Emergence of Organisms from Ordered Mesoscopic States of Water (Liquids)—Physical Instead of Chemical Origin of Life

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1 Introduction

The development of science is not a linear way of steady progression; it is more akin to a living organism and knows not only ebb and flow, but also critical bifurcation points. These are points of major decisions to be taken by the majority of scientists of a particular discipline. Once such decision is taken, the following way of scientific progress is separated from a part of previous achievements, explanations, models and findings as they are no more in harmony with the newly chosen paradigm. The science of biology is no exception to the rule. It passed through a very important decisive point during the period of Lamarck (the second half of the 18th century), where the majority of biologists—the moment coincided with the beginning of the biology as a separated natural science—decided that organisms follow different principles from the inanimate nature. Another important decisive point moved biology again away from its autonomous realm into the area of molecular reductionism, where life with all its richness of levels and ramifications is seen, studied and modeled as a complex chemical process individualized in organisms that are subject to natural selection; the latter being seen as a major evolutionary "force". Here, physics and the theory of dynamic systems have only a limited access, while there is no room for genuine biological laws. Since we still lack even a good and generally accepted definition of life, not to mention the lack of a deep and comprehensive theory of the living process, the last decision within biological community bereaved biology of very fruitful ideas, conceptions, views and considerations that were kept alive only by a small community of biological thinkers (e.g. the ones of biological fields—see more thorough studies of this topics by Bischof [1], Tzambazakis [2]). Hopefully, there are good signs that in a not very distant future, a new turning point in biological thinking will take place. Towards

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this event I devote this chapter concerning the origin of life, since the nature of life and the origin of it are only two facets of the same enigma. Namely, the effort to truly grasp the possibility of the origin of life inevitably leads us towards a deeper understanding of life and its laws, since the capability to identify the point of life's emergence is equal to understanding the life's very essence.

The mystery of the origin of life is tightly connected with another mystery that is becoming more and more topical with an increasing number of uncovered exo-planets that resemble the Earth: is there life anywhere else in cosmos? Our main premise will be that if life is understood and treated only as a molecular phenomenon, as the prevalent contemporary view holds, the possibilities of the life's origin are very minuscule indeed. However, if life is more then just chemistry and if it has strong, physically based, genuine aspects of orderliness, then its origin could have been much more probable then estimated by the majority of contemporary scientists and life should be widespread in cosmos, though it may chemically differ from the Earth bound (DNA-RNA-proteins) life.

2 Theories of the Origin of Life: Some Basic Problems and Their Possible Solution

The science of the origin of life also knew its crucial turning point that has been slowly preparing around 200 years, from Italian researchers Francesco Reddi (1626–1697) and Lazaro Spallanzani (1729–1799) until the great French scientist Louis Pasteur (1822–1895) with his famous experiment that yielded the proverb “Omne vivum ex vivo” (all living from the living). Until the experiment at least the unicellular organisms were seen as a creation of spontaneous generation from the inanimate matter. The perception and understanding was that matter had spontaneous organizational powers to generate at least the simplest organisms out of its inanimate chaos. The Pasterur's experiment shattered this notion, opened an abyss of unanswered questions, since it was also (and still is) logical that (a) there was time in the past of the Earth when there was no life at all and that (b) just under certain conditions once in the history of the Earth life emerged. A logical conclusion from the Pasteur's experiment and these two established facts was that contemporary matter on the Earth

(a) has no power to spontaneously generate life and that
(b) once it should have had it.

Therefore, in principle the Pasteur's experiment did not take away “creative” powers from the inanimate matter, but only limited them to some unknown conditions in the past. All scientific history of the origin of life enigma since “Omne vivum ex vivo”[1] concerned the identification of those special conditions. Mostly

[1]As we could see this proverb is problematic as it presupposes that life has been present since the origin of the universe.

they were sought for in some special complex chemistry, possible soon after the cooling of the Earth, but most certainly not possible now. The basic problem of these origin of life approaches stems from the fact that contemporary life, even in its simplest forms, is highly complex and ordered. In terms of informational theory, it has a relatively high informational content that should be stably reproduced from generation to generation. Therefore, we have two problems: chemical and informational. The first one demands identifying and reproducing a stable path from simple molecules (like ammonium ion, formaldehyde, hydrogen etc.) to macromolecules that would resemble the ones preset in contemporary organisms. This demand is spiced up with the condition that many primordial chemicals for the living chemistry should be chiral (optically active)—and we know that in nature spontaneously generated chemicals are ever represented by both enantiomers in equal proportion (i.e. optically inactive). Through time various partial scenarios for the synthesis of this or that essential chemical (like amino acids, organic bases etc.) were proposed. Some of them were also successfully empirically proved [3, 4]. However, there still exists a huge gap between these partial approaches and the orchestrated complex biochemistry of even the most primitive living forms. It may be said that it is difficult if not impossible to envision (and later to reproduce) a stable path that leads from the afore mentioned simple chemicals to the first living being. From the standpoint of the theory of dynamical systems it would mean it is most unlikely to find a stable (i.e. at least under certain conditions probable) trajectory from the chemistry of the ancient pre-life Earth to the evidently stable attractor of our first ancestor.

The second aforementioned problem concerns the problem of stable complex information that is capable of continuous reproduction. As it was smartly formulated in a relatively recent consideration by Walker and Davies [5], the starting point for the emergence of life should mean an establishment of causal powers from the side of organized information over molecules. Here information in living systems is not seen as coded in a straight line (as in DNA), but in a diffuse, non-localized, way. In other words, the causal powers of life are viewed as trans-material, whereby no supernatural factor is introduced, only dynamically organized, diffuse and active, operational information. In present day life this dispersed, organized and operational (active) information only partially resides in the DNA, it is also widespread in the whole living state of the organism—something perceived also by the structuralist line of organicism [6]. From experiments it is well known that *Acetabularia mediteranea* can reproduce its cap even without the nucleus, therefore with no DNA [7]. Consequently, and in line with Walker and Davies, we may safely abandon to understand organisms only as trivial duplicators with errors (i.e. like copying machines), which is the mainstream view of contemporary established biology. On the contrary, they should be perceived as non-trivial duplicators, systems which organized information is capable of multiplying the organization of energy and matter within the system in a complex and widely dispersed way and simultaneously actively process information and express a high degree of flexibility (variability).

According to this advanced view of the living process that is sufficiently abstract to enable capturing also some strange forms of life in larger cosmos, life can be defined as *dynamic and highly organized information, expressing itself through material systems and capable of further potentially limitless enrichment of its content (complexity) and its organization*. The origin of life then means only the emergence of such information together with its upholding material system. With the origin of life information as an active principle of nature gains the ability of causation from top to bottom (from the whole to its parts, from the cell—or the organism—to its molecules). It is behind the wholeness of organisms. This notion of information, even if sharing some basic features with the Shannon's information theory [8], at the same time far exceeds it. If the Shannon's theory concentrates on quantitative aspect of information, the biological concept should cover also its content (semantic aspect) together with its function and operational power. In this view, information as an active principle behind the living process arises as a powerful natural principle that works within matter and at the same time steering, directing its processes. According to this outlook, life has its special principle that surpasses ordinary (inanimate) physical and chemical world, but is on the other hand still a **fully natural principle**, like matter, time, space etc. This principle resides in inanimate matter as a more or less remote potential—and emerges under suitable conditions.

The theory of organized information sounds attractive, but has also its prosaic difficulties. In his inventive theory of the origin of life, Manfred Eigen tackled the problem of the emergence of the organized information at the molecular level that could lead to the origin of the simplest organisms. He analyzed the behavior of a special class of self-reproducing chemical entities called *autocatalytic cycles* and proved that simple autocatalytic cycles that would emerge on the primordial Earth as something similar to contemporary t-RNAs (i.e. self reproducing relatively short RNAs) would have a very limited evolution, in other words they would end in a shortest possible self-reproducing molecule [9]. Therefore, in simple self reproducing molecules we could achieve organized information, however on a pre-life level, incapable to engender a true living process with in principle limitless evolutionary perspectives. To cope with this short dead end of molecular evolution based on autocatalytic cycles Eigen invented entities called hypercycles [9]. The latter are interesting entities, but at the same time not very probable.[2]

Long after the triumphant Miller's experiment (dated on 1952), where he exposed simple molecules to electrical discharge in a chemically closed system and got many amino acids (though optically inactive) the solutions of the prebiotic chemistry leading to the origin of life is still far from convincing. It is similar with organizational (organized information) aspect, even if we jump from Eigen to Kauffman and his autocatalytic (still purely chemical) nets. He made sophisticated computer simulations of the possibility of spontaneous organization of information

[2]Eigen proposed the possibility of a direct polypeptide coding from a strand similar to contemporary t-RNAs without any genetic coding system.

and came further form Eigen, yet he still had to confess that the nets are only a necessary but not the sufficient condition for the origin of life [10]. This all speaks in favor of the idea that the exclusively chemical outlook on life may not be a fruitful attitude; it may be just a cul-de-sac that will never explain life itself nor its origin. Therefore, to regain a real chance to solve the mystery of the origin of life, we should make a bold step into supramolecular realms and try to identify a vital factor that

(c) would have a high probability to play an important role in biological processes, even if not yet acknowledged by the majority of biological science circles,
(d) could maintain a high level of orderliness even in highly diversified chemical systems, therefore systems with no "memory" molecule and with no genetic code,
(e) would be able to increase its informational content (complexity) through time (evolution),
(f) would be capable of specific interactions with a wide range of molecules, with a capability to direct their transformations similar to catalysts,
(g) would be at least physically feasible, if not probable within a supposed conditions of pre-biotic Earth.

Since this factor is not chemical (even if it should fully interact with molecules—as stated in the fourth line above), from its very beginning life should have had at least two levels: chemical and some other (let's say physical) with organized information working at both levels simultaneously and also connecting them.

3 Views of Life and Water That Promises Fresh Possibilities to Disentangle the Mystery of the Origin of Life

3.1 (Bio)Physical Basis of Life

Since the reductionist biology has begun to establish itself (this process started during the second half of the 19th century), the minority of biologists opposed to the more and more "molecularized" outlook on life. They sought a unifying principle that could explain the immense orderliness and complexity found even in the simplest organisms. They were accused of vitalism from the established majority and at least with the start of the DNA era in biology certain lines of vitalistic thought were completely banned from biology. However, the organistic, supramolecular outlook on life that tried to identify, research and understand the living process also in the light of a special field, never stopped; during the 20th century it simply moved from a more or less mystical perception to a more scientific one. The physical nature of the field was unclear, but at least through countless cases of observational and experimental embryogenesis its fingerprint became evident. Many such processes found an apt explanation through the terminology and mathematics of fields whose nature holds some similarity to physical fields [6, 11]. Mostly it was named *morphogenetic* field. The biggest difference to the known physical fields was that the morphogenetic field (sometimes named also biofield [12, 13]) functioned in a very dynamic way. It should have a very complex chreod (i.e. a dynamic attractor, stable path) from the zygote to the fully grown individual, pierced by many points of symmetry breaking.

If the first biological field approach stems mostly from embryologists the second one stems from a purely physical reasoning. In the sixties of the past century, a British biophysicist Herbert Fröhlich found that due to a high electric membrane field the living state at the level of cells rests on rhythmic and coherent[3] oscillations of polar (macro)molecules (called also polarons, see [14]) and that these oscillations can bring much order even into cellular biochemistry [15, 16]. Fröhlich's ideas were later elaborated by an Italian group of quantum physicists (Del Giudice, Vitiello, Preparata) on the level of quantum field theory. The theory that could be called the theory of quantum bio-electrodynamics [17–19] argues that life at the cellular level (biochemistry, molecular movements) is highly organized through coherent (laser like) electromagnetic (EM) field that can behave as a particle of a very small mass and would have a rather peculiar form, namely, the one of very thin filaments. Endogenous EM field therefore builds a fine filamentous network within cells, which is highly stable and should persist even some time after destruction of the underlying order of molecular dipoles. The essential thing here is that the filamentous EM field in organisms is not an epiphenomenon of chemical processes, an unimportant collateral entity, but an indispensable one that ensures order and coordination of chemical and (micro)mechanical processes within cells. This field is supposed to represent a basis for the synthesis and disintegration of one of the most important cellular organelles—microtubules and other microfilaments that build the cellular skeleton and locomotory organelles. If the frequency of an EM filament resonantly matches a neighboring molecule, the latter is attracted to its outer surface and is oriented at the same time. In the filamentous field, chemical interactions are therefore ordered and interconnected through the resonant induction. The field is also important from the thermodynamic standpoint: the output energy of a chemical reaction is not dispersed since it continues travelling as a polarization wave, the so called soliton. In harmony with Fröhlich, Del Giudice's group also postulates that the coherent field may leak only from some defects occurring on internal cell's surfaces and that this emission should be coherent at all frequencies.

The biological electrodynamic system is therefore abstract as to the specific molecular composition of the cell. It should only fulfill certain dynamic systemic conditions for attaining the coherent regime. If we look at the contemporary life, many articles devoted to endogenous cellular coherent regime argue that there is a strong connection between coherent oscillations of the endogenous EM field and the orchestration of chemical reactions. This would account for the fact that within

[3]Coherent means that all oscillations are in the same phase like with lasers.

cells a huge number of chemical reactions occur with well defined time sequences without mistakes and at rates much higher than in vitro. The high rate and the absence of mistakes imply that the underlying chemical dynamics should not be based so much on random molecular collisions (Brownian motion) but more on the mutual long range attraction of the molecules in a selective way that can be attributed to the coherent cellular regime, see also [20]. Further considerations on this line are given at length by Meijer and Geesink [14]. There are many empirical confirmations of such electrodynamic coherent endogenous cellular field and it was also directly measured [21, 22].

The third supramolecular approach to the orderliness of the living process does not originate from the research or considerations of organisms but from some quantum field theoretical and also empirical researches of water. This is especially important since water is regarded as a cradle of life. Regarding ordinary liquid water there are two basic scientific outlooks:

(a) "chaotic": conventional, strongly established, that sees the liquid water in a state of an entirely chaotic movement resulting in Brownian motion of colloidal particles;
(b) "ordered": unconventional, though also based on science and ramified in various theoretical streams. They see water partially in a state of chaotic motion and partially as a long-range ordered state (depending on temperature and some other conditions, like the concentration of polar molecules or ions).

It is the second one that interests us here. A long-range order water should stem from phase transitions of water from the chaotic vapor-like phase to an ordered oscillatory phase where all molecules fluctuate in unison, laser like, which is called also as *coherence*. They oscillate in tune with a self-trapped EM field within minuscule regions called *coherent domains* (CDs), spanning around 100 nm, see [17, 19, 20, 23]. This basic water order was extensively researched by Preparata and Del Giudice. Coherent regime stabilizes CDs and makes them resistant to thermal noise, i.e. to chaos that still characterizes bulk water encompassing CDs. The order of the latter is *long range long term* order. *Long range* means that not only neighboring but also distant molecules within a CD are moving or oscillating in harmony with one another. *Long term* means that the coherent vibration or better said, the vibrational pattern of molecules within a CD has a very long persistence.

As it is well known, water in organisms and cells is not pure. It is imbued with many ions, organic molecules, colloidal particles and what is also very important, it mainly borders to countless hydrophilic surfaces. And the water bordering to hydrophilic surfaces was found even more highly organized than ordinary (pure) water with its CDs.[4] This is evident especially from an extensive work by Pollack and coworkers [24, 25]. This water has many signs of long range long term order that could have static as well as dynamic characteristics. Since it tends to exclude

[4]In pure water at room temperature around 40% of water molecules should reside in CDs and 60% in the bulk water.

solutes it was called “exclusion zone water” or simply EZ water and may span up-to 0.5 mm away from the surface. As already said, in organisms and various organic vesicles the relative amount of the interfacial water is very high.

Therefore, we have identified three biological, physical or physicochemical phenomena that speak in favor of a supramolecular entity that together with appropriate chemistry makes life possible. They could be further reduces to two entities: an emergent[5] EM field (morphogenetic or Fröhlich’s field of coherent EM oscillations) and partially long range long term ordered water (coherent domains) surrounded by non-coherent (chaotic) bulk water. We may assume they are both real and have an essential role in living processes. In the following we shall discuss their essential role in the origin of life process.

4 Field and Ordered Water Approach to the Origin of Life

If chemical experiments into the origin of life proved to be only partially successful, actually a disappointment after Miller’s triumphant experiments, the situation was much more successful with various cell-like structures that resembled simple organisms. Even from basic text books of biology it is known that Alexander Oparin succeeded in creating so called coacervates, quasi cellular structures, actually aggregates of colloidal droplets within water [26]. They resemble living unicellular organisms with no sharply defined form, they have a boundary (a quasi membrane), they can change shape like amoebas, can produce and release vacuoles, can merge, divide etc. Sidney Fox went even further, his so called proteinoid microspheres [27], synthesized from amino acids, showed even more striking features, something similar to the resting membrane potential and action potentials, i.e. a sort of excitability [28]. The basic question here is whether these dynamic structures only superficially resemble organisms or do they tell us something important regarding the origin of life. The answer from the molecular reductionist standpoint is clear: various quasi cellular structures, even if having electrical activity, reproduction etc. are only superficial “counterfeits” of organisms, a short evolutionary route of colloidal systems with dead end regarding the possibility of the origin of life, in this respect similar to the already mentioned Eigen’s auto-catalytic cycles.

But from the deeper view of life that I disclosed above, the story may be quite different. Assuming countless researches and theoretical considerations concerning the most probable scenario for the origin of life on the young Earth, first living organisms should emerge in water systems that were

[5]This means the field is physical, but in a complex biological system it assumes new (i.e. emergent) characteristics. It is akin to emergent properties of superfluid He in comparison to the normal gas. The wave equation if the former cannot be derived from equations of the latter.

(a) rich in various hydrophilic surfaces,
(b) rich in minerals and organic molecules, many of them polar,
(c) abundant in free energy through appropriate molecules, e.g. polyphosphates.

If we take into account a relatively strong electric field surrounding hydrophilic surfaces [29], a lot of free energy (strong UV radiation, heavy storms, frequent volcano eruptions) and at least moderate concentration of longer polar molecules than according to the aforementioned research we may be pretty sure that such primordial water systems resulted in coacervate like forms, i.e. colloidal quasi cellular structures that have in principle large hydrophilic surfaces and thereby a high level of orderliness. From their very beginning they should have

(a) organized water on at least two or even more already postulated levels (basic and extended—higher level—coherent domains of various kinds) including exclusion zones and
(b) since all conditions (see [15]) are fulfilled for the emergence of coherent oscillations of polar molecules, we may expect the emergence of a Fröhlich-like regime even in these supposedly[6] non-living systems.

In other words, both regimes that are recognized as underlying contemporary organisms at the supramolecular level are very feasible even in the most probable pre-biotic water systems. But were they capable to connect with the molecular substance in a feed-back manner and were such systems capable to harbor dispersed active organized information?

If we try to answer the first question we may say in addition to the already disclosed considerations of quantum electrodynamics that biological macromolecules flowing in the bulk water between CDs are subject to influences from the coherent EM (so called evanescent) fields on the borders of CDs as they protrude from the latter. According to the general theorem of electrodynamics, molecules able to oscillate at the same frequency to the one of the CD field are strongly attracted and therefore able to react chemically [30, 31]. Hence, in an extended coherent region, i.e. the region that comprises many CDs and the space in between (see also next paragraph), the diffusive, Brownian motion of molecules is replaced by a selective dynamic regime, where molecules recognize and interact with one another via frequency matching. Here, biological dynamics appears as a mutual interplay between electromagnetism and biochemistry, where fields enable molecules to interact through resonance, and molecules are able to regulate the field frequency through their reaction energies.

According to the general scheme, water molecules in bulk are predicted to give rise to CDs having size of 0.1 μ [32]. In biological environments, however, these CDs are presumed to give rise to extended domains, i.e. domains of basic CDs together excited by the cellular metabolic energy flow, and may extend to the size

[6]As we have no generally accepted definition of life and we are tackling systems close to the emergence of life, it is not possible to be sure about the true place in the line living—non-living dimension.

of molecular complexes, or even to a whole cell [33]. Since the excitable spectrum of a CD is very rich [34], a variety of extended domains can emerge that may assume fractal (nested) architecture, as analyzed by Vitiello [35]. Extended domains entail two important consequences, namely a defined size of the coherent system, and the appearance of geometrical shapes [33]. In order to have a precise frequency matching, the relative positions of reacting molecules must assume a specific spatial configuration, corresponding to biological structures.[7] The concept of extended domains where the latter cover also the space between basic CDs connects the water orderliness with the already described Fröhlich's like regime of polar (molecular) oscillations. Therefore, from now on we will speak only of the *coherent regime* that would signify the concept of the extended coherent domain, implying also a possibility (if not likelihood) of Fröhlich's type of oscillations.

Taking all these together, there is plenty of supporting theoretical researches and considerations arguing that a coherent regime of water systems based on rich chemical grounds, especially if there is a constant flow of free energy, results in a mutual association between the coherent EM field and chemistry. The answer to our first question is therefore affirmative.

Now, what about the operational active information that should be the gist of life? The emergence of this sophisticated information would announce the origin of life, so let's repeat its basic characteristics: it should be stable, dispersed (non-localized), it should have control over chemical reactions and capable of increasing its own complexity. All what we know about coherent states of water and polar macromolecular systems and was spoken about at length above, speaks in favor of capability of such systems to give rise and to sustain it. Long term vibrational continuity enables its stability, long range phase correlations of oscillations enable its non-localized functioning. Through resonance and induction the vibrational states interact with countless molecules as well as with their ceaseless transformations and can direct the latter.

Therefore, we may safely assume that taking into account primordial conditions of the Earth (not going into much vaster possibilities of the origin of life elsewhere in cosmos, for instance on comets) systems with previously enumerated characteristics shouldn't be uncommon, difficult or improbable to find. But, would they be already alive? Where there is no true and generally accepted theory of life, the answer is difficult (of course it is easy and negative if we indentify life with DNA, proteins, metabolism etc., but then we loose generality and depth). According to the here presented definition of life (see the second chapter) we may claim that such organized systems are not yet alive if they do not have a clear possibility (actually a stable trajectory in a complex evolutionary phase space) to evolve into something more complex. With no such possibility, even if highly organized through the

[7] The recent experiments on photosynthetic systems provide an example where spatial arrangement of the component molecules within a coherent system must be carefully controlled in order to optimize the flow of energy [36].

coupling between coherent modes (field level) and chemistry (substance level), they would be similar to Eigen's autocatalytic cycles or Kauffman's autocatalytic nets.

5 From Abiotic Water Systems to Life

5.1 Expected Stages

Up to now we tried to understand life as a coupled pair of two mutually interacting and communicating levels: the field level and the one of molecular substance. The third element of life is non-material, namely emergent, operative and ordered information directing the living process and capable of further and potentially limitless evolution in the sense of increasing the system's complexity. Non living systems would then be the ones that would not fit into this scheme (the trio of molecular substance, coherent field and active information) and would have a very limited reach of a possible evolutionary "jump". The systems that would (a) include all three components and (b) would have only a limited reach of the next possible evolutionary jump could be treated as being somewhere between the living and the

Table 1 Three stages of evolution of matter-energy-information systems towards (and including) life

	A-biotic phase	Pre-biotic phase	Primordial life
Organization complexity	Simple coherent water domains	Quasi cellular structures (coacervates, microspheres, nanobacteria, …)	Evolving cellular structures
Evolution[a] = increasing complexity	Very limited reach, if any at all	Limited reach, but more or less frequently occurring	Potentially endless
The nature of molecular substance and processes	Water solutions of ions and polar molecules	Most probably complex and organized in autocatalytic cycles	Highly complex and organized in a huge autocatalytic network
The nature of field	Coherent domains of water systems are not in organized feed-back relations with molecular interactions of their own molecular level	Extended coherent domains are in partial feed-back relations with molecular interactions of their own molecular level	Extended coherent domains of cells are in full feed-back relations with molecular interactions of their own molecular level
Active highly complex information	Non existent	Gradually forming	Actual, full sway

[a]Biological evolution does not mean necessarily an increase in complexity, since many organisms evolved in a direction of a reduction of organs or tissues. But for the purpose of this article evolution is understood as an increasing complexity

non-living ones. Consequently, on the line between a chaotic non living systems and the assured highly organized life we may demarcate the following more or less three distinct stages (see Table 1):

With the help of this table we can assume that the origin of life took place between the second and the third stage, when the already complex systems with all three components and a limited evolutionary reach "mutated" into a new one which evolutionary capabilities became limitless, at least in principle, as it holds for contemporary life. We may hold the premise that "Natura non facit saltus" (the nature doesn't make jumps), which in our case would mean that the second stage was subject to a gradual evolution concerning less and less limited evolutionary reach (more and more remote mutational possibilities that are fitter from the predecessor systems).

5.2 Various Entities that Could Represent the Passage from Inanimate Systems to Living Beings

Now, let us move to real structures that could represent the first and the second stage of evolution of information-energy-matter systems towards life. The representatives of the first stage are not difficult to identify; these may be even pure water or various water solutions. With more complex polar molecules they are expected to contain more sophisticated coherent domains. Countless water systems (not necessarily water—many other polar solvents would behave in a quite similar way) bordering to a polar or ionized hydrophilic surface would also add up to this stage systems, maybe nearing the second one. Primordial Earth should possess many of them.

Are there any systems that would resemble the second stage? Yes; in the first place, these are the systems that were found and researched as possible candidates for the origin of life before these efforts were concentrated almost exclusively on the biochemical and molecular genetic level. We may speak of the already mentioned Oparin's coacervates and Fox's proteinoid microspheres. There are also a little more exotic entities, like Cairns Smith's clay systems, Reich's bions, Bahadur's jeevanus, Bechamp's microzymas, Naessen's somatids, nanobacteria, nanobes, biomorphs, nanovesicles etc.

Of all the above interesting creatures nanobacteria or more universally, nanoparticles[8] or nanovesicles (NVs in short), are the most examined. Nanobacteria are formations that are some 5–100 times smaller from ordinary bacteria ($\sim 1\ \mu$). They were first identified in Italian hot springs in 1993 [39] resembling also microstructures found in the Allan Hills meteorite remnants from Mars that were (in 1996) hypothesized to represent Martian primitive life forms [40]. They were also

[8]In [37] Kajander defines nanobacteria within the human body as calcifying nanoparticles. Martel et al. [38] extended this view since they treat nanobacteria as mineralo-organic nanoparticles.

found to accompany human life since they were discovered in all our bodily fluids and connected to many of our diseases, mostly to ones involving calcification (kidney stones, arteriosclerosis, tooth scale etc.).

While they were soon regarded as too small to be able to function as fully living beings by the majority of microbiologists, nanobacteria nevertheless demonstrated capability to contaminate cell cultures and even more, they proved to be resistant to ordinary sterilizing procedures like heating even over 90 °C and to many antibiotics [38, 39, 41]. They may form colonies larger than 1 mm and may exhibit budding and may propagate like microspheres and coacervates, even if at a much slower rate than Escherichia coli at optimal conditions [41]. Mostly, they appear as reproducing calcifying macromolecular vesicles [37] containing a sort of a wall and filamentous surface projections. By one of the most versed group of researchers (Martel, Young et al.) they are treated only as complex inorganic–organic systems [38, 39, 42].

The same group succeeded to make nanobacteria like creatures also artificially and on the basis of other cations than calcium, like Mn, Cu, Fe, Ni, Sr, Na etc. and some animal proteins, too [42]. They were called *bions*. Bions also form aggregates and colonies and are mostly (but not all of them) round shaped and of various sizes. Being produced absolutely artificially, they have no trace of genetic material and are classified as non-living, bio-mimetic complex chemical systems [42]. Biomimetic forms may be achieved also by solely inorganic chemicals, like silica, barium and calcium and are called biomorphs; they were aptly described by the group around Garcia-Ruiz [43].

Taken all these facts together, the behavior of these tiny bodies strongly resembles living organisms (their highly biomimetic nature, at least). Their complex multiplication indicates that **they do possess active organized information**. And since in general they do not possess the genetic apparatus distinctive for ordinary living beings and even viruses, their still very complex organization together with variable chemistry indicates a highly organized coherent electrodynamic field that we assumed as a basic condition for the origin of life. But at which point of the second stage they are? Are they only biomimetic or do they have a real potentials for the origin of life? If we return to nanobacteria there are authors claiming that they are definitely living creatures and criticize the previously mentioned estimation (see [37, 41]). A confirmation for their position they see in the nanobacteria' need for oxygen for their successful propagation. In their view nanobacteria are mostly infectious and harmful agents, usually where mineralization of tissues or teeth is at stake, but nevertheless they could be only opportunistic companions of our life, since they were found also in healthy humans. Moreover, they even see a possibility to heal some illnesses via appropriate chemicals together with nanobacteria [41, 44].

Therefore, the NVs are very interesting systems that, as already stated, roughly correspond to our second stage of the origin of life process. Various synthetic bions and biomorphs may truly represent only very complex forms of precipitation (crystallization) of various chemicals and could represent only an advanced first stage or a passage from the first to the second one. Then we may have various bions and perhaps also some nanobacteria that would represent the "middle" of the second stage. On the other hand, at least some nanobacteria—perhaps the ones found in bodily fluids—may represent systems that border the third stage or even trespass this boundary. This would mean a thrilling prospect that we do not need to go into a distant past, speculating a lot about the most probable path leading to the first living being and trying laboriously to reproduce the conditions that would have lead to it. No, we may be encircled by systems that are on various stages towards life at this very moment. To be sure, they are most probably quite different from the ones in the past or from the ones elsewhere in cosmos, yet they may be, according to the here presented definition still on the verge of life or even beyond it. Some of them may even be our companions within our own bodies or in the nature. If living, they could have a quite different biochemistry from our well known one, but they should have a capability for adaptation and in principle limitless evolutionary potential. These creatures may be called robust living beings with not so well defined biochemistry as the well known organisms. Therefore, if we take into account the here offered definition of life that is bound to specifically organized information expressing itself through a close and mutual interplay of the coherent field and countless molecular interactions, we may safely assume that our known and unambiguous (DNA-RNA-proteins) life (chemically highly specialized, S-life) is surrounded and even interspersed by a parallel life being much more robust (chemically robust, R-life). Its robustness is proved by its already described high resistance against many for ordinary organisms highly detrimental chemicals and physical conditions (extending even to a high gamma radiation, see [41]. This robustness indicates that the R-life is not organized on a detailed molecular informational matrix as is the case with the S-life, but is rather much more slack, only roughly defined in its chemistry. Nevertheless, its forms are still relatively highly organized owing to their specific physical characteristics discussed in the fourth chapter.

Even if we accept that at least some nanobacteria or bions are living beings, the question still remains, whether these forms may transit to the S-life. The answer to this question would demand an intensive further research. On the other hand, it is very probable that the S-life may not only pass to the R-life, but may actually *produce* some of its forms. Perhaps the R-Life can also be formed by an appropriate mixture and conditions involving various inorganic and organic substances as the research of bions by Reich showed [38, 45]; the name "bions" used in the works by Martel and Young was taken just from Reich [38]. Reich speaks about moving creatures, generated from purely sterilized conditions after autoclaving some living or formerly living material. They resembled paramecia or amoebas, which was confirmed also by a long and systematic research by DeMeo [46]. Here, one of very important things to be ascertained is whether the amoeboid movements—observed also with Oparins' coacervates—are the result of purely random Brownian motion of nanovesicles and their content or do they show at least some deflections from pure randomness. The latter would be a vey important evidence of truly organized systems that would merit the name *living*. The experiments of this kind are in preparation.

6 Conclusion

The story of the origin of life—a tremendously organized and complex process amid a chaotic world of matter and energy—is still a mystery. In this chapter I wanted to present a new, promising path towards its dismantling. It does not disregard conventional chemical and physical aspects of life. It only tries to connect them into a deeper whole, integrated via active organized information. As an essential factor of the living process, a coherent field together with partially dynamically ordered water were presented. This physical orderliness may have a pivotal role in maintaining a high organizational level of the systems approaching the first organism, since DNA or even RNA could be either too unstable, would lack chirality (optical activity, e.g. D ribose), would not achieve sufficient concentration, would intermingle with other molecules in a pre-living chaotic chemical system etc. As a result, the order of coherent modes of pre-living water vesicles would function as a dispersed systemic memory, would sustain organized information and would replace contemporary DNA or RNA. No genetic code would be needed—instead, the code of resonance matching between coherent field oscillations and molecular reactions would be in place. Only gradually and presumably long after the first organisms (at least considered so through the eyes of the here presented definition of life) appeared, the natural selection together with some laws of the living state dynamics would result in the transference of the dispersed memory contained in coherent oscillations into the focused molecular one (DNA, RNA). An interesting support for such transference may be found in a recent publication, stating that optical activity, so essential for contemporary life was found in ordered water systems [47].

Most probably, the origin of life was a long, gradual process, where various systems grew in their complexity, however, they did not have the open path (full potential) to limitless evolution. Many of such system are still here with us and are known as nanobacteria or more generally as nanovesicles. They may be quite natural or artificial, in any case they testimony that for nature it is not difficult to organize matter and energy into ordered dynamic structures so much resembling present day organisms that scientists still quarrel as to their living or non-living status. There is a real possibility that the origin of life was not an almost miraculous moment in some distant geological past—it can be continually happening all the time here with us, as a permanent passage of certain vesicular systems from a lower to a higher complexity. The message of this chapter is that the origin of life is not so unfavorable, so an improbable event as it is usually portrayed in the established biology. It may be quite widespread also on other planets and may there have a profoundly different (bio)chemistry from the Earth life. Any serious exobiology should seriously take this possibility into account.

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