EXTENDED CONCEPT OF KNOWLEDGE FOR EVOLUTIONARY EPISTEMOLOGY AND FOR BIOSEMIO蒂CS

Hierarchies of storage and subject of knowledge

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Abstract

A dominant view of evolution is that genes play a central role in it. What is important in genes is not the material, DNA, but the information that they contain. The relevant concept of information is the concept of meaningful information. This kind of concept of non-mental meaning is studied in evolutionary epistemology (EE) and in biosemiotics. However, it turns out that there are a number of relative concepts that demand similar non-mental redenifications. Concepts of knowledge, meaning, interpretation, and subject are extended so that they are applicable to both human and non-human actors.

Keywords

Action, adaptation, biosemiotics, epigenesis, evolutionary epistemology, information, knowledge, levels of evolution, phylogenesis, selection theory.

THE INFORMATION IN GENES

The standard neo-darwinist scheme of evolution consists of three parts: variation, selection, and reproduction (or heredity). The ‘scientific common sense’ view has specified it as follows: the variation takes place at the level of genes, different genotypes are selected on the basis of their phenotypic outcome, and consequently, gene pools are evolving. Although this kind of reductionism is a controversial doctrine, almost everybody seems to accept that genes or DNA play a central role in evolution. As Dawkins has noticed, genes, identified with pieces of DNA-strings, are ‘good replicators’. Replicators are defined to be entities with three characteristics: ‘fidelity’, ‘longevity’, and ‘fecundity’ (Dawkins, 1976). However, mere material of DNA (or RNA) does not yet make a DNA-string a gene, but it is its structural order or information that is essential to making it a gene. This has been pointed out by many biologists and philosophers (e.g. J. Hoffmeyer, D. Hull, A. Sharov, and even Dawkins), but the point is still often overlooked. But what kind of information is in question? It cannot be the mere physical or statistical information, which can be measured by objective and quantitative measures. It is true that the concept of statistical information is relevant in cell-division, in which the cell replicates its chromosomal DNA. The ‘fidelity of replication as well as the ‘longevity’ in the form of copies follow mainly from the physical characters of DNA (and from its cellular environment). But even if the fidelity of replication is an important factor in cell-division, it is not sufficient to make DNA essential for (the evolution of) the living world. The third property of a good replicator, ‘fecundity’, is strongly dependent on its capability to affect its micro- and macro-environment, e.g. a DNA-string can be a replicator only in a cellular environment. Protein synthesis is the major channel for DNA to affect its environment. And it is the particular order of nucleotides in a DNA-sequence which is important in protein synthesis, and on the ‘fecundity’ of DNA is dependent. Therefore, it is the contentious or meaningful information that is in a central role when a DNA-string is considered as a replicator.

We can use a common metaphor and consider DNA-strings as codes — as coded messages from past to present (or from present to future). Genes can be seen as DNA-codes, packages of information that were encoded in the past, and that are ‘meant’ to be decoded. Thus, there are (at least) two semiotic processes that are connected in genes: the encoding, the formation of the order of the DNA-code, and the decoding, the interpretation of a DNA-coded message. This code-metaphor gives us one further argument for regarding DNA-strings as ‘good replicators’. The ‘meaning’ of DNA is digitally coded, and digital codes are highly resistant to disturbances (Hoffmeyer & Emmeche, 1991, 134-135) — not only DNA, but also its ‘meaning’ is replicated with great fidelity, and can be preserved from generation to generation.

It is not only the purely objective characters of DNA-strings that make them replicators. Even the ‘meanings of DNA’ are meaningful only for certain cells — these ‘meanings’ have effects only subjectively interpreted. DNA does not replicate (nor produce proteins) by itself — it does not do anything by itself — it just exists. (Hoffmeyer, 1996, 50) DNA must be in a living cell that does the work by dividing itself. And it does a difference which type of cell the DNA is in, whether it is in a liver-cell or in a muscle-cell, or in an amoeba or in a neuron located in a human brain. If we consider a DNA-string being a gene, it is the subjective information-content of this DNA-string that makes it a gene. An arbitrary sequence of nucleotides (DNA ‘as such’), or any ‘freely floating’ DNA sequence, cannot be considered as a gene. DNA needs an interpreting subject and/or an appropriate environment if it is to work as a replicator. Therefore, the relevant concept of information is the ‘information that means something for somebody’ (the formulation is due to Gregory Bateson, cited through Hoffmeyer, 1996, 66). If a gene cannot simply be identified with some DNA-string, the idea of genetic reductionism becomes muddled. However, it is not at all clear what kind of ‘meaning’ associated within a DNA-string makes it a gene, and what or who could be that ‘somebody’ (and in what sense). There is a real danger to take these metaphors too literally, and as a consequence to load them with spiritualist metaphysics or religious mysticism. I think this danger is one apparent reason why this kind of ‘contentious-informational’ approach has not always been favoured by scientists. The naturalistic explications of these mental metaphors are not obvious. Still, there are two mutually relatively independent and for the most part naturalistic lines of thought that have both considered this kind of aspect of DNA: evolutionary epistemology (EE) and biosemiotics.1 In both of these the active role of phenotypes is emphasized. In EE, the knowledge of the non-conscious knower is discussed, and respectively in biosemiotics, non-human interpreters of meaningful signs are considered. I think biosemiotics is at its best when it considers how the DNA-codes are decoded. The evolutionary epistemology (EE) is, in turn, at its best when it has considered what has been encoded in DNA, and also why it has been encoded. I try to combine the best parts of both approaches, and conclude the explication of a general concept of knowledge.

KNOWLEDGE IN GENETIC CODE

Knowledge and adaptations

The standard philosophical conception of knowledge defines knowledge as a true well-justified belief or proposition. Knowledge is achieved, at least in standard empiricist dogma, by some learning process, either through perception or through the adoption of such a tradition that contains previously gathered knowledge. In the tradition of EE followed here, an analogy between evolution and adaptation through natural selection and the increase in environmental knowledge is emphasized. More specifically, this knowledge is not simply about the environment, but rather about the relationships between the knower (e.g. organism) and its environment. When natural selection makes changes in genetic information, this is interpreted to be a knowledge process, and if this change is adaptive, it means the increase of knowledge. Genes can code environmental knowledge that is not learnt individually but is innate or a priori for the individual organism.

Although it has been more common to use Darwinian ‘logic of natural selection’ (variation-selection-recombination and-reproduction) as an algorithm of learning in

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1EE does not form a very uniform tradition. I am following the line founded in the 40’s and 50’s by Konrad Lorenz and Donald T. Campbell. Henry Plotkin represents here the ‘second’ generation that relies on the base made by Campbell and Lorenz. Thomas Sorensen is often named as the founding father of biosemiotics, even though Jacob von Uexküll (who was the teacher of Konrad Lorenz) is also mentioned as its predecessor. Still, I am referring the recent writings of Jesper Hoffmeyer, Claus Emmeche, and Alexei Sharov.
the human sphere, as in many evolutionary theories of the development of science, the analogy may become better understood if it is viewed the other way round. Adaptation through natural selection can be seen as a kind of learning process, as an evolutionary learning, where lineages, populations, or species (but not individual organisms) are considered as individuals that are learning at the conditions of the survival of their ‘members’—these ‘collective individuals’ are ‘testing’ their environments by their ‘individuals’. These supraindividual learning processes explain how individual organisms have got the ‘a priori’ knowledge. It must nevertheless be stressed that natural selection is not necessarily adaptive, as e.g. Richard Lewontin has pointed out (Lewontin, 1978). Every evolutionary change cannot be labeled an evolutionary adaptation. All the changes in genetic information cannot be associated with (evolutionarily) learned knowledge. As is the case with humans, also ‘erroneous’ information can be adopted. Natural selection causes changes in the gene pool of a population through differential reproduction (i.e. the relative proportion of the DNA of the most numerous reproducers increases). However, the adaptiveness is not a property of gene-compositions (or single genes) but of single phenotypes. Adaptations can be inherited through genes, but both the encoding and the decoding of respective DNA-codes are essentially in adaptations. It is not enough that environmental information becomes encoded into DNA, but the code must have real effects in epigenesis (i.e. in the translation process from DNA to structural properties resulting in functional advantages for the developing phenotype (see e.g. Johnston & Gottlieb, 1981) — not all DNA-strings are functionally effective or even become ‘visible’ in ontogenesis. It is the concept of adaptation (or of adaptive learning) that is essential in the extension of the concept of knowledge, not evolution, selection, or learning per se. The proper way to understand the idea of evolution as a process of adaptation is to identify the growth of knowledge with adaptation, or with increasing fit between an organism and its environment. Like Donald Campbell, I am also searching for a redefinition of the problem of knowledge as a subtype of cases of fit between x and y. (Callebaut, 1993, 416) When an organism or something is adapting itself to its environment, it is adapting knowledge about its environment (or about its relation with its environment). However, I have not seen this redefinition properly made anywhere. It is quite odd that in EE this basic concept is not thoroughly specified.

The concept of knowledge

A genetic code is a paradigmatic example of a structure where one kind of environmental knowledge through adaptation can be stored, and how it is coded. Clearly, if we are talking about ‘environmental knowledge coded in DNA’, this kind of knowledge cannot be a belief or even a proposition. The traditional concept of knowledge is not appropriate. The criterion for the knowledge-content of DNA has to be specified as the adaptiveness of the developing phenotype. The ‘meaning’ of DNA is thus purely functional, it must also be ‘visible’ at the phenotypic level, and it is meaningful only for the cell that is interpreting it. Therefore, a DNA-code cannot be either true or false, unless we give some pragmatic definition of truth as ‘usable’ (and ‘profitable’). It does not need any justification either — a loose analogy between justification and adaptation can be drawn, but the subject is missing, for whom DNA is supposed to be justified in adaptation.

The main reason why the traditional concept of knowledge is too restricted for the DNA-code is its anthropocentric idealism: justification and ‘beliefness’ depend on the rational consciousness of the knower; truth seems to be connected to propositionality that furthermore refers to human language, and to its ‘immaterial’, mental meanings understood by some conscious mind. Because EE at its heart is a naturalistic program, we need a more ‘naturalist’ or ‘realist’ concept of knowledge — consciousness of a knower cannot be a distinctive feature of it. We need real knowledge of real (women concerning the real world, and existing in the real world. However, my aim is not to replace the traditional concept of knowledge totally, but to extend it so that the extension covers both the traditional and more realistic definitions of knowledge — the standard definition must be included as a special case. If we do not consider ourselves as more conscious beings or minds, we may ask two questions. What kinds of knowledge do we as living beings possess, and where do we have the kinds of knowledge we surely possess? It has often been said that one of the central themes in classical epistemology has been the fight against skepticism — do we have any real knowledge at all? If we do not limit ourselves by the traditional concept of knowledge as belief (or proposition), we can give a certain answer, yes we do! There are many things that we certainly can do (if we just want to) — in many respects we are capable of doing as we wish— we know enough about our world to be able to act in it. The ability to act successfully presupposes the knowledge how to act successfully. Discursive linguistically expressed justification is not always necessary — if the ability to act is (successfully) demonstrated, no argument can overcome this ultimate proof of knowledge. This kind of demonstrable knowledge connects us to other forms of life — everyone living creature needs at least some knowledge how to act successfully (in its environment). Of course, knowledge does not determine the action it enables, it is just the precondition for the action. Although an action can be seen as a presentation of knowledge, the actual action is not necessary for the existence of knowledge — knowledge is potential action, the potentiality of knowledge. We can associate knowledge with potential action by using the concept of power in quite a general sense, as an ability to do something. Both concepts are still considered as properties of individuals — it is something one possesses, have, or can do. We will also have knowledge of knowing (knowers) and of knowing (knowers) are equated. These subjects do not need to be conscious either of themselves or of their actions (but of course they may be). How should then the identities of the traditional concept of knowledge be realized? And what features of it can be preserved? The first estimate is the following.

1. There must be a real subject of knowing, a knower.
2. Knowledge is about something, it must have an object that is and known.
3. The known is represented in some structure as its order. Knowledge exists as a structural order.
4. There must be some correspondence between the knowledge and the known. The structural order that carries the knowledge have to be formed in a process where the fit between it and its object has increased.

These are very general characterizations, but they lend themselves to many different subjects of knowing and to many different structures of knowledge stores. The traditional concept of knowledge as well as environmental knowledge coded in DNA fulfill them. However, there are more species of knowledge in existence than only those two. Still, there is much to be said about the concepts of subject, object, structure, and correspondence by considering DNA-coded knowledge.

Dual coding in living systems

Biosemiotics forms a more general frame of reference than EE. The central idea is that life consists of semiotic processes. The interaction between a living system and its surroundings is not considered as causal chains of the necessary causes and effects, but as sign processes — and signs are not interpreted just by humans but by other organisms too. Jesper Hoffmeyer (together with Claus Emmeche) considers the biosemiotic theory in which the living systems are dually coded. Every living system must be represented within two codes, digital and one analog. The peculiarity of living systems, as compared to artificial ones, is their property of self-creation. The role of DNA is to carry an independent self-description that is needed for the reproduction of a system, and because of its digitality, DNA-code works well as a memory that assures the identity of the system through time (Hoffmeyer & Emmeche, 1991, 125-126) But, because digital codes have a strong resistance to disturbances in replication, they are not suitable for interaction with the rest of the world. The life of a system consists of actions in its world — living systems do not live in a vacuum, but they and their surroundings (that includes other living systems) are mutually interpenetrated. The phenotype in its analog is the analog codes of living systems being necessary for action, i.e. for life in the world. This pair of codes, DNA-cell (or genome-phenotype), is common to all living systems — humans included. 2(Ibid. 126)

In Hoffmeyer’s dual-code-scheme, biosemiosis can be divided into horizontal and vertical dimensions. The sphere of the horizontal semiosis of life is composed

2 For humans (at least), there is another important dual-coding (and it is much better known): language (digital) and social/interpersonal behaviour (analogical).

3 For example Campbell explains all the apparent cases of increased fit between two systems in terms of one abstract principle: “For Selection Theory, Darwin’s natural selection impresses an abstract ‘variation-selec­tion-extension-and-reproduction’ algorithm appropriate to all examples of increased ‘fit’ between one system and another. Biological evolution is only one such example. Trial-and-error learning, radar, sonar, computerized problem solving, and human thought are others.” (Campbell, 1987, 143)

4 This idea of looking at adaptation through natural selection as a form of learning is inherent in Konrad Lorenz’s ideas about the origin of Kantian synthetic a priori: “something that has evolved in evolutionary adaptation to the laws of the natural external world has evolved a posteriori in the natural order” (Lorenz, 1941, 181)

5 The parastatistical theory that has no phenotypic effects in an exception — it can be said to have adapted oneself only to its cellular environment (see Orgel & Crick, 1980). A string of parastatistical DNA is a replicator, but it is not much more to say it is a gene.
of all the semiotic interactions between analogically coded living systems and between any living system and its (analogic) environment. The vertical dimension concerns the communication between genomes and phenotypes inside each system. For a system to live (or survive), its digital code must be translated into the analog one. This epigenetic translation process (from digital to analogic) brings about the ontogenesis of an organism. On the other hand, there is also a back-translation process (at the level of population) from analogic to digital by the differential reproduction of phenotypes (i.e. by natural selection). Back-translating processes result in phylogenesis, in changes in gene frequencies (in the gene pool). These translation processes are not mere deterministic mechanical transformations, but they really are genuine sign-processes, the processes of subjective and context-sensitive interpretation.

Signs of vertical semiosis transferring the knowledge

The vertical biosemiosis gives a fine example if we ask how the subjects without mental sphere can really know their environment. As noted earlier, if we consider DNA-coded adaptations to be environmental knowledge, it is not enough to consider the encoding, but DNA-coded adaptions to be environmental knowledge. As noted earlier, if we consider the encoding, its digital code must be translated into the analog one. This epigenetic translation process (from digital to analogic) brings about the ontogenesis of an organism. On the other hand, there is also a back-translation process (at the level of population) from analogic to digital by the differential reproduction of phenotypes (i.e. by natural selection). Back-translating processes result in phylogenesis, in changes in gene frequencies (in the gene pool). These translation processes are not mere deterministic mechanical transformations, but they really are genuine sign-processes, the processes of subjective and context-sensitive interpretation.

The back-translation from analogic (phenotypical) to digital (genetic) code happens on a different level (figure 1B) -- its subject of interpretation (interpreter) is a population or a lineage in an evolving population (or a kimflok, a flock of germs, as Hoffmeyer and Emmeche suggest, 1991, 146-147). The object is the environment or the ecological niche (of the lineage). The lineage 'sees' the environment through differential reproduction of its organisms so that the primary sign or representamen is the differential reproduction. The result of this 'seeing', the interpretant, is changes in gene frequencies. Sharov's 'interpretant' of the back-translation may not fulfill the conditions of being a tridic sign. As odd as it might sound, there is no problem in seeing differential reproduction as a sign that represents the environmental conditions for the lineage (although it may represent a number of other conditions too). But does the lineage really interpret it? Or are these changes in gene frequencies (Sharov's 'interpretant') the direct (causal) consequences of differential reproduction, and not the only interpretation of differential reproduction? Or moreover, are they even the same phenomenon, but just described at different ontological levels?

I assume that there is a proper sign-relation between the environment and differential reproduction. But even if such a sign-relation could never be defined satisfactorily (in triadic form), and there were just two dyads one after another (or just one dyad), Sharov's 'pseudo-sign' is sufficient for the demonstration of an extension of the concept of knowledge. Signs presented in figure 1 can be chained. In figure 1A, the DNA of a zygote represents the 'ancestors' or 'parents' of the zygote, but in figure 1B, the genotypes of these 'ancestors' represent the environment of the lineage in which the zygote is involved through differential reproduction. It does not really matter whether this connection between the environment and the genotypes of 'ancestors' appears to be only a pseudo-sign, because we can still compose a new sign (figure 2). DNA represents (among other things) the environment of its ancestor-organisms, and that relation of representation appears as a construction of an organism that would be 'competitive' in the past environments of its lineage (this is of course only a statistical property). What is important is that now we can say that DNA contains meaningful information about the past environments (of its ancestors), i.e. environmental knowledge, for the cells that constitute the organism.

PHENOTYPIC STORES OF KNOWLEDGE

Nested hierarchies for memory

In EE, DNA is really just an example of knowledge — albeit a good one because of its close analogy with human languages, both work as digital codes. Gene pools are not the only stores of non-linguistic environmental knowledge. There are other stores too that are evolving, not in genetic, but in phenotypic evolution. In the Campbell-Lorenz-Plotkin-style EE the dominant idea is the nested hierarchy of levels of knowledge-processes (see Campbell, 1974).

The idea of nested hierarchy is basically systemtheoretical. Lorenz, in particular, has stressed that there is a trend in evolution to form more and more complex systems of (knowledge-processing) organizations. The emergence (or as Lorenz prefers to call it, the fulguration, Lorenz, 1973, 47) of a new level of complexity appears when a group of already existing systems starts to work together so that the whole starts to control the functioning (and reproduction) of its parts. When an integral system is formed it usually gets some totally new (functional) properties that are not reducible to the functioning of the parts. New emergent properties pop up in a unique historical accident. Now, one can wonder why new levels have emerged at all. Most likely the fact is partly coincidental, but there can also be certain selection pressures affecting the formation of new levels.

The idea of nested hierarchy drafted above does not as such contain anything peculiar to EE. But in EE (at least for Campbell and for Plotkin), it is common to unite at least three hierarchies: the genealogical hierarchy of descendance, the hierarchy of containment or embeddedness, and the hierarchy of control or connection (see Plotkin, 1988, 150-151). Moreover, when this is connected to the concept of adaptation, we can also find a continuity between genetic adaptation and knowledge in all its senses pertaining to human rationality. When organisms adapt themselves to (changes in) their environments, they have to adapt in different time scales, and it is also the cause why new levels of organization emerge (Plotkin, 1987, 85). Since DNA forms a digital code, the knowledge stored in DNA remains stable over several generations — it takes several generations to achieve any significant directional changes in a gene pool. In fact, it is a virtue for life that DNA forms such a stable structure. Chromosomal DNA serves as a long-term memory-bank for the organism so that knowledge already compiled is not forgotten too easily.
The existence of the second level: The developmental knowledge in the phenotype as a whole. Although the knowledge of an organism must not only be stored in a stable form (in genes), but there must also be mechanisms to update it. This need for the updatability of environmental knowledge can be seen as a selection pressure that has given rise to more and more complex hierarchical phenotypic organizations. (Plotkin, 1987, 84)

Henry Plotkin has (together with F.J. Odling-Smee) produced a theory of nested hierarchy of knowledge, which has four levels (Plotkin & Odling-Smee, 1981). The gene pool of a population forms the fourth level, because it brings along more effective means for individual adaptation — learning from other learners expands an experience beyond an individual experience both temporarily and spatially. However, it must still be noted that not all the learned habits etc. are adaptive. The third and fourth levels just make it possible to gain environmental knowledge faster and further afield — misinformation can also be gained and shared.

About the restrictions of EE

There are a number of weaknesses in evolutionary epistemological theories as in Plotkin's one drafted above. The most serious one is a common one: the lack of the proper definition of knowledge — sometimes it is talked about as if the traditional 'true well-justified belief or proposition' were a suitable definition, but most times it is not. Besides that, especially in Plotkin's theory, the subject of knowing, the knower, is quite unproblematically defined to be an individual organism. Point of view is restricted to concern only individual organisms.

The first observation is that in the level of genetic adaptation, it is not the individual organism that is gathering knowledge, but it is the lineage, the population, or even the whole species that acts as a subject. Although the part of the genetic knowledge is present in every individual gene, it is both gathered and stored collectively into a gene pool. The users of the DNA-coded knowledge are nevertheless individual organisms. At the genetic level we can, again, see two interconnected processes at different levels, as discussed in earlier sections: both decoding (from analogic to digital) at the level of population and encoding (from digital back to analogic) at the individual level are needed to define adaptation, and knowledge.

The socio-cultural level brings along another problem. At this level the knowledge is also stored in a kind of 'pool', a cultural pool, and the same questions arise here as at the genetic level. What kind of beings are the real subjects of socio-cultural knowledge? In Plotkin's theory, every adaptation in socio-cultural level is an adaptation in the level of individual learning too. There is nothing problematic in this if we are restricted to consider only individual organisms as subjects of knowledge/adaptation. But this is most probably too restrictive a definition for the socio-cultural level of knowledge (see e.g. Campbell, 1981). If we think about social innovations that re-organize the social community (e.g. its division of labor), we can see that their potential adaptability is not necessary individual. The social community together with its environment can form a self-organizing system, where the community and the environment give shape to each other so that their mutual fit-tedness increases. The process can be said to be adaptive, even though the environmental knowledge cannot be said to be transmitted through one individual. This kind of phenomenon is evident in social insects (see Bonabeau et al. 1997), and I cannot see any reason why this kind of adaptation cannot be available in mammal societies including human ones. Because the subjects of this kind of knowledge are not individual organisms but rather their collectives, this kind of socio-cultural adaptations are totally ignored by Plotkin. Thus, especially at the first and the fourth levels, the subjects of gathering, storing, and applying the knowledge may not be the same kind of entities.

The third common weakness for most evolutionary epistemologists is that only two ways of inheritance are considered: genetic inheritance and social communication. There are, however, also other mechanisms of inheritance that may well transfer adaptations from parents to offspring as mentioned in Douglas Wathisten's criticism (Wathisten, 1981, 256). Many of the cytoplasmic nonnuclear organelles and structural details (e.g. mitochondria and cell membrane) are reproduced without gene-interaction — these replicate using existing structures as templates. The chromosome of a structure in a cell can also be transmitted to descendant cells. Thus, the cytoplasmic structure of an egg-cell has, at least in principle, a capability to store heritable knowledge — the female parent replicates herself in sexual reproduction as an egg-cell. This kind of criticism (concerning the under-determined role of an egg-cell) does not necessarily oppose biosemiotics where the egg-cell has the most central role as a subject of interpretation.

The extended senses of meaning, subject, and knowledge

It has become evident that when studying knowing of, and signs meaningful for non-human subjects, we need to give up certain restrictions to consider only our human intuitions. Because biosemiotical subjects do not (in general) have any sort of mind (nor consciousness), we have to redefine the concepts of meaning, subject, and interpretation (of a sign) ‘naturalistically’, i.e. avoiding anthropocentric or mentalistic pre-understanding of these concepts.

What then is required for the concept of subject? First of all, consciousness has to be dropped as a defining character of subjectivity. We are interested in the kinds of subjects that are capable of interpreting signs. Therefore the minimum requirement is that the object, which is represented by a sign for a subject, has to be ‘meaningful’ or ‘significant’ for the subject, i.e. the subject has to react to the sign appropriately. There must be some subjectively active component through which the sign has an effect on the subject, an effect of significance for it. I would like to define this ‘appropriate reaction’ as a result of the interpretative act. The (subjectively interpreted) meaning of the perceived sign, the interpretant in Peircean terminology, becomes thus defined as the (appropriate) reaction of an interpreter when the sign starts to work as a sign, i.e. when the sign starts to represent the object for the interpreter — or when the interpreter interprets the sign.

These two characteristics might be enough for the concept of subject, but usually some kind of autonomy of subject is provided. Hoffmeyer's (and Emméche's) notion about this autonomy is justified by a cosmological-existential question that concerns the beginning of life. Who (or what) was the subject of the process that created the first subject? The answer is obvious if God is excluded: this subject must be the first subject itself — the first subject must be capable of creating itself. It must contain the distinctions necessary for its own identification — a kind of self-representation. (Hoffmeyer & Emméche, 1991, 125-6) The sense that the 'autonomy of subject' gets here is the following: a subject in order to be a subject must contain a self-representation, or self-description, by which it is capable of (re)creating itself. The 'self' of (analogically coded) living systems is represented digitally in their DNA.
The subjects of translation processes in vertical biosemiosis, cells and lineages or populations, are fine examples of natural subjects. But they are only the ends of the line, there is number of other subjects, the subjects of horizontal semiosis that are interacting with their surroundings by receiving and sending signs.6 It is the horizontal semiosis that is relevant for us when we talk of levels of preadaptation/knowledge in Plotkin’s nested hierarchy. In Hoffmeyer’s theory, horizontal communication was mostly analogically coded (or at least non-digitally), and analog codes could not preserve knowledge (nor any content of information) for long times. This matches perfectly with Plotkin’s hierarchy, because the phenotypical levels were needed for the range of updatability that digital codes cannot have. This also emphasizes the exceptional status of human languages in phenotypical evolution — they can be exploited in digital communication. Through languages interpreted as digital codes — and especially through written languages — knowledge and any information can be stored with relative reliability even for thousands of years. The main problem in interpretation of, say, ancient texts, is not in these texts, but rather our poorly preserved knowledge how to decode them. This is understandably because, the knowledge concerning the decoding of written text is usually analogically (or at least non-digitally) coded.

The organs in multicellular organisms may turn out to be subjects of horizontal semiosis, because they perceive their surroundings and react appropriately. But at least, the individual organisms are subjects that are receiving and interpreting signs from both the living and non-living world. Set theoretically speaking, all the subjects of knowledge or of biosemiosis are cells or are composed of number of cells. But whether or not their functioning is reducible to semiosis are cells or are composed of number of cells. Speaking, all the subjects of knowledge or of biosemiosis can be subjects of horizontal semiosis too. For example, cells interpret their DNA in a triadic sign structure and the object of knowledge has in some way to be accessible or interpretable to the knower — quite often the structure is part of the subject, but not necessarily (as in the case with writing). It is the order of a structure that represents the object — the order or information that can be copied and transformed into other structures.

Finally, as we noticed earlier, every signification process is not necessarily a knowledge process, and the above formulated characterizations do not yet differentiate adaptive from non-adaptive information. Mere representation of an object does not constitute the knowledge about the object. Therefore, knowledge (a structural order) must have been formed in a process in which the fit between the structure and the object has knowledge increased. This fits take the form of functional resemblance, not ‘structural isomorphy’ or ‘one to one correspondence’ between interpretant and object. The final test of knowledge of a structural order is the successfully of the actions it brings about. It is not enough to insist that knowledge is learned (either individually or evolutionarily) rather, it is effects in action that matter. This extended definition is very general, but it is applicable to various kinds of knowing subjects. The traditional concept of knowledge remains as a special case:10 knowledge that is not in the familiar, propositional form of linguistic or mental representations can be called structural knowledge. It must be noticed that the concept of truth is not applicable as a normative criterion for structural knowledge. For example, the way in which genetic information coded in DNA represents (or ‘corresponds’ with) the world cannot be considered without the interpretation made by the zygote (and by its descendant cells). It is the adaptedness of the descendant organism that ‘measures’ the content of knowledge in its DNA. The application of the concept of truth would be totally absurd without a pragmatist redefinition of truth.

The same can be said about most phenotypic stores of knowledge (at least those which are analogically coded). The concept of truth is not applicable until the store consists of linguistically structured concepts, i.e., propositional knowledge. Even though languages are considered as digital codes, also structural knowledge may be stored in linguistic structures. For example, logical or stylistic structures in languages may be capable of storing knowledge about, say, cultural sensitivities of people. The only criterion for structural knowledge is its applicability, i.e., its capability to successfully perform an action. Therefore, the real object of the knowledge (regardless of its possible propositional content) is the part of the world over which the knowledge gives power.

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