Bridging Membrane Computing and Biosemiotics

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The syntagma "membrane computing" was invented in 1998, by Gheorghe Păun, at a moment when G.P. already accumulated a considerable work in the field of formal languages and their applications to economics, linguistics and mainly to biology, related to DNA computing; see his joint monograph (with G. Rozenberg and A. Salomaa) on DNA computing at Springer. It happened that in the same year 1998, when membrane computing emerged, the biological membrane became a more important actor in the field of second order cybernetics and in biosemiotics. This fact stimulated us to try to bridge these two lines of development; see the following articles we have published in this respect:

1. Membrane vs DNA. *Fundamenta Informaticae*, 49, 1/3 (2002), 223–227.
2. An emergent triangle: semiotics, genomics, computation. *Proc. Of the International Congress of German Semiotic Society*, Kassel 2002, CD-ROM, 2003.
3. Bridging P systems and genomics. In *Membrane Computing* (G. Păun, G. Rozenberg, A Salomaa, C. Zandron, eds.), LNCS 2597, Springer, Berlin, 2003, 371–376.
4. The duality of patterning in molecular genetics. In *Aspects of Molecular Computing* (N. Janoska et al., eds) LNCS 2950, Springer, Berlin, 2004, 318–321.
5. The semiotics of the infinitely small: molecular computing and quantum computing. In *Semiotic Systems and Communication-Action-Interaction-Situation and Change. Proc. Of the 6th National Congress of the Hellenic Semiotic Society* (K. Tsoukala et al., eds.), Thessaloniki, 2004, 15–32.
6. Semiotic perspectives in the study of cell. In *Proceedings of the Workshop on Computational Models for Cell Processes* (Ralph-Johan Back, Ion Petre, eds.), TUCS General Publication No.47, 2008, Turku, Finland, 2008, 63–68.

In the following we will extract and supplement some basic ideas related to the biosemiotic line of development related to membranes. Bridging this line with Păun's membrane computing seems to be an attractive, if not also a necessary investigation.

Our aim is to reach the metaphorical slogan *Life is DNA software + membrane software.*

Let us first refer to Jesper Hoffmeyer ("Surfaces inside surfaces", in *Cybernetics and Human Knowing*, 5, 1 (1998), 33–42 and, the same author "The biology of signification", in *Perspectives in Biology and Medicine*, 43, 2 (2000), 252–268), claiming that "life is a surface activity", "life is fundamentally about insides and outsides". Hoffmeyer has in view the membrane and quotes in this respect Heinz von Foerster, one of the pioneers of the second order cybernetics, who proposed the Moebius strip as a topological representation of the kind of logic pertaining to self-referential cybernetic systems. Living systems may be seen as consisting essentially of surfaces inside of the surfaces. In this framework, we can speak of an outside interior and of an inside exterior. These categories are realized through semiotic loops.

Relevant parts of the environment are internalized as an inside exterior/inner outside (the so-called Uexkull's Umwelt (see J. Uexkull, "The theory of meaning", *Semiotica*, 42, 1 (1982) [1940], 25–82. The representation of certain environmental features inside an organism by various means, while the interior becomes externalized as an outside interior/outer inside, in the form of the "semiotic niche" (Hoffmeyer 1998), as informes and changed by the inside needs of the organism pertaining to that niche; see C. Emmeche, K. Kull, F. Stjernfelt, *Reading Hoffmeyer, rethinking biology*, Tartu Semiotic Library 3, Tartu University Press, 2002. This inside/outside interplay is made possible by the membrane strictly governing the traffic between them. Now we can claim that P systems (Gheorghe Păun, *Membrane computing: An Introduction*, Springer, Berlin, 2002) find their starting point in this biological reality, to which a computational dimension is added. In agreement with the ideas of DNA computing and membrane computing, S. Wolfram (*A new kind of science*, Wolfram Media, Inc, October 2001) proposed to see life as a universal Turing machine, to which G. Chaitin (In *Bulletin of the EATCS*, 2002) adds the condition of a high program-size complexity. So, the project of bridging genomics and P systems could have the slogan announced above: *Life is DNA software + Membrane software.*