In the quest for novelty: Kauffman's biosphere and Lotman's semiosphere

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Abstract. The emergence of novelty in the realm of the living remains, despite the long tradition of evolutionary biology, unwelcome, calling for explanation by old, established knowledge. The prevailing neodarwinian evolutionary paradigm approaches living beings as passive outcomes of external (and extraneous, hence "blind") formative forces. Many teachings opposing Darwinism also take the existence of eternal, immutable and external laws as a necessary prerequisite. Ironically enough, authors who oppose Darwinian theory, and admit that living beings possess a "self", often accentuate internal, ideal and eternal harmony, which is incompatible with historical changes; moreover such harmony is again imposed by external, atemporal "laws". I describe here a third approach embodied by the names of two unrelated scholars, Stuart Kauffman (biology, physics) and Juri Lotman (semiotics, culturology). Their approach suggests that the evolution of organisms, minds, cultures — is a continuous negotiation (semiosis) of 'laws', driving to ever broader spaces of freedom and constantly larger autonomy of existence.

> *Es klingt wie eine banale Selbstverständlichkeit, wenn man den Satz aufstellt: Die Kaffeetasse ist kaffeehaft. Doch besagt der Satz mehr, als es den Anschein hat. Er besagt, daß die Leistung der Tasse darin besteht, den Kaffee zu beherbergen, aber darüber hinaus, daß diese Leistung zugleich das Motiv für ihre Herstellung war.*
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> Jakob von Uexküll (1958: 146)[1]

[1] "It looks like a banal self-evident truth when we say that a coffee cup is of coffee-nature. Yet the sentence explains more than is apparent. It suggests that the performance of the cup is in harboring coffee; before all, however, it suggests that this very performance served as a motive for the making of the cup."

> *Nous verrons que certaines rêveries poétiques sont des hypothèses de vies qui élargissent notre vie en nous mettant en confiance dans l'universe.* […] *Un monde se forme dans notre rêverie, un monde qui est notre monde. Et ce monde rêvé nous enseigne des possibilités d'agrandissement de notre être dans cet univers qui est le nôtre.*
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> Gaston Bachelard. (1960: 7)[2]

Science is conservative: an innovation is rarely welcome. Reality does not change: this is the basis of its objectivity — and of scientific knowledge as well. Any novelty, or unexpected (unpredicted) phenomena, must be explainable (or explained away) within the frames of extant knowledge. Thus, the idea that novelty might appear in the world studied by natural sciences has always been met with the greatest suspicion. The quest of modern (Newtonian) science has focused on the axiom of timeless, eternal "natural laws". In such a world, there is no room for any genuine change: for contingence singularities, inventions, progress, creative acts, free choice etc. Actual history is not allowed, and the task of evolutionism is to merely reduce apparent changes of living forms to combinations and recombinations of chemical elements.

If chaotic, haphazard phenomena are observed in a world allegedly governed by mathematical rules, for science it simply means that the system is too complex (in the number of components or in the terms of computation) or our methods are not sensitive enough to decipher the order reigning in the background. The question *whence the rules themselves came into the picture* is forbidden — they are simply there — whether they originated as prescripts by god, or are implied by geometrical, mathematical and logical principles, or were a result of primeval events (symmetry breaking) following the Big Bang, which then froze forever. Hence the difficulties which great biologists like Hans Driesch, Theodor Eimer, Jakob von Uexküll or, in our times, Anderas Suchantke have had in accepting evolution. These and

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[2] "We shall see that some poetical daydreams represent hypotheses of our worldviews that enrich our lives by establishing our intimacy with the universe. From such daydreams will arise a world which is ours. And this dreamt-of world renders a possibility of uplifting our being to this universe which is ours."

other great German scientists tried to maintain the purity of science against haphazard and spontaneous events.[3] Their leading axiom was the existence of harmony in nature, nature as a *glockenspiel*: they saw the task of a biologist as being to write down the score (already existing, but hidden) of the natural symphony (as perfectly as possible).

We should not be misled by the contemporary neodarwinian paradigm concerned with the quest for tricks which allow chance to be introduced into biological science, while remaining in the good old realm of eternal computable rules. Yet uneasiness and perplexity is being felt, leaking through statements from people trying to make a serious attempt to reconcile mechanistic science with blind chance (for a superb illustration of such a vain enterprise see Monod 1970, or Jacob 1970).

On the other hand, in some realms of the humanities, the existence of novelty and creativity is being admitted. Hermeneutics, semiotics, history, poetry etc. teach us how meaning can and *does* arise. The problem is that these fields indeed are "humanities", i.e. they concentrate on *human* affairs. Attempts to broaden their realm into biology are received with suspicion or even contempt — paradoxically from both sides of the trench dividing the realm of human knowledge. Thus, a phenomenologist speaking of the lived world (*Lebenswelt*)

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[3] Here are some examples of such a bureaucratic science, which describe a lawful, strictly disciplined world: (1) "Alles in der Natur muß selbstverständlich Gesetzen folgen — kein Vernünftiger wird das bestreiten. Aber das von Darwin angenommene Abändern nach den verschiedensten Richtungen ist ein regelloses, zufälliges im Vergleich zu dem gesetzmäßig nach bestimmten Richtungen vor sich gehenden, wie ist es thatsächlich nachweise" (Eimer 1897: xi); (2) "The 'law of nature' is the ideal I am speaking about, an ideal which is nothing less than one of the postulates of the possibility of science at all" (Driesch 1929: 4); (3) "Die verschiedenen Tiere und die Pflanzen eines bestimmten Lebensraumes gleichen Organen oder Zellen eines Einzelorganismus darin, daß sie innerhalb des ihnen übergeordneten lebendigen Ganzen bestimmte festumrissene Funktionen erfüllen und in diesen Aktivitäten mit anderen Mitgliedern dieses Gefüges in Verbindung und Austausch stehen; in seiner Gesamtheit ergibt das ein lebendiges Funktions- und Tätigkeitsgeflecht von unerhörter Komplexität. Das alles hat sich nicht irgendwie zusammengefunden, sondern unterliegt formenden, dirigierenden Kräften übergeordneten Charakters, wie es sich etwa im Zusammenspiel von Feuchte und Trockenheit, Helligkeit und Dunkel, Wärme und Kühle zeigt" (Suchantke 1994: 68).

feels *quite* indignant when a biologist suggests applying his insights on non-human living beings: he simply finds the idea improper.

By the same token, concepts borrowed from humanities soon suffer semantic degradation. Thus, in informatics, *information* became but another calculable magnitude upon such a transfer. A similar fate meets the very concept of *meaning* if somebody dares to use it. "Biological meaning" either has something to do with survival, or it points to the effect of a signal. Other meanings of "meaning" are forbidden — at least in contemporary, orthodox biology. Attempts to introduce it come to, as a rule, the simplistic conclusion that meaning is something that has always been there or at least was produced, and could have been produced at any time, according to (decipherable) rules of "contrapunct" (Neubauer 1991; Markoš *et al*. 2003). This is the case when it comes to otherwise incomparable authors like, e.g., J. von Uexküll (1958) and M. Barbieri (2003). *Meaning* stripped off its hermeneutical dimensions, produced according to rules, will become the simple decoding of signals. This reduction to a stimulus/response scheme is but a pale ghost of how *meaning* is generally understood by common sense — not to speak of hermeneutics or poetry!

What all such activities have in common with "objective" science is their understanding of living beings as passive pieces on the chessboard of nature, pushed and pulled according to rules imposed from outside.

> Since we humans are used to conducting our affairs with effort from one goal to another, we believe that animals live in the same manner. That is a basic error, which so far has misled all research. […] Therefore our first concern must be to quench the will-o'-the wisp of a goal when observing Umwelten. […] [Animals] are controlled directly by a plan of Nature, which determines their characteristics (*Merkmale*). (Uexküll 1958 [1934]: 60)

Does this mean making science out of what principally cannot be subordinated to any strict rules?

Contemporary attempts to find a common language for both parties on opposite embankments of the trench are therefore *nihil novi sub sole*. What is new is that such calls for synthesis are usually led by a conviction that objectivist and reductionist natural science (in its current form) is the sole owner of correct knowledge. Such proposals argue in favor of the transformation of all knowledge into a branch of natural sciences, within the lines of the worn out 17th century

Enlightenment ideals (Wilson 1998). Fortunately, they are not usually followed by any practical action.

Meanwhile, in the backyard, a real process of a genuine "consilience" — mutual interpenetration with the aim of synthesis — has taken place. Instead of being an artificial construction of solid beams which should bridge the ditch in a unique and definitive way, it is made of a fabric of multiform tangled brambles. Soon, hopefully, it will cover up the ditch completely; soon it will be strong enough to form a natural bridge… Formally, particular fibers do not lose their identity in the web, but our discrimination ability is limited, and not all fibers, shoots and sprouts can be distinguished at the same time. The basic theme, emerging from the background web is *competence*: we have gained the understanding that the living world (or maybe even the whole world) is *taking care of its own affairs*. The rules and laws are not imposed from outside: they are being negotiated and enacted by a spontaneous, internal effort (as, after all, are *any* laws) through an internal, integrating dialogue. Competence and self-imposed laws (habits, rules), then, raise evolution from its marginal status of a Cinderella malevolently disturbing the ideal circles of our objective science to the basic principle ruling the universe!

Let me illustrate this rather inconspicuous process by following two such "fibers" selected from the fabric (in more detail see Markoš 2002): one is the work of the Russian linguist and culturologist Juri Lotman, the second is the theoretical biology of the American biologist and mathematician Stuart Kauffman. Many parallels can be traced in their language and thus also in their models of the world, called semiosphere by the first author and biosphere by the second.

Semiosphere

In the first part of his *Universe of mind*, Juri Lotman (1996 and 2001) criticizes the attempts to reduce natural languages (and texts) to a code in a way reminiscent of the models of genetic information processing provided by molecular biologists. Such attempts suggest parallels with the reduction of natural phenomena to natural laws in natural sciences: here as there, whatever is beyond the code is ignored. If such an approach is adopted in semiotics, it is assumed that the user of language is interested only in receiving the relevant messages, by specific

selection from the plethora of background noise. All other aspects of the text — its multiple and variable relation to the context — is ignored. The recipient is "hardwired" or, to express it within the context of this meeting, "*Umwelt*-bound". A text plays the role of a mere carrier of transmitted messages, and the single goal of a semiotic process is an adequate transmission of the message. It is taken for granted that the meaning of the text remains invariant with regard to the transformations of the text itself. Upon this assumption rests most of the reasoning concerning the relations between text and meaning. The *Umwelt* remains constant and the codes are frozen.

According to Lotman, by accepting such a scheme, we are confronted with a lot of patent paradoxes. First of all, all natural languages are very poorly equipped to fulfill such a role. Problem-free transmission requires that the sender and the receiver of a message have an identical table of codes. This can be achieved, however, only if the sender and the receiver are identical, and new information will change neither the receiver nor the context. A shared natural language is not a prerequisite of code identity — on the contrary, *this* fact especially hinders the achievement of sender–receiver identity! It follows that an identity of codes can be achieved only in special cases, to serve very special, narrow purposes, at the price that the language is no longer natural.

> For a total guarantee of adequacy between the transmitted and received message there has to be an artificial (simplified) language and artificially simplified communicators: these will have a strictly limited memory capacity and all cultural baggage will be removed from the semiotic personality. The mechanisms created in this way will be able to serve only a limited amount of semiotic functions; the universalism inherent to natural language is in principle alien to it. (Lotman 2001: 13)

Thus, artificial languages model not language as such, but only one of its functions: the ability to transmit a message (e.g., Eco 1995; Hofstadter 1979). Language would be deprived of its additional — actually essential — functions, and after some time such functions would even be forgotten: language would turn into a sort of algebra and its function would scarcely differ from a mechanical cause–effect relationship. The creative function of language is the most important factor that would be swept aside: the text works not only as a transmitter of messages, but also as a generator of new ones. In this

sense, not only understanding, but also misunderstanding is an important and useful means of communication (remember jokes, metaphors...). It follows that neither unambiguous transmissions nor mathematical solutions can be characterized as *new* messages.

Artificial languages are but a special cause from one extreme of an imaginary continuum, states Lotman (in agreement with many others, of course). On the other pole we find languages in which the creative constituents are emphasized — like poetical language. In such a case, receiving and translating the message are creative acts. In special cases the codes cannot even be translated at all: Lotman provides an example of a canvas showing a scene from the Gospels. The image cannot be translated into the particular text of the Gospel, and, of course, it does not follow that reading the text will bring to mind this very scene.

From the semiotical point of view, it is important that new meaning can originate in the process of extracting meaning from the text. The language precedes the messages transmitted, and is an integral part of them. Great deeds in, for example, the arts, are often followed by boisterous applause or, on the contrary, embarrassment, simply due to fact that the audience does not understand the language of the message — in spite of the common cultural tradition. As time goes by, such a novelty may end up in a kind of machine meta-language (cf. Peircean *habit*). Only then will information be communicated as codes given beforehand — but this does not mean that natural language has been transformed into a machine language. Although transmitted digital messages can be quantified objectively in the machine language, nothing like this is possible in a natural language. Well, of course, a written message can be easily digitized, says Lotman — but this simply means that *it is always on the decision of the receiver of the message whether he accepts the text received as a code or as a message.* This double function of the text enables even petrified truths of religious, cultural, or scientific communities to escape canonical (i.e. coded) interpretation and allow the emergence of novelty. Such truths may breach the narrow hold of previous clichés and start again to circulate in broader contexts. This happens again and again in cultural evolution — but is biological evolution different in this aspect?

Since a live language never excludes a new interpretation of even very canonical codes (habits), it may resist the evaporation of infor-

mation from texts with time. On the contrary — if the text is active in a culture, it will ceaselessly pick up new meanings. Lotman gives a Hamletian parable:

> Nowadays Hamlet is not just a play by Shakespeare, but it is also the memory of all its interpretations, and what is more, it is also the memory of all those historical events which occurred outside the text but with which Shakespeare's text can evoke associations. We may have forgotten what Shakespeare and his spectators knew, but we cannot forget what we have learned since their time. And this is what gives the text new meanings. (Lotman 2001: 18–19)

The part devoted to autocommunication is also of great interest. Lotman here upbraids semiotics for preferring communication between subjects (I – thou) and neglecting the question of how novelty can emerge in the mind of a single subject (communication I – I). Again and again he returns to examples of how a thinking subject introduces new levels into already established codes — generated endogenously or evoked by the environment. We can even make a generalization about a whole culture:

> The laws of construction of the artistic text are very largely the laws of the construction of culture as a whole. Hence culture itself can be treated both as a sum of messages circulated by various addressers […] From this point of view human culture is a vast example of autocommunication. (Lotman 2001: 33)

Culture is therefore a function of paired communication systems (I–thou, I–I); what will emerge is a collective personality with a collective memory, mind, and history. Lotman named this entangled web a *semiosphere*, a system integrated across all levels of its organization! (Compare with the Kauffmanian *biosphere* below.)

The importance of this statement is apparent when we compare it with two other outlines which allow us to grasp organization: the atomic and dissipative-structure models. The atomic (or reductionist) system aims to explain organization from a single basic level. Other levels (it is strange that their slavish position is labeled as "higher") only reflect the behavior of elements from the basic level, according to pre-established and immutable "laws". The "communication" between levels (if it can be called *communication* at all) is one-way only: the lower level determines phenomena on the higher one(s). But the very expression — "communication" denotes that which is in common —

commune! I. Prigogine — who developed the theory of dissipative structures — had upset this hierarchy when he showed that each of the particular *domains* of description has its autonomy. Communication between domains is bi-directional, but at the price of non-canonicity: the change of language between domains always brings about losses as well as gains (Havel 1996). Dissipative structures, however, lack memory and anticipation — features that are natural for both the semiosphere and, as we shall see, the biosphere. These systems (and the real biosphere as well) behave as if they contained no domains. Yes, we can distinguish elements — atoms, molecules, words, and sentences — but these are interconnected, not only within a particular domain, but also *across* domains; moreover, the flow of information between the domains is reciprocal. What really takes place at the interface is *communication*, a semiotic process, not simple decoding.

It is, however, very difficult to manage — or even imagine — such entangled hierarchies in the context of our culture. This is why I consider Lotmanian or Kauffmanian spheres to be important. Lotman shows that even if we succeed in distinguishing a "basic element" in a cultural continuum symbol, we cannot avoid paradoxes. It can be demonstrated through the concept of *symbol*.

a. The symbol indeed belongs among the most durable elements of the continuum, however not in the atemporal sense typical of the "atoms" from basic levels of description in science. This is because:
b. The symbol is never synchronous — its memory goes deeper than the memory of its (non-symbolic) context. The symbol exists before the texts; the user literally digs it from the deepest layers of his culture.
c. The sensory and communicative potential of symbols is always broader than what comes up in a particular actualization.
d. Thanks to symbols it is possible that text and topics can be transferred across different layers of the culture, thus preventing fragmentation into different cultural layers.
Lotman compares the function of symbols in a culture to the genetic memory in a body. Such a comparison invites a reciprocal view from the side of biology. Genes — originally the presumptive "atoms" of heredity, have experienced during the last century a strange transformation into strings of signs — codes and even texts. This prompts us to draw a parallel to Lotman's points above:

aa. Genes belong to the most durable elements of the continuum comprised of cells, individuals, species and biosphere.
bb. Genes are not synchronous: the user, i.e. the living being, receives them from the thesaurus, memory of its "culture"; by culture we shall mean species or genealogical lines. Individuals dwelling at the current endpoints of such historical chains thus govern the whole experience of the line, i.e. both the genes and the directions for their usage and interpretation.
cc. The impact of genes cannot be localized to a single concrete realization — most of the genes become engaged in a plethora of topics and their effect cannot be sharply demarcated (Dawkins 1982).
dd. Thanks to genes, topics can percolate across different layers (domains). To elucidate this last point, let me give three examples:

(1) In ontogeny, whole complexes of genes become repeatedly activated in totally different contexts. For example, the products of a gene set may assist in the establishment of body axes in early embryogenesis, later they work in organizing the primordia of appendages or inner organs, and then in patterning marginal features, like the structure of a feather or wing ornaments in butterflies.
(2) The same complexes of universal genes (i.e. symbols in our parable) work within a broad spectrum of species (i.e. cultures). Their impact, however, is determined by the modulation via the "cultural" medium they find themselves in. The forelimb of a human, a horse, or a bird, was induced — evoked into life — by the same group of genes — symbols; yet their final appearance is species- (culture-) specific.
(3) Gene complexes can be transmitted horizontally: such a "transcultural" transfer is especially common in prokaryotes, enabling them to engage in genetic communication throughout the whole biosphere. Dissemination of, for example., resistance towards antibiotics, is a good example of this phenomenon.

How, then, do genes–texts–symbols work? What *laws* determine their different engagement in different contexts — temporal or cultural? Or better, what game do they play?

Let us take seriously Lotman's assertion that language, culture and texts live. All participants of communication enter the game with a certain background of experience and memory. Living beings are

participating parts, active creators/builders of their own *Umwelt*, not merely thoroughly tuned into a given one! As we shall see below, Kauffmanian autonomous agents are in a similar situation. Neither biosphere nor semiosphere can originate *de novo* like simple dissipative structures, such as a flame or a vortex. Lotman compares semiosphere to a museum hall, full of visitors: inside it you can find a semantic overlap of dinosaur bones, teachers, clay tables with cuneiform script, school children, old china collection etc. A text, says Lotman, has an internal drive towards becoming a unique long word, thus opening a multidimensional space, influencing, in a feedback, the meanings and morphology of the language. Such transformations from the discrete (digital) into the multi-dimensional (analog) do not take place at a single interface: the same game is played again and again at different levels of organization — domains. Articulation of a topic by means of a language typical for different domains helps to disclose its nature. Semiosphere is indeed a generator of *new* knowledge (see, again, Kauffman below).

Let us return to the game and to its antipode — the law. Lotman states that if a goal is given in advance, there is no room for liberty:

> As the reserve if indeterminacy becomes exhausted, the degree of information drops, falling to zero at the moment when it becomes entirely redundant, i.e. totally predictable. […] When we can predict the next link in the chain of events then it follows that there was no act of choice between equal alternatives. But consciousness is always a choice. So it follows that if we exclude choice (unpredictability which the outside observer sees as chance) then we exclude consciousness from the historical process. And historical laws are different from all others in that they cannot be understood without taking account of people's conscious activity, including semiotic activity. (Lotman 2001: 227, 234)

In other words: if the trajectory of a thrown stone can be predicted to the tiniest detail, i.e. if nothing unpredictable can happen during its flight, there is no need to throw it. If this holds, then history would be superfluous; God would not play dice. He would be merely watching ready-made videotape — and not even that, since He would be able to see it all at once! But in a culture, the less expected a phenomenon is, the greater impact it has, and the same probably holds true in other areas of human activity, even in science. This is why linguistic topics like interpretation, translation, evolution etc. nowadays enter all sciences; this indicates the end of the belief in timeless laws.

Moreover, opposites like culture — species or evolution — history become blended. We cannot avoid the strange feeling that Lotman himself does not fully allow for such a blending: phrases like "historical laws are different from all others" or "people's conscious activity" suggest that, in spite of all his ambitions, he still remains in the realm of *human* affairs. A more consistent attempt at such a blending comes from the sciences.

Order for free and the expansion into adjacent possible

Stuart Kauffman, mathematician and biologist, has experience with mathematical models, as well as their "incarnation", whereby an ideal mathematical map becomes a mutable and living landscape, when eternal timeless laws give room to *physis*. In the preamble to his book *Origins of Order* (1993) we read:

> Simple and complex systems can exhibit powerful self-organization. [...] Yet no body of thought incorporates self-organization into the weave of evolutionary theory. No research program has sought to determine the implications of adaptive processes that mold systems with their own inherent order. (Kauffman 1993: vii)

The last sentence could serve as the epigraph for Kauffman's lifelong scientific activity. Where does order come from in nature and in living beings? He does not take the neodarwinian explanation rooted in frozen accidents sieved by natural selection and shared in genealogical lines. Organisms come out from such an image as passive, ad hoc contraptions: they represent the outcome of historical contingency, their ontogeny being determined by "blind" genetic programs. Evolution is opportunistic and no room is given to the spontaneous emergence of order. Kauffman, on the other hand, aims to prove that order is for free: it is here not *because* of natural selection, but *in spite* of it. The greater the complexity of the system, the less power selection has to change its properties; order emerges not through a random walk, but as a result of a system's internal dynamics.

Even more advanced in this respect is another treatise by Kauffman (2000), *Investigations*, inspired, as he says, by Wittgenstein's *Philosophical Investigations*. The crucial idea is that the properties of a system cannot be stated in advance, by providing a list of a kind. It

follows that deterministic laws of physics enabling the calculation of the behavior of a system (its configuration space) are not general, but *special* cases. They only work if we can state initial and boundary conditions for the system. Newtonian or Einsteinian physics thus cannot be applied to systems with evolution, where this condition cannot be fulfilled. It was demonstrated that general laws for such systems couldn't be stated at all; Kauffman, however, asks whether they couldn't be found at least for a special class of system — the autonomous agents.

The definition of an autonomous agent at first looks quite bizarre. It is a system acting on its own behalf:

> All free-living cells and organisms are autonomous agents. But a bacterium is "just" a physical system. In its Kantian form, my core question became, What must a physical system be such that it can act on its own behalf? The stunning fact is that autonomous agents do, every day, reach out and manipulate the universe on their own behalf. Yet that truth is nowhere in contemporary physics, chemistry or even biology. So, what must a physical system be to be an autonomous agent? (Kauffman 2000: x)

It must embody two features, says Kauffman: autoreproduction and the ability to perform working cycle(s). The last condition is crucial and distinguishes an autonomous agent from the dissipative systems described by Prigogine, such as a flame or a tornado. To perform work in a cycle means to have a contraption — a machine, which is able to return periodically to its initial state. Thus, cyclical processes lie in the heart of the acyclical, historical process of evolution.

To perform work, the autonomous agent must be able to build a machine to lower the degrees of freedom available for the dissipation of energy. Making a machine, however, requires an investment of work. The agents are thus characterized by a cycle (or spiral) of work, and the work extracted may be utilized to reproduce the system or to increase its organization (e.g. by building new machines allowing new kinds of work cycles). It can also be used for mapping the surrounding universe in an active search for resources which can be used to perform work. The author thus leads us towards a kind of hermeneutical circle in nature.

This aspect will become even more accentuated when it comes to communities of autonomous agents — biospheres. By expanding from the actual state into the adjacent possible (defined as a state one time-

interval from the actual, time interval being defined deliberately) the biosphere explores the field of possibilities and accomplishes, or chooses, one of them. The two states may differ in the number and/or quality of particles (creating new ones never seen before in the universe) and in creating new, unpredictable structures. Due to this uncertainty, it is not possible to predict the evolution of a biosphere, even in a single time interval separating the present from the adjacent possible.[4]

Biospheres are thus characterized by a ceaseless flow from the actual into the adjacent possible, *en passant* increasing their organization. The problem is, says Kauffman, that expanding organization does not fit into the established set of physical concepts like entropy, matter, information, energy etc., nor can it be derived from them. In spite of this, the biosphere *is* a physical system. We know the molecular structure of living beings, the metabolic pathways, membrane function etc., but we have no idea what causes this assembly to be alive — we lack concepts for self-propagating dynamic systems. Even worse, our ability to generalize is somewhat limited when unique exemplar cases of autonomous agents and biospheres are provided by earthly living beings. Would it be possible to generalize about any possible agents and biospheres? Is it possible to formulate laws valid for such systems? Kauffman takes the challenge and formulates several variants of what he calls "The fourth thermodynamic law". The most general definition is as follows:

> Biospheres, as a secular trend, that is, over the long term, become as diverse as possible, literally expanding the diversity of what can happen next. In other words, biospheres expand their own dimensionality as rapidly, on average, as they can. (Kauffman 2000: xi)

How, then, do the biospheres construct themselves? Autonomous agents are ceaselessly measuring the parameters of the surrounding universe (which is a co-construct of the whole biosphere), they detect the resources utilizable to perform work and canalize it via machines built for this purpose.

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[4] Compare with deterministic systems of statistical physics, which allow such moves both into the future and into the past. The solution is not in shortening the time interval between the actual state and the adjacent possible — we'd only end up in the realm of uncertainty principle.

Curiously, at this very point, semiotics enters the scene. When a system is in a thermodynamic equilibrium, no work can be extracted out of it. Even the trick with Maxwell's demon will not help, because the amount of work necessary to measure and store information about the microstates of the system equals the amount of work subsequently gained. Kauffman, however, notes that if the system is far from equilibrium, it pays off to perform such measurements. Under such a condition, the demon uses up only a small fraction of the energy available. Thus, under ordinary circumstances the problem is not that of the energetic balance but that of knowledge. And knowledge means useful, relevant knowledge — not just information of any kind! To look for the right kind of knowledge, sorting the useful (or at least promising and hopeful) type of data from the "garbage" requires the interpretation of the signs of the surrounding world. In other words, how is the demon (i.e. the autonomous agent), first of all, to *know* which particular properties of the surrounding universe to measure, to *decide* what measurements are likely to provide him with energy resources?

We are already amidst semiotic problems: how does Kauffman's "agent" come to know how to build an appropriate machine, able to canalize that very type of the energy gradient? The universe offers an endless number of qualities that can be distinguished from the background and measured. Only some of them, however, are *relevant* — leading to the recognition of a utilizable energy source that can be coupled to the extraction of work by a machine. The agent is a demon of a world not in equilibrium. It performs natural games based on incessant scanning of the environment, the selection of data and comparison of it with the thesaurus of its (his? her?) experience and memory. It actively breaks symmetries, looks for and discovers new ways of energy canalization (and, of course, puts at stake its own integrity or even existence), extracts meaning, constructs the adjacent possible.

> The heart of mystery concerns a proper understanding of "organization" and "propagating, diversifying organization." [It] concerns the historical coming into existence since the Big Bang of connected structures of matter, energy and processes by which an increasing diversity of kinds of matter, sources of energy, and types of processes come into existence in a biosphere, or the universe itself. (Kauffman 2000: 93)

Thus — by definition — autonomous agents are *endowed with endogenous activity*, they are by no means passive substrates molded by external forces. The co-evolution of autonomous agents then drives them into the adjacent possible along a trajectory, which is non-deterministic, (but determining) i.e. selective. By doing so, they open/create a larger space of possibilities. The definition of the autonomous agent is at the same time the very definition of life, says Kauffman. We — autonomous agents — are co-constructors of our universe.

But how do we perceive our "autonomous activity"? Kauffman provides an answer:

> Story is the natural way how we autonomous agents talk about our raw getting on with it, mucking through, making a living. If story is not the stuff of science yet is about how we get on with making our ever-changing living, then science, not story, must change. Our making our ever-changing livings is part of the unfolding of the physical universe. (Kauffman 2000: 119)

Story is the most adequate, maybe the only way, of storing experience. Problems, situations, tasks never repeat themselves in exactly the same way. But problems successfully solved in the past may be of enormous help when one is confronted with a similar situation again. Not because of what is constant, invariant, equivalent, but because of similarities, analogy, correspondence in dealing with novelties — in how to mutually respond (co-respond!) to new challenges. One must first be "versed" in being able to con-verse, with changing rules of game. Such experience in versatility cannot be provided (or re-presented) by static data. It is the 'tune' — the course of the change that makes one tuned to the changing world according to its past trajectory modifications — both gradual and sudden. Thinking in terms of stories seems to be a type of "information processing", which became most effective in evolution.

The bounty of life around us represents players of winning strategies in natural games. But this is but a story, a narrative. Does it belong to science at all? Can this be formalized as science? Kauffman says yes, and gives the outlines of a general biology leading, to the biologization of physics, as an alternative to several centuries' unsuccessful effort to achieve the physicalization of biology.

This would undoubtedly be a great triumph if a semiotic physics could arise one day — it would be a great satisfaction for people like Peirce. Compare such a concept with the prevailing contemporary

worldview which takes reality (the true, ultimate reality — the objective one!) to be hidden: people or living beings do not take care of themselves, they are pulled and pushed by invisible forces governed by the hidden laws of physics, genetics, economy, market, selection… But what if they do, as Kauffman states, take care of themselves? Then science rooted in Newton is doomed…

When read out of context, Kauffman, Lotman, and co. may well evoke an impression of bringing about something completely new. Within a broader cultural and historical horizon this is definitely not the case. Their great merit lies rather in their timely and priceless contribution to cultural memory: their courage and ability to bring back to the contemporary consciousness the half-forgotten truths and narratives as old as humankind. They show our generation that the realm of life, history, symbols and stories is as living and unbound by "objective laws" as ever — still binding themselves with responsibility — binding together science with conscience.[5]

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Поиск новшества: биосфера Кауффмана и семиосфера Лотмана

Появление новшеств в сфере живого осталось, несмотря на долгую традицию эволюционной биологии, нежелательным явлением. Преобладающая неодарвинистская парадигма рассматривает живые существа как пассивный результат внешних (и чужих, следовательно, “слепых”) формирующихся сил. Многие учения, противопоставляющие себя дарвинизму, считают также необходимой предпосылкой существование вечных, неизменных и внешних законов. Часто те, которые противопоставляют себя дарвинизму и признают, что живые существа обладают “самостью” (self), подчеркивают внутреннюю, идеальную и вечную гармонию, которая несовместима с историческими изменениями. Поэтому подобная гармония опять-таки обусловлена внешними, вневременными “законами”. В данной статье описывается третья возможность, которая связывается с двумя отдельно стоявшими исследователями: Стюартом Кауффманом как биологом и физиком и Юрием Лотманом как семиотиком и культурологом. Их сближение выявляет, что эволюция организмов, сознаний, культур — непрерывный диалог (семиозис) между “законами”, что приводит к росту свободы и автономии.

Uudsuseotsing: Kauffmani biosfäär ja Lotmani semiosfäär

Uudsuste ilmumine elusa sfääris on jäänud, vaatamata evolutsioonilise bioloogia pikale traditsioonile, soovimatuks nähtuseks. Valdav neodarwinlik paradigma vaatleb elusolendeid kui väliste (ja võõraste, järelikult "pimedate") kujundavate jõudude passiivseid tulemeid. Paljud darwinismile vastanduvad õpetused peavad samuti igaveste, muutumatute ja väliste seaduste olemasolu vajalikuks eelduseks. Tihti need, kes vastandavad end Darwini teooriale ja tunnistavad, et elusolendeil on "ise", rõhutavad sisemist, ideaalset ja igavest harmooniat, mis aga on kokkusobimatu ajalooliste muutustega; seega selline harmoonia on jällegi tingitud välistest, ajatutest "seadustest". Kirjeldan käesolevas artiklis aga kolmandat võimalust, mis seostub kahe eraldiseisjaga — Stuart Kauffmani kui bioloogi ja füüsiku ning Juri Lotmani kui semiootiku ja kulturoloogiga. Nende lähenemine toob esile, et organismide, teadvuste, kultuuride evolutsioon on pidev läbirääkimine (semioos) "seaduste" vahel, viies seeläbi vabaduse ja autonoomia kasvule.