



## The Organic Codes – an introduction to semantic biology

By Marcello Barbieri\*

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After an interval of almost two decades\*, Marcello Barbieri has released his second book on evolutionary biology. He is not only courageous but careful; two previous versions of the book have been available to a smaller circle of readers. This approach is the result of his interdisciplinary nature, for although being primarily an embryologist he is also accomplished in mathematics, molecular biology, evolutionary theory and philosophy.

In this book, Barbieri is trying to bridge the gap between several famous dichotomies, *i.e.* the body and mind dichotomy described by Descartes in the Seventeenth century, the dichotomy of genotype and phenotype noted in the early Twentieth century, the genomic strings and spatial structure of proteins dichotomy first broached in the mid-Twentieth century and still not fully solved, the computer hardware and software dichotomy, and the dichotomy between the present information-based theories of life and the 'vital energies' theories of the Nineteenth century.

The difficulty is that the derived properties are more complex than what produces them and the problem becomes one of building three-dimensional systems 'from incomplete information' in a process akin to *epigenesis*. The author approaches this problem by using a model inspired by procedures taken from tomography, where complex forms are generated from two-dimensional projections. The model, which Barbieri applied to biological processes, was developed by him almost three decades ago and involves 'memory matrices' (memory systems, not always well defined, but modeled as matrices) and 'conventional codes' (it is implied that all codes are conventional). This model supplements the traditional biochemical catalysis mechanisms, which are qualified as informatic, with codified mechanisms. The latter are able to give semantic meaning to organic processes.

The early evolutionary path was from a minimal cell, whose origin, and thus the origin of life, coincided with the appearance of the genetic code. The cell is defined as an autopoietic and *epigenetic* system, with at least one organic memory (the genome) and at least one organic code (the genetic code). In *epigenesis*, the added complexity arises through reconstruction from incomplete information, and evolution occurred by natural selection and natural conventions (the codes).

Microorganisms were the only form of life for 3 billion years. The signal transduction code was already present in prokaryotes, eukaryotes adding the splicing codes. Multicellular organisms depended on cell adhesion codes, and the proliferation of these and other codes has taken place only over the last half a billion years. It is indicated that the organization of a single cell is much more complex than the developmental processes of multicellulars and that most of the crucial and basic evolutionary innovations had already occurred in unicellular organisms.

According to Barbieri, collective or organic memories are modeled as matrices developed in discontinuous stages and dependent on their respective codes. They go from, *e.g.*, Spemann's determination mechanisms at the cellular or tissular stages, to Cuvier's body plans or von Baer's patterns at embryogenesis. Following the same line of argument the author suggests that the development of language is based on a linguistic code or 'mind plan', akin to the innate universal grammar suggested by Chomsky, encompassing the nature *versus* nurture, and the heredity *versus* environment dichotomies.

Barbieri's 'memory reconstruction method' is capable of increasing the complexity of a system and also functions as an anti-chaos mechanism. The processes work in a necessarily convergent way, for integration of tissues and organs into the system of multicellular organisms, a degree of divergence being added by phylogenetic processes. Codes for the organic (epigenetic) memory matrices can be used to reconstruct the 'real space' of the organic system, thereby reaching meaning.

Meaning becomes just the procedure through which an object can be related to another *via* a code. Codes are defined as conventional sets of rules that establish correspondence between two independent worlds. Information is the simple structure of signs, chemical radicals or words. These are individually arbitrary but acquiring meaning when integrated into a systemic collectivity through community laws. Meaning and semantics are always relative to the working system.

Transcription (catalyzed assembly) is only informatic, while translation is coded assembly. The codes have to be rigid enough to provide biological specificity. Barbieri assumes that the genetic code arose as a mechanism *for* the translation of mRNA strings. The world of RNA-derived proteins did not yet exist but came into being after the development of 'adaptors' (tRNAs), this protein

world being independent, with structures and functions of a different nature to the RNA world. The fact that both proteins and adaptors are derived from or are themselves RNAs does not seem to bother Barbieri in considering the intermingling of the two worlds. The authors argument for a code is that the connection between the nucleic acid world, through anticodons, is independent of the amino acid acceptor sites.

Genes intervene only at the primary transcripts step and a splicing code in the form of adaptors such as the small nuclear RNAs of spliceosomes gives mRNAs their meanings, and these are further decoded at translation.

Acquisition of tertiary structure by proteins and the formation of metabolic networks are not among the main subjects of the text, nor is there a full discussion of the role of environmental interactions, although it must be acknowledged that Barbieri's main focus is on the endogenous properties of organisms. Receptors and the signal transduction code — cAMP, calcium ions, inositol triphosphate and diacylglycerol — are more important than effectors. The reader is left with the feeling that environmental factors are too 'diffuse', non-specific and poor. This 'poverty of stimuli' approach seems to be acceptable from a linguistic point of view but may provoke reactions from the bio-semiotic school. The code-maker and the code itself are the two other parts of Peirce's triadic system of giving meaning to objects.

Barbieri also questions why biologists have failed to look for other codes and are satisfied with the genetic code alone, theorizing that, unlike the genetic code, biologists did not see other codes as being necessary. The genetic

code was theoretically predicted and then found, while there was no prediction of other memories and codes; so these were not looked for and obviously would not be found. 'Now the theory is clear and they will be found'. According to Barbieri, all the mechanistic descriptions which constitute the large edifice of biochemistry and biology should now be rearranged and grouped into the new categories, marking the birth of semantic biology. Codes are everywhere, and it might be envisaged that in the near future the biological community may be much more concerned with codes not only as a theoretical necessity but as entities in themselves residing in organisms.

The text of Barbieri's book is clear and very enjoyable to read, consisting of an Introduction in the form of an overview of the whole book and further nine chapters (The microscope and the cell; Theories of evolution; A new model for biology; Organic codes and cell memories; The origin of life; Prokaryotes and eukaryotes; The Cambrian explosion; Semantic biology; A brief summary, with eight basic propositions – principles and models) plus an Appendix containing a collection of more than 60 Definitions of Life. It introduces relevant and challenging ideas to the body of thought of biologists and of other science readers, but comes with 'certificates of qualification' by Michael T. Ghiselin (Foreword) and Jack Cohen (Afterword).

\*M. Barbieri, *Teoria Semântica da Evolução*. Editorial Fragmentos Ltda, Col. Biblioteca Científica, Lisboa, 1987, (tradução de M.L. Pinheiro do original italiano *La teoria semantica dell'evoluzione*, Boringhieri), 187 pp; *The Semantic Theory of Evolution*. Harwood, Chur - Switzerland, 1985, ISBN 3-7186-0397-7.