EVOLUTION AND ORIGIN OF THE LIFE: SOME GENERAL APPROACHES

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Abstract. In this article it isn't discussed concrete chemical mechanisms of origin of life but is presented different general considerations, which can promote to the critical comprehension of existing approaches: the cybernetic aspects of the life evolution, the physical model of the evolution of biological systems, and some others. The attention is also focused on the external causes of the evolution of biosphere, which is regarded as a control factor for the biological evolution. At the last sections of the article the problem of the origin of life is discussed. New hypothesis of so-called the embryosphere (pre-biosphere) is proposed.

Introduction

In this article it isn't discussed concrete chemical mechanisms of origin of life but is presented some general considerations, which can promote to the critical comprehension of existing approaches. The first section concerns cybernetic and anticipatory aspects of the life evolution. In the second section the physical model of the bio-system evolution is briefly given. Some other different approaches to the problems of the biological evolution are discussed in the third section of the article. The attention is focused on the biosphere evolution, which is regarded as a control factor for the biological evolution. In the fourth section the problem of the origin of life is discussed. One of the conclusions is the mechanism of panspermic hypothesis could work only if the conditions on planet has specific features which can be described within a framework of so-called the embryosphere (pre-biosphere) hypothesis.

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1 Physics of the life as cybernetics

Traditional approaches to the problem of the origin of life concern as a rule the different mechanisms of origin of known structures of organisms. At the same time, every living biological system isn't a simple sum of separate parts. Any bio-system (not only an organism but an ecosystem too) is a functional system in which the activities of different components are inter-coordinated. It is a consequence of that any bio-system has the developed control systems; they promote such conduct of the components (Rosen, 1988). Therefore in order to understand how the life arises it is important to find out general patterns of the functioning of any living systems, in other words, to investigate cybernetic aspects of life. Unfortunately, this direction of studies isn't enough developed yet. But some present works demonstrate the genetic interconnection between the survival and the **anticipatory capability** to predict the "local future" by means of simulation of current situations along the life of bio-system (Dubois, 1998a; Rosen, 1985). How such simulation can be accomplished is a very interesting problem; obviously that is not possible if the system has no mechanisms of memory (Dubois, 1998b).

In the case of any living systems, their levels of entropy "strive" to be less than the entropy level of surroundings. This is the result of that any living system is able to modify the peculiarities of interaction with surroundings in order to avoid destructive influences and to use external energy flows to support necessary for vital functions the reduced level of entropy of its own structures. Thus, just the management by the interaction with surroundings by means of specific regulations enables these systems to be surviving and, hence, such management converts any bio-system into non-classical thermodynamic system. It is necessary for such management to apprehend the surroundings situation and to have the possibility to act according to some rules of behavior which have to be appropriate to concrete situation. In the case of living systems (and complicated technical systems as well) these rules are not immutable algorithms of behavior. These algorithms are not hard and they don't determine hard progression for every step. The "diffuse" algorithms (or regulations) set only the final results (aims) for some group of the closing steps but permit biological system to choose intermediate steps. This type of strategic tasks is considered in the mathematical games theory (Welbull, 1995). The above peculiarities of the regulations give relative freedom to many biological processes including evolutionary ones.

In order to emphasize that managing regulations support the preserving of the biological system, the notion of the **Life Demon** was introduced (Levchenko and Khartsiev, 2000). Any Life Demon is in fact some main meta-prescription (a supervisor), which governs other regulations. One of the main features of any Life Demon is that it is a diffuse algorithm which works to maintain some function(s)

among vitally important ones, therefore any Life Demon provides the self-preserving of the biological system. The Life Demons are transmitted along the generations genetically i.e. through so-called "vertical" information transfer. After appearance of possibility of informational exchange by linguistic way, the effective "horizontal" information transfer was finally established. Such process can be similar to the process of virus propagation. Not difficultly to see that the evolutionary Demon strategy resembles in some aspects the strategy of so-called "egoistic", selfish gene (Dawkins, 1976).

These brief notes will help to discuss the problems of both the biosphere evolution and the origin of life in the planet. Some of them were already considered in previous articles in International Journal of Computing Anticipatory Systems (Levchenko, 1997, 1999; Levchenko, Khartsiev, 2000, Levchenko, 2002: http://biospace.nw.ru/astrobiology/.

2 Physical Evolution of the Biosphere

In previous works (Levchenko, 1992, 1993a, 1997, 1999; Levchenko and Starobogatov, 1986; Starobogatov and Levchenko, 1993) the model of physical evolution of the biosphere regarded as a unified organism (Lovelock, 1991; Vernadsky, 1989) was elaborated.

In the model the increasing of energy flow passing through the biosphere is understood as the **physical evolution** of it. At the earliest stages (Proterozoic) the physical evolution was connected with intensification of chemical aspects of photosynthesis and with evolution of chlorophylls. At the later stages (Phanerozoic), the physical evolution was connected with the augmentation of photosynthetic surface (leaves and other photosynthetic formations). The increasing of energy flow through the biosphere leads to growing of complication of its organization, in particular, to the creation of new vital **licenses** — i.e. conditions which are provided by ecosystems — for different taxa (Levchenko, 1993a, 1997). These changes are interconnected also with so-called "progressive evolution" of many biological forms (Grant, 1985; Krassilov, 1986; Timofeev-Resovsky at al., 1977).

In order to explain the biological evolution as a consequence of physical evolution of biosphere, a general model for any biological systems was proposed (Levchenko, 1992). Based on Schroedinger's ideas (1955), in the model it is postulated that each biological system (for example, organism, ecosystem, biosphere) "strives" to function not to decrease an energy flow through itself because just such bio-systems are being self-preserved under being altered environmental conditions. This means that every temporary decrease — **interruption** — of energy flow through the bio-system leads to finding of new ways of energy reception and, eventually after that, either to the appearance of a new way for the

energy reception or, in the case of failure of the finding, to the death of the bio-system. Thus, each interruption stimulates this bio-system to its physical evolution because the quantity of ways for energy reception grows in reply to every interruption. At the same time, this leads up to the creation of new licenses, hence of new canalization factors for the following ways of evolution as a result of irreversible modifications of organisms and surroundings.

The searching of new ways of energy reception needs experiments in order to find such ways. In the case of ecosystems and biosphere it is provided by mechanism of selection of more suitable genetic lines in every moment of evolutionary time.

In general case, the physical evolution of a bio-system may be described by the following equation:

$$G(N) \leq J_0 + \Sigma_{1,N} J_k \qquad (1)$$

where G(N) is the energy flow passing through the bio-system after N interruptions, J_0 is the initial flow of energy passing through bio-system in some initial moment of time, J_k is the amount of decrease in energy during the interruption with number k and $\Sigma_{1,N}$ is the algebraic sum of 1 to N. If J_k is proportional to G(K), i.e. $J_{k+1}=J_k(1+b)$, where b is the relative decrease in the energy flow then

$$G(N) \leq J_0 (1+b)^N \qquad (2)$$

One can be shown that this case (*Eq.*2) is realized for biosphere evolution; J_0 characterizes the moment of origin of the biosphere. The physical evolution of the biosphere is interconnected with the development and broad distribution of more and more effective producents (primarily plants — see Levchenko, 1993a, 1997, 1999).

The palaeontology data confirm such approach and permit to suppose that both orbital parameter oscillations as well as the periodical decreases in the carbonic acid flow from the entrails of Earth are important external causes for interruptions in the biosphere scale at least since the Phanerozoic. The former factor even seems more important than the second one. The orbital oscillations are several tens of thousand years in periodicity (Milankovich, 1930; Vernekar, 1977). They initiate changes in the duration of the seasons and the freezing in higher latitudes; some of them redistribute also the flow of solar radiation in all latitudes. All important calculations with using of astrophysical data concerning oscillations of solar radiation are presented in detail in the monograph (Levchenko, 1993a, in chapters 4 and 5). They confirm that the equations describe above-mentioned factors correctly in the first approximation. It is interesting that oscillations in Milancovich's model can explain some features of Martian freezing.

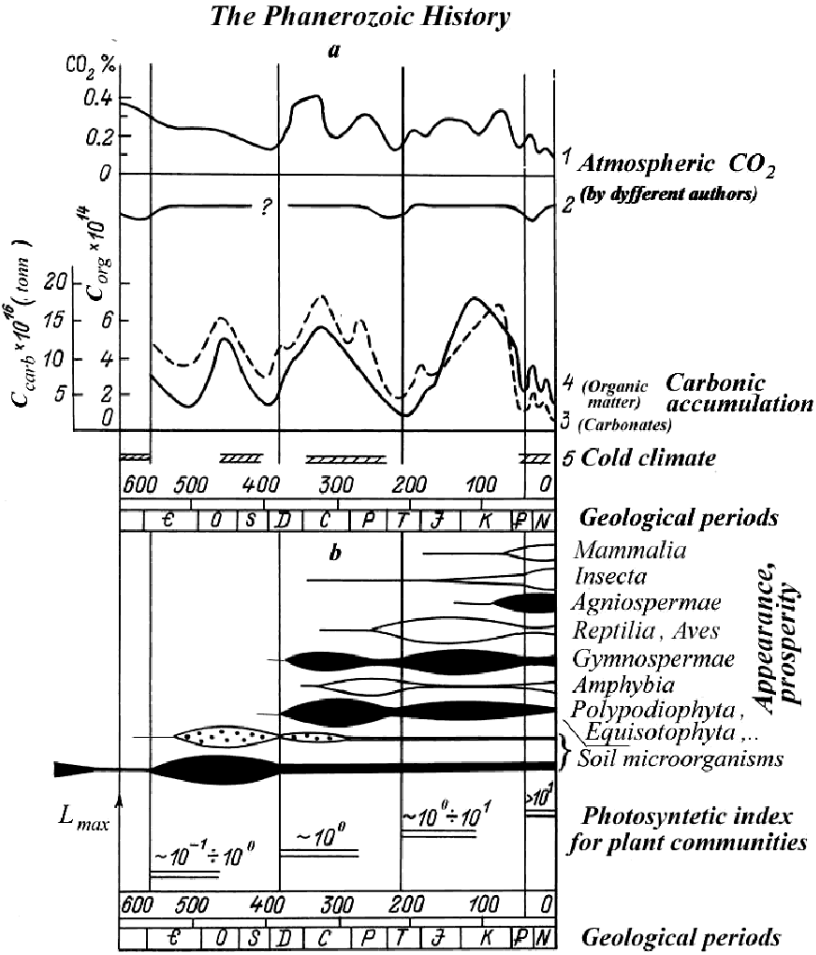

Fig.1 The paleontology history of the biosphere by different authors: Budyko, 1984; Monin, 1977; Ronov, 1976 and others (Levchenko, 1993a).

The geological data demonstrate that a gas eruption of carbonic acid from the entrails of the earth is not constant but oscillates with period about 200 million years (this period is near to a galactic year). The decrease of this flow may also be considered as an interruption, because the carbonic acid is one of the limiting factors for photosynthesis. The paleontological records reveal that the beginning of each wide spread of the most important terrestrial plant macrotaxa (Devonian, Triassic, Cenozoic) is always associated with the end of the preceding epoch of decrease for the gas eruption (Ronov, 1976; Budyko, 1984) — see Fig.1. After

each of the interruptions — in fact, of energy crisis because of reduction of photosynthesis — a new dynamically stable system of the biosphere, which has characteristic distinctive producents, arises. There are Paleozoic, Mesozoic, Cenozoic (Kainozoic). The wide spreading of a new animal macrotaxa seems to reveal twice faster periodicity, i.e. about 100 million years. The origin of the new more developed, «progressive» vital forms appears to have taken place long before until their prosperity - see Fig.1. The above data give a possibility to explain known changes of biosphere systems by external causes that disturb its current equilibrium (about hypothesis of «punctuated equilibria» see, for example, Eldredge and Gould, 1972).

All this allows supposing some predetermination for the physical evolution of biosphere (Levchenko, 1992, 1993a, 1997; Levchenko and Starobogatov, 1986; Starobogatov and Levchenko, 1993). At the latest stages of the biosphere evolution the informational exchange between different organisms helps them to use resources of surroundings and begins to play an increasingly important role in the physical evolution of the biosphere (see section 1 and Levchenko, 1999).

3 Some considerations to the problem of evolution of the biosphere life

The discussion about the evolution within the framework of the traditional biology is going usually in the context of both morphology and functional complication or complexification. Such approach is almost obvious but it doesn't allow to measure the «quantity of evolution» and, thus, to calculate and predict the possible ways of the further evolution. The successes of physics in XX century stimulated the elaboration of the evolutionary conceptions, which are based on physical principles and use physical characteristics of biological systems. They can be formulated in the form of some variation principles, for example, «increment of efficacy of energy using for organisms along the evolution» (Shnol, 1979). Of course, this principle can work in some separate branches of evolutionary tree but it doesn't explain the growth, the development of this tree. Thus, before the discussion about the problem of the origin of life I would like to present also some other not so popular evolutionary approaches.

3.1 Physical evolution of the biosphere

This approach is already described in the section 2 of this article and in the articles (Levchenko, 1997, 1999). Therefore I will not repeat the same here.

3.2 The increasing of algorithmic power of the biosphere along the evolution

The physical evolution of the biosphere in reply to different interruptions is connected with the complication of organization of the biosphere and with the development of its adaptation mechanisms (Gore, 1993; Gorshkov, 1994), i.e. with growing of algorithmic complexity of the biosphere system. The development of

behavioural regulations of the biosphere gives possibility to adapt for more and more broad diapason of conditions. The growing of quantity and quality of the algorithms along the evolution means that algorithmic power of the biosphere increases throughout the evolutionary time. This leads to the appearance of new canalization factors for the posterior ways of evolution (this is one of the consequences of existence of the bio-system memory). The value of the algorithmic power can be measured in the energy units and it gives the maximal energy flow, which can be managed by the bio-system (Levchenko, 1999; Levchenko and Khartsiev, 2000).

3.3 Auto-canalization of the biosphere evolution

One of the traditional approaches to the problem of biological evolution is the assumption of some predetermination: both the laws of nonliving nature and the pressure of morpho-genetics restrictions (the memory about previous evolution) canalize, or determine, the ways of the posterior evolution (Lima de Faria, 1988). But the biosphere can change characteristics of local areas in the planet and therefore it can also influence its own surroundings and change some factors of canalization (Zavadsky and Kolchinsky, 1977; Zherikhin, 1987, 1994). This means that the biosphere can auto-canalize its own evolution (see **paradigm of auto-canalization,** Levchenko, 1997). Certainly, such biosphere influences on the way of its evolution by means of feedback through the environment are slow (as, for example, the consequence of appearance of oxygen atmosphere) but they are eventually very important.

3.4 The evolution as cognition and expansion of interactions of living organisms with their surroundings

A perception of information from external world by bio-system is important in the context of survival of the bio-system: the information helps to use useful properties of environment and to avoid harmful influences. In order to specify what is the biologically important information, it was proposed to introduce the notion of **informational message.** It is a part of informational flow, which may change development (evolution) of the bio-system because the message changes the bio-system features (see section 1 and Levchenko, 1994, 1999). Then, we come to the problem of selecting, separating of the informational messages from the common external informational flow. That can be described in terms of «biological context»: organisms have to be «tuned» to the acceptance of the informational messages, which help to understand external world and survive in it. The biosphere determines some diapason of possible environment for living organisms and, thus, the diapason of diversity for objects, which can be perceived in the process of cognition of the world by actually living organisms. On the other hand, the life on the Earth is changing the biosphere system throughout the time when the life exists. Hence, the following feedback exists: the living organisms are studying the biosphere and are being changed as a result of that; simultaneously

they are building this biosphere (in particular, new biological forms appear). Thus, the cognition canalizes cognition process (see Levchenko, 1999 about auto-canalization of cognition) and we come to the fundamental evolutionary problem: has this process a termination or not? The hypothesis is in the following: if the biosphere system is restricted in size and if the planetary conditions are relatively stable then the process gradually dies out and the system aspires to the status of some «living machine», which is well-tuned for this condition (Levchenko, 1993a). If the life is able to go abroad the planet, the evolutionary process is unlimited through the time. Note also that these limitations for the biosphere means that living organisms are not able to interact with any objects, which are placed farther (deeper) some physical boundaries. Therefore, **the expansion of the interactions** diapason of living organisms with their surroundings is the cause of the biosphere evolution and of the origin of new biological forms (Levchenko, 1999).

3.5 The evolution after the origin of man

On the latest stages of the biospheric evolution when *Homo sapiens* arises the informational exchange between different organisms begins to play an increasing role in the biosphere evolution (Levchenko, 1994). This new stage of evolution of the biosphere is characterized by extremely fast expansion of one species — *Homo sapiens* — in all places of the Earth, which are accessible for the life. Every new step of the development is caused by appearance of new ways of exploitation of the nature. In fact, we are the eyewitnesses of such biosphere evolution, which is ultra-speed, ultra-rate. This is possible because the man has such intellect which allows him to be super universal among all other species: the new knowledge and the new experience broaden the ecological fundamental (potential) niches of the human population (Levchenko, 1999). The realized niches expand into new spheres thereupon too (Odum, 1975). The consideration of processes of the new information producing by men and of the information propagation as well gives possibility to deduce some simple equations. These formulas demonstrate extremely high evolutionary role of so-called a priori value of information (Levchenko, 1999) and therefore of such thought processes, which are used for the creation of a priori models of reality. This dependence of ecological characteristics of *Homo sapiens* species from the modeling of future is the distinctive trait of ultra-rate evolution (Levchenko, 1999).

3.6 The life demon is immanent component of all living systems

The Life Demon is briefly described in the section 1 of this article and in detail in the article (Levchenko and Khartsiev, 2000).

3.7 Pan-biospheric paradigm

All organisms of the biosphere are dependent on each other; the life of separate organisms, which are isolated from the biosphere, is impossible. This assertion was named as **pan-biospheric paradigm** (Starobogatov and Levchenko, 1993). The problems of both biological evolution and the origin of the life have to

be considered within a framework of this paradigm. Only the biosphere as a whole is a relatively independent living system from other ones. The **ecocentric conception of evolution,** in which relationships between the evolutionary processes in different levels of the biological organization (including macroevolution and microevolution) is described, is deduced from above paradigm.

3.8 The embryoshere hypothesis

It can be proved that several evolutionary principles can be applied to organisms, to ecosystems and to biosphere. They are in particular: **a**) the principle of evolution of functions; it can be formulated as the intensification of processes providing some function of the separate functional systems within bio-system along the evolution, **b**) the principle of increasing of multi-functionality of separate sub-systems for organisms or ecosystems along the evolution, **c**) the principle of over-basis (or of superstructure): new functions do not replace previous ones but superimpose over old ones and subordinate them (Orbeli, 1979). These principles can be applied also to the development of embryos (Levchenko, 1990, 1993b). Comparing all these traits of evolution and development, we can suppose that the initial biosphere was the self-preserving system, which can be regarded as some whole primitive organism. In other words, it was weakly differentiated system, which developed as embryo by means of differentiation. That led to the complication of its structure and of its functioning. The primary biological organisms, which are known as microfossils, were not perhaps independent separate organisms but were somewhat alike cell organelles. This hypothesis is called the **hypothesis of embryosphere** or, in other words, the hypothesis of the developing pre-biosphere (Levchenko, 1993a, 1993b, 1997).

4 Origin of the life: as this could to be? Some general considerations

The above general consideration can be translated to the problem of the origin of the different forms of life on the Earth and other places of the Universe as well (Rosen, 1991; Shklovsky, 1976). I would convert it to the following main assertions:

1. First of all the origin of the life on the planet was probably connected with the origin of embryosphere. This assertion doesn't co-ordinate with so called **panspermic hypothesis** of Arrenius (Ponnamperuma, 1972) because we suppose that the life doesn't exist without biosphere (Levchenko and Starobogatov, 1993; Levchenko, 1997). It isn't difficult to agree with this approach if to take into account that any living organism requests the specific and concrete conditions of surroundings in order to be able to develop and reproduce beings similar to it. It is unlikely that lifeless nature can create sufficiently often such conditions, which are appropriate for some life. The seeds die if they fall on the bad soil, it is notified

even in both the Bible and the Koran. The panspermic hypothesis supposes latently that early Earth was «good soil» or, in other words, the planet was quasi ovule, egg for the «cosmic sperm». The embryosphere hypothesis tries to explain how this ovule could be created by some natural way.

2. The first step of origin of embryosphere was connected with the origin of **self-sustained** streams of matter through pristine "bouillon" (liquid environment is very likely for that) on the basis of using of planetary resources of matter and energy, chemical at least. That could happen by means of **autocatalytic reactions** (Eigen, 1971). Just autocatalytic reaction regulates its own intensity and, thus, has primary elementary logic. In other words, such reaction has some algorithm, program of passing. The self-organization (Eigen, 1971; Nicolis and Prigogine, 1977) of powerful global **pan-planetary** auto-catalytic processes, which can control planetary conditions and can support them in some diapason, implies **a**) the appearance of long-continued self-sustained processes with concrete logic of passing and **b**) the selection of processes. This is equivalent to the origin of the Life Demon of the embryosphere and as a result the origin of the embryosphere

3. In order to provide the self-preserving of embryosphere through the time the mechanism of physical evolution could be used. It could be realized as a successive origin of new autocatalytic processes under the physical and chemical conditions, which are produced by already existing processes. The mechanism of that could be following: when any of the existing processes happens to be weakened because the conditions are changed (this means that the interruption occurs) then a new similar process, which in new conditions is able to be in progress arises if the necessary resources exist. The competition for resources between the existing processes can be decreased through the time of interruption and, therefore, both appearance and expansion of the new process in surroundings can be more probably. As a result of that the quantity and diversity of different autocatalytic processes are being increased through the time and the use of resources of the environment grows.

4. New autocatalytic processes create new structures; the differentiation of the embryosphere grows. Its different parts exchange matter between each other. The diversity of the processes gives possibility to support the level of consumption of resources under the changing conditions. The growing of energetic flow through the embryosphere along its physical evolution leads to the appearance of new levels of hierarchy organization of embryosphere (Levchenko, 1997, 1999). All this is the auto-canalized process of the **chemical evolution** (Kenyon and Steinman, 1969; Rutten, 1971; Fox and Dose, 1977) of the embryosphere; this process leads to the gradual forming of environment, which is suitable for the origin of pristine biosphere. At the same time, the regulations of adaptive reactions of the embryosphere (they ensure self-preserving of the system) are being complicated because both quantity of components and their complexity are

increasing. This means that the Life Demon of embryosphere masters new modes for functioning.

5. In some aspects the embryosphere resembles primitive cell without its own reproductive organs. The embryosphere forms the environment, which can be suitable either for «fertilization» by cosmic sperm according to the panspermic hypothesis (but then we have to say about not panspermic but about **pan-fertilization hypothesis**) or for the origin and development of its own version of life. In the second case, the origin of primary organisms can be result of **a**) mixing, the complication and complexification of chemical components and complexes (the lipid membranes, for example) of different parts of embryosphere and **b**) self-organization of self-sustained reactions, which are preserving these structures. These processes can also be described as **c**) the successive structural and functional differentiation of embryosphere and **d**) the appearance of simple regulations of functioning for some separate functional modules of embryosphere; this regulations contribute to the self-preserving of above modules and their appearance can be interpreted as the origin of their Life Demons. At last, the origin of organisms isn't possible without **e**) the appearance and using of the mechanisms of molecular memory (on the basis of RNA and DNA); that could be the consequence of natural selection of some functional modules within the multitude of different self-sustained structures (Eigen, 1971; Kenyon and Steinman, 1969). There are also different extravagant hypotheses about abiotic origin of DNA for example in comets (Kaimakov, 1977) but they aren't a subject of this article.

6. The many self-sustained processes within modern cells (the energy processes, the photosynthesis, for example) could arise in some fragments of the embryosphere until the origin of separate organisms. Some processes in modern organisms may repeat in general traits ancient processes, which maybe were passing within empryosphere. Hence the principal moments in the history of origin of the biosphere resembles the history of origin of separate cell in another scale of time.

Now the human and another hypothetical intelligent life before now or in the future, which are able to support the life outside the own planet can also contribute to the life propagation in the Universe i.e. they can perform the role of "panspermic carrier" for reproductive substance (Shklovsky, 1976). This can be not only an incidental infection by life germs but can be also some purposeful action. In any case this is something like Adam who is talented by possibility to fertilize the "egg" of embryosphere, and, hence to give impulse for development of life which has traits of both parents.

5 Several conclusions

The objects of classical physics conform to the rules of thermodynamics. This means that the interactions between these objects and surroundings are such that the entropy of every object strives to be near to the surroundings entropy. But in the case of any living systems the levels of entropy strive to be less than the entropy level of surroundings. These features are maintained by the following: any living system is able to modify the peculiarities of interaction with surroundings in order to avoid destructive influences and to use external energy flows to support necessary for vital functions the reduced level of entropy of its own structures. It is necessary for such management by the interaction to apprehend the surroundings situation and to have the possibility to act according to some regulations of behavior, which depend on the concrete situation. In order to simplify the description of functioning of the regulations the notion of the Life Demon was introduced (Levchenko and Khartsiev, 2000). Any Life Demon is some main meta-prescription, which subdues other regulations. One of the main features of any Life Demon is that it ensures the self-preserving. This approach enables to translate both the problems of biological evolution and the origin of the life into the language of description of specific regulations.

The above considerations allow to formulate the "engineering" definition of life: the life is the self-sustained process which reestablishes all the time organization and low entropy level of own structure by means of using of external sources of energy and matter and also of specific regulations of behavior. The physical evolution concept (see 3.1), which can be used for embryosphere and biosphere, is deduced from such definition. In order to save the regulations for functioning of bio-system, the memory systems are required. The origin of separate organisms is connected with the origin of molecular memory mechanisms. We have not enough data yet to solve if the reasons are the terrestrial or cosmic (panspermic, for example) factors. On the other hand only the biosphere as a whole is independent living system (see 3.7) while all organisms of the biosphere are dependent on from each other and, therefore, it is impossible the origin of separate organisms isolated from the biosphere. Thus, the question «what is the origin of life: either origin of organisms or origin of biosphere?» — isn't correct. In any case the appearance of successfully surviving separate organisms with molecular memory was a natural step of conversion from embryosphere to pristine biosphere.

For the observed «flow of life» on the Earth one can point to two main regularities, which are connected with the problem of predetermination of evolution. The first regularity demonstrates some predetermination of physical evolution of the biosphere. This allows describing the development of planetary condi-

tions from primitive chemical processes up to pan-planetary ones, or from embryosphere up to the modern biosphere. The second regularity demonstrates indetermination of the phenotypical realizations of biological evolution. That is connected with the following: the many changes of biological forms along the biological evolution are ecologically neutral ones (Levchenko and Menshutkin 1988; Starobogatov and Levchenko, 1993).

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