umwelt calibrated to the de facto challenges of the semiotic niche it is supposed to encounter. Taken together, these two coupled canalizations effectively break the determinism generally supposed to rule over the genotype-phenotype transformation.

In creating big-brained animals, natural selection managed to take advantage of the adaptive capacity of brains, but in doing so, it also partially subsumed itself under the semiotic determinations that this new kind of adaptive talent opened up the way for. An octopus quickly adapts to changing conditions - and if these changed conditions persist through many generations, it is hard to see how it could be avoided that other new adaptations would not also occur, so that an eventual return to the original conditions would now lead not to a loss of the original adaptations, but rather, to yet other adaptations.[24] This idea comes close to *genetic assimilation* as Waddington conceived it. The point is that it is the *semiotic competence of animals* that seriously puts (or should put) this *intermediate embryological zone* (the combined epigenetic-Umwelt landscape) at the forefront of the agenda in evolutionary thinking. Genes are assimilated as *support mechanisms* for changes of behavior that are necessitated by changes in the eco-semiotic interactions of organisms.

If we put such genetic assimilations of the semiotic niche into the context of the interspecific semiotic patterns described in the preceeding section, it seems amply substantiated that selection *is a tool for the increasing semiotic refinement* rather than the converse. Selection surely does occur, but it flows down semiotically constructed pathways.

Louis Pasteur has been credited for coining the saying that “chance favors only the prepared mind.” In essence, this captures the idea being expressed here. Chance mutations are not selected because they are beneficial; they are beneficial because they happen to appear in a relational system which was already well suited for them. That blind selection should be the sole cause of evolution is one of the mightiest fictions of our time. Selection is never blind; it is always guided by the prior formation of developmental and semiotic integration. Semiotic integration is not exclusive to the level of species, but instead takes place on many levels - e.g., as symbiosis and as more diffuse ecosemiotic interaction structures.

Semiotic Partitioning

One particular aspect of the biosemiotic approach that should be mentioned in connection with this discussion is that of semiotic partitioning (Hoffmeyer 2001c). *Semiotic partitioning* consists in the sympatric isolation of particular segments of a population that happen to share a particular kind of Umwelt (whether by common conditioning, learning, or heritage). By sharing a particular deviation from the prevailing dominant Umwelt, organisms are lead to share in certain aspects of behavior as well, and this in itself might tend to bring them closer together in sub-niches. Such *semiotic partitioning* has a built-in positive feedback mechanism in that individuals that share in similar behavior will also tend to share in similar conditioning or learning outcomes, thereby reinforcing or accentuating the shared deviation. If further reinforced by *genetic assimilation*, semiotic partitioning might eventually lead to genetically based isolation mechanisms and sympatric speciation.[25]

The Baldwin Effect

As already mentioned, Waddington’s theory of genetic assimilation did not resonate well with his contemporary neo-Darwinians. The leading figure in paleontology at that time, G. Gaylord Simpson, identified it with a theory that had been advanced half a century earlier by the American child psychologist James Mark Baldwin - a theory that, according to most neo-Darwinists was considered as Lamarckism through the backdoor (Depew 2003).[26] As David Depew has shown, Simpson’s evaluation of the theory was heavily colored by a kind of paradigmatic blindness towards both theories: Waddington’s and Badwin’s ideas were in some respects related, but they were definitely not identical (Wiles et al. 2005; Longa 2006).

Through the last two decades, however, a change of view has happened in evolutionary thinking that has led to a revival of Baldwinism. It is perhaps noteworthy that this change was not inspired by biological findings, but by computer simulation studies (Hinton and Nowlan 1996 (1987)). Among others, Daniel Dennett was enthusiastic but also - and in a very different sense - was Terrence Deacon (Dennet 1995; Deacon 1997; 2003). Baldwin’s theory, quite generally, assumes that learned behavior may *feed back* on both the direction and the rate of the continued evolutionary process. Superficially seen, this does indeed look like Lamarckism in disguise - but, in fact, Baldwin believed that this effect might be caused through wholly Darwinian processes of evolution. As a child psychologist, he was particularly attentive to the phenomenon that we today would call social inheritance: “In the child’s personal development, his ontogenesis, his life history, he works out a faithful reproduction of his social conditions. He is, from childhood up, excessively receptive to social suggestions; his entire learning is a process of conforming to social patterns. The essential to this, in his heredity, is very great plasticity, cerebral balance and equilibrium, a readiness to overflow into the new channels which his social environment dictates” (Baldwin 1902, 53).

Baldwin was also a confirmed Darwinian and, in essence, what he suggested was that social inheritance was operational not only in children, but in the animal world at large, if only to a lesser extent. In this way, he could synthesize what he could not deny as the results of his studies in child psychology with his belief in Darwinism. He saw the intellectual *plasticity* of the child - or, in general, the young - as a *trait* for natural selection to work upon. And since social transmission is itself enough to explain the behavioral likenesses bewteen father and his son, there is no need for a Lamarckian theory of *acquired mental characteristics* (Hoffmeyer and Kull 2003). In fact, quite to the contrary, "the only apparent hindrance to the child's learning everything that his life in society requires would be just the thing that the advocates of Lamarckism argue for - the inheritance of acquired characters. For such inheritance would tend so to bind up the child's nervous substance in fixed forms that he would have less or possibly no plastic substance left to learn anything *with*" (ibid., 55).

The decisive point here, of course, is that Baldwin thought social heredity might facilitate the formation of genetic heredity - for this is where the modern Darwinist has been trained to suspect a Lamarckian "catch." Yet Baldwin explained this phenomenon through a mechanism he called *organic selection* that implied the appearance of developmental adaptations in the lifetime of individual organisms.[27] These adaptations were caused by "the great series of *adaptations secured by conscious agency*, which are all classed broadly under the term 'intelligent,' such as imitation, gregarious influences, maternal instruction, the lessons of pleasure and pain, and of experience generally, and reasoning of means to ends" (Baldwin 1996, 442-443; italics added).

Taken together, these adaptations would mean that individuals might survive even under odd conditions and "thus kept alive, the species has all the time necessary to perfect the variations required by a complete instinct" (Baldwin 1902, 97). *Organic selection and natural selection* were thus, as Baldwin saw it, opposing mechanisms, and what organic selection achieved was to give stressed individuals a place where they could breathe freely as a safeguard against the sharp knife of selection. This, he thought, might permit them to survive until genetic adjustments appeared and were fixed through natural selection, offering more permanent support for the new adaptation.

Baldwin thought that his theory on organic selection showed "that the ordinary antithesis between 'nature and nurture,' endowment and education, is largely artificial, since the two are in the main concurrent in direction" (Baldwin 1902, 106). He illustrated this by reference to complex instincts where physical heredity and social transmission are inextricably combined. Thus, in certain instincts, "we find only partial coordinations given ready-made by heredity and the creature actually depending upon some conscious resource (imitation, instruction, etc.) to bring the instinct into actual operation… [In animals,] social heredity serves physical heredity, while in man we find the reverse" (ibid., 107).

Probably the most serious conflict between the Baldwin effect and classical neo-Darwinism concerns the question of the primary causal role of the genes. It is close to dogma to claim, as Simpson (1953) did, that "the ability to acquire a character has, in itself, a genetical base" (Simpson 1953, 116; Depew 2003). According to neo-Darwinian dogma, any population therefore always carries a large reserve of hidden genetic variation, and by implication, variants will nearly always by necessity appear to take advantage of eventual changed conditions.

The Russian-born American geneticist, and one of the great figures behind the *Modern Synthesis*, Theodosius Dobzhansky, proposed a theory of *balancing selection* that reflects this very conception. The disease of sickle cell anemia is the prototypical example of balancing selection at work. In areas of Africa with severe occurrences of malaria, there is also a high frequency of sickle cell anemia - a disease caused by a point mutation in the gene for the beta-chain of hemoglobin that seriously impairs the health of persons that are homozygous for the mutation.[28] Only few homozygotes survive to adulthood, whereas heterozygote carriers of the disease gene normally have no problems as long as they are not exposed to low oxygen pressures.

The reason why selection has not eliminated this serious monogenetic disease is that the heterozygote carriers of the disease are much more tolerant to malaria than are the healthy people. In malaria-threatened areas, a balance therefore will often obtain, causing the disease gene to be maintained in the population through its being rewarded by the increased number of healthy offspring left by heterozygous carriers. How, precisely, this balance will be set, is wholly dependent on how serious is the malaria threat.

Terrence Deacon (1997, 323), however, has given a Baldwinistic explanation for the incidence of sickle cell anemia:

> The sickle cell trait spread quite rapidly in Africa in recent prehistory because of human activity… Probably the critical historical event that catapulted malaria to an epidemic disease was the introduction of agriculture and animal husbandry into Africa between five and ten thousand years ago. This culturally transmitted practice modified the tropical environment to create the perfect breeding ground for mosquitoes… The human population was thrust into a *context* in which powerful selection favored reproduction of any mutation that conferred some resistance to malaria.

As Depew explains in his analysis of the modern revival of Baldwinism, one need not see any strict opposition between Deacon's position and that of

Dobzhansky. Rather, what has happened is that genes are now to a lesser extent seen as deterministically *coding for a trait* but rather as tools recruited to support already established practices - such as, for example, making it attractive for people to eat vitamin C rich citrus fruits rather than reestablishing the gene that, by mutation in our distant ancestry, got lost and thereby eliminated the human capacity for synthesizing ascorbic acid (vitamin C) (Depew 2003).

From a biosemiotic standpoint, Baldwinism in its modern version is quite unproblematic. Organisms, and the cells and tissues of which they are built, are not just objects but also subjects - in the sense that they are semiotic agents capable of interacting with their surroundings in "intelligent" ways. And the history of how these semiotic interaction patterns have been scaffolded into the myriads of ontogenetically consistent dynamics of this world - i.e., the life cycles of organisms - is what evolution is all about. Genetic fixation, of course, plays a crucial role in such scaffolding - but I believe that there are countless semiotic ways of obtaining a relatively secure scaffolding of intra- and inter-specific interaction patterns (semethic interactions see Hoffmeyer 1995). I see no reason to believe that all - or even most - of these semiotic scaffolding mechanisms are unambiguously "coded for in the genomic setup." On the contrary, I think that there are serious reasons to believe they are *not*, since *flexibility* is at the core of such semiotic scaffolding (Bateson 1963; Hoffmeyer and Kull 2003).

Intelligence and Semiosis

The extent to which different animals *possess intelligence* has been highly disputed. It has often been overlooked, however, that intelligence is not just something one has between the ears, but is very much a social skill, an ability to use physical marks as well as social relations to scaffold and organize one's knowledge and behavior.

From the very beginning, nerves were developed as tools for movement. Their task was to facilitate long-distance communication between cells in different parts of a moving animal. But the presence of fast moving animals implied the creation of fast moving environments (e.g., the co-presence of fast moving prey - or predators!) and brains developed to allow certain animals to cope with this situation in new ways. The combinatorial possibilities of moving in a moving world are enormous of course, and from the beginning, the task of brains was to help the animal make proximal decisions which might be assisted by learning, but which could not possibly be deterministically based on genetic anticipation. Brains were means for nurturing nature.

One aspect of brain action which may deserve special emphasis is *proprioception* - i.e., the awareness of one's own movement and position. Even the simplest movement presupposes a continous feedback from proprioceptive organs in the body measuring muscle tensions and displacements of cell layers including the sense of gravitational orientation. The American philosopher Maxine Sheets-Johnstone (1998, 284) has recently suggested that the proprioceptive sense serves as a *corporeal consciousness*: "Any creature that *moves itself*, i.e., that is not sessile, senses itself moving.[29] By the same token, it likewise senses itself when it is still. Distinguishing movement from stillness, motion from rest, is indeed a fundamental natural discrimination of living creatures that is vital to survival."

It was the French philosopher Maurice Merlaeu-Ponty (2002 (1945), 160) who observed that "originally, consciousness is not an 'I think that' but an 'I can.'" Sheets-Johnstone (1998, 285) echoes this insight when she writes that "a creature's initiation of movement is coincident with its kinesthetic motivation, its dispositions to do this or that - turn, pause, crouch, freeze, run, or constrict; its kinestethic motivations fall within the range of its species-specific movement possibilities… [which] are the basis of its particular repertoire of 'I can's… [and thus] any item within its repertoire of 'I can's is undergirded proprioceptively (kinesthetically) by a sense of agency."

It is a well-known fact that animals can and do dream. This implies that mental states may sometimes be uncoupled from bodily action. But the extreme *extent* of *uncoupling* between behavior and mental activity that characterizes the human mind is probably unique among animals. The uncoupling has made philosophers wonder how it can be that mental states are always *about* something. But seen from the perspective of biology, this is no surprise at all, since *mental aboutness*, (human intentionality) grew out of a *bodily aboutness* (Hoffmeyer 1996 a). Whatever an organism senses also mean something to it - e.g., food, escape, sexual reproduction. This is one of the major insights brought to light through the work of Jakob von Uexküll (1982 (1940), 31): "Every action, therefore, that consists of *perception and operation* imprints its meaning on the meaningless object and thereby *makes it into a subject-related meaning-carrier* in the respective Umwelt."

Seeing "I can" as the center around which mental processes are organized by evolution implies a blurring of the mind-body dichotomy. The acts of thought and the acts of body are not totally separate categories, but are essentialy connected via the intentionality of the animal that instantiated them - and therefore mental activity is just a particularly sophisticated extension of traditional animal behavior. It follows from this understanding that we do not have to operate with two quite different categories such as *phenotypic flexibility* and *learning*. Learning is just an especially smart form of phenotypic flexibility.

The Ghost of Lamarckism

The French naturalist Jean Baptiste Lamarck - who in 1809 (fifty years before Darwin) suggested the first scientific theory of evolution in the history of the world - is a sad figure in the history of biology, outmaneuvered and overruled by his contemporaries, scorned and misunderstood by posterity (Burkhardt 1977). Lamarck's misdemeanor, seen with modern eyes, was that he believed that properties acquired by plants or animals in the course of their lifetimes could become inherited by their offspring. It is this, to the best of our knowledge, false conception that nowadays is called *Lamarckism*. For instance, as the wading bird delicately set out to feed at still deeper water, Lamarck posited that its stilted legs would become incrementally prolonged in the process, and this, he claimed, would prove of use to the offspring as manifested in an ever so little prolongation in the length of the legs already from birth. Lamarck felt that through many generations, this process might lead to the substantial kinds of change that we can observe when comparing present species with fossilized specimens. By suggesting this (intuitively quite reasonable) connection, Lamarck in one bold stroke broke down the millennia-old wall inherited from both the Bible and from Plato and Aristotle that guarded the static image of the composition of the natural world. And yet, this world-changing figure is nowadays remembered mostly as the defender of a wrong theory that was successfully replaced by Darwin's.

The idea of acquired properties as inheritable was, in fact, common sense in Lamarck's own time and to identify his theory with this simplistic idea is to blind oneself to his real achievement.[30] Nobody at the time had the faintest idea about the existence of genes, and there was therefore no good reason to distinguish so sharply between biologically *innate* and biologically *acquired* properties. For Lamarck it was, in fact, something very different that seemed central - namely, that *habits create forms*. When circumstances change, organisms will have to change their patterns of activity accordingly - or, in other words, they must take up new *habits*. But new habits will usually make anatomical, physiological, or behavioral innovations desirable, and Lamarck thought that the "inner feeling" (*le sentiment interieur*) of the species imperceptibly guided the appearance of innovations that satisfied just these needs. This, of course, required a huge number of generations, and it was therefore necessary that the small improvements acquired in each generation were heritable, so that they would be added to the accumulated result of the efforts of the preceding generations.

The idea that a species could possess an *inner feeling* is of course a stumbling block for the modern scientific mind. Lamarck himself speculated that this inner *feeling* was caused by so-called *subtle fluids* (an expression that is not likely, either, to meet acceptance by the sharp scientific minds of of the twenty-first century). But these immeasurable subtle fluids were, in fact, the only explanatory tool eighteenth-century science had at its disposal for explaining strange phenomena such as electricity, magnetism, or even wickedness.[31] Lamarck's own time, of course, lies right at the border of the nineteenth century where subtle fluids were no longer looked upon with much sympathy. But perhaps for the same reason, nineteenth-century science no longer pondered the kind of "big" questions that were the focus for Lamarck's work.

Lamarck, however, further had the sad misfortune, long after his death in 1829, to have his name drawn into the heated controversies surrounding Darwinism. This would last for three quarters of a century until, in the 1930s, the neo-Darwinian synthesis finally seemed to extinguish the last hopes for a Lamarckian kind of evolution. And, although many neo-Lamarckian biologists could and did adduce quite weighty arguments in defense of their opposition toward Darwinism, Lamarck's thinking unavoidably became vanquished by the thinking of the more victorious theory.

It didn't help either, of course, that neo-Lamarckism had increasingly become an asylum for religious, antiquated, or nostalgic elements in the debates. That *the inheritance of acquired characteristics* should be misunderstood as the central core of Lamarckism is precisely what might be concluded when the theory is evaluated through Darwinian glasses. For Darwinism sees evolution as a product of the *differential reproduction* between individuals - and in this light it becomes fatal, of course, that Lamarck's theory poses an *instructivistic* concept of change.

Offspring (in Lamarckism) are instructed to perform better; they do not (as in Darwinism) perform better because they happened to have inherited winning properties.

Yet the linking of *change* exclusively to the hereditary mechanisms is a Darwinian bias - and seen from this bias, the *essence* of Lamarckism dwindles away to be caricaturistically replaced with Lamarck's (admittedly poor) understanding of how inter-generational heredity works. Seen with a Lamarckian bias, on the other hand, Darwinism is a narrow-minded exegesis of an absurdly *mechanical* philosophy, and it never achieves an explanation for what it ought to explain, i.e., how it is that the perfectly adapted decends from the less perfectly adapted. With our twenty-first-century eyes, Lamarck's error is not difficult to see, but do we yet see Darwin's?

In this article I have pointed to a diversity of epigenetic-heredity forms with inherently instructivist potentials - and yet, I basically agree with Darwinism that evolution can not be explained through instructivist *heredity*. The core of the Lamarckian theory, however, does not so much depend on his theory of heredity, for evolution, in his eyes, was a process that operated on species, not on individuals. Not mystical, but rather, *biological* "inner propensities" *at work* in a species was the real causal agent in Lamarck's scheme. I am inclined to think that Lamarck in this respect had discovered an important point, and that the Darwinian focus on hereditary mechanisms has tended to distort our understanding of evolution.

It is interesting in this connection that Baldwinian ideas are Lamarckian in the broad sense that "something learned" *influences evolution*, but they are not Lamarckian in the narrow sense that Darwinists have attributed to his name. Neither Baldwin, nor Waddington, believed in the direct inheritance of acquired properties in a genetic sense. But it seems that the justified rejection of Lamarckism in its narrow sense is confused with a never-justified rejection of Lamarckism in its broad sense. The implication of this blatant ambiguity is that a highly legitimate discussion of the eventual *influence of the organism upon evolution* is relegated to a dim no-man's-land. Susan Oyama (2003, 172) observed,

> Once Lamarck was firmly identified with the inheritance of acquired characters, and once the inheritance of acquired characters was set in place as the defining contrast to Darwinian natural selection, all sorts of other things followed. Whether Lamarck's heresy was ruled out of bounds altogether… or safely confined to the "transmission of culture," anyone wishing to explore the evolutionary roles of organismic activity, phenotypic plasticity in general, or learning in particular was obliged to engage in some theoretical acrobatics to do so. These might involve opening up a separate informational "channel" relying on hidden genetic variation, or hoping for fortunate mutations, but there seemed to be a need for fancy footwork to avoid the dreaded charge of Lamarckism.

Lamarck believed that evolution was not just a process of change, but also a process of progression. He even suggested a new term, *biology*, as a designation for the study of this phenomenon of perfection that characterized the two kingdoms of animals and plants in contrast with the kingdom of minerals. And thus his idea of the *inner feeling* was needed as a means to justify *la marche de la nature* in this sense - i.e., as a progression (Burkhardt 1977).

The twentieth century's landmark discoveries in thermodynamics and complexity research imply that we no longer need explanations *à la* mysterious subtle fluids in order to explain evolution as a directional process. The modern scientific version of subtle fluids is called *self-organization* and is generally considered quite legitimate (although, as we saw earlier in this article, the notion of self-organization implies some rather heavy philosophical or ontological problems). If in place of *inner feelings* we put *the processes of self-organization* at work in a species, the Lamarckian scheme does, in fact, approach the most modern conceptions of the ways of nature.

Compared to this, Darwinians generally are obstinately opposed to the conception of organic evolution as obeying a deeper "directedness" of *any* sort. For modern Darwinists, the flow of *chance mutations* coupled to *competition among conspecific organisms* is all we need to explain not only the multiple forms of life on Earth, but also the superordinate ecological and behavioral patterns that have appeared among these entities. And one may be allowed to suspect that the popularity of Darwinian explanations does not suffer damage by being so close an analogue to the dominating "economic realities" of Western societies. The idea that an "invisible hand" behind the back of the endlessly *competing* creatures has - all by itself - assured a healthy evolution of nature, has shown itself to possess an overwhelming appeal to the modern mind.

In this article, I have suggested that the agency of organisms has an experience-like component, and I have sketched evolution as a perpetual increase in semiotic freedom produced through the semiogenic interactions of organisms. To call this *perfectioning* (*modus* Lamarck) is, of course, to apply a very anthropocentric perspective. But it feels hard - and this is no superficial feeling - not to think that the string quartets of Beethoven or the songs of John Lennon surpass the cries of macaque monkeys, or that the songs of birds are more exciting than courtship trembling in the water mite. The fact that creatures and interactive patterns expressing high levels of semiotic freedom make stronger appeal to our sensitivities than do the more law-based activities of simpler animals may have an anchoring in the natural history of human origins (further on this in Hoffmeyer 2008b). Here it will be adequate to note that this propensity apparently brings us into harmony with the internal dynamic course of the universe - which should not surprise us too much, since the universe has itself created us.

Note

[1] One might be tempted to call such people *clairvoyant*. And while literally this is of course rubbish, it may hit quite well into the heart of the superstition. For blindsight illustrates what clever people have always known - i.e., that undreamt of resources may be found outside of consciousness's little enlightened room. Or, as Pascal usually gets the honor of saying that *the heart has its reasons that reason doesn't know*.

[2] The term *Umwelt* can be traced back to a Danish poet, Jens Baggesen, who lived in Kiel (which is now part of Germany, but still belonged to Denmark in Baggesen's time). Baggesen wrote in German and translated the Danish term *omverden* (surroundings) to German as *Umwelt*, around the year 1800 (Albertsen 1990).

[3] Stjernfelt has recently returned to an in-depth analysis of these questions, with particular emphasis on the connection between Uexküll's, Husserl's and Peirce's positions (Stjernfelt 2007: see also Bains 2001).

[4] In this computer age of ours, the term *virtual reality* may perhaps express Uexküll's fundamental idea better than the slightly awkward term *Umwelt.*

[5] And while animals are *absorbed in* their virtual realities, it is human fate to see through the illusion. The "gift" of speech implied that humans could not escape comparing their individual experiences with those of each other, and thus drawing the logical conclusion: there exists a shared world, a *reality*, which is neither wholly another's, nor mine. Thus, whereas the Umwelt comes to us *for free* (in that experientially, we *start from there*), the notion of a mind-independent reality per se, was from the beginning an intellectual achievement. That we now, finally, have come to understand that this reality, too, is itself (at least partially) a construction, does not make it any less real. (This discussion is found in detail in Hoffmeyer 1996b, chapter 8).

[6] Unfortunately, as Stjernfelt (2007, 228) observes, Uexküll has a tendency to fall prey to "a widespread German temptation to naturalize this constitutive subjectivism" with the consequence that "physical laws of nature, for instance, become mere extrapolations and abstractions in the specific human Umwelt." However, as Stjernfelt himself, points out, the acceptance of a naturalized subjectivism, as Uexküll develops it, is not reconcilable with constitutive subjectivism at any rate. (Nor need we follow Uexküll - or any other thinker - in *all* of his conclusions, in order to use the conceptual tools that he developed. Were such a rule required, science could hardly progress at all!)

[7] See the bladderwort system - analyzed by Ulanowicz (1997) that exhibits this same type of causality. Kant already, with some alarm, noted this kind of causality (Stjenrfelt 1999, 2007).

[8] The bizarre finding that in Siamese twin salamanders - i.e., salamanders that have developed two independent bodies apart from a shared stomach - each head competes for food intake, although the food will end, anyway, in the shared stomach, illustrates the necessity for a kind of holistic marker, the absence of which, of course, is the reason why this pointless competition takes place in the poor creature (Hoffmeyer 2006). My suggestion is that the German embryologist Hans Spemann has told that the wonder he once felt toward this little creature was the reason why he was originally spurred into a lifelong carrier in embryology (mentioned in Hamburger 1988).

[9] Uexküll did not himself say anything about the subjective and experiential aspect. In this regard he is, as Stjernfelt (in personal communication) has said, a "methodological behaviorist."

[10] As Don Favareau (in a personal communication) comments, this leaves the scientists in the same position as Zeno of Elea (of the fifth century BC) who could not understand how an arrow can ever be in motion, since at each discrete time interval it must be located in a single place!

[11] Zeno again! Here, the well-known Achilles paradox

[12] Myrdene Anderson hints that Hutchinson may have been acquainted with Uexkull's work and tells us that when Hutchinson was once asked, late in his life in 1991, to indicate "the singular puzzle left us at the end of the twentieth century," he spontaneously replied, "Insides and outsides" (Anderson 1998). And this is of course a basic semiotic theme.

[13] This example, by the way, also illustrates the danger or insufficiency of the Uexküllian concept about life as a perfect symphony!

[14] An alternative and perhaps equally likely explanation might be that these thirty-five basic animal architectures simply were the "lucky ones" that came in for the share before all others, effectively blocking the way for newcomers (Gould 1989).

[15] But even a bacterium is a very complex physico-chemical system that is underdetermined by its internal parameters in the sense that its contextual situatedness cannot fully account for cellular controls.

[16] We do not claim complete knowledge of the literature, of course, but the Nobel laureate and French molecular biologist François Jacob's statement that "evolution depends on setting up new systems of communication" (Jacob 1974, 308) is the closest case known to us.

[17] In the original Danish edition of this book I said this, more succinctly I suppose, by using the old expression: it is time to call a spade for a spade. But apparently this, in the US context, might be read with racist connotations that are absent in the Danish context and were, of course, not intended.

[18] Heterotroph organisms, like animals, cannot make organic compounds from inorganic compounds and therefore have to procure such organic compounds (e.g., other organisms) by eating them. This is contrary, of course, to the ways of autotroph organisms, such as plants that survive by the photosynthetic utilization of light - or bacteria that get energy by degrading the energy-rich inorganic compounds they uptake.

[19] Sebeok's point in presenting this example is a little more sophisticated than we have felt necessary to show here. For, interestingly enough, this "wedding gift" varies quite a lot from species to species, so that in some species of *empididae* there are no such gifts at all (and there is thus a corresponding risk for the male of succumbing to the cannibalistic propensity of the female), whereas rituals amongst other species form a graded series wherein the insect steadily decreases in size (and hence in food value) while the balloon that the flies construct around the gift increases commensurably in complexity. Finally a stage is reached in evolution where the female receives only the empty balloon. Sebeok (1979, 19) says that at this stage, "from a strictly synchronic point of view, the link between a representamen and the object for which it stands has now become 'arbitrary,' and . . . thus (as well as in other familiar ways) the sign meets every viable definition of a symbol." This succession of evolutionary steps is, in itself, a splendid illustration of evolution's tendency to develop higher and yet still higher levels of semiotic freedom.

[20] Alternately, there are dung beetles that forage by reading the polarization patterns of moonlight (*Nature* 424, 33).

[21] *Developmental constraints* refer to the limitations that the developmental process puts on the evolutionary construction of phenotypes. One might, for instance, think that it would be simpler for horses to develop hoofs directly, but instead the horse embryo develops through a stage where the embryonic limbs have five digits. The likely explanation for this is that the internal logic of the developmental schemes in tetrapods makes it impossible to skip the five-digit stage. Evolution is thus constrained by structural bindings caused by the historical process whereby the developmental schemes were first established. It is probably for the same reason that no tetrapods have wings although such a feature might well be advantageous in some species.

[22] Meaning here, measured over a wide range of genetic backgrounds.

[23] As pointed out by Terrence Deacon (lecture at Copenhagen University May 29, 2002), *genetic assimilation* and the Baldwin effect are in fact describing opposite events. The Baldwin effect consists, as we shall see, in the *masking* of genetic weaknesses by the help of social adaptations that *compensate* for the potentially lowered fitness these weaknesses have caused. Genetic assimilation, on the contrary, depends on a *de-masking* whereby a "weak" gene suddenly becomes "visible" to selection through the creation of an extreme situation (see further in Wiles et al. 2005).

[24] Parts of the genome that are not functional under prevailing conditions undergo much faster changes than do functional parts of the genome. As observed by Kalevi Kull, temporary adaptations lead to a changed use of the genomic resources so that formerly functional areas of the genome now, under the new adaptation, may become nonfunctional and thus experience a fast accumulation of mutations. This might, in turn, contribute to a blockage for an eventual return to the earlier adaptive strategy. This model, that Kull called "evolution via the forgetting of the unused" is, in fact, a model for nonselective adaptation (Kull 2000; Hoffmeyer and Kull 2003).

[25] A special, but by no means exhaustive, case of semiotic partitioning is the specific mate-recognition system as studied by Hugh Paterson (Kull 1992; 1999b; Paterson 1993).

[26] A largely identical theory was suggested the very same year by the British psychologist Conwy Lloyd Morgan, but to his historical disadvantage this fact was overlooked by Simpson, who ascribed the mechanism, or effect, to Baldwin alone.

[27] The use of the word *adaptation* here (instead of *adaptive behavior*) is nearly incomprehensible from a neo-Darwinian perspective, where an adaptation is, by definition,"the result of selection" (Depew 2003).

[28] Homozygote persons in this case have a mutant gene for the beta-chain on both of their chromosomes, contrary to heterozygotes that carry a mutation on only one of the two homologue chromosomes.

[29] Unicellular organisms who can move themselves (e.g., using flagella) may not always be able to distinguish between the moving of their own bodies and the changes or movements in their surrounding. In that respect, Sheets-Johnston's case may be just slightly overstated. However, the principal meaning of her statement is clearly correct.

[30] One might just as rightly (and wrongly) conflate alchemy with Newtonism, for Newton spent the last thirty years of his life doing alchemical studies in his search for the deeper causes behind the mathematical connections he had discovered.

[31] Our modern parallel to "subtle fluids" would be the (still far too common) misconceptions of "gay genes" or "genes for morally decent behavior." Here too, we are concerned with speculative entities that none has ever seen nor measured directly, and yet the existence of which is accepted by many researchers because they might explain human personality traits without any need for psychosocial theories (which are looked upon with skepticism).

Literature

Alberch Pere, 1982. “Developmental Constraints in Evolutionary Processes”. Bonner, J. T. (ed.): Evolution and development. Berlin: Springer. 313-332.

Albertsen Leif Ludwig, 1990. “Hvor Kommer Ordet Omverden fra?” OMverden 1, 39.

Anderson Myrdene, 1998. “Apoptosis, the eradication of old ideas, and the persistence of weeds”. Semiotica 120, 231-241.

Anderson Myrdene, et al., 1984. “A Semiotic Perspective on the Sciences: Steps Toward a New Paradigm”. Semiotica 52, 7-47.

Bains Paul, 2001. “Umwelten”. Semiotica 134, 137-166.

Baldwin James Mark (1896). “A New Factor in Evolution”. The American Naturalist 30, 441-451.

Baldwin James Mark, 1902. Development and Evolution. New York: Macmillan.

Bateson Gregory, 1963. “The Role of Somatic Change in Evolution”. Evolution 17, Reprinted in Bateson 1972, 346-363.

Bateson Gregory, 1979. Mind and Nature. A Necessary Unity. New York: Bentam Books.

Brown James Robert, 2001. Who Rules in Science. An Opinionated Guide to the Wars. Cambridge, MA: Harvard University Press.

Bruin Jan and Marcel Dicke, 2001. “Chemical Information Transfer between wounde and unwounded Plants: Backing up the Future”. Biochemical Systematics and Ecology 29, 1103-1113.

Burkhardt R.D., 1977. The Spirit of System: Lamarck and Evolutionary Biology. Boston: Harvard University Press.

Buss Leo, 1987. The Evolution of Individuality. Princeton: Princeton University Press.

Chandler Jerry and Gertrudis van de Vijver, 2000. Closure. Emergent Organizations and Their Dynamics. New York: New York Academy of Science.

Collier John, 2000. “Autonomy and Process Closure as the Basis for Functionality”. Chandler, J. and G. v. d. Vijver (eds.): Closure. Emergent Organizations and Their Dynamics. New York: New York Academy of Science. 280-290.

Cooper Barry, 1981. Michel Foucault. An Introduction to his thoughts. New York: Edwin Mellan.

Deacon Terrence, 1997. The Symbolic Species. New York: Norton.

Deacon Terrence, 2003. “Multilevel Selection in a Complex Adaptive System: The Problem of Language Origins”. Weber, B. and D. Depew (eds.): Evolution and Learning. The Baldwin Efect Reconsidered. Cambridge, MA: MIT Press. 81-106.

Dennett Daniel, 1995. Darwin’s Dangerous Idea. New York: Simon and Schuster.

Depew David, 2003. “Baldwin and his Many Effects”. Weber, B. and D. Depew (eds.): Evolution and Learning. The Baldwin Efect Reconsidered. Cambridge, MA: MIT Press. 3-31.

Dewey John, 1948. Reconstruction in Philosophy. Enlarged edition with a new forty page introduction by the author. Boston: Beacon Press.

Einstein Albert and Leopold Infeld, 1938. The Evolution of Physics. New York: Simon and Schuster.

Emmeche Claus, 1994. The Garden in the Machine. The Emerging Science of Artificial Life. Princeton, N.J.: Princeton University Press.

Favareau Donald, 2002. “Constructing Representema: on the Neurosemiotics of Self and Vision”. SEED 2, 3-24.

Favareau Donald, 2007. “The Evolutionary History of Biosemiotics”. Barbieri, M. (ed.): Introduction to Biosemiotics. Dordrecht: Springer. 1- 67.

Foucault Michel, 1970. The Order of Things. An Archaeology of the Human Sciences. London: Tavistock.

Gould Stephen J., 1989. Wonderful Life: The Burgess Shale and the Nature of History. New York: Norton.

Haken Hermann, 1984. The Science of Structure: Synergetics. New York: Van Nostrand Reinhold.

Hamburger Jean, 1988. The Heritage of Experimental Embryology. Oxford: Oxford University Press.

Hediger Heini, 1974. “Communication Between Man and Animal”. Image Roche 62, 27-40.

Hinton G. E. and S. J. Nowlan, 1996 (1987). “How Learning Can Guide Evolution”. Belew, R. and M. Mitchell (eds.): Adaptive Individuals in Evolving Populations: Models and Algorithms. Reading: Addison-Wesley. 447-453.

Hoffmeyer Jesper, 1992. “Some Semiotic Aspects of the Psycho-Physical Relation: The Endo-Exosemiotic Boundary”. Sebeok, T. A. and J. Umiker-Sebeok (eds.): Biosemiotics: The Semiotic Web 1991. Berlin: Mouton de Gruyter. 101-123.

Hoffmeyer Jesper, Year. “The Swarming Body”, Rauch, I. and G. Carr, 5th Congress of The International Association for Semiotic Studies, Mouton Gruyter, 937-940.

Hoffmeyer Jesper, Year. “The Global Semiosphere”, Rauch, I. and G. Carr, 5th Congress of The International Association for Semiotic Studies, Berlin, Mouton de Gruyter, 933-936.

Hoffmeyer Jesper, 1996. Signs of Meaning in the Universe. Bloomington, IN: Indiana University Press.

Hoffmeyer Jesper. “Evolutionary Intentionality”, Pessa, E., et al. (eds.), Third European Conference on Systems Science, Edzioni Kappa, 699-703.

Hoffmeyer Jesper, 1997. “Biosemiotics: Towards a New Synthesis in Biology”. European Journal for Semiotic Studies 9, 355-376.

Hoffmeyer Jesper, 2001. “Seeing Virtuality in Nature”. Semiotica. Special Issue: Jakob von Uexküll: a Paradigm for Biology and Semiotics (Kalevi Kull ed.) 134, 381-398.

Hoffmeyer Jesper, 2006. “Genes. Development and Semiosis”. Neumann-Held, E. M. and C. Rehmann-Sutter (eds.): Genes in Development. Rereading the Molecular Paradigm. Durham, London: Duke University Press. 152-174.

Hoffmeyer Jesper, 2008. "From Thing to Relation". Hoffmeyer, J. (ed.): A Legacy for Living Systems: Gregory Bateson as Precursor to Biosemiotics. Dordrecht: Springer. 27-44.

Hoffmeyer Jesper, 2008. Biosemiotics. An Examination into the Signs of Life and the Life of Signs. Scranton and London: University of Scranton Press.

Hoffmeyer Jesper and Kalevi Kull, 2003. "Baldwin and Biosemiotics: What Intelligence is for". Weber, B. and D. Depew (ed^eds): Evolution and Learning. The Baldwin Effect Reconsidered. Cambridge, MA: MIT Press. 253 -272.

Holley Anthony J., 1993. "Do Brown Hares Signal to Foxes?" Ethology 94, 21-30.

Hutchinson G. Evelyn, 1957. "Concluding Remarks". Cold Spring Harbor Symposion on Quantitative Biology 22, 415-427.

Jacob Francois, 1974. The Logic of Living Systems: A History of Heredity. London: Allen Lane.

Johnstone Rufus A., 1997. "The Evolution of Animal Signals". Krebs, J. R. and N. B. Davies (eds.): Behavioural Ecology. An Evolutionary Approach. Oxford: Blackwell. 155-178.

Juarrero Alicia, 1999. Dynamics in Action. Intentional Behavior as a Complex System. Cambridge Massachusetts: A Bradford Book. MIT Press.

Kauffman Stuart, 1993. Origins of Order: Self-Organization and Selection in Evolution. New York/Oxford: Oxford University Press.

Kelso J. A. Scott, 1995. Dynamic Patterns. The Self-Organization of Brain and Behavior. Cambridge, Mass.: A Bradford Book, MIT Press.

Kull Kalevi, 1992. "Evolution and Semiotics". Sebeok, T. and J. Umiker-Sebeok (ed^eds): Biosemiotics: The Semiotic Web 1991. Berlin: Mouton de Gruyter. 211-233.

Kull Kalevi, 1999. "Outlines for a Post-Darwinian Biology". Folia Baeriana 7, 129-42.

Kull Kalevi, 1999. "Umwelt and Evolution: From Uexküll to Post-Darwinism". Taborsky, E. (ed.): Semiosis. Evolution. Energy: Towards a Reconceptualization of the Sign. Aachen: Shaker Verlag. 53-70.

Kull Kalevi, 2000. "Organisms Can Be Proud to Have Been Their Own Designers". Cybernetics and Human Knowing 7, 45-55.

Langer Susanne, 1967-1982. Mind: An Essay on Human Feeling, vol. 1-3. Baltimore: Johns Hopkins University Press.

Longa Victor, 2006. "A Misconception about the Baldwin Effecy: Implications for Language Evolution". Folia Linguistica 40, 305-318.

Margulis Lynn and Dorion Sagan, 2003. Acquiring Genomes. A Theory of the Origins of Species. New York: Basic Books.

Matsuno Koichiro, 1989. Protobiology: Physical Basis of Biology. Boca Raton, FL: CRC Press.

Matsuno Koichiro, 1996. "Internalist Stance and the Physics of Information". Biosystems 38, 111-118.

Matsuno Koichiro and Stanley Salthe, 1995. "Global Idealism/Local Materialism". Biology and Philosophy 10, 309-337.

McFarland David, 1987. The Oxford Companion to Animal Behaviour. Oxford: Oxford University Press.

McShea Daniel W., 1991. "Complexity and Evolution: What Everybody Knows". Biology and Philosophy 6, 303-321.

Merleau-Ponty Maurice, 1995 (1968). La Nature. Notes Cours du Collège de France. Paris: Editions du Seuil.

Merleau-Ponty Maurice, 2002 (1945). Phenomenology of Perception, Transl. by Colin Smith from Phénoménologie de la Perception. London: Routledge.

Oyama Susan, 2003. "On Having a Hammer". Weber, B. and D. Depew (eds.): Evolution and Learning. The Baldwin Effect Reconsidered. Cambridge, MA: MIT Press. 169-191.

Paterson Hugh E. H., 1993. "Collected Writings". McEvey, S. F. (ed.): Evolution and the Recognition Concept of Species. Collected Writings. Baltimore: The Johns Hopkins University Press.

Popper Karl, 1990. A World of Propensities. Bristol: Thoemmes Antiquarian Books.

Port Robert and Timothy van Gelder, 1995. Mind as Motion: Explorations in the Dynamics of Cognition. Cambridge, MA: Bradford Books/MIT Press.

Robbins Bruce and Andrew Ross, 1996. "Mystery Science Theater". Journal

Rocha Luis, 2001. "Evolution with Material Symbol Systems". BioSystems. Special Issue (Guest edited by Luis Mateus Rocha): The Physics and Evolution of Symbols and Codes:Reflections on the Work of Howard Pattee. BioSystems 60, 95-121.

Searle John R., 1992. The Rediscovery of Mind. Cambridge, Massachusetts: MIT Press.

Sebeok Thomas A., 1977. How Animals Communicate. Bloomington/ London: Indiana University Press.

Sebeok Thomas A., 1963. "Communication in Animals and Men". Language 39, 448-466.

Sebeok Thomas A., 1972. Perspectives in Zoosemiotics. The Hague: Mouton.

Sebeok Thomas A., 1979. The Sign & Its Masters. University of Texas Press.

Sebeok Thomas A., 2001. The Swiss Pioneer in Nonverbal Communication Studies Heini Hediger (1908-1992). New York: Legas.

Sebeok Thomas A. and Jean Umiker-Sebeok, 1980. Speaking of Apes: A Critical Anthology of Two-Way Communication with Man. New York: Plenum Books.

Sheets-Johnstone Maxine, 1998. "Consciousness: A Natural History". Journal of Consciousness Studies 5, 260-294.

Simpson George Gaylord, 1949. The Meaning of Evolution; A Study of the History of Life and its Significance for Man. New Haven, Conn: Yale University Press.

Stjernfelt Frederik, 1999. "Formal Ontology". Semiotica 127, 537-66.

Stjernfelt Frederik, 2001. “A Natural Symphony? To what Extent is Uexküll’s *Bedutungslehre* Actual for the Semiotics of Our Time?” Semiotica. Special Issue: Jakob von Uexküll: a Paradigm for Biology and Semiotics (Kalevi Kull ed.) 134, 79-102.

Stjernfelt Frederik, 2007. Diagrammatology. An Investigation on the Borderlines of Phenomenology, Ontology, and Semiotics. Dordrecht: Springer Verlag, Synthese Library.

Swenson Rod and M. T. Turvey, 1991. “Thermodynamic Reasons for Perception-Action Cycles”. Ecological Psychology 3, 317-348.

Uexküll Jakob von, 1973 (1928). Theoretische Biologie. Frankfurt: Suhrkamp.

Uexküll Jakob von, 1982 (1940). “The Theory of Meaning”. Semiotica 42, 25-87.

Ulanowicz Robert E., 1997. Ecology, the Ascendent Perspective. New York: Columbia University Press.

Van de Vijver Gertrudis, 1996. “Internalism versus Externalism: A Matter of Choice? (in Japanese)”. Contemporary Philosophy 24, 93-101.

Van de Vijver Gertrudis, et al. 1998. Evolutionary Systems. Biological and Epistemological Perspectives on Selection and Self-Organization. Dordrecht: Kluweer Academic Publishers.

Waddington Conrad H., 1956. “Genetic Assimilation of the Bithorax Phenotype”. Evolution 10, 1-13.

Waddington Conrad H., 1957. The Strategy of the Genes. London: Allen & Unwin.

Waddington Conrad H., 1968-72. Towards a Theoretical Biology, Vol. 1-4. Chicago: Aldine.

Wiles Janet, et al., 2005. “Transient Phenomena in Learning and Evolution: Genetic Assimilation and Genetic Redistribution”. Artificial Life 11, 1-13.

Yates Eugene F., 1987. Self-Organizing Systems: The Emergence of Order. New York: Plenum.

Yates Eugene F., 1998. “Biosphere as Semiosphere”. Semiotics in the Biosphere: Reviews and Rejoinder. Special issue of Semiotica 120, 439-453.

Zeki Semir, 1993. A Vision of the Brain. Oxford: Blackwell.

Zeki Semir, 1999. Inner Vision: An Exploration of Art and the brain. Oxford: Oxford University Press.