

Originally “Biosemiotics and Formal Ontology”, *Semiotica* 127 -1/4 1999, 537-66.

In its adapted version, ch. 9 of *Diagrammatology. An Investigation in Phenomenology, Ontology, and Semiotics*, Dordrecht 2007: Springer Verlag, 197-224.

Biosemiotics as material and formal ontology

“Therefore, if botany and zoology must perforce rest upon metaphysics, by all means let this metaphysics be recognized as an explicit branch of those sciences, and be treated in a thoroughgoing and scientific manner.” Peirce “On Science and Natural Classes”, 1902 (EPII, 116).

The notion of biosemiotics is no doubt so intriguing because it unites the foundational problems of no less than two sciences within its name. The first is, of course, biology. The concept of biosemiotics is coined by Ju. S.

Stepanović in 1971, and the idea is that biology must take seriously the amount of semiotic terminology used in it, seemingly impossible to reduce. Biology, even in its most recent Neo-neo-Darwinian brands, seems not to be able to get rid of a whole vocabulary taken from linguistics, semiotics, informatics, philosophy, logic, and related sciences of meaning. Thus, concepts more or less explicitly borrowed from these domains now fill the gap which was earlier filled by vitalist dreams of yet undiscovered physical forces and the like. All currents in biology – from vitalism proper with its exaggerated ontological commitments to strange, yet unknown forces, and to neo-Darwinist reductionism - each in their manner bear witness to the predicament so brilliantly predicted by the often overlooked masterpiece of 18th century theoretical biology, Kant’s “Kritik der teleologischen Urteilskraft”ⁱⁱ. Here, Kant predicts that no “Newton of the grass straw” will ever appear, because biology can not be reduced to mechanistic physics. Yet, on the other hand, no substantialist vitalism is deemed possible; the only means left to interpret biological phenomena is to understand them in analogy with the teleological principles also used in the appreciation of goal-oriented activities. The semiotic metaphors abundantly used by the biology of our day have often been noticedⁱⁱⁱ: “genetic information”, “messenger-RNA”, “DNA code” etc. pointing to the semiotic role of certain entities in a goal-oriented process and thus bearing witness to the indispensability of the teleological or intentional concepts even at the most tiny orders of

magnitude in biology. Now, the introduction of biosemiotics is an attempt to take this mass import of metaphors seriously without on the other hand falling prey to vitalist excesses. Such recurring expressions must be a sign that biology is basically a semiotic science and that it - pace Kant - will never get rid of its semiotic vocabulary. Thus, the basic idea of biosemiotics is to establish the sign as a primitive concept in biology, and something like a Bohrian complementarity seems to appear: no matter how thorough a purely biochemical description of biological processes might become, it seems it will still be lacking the intentional understanding conveyed by the semiotic concepts or metaphors - and, probably, vice versa, semiotics needs the biochemical underpinning before becoming real biosemiotics. The biosemiotic program remains, it must be admitted, still a mere program; until now it has not made significant contributions to the development of biology and there is even a considerable confusion as to the precise meaning of semiotic concepts when transferred to biology as well as to the amount of semiotic assumptions being carried with them.

The other science shaken in its foundations by biosemiotics is, no surprise, semiotics. In the substantial part of semiotics inspired by linguistics, the assumption is often made (tacitly, that is) that semiotics is a human science; the ability to produce, communicate and understand signs is in this tradition spontaneously seen as a human privilege. Thus, the claim of biosemiotics to be a candidate for a real science also threatens this type of foundation for semiotics. The biosemiotic project invariably involves the idea that a substantial part of the semiotic vocabulary may be meaningfully exported from semiotics proper to biological phenomena. Thus, the very idea of a biosemiotics tends to dissolve the borderline between natural and human sciences, to attack it from so to speak both sides. But if this attack should really prove successful, it will invariably entail deepgoing consequenses for the sciences on both sides of this borderline: biosemiotics as a science is not possible as a simple expansion of well-established semiotics onto a new field, on the contrary, it necessarily implies a foundational crisis for semiotics and a thorough discussion of the basic semiotic assumptions in a biological light.

It is well known that in semiotics as a whole, there is a very wide disagreement as to which domains do fall under the scope of semiotics, ranging from very restricted doctrines, admitting only conscious, completed acts of communications by human agents as semiotic phenomena, and to ultra-Peircian versions of pan-semiotics implying that any physical process in the universe falls under the reign of semiotics. It is less well-known that a subspecies of this vagueness - so fatal to semiotics' claims for being

recognized as a unified science - characterizes the attempts at founding a biosemiotics. One school simply identifies biology and semiotics on the basis of the strong intuition that the physical world (or, more properly, the simple physical world, apart from more complex phenomena as biology) in itself does not contain sign processes. This idea - first advocated by Th. Sebeok (e.g. 1991) and supported by many, for instance A.U. Igambardiev (1992), Floyd Merrell (1992, 1997), the actual Copenhagen biosemiotics school (Hoffmeyer, Emmeche) - is counterargued by various arguments, not only by a version of Peirceanism (cf. Peirce's claim from his absolute idealism period that matter is just inert mind and thus part of semiosis proper), but also by the idea that a continuity must prevail between simpler and more complex physics (e.g. John Deely (1992, p. 63). Thus, the foundational questions raised by biosemiotics in biology by the same token becomes a foundational question for semiotics: how far does semiotics extend?

This and the following three chapters investigates these issues and thus form an integration of my contributions to the Copenhagen School of biosemiotics since Jesper Hoffmeyer's pioneering effort took its beginnings around 1990^{iv}.

In this chapter, I shall try to trace the possible consequenses for both disciplines, semiotics and biology. Let us begin by investigating the basic antinomies of biology as laid out by Kant in his already mentioned basic doctrine on the possibility of theoretical biology, "Kritik der teleologischen Urteilskraft".

The basic antinomy of biology in Kant

This treatise takes as its object the realm of physics left out of Kant's critical demarcations of scientific, that is, mathematical and mechanistic, physics in the *Kritik der reinen Vernunft*. Here, the main idea was that scientifically understandable Nature was defined by *Gesetzmässigkeit*, by lawfulness. In his *Metaphysische Anfangsgründe der Naturwissenschaft*, this idea was taken further in the following claim: "I claim, however, that there is only as much *proper* science to be found in any special doctrine on nature as there is *mathematics* therein ...", and further "... a pure doctrine on nature about certain things in nature (doctrine on bodies and doctrine on minds) is only possible by means of mathematics ..."^v. The basic idea is thus to identify Nature's lawfulness with its ability to be studied by means of mathematical schemata uniting understanding and intuition. The central schema, to Kant, was numbers, so apt to be used in the understanding of mechanically caused

movement. But already here, Kant is very well aware of a whole series of aspects of spontaneously experienced Nature in the “*letzten Grenze der Dinge*” is left out of sight by the concentration on matter in movement, and he calls for these further realms of Nature to be studied by a continuation of the Copernican turn, by the mind’s further study of the utmost limits of itself. This is what he undertakes in the “*Kritik der teleologischen Urteilskraft*” where the very judgments we use in seeing Nature as endowed with purposes are investigated. Why do we spontaneously see “*Naturzwecke*”, natural purposes, in Nature? Purposiveness is wholly different from necessity, crucial to Kant’s definition of Nature. There is no reasons in the general concept of Nature (as lawful) to assume that nature’s objects may serve each other as purposes. Nevertheless, we do not stop assuming just that. But what we do when we ascribe purposes to Nature is using the faculties of mind in another way than in science, much closer to the way we use them in the appreciation of beauty and art, the object of the first part of the book immediately before the treatment of teleological judgment. This judgment is characterized by a central distinction, already widely argued in this first part of the book: the difference between determinative and reflective judgments, respectively. While the judgment used scientifically to decide whether a specific case follows a certain rule is *bestimmende*, that is, it results in explanation by means of a derivation from a principle, and thus constitutes the objectivity of the object in question - the judgment which is *reflektierende* lacks all these features. It does not proceed by means of explanation, but by mere analogy; it is not constitutive, but merely regulative; it does not prove anything but merely judges, and it has no principle of reason to rest its head upon but the very act of judging itself. These ideas are now elaborated throughout the critic of teleological judgment.

In the section “*Analytik der teleologischen Urteilskraft*”, Kant gradually approaches the question: first is treated the merely formal *Zweckmässigkeit*: We may ascribe purposes to geometry in so far as it is useful to us, just like rivers carrying fertile soils with them for trees to grow in may be ascribed purposes; these are, however, merely contingent purposes, dependent on an external telos. The crucial point is the existence of objects which are only possible as such in so far as defined by purposes: “That its form is not possible after mere natural laws, that is, such things which may not be known by us through understanding applied to objects of the senses; on the contrary that even the empirical knowledge about them, regarding their cause and effect, presupposes concepts of reason.”^{vi} The idea here is that in order to conceive of objects which may not be explained with

reference to understanding and its (in this case, mechanical) concepts only, these must be grasped by the non-empirical ideas of reason itself. If causes are perceived as being interlinked in chains, then such contingencies are to be thought of only as small causal circles on the chain, that is, as things being their own cause. Hence Kant's definition of the Idea of a natural purpose: "... an object exists as natural purpose, when it is cause and effect of itself."^{vii} This can be *thought* as an idea without contradiction, Kant maintains, but not *conceived* (*begriffen*). This circularity (the small causal circles) is a very important feature in Kant's tentative schematization of purposiveness. Another way of coining this Idea is now: "Dinge als Naturzwecke sind organisierte Wesen" (op.cit. p. 235) – things as natural purposes are organized beings. This entails that naturally purposeful objects must possess a certain spatio-temporal construction: the parts of such a thing must be possible only through their relation to the whole - and, conversely, the parts must actively connect themselves to this whole. Thus, the corresponding idea can be summed up as the Idea of the Whole which is necessary to pass judgment on any empirical organism, and it is very interesting to note that Kant sums up the determination of any part of a Whole by all other parts in the phrase that a Naturzweck is possible only as a "... organisiertes und sich selbst organisierendes Wesen" (op. cit. p. 237) – as an organized and self-organizing being. This is probably the very birth certificate of the metaphysics of self-organisation. It is important to keep in mind that Kant does not feel any vitalist temptation at supposing any organizing power or any autonomy on the part of the whole which may come into being only by this process of self-organization between its parts. When Kant talks about the "bildende Kraft" (so beloved and hypostatized by later romanticism and vitalism) in the formation of the Whole, it is thus nothing outside of this self-organisation of its parts. It is, he maintains, analogous to the arts - but without the artist. This implies an interesting consequence: even if we conceive of these organized beings by analogy to our own soul, these beings cannot be organized by means of any soul (if they were, an artist was added or the organized matter would already be there for the artist to collect). And it is thus not explainable - *erklärlich* - through the analogy with our art, Kant adds in an interesting remark, because we ourselves - including our own purposes - in this respect belongs to nature (we are so to speak an empirical part of the problem, not of the solution!).

This leads to Kant's final definition: an organized being is that in which all alternatingly is ends and means. This idea is extremely important as a formalization of the idea of teleology: the *Naturzwecke* do not imply that there exists given, stable ends for nature to pursue, on the contrary, they

are locally defined by causal cycles, in which every part interchangeably assumes the role of ends and means. Thus, there is no absolute end in this construal of nature's teleology; it analyzes teleology formally at the same time as it relativizes it with respect to substance. This definition, Kant affirms, lacks a constitutive concept of understanding - like the concept of movement for mechanics - and can thus not be mathematized and reach the status of a principle but must remain a mere "maxim" (op. cit. p. 237)^{viii}. Kant takes care to note that this maxime needs not be restricted to the beings - animals - which we spontaneously tend to judge as purposeful: "this concept now necessarily leads to the idea of the totality of nature as a system after purposive rules, an idea under which all mechanisms of nature must be subsumed after principles of reason."^{ix} The idea of natural purposes thus entails that there might exist a "plan" in nature rendering processes which we have all reasons to disgust purposeful for us. In this vision, teleology might embrace causality - and even aesthetics: "Also natural beauty, that is, its harmony with the free play of our epistemological faculties in the experience and judgment of its appearance can be seen in the way of objective purposivity of nature in its totality as system, in which man is a member."^x As is evident, these speculations entail that it is not implied in this maxime which size these *Naturzwecke* may possess: theories like Lovelock's "Gaia"-hypothesis belong to the same domain in so far it is not metaphysically decidable beforehand which size the self-organized system may possess. But no matter the size of organisms, an important consequence of Kant's doctrine is that their teleology is so to speak "secularized" in two ways: 1) it is *formal*, and 2) it is *local*. It is formal because self-organization does not ascribe any special, substantial goal for organisms to pursue – other than the sustainment of self-organisation. Thus teleology is merely a formal property in certain types of systems. This is why teleology is also *local* – it is to be found in certain systems when the causal chain form loops, as Kant metaphorically describes the cycles involved in self-organization – it is no overarching goal governing organisms from the outside. Teleology is a local, bottom-up, process only.

This Idea of *Naturzwecke* is now subjected to the Kantian discipline of dialectics which reveals an antinomy of judgment. The *bestimmende* judgment has no principle of itself, but acts according to a principle given from outside, guided by which it subsumes objects under concepts. In this way, it presupposes a schematism which exposes a concept in intuition (that is, makes it possible to list which beings in time and space fall under the concept). On the other hand, the *reflektierende* judgment must, lacking

appropriate concepts, serve as its own principle (what is meant by this seemingly strange idea is that judgment is in itself a purposeful use of the faculties of mind, so that reflective judgment amounts to finding processes in nature similar to its own purposeful judging procedure). These two opposed types of judgment, then, form the antinomy of judgment: 1) all material things and their forms must be judged according to mechanical laws 2) certain material beings can not be judged by mechanical laws only. (op.cit. p. 250). These two maximes obviously do not contain any contradiction, only if they are converted into assertions of constitution: *all material things can (can not, respectively) be constituted by mechanical laws.*

Of course, it is possible that in Nature *an sich*, these two relations between things do possess one and the same root, but we are not gifted to tell due to our finite mind, so we stand split between determination and reflection. And any idea of assuming the absolute antinomy between them derives only from our tendency to mistake the reflective judgment for a determination. Thus, Kant does not in any way doubt the existence of organized beings, what is at stake is the possibility of dealing with them scientifically in terms of mechanics. Even if they exist as a given thing in experience, natural purposes can not receive any concept. This implies that biology is evident in so far as the existence of organisms can not be doubted. On the other hand, biology will never rise to the heights of science, its attempts at doing so are beforehand delimited, all scientific explanations of organisms being bound to be mechanical. Following this line of argument, it corresponds very well to present-day reductionism in biology, trying to take all problems of phenotypical characters, organization, morphogenesis, behaviour, ecology, etc. back to the biochemistry of genetics. But the other side of the argument is that no matter how successful this reduction may prove, it will never be able to reduce or replace the teleological point of view necessary in order to understand the organism as such in the first place: no Newton of the straw of grass is ever going to appear.

Evidently, there is something deeply unsatisfactory in this conclusion which is why most biologists have hesitated at adopting it and cling to either full-blown reductionism or (today, the very few of them) to some brand of vitalism, subjecting themselves to the dangers of “transcendental illusion” and allowing for some Goethe-like intuitive idea without any schematization (some kind of *élan vital*, *entelechy*, *Lebenskraft*, or the like). It seems obvious that the author of the “Kritik der teleologischen Urteilskraft” has felt the same uneasiness. In the strange heap of posthumous writings, the famous *Opus postumum*, he returns over and over again to the question; never,

however, to allow for a substantialist vitalism which is precluded by the critical consciousness about the dangers of the transcendental illusion. Instead, he tries to soften up the question by philosophical means. Here, he tries to establish an *Übergang* from metaphysics to physics as he awkwardly puts it, that is, from the metaphysical constraints on mechanical physics and to physics in its empirical totality, including the organised beings of biology. Pure mechanics leaves physics as a whole unorganised, and this organisation is sought established by means of “mediating concepts”. Among them is the “bildende Kraft” which is not conceived of in a vitalist substantialist manner, but rather a notion referring to the means by which matter manages to self-organise. It thus comprehends not only biological organisation, but macrophysic solid matter physics as well (the “texture of fibers, laminae and blocks, which is formed by crystallising minerals” (Kant 1993, p. 35). Here, he adds an important argument to the critic of judgment: “Because man is conscious of himself as a self-moving machine, without being able to further understand such a possibility, he can, and is entitled to, introduce a priori organic-moving forces of bodies into the classification of bodies in general” (op. cit. p. 66) - and thus to distinguish mere mechanical bodies from self-propelled organic bodies. This argument is akin, in fact, to present-day cognitive semantics: it is because we ourselves are natural bodies that we are able spontaneously to understand the biological aspect of physics. It is probably here we shall find the explanation of the idea that reflective judgment takes itself as its principle: this is to say that the very teleological orientation of judging makes it possible for judgments to find judgment-like processes in nature - still without being able to further understand it.

To sum up Kant’s masterful achievements in these early sketches of a theoretical biology: biology is trapped between, one the one hand, a mechanist physics, being able to explain things only in causal terms mathematically formalized in the differential calculus, and, on the other hand, the spontaneous recognition by the judging body of other judging bodies in the physical world. The scientific entry to this experience is forever banned, but it may be possible to integrate it into philosophy by new “mediate concepts”.

The relevance of Kant’s musings for biosemiotics ought to be evident. The very reason for the coming into being of biosemiotics is the apparent indispensability of semiotic, teleological concepts in the would-be mechanist biology of our day. It immediately implies that biosemiotics is not, and can never be, a science in Kant’s mechanist, causal use of the word. Instead, biosemiotics must be seen as a refined attempt at formulating the “mediate concepts” of the *Opus Postumum*. In fact, Kant already anticipates

biosemiotics in so far as he, in the idea of the reflective judgment's taking itself as principle, articulates the idea that we - because we are judging bodies - that is, biosemiotic beings - are able to see other biosemiotic beings and formulate the Idea of self-organised *Naturzwecke* to understand them^{xi}. The teaching of Kant's theoretical biology for biosemiotics will then be: biosemiotics can never free itself from this formal, teleological root; its mediate concepts of sign, meaning, information, communication etc. will invariably express aspects of a teleological kernel - and thus stand in opposition to the attempts in Darwinism and Neo-Darwinism to expel all teleological concepts from biology^{xii}.

Various Neo-Kantians have sought to elaborate this third way between vitalism and reductionism. Ernst Cassirer who elaborated a brand of Kantian semiotics in his chef-d'œuvre *Philosophie der symbolischen Formen*, also left a - albeit little noticed - sketch of a philosophy of biology in a chapter in the last of the four volumes of his impressive *Das Erkenntnisproblem*. Even if this account is now more than half a century old and lies well before Crick and Watson's DNA breakthrough, it is still surprisingly fresh. Cassirer concludes his historiography of biological thought with the *Vitalismusstreit* and its consequences in the beginning of the century. As a Kantian, he opts for a third way and sees both the Darwinists' reductionist claims and vitalisms, like Hans Driesch's reference to a *Seele* or a *Psychoïd* in the living being, as aberrant developments. Instead, he makes a synthesis of the leading biologists of his time, especially his colleague in Hamburg, von Uexküll, Ungerer, and von Bertalanffy.^{xiii} Their "Organizismus", as he coins it, does not aim at neither mechanist reduction nor the accept of vitalist forces, but towards the recognition of a "nicht-stoffliche Ordnung" (209), a non-material order, in addition to the causal organization of matter. Thus, in this analysis, the holist character of Kant's analysis of the *Naturzweck* is pulled into the foreground. The notion of "Zweck", so Cassirer argues, tends to make us believe the parts in question possess an intention they do not; the concept of "Ordnung", "Form", "System", "Struktur" better satisfies Kant's analysis: "They substitute for the concept of purpose the concept of order and system, and they characterize life by attributing to it the property of a system."^{xiv}. This step, we could add, already lies as a possibility in Kant's ingenious analysis of the concept of ends in terms of causal circles, necessarily possessing a morphological organisation. In these passages, Cassirer in fact paves the way for an epistemology of a structuralist biology in so far as he sees the consequence of Uexküll's thought as the fact that "... es ein selbständige

Formproblem gibt, für das die Biologie eigentümliche Begriffe und Denkmittel auszubilden hat.” (209) – there is an autonomous *form problem* for which biology must build special concepts and means of thought. What is even more interesting is his fertile correction of Kant: when physics now long since has supplied Newton’s mechanics with other modes of thought, the narrow constraints of a Newtonian epistemology are no longer valid for physics where holist concept like that of “fields” now prevail; then why shouldn’t they do as well for biology? Cassirer thus points in the direction of the notion of “Form” as the Kantian “mediate concept” which will enlighten biological thought.

If we now measure the claims of biosemiotics against these epistemologists of biology, it is easy to see that it stages itself as a further investigator of these third-position “mediate concepts” of the Kantian tradition. A crucial question for biosemiotics, then, will be: what does the semiotic vocabulary add to the problem of form, of order, of *Naturzwecke*? What is won with the import of concepts like “sign”, “codes”, “semiosis”, “information”, “messenger”, “semiosphere”, and the like into the description^{XV} of biological form? One should here keep in mind René Thom’s cautious remark: “... when we speak of “information”, we should use the word “form”” (Thom 1975, 127).

It must immediately be added that the word “form” here plays several roles. First, one central role is the reference to the many different aspects of internal architectonic organization of biological beings, ranging from the structure of the cell and to multicellular organisms. Second, it refers to the global, stable structure - the organism - which results as the sum of the architectural building-stones just mentioned, kept stable by metabolism and the organism’s register of specific actions to avoid states too far from metabolic stability. This fact opens two ways of inquiry: first, what does the very concept of life as organized beings imply semiotically, that is, does an a priori analysis of the concept of life in itself entail semiotic phenomena? Second, the question of organized form is more general than living beings and hence connects biology to the cross-disciplinary question of emergence, the coming into being of “new properties” in sufficiently complex systems.

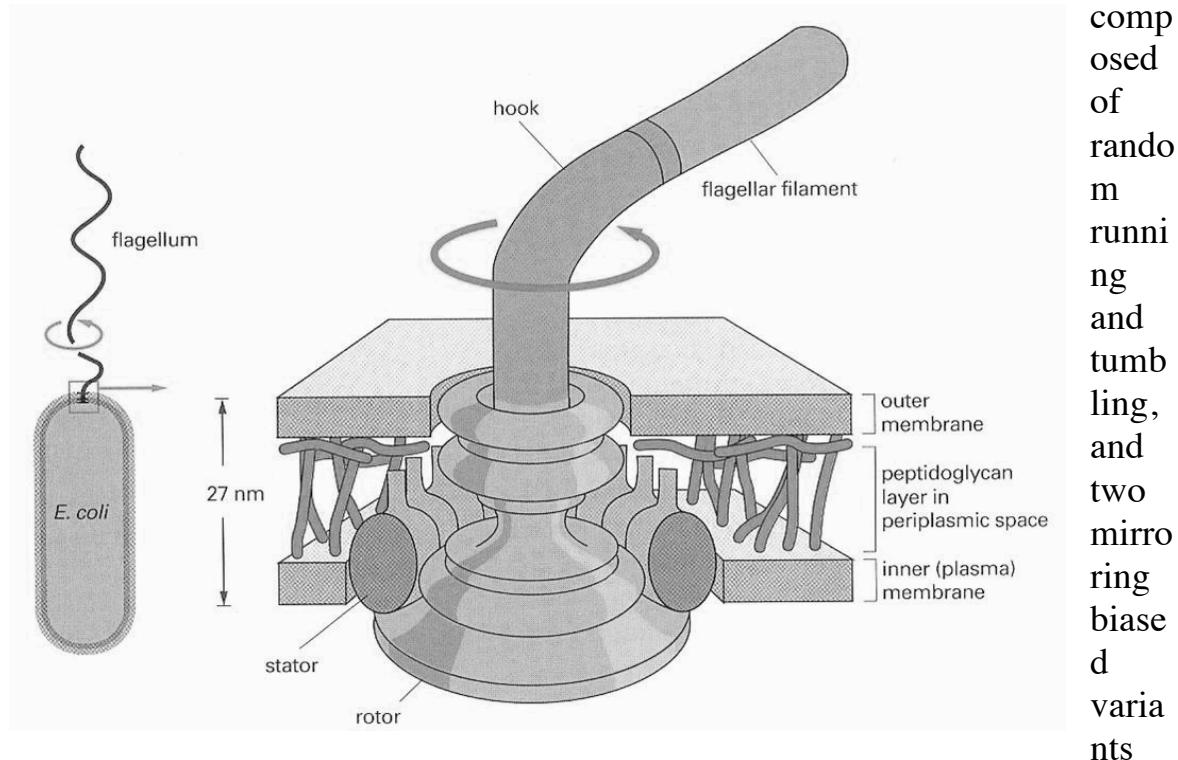
Categorical perception: bacterial chemotaxis as semiotic case

Let us take a concrete example as introduction to the investigation of semiotic a priori constraints on life. Since the classic paper by H.C. Berg, “A

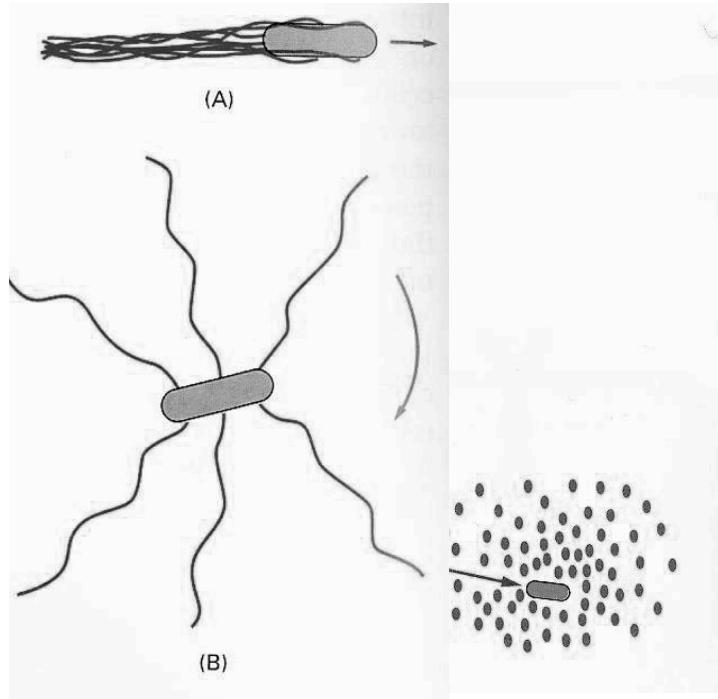
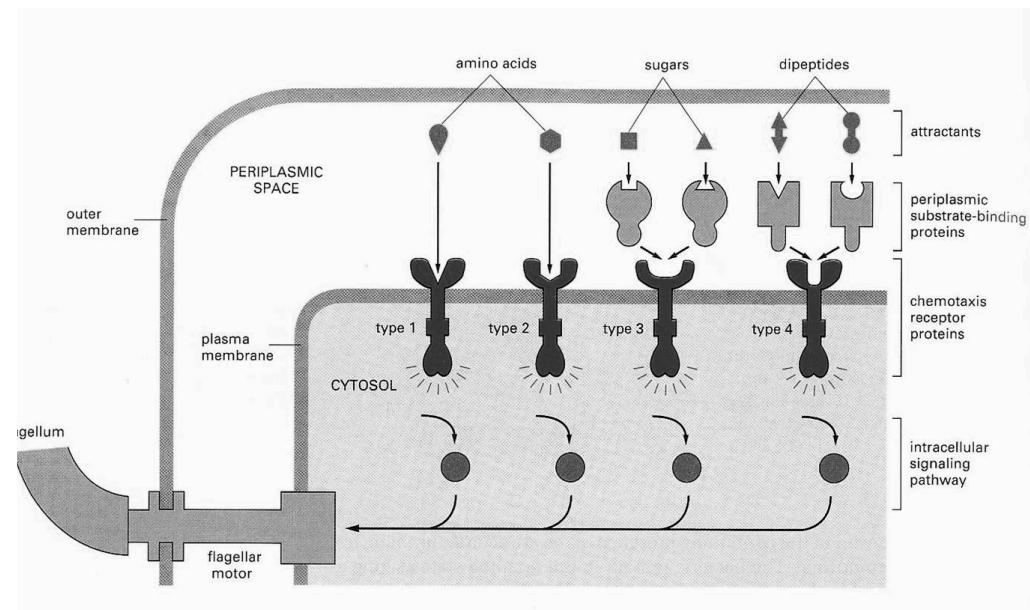
Physicist Looks at Bacterial Chemotaxis” it has been known that as simple an organism as E. Coli is able to process semiotic information from its environment and act accordingly: in the presence of a sugar gradient, it is able to swim “upstream” in the gradient and so approach a locality with higher nutrition concentration.^{xvi} How are the details in this process? The bacterium undertakes this goal-oriented behaviour due to a specific coupling between sensors – a primitive perception – and action, organized in what Berg calls “biased random walk” (see ill.)^{xvii}. The unicellular organism has 6 thin filaments protruding from its cell membrane, and in the absence of any stimuli, it simply wanders randomly around by changing between two characteristical movement patterns. One is performed by rotating the flagella counterclockwise. In that case, they form a bundle which pushes the cell forward along a curved path, a “run” of random duration with a mean length of 1 second. These runs interchange with “tumbles” with a mean value of 0.1 second where the flagella shift to clockwise rotation, making them work independently and hence moving the cell eratically around with small net displacement. The biased random walk now consists in the fact than in the presence of a chemical attractant, the runs happening to carry the cell closer to the attractant are extended, while runs in other directions are not. The sensation of the chemical attractant are performed temporally rather than spatially, because the cell moves too rapidly for concentration comparisons between its two ends to be possible. A chemical repellant in the environment gives rise to an analogous behavioral structure – now the biased random walk takes the cell away from the repellant. The bias saturates very quickly – within 0.2 seconds – which is what prevents the cell from continuing in a “false” direction, because a higher concentration of attractant will now be needed to repeat the bias. The reception system has three parts, one detecting repellants such as leucin, the other detecting sugars, the third oxygen and oxygen-like substances. The biochemical machinery for signal transduction and for flagella activation are rather well-understood, and the whole mechanism has long since become standard textbook material, cf. the illustrations reprinted here.^{xviii} These well-established empirical results, however, seem to await their proper semiotic interpretation.

As always, it is interesting to note the ubiquity of spontaneous semiotic vocabulary: “information-processing pathways”, “measurements of external concentration”, “sensory information”, “the cell cannot solve this problem”, “The cell sets the men run length at 1 second to provide ample head room for response”, “When watching such tracks evolve on a computer screen, one gets the impression of a bloodhound following a scent.”, etc. (all examples from Berg, 4-6). Our contention is that this terminology cannot be

mere verbiage but reflects core properties of the process investigated. What are those properties, then, in semiotic terms? The cell's behaviour forms a primitive, if full-fledged example of von Uexküll's functional circle (see ch. 10) connecting specific perception signs and action signs. Functional circle behaviour is thus no privilege for animals equipped with central nervous systems (CNS). Both types of signs involve categorization. First, the sensory receptors of the bacterium evidently are organized after categorization of certain biologically significant chemicals, while most chemicals that remain insignificant for the cell's metabolism and survival, are ignored. The self-preservation of metabolism and cell structure is hence the ultimate regulator which is supported by the perception-action cycles described. The categorization inherent in the very structure of the sensors are mirrored in the categorization of act types. Three act types are outlined: a null-act,



triggered by attractants and repellants, respectively. Moreover, a negative feed-back loop governed by quick satiation grants that the window of concentration shifts to which the cell is able to react



appropriately is large – it so to speak calibrates the sensory system so that it does not remain blinded by one perception and does not keep moving the cell forward on in one selected direction. This adaptation of the system grants that it works in a large scale of different attractor/repellor concentrations. These simple signals at stake in the cell's functional circle display an important property: at simple biological levels, the distinction between signs and perception vanish – that distinction is supposedly only relevant for higher CNS-based animals. Here, the signals are based on *categorical perception* – a perception which immediately categorizes the entity perceived and thus remains blind to internal differences within the category.

One further peculiarity deserves to be mentioned: the mechanism by which the cell identifies sugar, is partly identical to what goes on in human tastebuds. Sensation of sugar gradients must, of course, differ from the consumption of it – while the latter, of course, destroys the sugar molecule, the former merely reads an “active site” on the outside of the macromolecule. This has, however, huge semiotic implications, for this entails that E. Coli – exactly like us – may be fooled by artificial sweeteners bearing the same “active site” on their outer perimeter, even if being completely different chemicals (this is, of course, the secret behind such sweeteners, they are not sugars and hence do not enter the digestion process carrying the energy of carbohydrates). This implies that E. Coli may be *fooled*. We recall Umberto Eco's definition of semiotics as the study of all devices which may be used to lie. Bacteria may not lie, but a simpler process than lying (which presupposes two agents and the ability of being fooled) is, in fact, being fooled (presupposing, in turn, only one agent and an ambiguous environment). E. Coli has the ability to categorize a series of sugars – but, by the same token, the ability to categorize a series of irrelevant substances along with them. This is semiotically extremely important - semiotics seems to begin with this duplicity: On the one hand, the ability to recognize and categorize an object by a surface property only (due to the weak van der Waal-bonds and hydrogen bonds to the “active site”, in contrast to the strong covalent bonds holding the molecule together) facilitates perception economy and quick action adaptability. On the other hand, the economy involved in judging objects from their surface only has an unavoidable flip side: it involves the possibility of mistake, of being fooled by allowing impostors in your categorization. So in the perception-action circle of a bacterium, we find some of the minimum requirements for semiotic processes: the self-regulatory stability of a metabolism involving categorized signal and action involvement with the surroundings. An a priori

semiotic hypothesis is that these properties characterize semiotic processes as such and that the types of processes described here function as building-blocks in more sophisticated and complex semiotic phenomena, from intercellular communication in multicellular organisms and to complicated perception and communication in higher animals.^{xix} A long-range goal of biosemiotics will be to analyze all such types of sign processes in biology and discern the network mediate concepts of semiotics are necessary to characterize them, from the simplest to the more complex cases. In a certain sense, these constraints on life would constitute the material ontology of biology.

Semiotic A Priori constraints on life?

It has often been noted (e.g. de Loof & Broeck 1995) that no concise definition of the concept of life exists^{xx}. Most attempts at definitions end up as lists of properties required. An extreme opponent to this view, however, is the “strong” school in the “Artificial Life”-community, parallel to so-called “strong AI”. The idea here is that computer modelings of life may themselves be considered living because they instantiate certain formal characteristics of living beings: they reproduce, fight, develop and even form symbiosis- and ecological niche-like compromises between them (cf. Langton 1997). This trend is right in leaving the “carbon-centrism” of empirical biology behind and seeing life as a theoretical and purely formal question in its own right, but, on the other hand, an argument analogous to the AI case seems valid: merely formal calculi do not result in intelligence nor life like we usually understand them. Computer-based AI lacks qualia, genuine insight and the discussion of its limitations due to Gödel’s theorem is an ongoing and yet unsolved strife in AI studies (the same goes for the discussion of life, cf. Rosen 1989^{xxi}); computer-based AL lacks all the same properties (and in so far life comprises intelligent beings, AL must obey the same constraints) as well as the central biological property of metabolism. This calls for an a priori analysis of the concept of life and related concepts^{xxii} in order to determine the “mediate” concepts required for the study of the living. Taking the Austrian interpretation of the a priori, these mediating concepts will, simply, constitute the conceptual network of regional ontology of biology. Recurrent features in the various list definitions of life include the following:

Metabolism. Life is characterized by (at least in decisive phases of its being) the necessity to organize and sustain itself by means of a metabolism, during which low-entropy energy is consumed while the same energy is excreted in a higher entropic form. This rise in entropy makes possible a lowering of entropy in a smaller part of the energy used (so that, of course, the total entropy change is governed by the 2nd law of thermodynamics) which may consequently be used for the construction of the organism and its ordered patterns of behaviour. This implies that the organism somehow must be located in an environment permitting a relatively steady supply of highly organized (low entropy) energy in some form. Some marginal kinds of life (virus in its non-active phase) may display lack of metabolism, but we would not call virus living if not for its possibility for an active, self-replicating phase when coupled to the metabolism of more complicated host organisms. The same goes for simple animals (e.g., some shrimp species) able to stay completely metabolism-less during long, cold seasons: it must display metabolism in other phases of its existence, otherwise we would not call it living at all. Metabolism involves a negative feed-back coupling making stable its circular process, preventing it from going off in any of two directions – the speeding up which would destroy the organism viz. the slowing down which would starve it to death. □ Metabolism as a crucial feature in the concept of life is ripe with proto-semiotic categories. Already Kant's definition of the *Naturzwecke* as defined by organisms in which every part is interchangeably means and ends, implies the cyclical organisation of metabolism. **Life** and **death** are defined by the continuation versus the definitive ending of metabolism. A priori categories of **food** and **poison** must pertain to any metabolist being: food will be energy-bearing elements of the environments necessary to develop and sustain metabolism; poison will be elements of it which hinders metabolism to an extent such that the metabolism or parts of it are damaged. **Illness** will be an a priori notion for conditions implying a reduction in the stable possibilities of metabolism. **Excrements**, on the other hand, will be an a priori category for high-entropy energy in some form (faeces, urin, heat radiation etc.), leaving the organism. These simple semantic consequenses of metabolism yield, of course, an enormous amount of semiotic primitives when combined. The very concept of **intention** has its foundation here: the metabolism's cyclical structure implies that it includes a self-preserving “intention” in so far it is constituted by a structure of cyclical attractors for the metabolic system. A later part of the cycle may be seen as intended (in a teleological, not a psychological, sense of the word) by a former part of it, and the same goes for the external means (food, for instance) necessary to obtain the later phase

of the cycle. The very concept of **narration** finds its bases here - the possible dramas unfolding in cases of **crises** of lack of food, threats of poisoning, pollution by own excrements, etc., and the more or less happy **solution** of the crises forms the basis of narrative drama.

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Boundaries. Apart again from the limit case of virus, all life as we know it is spatially defined by membranes, conchs, shells, skins, shields, armour, layers etc. which delimit and shield the internal finely tuned homeostatic system of metabolism from the uncontrollable energy fluxes of the environment. This, of course, entails that the traffic across these boundaries are subjected to control so that a priori categories of **mouth** and **anus**, respectively, is a consequence, each of them being selective and equipped with some means for selection. Santa Fe theoretical biologist Stuart Kauffman - whose work we shall later return to - argues that the inside of a cell must necessarily be subcritical with respect to the formation of new chemical compounds, in opposition to the biosphere as a whole which must

be supercritical. The boundary of the organism introduces a topological distinction between spatial regions and thus implies semiotic basic categories like **proto-subject**, **inner/outer**, **here/there**.

Perception-Action As a sophisticated means of fulfilling the needs of metabolism is the possibility of perception and ensuing action. As soon as the metabolism acquires means of (ever so slightly) changing its relations to the environment, that is, it displays a variety of behavioral options facing different environment aspects, this will imply proto-perception (not necessarily with any psychological implications, of course). This use of the notion of “perception” is a generalization and does not necessarily include the presence of consciousness, qualia, map-like representation of the surroundings etc. It goes without saying that organisms in environments with a plethora of relevant energy would not need to develop organs of perception of any kind in order to locate food, but typically, the contingent changes in food supply makes some kind of perception add to the metabolism’s fitness. It is well-known that plants may orient leaves towards the sun, just like E. Coli will swim upstream in the gradient of nutrition. These phenomena are, of course, ripe with consequences of seemingly semiotic kind: the **feed-back** between the organism and its environment is tempting to interpret in semiotic **dialogue** notions: the organism **reads** some **sign** in the environment and **reacts** accordingly. Other species in the environment may now register the organism’s change of behaviour and in turn “decode” it as a “sign” to the extent that it has any consequence for their own metabolism.

This interdependence of the organism with its environment received its first semiotic interpretation in von Uexküll’s “theory of meaning”, but the interdependence of perception and action in Peirce’s pragmatism forms an important predecessor. We shall return to the details of Uexküll’s classic of biosemiotics in the next chapter; as we saw in the E. Coli example, the definition of an organism’s environment, *Umwelt*, on the basis of the “functional circle” connecting the organism with its environment via two classes of signs, perceptions (“Merkmale”) and actions (“Wirkmale”). The *Umwelt*, then, is the parts and aspects of surrounding world in so far it enters into cyclical interaction with the organism. The functional circle may be seen as an extension of the cyclical structure of the metabolism; it consists of those metabolic cycles which cannot be completed except for their active integration of some outer segment into the cycle. Thus, metabolism and functional circle form the bases of so-called “endosemiotics” and “exosemiotics”, respectively. In so far one accepts the semiotic vocabulary

in the description of these cycles, it must be added that the signs in question do not yet obey the distinction between simple signs and propositions. The organism's recording of the presence of an edible part of the surroundings might be translated as "food" or "this is food", interchangeably. An important aspect here is that the engagement of metabolism's perceptual parts in an *Umwelt* makes necessary the reduction in complexity of the possible "Merkmale". The organism excludes potential "Merkmale" not relevant for the metabolism, and among the perceived "Merkmale", it arranges a certain **granularity**^{xxiii}. The more simple the organism, the more simple and 'corny' will this granularity probably be, as a tendency. As discussed above, *E. coli* is unable to discriminate edible glucose from irrelevant saccharine - the two substances are categorized together due to a morphological similarity between the "active sites" on the macromolecules' outside as perceived by the bacteria. In general, granularity implies that a host of different, more and less cognate, "Merkmale" will give rise to the same type of chemical reaction in the metabolism; they will possess the same immediate signification for the organism and hence involve a primitive version of **categorization** or **categorical perception**.^{xxiv} The very notion of a sign seems to imply this much: a distinction between an immediate signification and a mediate signification - proto-forms of **meaning** versus **reference**, *Sinn* versus *Bedeutung*. The fact that sugar and saccharine tastes similarly to man or bacterium rests on their immediate resemblance due to the active site on the molecule (a particular atomic configuration on the periphery of these molecules) - but the nutrition value differs highly, that is, the "same" signification ('sweet' - the word is used here, of course, with no necessary assumption of the existence of sweetness qualia in the process) refers to different objects ('food'/'non-food'). This possibility for the metabolism's perception to be **fooled** or **surprised** thus seems to be basic for the category of sign. Seen from the point of view of efficiency, the metabolism must do with in an important sense of the word *small* signs (cf. the active sites' specific 3-D configuration as opposed to the whole of the macromolecule) in order to be categorical, general and hence efficient, the flip side of this being of course the possibility of **mistaking**. Seen from the point of view of form, the substance of the macromolecule as a whole is represented through (a small subset of its) form: the "active site". This "**smallness**" of the sign in comparison to its signification is very important for the necessity of the sign concept at all - if the sign was not "smaller" in this way, we would have no reason to use it as referring to a category (This is what Bateson (1979) refers to as "collateral energy", his

third criterion for what he called “mental process”). But what does this “smallness” consist in? One level is energy. The sugar molecule in the *E. coli* case is discriminated by means of the weak polarity on the outside of the macromolecule due to hydrogen bonds; energies far smaller than the energies released by the ensuing consumption of the macromolecule involving the breaking down of the ordinary, strong chemical covalent bonds between its parts. If it was not for this decisive energy level difference, we would not speak of signs^{XXV}. Another level is size and dimensionality; the “active site” on the macromolecule’s outside is less in size and dimensionality than the macromolecule as a whole. This implies a natural instantiation of the Aristotelian distinction between **form** (active site) and **matter** (molecule), the same form being able to subsume (and hence signify) several different matters^{XXVI}.

The first of these differences permits the sign to save energy on behalf of the organism: at a very low energy cost, it may perceive the possibility of obtaining energy to fulfill a phase of the metabolic cycle. This economy (measured on the background of the metabolism’s demands) is crucial to the primitive sign. The second of these differences permits the sign to erect categorical and hence general classes. In so far, any sign is underdetermined^{XXVII} which, as we noted, makes it at the same time efficient and fallible. These speculations immediately entail certain abilities on the side of the sign reader: it must be able to amplify the low-energy sign perception in order to let it result in (higher energy) action; it must possess stockpiled energy in order to do so; and it must be able to restore the perceptual organ quickly and with low energy cost in order to function in later metabolical cycles (the eye must not be destroyed by the light; the cell membrane not by the active site)^{XXVIII}. Between sign and reader must persist a weak, stable interaction of resonance type, while the reader must possess a high energy, comparatively unstable system able to amplify the form perceived in the sign and take one among a whole range of different action measures.

These deliberations show that even at this primitive level, the notion of virtuality or potentiality - Peircean real possibility - is crucial to the sign. The sign - the active site - releases a specific behaviour in the organism (f. inst. swimming up-gradient) which will result in one outcome among several possible outcomes (staying, fleeing). On a higher level, the reading of other active sites may result in other sets of specific behaviours. Thus, the meaning of one active site for the organism is embedded in a virtuality of other active sites leading to other specific meanings. The meaning of the

primitive sign, consequently, is only possible as one choice among a (maybe open-ended) set of alternative choices. Here, the linguistic idea of **paradigm** finds a primitive proto-version^{xxix}. As soon as signs become more complicated than at the molecular level, more possibilities within the interpretation of one sign come into being, and the immediate meaning of a sign will constitute a **schema** able to flexibly incorporate a range of different but cognate empirical instantiations of it.^{xxx} As soon as animals with CNS become able to distinguish species fellows, predators, preys, from perceived visual profiles etc., we must expect that such simple schemata complexify into action schemata involving several different slots to be filled in, forming simple **diagrams** for characteristical action sequences.

A simple organism - defined by a simple metabolism with few systematic stable variations - will typically possess an extremely simple *Umwelt* with few categories and large granularity while higher discrimination ability will require more complexity on the part of the organism and its behaviours. Similarly, the more complex the organism, the more complex the schemata it must embody, and, in turn, the more action possibilities the schemata must possess. This further separates meaning and reference, in so far as the schemata leading to a series of different possibilities of action must now to some extent contain representations of those actions with specific sign "slots" connecting the parts of each action series. Thus, a sign may "mean" a range of different schematic action possibilities, each equipped with further releasing signs to determine the choice between them. (The perception of a predator may "mean" escape, freezing, attack ...). We shall return to the more precise status of the "Umwelt" below.

In multicellular organisms with central nervous system, the integration of a whole set of cells in complicated, schematic perception-action cycles becomes possible, and it seems likely that it is only at this stage that a detailed inner representation of the environment – be it conscious or not – becomes available. That is, only at this level perception, as we usually understand it, involving such mappings of the surroundings, becomes possible. This implies a crucial consequence: that signs are much simpler and much more biologically widespread than full perception – this in contradistinction to the phenomenological idea of signs as derivative entities only, as compared to the primacy of perception. In higher animals, it is true, special, complex signs, like in animal communication or human language, may appear which take sets of possible perceptions as their objects – signs which for that reason presuppose full perception. Signs on this primitive

level transgress the distinction between sign and perception in higher animals. They might just as well be called primitive perceptions, but their simplicity makes it more apt to call them signs. Perception involving representation in the shape of environmental maps probably only appear in animals equipped with central nervous systems – and only in such mappings, a distinction between primary perceptions and secondary signs, signs in a more narrow sense, becomes possible. Here, signs in the narrow sense will refer to information-bearing entities foregrounded on the background of perceptual environmental maps. But perception, in turn, is possible only as a composite of simpler, biosemiotic signs which are hence primary both in complexity terms and in evolutionary terms.^{xxxii}

Inner architecture. The fact that life necessarily is articulated in “organized” beings is already implied in Kant’s definitions. In biology, the conception of the cell as a “protein bag” has long since given place to a charting of its complicated inner architecture with various organelles, the kernel including the genome, mitochondria, chloroplast etc. Already the boundary constitutes a sophisticated minimal architecture, and the flux of energy running through metabolism from outside to inside and back to outside necessitates a further minimum of internal organization, in so far the energy flow must be separated in its two characteristic high and low entropic components, respectively. The very process of this separation has in itself low entropic character and requires a spatial organization in contrast to the idea of a disorganized inside; such a structure would be unable to perform the low entropic teleological proto-action connected with life. This inner organization immediately implies the partwise articulation of metabolism tasks giving rise to organelles (in the cell) and organs (in multicellular organisms). Life is thus necessarily **modular**, seemingly more modular, the higher the complexity of the tasks involved is, implying the pertinence of specific types of **mereo-topology** for the study of life, making it possible to discern modular parts defined by inner boundaries etc. Metabolism, of course, is only controllable by means of the genome for this very reason: a specific gene must “code for” a specific type of reaction in a specific modular part of metabolism. Evolution makes possible the further differentiation, articulation and modularization of metabolism’s cycle which is then ripe with potential new categorizations and discriminations relevant for the single “organs” and their partial tasks. This modularity of life entails the possibility of the **modularity of signification**.

Intelligence. In its primitive form, intelligence is no doubt already implied by concepts like the just mentioned, metabolism, boundary, perception, inner architecture. In this view, the concept of intelligence must be completely discriminated from the concept of consciousness, this being probably a property in a much smaller class of biological beings equipped with central nervous system and highly developed cortex. In any place, it is impossible yet to tell whether primitive animals might possess some diffuse and marginal proto-consciousness, as has often been suggested^{xxxii}. It is probably an empirical question whether this be the case, and the question must be abandoned presently and left for possible future research. It is still a subject of much discussion whether high intelligence requires consciousness or whether all intelligent tasks could in principle be fulfilled by non-conscious apparatuses (cf. David Chalmers' much discussed book); in any case it seems reasonable to use the concept of intelligence in connection with metabolisms' way of coping with their *Umwelten*. The biosemiotic notions of sign, meaning etc. must for this reason be cleaned for assumptions of consciousness and must be defined only with reference to function and form. Still, the evident skills displayed by biological species at coping with their *Umwelt* makes the notion of a higher or lower degree of **intelligence** an a priori concept of biosemiotics.

Reproduction. In light of our Kantian exegesis, we remarked that metabolism is one crucial empirical process instantiating Kant's cyclical alternatingly-means-and-ends definition of *Naturzwecke*. Now reproduction will be another. But it is important here to underline that it ontologically depends on the first. We can imagine metabolic life without the ability to reproduce, but not reproducing life with no metabolism. Reproduction is hardly a necessary feature in the definition of life; in principle, one could imagine an eternally living cell in an optimal environment supplying all chemicals needed, a cell which consequently would not have to perform mitosis or any other reproduction in order to survive^{xxxiii}. However, the empirical instability of nutrition flow and the competition from other individuals and species make the basic Darwinist principles generic: the pressure of selection entailing that reproduction pays and ensures growing fitness (and of course also that gendered reproduction and the following larger pool of selection pay even better). The secondary status of reproduction, however, entails that the Neo-Darwinian attempts at letting the principles of reproduction (scarcity of nutrition, offspring variation, competition, survival of the fittest etc.) count as the basic principles of

biology, from which all other features should in principle be drawn, do not hold. Metabolism, organisation, inner architecture are logically primary to the Darwinian concepts which consequently can not define them. As Stuart Kauffman has pointed out, a certain amount of “order for free” giving rise to stable, self-reproducing systems is the condition of possibility for selection to do its work: there must exist possible biological entities for selection to be able, in turn, to select between them and force them to evolve. Even if the Darwinist principles of reproduction, variation, selection, evolution are thus ontologically secondary to the principles of metabolism, it probably remains true that sufficiently complicated forms of life are impossible without evolution. Pure metabolic life with no reproduction would most probably remain extremely primitive. The metabolic stability of complex life forms is not *created* by evolution (just like neo-Darwinist metaphors taking genes to be effective causes of most if not all aspects of biology often imply), but must be supposed to exist beforehand as domains in the overall space of all possible species, like Stuart Kauffman argues. The possibility of reaching these optima in the space of species nevertheless depends on evolution as the most efficient natural searching algorithm in the space of possible species. Even if ontologically secondary, then, the principles of evolution seem necessary for the historical coming into being of complex organisms. Thus, the Darwinist scenario gives rise to further primitive a priori concepts: **competition, relative fitness, partner selection** (in gendered reproduction), and, in connection with the inner-architecture, boundary and metabolism properties, it yields categories like **co-working societies of cells, symbiosis, multi-cellular organisms** etc.

This series of interrelated a priori concepts for biology is intended to satisfy the role of “mediate concepts” from the alternately-means-and-ends analysis of *Zwecke* in Kant. It should come as no surprise that the majority of them are well-known biological concepts, even if maybe not technically so. The important idea is that they form an interconnected cluster of material-ontological concepts which organize biological thought as such rather than being mere human conventions. The use of semiotic vocabulary in biology thus seems to form a crucial part of a whole conceptual network of theoretical biology. This implies, on the other hand, that all sorts of semiotic terminology developed about human signifying processes may not effortlessly be exported into biology. Rather, a certain caution is required – biological signs probably involve a large range of complexity levels below that of human semiotics. On the other hand, caution should also be taken in

not taking biosemiotics as indication that all of nature all of a sudden possesses semiotic aspects.

One reason why it might be difficult to decide whether there are Peircean symbols and even life in anorganic nature is that Peirce is not himself unambiguous on the issue. Many authors supporting versions of the pan-semiotic ideas of symbols everywhere like to quote this famous Peirce idea:

The October remarks [i.e. those in the above paper] made the proper distinction between the two kinds of indeterminacy, viz.: indefiniteness and generality, of which the former consists in the sign's not sufficiently expressing itself to allow of an indubitable determinate interpretation, while the [latter] turns over to the interpreter the right to complete the determination as he please. It seems a strange thing, when one comes to ponder over it, that a sign should leave its interpreter to supply a part of its meaning; but the explanation of the phenomenon lies in the fact that the entire universe -- not merely the universe of existents, but all that wider universe, embracing the universe of existents as a part, the universe which we are all accustomed to refer to as "the truth" -- that all this universe is perfused with signs, if it is not composed exclusively of signs.

(Note from "The Basis of Pragmaticism", 1906, 5.448)

Most often, only the last, audacious claim is quoted - so John Deely in the very conclusion of his recent 1000-page semiotic history of philosophy (Deely 2001, p. 742). Peirce's idea here seems to be that indeterminacy is generic in sign use because indeterminacy, following Peirce's ontology, is generic in the universe as such. Strictly spoken, it does not follow from the idea that indeterminacy exists in the universe plus the idea that indeterminacy exists in signs that all universal indeterminacy has a sign character. But the idea thus seems to be that the objective existence of generality (like in any physical law as for instance gravitation) gives the cosmos a sign-like structure, because individuals embodying generals function as signs for those universals.^{xxxiv} And as we saw in the discussion of "real possibilities", Peirce often extends this claim to embrace also the existence of symbols, teleology, and life in anorganic physics. But this runs counter to other, more modest ideas in Peirce. Take for instance the claim that

In short, the problem of how genuine triadic relationships first arose in the world is a better, because more definite, formulation of the

problem of how life first came about; and no explanation has ever been offered except that of pure chance, which we must suspect to be no explanation, owing to the suspicion that pure chance may itself be a vital phenomenon. In that case, life in the physiological sense would be due to life in the metaphysical sense.

("Some Amazing Mazes, Fourth Curiosity", 1909, 6.322)

Here, an idea closer to Thomas Sebeok's claim is produced: the growth of genuine triadic relationships seems to be coextensive with biology. Again, indeterminacy, now in the guise of "pure chance" plays the decisive role, but in order to mend the obvious gap between biology and all of the universe, a metaphysical distinction is made, that of biology in a metaphysical viz. a physiological sense. Peirce's idea here seems to be that while biology proper should be taken in a restricted, physiological sense, referring to the evolution of existing organisms, biology in a wider, metaphysical sense should be taken as referring to the conditions of possibility for life inherent in the universe as such. But the trivial fact the such "vital" conditions must in some sense exist in prebiological physics is not the same as to claim that the cosmos as such is alive or that the cosmos as such consists of signs or symbols. In Peirce's doctrine, the problem is connected to the issue of the status of thirdness. In Peircean phenomenology (at a more general level than semiotics), thirdness is defined as habit, generality, tendency, etc. – but at the same time it is often claimed that thirdness and genuine triadic relations are in themselves semiotic and posseses a sign, or even a symbol structure. If that be the case, and if thirdness is generic in the universe, then all of the universe is semiotic and even symbolic. There is ample evidence, that Peirce (sometimes) believed this. As already mentioned, I do not belong to those who see a great metaphysical point in this idea. I see few interesting semiotic aspects in the mere fact of events being governed by laws or tendencies, so I prefer the restriction of the whole terminology of semiotics to biology proper, biology in Peirce's narrow, "physiological" sense of the word. I have nothing against, to be sure, the idea that physical processes may be described in semiotic vocabulary, but I just do not see that vocabulary adds anything to our knowledge of such processes. Thus, they seem to constitute a sort of semiotic zero-case where semiotic terminology may be added or not. To say that the crater on the moon is an index of the meteor responsible for it does not add to our normal understanding of the physical process having taken place. Rather like you could describe colorlessness as a zeroeth degree of coloring or your could describe the absence of mind as a zeroeth degree mind – without assuming that this implies that colorlessness

is a special sort of color or that matter is a special sort of mind. Quite the opposite of the physics cases, however, seems to be the case in biology where more or less explicit semiotic vocabulary seems positively indispensable: even the most die-hard reductionists invariably use such terminology and seemingly are unable to avoid it. I would not hesitate to support Peirce's argument that biological nature must, of course, possess conditions of possibility in pre-biological physics, but I think it is to go unnecessarily much too far to claim that these conditions should, in themselves, in any non-trivial way make all of physics alive or vital or semiotic or symbolical in any acute sense of the word. This leaves open, in Peircean terminology, the task of accounting in more detail for the intricate relations between thirdness, biology, and semiotics, to be sure. This issue, however, may not be solved by mere Peirce philology. Rather, it requires much further research, ranging from empirical biophysics and -chemistry and to theoretical biosemiotics. The primacy of the notion of metabolism in these deliberations (which we have underlined by beginning with it) supports Kant's embryonic idea of the cyclic structure as basic to the 'mediate concept' needed for living beings^{XXXV}. Following further Kant's lead, the above deliberations should - despite their clothing in earthly-biological specific terminology - be pertinent for any form for life, not only the terrestrial variants. This leads us to the question of their more precise status.

Material and formal ontology for biology

Our hasty sketch of an a priori analysis of the concept of life immediately entails an indefinite host of seemingly a priori concepts (in bold during the preceding paragraphs) - concepts which we recognize in unproblematical everyday use not only in biology, but in a whole range of other sciences where they most often - but not always - count as metaphors. Without further notice we may talk about the metabolism of an economy, the society as an organism, the narration of a text, and, of course, the signs' life in a society. What is the status of these concepts? Let us begin the answer to this question via a detour around the concept of "emergence". Emergence refers, in the epistemological debate in theory of science in the recent decades, to the idea of "new properties" showing up in systems of sufficient complexity^{XXXVI}. Thus, it seems intuitively suitable to speak of the emergence of life and hence biology out of physics, the emergence of minds and societies, hence psychology and sociology, out of biology, but also e.g.

the emergence of multi-cellular biology out of cellular biology etc. The existence of the concept is, of course, due to the conceptual knot presented by the theory of evolution: if nature, on this scale, is basically continuous - as the theory of evolution maintains (*natura non facit saltus*), then what is to be done with the phenomenologically striking “domains of being” that nature displays? They must, consequently, have evolved as a sort of discontinuous cuts into continuity, and these cuts are then *eo ipso* unexplainable within each of these “domains of being” which the single sciences occupy. “Emergence” is a philosophy-of-science denomination for this problem. It implies several consequenses for its strange in-between position between epistemology and ontology. The level-jump of emergence is for a first glance of epistemological character, because it is given by cross-domain unexplainability (an epistemological property) in the domain-defined disciplines. On the other hand, the phenomenological “domains of being” seem so strikingly evident that it is tempting to give them an ontological status and hence not to reduce the problem to mere epistemology implying that we in a number of generations might reach an all-encompassing, unproblematic, and continuous unity science. From this point of view, then, the distinction between single sciences of our day would appear left behind like a curious Middle-age cul-de-sac, just like we today see the distinction between the sublunar and supralunar worlds in Aristotelism. The distinctions seem much too evident to be ever subject to such a reduction, and the place of emergence between epistemology and ontology is (yet?) undecidable. Maybe, even, is it in principle undecidable, because every observation of emergence implies unexplainability and hence ontological undecidability - while only an emergence-explained-away can have its ontological status revealed, that is, as a non-existing case!

If emergence shall not, consequently, be only a vague and negative concept for the not-yet-understood, then it must receive more positive determinations. The very idea that one concept may be used to subsume all cases of “appearance of new properties” does rest on this supposition: that there is, somehow, something in common between the emergence of biology out of chemistry on the one hand and the emergence of psychology out of biology on the other - *in addition to* the mere “appearance of new properties”. The philosophical reason for accepting a concept of emergence must hence rest on an (most often not explicit, that is) idea of *formal ontology* - formal to the extent that the various level-jumps so named do not have the same material base in common. The concept of formal ontology refers to Husserl’s famous distinctions. On the one side, “formal ontology” is the science of abstract objects and their properties and interrelations, just

like formal logic is the science of abstract concepts and propositions, their properties and interrelations. Prominent candidates to formal ontology in Husserl (cf. for instance the famous 3rd *Logische Untersuchung*) is mereology, the science of wholes and parts, the distinction between genuine parts and moments, dependency, the category of object etc. - formal properties assumed to be relevant for any field of knowledge whatsoever. On the other side, formal ontology is contrasted to what Husserl interchangeably calls “regional” and “material” ontologies. They are plural and constitute, in fact, his way of dealing with the different “domains of being”. To him, the regional ontologies are three: “materielles Ding, Leib, Seele” (cf. *Ideen*, vol. III), crudely corresponding to physics, biology, psychology/sociology, respectively. What, now, constitutes the very relation *between* these regional ontologies? Husserl does not, to my knowledge, pose this question: this very distinction between material ontologies, is it material or formal? Of course the distinction has a material side (cf. the relation physics/chemistry and biology, where the matter of the latter presupposes and in some sense contains the former.) But the distinction between material ontologies must, if the concept of emergence has any philosophical interest whatsoever, have a formal side. If it does not have a formal aspect - that is, an aspect that can be described without reference to the material character of the particular level-jump - then the concept of emergence would degenerate into a purely nominalist denomination of a bundle of problems having nothing ontologically in common. It follows that “formal ontology” applied to this distinction has another meaning than ontology in the discussion of epistemology and ontology above. There, the question was whether the level-jump did exist as anything but a lack of satisfactory scientific explanation. Here, it is supposed it does indeed exist, and that it possesses both material (specific) and formal (general) properties. But as the concept of emergence is characterized precisely by being unable to “fill in” the hole in the continuity of explanation, then the formal ontological version of it must necessarily be no exhaustive explanation, but a necessarily non-exhaustive, general description comprising all cases of emergence (if not, they would not be conceivable as instantiations of the same category). Thus it seems, that either emergence is part of formal ontology, or it does not exist.

Which formal and general properties are now central to emergence? If physics in its present-day version is assumed as basic ontology, in the sense that all phenomena are based on interactions between microphysical elements, then emergence seems to be the coordination of a larger amount of particles into a pattern not itself physical, a pattern which is now the bearer

of the “new properties”. This implies that the objects on the emergent level necessarily have a larger physical extension than the elementary level of physics, as well as the fact that these objects must be characterized by some kind of coordinated, collective behaviour taking place between the physical entities of the lower level. Here, the concept of *form* becomes central to understand the pattern formation of collective behaviour. But if this model - generalized from the prominent level-jump physics-biology - is valid, then it sets certain restrictions on which other phenomena may obtain status as emergence. The jump from cellular to multicellular biology seems to satisfy these requirements, in so far we here have a case of pattern-forming behaviours of entities defined on the lower level, and multicellular organisms are then the entities pertaining to the upper level. This consequence now meets the hindrance that we usually understand biology as being one, from virus to primates - but this intuition might be a consequence of our own being multicellular beings. If we were ourselves thinking bacteria, then the jump from cellular to multicellular biology might assume the character of a violent and unexplainable jump ... This formal ontological point of view implies another consequence for the jump biology-psychology. If the emergent level is characterized by being composed by collectively acting parts from a lower level, then the *object* of psychology can not be the psyche; then its object must be the brain (or even: organisms equipped with brains), brains which, in turn, as a new and unique *property* have the psyche. The idea is not that the object of psychology should be the brain in a merely physiological use of the word (if so, it would not be a case of emergence), but that the object of psychology - as any higher order science, must be a complex, coordinated whole consisting of entities from a lower level. In the other end, nothing prevents us from assuming that formal ontological concept of emergence may already be indispensable in physics, cf. the emergence of macrophysical objects (crystallography, hydrodynamics, solid matter physics, meteorology, etc.) out of interactive patterns of microphysics. Here, it seems, formal ontological concepts related to emergence are needed in addition to the basic formal ontology at stake in microphysics and elsewhere: concepts such as self-organization, complexity, level, etc.

Biosemiotics as material and formal ontology

These deliberations now take us to the last main point of this chapter. If we accept the regional a priori character of the basic concepts of biosemiotics, and if we accept the formal ontological character of the concept of

emergence, then the road is paved for the conception of biosemiotics as a special branch of formal ontology, as pertaining to a specific subclass of emergent interactive pattern-forming systems. Valid for the material region of biology, the basic biosemiotic ontological categories also hold for higher emergent levels of psychology, sociology, etc. (even if these will add, of course, their own further categories). Material ontologies are *nested*, and they inherit the material categories of the lower levels as formal constraints on their own level. Barry Smith has taken up the study of formal ontology in the wake of the Austrian tradition from Brentano and Husserl, and in some recent papers he suggests to introduce the concept of “niche” as a fundamental concept in formal ontology. As predecessors, he refers to Aristotle (his definition of place, “khora”), von Uexküll (the *Umwelt*), to the biologist Evelyn Hutchinson’s modern definition of the “ecological niche” (as a “volume in an abstract space determined by a range of physical parameters pertaining to food, climate, predators, parasites, and so on”, Smith and Varzi 1999, 201), to the psychologist Roger Barker (“physical-behavioral units”), and to the founder of the “ecological” theory of vision J.J. Gibson. Smith remarks the strange fact that despite all human action is defined by the niche it belongs to, very little attention has been paid to the subject, and almost no attention to the subject as an ontological issue. In his own development of formal ontology, he takes his departure in the Husserlian idea of mereology (which, in contrast to set theory, does not assume knowledge on any basic elementary level and thus is phenomenologically “bottomless”, cf. ch. 7). Because of its high generality, mereology still lacks notions to grasp connected objects (it can not distinguish between, say, a composite red object like a red car, and the mereological sum of all red objects), and some sort of *topology* must be added to the formal ontological repertoire, making it possible to formalize the notion of bounded, connected objects. Furthermore, formal ontology must be able to assign its objects places in a space, giving rise to *locality* as a third formal ontological basic concept. Now, the concept of *niche* (or, physical-behavioral unit, setting, environment) must be added in order to understand the organized space-time cell which an agent and its specific actions unfolds around it. In Barker’s version, the “unit” is a bounded space-time region in which a human activity takes place and unites its parts into a whole (a chess game, a football match, a real estate sale, an education process, etc.). “Environment, person and bodily interior are thus combined together topologically within a nesting arrangement.” (Smith, p. 12) - thus agent and environment is connected in a non-random pattern. Gibson’s “ecological niche” permits Smith and Varzi (1998b) to generalize this idea

to any object which is tuned into its environment by a specific set of perceptions and actions.

Now, if “niche” is a sufficiently general formal ontological concept as to cover the bowling bag containing a number of bowling balls (Smith and Varzi (1998b), p. 22), and Barker’s “physical-behavioural unit” is a special subcase with a human agent - then biosemiotics seems to be the formal ontology for those niches containing a living agent equipped with metabolism and *Umwelt*. So, we would get a relation as follows:

Physical-behavioural units \subset metabolic niches \subset niches in general

In our a priori analysis of the concept of life, metabolism with its ensuing networks concepts was a central idea, and the whole biosemiotic vocabulary seems, in fact, to be constructed in order to suit into the metabolic cycles of an organism. The genes are codes in so far they direct the details of the metabolic growth of an organism, the messenger RNA brings a message relevant for the direction of the metabolism, just as animal perception is relevant for the continuation of metabolism. In short, it is the cyclical organization of metabolism which makes it meaningful to speak of “intention” (whether conscious or not), because the directedness of intention, be it inside the organism or directed outwards into the niche is governed by the cyclical attractor of metabolism. René Thom once remarked that extrapolation of the concept of formal cause in biology made it possible to let it subsume the effective and the teleological cause, respectively, in so far they are only two different viewpoints on one and the same metabolic process^{xxxvii}. Thus the biosemiotic vocabulary centered, like Kant predicted and Cassirer further argued, around the concept of intentionality, of telos, formally interpreted as cyclic pattern or order, gives meaning in relation to the notion of the cyclical flow of metabolism.

But is this not a bunch of anthropomorphisms, the sceptic will say. Is this not only a grandious illusion projecting semiotic concepts from the human sphere onto our innocent surroundings? In so far we ourselves engage in biological niches (and even extend and develop them into sophisticated psychological, sociological, etc. niches) we of course know the semiotic vocabulary from phenomena in our own everyday life - but this does not imply it is a subjectivist vocabulary; it simply pertains to objects which possess the same ontological structure as our niches. Of course, one must be careful that the biosemiotic vocabulary is kept objective: there is no need to assume, for instance, that our idea of an intuitive content, including

qualia, consciousness, etc., will be pertinent for lower-order biological niches. When speaking about “signs” at these levels, a qualia-less, consciousness-free sign concept must be assumed before, in each case, to investigate whether anything makes probable the presence of qualia. Biosemiotics as a formal ontology must be completely emptied for any presuppositions about consciousness, this being (maybe only until further research, it should be kept in mind), a purely empirical question (even if possible empirical facts veri- or falsifying the assumption of consciousness in other beings are of course hard to come by).

But the decisive hint which makes us think biosemiotics is in fact the relevant formal ontology for higher niches is precisely the fact that its notions seem to be transcategorical. We may use the vocabulary not only about organisms and human beings, but also about those meta-organisms at higher levels made out of patterns in organism and human behaviour – families, groups, firms, countries, cultures, etc. – in economics, sociology, political science, psychology, historiography. One animal society may signal to another, one anthill compete with another, one species with another; one state may bring message to another, compete with another, wage war on another, enter into symbiosis with another. Biosemiotics as a material ontology for biology, in fact, has formal bearings for all complex systems and thus become part of a formal ontology for emergence and the behavior of complex systems in general.^{xxxviii}

This finally raises the issue of the relation between formal and material ontologies, respectively. Semiotics, on the one hand, seems to be transcategorical and its categories applicable on all complex systems with a metabolism; on the other hand, it seems to have a privileged relation to biology as its most simple instantiation^{xxxix}. Thus, the seemingly inevitable semiotic vocabulary in biology has no equivalent in physics (that is, in non-biological physics). Hence, even if being a piece of formal ontology, biosemiotics does not seem to possess the same generality as for instance mereology. But this points to the fact that material ontologies must also be described by formal means. We have no direct, extra-formal access to these ontologies; hence they will rather be characterized by the amount of formal tools appearing necessary for their description. Thus, biology and higher complex systems can not be described adequately without a set of Kantian “mediate concepts” of biosemiotic kin while physics (present-day physics, that is) seem to be doing fine without it. Simple, that is, pre-biological physics seems to be a semiotic zero-case where the introduction of the

formal ontological biosemiotic vocabulary does not lead to new insights: the crater on the moon as an index makes no harm, indeed, but does not add anything to the normal physical understanding of the process. On the other hand, sufficiently complex physical systems call for the vocabulary of “mediate concepts” and are indeed, despite hard attempts, impossible to describe without it.

What is, on the other hand, gained by the recognition of semiotic vocabulary in biology? It is striking that biosemiotics has hardly, until now, yielded any new empirical biological insights. The recognition of semiotics as formal ontology rather has the role of explaining the necessity of the omnipresence of semiotic terminology in biology as it already is pursued and thus liberates biology from vain attempts at reducing it. Furthermore, it encourages biology to develop its spontaneous semiotic vocabulary into a common, agreed-upon, ontological conceptual system – just like the case in theoretical physics where the material physical ontology of powers, matter, fields, mechanical causes and effects, etc. is under constant critical development and are never taken for dispensable metaphors only. It consists, then, rather of a material ontological framework necessary for the empirical findings of biology to be understood precisely *as* facts of biology – and, in addition, serves as a formal ontological tool for higher domains.

ⁱ In Stepanov 1971, cf. Sebeok 1991, p. 7. Around the same time, C.H. Waddington concluded his *Towards a Theoretical Biology* (vol. III, 1972, s. 289) with the idea that language should become “a paradigm for the theory of General Biology”, and René Thom founded his biolinguistics in Thom 1972.

ⁱⁱ The latter half of the *Kritik der Urteilskraft*, 1790.

ⁱⁱⁱ For instance René Thom (1972), or Emmeche and Hoffmeyer (1991).

^{iv} Hoffmeyer has recently summed up his own work in the field in *Biosemiotik* (2005).

^v Translations from *Kritik der Urteilskraft* are my own.

“Ich behaupte aber, dass in jeder besonderen Naturlehre nur so viel *eigentliche* Wissenschaft angetroffen werden könne, als darin *Mathematik* ist ...” (Kant 1786, p. A IX)

“... eine reine Naturlehre über bestimmte Naturdinge (Körperlehre und Seelenlehre) ist nur vermittelst der Mathematik möglich ...” (ibid. A X)

^{vi} “Dass seine Form nicht nach blossen Naturgesetzen möglich sei, d.i. solchen, welche von uns durch den Verstand allein, auf Gegenstände der Sinne angewandt, erkannt werden können; sondern dass selbst ihr empirischens Erkenntnis, ihrer Ursache und Wirkung nach, Begriffe der Vernunft voraussetze.” (Kant 1974 [1790], p. 232

^{vii} ”... ein Ding existiert als Naturzweck, wenn es von sich selbst [...] Ursache und Wirkung ist” (Kant 1974 [1790], p. 233).

viii That is to say, it could not be mathematized with the mathematics available to Kant. But there is no reason to accept Kant's identification of mechanical explanation with mathematical formalization of a given domain; the latter is far richer than the former. Whether more advanced mathematics might do (parts of) the job is a possibility open for an historicized version of Kant's apriorism, permitting the synthetic a priori field to develop. As we have already mentioned, Petitot has a strong argument for the possibility of qualitative dynamics to mathematically describe phenomenological aspects of non-mechanical reality aspects – “pheno-physics”.

ix “dieser Begriff führt nun notwendig auf die Idee der gesamten Natur als einer Systems nach der Regel der Zwecke, welcher Idee nun aller Mechanism der Natur nach Prinzipien der Vernunft (...) untergeordnet werden muss.” (op. cit. p. 242).

x “Auch Schönheit der Natur, d.i. ihre Zusammensetzung mit dem freien Spiele unsre Erkenntnisvermögen in der Auffassung und Beurteilung ihrer Erscheinung kann auf die Art als objektive Zweckmässigkeit der Natur in ihrem Ganzen als System, worin der Mensch ein Glied ist, betrachtet werden.” (op. cit. p. 243).

xi One could say that Kant admits the anthropomorphic character of the concept of organism and related notions - but at the same time he offers a naturalistic (!) explanation of it: it because we ourselves are animals and thus teleological beings that we are able to discern organic properties in other objects. Thus, the tragedy of teleology is not that it is wrong or misleading, it is, rather, that we are unable to understand its “inside”.

xii In this interpretation of Kant, it must be emphasized, we do not subscribe to subjectivism, nor to the idea of a prioric regularities are a privilege of some transcendental subject. They are, rather, objective conditions valid for, but not necessarily known by, any possible subject whatever, cf. ch. 8.

xiii On Cassirer's Uexküll inspiration, see Stjernfelt (forthcoming) b.

xiv My translation. “Sie setze an die Stelle des Zweckbegriffs den Ordnungs- und Systembegriff, und sie charakterisiert das Leben dadurch, dass sie ihm die Eigenschaft des Systems zuschreibt.” (Cassirer 1957/1991, 221)

xv Of course, the problem here deals with the idea that semiotic concepts might contribute to the very basis of biology, not, for instance, to its import into more restricted subarea like zoo-semiotics where their use is much more unproblematic, at least for higher animals with elaborate mental representations of the surroundings. Already phyto- and myco-semiotics investigating plants and fungi, take the problem much deeper into the metaphysics of biology.

xvi The semiotic interpretation of the behaviour of E. Coli presented here has been developed through discussions with the biologist Claus Emmeche.

xvii The illustrations are from Alberts et al. 1994.

xviii Such as the fine introduction in Alberts et al. 1994, 773-785.

xix The fact that man and bacterium alike may be fooled by exactly the same chemical supports such a hypothesis. The qualia of sweetness, somehow released by our gustatory system, is no doubt lacking in the bacterium and bears witness to a much more sophisticated process of tasting in higher animals – but still exploiting the same rather simple mechanisms. Categorial perception by means of ”active sites” probably plays a central role in the important transition from uni- to multicellular animals studied by Lynn

Margulis. According to her endosymbiont hypothesis, already the eucaryote cell forms a symbiosis between simpler species: mitochondria, chloroplast, cell kern, and maybe the undilipodia facilitating cell movement like cilia or the flagella as in E. Coli. Further symbiosis at a higher level requires the coordinated cooperation between bacterial colonies able to communicate, and the interesting intermediate forms behaving like single cells in some phases and environments only to change to more coordinated behaviour in other environments are possible only through elaborate intercell communication. During unfavorable environment constraints, e.g., the outer bacteria of the colony are able to secrete chemical signs in order to communicate the danger to the more inner layers, causing them to take defensive action and change into a more inert, spore-like form. Simultaneously, the whole colony changes shape forming a sort of fruit stalk able to let these spores spread to faraway, hopefully more favorable locations. To that extent, bacterial colonies share certain of the coordinated behaviours in much more sophisticated multicellular organisms where intercell sign use may be harder to observe directly.

^{xx} Even if biologist like de Loof and Broeck (1995) maintain a short definition not far from what follows here: life as the total sum of all acts of communication performed by a compartment (an organized, bounded whole) from the lowest to the highest level at a given moment t .

^{xxi} Rosen (1989) argues from Gödel's incompleteness theorem for the introduction of semantic notions in biology. Gödel's theorem may be expressed as stating that for a given, sufficiently rich system, syntactic truth (that is, theorems provable in the system) is but a subset of semantic truth (true theorems not provable in the system). Rosen calls "complex systems" material systems which embody this property, in opposition to mechanic systems, and sees living beings as prototypical examples of such complex systems. As is evident, this argument is structurally analogous to the anti-functionalist Gödel argument in AI (from Lucas to Penrose).

^{xxii} A priori analyses of various domains' conceptual structures still often have an ill reputation due to empiricist prejudices or to the widespread myth that a priori analyses necessarily implies subjectivism; see ch. 8.

^{xxiii} We also find this crucial idea in Kauffman as a property in "autonomous agents", e.g. his (1996).

^{xxiv} In Stjernfelt 1992b, I proposed this property as a prerequisite to all formation of signs. The notion of "categorical perception" is taken from experimental phonetics (Liberman, Studdert-Kennedy etc.) where it refers to the ability of language speakers to immediately identify and categorize different variants of spoken phonemes, cf. Petitot 1985a. The fact that the set of macromolecules possessing the same active site can probably not be mapped by any effective procedure supports the Robert Rosen-like idea that the semantics inherent in this primitive categorization is subjected to undecidability limitations. The set of macromolecules triggering a specific reaction in the organism is (just like the whole of organic chemistry) potentially open-ended and thus can not be defined extensionally. I did not know, in 1992, that Giorgio Prodi had some years before put forward almost exactly the same proposal (Prodi 1988).

^{xxv} This crucial difference is noted already by Pattee 1977 ("our *conceptual* distinction between a molecule and its message or interpretation depends on the *physical* distinction

between strong and weak forces”, 265) and more recently by Igambardiev’s (1992) distinction between information and energetic levels (128).

xxvi This crucial size differences between the sign and its signification probably entails that semiotic systems must constitute a part of what Bak (1997) calls self-organized critical systems. The idea here is that a long range of different systems from physics and geology over biology and well into the human and social sciences (sandpiles, earthquakes, traffic jams etc.) display a characteristical relation between the size of events (avalanches in a sand pile, for instance) and their frequence, so that a power law holds between event size and event frequence. Bak argues that brains must be at the self-organized critical limit by a negative argument: if brains were subcritical, too few events would influence their behaviour, rendering them insensible; if they were supercritical, too many events would influence them and make them chaotic (Bak 1997, p 176-77). This brain argument may be generalized to all semiotic systems: they must react with insignificant changes to most small impulses but with significant changes to few small impulses; the latter class now constitute signs of various “sizes” dependent on the size of events they trigger.

xxvii I borrow this use of the term from Merrell (1997).

xxviii These ideas resume deliberations in Thom 1977, 128f.

xxix And even science - according to René Thom’s fertile definition of science as a charting embedding actual events into a space of virtuality - find its roots here.

xxx As discussed in ch. 4, the concept of *schema* goes back to Kant’s first Critique (as a notion for the possible meeting point for concepts and intuitions) and plays a central role for realist semiotics from Cassirer to cognitive semantics. Santa Fe complexity theory school has recently realized the necessity of the presence of *schemata* in complex, adaptive systems (Martin 1994, Gell-Mann 1995) and found coarse graining and perception of regularities among their chief properties.

xxxi As to consciousness involving qualia, experienced selfhood, etc., we have no behavioral criteria for determining its occurrence during evolution, but a first hypothesis might be that it appears as an integrating factor in organisms with central nervous systems, facilitating more efficient perception-action cycles.

xxxii Peirce’s pan-psychism of course implies that even inanimate matter would possess some kind of dull “feeling”. A recent argument for the existence of proto-consciousness in living beings has been put forward by Penrose (1990, 1994): the remarkable fact that most life reacts similarly to the same basic types of anaesthetic chemicals. The question of when consciousness shows up in the course of evolution, however interesting it is, is not decisive to the discussion of the relevance of semiotics for biology, so we shall leave it in this context.

xxxiii Thus, the code duality (analogue/digital, cell architecture/genome) discussed by my colleagues in the Copenhagen biosemiotic school is probably no logical necessity for life as such, even if it seems to be for the reproduction of it.

xxxiv Elsewhere, Peirce restricts himself to claiming that the universe is representable (because of appearing in the three categories) – this would be a more modest, Scotean claim that symbols and arguments may chart the universe because they mirror structures

in it and thus have a *fundamentum in re* in such proto-semiotic *realitates*, rather than claiming that the universe *consists* of symbols.

xxxv A further support for this thesis comes from Santa Fe theoretical biologist Stuart Kauffman and his theory of “autonomous agents”. The idea here is that they derive from “autocatalytic sets” of chemical compounds giving rise to chemical cycles. When they become able to stabilize and reproduce, we get “autonomous agents” as a general notion for (not only biological) organisms. Furthermore, by the introduction of Per Bak’s “self-organized criticality” into this framework, Kauffman makes the guess that the biosphere as a whole - maybe even the whole universe - evolves at the maximum speed possible into what he calls the “adjacent possible”, defined by consisting of yet unexisting chemical compounds at one-reaction-distance from existing compounds. If this radical version of a naturalized Enlightenment optimism is really correct, it would probably imply that biological evolution takes the shortest way possible in the evolution of still more intelligent beings. Kauffman specifies in this context an interesting assumption in our context: even if the biosphere (and maybe cosmos as a whole, he speculates) thus must be supercritical with respect to the autocatalytic power of its chemical networks, the single autonomous agent (organism, cell, or whatever) must necessarily be subcritical inside its skin - if not, autocatalytic bursts of still new compounds (following Bak’s power law distribution of events at the critical limit) would rapidly destroy it. This hypothesis - speculative as it is - would imply interesting semiotic consequences; the Kantian notion of the finitude of the subject (here, the agent) in relation to the thing itself (here, the biosphere) would have a naturalistic counterpart, as would the Hegelian idea of a “ruse of reason” where the individual agent unknowingly contributes to the common best. Semiotically speaking, this asymmetry between the agent and its environment would arithmetically necessitate categorization (by a finite mind of an infinity of possibilities) and hence schematic signs as general and underdetermined means of coping with an overdetermined environment, cf. our remarks on the economy of sign use above.

xxxvi See, for instance, Emmeche, Køppe, and Stjernfelt 1997 and 1998.

xxxvii Thom 1989, p. 43: “Efficient causality and final causality may be subsumed under the heading of formal causality. It should be observed that in Aristotelian theory final causality is in fact always conditional. An “act,” described as a process by an analytical model, may be stopped short if some impediment intervenes during its course. So the act may fail because of interaction with an accidental factor. When so considered, Aristotelian finality is perfectly compatible with our modern view of (local) determinism.”

xxxviii The fact that biosemiotic vocabulary is indispensable also for higher ontological levels does not in any way imply that higher domains may be *reduced* to biology. von Uexküll’s dark *Staatsbiologie* – in fact no less than a fascist biologist doctrine of state – should be sufficient as a warning against such shortcircuits.

xxxix It might be argued that this privilege of biology might be a coincidence due to our biological being. Kauffman (1996), for instance, toys with the possibility that his equivalent concept to biosemiotic organisms, “coevolving autonomous agents” may be applied on a cosmological scale (such as the organization of galaxies) as well as on a microphysical scale (the organization of elementary particles and below). Of course,

there may be several levels of organization between the fermion-boson level and Planck scale; we do not know and might never come to know.