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BIOSEMIOTICS: A NEW SCIENCE OF BIOLOGY?

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Biosemiotics is a new approach to the explanation of living. The central thesis of biosemiotics, "life is semiosis", is a basis for a new science of living which should replace contemporary (or traditional) biology. The reason is that biosemiotics reveals new qualities of living, which are unaccessible through the methods of contemporary, pure empirical biology. The paper outlines basic theses of biosemiotics, distinguishes two main approaches, and challenges the central thesis with the focus upon its interpretation in "scientific" biosemiotics.

Keywords: Biosemiotics – Biology – Semiosis – Semiotics – Sign – Code – Sebeok – Uexküll – Barbieri

Introduction. In biology similarities between human language and other systems of information interchange are sometimes subject of considerations and discussions. Maybe the most popular – in the sense using the word "language" in a context different from specific human communication – are the language of nucleic acids and language of bees. Especially the language of nucleic acids may be seen as a "paradigmatic" example of such an analogy. When the structure of DNA and subsequently the genetic code were revealed in 1950s and 1960s, the similarities between information coding in human language and information (genetic information) coding in "language" of nucleic acids became interesting and inspiring. Points of possible contacts between biology as a natural science and linguistics as a science of humanities were sought, but due to superficial nature of similarities and analogies between two coding systems quite different in many other respects, and also due to the unbreakable differences between natural science and science of humanities (theoretical, methodological, conceptual), the debate was abandoned very soon. What has remained in biology from this experience is the using of terms like "transcription" (of the sequences of nucleotides in DNA into the sequences of nucleotides in RNA), "translation" (of the sequences of nucleotides in RNA into the sequences of amino acids in protein), "letters" of genetic code or the "language" of DNA, of nucleic acids etc.

Nonetheless, the idea has survived and has transformed into new forms. In 1960s the semiotician Thomas Sebeok (Sebeok 1968) develops so called "zoosemiotics" as a study of the animal communication. From his point of view the animal communication is based on the same (or at least similar) processes of semiosis as the human communication. Later Sebeok broadens his views in a sense that not only communication, but all the realm of living is a process of signs interpretation and adopts the term "biosemiotics" (used for the

first time by Friedrich Rothschild in 1962). Sebeok as a semiotician was inspired by the ideas of Jakub von Uexküll, German biologist of the first half of 20th century, especially by his idea of the organim's "Umwelt". Contrary to the contemporary meaning of "Umwelt", which means organism's external environment, Uexküll's "Umwelt" meant the inner world of organism, the fact that every living organism creates its own world, its own reflection of the surrounding environment and acts in this environment according to this reflection. Living organisms are not passive objects of the operation of natural laws, but active subjects which influence the processes in nature. It is worth noting that the same idea was an inspiration for the theoretical foundations of ethology, comparative research of animal behavior, in 1930s, and later also for the evolutionary theory of knowledge. In evolutionary theory of knowledge this was one of the reasons for the change in the theory of evolution and also in the theory of knowledge, where the later should achieve a status of a scientific discipline (see Gálik 1992, 1993). In biosemiotics the role of the "Umwelt", as to the status of biosemiotics, is a little bit different.

Despite Sebeok's effort biosemiotics remained marginalized and almost untouched by biologists. Only recently, during the last 20 years and especially after 2000 we can see growing interest in biosemiotics and biosemiotical studies not only in the works of semioticians, but also biologists, philosophers, physicists, IT scientists etc. In 2005 the International Society for Biosemiotic Studies was established and in 2008 the journal *Biosemiotics* was launched (after the unsuccessful launching of the *Journal of Biosemiotics* in 2005) as a forum for exchanging ideas about various forms, approaches and methods in biosemiotics and as a medium for spreading the biosemiotical ideas.

What is biosemiotics. It is necessary to stress that biosemiotics is not, at least from the point of view of its proponents, just a new field of study in biology or a new discipline studying biological foundations of semiosis, be it human or animal, as a process of interchanging meaning through signs. Contrary, for biosemioticians biosemiotics is a new science of living, a new paradigm for biology, its new theoretical framework which should lead us to deeper understanding of life. It is not hard to find similar expressions in almost every biosemiotic book and in number of papers dealing with basic problems in biosemiotics (see for example Sebeok 1968; Barbieri 2002, 2008a, 2008e; Kull et al. 2009; Markoš et al. 2010). These are rather bold claims, the question is what are the arguments they are build upon.

The basic thesis of biosemiotics, the basis for a turning-point in contemporary biology, may seem very simple – semiotics or semiosis, the processes of signs coding, interpreting of the meaning, is another fundamental principle of life (Sebeok 1968, Barbieri 2002, 2008a, 2008d). Semiosis is not a process containing a narrow range of phenomena such as human communication, human language. It is a universal principle underlying the basic processes of life: "Semiotics is a science of signs, and biological semiotics, or biosemiotics, is a new field of research which originated as a study of semiotic phenomena in animals and then it spread on all living organisms. The aim of biosemiotics is an idea that all living organisms are semiotic systems and that semiosis is not a side effect, but the fundamental process of life" (Barbieri 2006). This means that it is not sufficient to define living systems, living organisms in terms of reproduction and

metabolism (or, alternatively, as autopoietic systems). Processes of signs interpretation, information coding and decoding appear on every level of the life organization. Human or animal communication or information coding on the genes level are just specific cases of semiosis in living organisms. The development of the organism, or the process of epigenesis, is a process of information interpretation, and we can not understand what the life is if we do not understand this process. This is why semiosis (because this is the process of semiosis) is the crucial principle of life.

The thesis "life is semiosis" (again, we can find similar thesis in evolutionary theory of knowledge – life is knowledge, evolution is a knowledge gaining process), has two main consequences. The first is the reformulation, reconceptualization of the theory of evolution. Evolution is not merely a process of natural selection acting upon genetic variations. There is another fundamental level in evolution, the level of epigenesis, i. e. the level of organism as an acting agent. What we are lacking in order to achieve appropriate comprehension of life processes is a true unification of evolution and embryology. The aim of such synthesis is to reveal the bridge that exists between genes and organisms. In this way we can understand the mutual connection of molecular evolution, phenotypic evolution and macroevolution. We have to identify the processes that create deeper logic of life. Without this new logic no real unification in biology is possible (see Barbieri 2006). Again, we can find this idea, although in another formulation binding the life and evolution of life to the processes of knowledge, in evolutionary theory of knowledge.

The second consequence is the change in semiotics. When Sebeok writes about "biological roots of semiosis", what he has in mind is semiosis as a general process, general characteristics of life. And this can be described and explained only via semiotics as a general science. If semiotics is a science of signification in language, then biosemiotics is a general science, a science of life as a signification.

Although we can distinguish different approaches on how to develop biosemiotic views on living organisms, the main ideas are more or less common. Barbieri (Barbieri 2009a) distinguishes four different theoretical frameworks or schools of biosemiotics: (1) the physical biosemiotics and Darwinian biosemiotics (Howard Pattee, Terence Deacon), (2) the zoosemiotics and sign biosemiotics (Thomas Sebeok, Jesper Hoffmeyer), (3) the code biosemiotics (Marcello Barbieri) and (4) the hermeneutic biosemiotics (Anton Markoš). In order to identify shared theoretical assumptions and to create a basis for common terminology, in 2009 in the journal *Biological Theory* the main eight theses in biosemiotics were published. These are (Kull et al. 2009):

1. *The semiosic-non-semiosic distinction is coextensive with the life–nonlife distinction, i.e., with the domain of general biology.* This is the thesis about semiosis as a fundamental feature of life. It also means that the concepts of function and semiosis are intertwinned.

2. *Biology is incomplete as a science in the absence of explicit semiotic grounding.* According to biosemioticians biology is dependent on unanalyzed semiotic assumptions and uses "a plethora of implicitly semiotic terms" like 'information', 'adaptation', 'signal', 'code', 'messenger' etc. which are "often applied in allegedly metaphoric way" (ibid, 169). The authors give an example of what they believe to be a proper explanation

of hemoglobin function as a transporter of oxygen. It is not possible to know this function only from its three-dimensional structure, and explaining the function would be only a guess. "But knowing that hemoglobin is a reflection of the need of multicellular organisms to provide energy for the metabolism of somatic tissues, it immediately becomes clear (1) that it must have some structural features conducive to binding and transporting oxygen in blood, (2) that the oxygen-binding region of the hemoglobin molecule is expected to be conserved throughout evolution, and (3) that different forms of hemoglobin differ in specific ways that correspond to different oxygen transport requirements (e.g., in different species or in mammalian gestation)" (ibid, 169).

3. *The predictive power of biology is embedded in the functional aspect and cannot be based on chemistry alone.* For biosemiotics the physicochemical account is necessarily incomplete, it cannot answer the question "What is it (macromolecule, tissue etc.) for". This task can be fulfilled only with adding semiofunctional analysis.

4. *Differences in methodology distinguish a semiotic biology from non-semiotic biology.* The aim of this thesis is to reconcile teleological and physicochemical characterizations of life, which is not possible in traditional biology where the physicochemical and teleological approaches are incompatible.

5. *Function is intrinsically related to organization, signification, and the concept of an autonomous agent or self.* Although the thesis of function-organization relation and function as an output and in the same time as prerequisite for organic evolution (ibid, 170) may seem trivial from the traditional biology point of view, for biosemiotics this is the grounding for a new "logic" of life. This is, of course, not a "logic" as a product of abstract human cognition and thinking, but the process of organism's development in inference-like manner consistent with its environment (ibid, 170).

6. *The grounding of general semiotics has to use biosemiotic tools.* As I have already pointed out, general semiotics is a necessary consequence of the basic biosemiotic assumption, of the identification of life with signification, semiosis.

7. *Semiosis is a central concept for biology that requires a more exact definition.* Perhaps this is the most problematic point of biosemiotics. On the one hand it is ready to challenge the incompleteness of traditional biology, inaccuracy, vagueness and metaphorical nature of some of its concepts, on the other hand the proposed remedy itself seems to be even more inaccurate, vague and metaphorical.

8. *Organisms create their* umwelten. This idea of Jakob von Uexküll, strongly influenced by the philosophy of Immanuel Kant, has already been mentioned. It stresses the active reflection of environment by organism, the fact, that every organism distinguishes different features of the environment and creates its own umwelt.

These theses represent not only theoretical basis more or less common to different schools in biosemiotics. They also identify some crucial problems in biosemiotics.

Problems with biosemiotics. The first problem we are faced with is the diversity of schools, approaches within biosemiotics. There would be no problem with diversity as such (maybe except terminological and/or conceptual problems), if theories, methods, concepts are closely related and working in the same basic theoretical and methodological

framework. This is not the case of biosemiotics, where we can clearly distinguish two fundamentally different and mutually incompatible approaches. On the one side there are authors like Marcello Barbieri and his followers, who stress the scientific nature of biosemiotics (or code biology, the term often used by Barbieri) and the reinterpretation of biology in terms of semiotic should follow rules and principles common in empirical sciences. Barbieri himself explicitly expresses his commitment to the Popperian philosophy of science, his research in biosemiotics should result in creating empirically falsifiable hypotheses. On the opposite side of the biosemiotical spectrum there are the authors representing the *hermeneutic approach* to biosemiotics (Anton Markoš and his Prague colleagues Dan Faltýnek, Fatima Cvrčková, and also semioticians as Emmeche, Kull or Deely).The hermeneutic approach is based upon the idea that semiosis as an essential feature of life is a process of revealing the meaning, and as such in principle inaccessible to empirical sciences. The empirical science, or biology in traditional sense, cannot understand the real essence of life, knowledge of life the science provides is necessary incomplete.

The hermeneutic criticism includes not only traditional biology, but also "scientific" biosemiotics. The views exchange between these two approaches is intensive and sometimes fierce. The hermeneutic approach proponents claim that scientific investigation of meaning is impossible. They see the scientific biosemiotics as "the last cry of positivism" (Deely, see in Markoš et al. 2010), Barbieri's interpretation of organic semiosis as inappropriate, build upon tacit assumption that "anything what is known about living, *must* be the subject of science" (Markoš et al. 2010, 221). This debate is based upon different understanding of science, its status, role and possibilities of empirical methods (for many biosemioticians the dispute is between modern and postmodern science). But not only this. The proper understanding of semiosis in living world itself is also subject of disputes. Whereas Barbieri develops his scientific biosemiotics as semantic or code biology, where the language represents only the third innovation in semiosis evolution (that is in evolution of living) directly connected to human mind and culture (Barbieri 2008b), Markoš and his colleagues claim that the language analogy (which means also the ability of interpretation) is always present at all levels of living. It is possible to understand the essence of life through the language analogy (Markoš et al. 2010, 225).

Besides these distinctions the main problem of biosemiotics seems to be its central thesis. What is the real meaning of stating "life is semiosis, life is signification"? What is the real contribution to the understanding of life and its evolution, if we label them as processes of semiosis and signification? How the methodology will be enriched? How can theory based upon even more vague conceptual apparatus than the criticized theory contribute to deeper understanding of organic processes? And what is the foundation of the central these of biosemiotics? Let us take the example of hemoglobin function explanation from the second of eight theses (Kull et al. 2009, see above). The function of hemoglobin as an oxygen carrier is explained not from its three-dimensional structure (this could be only a matter of guess, authors claim), but from "knowing that hemoglobin is a reflection of the need of multicellular organisms to provide energy for the metabolism of somatic tissues". But how do we know, that hemoglobin is a reflection of the need of

multicellular organisms to provide energy etc.? How did we achieve to such assumption? How can we infer the function of hemoglobin from the reflection of the need of organism? How do we know at all that there is such a molecule as hemoglobin? How do we know about this and other reflections of needs of organism? What is the meaning, if any, of the expression "reflection of need"? Is it not that we can state this only because we know it from previous empirical research? Is it not that knowing the structure is crucial for knowing the function? Would it be possible to guess the function of hemoglobin without knowing its structure?

Another doubts will raise after a look at the logical structure of the argument. From the assumption about the reflection of the need it "immediately becomes clear (1) that it must have some structural features conducive to binding and transporting oxygen in blood, (2) that the oxygen-binding region of the hemoglobin molecule is expected to be conserved throughout evolution, and (3) that different forms of hemoglobin differ in specific ways that correspond to different oxygen transport requirements (e.g., in different species or in mammalian gestation)". The argument resembles the structure of deductive inference. The problem is none of the three consequences follow from the premise. There is neither formal nor semantic connection between the "reflection of need" and proposed empirical features of hemoglobin. In fact, all these features are the result of empirical research which the author use as an obvious (maybe even axiomatic) and tacit assumption of their argument. From this point of view the main thesis of biosemiotics represents only a reinterpretation of existing research results, reinterpretation, which seems vague and resting on unjustified assumptions, and as such redundant and useless.

Barbieri's semantic biology. Marcello Barbieri is one of the leading figures in scientific biosemiotics. He created so called semantic or code biology which is an attempt to reinterpret contemporary biology in terms of Peircean semiotics. The central idea is that there is a coding system not only at the level of genetic information. Organism as an epigenetic system built upon genetic information, but not only from this information, represents the interpretation of organic information. There must be a coding system not only at the level of genetic information, but at every epigenetic level. The development of organism is a process of coding and decoding the information, not only genetic information, but "organic" information, through the "signs" in external world. From Barbieri's point of view a code joins three entities: two independent worlds and a co-demaker. In genetic code the codemaker is a ribonucleoprotein cell system, which is the equally important part of genetic system as genes and proteins. Now it is necessary to identify the parts of this triadic system, which is philosophically an analogy with Peirce's triadic system in semiotics, at every level of epigenesis. In order to stress the importance of codemaker Barbieri proposed to replace the duality of genotype-phenotype with the genotype-phenotype-ribotype triad, where ribotype not only shares the genotype and phenotype ontological status, but also has logical and historical priority (Barbieri 2002, 2006).

The sense of Barbieri's considerations is in stressing the role of epigenesis as another fundamental feature of life. Epigenesis, i. e. the individual development of organism, is a process of semiosis. In fact, it is a process of reconstruction from

incomplete structures, from incomplete information. The genetic information is not the only source of information needed for organism's development, because phenotype is more complex than genotype. The epigenesis as a reconstruction from incomplete structures, incomplete information is a process of convergent increase in complexity, contrary to the evolution which is a divergent increase in complexity. The organic epigenesis as a convergent increase in complexity requires memory (organic memory, memory space, memory matrix). This memory is a place where new informations about the original structure appear in order to compensate the incomplete informations at the beginning. As far as it is possible to connect two independent worlds, such as memory space and structural space, only and exclusively through codes and coding rules (i. e. the set of rules that translate the memory space into structural space and vice versa), whenever there exist two really independent worlds, there must also exist organic codes. For Barbieri, this is an argument justifying the necessity of organic codes existence and also the necessity of code or semantic biology as a new science of living (ibid). And, to go further, this is also an argument for the change in the theory of origin of life and theory of evolution. The thesis "life is semiosis" means for Barbieri "a new paradigm that accounts for the existence of organic codes in the living world and for their contribution to the origin and the evolution of life" (Barbieri 2008a). The organic evolution is not only a process of natural selection acting upon genetic variation, but also a process of natural conventions. The epigenesis plays crucial role in evolution. The core of evolution, i. e. processes of macroevolution, have always been associated with the origin of new codes (representing new natural convention, new relationship between memory and structural spaces. The proper explanation of evolution lies not in the natural selection (which cannot explain the macroevolution), but in the discovery of organic codes (Barbieri 2002, 2006).

Conclusion. There are many problems with Barbieri's semantic biology, but also with biosemiotics as such. First it is its main thesis, its quasi-Peircean interpretation of life. It is truth, that Barbieri's account is a subject of criticism even within biosemiotics, especially from the side of semioticians for his improper interpretation of Peirce's semiotics (see for example Deely 2004, Markoš, Faltýnek 2010). It seems that Barbieri uses Peirce rather as an inspiration for his own organic semiosis. Then, and this seems to be more serious problem concerning each school of biosemiotics, it is using semiotic apparatus in biology. Whenever we take a concept from one discipline and try to use it in another discipline for description and explanation of quite different phenomena, the shift in meaning is a necessary consequence. The result is that the terminology which was thought to replace the old, vague and inaccurate one, is far from being more precise, clear and unambiguous. It is true that contemporary biology also uses terms that are not precise enough (for example information, genetic information, where there are different views whether the sequence of nucleotides is the information itself or whether there is something "more"). I also agree with Barbieri and other authors about the need to distinguish different kinds of information in living systems. The status of epigenetic system and its role in evolution is also another point of discussions in contemporary biology. But I doubt these problems can be solved via the implementation of semiotical concepts and methods, i. e. via implementation of pure interpretational approach without

any serious empirical background. From my point of view biosemiotics offers only a questionable reinterpretation of existing research, only a language metaphor for describing life in terms of semiotics. It is not a step forward, but a step back in science rationale, which is "whatever claims you make, you should always provide a method how to justify or refute them independently of your own beliefs".

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