Informational Dynamic Systems: Autonomy, Information, Function

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The main purpose of this paper is the conceptual exploration into the pre-biotic world, a world that we consider to be made up of a relatively continuous sequence of systems directed toward the origin of the first life forms. In a tentative way, we propose the 'Informational Dynamic System'. This type of system would constitute the ancestral system that definitively opened the door to the pre-biotic world. Also, it explains, in a naturalistic way, the physical emergence of functions and information.

1. Introduction

The so-called self-organization phenomena feature multiple types of dynamic systems, and we find them in different sectors of our reality. For example, we have the Bénard cells and the Belousov-Zhabotinskii reactions (or Brusselator when this type of chemical reaction is computer simulated). It was Ilya Prigogine who, working on these chemical processes, coined the term "dissipative structures", allowing us to understand the emergence of 'novelties' in the systems that are far from thermodynamic equilibrium state. From the thermodynamic point of view, these systems are open systems (they exchange energy and/or matter with their environment), and the self-organization phenomena are produced due to the continuous changes in the local interactions of the components that form the dynamic system [1].

The Belouzov-Zhabotinskii (B-Z) reaction is an oscillating chemical reaction that is autocatalytic. In other words, products of the reaction increase the rate of their own production. In this process, different steady-states and periodic orbits can be observed. The Cerium oxides, Ce(III) and Ce(IV), are the chemical compounds in solution that produce an oscillation dynamic in the reaction. The periodic increase in the concentration of one of the chemical compounds and the subsequent decrease of the other is seen at the macroscopic level as periodic changes and rhythms of color [2].

What this type of self-organized system has in common with others of the same type is that the continuous entropy production in the system is actively exported (dissipated) to the outside of the system.

These types of self-organized dynamic systems reveal to us certain generic properties that can be applied to the rest of the self-organizational phenomena [3-5].

(1) The appearance of a global order starting from local interactions. (2) The control of the organization is distributed throughout the whole system. (3) They have a relative "insensitivity" to environmental changes; they are robust. (4) Self-organized phenomena are essentially non-linear. (5) Self-organization contains feedback processes – positive and negative. (6) The degree of coordination or correlation between the system components is associated with the degree of organization in the self-organized dynamic system. (7) Self-organization is fundamentally caused by a dynamic inside the system; because of that, the system possesses "organizational closure". (8) There are additional properties that begin to emerge in self-organized systems as the internal dynamic becomes more complex.

The interest of our work will be centered on the emergence of certain properties in determined, self-organized systems: those that we find in the time before the appearance of the first life forms.

We will propose an initial working hypothesis with the purpose of contributing to the discussion and improving the understanding or clarification of what more than likely happened in the distant past, in the transition from being inanimate to being animate.

Therefore, we will be occupied with exploring the nature of the local interactions that made it possible for the appearance of the initial forms of dynamic systems that had the global property of being an autonomous agent [6-8].

Our strategy will be to approach the problem from a bottom-up perspective in naturalist terms. Consequently, we will make explicit references in our arguments to the ways in which a dynamic organization might be produced in systems that use matter and energy components governed by the laws of physics, chemistry, and physical chemistry.

With this in mind, we will put forward the possibility of the emergence of other properties that will, gradually, provide the dynamic systems we are talking about with a character that is more similar to living phenomena. These systems will continue to be governed by the abovementioned laws; however, these new properties will begin to participate actively in its dynamic organization such that they would allow the emergence of the dawn of an open-ended evolution (biological evolution).

Our conceptual proposal furthermore has two additional ends: the construction of arguments that support the possibility and the necessity of proposing one definition of information and one definition of function in naturalist terms. In other words, we defend that both notions are not purely thought exercises, whether in abstract, formal, or epiphenomenal terms, or that for their definition they need some type of adscription imposed from the human world or from that of the human-generated devices.

In this work, we put forward a type of self-organized dynamic system that we believe to be the system that opened the doors of the pre-biotic world, and because of that, will begin the step from the world of the inanimate to the world of living systems: the Informational Dynamic System.

2. Some preliminary reflections

We consider it to be reasonable to postulate theoretic constructs that can provide us insight into the nature of the dynamic organization that those preparatory systems must have possessed for the future emergence of living systems. We also believe that the origin of pre-biotic systems already carry with them a certain level of complexity in their dynamic organization.

Put in different terms, to understand the conditions that make the appearance of living forms possible is to understand that their most basic properties were present at the origin of the pre-biotic world. So, Informational Dynamic Systems already have in their organization those minimum capacities that are present in whatever living system and are expressed at levels of increasing complexity as we advance in evolution.

We can state that the self-organized type of system that is related to living phenomena is one of a chemical nature. Hence, the normativity that encompasses chemical reactions and the physical chemical requirements will occupy a special place in our discussion.

In addition, it is feasible to envision the pre-biotic world made up of a series of systems that are related in more or less successive stages. In each step, we would find systems with certain capacities that they had incorporated from previous systems. In turn, they would explore different strategies for improving what they already had and would have the chance of producing the emergence of new capacities that together with the existing ones would prepare for the emergence of the first living systems.

Before the genesis of pre-biotic systems, we find different, self-organized systems that should gradually carry us to this new form of existence. It must be pointed out that even though the purpose of our work is not to discuss this prior time, it is possible for us to make certain clarifications about it.

These very simple, inorganic, chemically composed, self-organized systems were found in extremely specific regions of the planet. The Earth's planetary conditions during those epochs make it possible to hypothesize the existence of the first forms of chemical self-organization on the surface of certain minerals [9-13] or in regions very close to volcanoes [14-18].

What must be stated clearly is the definite impossibility of trying to find a pre-biotic system as we have visualized in our proposal. In the first place, after so long a time since their disappearance, all traces of them would have vanished as well. In the second, their "building blocks" must have been metabolized by other systems in the pre-biotic world as well as by the first living ones.

We also want to explain that when referring to the origin of the pre-biotic universe, it is illogical to speak in terms of a Darwinian evolution since neither DNA nor RNA had appeared, and there was nothing at all like "genetic material" in existence. These emerged in the far distant future of the history of the pre-biotic world. Therefore, we cannot speak of fitness and other concepts connected with biological evolution. There is just open-ended evolution – a type of evolution whose components are related to the idea of evolution by natural selection.

Nevertheless, it is possible for us to refer to the capacities that permit the gradual building of the structure and dynamic organization of those systems in terms of their internal properties.

Therefore, at some moment, future generations of the different populations of these systems will possibly be 'seen' by natural selection [19-21].

If we want to suggest some reference to the succession of changes in the dynamic systems, those that are strongly linked to the emergence of life, we could speak of a certain proto-evolution. An example of such could be a variant of the *evolvability* notion applied to the pre-biotic world [22-26].

3. The Informational Dynamic Systems

We place our theoretical reflections in the distant past, and this era tell us that the types of chemical constituents we might find available on the Earth would be incredibly simple chemical compounds, mainly inorganic, yet perhaps a very small amount of organic ones. We might even consider a possible abiogenic synthesis of such compounds like the thioester [27]. The thioester compounds are those that are formed when sulfhydryl, an organic group that contains a Sulfur-Hydrogen bond (R-SH), joins with another compound called carboxylic acid (R'-COOH). During the chemical reaction, a water molecule is released, forming this way the thioester compound (R-S-CO-R').

Taking into account the current understanding about what the conditions of primitive Earth could have been like and meteor impacts during this time period, it is possible to theorize the feasibility of the existence of amino acids and carboxylic acids. Furthermore, the fact of massive volcanic activity makes it possible to theorize the existence of sulfhydryl [28-32].

For the purposes of the work, we set a line of demarcation around the origin of pre-biotic systems: it would be a type of system that has managed a certain degree of autonomy by its own, self-maintained organization dynamic. Therefore, it is a type of dynamic system much more robust than the self-organized system we mentioned at the beginning, which we will call a "strict sense" self-organized system.

This opens up space for the possibility of returning to the most robust and complex dynamic organization in the continuous succession of a type of pre-biotic system that will end up producing the first life forms.

In that sense, we consider that our hypothetical informational dynamic system provides an explanation for the emergence of that organizational dynamic, and with it, allows us to understand the emergence of the global property known as autonomy.

Generally speaking, self-organized systems are systems far from thermodynamic equilibrium. Bénard cells, Belousov-Zhabotinskii reactions, living systems, and pre-biotic systems are ones that are far from thermodynamic equilibrium.

One difference that is crucial to our argument is that the first two examples are systems far from equilibrium because of external causes: the matter and energy requirements that their processes needs invariably depend upon the environmental conditions.

On the contrary, the other two cases maintain themselves in nonequilibrium conditions for reasons that are systemically intrinsic. With this statement, let us begin our study.

The correlation among processes is an expected phenomenon when a system is in far from equilibrium conditions [33, 34]. One important step to the pre-biotic world is the appearance of a correlation between endergonic and exergonic processes. The former needs energy requirements, whereas the latter produces energy.

The existence of compounds with "high energy" bonds significantly favors this correlation between the abovementioned processes, forming a micro-cycle that is capable of generating work (chemical work).

The inorganic pyrophosphate and/or a simple thioester could have been the ancestral "energy currency" molecules of these types of chemical bonds. In current cells, we find that the thioesters are bound up with the esters formation, including those we find in complex lipids. We also find them actively participating in the synthesis of peptides, fatty acids, sterols, terpenes, porphyrins, and other compounds.

With this last reference, we have just established the feasibility of maintaining an adequate energy interchange between the exergonic-endergonic cycle and the production of compounds (accomplishment of a chemical work) that have much to do with the formation (and reparation) of a protomembrane (Amphiphilic polymers) [35, 36].

In this way, the informational dynamic systems manage to keep themselves in nonequilibrium conditions because there are two fundamental requirements within its dynamic organization. Another way of putting it is that in the first place, we would have the exergonic-endergonic cycle made possible by a high energy bond carrier compound that as a group is a process with the capability of producing work. In the second place, we would have the protoplasmic membrane related in some way to the compound acting like the "energy currency" molecule.

As we are visualizing the possible interaction of these types of processes, later on, we will see how it is that they allow certain initial degrees of autonomy with respect to the ever changing environmental conditions.

Another important topic to cover is what we refer to as the possibility of forming oligomeric compounds by noenzymatic condensation. Much has been said concerning abiotic chemistry in regards to this theme and until recently the results were very limited for abiotic polymerization reactions starting from their monomers – whether amino acids or nucleotides.

Nevertheless, a group of researchers has recently proven, experimentally, that 'carbonyl sulfide (COS)' – a very simple gas formed from volcanic activity and doubtlessly present in the pre-biotic era – intervenes in short-chain peptide condensation.

In short, the molecular reaction involves the bond of the COS to the amino acid by the amino group, producing afterwards a cyclical compound called amino acid N-carboxyanhydride (NCA). The NCA will bond with another amino acid and a dipeptide will form, freeing a CO_2 molecule [37].

The results of scientific research demonstrate to us the complete possibility of abiogenic short-chain peptide synthesis in very similar conditions to those existing in the pre-biotic times. With these results, it is possible to propose in a rational way that short-chain peptides could have managed to attain a sequence of interdependent reactions: the beginnings of protometabolism.

The three groups of processes that we have presented bring us directly to the dynamic organization that constitutes the informational dynamic system.

3.1. *Organization of the Informational Dynamic System*

In order to have the capacity of being more robust than the "strict" self-organized systems and to be able to have the necessary and sufficient conditions to begin the slow but sure road to improving their levels of complexity, the informational dynamic system has to be made up of at least three different classes of process groups.

The first class of processes is fundamental for providing the system a certain degree of independence with respect to its environment since it generates the conditions for being in nonequilibrium state. This is the endergonic-exergonic cycle capable of producing – in each cycle – quantities of free energy to the system that are appropriate to generate work (of a type fundamentally chemical).

This cycle is, in its own right, the one providing the system with the far from equilibrium characteristic since it forms a component part of its dynamic organization. To be a system in the nonequilibrium state is a priority intrinsic to the system; because of that, it is the most basic fundamental of informational dynamic systems.

The second process group would form another important part of the dynamic organization of these systems. This is the one that makes up the protoplasmic membrane.

First, this component permits a separation, a physical barrier between the system and its environment, causing from there a different distribution of compounds, a different dynamic, and a different interaction among the processes. It also permits certain properties of chemistry to have a focal point of action to generate possible problematic circumstances which in turn produce the conditioning situations for exploring different solution strategies for the system in the future. Some examples we can cite are colligative properties, cinetic chemistry, electrochemical gradients, and others.

It is in the protoplasmic membrane that we will objectively be able to observe the emergence of the autonomous capacity. It is the part of the system that regulates the interaction with its environment as well as providing the necessary constituents (matter and energy) so that the internal system processes continue producing their mechanisms in conditions compatible to their survival. In this way, system cohesion[a] is not disturbed [38, 39].

This part of the system organization is one that is a complete agent since it allows for the resolution of the osmotic problems, the adequate concentration of components in the internal system processes, the management of electrochemical gradients, the reduction of chances for the entrance of foreign elements into its organization, etc. We can state at the same time that the system contains two different types of constriction [40, 41]. The first one we call "basic constriction", which directly maintains the far from equilibrium state. It is a cycle between the endergonic processes linked with the exergonic ones and with the added capacity of generating work (a necessary and sufficient condition to produce the organizational dynamic phenomena). The second permits a dynamic and agent interaction with its external and internal environment: a semi-selective membrane (protoplasmic membrane) that contains the compounds which will generate processes to give the system the capacity of managing both external and internal conditions. Both types of constriction are so interrelated that a very basic, direct communication exists between them.

In addition, we will find other types of processes (that make up, along with the last two, the organizational dynamic identity of the system). The third group is a network of reactions that would perform the organizational dynamic's reparation, maintenance, and reproduction processes of the informational dynamic system and is in one way or another connected to the constrictions.

The informational dynamic system is organized by the interrelation and interdependence of these three classes of processes.

The expression of an autonomous and agent behavior implies certain capacities that are made real in the way that the protoplasmic membrane performs and coordinates its internal processes. For these reasons, the detailed analysis of this part of the informational dynamic system is valuable.

We must remember that the informational dynamic system ***is*** the dy-

[a]The idea of cohesion is applied to dynamic systems and their properties that are bonded by an internal dynamic of relationships. This allows the establishment of a causal substrate for delimiting the dynamic system identity [39]

namic organization that constitutes it. So, the system's dynamic organization is in fact a collection of processes, interrelated and interdependent, with the additional element that this interconnection among the processes maintains a determined form of concretely connecting themselves with the constriction that permits the system to remain in the far from thermodynamic equilibrium state.

An agent behavior brings us to the understanding that a certain degree of managing their internal and external conditions would exist. This management (even though very minimal at the beginning) directs our attention to those processes that would be responsible for interacting and performing recognition, selection, and active or passive transport processes.

And this management is done because it is "dictated by" (there is a strong correlation with) the tendency to persist as such - to maintain itself – in the state that fundamentally characterizes it; the most primary aspect of its nature is constituted by being a far from thermodynamic equilibrium system.

It is possible to conjecture that the basic constriction causes the change of the system's free energy (ΔG_{sys}) to have a tendency towards negative values. Taken as a totality of the processes and its interconnection, this causes it to be immersed in continuous and successive dynamics of increasing order.

Therefore, to stop being a far from thermodynamic equilibrium system is the same as saying that the system no longer exists. To strongly influence the conditions for remaining in that state implies seriously placing its survival at risk.

This central aspect of its nature is now maintained by the system itself through the incorporation of the basic constriction. This allows the system to maintain itself in the far from equilibrium state.

As this constitutes the most original aspect of these systems, it seems to us that we can assume that it governs the multiplicity of transformations of behaviors, components, capacities, and characteristics of the future system.

This way, our proposal rests upon the naturalist supposition that informational dynamic systems develop their difference from "strict sense" self-organized systems because they have been able to develop and maintain a capacity that is elemental for their existence: maintaining or increasing the far from equilibrium state.

As the constriction maintaining them far from equilibrium is an intrinsic part of their dynamic organization, there are strategies they can develop that manage to keep this state in conditions compatible with the laws imposed on them by the material world.

The strategies we are referring to will be two new characteristics that emerge in the system – in the local interactions – and are directed at maintaining the far from equilibrium state by a direct or indirect connection with the basic constriction: information and function.

Briefly, we think that both information and function emerge at the same time, in unison, in the informational dynamic systems and that the physical emergence of both notions happens in an interrelational way: ***information-function***. Moreover, we postulate that both information and function are relational concepts.

For our intentions, understanding the basic difference that exists between a system in an equilibrium state and one in a far from equilibrium state is very important. This important difference permits us to construct a type of norm that is found in certain laws of nature without any adscription coming from the human world: the laws of thermodynamics.

Therefore, our proposal of the notion of information-function – as a characteristic emerging in the informational dynamic systems – is a relational concept that is strongly governed (ruled) by the far from thermodynamic equilibrium state.

The information-function characteristic has two aspects: the *informational* ***function*** aspect and the *functional* ***information*** aspect.

When we observe the transmission of some information in informational dynamic systems, this happens because some type of function is produced. Similarly, when we observe the presence of some function, it happens because some information has been transmitted.

3.2. *Information and Function Emergence*

Both ideas of information and function are directed towards the network of interrelations among the processes. It is in the processes and the relationships among them that both capacities emerge for the first time in the physical world in such a way that through the function pole ("informational function"), we observe that the *contribution* of the processes among each other for their appropriate performance in the integral logic of the system's organization causes the system to maintain itself far from thermodynamic equilibrium.

Through the information pole ("functional information"), we observe that the *meaning* for the system of some signal or sign (that is the physical means of transporting some matter-energy variation) will be expressed in agreement with maintaining the system in the far from equilibrium state. However, it can also be that it was in opposition to maintaining the far from equilibrium state.

In the first situation, the meaning of the matter-energy variation that comes to the system will cause a positive response by the system. In the second case, the meaning will generate a negative response by the system.

We can see that both information and function are strongly connected by their definition with the idea of far from thermodynamic equilibrium. And this is precisely what we propose.

Because of this, it is possible to consider, through a naturalist perspective, the far from thermodynamic equilibrium state as a basic norm that the system imposes on itself for continuing to be the system that it is.

This way, information and function will have to be defined starting from what we physically have right now, where there is no place for human adscription, and hence, the possible epiphenomenal interpretation of some of them is avoided from the start.

The differences that exist between a system in a thermodynamic equilibrium state and a system in a far from thermodynamic equilibrium state is something we possess firmly in our minds and have been well defined through experimentation. The group of causes and contour conditions to differentiate them can be used in the most explicit way possible.

Therefore, for our defense of a class of system with the characteristics we mentioned, we would have in the realm of physical laws a naturalist principle for building up the essential aspects in a normativity.

Effectively, a normative principle points out precisely those circumstances when the norm is fulfilled and the difference in those situations when the norm is not fulfilled. For our work, those circumstances in agreement with the far from equilibrium state are fulfilling the norm, and those circumstances not in agreement with that state are not fulfilling the norm.

What is interesting about the case is that the norm we just explained essentially permits the way these systems exist. Therefore, this normativity is derived naturally from the physical world. Moreover, the normativity comes from and is dictated by the system itself.

In its origins, what we would have might be a normative definition of the information-function notion. It is from this initial appearance of both ideas that we can postulate later on that a kind of symmetry break would arise in the primitive idea so we would find both characteristics acting independently (although on occasion, in some way, interacting as they did at the beginning) and with the possibility of increasing the levels of complexity and sophistication in one of them or in both.

Everything taken together brings us to the thesis that starting the process from inanimate to animate could have been produced by the appearance of a type of dynamic system whose organization is an ***informational and functional dynamic organization.***

The normative idea of functions (we understand the functions to be "contributing to what") is founded precisely on this internal normativity that is produced in the informational dynamic system by the components and processes that sustain and constitute it. And all of this creates a tendency to maintain the far from equilibrium thermodynamic state.

We consider the function to be located in the action that generates a determined process and what we can understand as "what contributes" (co-operates, favors, supplies) to the interrelation and interdependence among the processes with a view to maintaining the far from equilibrium state [42].

On the inside of the process, each component will have the mechanism that is proper to its chemical constitution, but that chemical action (or group of actions) will have its *raison d'ê tre* because of the process. Then, each process that carries out a determined and particular action (made up by the causal nexuses among the component mechanisms that constitute them) will be assimilated into the dynamic organization *only* if this particular action is maintaining, improving, or achieving the far from equilibrium. And this action is precisely **its function** in this organizational logic of the informational dynamic systems.

Thus, a function is something that contributes or facilitates to maintaining or increasing the far from equilibrium state. A dysfunction, on the other hand, is something that does not contribute or facilitate to maintaining the far from equilibrium state.

Concerning information, any type of signal or sign can be a carrier of what might be information (or what we call 'potential information'). We consider a signal or sign to be any matter-energy variation (sound wave, electromagnetism, concentration of a chemical compound, change in pH, etc.). The signal or sign that is a 'potential information' carrier must be in the surroundings, on the inside, or have transmitted the information to some system component. The important thing for our idea is that the information, properly said – The Information – **"has a meaning"** (very basic semantic) that is created on the inside of the system. As Menat would say, "It is meaningful information." [43].

In a naturalist perspective, any signal, sign, or information must always exist with respect to something else and not imposed by some observer (we can find other approaches to Biosemantics in [44-48], among others). Therefore, we do not accept the existence of things like signs, signals, or information by *themselves*.

In this way, information will always be *information for the system*. How can we understand this information for this system?

First off, that potential information that carries the signal must have been incorporated to some process. It is in that particular process where the information might be transmitted. Secondly, the 'potential information' becomes Information (*"information with meaning"* for the system) since it has the capacity to produce something (an effect) in the process that incorporated it, in some other process that is directly or indirectly connected to the initial process that incorporated it, or with some aspect of the constrictions that are effectively maintaining the system far from thermodynamic equilibrium. Third, the effect has a repercussion in the system, influencing its own dynamic organization.

For the purposes of our work, we will use Collier's notion of cohesion [38, 39]. Cohesion is the idea that would provide the informational dynamic system its identity, in all its transformations in time.

Such cohesion is constituted by the group of relationship and interdependencies that exist among the processes; it is a relational and dynamic definition that encompasses the nature of the system organization.

The effect of the information that has meaning for the system can be in the maintenance or the increase of the system cohesion. As well, the effect could produce some level of interference in the system cohesion, possibly interrupting one or more processes. It is clear that meaningful information can be caused by some signal (that carries potential information) coming from the environment like a signal that is generated in the internal dynamic of the system. In all cases, whether an effect in favor of or in contrast to cohesion, the system will develop some type of response that will be correlated to that meaningful information and the process or processes enveloped by the effect.

Let's imagine an ideal situation in which all the system processes perform each and every one of its actions in a perfectly balanced and interdependent way. In this situation, the informational dynamic system is normally far from thermodynamic equilibrium (there is a sustained correlation among the processes such that the tendency towards irreversibility may increase).

In this ideal case, we can see what is happening in the entire system, what happens among the processes, and inside each one of them as well.

In this case, each process performs its determined function (contribution) in which this integrated network of relationships is directed towards the cohesion of a far from equilibrium system. At the same time, the information generated in each process and in the interaction among this integrated network of processes will be considered by the system as a type of system checkup to see if the cohesion has not been disturbed.

In that sense, the state of being far from thermodynamic equilibrium behaves like the most fundamental norm that the system imposes on itself, for which every strategy elaborated by the system (component, process, relationship, or matter-energy management) for maintaining or increasing this norm will be incorporated as part of its dynamic structure.

In order to finish our argument, we present some examples that we consider supports our working hypothesis to a certain degree.

First, it is known that the fibrodendritic projections coincide with the isofrequency organization planes (high, medium, and low) in the Central Nucleus of the Inferior Colliculus (CNIC). Tonotopic organization is a fundamental property of the auditory system [49], and it is now well established that the morphological substrate for such tonotopy in the CNIC is its laminar organization [50].

The inhibitory action of GABA and Gly is what shapes the temporal and spectral response of Inferior Colliculus (IC) neurons. Due to the relevance of inhibitory processes in the physiologic responses of the IC neurons, it is realistic to think that we might obtain some explanations of the acoustic information flow dynamics from the neural populations and the histochemical and cytoarchitectural organization of this nucleus.

Working with a colleague, who is a neuroscientist, on his acoustic system research [51], we have found a certain correlation between the distribution of neurons in the Central Nucleus of the Inferior Colliculus and the way in which the flow of acoustic information travels through it.

It is observed through densitometric quantitative methods that different populations of GABAergic neurons (which are inhibitor neurons) exist in each isofrequency plane that are oriented in transversal planes to each isofrequency plane. Thus, a topological relationship of neurons exists with respect to the laminar organization. This topological dynamic organization in each isofrequency plane correlates clearly with GABA gradient concentration such that it would generate a determined rhythm to the temporary excitatory flow. If only one type of neuron population would exist in each isofrequency plane, then this hypothetical fact could be considered by us as a counterexample to our working hypothesis.

Second, erythrocytes mature in bone marrow by means of the hormone, erythropoietin, and then are released into the blood stream in where usually are destroyed 120 days after. Recently, levels of anemia have been discovered in returning astronauts as a result of the destruction of erythrocytes. What is surprising in this case is that in place of destroying the oldest cells (which is the expected) the focus of the destruction is the youngest cells. This is a phenomenon known as "neocytolysis" [52]. This leads to the question: Could certain signals exist that would carry a determined type of information for the organism as a whole system such that it would make "functional" the massive destruction of the youngest erythrocytes before the oldest? It is important to point out that erythrocytes do not have nuclei.

The topic of viruses seems to us a very revealing case as well. These are entities that are not autonomous systems; nevertheless, in determined conditions, they develop processes that come out to be informational and functional. The processes for entering a cell begin with "recognition" of the target cell receptors, whose activation by the virus will cause notable changes in the plasmatic membrane, and end up with the virus entering the cytoplasm [53].

Here, we can visualize certain "functional information" for the virus that is "dysfunctional information" for the host cell. Its molecular components are such that they can perfectly *interact* with the organizational logic of the target cell and only because there is that organizational dynamic (informative and functional in the target cell); it is that its components, upon interacting, will carry determined information that makes the functional actions concrete since they contribute to its reproduction and survival. The relational character is revealed in that these same processes are dysfunctional for the cell and the information that certain components of the virus transmit are counterproductive for the cell (to such a degree that the virus's use of the synthesis and replication machinery of the cell will end up destroying the cell). These are interesting lines of research, attempting to find out which signals permit "blocking" the mechanisms and processes which monitor the internal states so that the virus "takes possession" of a large part of the cellular metabolism.

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