IRREVERSIBILITY AND ERGODICITY

Walter Riofrio
Neuroscience and Behavior Division. Laboratory of Pathology,
Faculty of Veterinary Medicine and Animal Sciences
Universidad Peruana Cayetano Heredia[*]

ABSTRACT

In this paper we examine one basic component of complex systems: Self-organization. We establish the links and relations among self-organization and the far from equilibrium thermodynamic processes. We also establish its relation with the ergodic hypothesis. In this way, we propose a defense for a universal definition of life. We argue that this search is intrinsically connected with the investigations on its origins.

Keywords: Self-Organization; Irreversibility; Autonomy; Ergodicity; Evolution.

1. INTRODUCTION

We know that the Newtonian theory is a mechanic and deterministic theory in its ontologic foundations. Every physical phenomenon of the universe can, in principle, be described by the last constituents of the physical reality.

It is enough to know the position and the moment of each of the particles that constitute the phenomenon under discussion, to decide what will happen to each one of them in the near future. The same can be said if we wanted to know what had been of the phenomenon some time in the past. The ontology of the Newtonian mechanics affirms that the universe is complete and totally describable by the knowledge of the two basic components that define the particles that constitute it: their position and their moment.

It also affirms that the mechanic legality is valid whereas the time travels towards the future, or if it travels towards the past: the mechanical laws are reversible.

[*] Av. Honorio Delgado 430, Lima 31, PERU.
Phone: 511-3190000 (2266) / Fax: 511 3190039
E-mail: wriofrio@upch.edu.pe ; wriof@terra.com.pe

2. THE SECOND LAW AND IRREVERSIBILITY

It is thanks to the work by Ludwig Boltzmann, that a supposed contradiction between the mechanic laws and the thermodynamics was addressed. Specially the second law, that refers to the change of entropy in a system.

In 1872 , Boltzmann achieves a generalization of the Maxwell studies on the changes in the distribution of the molecules inside of a gas. This formula, known as the "Boltzmann Transport Equation" facilitated the mathematical developments that allowed him to describe the concept of entropy. He finds a mechanical equivalent for the second law of thermodynamics: he shows that a gas in any initial arbitrarily elected state will tend to approximate to the equilibrium state (that is a state of highest entropy) because of the collisions between the molecules.

However, the "Boltzmann's H theorem", as the above-mentioned equivalence is called, presents a certain conceptual difficulty. We know that the laws of Classical Mechanics are reversible and, the H theorem indicates that certain mechanical processes **are irreversible**.

In other words, if we choose any initial state of distribution of the molecules of a gas, the final state will always be the one that comes near to equilibrium. When measuring the entropy of both states we find that in all the cases the final state is of major entropy.

For the investigators of the XIX century, this was a completely unexpected, "surprising" fact. It was not possible to comprehend that the frame of the Newtonian mechanics had a contradiction to the most basic foundations of theoretical Physics. For this reason, Boltzmann took charge of finding an explanation to these facts.

In fact, said Boltzmann, the H theorem doesn't just derive from the laws of the mechanics because added to the previous we have to take into account the concept of probability. In this way, the real sense of the H theorem is the indication of the overwhelmingly probable that the gas tends to approach to the state of equilibrium, as a consequence of the collision of a great numbers of molecules in the temporal course.

Accordingly, the H theorem doesn't contradict the reversibility of the laws of mechanics and, at the same time, explains the irreversibility of the second law in probabilistic terms. Here, he proposes that the probability in the kinetic theory, can be defined in terms of the "average time" of the gas in a state. That is, the average time of a state is the relative proportion of time in which the gas is found in that state. We can identify the "average time" with the probability of a state.

In 1877, encouraged by all these results, Boltzmann takes the task of offering a complete physical correspondence between thermodynamics and the laws of mechanics. In this attempt, he develops the notion of probability in terms of the numbers of microstates. He proposes a distinction between the macrostate of a gas and the microstate of the molecules that constitute that gas.

The first term corresponds to the thermodynamic state (which, we certainly can measure), the second corresponds to the mechanical state (that usually cannot be measured). In other words, a microstate is a particular way of distributing a determined increment of energy between a specific numbers of molecules and, of course, the differentials of energy that –we can understand-, will be given to a group of molecules and will be different of other differentials of energy of other groups of molecules of the same gas. However, the dynamics of the changes at these levels of reality will escape completely our means of detection.

We can measure the probability of a macro-state observing the relative proportion of the time spent in that state with respect to the total. But, a serious problem that Boltzmann was faced with refers to the following: how can we assure that every macro-state has only one and only one average time at any moment?. Also, nothing is gained assuming that each microstate is "equiprobable". Because, first, with this assumption we completely loose the significance of probability in physical terms. Second, the same question remains but in this form: how to ensure that we can obtain only one value of probability under these conditions?.

If we could justify the presumption of equiprobability completely in mechanical terms, both problems would disappear. In a very sophisticated way, the Ergodic hypothesis, is known to have achieved this task. We will see, in an intuitive way, that if we can assume the notion of equiprobability for all the microstates of a gas, then, we would reach the conclusion that the more probable state that a gaseous mass can approach is the state of equilibrium.

This hypothesis establishes that a system of molecules will assume, in the long run, all those microstates that are compatible with the Principle of conservation of energy. This way there will only exist one average time for each microstate. This makes it possible for us to calculate its value inside the Newtonian mechanics. The conceptual importance of the ergodic hypothesis**,** takes root in the fact that the mechanical concept of "average time" has to have the same mathematical structure than that of probability.

During almost the whole XX century, the successive theoretical consequences that derived from the Ergodic Hypothesis, specially, for the justification of the second law of thermodynamics, allowed certain lines of thought that settled strongly in the biological sciences. Therefore, if a system of molecules traveled arbitrarily around all microstates rationally conceivable –which is another way of paraphrasing the ergodic hypothesis- then, the validity of the second law for the biological world is out of doubt.

As we now understand, the processes of adaptation of the biological population in the frame of the evolution by natural selection, must find its last foundations in the genome behavior. That is why, for a determined environment, the favorable mutations in the genetic material share the conditions that make possible that certain individuals of a population find themselves in an improved condition to contribute with greater numbers of descendants to the following generations. One of the investigation topics that will occupy the investigators in evolutionary biology is the discussion about whether evolution is gradual (as derived from Darwin's reflections), or, if it happens in gaps.

The apparent incompatibility between the mechanical and thermodynamic laws from the past century are practically forgotten. Even more, the investigations in the laboratories are mainly directed to the discovery of the components that are involved in the different metabolic and regulation processes in the different levels of living individuals.

Interestingly, we can observe that in those mathematical treatments that involve interactions of molecular compounds, the developments are carried out fundamentally analyzing the behavior of these interactions in the equilibrium.

In that way, the interactions between the components of an entity are guided fundamentally by the chance of the big numbers and its probabilities of occurrence. Moreover, the parts of a totality such as the biological phenomenon, get added by fragments. In where the success or not of such addition is regulated by the basic strategy of trial and error.

It is important to mention here, the astonishment of reaching the conclusion that life is not an expected phenomenon of the universe. We are an accident in its development. Our opportunity of reaching to the existence is compared, in this ontic frame, to the opportunity of being the winners of a great cosmic lottery. It is a fortunate highly unprobable event [1].

3. ONE BASIC COMPONENT OF COMPLEX SYSTEMS

As we now understand, the consequences that we derive to the assertions of the complex systems program are opposed radically to the previous chapter. And this itself, make it possible to propose again ancient questions that almost did not provoke astonishment.

Questions that again -inside this new scientific program- reach the state of big questions with great levels of perplexity: how is possible that millions of cells (in where all they are almost identical), "organize among themselves" to "produce" a living entity?. How a fecundated ovule can be developed until a complete human being?.

They are very basic ask but with immense possibilities of disaggregated in multiple derived questions. Therefore, this "organize among themselves" of many structures (very organized in turn), open the door towards a universe of new questions (or, that already we consider has been answered in the past).

For that reason, the self-organization as an emergent property of certain physical and chemical phenomenon became (in this great conceptual framework), in a completely accepted fact for the dynamics of our universe. But how we can understand this acceptance and their possible analysis and explanation, so much scientific as philosophical?

Remember that Prigogine outlined the notion of "dissipative structures", that refer to integration processes of structures in the physical-chemical level [2]. Also, in the level of the so called social insects, it is produced something like a "collective intelligence" [3]. And, don't forget the processes of basic and fundamental integration in the development in biology [4], or, the processes of self-organization in the dynamics of computational simulations [5], among others.

With respect to self-organization -apart of the different kinds of approaches and themes adopted by the investigators-, when we speak about to a collective dynamic phenomenon as such, then, we are talking about to the nucleus of the argument.

Moreover, this dynamic involves different transitions that cause the emergence or appearance of new behaviors in that addition of components, which we knows as "ruptures of symmetry".

We pointed out that a central aspect in the acceptance of these phenomena is the fundamental treatment in far from equilibrium conditions, in ***irreversibility conditions***.

If the addition of components produces a certain phenomenon, this itself implies necessarily adopt a dynamic perspective. And as long as this dynamism generates, in turn, a whole of transformations in time in the same logic of the addition. It implies, that we cannot study a dynamic perspective in conjunction with an arsenal of concepts, and its concomitant conditions in equilibrium conditions, that study the reality in static situations.

The irreversibility of a phenomenon under discussion, takes place in distant or very distant of equilibrium conditions and it supposes dynamic conditions in its constituents or "producers", as well as, of their particular dynamic of addition. We realize that the scientists of different areas, begin to confront with different problematic on the more basic designs and suppositions in their researches.

For that reason, the complete explanation of the parameters and behaviors of any entity –in isolation conditions to other entities that in conjunction are involved in a certain phenomenon-, doesn't fulfill with the expectations, so much epistemic as ontologic, in this generation of contemporary scientists.

We can see these ideas in Schrödinger’s investigations, fundamentally, with respect to self-organization. Usually, this scientist is associated with the statements of thermodynamics, that was developed in the nineteen century by Carnot, Clausius, Boltzmann and Gibbs. However, we pay little attention to the equally important contributions in his observations and analysis, that begin with “the appearance of order from the disorder in nature” premise [6].

In his works shows the spreading of levels of arranging created from the disorder of reality. Schrödinger recognizes that life is a far from equilibrium system that keeps its local level of organization at the expense of a global entropy increase. He proposes that the study of the alive organisms from a nonequilibrium perspective will be able to reconcile biological self-organization with thermodynamics.

A question of interest in these circumstances is related with the kind of approach that facilitate develop a nonequilibrium theory that equally compete with the classic thermodynamics. Moreover, this approach has to permit resolve, in the best way, the subject of harmonizing the biological self-organization with thermodynamics.

Three scientists was dedicated to a review of the suppositions in the classic thermodynamics. They say: "When an isolated system performs a process after the removal of a series of internal constraints, it will reach a unique state of equilibrium: this state of equilibrium is independent of the order in which the constraints are removed" (Kestin 1966 quoted in [7]).

It indicates a way to generate a synthesis of thermodynamics laws that predict how could behave a system -and, the entropy concept doesn't appear, in principle, in play. Rather, this approach remarks the irreversibility character that shows the thermodynamics laws. May be, it is the more fundamental ground of the second law [7].

It also puts the attention on the existence of constraints that a certain system presents. From almost the origin of the tradition that develops in the cybernetics disciplines, artificial intelligence, science of systems and computation, until the more recent artificial life, outline a radical distinction between the informative-organizational and the energy-material aspects. And it affirms that to explain the main logic of these systems not results indispensable the energy-material component.

It is not necessary, we believe, to take in to account the great successes that offer the simulations and models of numerous phenomena in these disciplines. However, although the investigators in this disciplines are in agreement in make references to the "material" component when we view the biological phenomena, is only for to give a content more in agreement with the current phenomenology in the earth, since doesn't have influence on their formal organizational implementation.

Subsequently, I will continue with the implications of this last paragraph, but turn again to the unified definition of thermodynamics. In terminology created by Prigogine, the only state of equilibrium that is reached when are removed all and each one of the constraints of the system behaves like an attractor. Thus, the spontaneous natural tendency of the system is to reach that attractor state.

To obtain this, the system will try to remove each one of the factors (constraints) that move away of that attractor state. The logic is the following one: the removal of constraints, implies that the same system will devise some strategy that permit this removal. The emergence or appearance of some strategies in the system, are direct linked with an information increase. That is, organization: in the form of new arrangements in the system.

The Bénard cells, the tornadoes, the chemical autocatalytic reactions and life itself, are examples of the omnipresence of self-organization. In the majority of them, the gradual removal of constrictions approach the system toward the equilibrium. At the end, the emergence of those new aggregations or structures will finish for disappearing.

However, what is the matter if in this context, at least one of the constraints that maintain the system far or very far from the thermodynamic equilibrium is the result of the assembly of actions and processes of the system itself?. That possibility exists?.

4. ON THE ORIGIN OF LIFE

The initial answer could be affirmative: the current knowledge in physics, chemical and biology, don't establish any kind of restriction or prohibition in the presence of the possibility outlined in the questions of previous chapter.

The question doesn't finish there. Rather, we begin to elaborate now an argumentation, more detailed and rigorous, on the conditions that delimit the previous answer.

To achieve this, turn to the dichotomy between the informative-organizational and the energetic-material aspects. We defend a thought that considers very important -but indispensable-, the energetic-material aspects when we carry out investigations and conceptual explanations in certain systems. When we ascertain that that constitutes its internal logic of construction and development, for example: [5] [8] [9].

It is in the alive systems where we see the importance of a non-eliminative perspective with the energetic-material component, to carry out a study on its constitution and more fundamental maintenance.

We can affirm that we consider the reality structured in different levels (the themes of investigation in the different sciences) and where each level presents objects, interrelation among them, processes, behaviors and quite characteristic properties and, in principle, distinguishable for each level. Moreover, each one of the levels are related. The pre-existence of the previous levels is indispensable requirement for the emergence or appearance of the other.

With regard to living systems we do not consider appropriate the approximation that obvious what refers to the materiality of life, together with the requests and energy limitations, to define and to explain the arise and maintenance of living systems.

The self-organization concept is related to dynamics and to be far from the thermodynamic equilibrium. Nevertheless, there is diverse ways to understand what dynamism is. For example, in the classic sense of physics, the dynamic is associated to a change in the position of a body or clusters of bodies.

Therefore, an assembly of constraints that impose on a system (or, an addition of entities) the respective changes of position that can be "simulated" or "modeling" with some associated parameters to this particular meaning of change, only they manage to unfold a determined phenomenon until those constraints "they exist" or they continue "acting" in the program designed for those needs.

The outlook that defends the informative-organizational component of a system -for the study of its more basic levels of arranging-, carries us to consider "the form" as the fundamental thing. For that reason, necessarily, to maintain a position enough idealized of the phenomena. They cannot be understood in its real dimension -as in the case of living system and other similar-, when we leave sideways the successive circumstantial moments, that are coextensive to the relations among them and with the environment.

This production of circumstances, constitutes a space of future processes and phenomena that are not collected in the simulation models at present designed (at least, in the theory of dynamic systems that is used in the behavior of complex systems simulations).

We leave open the question on if an improvement in the mathematical tools or a change in the formal perspective, it would does feasible a certain degree of contingency in these models. Together with the possibility of the emergence of certain patterns that "produces" constrictions generated inside the system in their dynamics of development. And now, the self-organization would not depends so hardly of external agents.

In this way, the change of direction in the different sciences would have also to be linked with a certain change in our methodology and conceptual tools. It seems necessary a revision of our way to do the scientific investigation and, up to now, the change in this direction is not produced.

In these last years, a greater consensus by the search of a universal biology appears. In this way, the living systems in our planet would result to be a particular case of a totality of phenomena extended in the universe. The large lines of investigation that develops, since the second half of the nineties in the incipient Astrobiology, can be considered like the indicators of that that we affirm.

The different intents to find the main lines that direct us to develop a universal theory of the biological systems go pass, necessarily, by discovering the fundamental properties of all that that would be able to receive the meaning of living in our universe. Therefore, wouldn't be empty to devise -in the more precise and rigorous way- tentative definitions of what by life we can understand.

The attempts in this direction are very varied, some of a skeptical point of view [10] and another that reflects many confusions, product of misunderstanding in its real magnitude the present advances in different sub-disciplines as bioenergetic, thermodynamics, enzymology, supramolecular chemistry, genomic or proteomic [11].

It is extremely important to establish certain initial framework that permit us to reach the core of this research: to elucidate the minimum properties along with their fundamental nature. As well as, the basic dynamics of its mechanisms and organization [12].

In this context, to define the properties of life implies a reference to the physical-energetic component. Even, if the chemical phenomena arise of the physical level, are also important the physicochemical level.

And it is here where the notion of dynamics reaches an adequate degree of determination. Specially, to the different and various types of dynamics that are presented in the organic chemistry. During the XX century, the chemists have been dedicated to explore and to develop the uses of the covalent bonds. During those years, the immense quantity of chemical compounds and its concomitant reactions, spread out to antibiotics until the diverse variety of plastics.

However, it is only recently that the specialists in the chemical sciences have begun to take advantage of another wonder of the natural world: the noncovalent bonds. So, from ends of the eighty (in 1987 three investigators win the Nobel prize of chemistry for their works in the construction of small complexes molecules united by noncovalent forces), appears officially the "Supramolecular Chemistry" that, in essence, is the science of the noncovalent bond.

It is the ability to form looser links between small molecules by the bonds (or, bridges) of hydrogen, the van der Waals forces, the $\pi-\pi$ interactions, the hidrofobicity, among other noncovalent interactions. And it will have a great impact in the materials science, the medicine and other technologies [13].

An important task in the biological investigation, should find the basic properties that differentiates an alive system of what it is not. Even, an adequate differentiating line will permit us to distinguish among what resembles a living system (it has certain aspects, or, properties, or behaviors) of what is alive. Undoubtedly, the origin of the dynamic organization that guide the material and energy requests in a finite and variable environment, is a characteristic to be universalized.

In the past, different classes of definitions of the alive systems have elaborated. Nevertheless, we prefer to present and to argue in agreement of the definition that we believe contains the essential elements. We seek to open the field for the discussion and that conduct to generate a definition extensively accepted (for an interested reader there are this works: [5] [14] [15] [16] [17] [18] [19] [20].

The definition that we mention is the following one: "*a living being is any autonomous system with open-ended evolutionary capacities*". The autonomous system is understood, like a system distant of the thermodynamic equilibrium that establishes an organizational identity by itself. And the open-ended evolutionary capacity, is the potential of the system for re-produce its basic functional dynamics and constituents, that is not subject to any predetermined limit with respect to their organizational complexity [12].

Oparin said, the search for a definition of life directs us invariably to a search on its origin [21]. Then, a good definition of a living system should explain the conditions on its origin. How since an environment saturated of inert components, in a continuous succession of states, came the living system arise.

It is an agreement among the investigators in the Complex Systems Program that the most minimum complexity in any region of the universe, is produced when an appreciable number of components or elements establish interconnections beyond a certain critical threshold, where we verify the emergence of new properties that belong to the totality (global properties).

We indicate that the search of an appropriate definition of complexity, is also an important task that has to be clarified. When we undertake the task of defining life and the nexus on its origin, within the framework of the complex systems, we must make certain precisions.

In the first place, a good definition has to have an explicit reference to complex characteristics that display the phenomenon of life. In second place, this complexity has to do reference to the ways in concrete the maintenance, enlargement and diversification in time, because is originated of the management of energy and matter of the universe. Finally, together with the diversification and capacity to be established as a new level of reality, also, the reference to the mechanisms and processes that carry to an increase in the degrees of complexity.

These themes should form part of a conception that present the matter of the viability of living system in the natural dynamics of the universe. It is important to study on the necessary and sufficient conditions, to establish the framework of the problem.

When we accept the fact that our universe constitutes "a good place of laboratory" for the emergence of life we refer to, that the dynamics of stars can produce the necessary elements for the subsequent synthesis of the "building blocks" of alive phenomena (specially, the organic chemistry). It constitutes a necessary, and not sufficient condition for the emergence of life ([22], pp. 115).

Currently arise questioning in astrophysics and cosmology on if our universe had a special origin or, if the values of certain constant (such as the mass of the electron, the strength of covalent bond and many more), are caused for the development of the universe governed by the fundamental fields. For example, “the cosmological constant must be tuned to 120 decimal places and there are also many mysterious ‘coincidences’ involving the physical constants that appear to be necessary for life, or any form of information processing, to exist” ([23], pp. 79).

In the session "The evolution of biological fine-tunning", in the frame of the Workshop "Fine Tunning in Living Systems" in the Windsor Castle, were analyzed since different perspectives themes such as if to explain the evolution, has to take into account the impact of the possible accidents in the history of the alive phenomena in our planet or, if only was sufficient to be referred to natural selection. Also, on the character of the initial conditions that must be given for the evolving of life, and the possibility of different and independent evolutionary histories of the living being on Earth.

Cairns-Smith studies the theoretical consequence of the astonishing unit of biochemical processes in the alive beings, and its relation with the early evolution of life. He indicates that of the near identity everywhere of so much of central biochemistry, does not mean that the molecules that are universal in organisms on Earth now must have been in at the beginning. On the contrary, the complexity of this central machinery, and its efficiency, strongly suggest that it was, all the same, a product of evolution through natural selection, some prior evolution.

As Lipmann said (Lipmann, quoted in [24]), an initial problem exists of assembling the monomers that constitute the nucleic acids. The studies in chemical synthesis arrives at the conclusion that is less complicated to synthesize amino acids than nucleotides. Lipman suggested that glycine and aspartic acids are necessary for the respective synthesis of purines and pyrimidines.

On the other hand, Cairns -Smith proposes, if we deepen in the conditions on the origin of life in our planet, we should carry out a search in the inorganic chemistry. Since the crystals can be behaved as primitive “replicators” in the origins of life [24].

In this direction it also inscribes the Wächtershäuser, Hazen and Maden proposals. The first of them, is occupied on the origin of life outlining first a dichotomy between an autotrophic or heterotrophic origin . The central problem -says Wächtershäuser-, it is how to can be primarily fix the carbon.

Wächtershäuser proposes the possible existence of an autocatalytic cycle (that is the predecessor of the citric acid cycle) that, in essence, is quimioautotrophic. Assuming that the required reducing power, to the establishment of that cycle, is obtained from the oxidative formation of pyrite (FeS_2) [25].

Hazen and their group of investigation manage the idea that minerals might have sheltered the ingredients of life. If we consider that almost 4.5 billion years the earth counted on oceans, an atmosphere and minerals, then, the minerals have to play a crucial part in the origins of life. His investigations -that start in 1976-, reveal a wide diversity of behaviors in similar conditions to the primitive earth.

The crystals of different compositions behaves as containers, as scaffolds, as templates, as catalysts, among others. For example, he began to suspect that calcite surfaces may feature chemical bonding sites that are ideally suited to only one type of amino acid or the other, a selected agent of molecules: this could be an alternative explanation of why the great majority of amino acids that constitute the proteins are of L series [26].

Maden, in turn, takes charge of carry out a defense of Wächtershäuser's proposals, and continue with the discussions on if the origin of the alive organisms went autotrophic or heterophic. Like a work of half of the nineties, reveals the polemic that it gave as majority the supposition that, some kind of genetic pre-material must arise first before the emergence of a certain metabolism, both separate and without continuity, so much logical as material [27].

Although this three authors remarks the complexity of the mechanisms and processes involved in the initial phenomena that open the doors to the origin of life, we consider that their experimental works are still designed in the frame of the classic sciences.

This theorizations don't get capture the minimum that must be gathered in a definition of life, that bring us lights on where searching for its origins. In the other side, neither it see clearly how to can be establish the links of the first precision (the complex character of the alive phenomenon) with the other two that I was mentioned.

In the last chapter that follows I will dedicate to develop the implications of the definition of life that we adopt in relation with the precisions annotated. Moreover, we will explore the nexus and implications that have the definition with the ergodic hypothesis .

5. ERGODICITY AND DEFINITION OF LIFE

As we now understand, the traditional use of the ergodic hypothesis is the foundation of statistical mechanics at equilibrium, offering the links among the observable thermodynamic and the probabilities of microstates in a system [28]. Nevertheless, the problems in the interpretation of probability travel through many environments of knowledge beginning, of course, by the interpretation in quantum mechanics .

Where the polemics on if the universe is deterministic or indeterministic generates, on the one hand, the interpretation of probability as ignorance in a deterministic context. That is, in a deterministic theory arise the probabilistic explanations due that the observer doesn't know some prominent parameters of a system (hidden variables of determinist character) [29].

The investigators that are agree in considering that quantum mechanics reflects a fundamental randomness of the universe attribute it, in part, to the thermodynamics of the Black Holes [30].

For Prigogine [31] the subject it centers in the treatment of the irreversibility, in the context of the universe as a whole. In a first approximation, seems to be that the meaning of the irreversible processes suggests a relationship with the space, and with the direction of time. As long as the dynamics of many systems involves that, in a determined moment be produced a break of symmetry in the space of phases, two solutions from that moment of break can be found: one goes towards the past and the other towards the future.

It is precise, if we can speak of an Arrow of Time, that one of the possibilities (the one that is going to the past) be not congruent with reality. As long as several systems in the universe develops their dynamic behavior far from thermodynamic equilibrium, it implies that those systems are nonergodic, just as the majority of the quantum systems.

We can find in Kauffman similar arguments: "The universe, at levels of complexity of complex organic molecules, is vastly nonergodic... At a level of complexity above atomic nuclei, once into the realm of complex molecules, the universe will not, cannot, come to equilibrium, on vastly long timescales compared to its historical age" ([14], pp. 144).

Our universe is in constant changes, and its internal dynamics permits understand that the consequences of the ergodic hypothesis for the growing set of complex organic molecules, cannot be reached. The fundamental reasoning is that, only in a scale of considerably greater time to which presents at present our universe, the ergodic hypothesis can be correct. Nevertheless, as we can verify in our planet, the degree of molecular complexity and the different artifacts created for these molecular aggregates, carries ourselves to the conclusion that the increase in the complexity doesn't contain limits.

In other words, the living systems and its environment (as a whole: a Biosphere), they seem to spread towards an increase in the complexity, so much of its components, mechanisms as well as its interrelationships.

Then, the initial issue that it is necessary condition for the possibility of life in our universe is related with the expansion and dynamic state in which is found the universe. It involves that the universe, taken as a whole, results to be a **nonergodic system**.

We could continue with other requisites (in part annotated in the previous chapter) that constitute the set of necessary conditions for the to arise of alive phenomenon. Nevertheless, yet we have not indicated what constitutes the framework of the sufficient conditions, so that life can appear, to be maintained and to be diversified in a part of our universe.

We return to the definition of life that we are defending, to indicate some decisive moments from the inanimate kingdom towards the alive kingdom. We will mention the steps of the successive processes and mechanisms, that it involves a substantive changes in the internal logic of aggregation and their relationships with the other systems and with the environment:

SELF-ORGANISATION PHENOMENA → AUTONOMOUS SYSTEMS → ONEPOLYMER WORLD → TWO POLYMER WORLD → OPEN-ENDED EVOLUTION

The proposal that present Alvaro Moreno and his team of investigation, is dedicated fundamentally to try to harmonize the genetics and energetic aspects of the living systems. An alive system is constituted for both components, as we can appreciate in our planet. They faced to the question on the origin of living systems, they consider that a continuous passage among the inanimate events, takes to certain states of aggregation and management of matter and energy, in certain systems that constitute the universe of pre-biotic evolution.

Thus, in the search on the origins of the alive systems is presented, before that the way how the building blocks could be added to generate the first genetic molecules, another more original problem.

In fact, a question of central importance to differentiate it most minimum living of that that it is not, is to try to explore how is possible the emergence of "functional or informational constrictions" ([17], pp. 6). It is important to understand that our conceptual approximations should take into account, seriously, the intricate character of the processes and integration dynamic that have the living systems since their own origin.

Then, it has sense the questions that conduct us on the search of mechanisms that are related to constrictions, and that promote the emergence of life. In other words, is important to investigate the different types and classes of mechanisms-constrictions, that are sufficient and necessary to unfold the alive phenomenon.

It permits us to be capable to visualize a great assembly of evolutionary events in a pre-biotic world, that should appear in any place of the universe before the emergence of life. This pre-biotic evolution will pass by certain succession of stages, where transition of **molecular complexity** be produced. That it involves an increment in the complexity of the components (increasingly macromolecular).

On the other hand, also transition of **structural complexity** will be produced. These involve an increment in the complexity of interrelation among the components, producing the rise of new functions and properties of integration and robust maintenance in time ([17], pp. 10).

Another important aspect is referred to the **autonomy**. Nevertheless, the emergence of autonomous systems contains the supposition of the prior existence of another class of systems: those systems that generate **self-organization processes**.

The spatial and temporal organization pattern that are observed in all the living systems of the present time, indicate that is a primary capacity that is produced at the beginning of the pre-biotic evolution.

This capacity, that constitutes the environment that favors the start of the pre-biotic phenomena and evolutionary processes, indicates that only it is possible to find these phenomena in far from equilibrium thermodynamic conditions.

The following step -for these investigators-, is the appearance of a **basic autonomy**. A basic autonomy implies that the system already possesses a certain so much physical, chemical as dynamic identity by virtue of its homeostatic capacity. Regarding the sources that has at your service in the environment to obtain the energy and material requests that needs for its self-construction.

The concept of autonomous agent already is developed by Kauffman [14]. Where an agent will be called autonomous, when achieve a closing or closure in the space of catalytic task, generating one or more work cycles. The work cycle will achieve it when establish an interaction and coupled among endergonic and exergonic processes.

The notion of basic autonomy implies a step more in the explanation or detail of what we understand for autonomy, as a process to establish distinctions among the living systems and other phenomena of the universe. The intrinsic relation between works and constriction, that already is outlined in the notion of autonomous agent in Kauffman, will be more specific in the notion of basic autonomy.

The identity of a system with basic autonomy expresses the coupling set of chemical processes between exergonic and endergonic reactions (that is the network of action of work-constriction cycles). This makes possible that processes of self-maintenance be established so much inside the system, as in the limit region between the system and its environment.

This dynamics will originate certain constrictions in the system, that are generated for own components of the system. Accordingly, the own system is the one that is maintained far from the thermodynamic equilibrium, with regard to that own components of the system impose the constrictions at the system as a whole.

This component-constriction will permit to resolve the problems that will face the system for its maintenance outside of the thermodynamic equilibrium: the problem of its frontier or border from the exterior, the problem of the osmotic crisis, the spatial and temporal coordination of its constitutive processes, and the problem of an efficient management of energy incorporation ([17], pp. 113).

The step of an autonomous system toward a living system, permit to explain those two precisions that we mention before. In one side, with the reference to the ways in concrete the maintenance, enlargement and diversification in time. For the other side, with a reference to the mechanisms and processes that carry to an increase in the degrees of complexity.

The increment in the degrees of complexity requires the appearance of a reliable mechanisms of copy in time. It achieves with the emergence of the first molecular structures that can function as molecules molds or templates.

The other precision, is when a differentiation among two kinds of tasks is produced, that although interrelated, is not clear to think that they can be executed in an efficient way by the same molecular type: (1) the metabolism (the catalytic control of the different reactions sequences in the system) and (2) the storage, replication and the reliable transmission of the important information for the system (or, registers).

For that reason, in the scheme presented above have indicated after the appearance of the autonomous systems, the existence first of the one-polymer world systems, subsequently, the two-polymer world systems, to end with the open-ended or alive evolution ([17], pp. 164-65).

Although it is precise to indicate the need of more investigations, to contrast adequate the empirical feasibility of the generic delineated proposal, we believe that it is found in the correct line to carry out improvements on this definition of life. Besides, we find that other investigators, although don't explicitly indicate their agreement with this definition, present a revision of the bases that Moreno’s group do explicit [32] [33].

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