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Review article by Marcello Barbieri

Has Biosemiotics come of age?

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Jakob von Uexkull: A paradigm for biology and semiotics

This very special issue of *Semiotica* is dedicated to celebrating the coming of age of biosemiotics, the study of living systems from a semiotic perspective, by celebrating Jakob von Uexküll as the once forgotten chief architect of the new discipline. The recovery of *a "neglected figure in the history of semiotic inquiry"*, and the proclamation of a new scientific domain, are certainly worthwhile academic pursuits, but the general reader may feel, at first, that such specialized items do not concern him. In this case, however, he would be wrong, because underneath the academic niceties one can feel, in almost all papers of this volume, a powerful, pulsating new vision about the fundamentals of life: a new theory of signification and biological meaning.

In the very opening paper, Kalevi Kull, the guest editor, puts the cards on the table in no uncertain terms*: "Sign science and life science are coextensive"*, *"semiotics is biology and biology is semiotics"* (p.3). And the message is promptly reinforced with a quotation from Umiker-Sebeok: *"If, according to semiobiological theory, all living things are signs, and signs are living things, then life* qua *signs must be seen as constantly evolving according to certain general rules, for* '*symbols grow*'*"*. The concept is hammered out again in the following paper by Thomas Sebeok: *"Because there can be no semiosis without interpretability – surely life's cardinal propensity – semiosis presupposes the axiomatic identity of the semiosphere with the biosphere"* (p.68).

The reader is warned. It is not a small academic niche which is discussed here, but an entirely new conception of biology: *life as semiosis*. And more is to come. The third paper, by Frederik Stjernfelt, begins with the announcement that *"Jakob von Uexküll's theoretical biology is a main contribution to the developmental, or epigenetic, trend in the biology of recent centuries, a lineage involving scholars like Goethe, Saint-Hilaire, von Baer, d'Arcy Thompson, Spemann, Driesch, Waddington, Brian Goodwin, René Thom and Stuart Kauffman"* (p.79). This lineage has been the historical antagonist of the 'mechanistic' approach of Galileo, Descartes, Newton, Lamarck, Darwin, Mendel, James Watson, Francis Crick and Jacques Monod, an approach which has produced what is still the main paradigm of modern biology. This special issue, in short, not only presents a revolutionary idea of biology, but also announces that such a revolution comes from the heirs of the historical opposition to mechanism. And this is no isolated announcement. 41 distinguished academics from 15 different countries have produced a 828-page volume with papers on history, philosophy, theoretical biology, ecology, linguistics, arts, literature and computer science, and all come, by varying degrees, to similar general conclusions. The

volume owes in fact its remarkable overall unity to this ideal convergence, and there is no doubt that its aim is to strike at the very heart of the life sciences.

In such a situation, a reviewer can hardly avoid getting involved, but first I will try to describe, as impartially as I possibly can, the three main points of this book: (1) the making of biosemiotics, (2) the redeployment of Jakob von Uexküll, and (3) the endorsement of a non-mechanistic science of life.

The making of biosemiotics

Semiotics, *the science of signs*, belongs to the humanities, because it has always been taken for granted that signs, or symbols, are quintessential cultural products. The idea that man evolved from animals implies of course that culture has biological roots, but this has never undermined its independence from 'the brute forces of nature'. For the development of mathematics, for example, it is irrelevant whether animals are able to count or not, and similar considerations appeared to apply to the humanities in general and to semiotics in particular. Even the discovery of animal psychology and the development of ethology did not much change the status of semiotics, since primitive forms of communication seemed to have very little to say about the complex architecture of human semiosis. It was therefore very bold, and very risky, of Thomas Sebeok, to suggests, in the early 1960s, that human semiotics *needs* to be complemented by animal semiotics (or *zoosemiotics*, as he called it in 1963) in order to find its proper place, and its real nature, within the larger framework of general semiotics.

Sebeok knew of course that this idea would not have stood a chance unless he could back it up with some experimental data, and so he started looking around and digging in various gardens, particularly in psychology, medicine and molecular biology. And the hunt paid off. In his contribution to this volume, Sebeok presents a streamlined account of his life-long chase, and declares that he got the crucial experimental clues from three men: Heini Heniger (1908-1992), Giorgio Prodi (1929-1988), and, above all, Jakob von Uexküll (1864-1944). The first two he met personally, while the encounter with Jakob came from reading, in 1976, the original German edition of *Theoretische Biologie* (1928). This was apparently a kind of 'fulguration on the road to Damascus', so much so that Sebeok decided to end his individual search and start an active campaign of proselytization. In August 1977 he delivered his now historical speech on 'Neglected figures' at a congress in Vienna, and from that time on the making of biosemiotics became a collective enterprise that Sebeok led with all the academic and editorial power he could muster. In this campaign he was quickly joined by Thure von Uexküll (Jakob's son), who could argue, from within his own professional field, that medicine has been a semiotic discipline since antiquity, because it has always been concerned with the interpretation of clues.

Sebeok's own idea of zoosemiotics was generalized in the process. Originally he had only taken animals into consideration because of the commonly held idea that semiosis requires a nervous system, but in 1981 Martin Krampen showed that plants too engage in vegetable semiosis (phytosemiotics). In 1988, Giorgio Prodi spoke of *signs and codes in immunology*, thus extending his 1977 idea of the natural semiosis of cells, and Sorin Sonea proposed that semiosis goes on even in the bacterial world, which can be regarded as a true global organism. The word 'zoosemiotics' was clearly inadequate, and Sebeok decided to replace it officially with 'biosemiotics', a term proposed by Juri Stepanov in 1971, but which appeared for the first time (with a

restricted meaning) in 1961, when Friedrich Rothschild used it to indicate a semiotic approach to psychology.

The making of biosemiotics gathered further momentum in the 1990s, with the joining in of a younger generation and the increasing participation of biologists. Among these, Jesper Hoffmeyer and Claus Emmeche, who founded a Biosemiotic Group in Copenhagen, and Kalevi Kull, who became director of the Jakob von Uexküll Center in Tartu, Estonia. Biosemiotics has thus become a well established interdisciplinary field, and perhaps it is fair to say that its development was formally completed in 2001, when the first Gathering *exclusively* dedicated to biosemiotics took place in Copenhagen (by which time the official Directory listed 61 biosemioticians from all countries of the world).

The making of biosemiotics has been therefore a 40-year-long affair (1961-2001), which can be divided into two phases: the first (1961-1977) was a period of uncoordinated attempts, often of utterly isolated initiatives, while the second (1977-2001) was a period in which individual ideas could fall on a more receptive ground and contribute, under the discreet supervision of Thomas Sebeok, to the collective growth of the field.

The redeployment of Jakob von Uexküll

In 1905, Jakob von Uexküll published a book on the physiology of marine animals (*Leitfaden in das Studium der experimentellen Biologie der Wassertiere*) where he described a neuromuscular cycle (later a functional cycle) which can be regarded an early formulation of the feedback principle. In a second book, published in 1909 (*Umwelt und Innenwelt der Tiere*), he adopted the word *Umwelt* (coined by a poet in 1800) to indicate the subjective world of an organism (the combination of its *perceptual* world with its *operational*, or *motor*, world). These two concepts – functional cycle and Umwelt – formed the basis of his major book, *Theoretische Biologie* (1920 and 1928), and are to this day his true biological heritage.

The functional cycle was further developed by Charles Sherrington into the negative feedback principle of the reflex arc, while the Umwelt idea had an influence on some philosophers (Ernst Cassirer and Martin Heidegger, for example), and was instrumental for Konrad Lorenz's development of ethology. All of which explains why, in biology's history books, Jakob von Uexküll is mentioned as a precursor (some say a co-founder) of both animal cybernetics and ethology. And that is probably what he would have continued to be remembered for, had it not been for Thomas Sebeok's 'discovery' that Uexküll's greatest merit was his contribution to *semiotics*.

As a matter of fact, Uexküll himself categorically denied (in a letter to a linguist friend) that he ever had anything to do with semiotics, and Sebeok did not actually call him a semiotician, but only a *cryptosemiotician ("einer der grössten Kyptosemiotiker seiner Zeit"*). Be that as it may, the fact is that in this special issue of *Semiotica* Uexküll is extensively redeployed as a chief architect of the modern discipline of biosemiotics, and so we can only ask ourselves if such a claim can be justified.

First however let us notice that the redeployment operation had to face the fact that Uexküll's philosophy of life was, to put it lightly, somewhat dated. He was not only a staunch anti-Darwinist, but also a feeble evolutionist (verging on creationism), had strong sympathies for Hans Driesch's vitalism, and often resorted to musical metaphors to explain the perfection of the living world. To the credit of this issue's contributors, these points have not been swept under the carpet, and this makes it

easier to leave them in the background. It is only the main idea, after all, which must be good. And Umwelt is indeed an excellent idea. More than that. It is a deep concept, not at all easy to grasp, but once grasped is breathtaking. Surely one of the most original concepts of twentieth-century biology.

Uexküll started from Kant's idea that we do not know the world as it is (the thing in itself), but only what our mind reconstructs from the inputs of the senses, and the mind does not start from scratch in this enterprise but from inborn ideas, that is, from 'inner forms of perception'. The mind is therefore two things in one: an inner mind which provides the basic tools, and an outer mind which builds the world of appearances around us. Uexküll was deeply committed to this brand of idealism, and even when he had to take some liberties in order to apply it to biology, he never thought he was being unfaithful to his master. But liberties he had to take, and he took them.

The first was to recognize that the body takes an active part in the production of mental objects. This is why Uexküll did not speak of inner and outer minds, but of inner and outer subjective worlds: *Innenwelt* and *Umwelt*. In any organism there is something which remains private, and something else which is projected to the outside to become the world of appearances. This is Umwelt: the mental bubble that we perceive as our surrounding world.

The second liberty that Uexküll had to take was the recognition that animals have nervous systems similar to ours, and so they too must have Umwelts. Which is more or less what we mean today when we say that animals too have minds. But together with similarities there are also differences between the nervous systems of our fellow animals, and so their Umwelts are not alike. As a matter of fact, every species must have its own Umwelt because it reacts in a distinctive way to the same signals from the physical world. The concept of space is a good example here. We are convinced that we live in a three-dimensional world, but this is because the semicircular canals of our inner ear are at right angles and allow us to perceive three different directions. The same is probably true for all animals which have semicircular canals, but not for those which are deprived of them. Many animals therefore have a perception of space which is totally different from ours, and we cannot even imagine what it must be like living in a different space.

Uexküll's greatest insight, however, was probably his third amendment to Kant. He was drawn to it by the fact that animals can play, cheat, threaten, court and act (and now even dream), all of which suggests that they can react to the same stimulus in many different ways. Which in turn means that animals are *interpreters*, not just receivers, of signals. Interpreting implies the ability to transform signals into signs by giving meaning to them, and so we have before us all three basic elements of semiosis: object, interpreter and sign. Uexküll however used the word 'cue' instead of 'sign', and this is why he was not aware that he was dealing with semiotics. But 'cue' can well be regarded as a 'cryptosign', and so Sebeok was right after all in defining Uexküll a 'cryptosemiotician'. Which brings us to the conclusion that it was indeed right and proper to celebrate him as a chief architect of the modern field of biosemiotics.

The endorsement of a non-mechanistic biology

Most contributors to this special issue of *Semiotica* have openly admitted that some of Uexküll's ideas are no longer tenable, but no one has objected to his opposition to mechanism. And this for the very good reason that they too share, more or less

wholeheartedly, this attitude. The endorsement of a non-mechanistic approach to life is indeed a constant underlying theme of this volume, to the point that one is almost unwittingly driven to the conclusion that biosemiotics must be incompatible with mechanism. The most outspoken expression of this stance comes from Claus Emmeche, and so it is his paper that I am referring to, but only in respect to the points that are shared by most biosemioticians. Emmeche starts by debunking one of the most common cliché of our times: the idea of *"twentieth-century biology as a fight between vitalism and mechanicism that finally was won by mechanicists".* He points out that *"the resolution of the debate was not a mechanistic stance but a sort of historical compromise"* that has been called *organicism* (p.657).

This is very thoughtful and, sadly, very true. The fight has indeed been between three ideologies, and the winner, today, is not mechanism but the 'third road' that has *improperly* been called 'organicism'. I say improperly because the debate has been between three theoretical stances that according to logic correspond to *mechanism*, *antimechanism* and *non-mechanism*. Antimechanism is virtually synonymous with vitalism, and in this case the two names are interchangeable (antimechanism is only slightly more general). Organicism and non-mechanism, instead, are not equivalent at all, and in this case we will see that the distinction is important because it is a matter of substance, not of terminology. In order to develop this point, however, we first need to make clear what mechanism actually is.

One of the expressions that best catches the spirit of mechanism is John Maynard Smith's statement that *"we understand biological phenomena only when we have invented machines with similar properties"*. In fact, 'understanding' something means explaining it with a model that we are familiar with, and a machine gives us an immediate sense of familiarity. When we see it working before our eyes, we instinctively feel that we 'know' it. Actually, we do not even need to build a machine to get this feeling. A description is enough, and so a 'machine' is often just a 'machine-model', or an *algorithm*. One of the most famous machines of all times was built by Turing with just pencil and paper. A machine model, furthermore, is not necessarily a set of mathematical equations. Natural selection, for example, is a mechanistic model which is entirely expressed in words. The important point is that the model has the *logic* of a machine (i.e. that it delivers the same sense of familiarity that we get from a real functioning machine). Mechanism, in short, is the view that scientific knowledge is obtained by building machine-like models of what we observe in nature.

Let us now examine 'organicism', the dominant paradigm of modern biology. The standard view, faithfully reported by Emmeche, is that organicism is qualified by being *"non-vitalist, non-reductionist, and emergentist"*, and so let us see where the contrast with mechanism comes from. Needless to say, mechanism too is non-vitalist, and so the difference seems to come from non-reductionism and emergence. But a machine is a machine not when it is reduced to pieces, but precisely when it is put together into a functioning whole, which means that mechanism is *quintessentially* a non-reductionist approach. As for emergence, there is absolutely nothing in mechanism that prevents it. Take a machine that brings in hydrogen from one side and oxygen from another and there you can witness the emergence of water. In brief, it is not only misleading but downright wrong to say that the combination of 'non-vitalism+non-reductionism+emergence' amounts to something different from mechanism, because those three properties actually *belong* to mechanism.

The real problem is: why do so many biologists believe in such a muddled conclusion? This is where the difference between organicism and non-mechanism becomes a matter of substance. What most contemporary biologists share is actually

non-mechanism, i.e. the feeling that mechanism is not enough, that there must be something else in life, and this is a profoundly respectable view. The point is that one cannot make a science out of doubts, and so some people (Ernst Mayr first in line) had this splendid idea of taking three outstanding properties of mechanism and saying that together they form 'organicism', the new philosophy of life that liberates biology from mechanism.

Claus Emmeche does not comment on organicism as such, but he must have felt uncomfortable with it, because he quickly distinguishes between *mainstream organicism* (the official version) and *qualitative organicism*, an interpretation that comes out of this volume as the view which is shared by most biosemioticians. Qualitative organicism (that in my opinion should be called qualitative biology) is the most serious attempt produced so far to put some substance into the empty container of non-mechanism without resorting to the tricks of official organicism. Emmeche describes it in this way: *"Qualitative organicism is concerned with qualities which are not only of the famous category of 'primary' qualities (roughly corresponding to the scientifically measurable quanta), but also concerned with the 'secondary' qualities of color, taste, sound, feeling, etc."* (p.658*) … "It is obvious that the Umwelt notion is of central importance to the development of a coherent theory of the qualitative experiential world of the organism, a task present day biology must face, instead of continuing to ignore a huge phenomenal realm of the living world – the experiential world of animal appetites, desires, feelings, sensations, etc."* (p.659).

Here we are then. So far biosemiotics has been the discipline which has discovered that animals are interpreters, or semiotic agents; now we are told that mechanism is not competent to study this new world. Only a qualitative science can do that. Why? Because mechanism cannot explain *meaning*, that's why.

One is not supposed to object to this piece of wisdom, but mechanism has proved to have an unsuspected resilience in the past, and has changed its skin many times in the face of adversity. The first mechanistic model of the body was the clock-machine, then came the steam-engine-machine, and lately the computer-machine. Which is equivalent to saying that mechanism introduced in biology first *mechanical energy*, then *chemical energy*, and finally *information*. Are we really sure that it cannot introduce meaning? This special issue of *Semiotica* seems to be saying that only a qualitative approach can cope with biological meaning, but we really cannot rule out a mechanistic approach. Our only option, I am afraid, is to discuss both views.

The biosemiotic approach to meaning

Perhaps the most instructive and surely the most enjoyable part of Uexküll's work is his description of real-life cases of animal behaviour, cases that he reports with the light touch of the consummate expert and a masterly attention to details. It is in fact this evidence which convinces us that animals are indeed interpreters of the world, and not pre-programmed puppets. And that is really all we need to know in order to conclude that animals are 'subjects' (i.e. semiotic agents). We would need something else if we wanted to know *how* they do their semiosis, but in order to realize that they do it, the description is enough. In this case, seeing is believing.

Uexküll's biology is therefore first and foremost a descriptive science, not an explanatory one, a point which is underlined in the excellent paper contributed by Tuomo Jämsa*: "Uexküll does not expressly aim at creating an articulated theory of sign and meaning but at a description of the functions of the organisms in terms of*

signs and meaning" (p.493). On many occasions it may appear that Uexküll is not just describing animal behaviour but also explaining it, and his theory of functional cycles may look like a mechanistic model, but it's nothing of the kind. A mechanistic model would say that animals receive signals from the physical world and react to them in a subjective way, which means that somehow and somewhere the signals are transformed into signs and the signs are processed by an interpreter, but all this partitioning is thoroughly alien to Uexküll. As a dyed-in-the-wool idealist, he regards signifying and interpreting as subjective operations which are *consubstantial* to any signal processing act.

In the physical world there are inanimate objects without 'qualities', but life is like a world where a sun is shining, and in such a world you cannot have objects without shadows, the shadows being the qualities which are cast into the subjective world from the quantities of the physical world. In a truly idealistic philosophy, the positions are actually reversed: the qualities, or ideas, being the real bodies, and living organisms being their shadows. This 'swapping of the roles' was operated by Plato in his famous *myth of the cave*, and has stuck in our culture ever since.

When Uexküll speaks of perception, he may seem to be putting signals first and signs second, which would be like an attempt to 'naturalize' Kant and Plato, but that is just an impression. The idea that perception starts with objective signals from the outside which are transformed into subjective signs by the organism is a mechanistic way of looking at things that Uexküll regards as pitifully naive. For him, the objects 'out there' are in fact mental entities created by the subject and projected to the outside, and so there is never a divorce between signals and signs. Quantities and qualities, objects and subjects, bodies and shadows can never be taken apart when the sun of life is shining.

A similar view of the world was also proposed by Charles Peirce, the acknowledged father of semiotics. He stated clearly that semiosis requires three basic elements – object, interpreter and sign – which are *preconditional* and therefore *primitive* entities. They must be present simultaneously in order to have semiosis, and since they are the starting point they cannot be reduced any further. Again, they are consubstantial agents of semiosis, just as Uexküll treated them.

From this special issue of *Semiotica* it seems that most biosemioticians accept both Uexküll's approach and Peirce's scheme, and therefore it is fair to say that the theoretical framework of biosemiotics is based on the ideas of Immanuel Kant, Charles Peirce and Jakob von Uexküll. In this framework, objects, interpreters and signs are primitive entities, consubstantial protagonists of any semiotic act. But a semiotic act is always associated with a signaling process, and signaling is everywhere in life, so semiosis too must be everywhere. This is why we are told *that "semiotics is biology and biology is semiotics"*, *"the semiosphere is coextensive with the biosphere"*, *"the basic unit of life is the sign, not the molecule"*.

If semiosis is everywhere, life is immersed in it like in Hegel's famous night where all cows are black. When something is everywhere and primitive you don't need anything else. You just accept it and contemplate the omnipresence of meaning in life. That is the comfort that philosophy and biosemiotics can give us, and thank you very much for it.

But mechanistic science is not like that. Stubborn, nosy old mechanism wants to open up even primitive boxes and look inside them: Where is the interpreter? What it is made of? How is the interpreting done? What is a sign? Where does meaning come from? What is meaning?

A mechanistic approach to meaning

If you are a mechanist and you want to study the problem of biological meaning, you don't start with the assumption that meaning is everywhere, but the other way round. You say that you are not going to recognize the existence of anything which may be called 'meaning' unless you fall flat in its face. The evidence provided by animal behaviour is convincing enough, but animals are complicated things, and are also late-comers in the history of life, so they are not the best to start with. It seems much more sensible to begin from the beginning (i.e. from molecules), and work our way up.

Down there, at the molecular level, there are all sorts of transactions going on, and we can scrutinize them one by one to find out what makes them tick. Take for example the breakdown of sugar. At every step there is a transformation of energy with the assistance of catalysts, and that is really all there is to it, from beginning to end. In the replication of DNA molecules, instead, we encounter something else. Again we find energy exchanges and catalysts at each step, but here the end-products can be very different even when the energies and the catalysts are exactly the same. The difference is due to the linear order of the building-blocks (the nucleotides), an order that amounts to no less than a new physical quantity which has been called *information*.

If we extend our scrutiny, we realize that countless biochemical reactions can be divided, like the above examples, into two great categories: the class where all that takes place is transformations of energy, and the class where the physical quantities that count are two, energy and information. With just these two quantities we account for so many molecular transactions that there seems to be no need for anything else. Except that Nature, as usual, seems to like coming up with surprises. In our case the unexpected takes the form of protein synthesis, because by using only energy and information there is no way we can explain the fact that a chain of nucleotides is always transformed into a unique chain of amino acids. It is like obtaining the letters of the alphabet from combinations of dots and dashes. There simply is no necessary connection between those entities, and the only way to establish one is by inventing it (i.e. by creating a code). A Morse code in the case of the alphabet, and a genetic code in the case of protein synthesis.

The Morse code is built by a human being (the interpreter) who attaches a meaning to arbitrary combinations of dots and dashes (the signs) by setting them in correspondence with the letters of the alphabet (the objects). In protein synthesis, combinations of three nucleotides (the signs) are set in correspondence with amino acids (the objects) by special compounds known as *adaptors*, i.e. *by molecules that perform two independent recognition processes* (one in the nucleotide world and one in the amino acid world). In this case the agent implementing the code (the interpreter) is the entire set of adaptor molecules. Protein synthesis, in short, is a true semiotic act because the three defining protagonists of semiosis are all present, the only difference with cultural semiosis being that the interpreter is not outside the system but very much inside it. Can we generalize this experimental result? Indeed yes, we can. Any time we discover that the link between two organic worlds requires not only catalysts but also adaptors, we are very likely to be in the presence of an organic code, and therefore of organic meaning.

All this seems to be accountable with the step-by-step procedures of mechanism, but qualitative organicists apparently do not agree. Semiosis is not explicable by mechanism, they say, and a good empirical proof of this is that semiotic machines do not exist. Nor it is helpful to suggest that they may exist in the future, because the

issue is not the technicalities of implementation of such machines, but the very possibility of their ontological existence. We seem to be in a no-win situation here, because it is true that all mechanistic models proposed so far, including the heterogeneous approaches which are collectively known as 'non-linear methods', have nothing to do with codes and meaning.

Clock-mechanism, steam-engine-mechanism, computer-mechanism, and now even nonlinear-mechanism, have solved many biological problems, but have not even touched the problem of meaning, which remains 'in principle' outside them, like an alien creature. In a recent book however (Barbieri, 2001), I have described a mathematical model of epigenesis where codes have an *internal* role, and this does make a difference. It tells us that there is a whole new class of models, and therefore a new type of mechanism (we may call it *epigenetic mechanism*), where codes are not alien creatures but components of the system that must necessarily be present for the system to work. It is not the solution, yet, but it does look like the foot in the door.

Mainstream organicists and qualitative organicists may well be responding with enthusiasm to the *"United against mechanism?"* rallying question that Malte Herwig is launching from this special issue (p.569), but I am not. The best chances to solve the new problems of life are still likely to come from where all our solutions have always come in the past: from good, rational, old-fashioned machine-like models.

Conclusion

This special issue of *Semiotica* is truly a rare book. It gives an overall view of a fascinating new field in its adolescence, when it has just completed the difficult process of growth and it is preparing to enter the creative phase of maturity. The volume is also an excellent example of a fresh way of doing academic research, where interdisciplinarity is not just an empty word but a convincing reality. The contributions from history, philosophy, linguistics, biology, art, literature and computer science integrate each other with an ease that makes one wonder why on earth the same approach has not been applied to all other fields.

The first two main points of this special issue – the making of biosemiotics and the recovery of Jakob von Uexküll from oblivion – come out with clarity and force, and are definitely a success. Normally this would have been more than enough for one book, but unfortunately there is also a third less happy theme that is developed throughout the volume. The endorsement of non-mechanism, or qualitative organicism, is in my opinion the first serious mistake of the young field of biosemiotics. Indeed it is the one drawback that can prevent it from growing into a true science. I must conclude therefore that biosemiotics has not yet come of age, but I do hope that this criticism is taken for what it is: a diagnosis that is supposed not to hurt but to help.

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Marcello Barbieri (b. 1940) is University professor of embryology at the University of Ferrara in Italy. His research interests include embryology and theoretical biology. His major publications include ‘The Ribotype theory on the Origin of Life’ (1981), *The Semantic Theory of Evolution* (1985), and *The Organic Codes. An introduction to semantic biology* (2003).