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Evolution of the Life as Improvement of Management by Energy Flows

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Abstract

Different mechanisms of the biosphere evolution are described in this article. The physical evolution which is the increasing of energy flow passing through the biosphere plays main role before the origin of man. This increasing is a consequence of perfection of photosynthetic possibilities of plant communities and of all biosphere system. It is shown that the life uses optimal evolutionary ways for physical evolution and, hence, optimal behavioural reactions in every moment of evolutionary time. The ultra-rate evolution of the modern biosphere is connected with a human activity which is not possible without informational exchange between individuals. This exchange leads to training of individuals to new ways of survival and, therefore, to modifications of ecological niches of human sub-populations and ecological licenses of the biosphere. The mechanisms of both producing of new information in human community and dissemination of this information are considered. One of the important deductions of the such approach is the rates of these processes depend strongly on the parameter which is named as a priori values of information. The evolutionary modifications of the modern biosphere are interconnected not only with slow physical evolution but with very fast cognitive anticipatory evolution.

Keywords: evolution, biosphere, flow of energy, informational theory

1 Physical Evolution of the Biosphere

As it was described in (Levchenko, 1993, 1997) 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 interconnected with an intensification of chemical aspects of photosynthesis, 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, 1993, 1997). These changes are interconnected also with the known progressive evolution of many biological forms. In order to explain the biological evolution as a consequence of physical evolution of biosphere, a general model was proposed (Levchenko, 1992). It is postulated in the model that each biosystem (biosphere, in particular) “strives” to function not to decrease an energy flow through itself; just the such biosystems are being selfpreserved under being altered environmental conditions. This means that every temporary decrease – **interruption** – of energy flow through the biosystem leads to finding of new ways of energy reception and, eventually after that, either to the appearance of new way for the energy reception or, in the case of failure of the finding, to the death of the biosystem. Thus, each interruption stimulates the above biosystem to its physical evolution because the quantity of ways for energy reception grows in reply on every interruption. Simultaneously, this leads up the creation of new canalization factors for the following ways of evolution (as a result of unreversible modifications of organisms and surroundings).

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

every moment of evolutionary time.

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

$$G(N) = \text{or} < J_0 + S_{1,N} J_k, \quad (1)$$

where G(N) is the energy flow passing through the biosystem after N interruptions, J_0 is the initial flow of energy passing through biosystem in some first moment of time, J_k is the amount of decrease in energy during the interruption with number k and $S_{1,N}$ 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

$$G(N) = \text{or} < J_0 (1+b)^N \quad (2)$$

It can be shown that this case is realized for biosphere evolution; J_0 characterizes the moment of origin of the biosphere (Levchenko, 1993, 1997; in the last article this formula has misprint unfortunately). The physical evolution of the biosphere causes the development and broad distribution of more and more effective producents (plants, at first).

The paleontological data confirm the such approach and permit to suppose that both the Earth's orbit parameters oscillations and the periodical decreases of the carbonic acid flow from the entrails of Earth with the period about 200 million years (this period is near to the galactic year) are important external causes of the interruptions in the biosphere scale during Phanerozoic at least. After every of the such interruptions – in fact, of energy crisis in the reason of reduction of photosynthesis – new dynamically stable system of the biosphere arises which has characteristic distinctive producents. There were Paleozoic, Mesozoic, Cenozoic (Kainozoic). All this allows to believe some predetermination for the physical evolution of biosphere (Levchenko, Starobogatov, 1986; Levchenko, 1992, 1993, 1997; Starobogatov, Levchenko, 1993; Levchenko, http://www.iephb.nw.ru/labs/lab38/). Later, on the last stages of the biosphere evolution the informational exchange between different organisms is helping them to use resources of surroundings, begins to play more and more risen role for the physical evolution of the biosphere (Levchenko, 1994).

2 Evolution and Informational Flows

It is known that the informational exchange between living organisms promotes the survival of them and, on commonsense language, provides necessary for that “intellectual level” of some organisms and species populations. This level for some genetical lines may increase along evolution of the life and this is a consequence of using of that knowledge which was accumulated by different biological systems of memory about surroundings. How are joined with this approach other evolutionary ones?

A perception of a information from external world by a biosystem is important factor for survival of the biosystem: the information may help to use useful properties of surroundings and to avoid either harmful influences. In order to specify what is the biologically important information, it was proposed to introduce the notion of **informational message** (Levchenko, 1994) which is defined as the such part of informational flow which may alter either development or evolution of the biosystem in the reason of modifications of its features (the message plays a role of directional mutation in this case). The perception and using of the such informational messages may help to survive for biosystem along its life. Then, we come to the problem of revealing, detailing of informational messages from common external informational flow. That can be described in terms of biological context: any organism has to be “tuned in” on the acceptance of the such informational messages, which help to understand events of external world by the such way in order to survive in the surroundings. The last means that the organism is “taught”, trained by the surroundings, has created the models concerning some its aspects and begins to react upon some class of external signals correctly: this organism realizes necessary sequences of actions to survive. Thus, the survival means in this context not more that biosystem uses some “correct” sequences of actions in accordance with behavioural programs (including heuristic ones sometimes). Informational messages from other living organisms help to use not only own experience for survival and development. The evolution means then the process of learning of world regularities by life.

In order to estimate the effect of either informational message the «population approach» was proposed in (Levchenko, 1994). This approach reminds Eigen's (1971) and Kharkevich's (1965) ones. Let N_1 be the number of individuals in a population of biosystems in equilibrium with its environment prior to the perception of some valuable message; let N_2 be the number of the such individuals after the perception of the message, and let N_{max} be the maximum number of biosystems able to survive in principle under these environmental conditions in the reason of they are trained. Note, that all individuals are energy similar each to other and they use all possible for them resources of surroundings in this case. Then the value V of the information message is given by

$$V = (N_2 - N_1)/N_{max} \qquad (3)$$

In another terminology, the case N_{max} corresponds to the such situation when vital **license** (i.e. conditions which is provided by surroundings; see Levchenko, 1993, 1997) has no free parts because all energy resources of surroundings are being used fully; N_1 and N_2 corresponds to the situations when some parts of license are free; as it was above – prior to and after perception of an informational message. Hence, we can transform eq. 3 to the following one:

$$V = (G_2 - G_1)/G_{max} = j/G_{max}\,, \qquad (4)$$

where G_1 is the energy flow prior to the perception of some informational message by a population and G_2 is the flow after the perception, G_{max} is maximal energy flow which can be provided by the surroundings (it can't there exist any alternative sources of energy for this kind of organisms), j is the energy effect after perception of informational message. Then for N messages we have:

$$V(N) = S_{1,N}\, j_k/G_{max}\,, \qquad (5)$$

where j_k is energy effect of perception of informational message with number k. We can see here the same sum for j as in section 1 for J and that means it has no differences between energy effects of informational message and an interruption. By other words, one of the effects of interruption is the perception of some informational message from external world. Obviously, during every interruption, the probability of success in search of new source of energy and perception of the such informational message is proportional to the number of the population or, more broadly, to the number of attempts.

It is clear that the above formulas can help to link energy characterizations the such as j and G with thermodynamic and informational ones if to use known equations of thermodynamics (for example, the classical second law of it). Moreover, this approach allows to redefine the notion of **realized niche** of a population (Levchenko, 1993, 1997; Starobogatov, Levchenko, 1993) as an multidimensional space of the such used resources (in particular of energy) which are located within perceptual field of the biosystem. Then the license is the factual space of all resources (within a framework of some concrete approach, for example, terrestrial biology), the **fundamental niche** is the potential possible space of resources which the described population is able to utilize in principle. If the capacity (volume) of fundamental niche of population is proportional to energy flow then:

$$V = (s_2 - s_1)/s, \qquad (6)$$

where s is the multidimensional capacity of the fundamental niche, s_1 and s_2 are the capacities of realized niches of populations prior to and after perception of an informational message correspondingly.

This approach leads us also to some interesting outputs in evolutionary aspects. The biosphere creates and determines some diapason of possible surroundings (licenses) for living organisms and, thus, the diapason of diversity for objects which can be perceived in the process of cognition of the world (nature) by actually living organisms. On another hand, the life on the Earth is modifying the surroundings and whole biosphere during all the time when the life exists on the planet. Hence, we can see that the following feedback exists: the biosphere canalizes the process of cognition, the life which is learning modifies the biosphere. By other words, organisms which investigate of the biosphere are being changed in the reason of appearance of new

behavioural programs (and models of reality) and, therefore, of new biological particularities; new changed organisms build new modified surroundings and biosphere which offer new conditions for the life, steer cognitive process and canalize it. In some aspects, this resembles F.Hegel's (1927) cyclic absolute idea of his "Science of Logic", V.Vernadsky (1989) theory of so called "noosphere" (a thinking biosphere) and some other ancient and modern conceptions including religious ones in which ideas "create" new world (with either specific laws of nature) and the nature is an self-knowledge system. It was proposed the principle of **autocanalization of evolution** (Levchenko, 1993, 1997) in order to describe this feedback phenomenon which can also be considered within a framework of conceptions of anticipatory evolution (Dubois, 1997, 1998; Rosen, 1985; see also the sections 4, 5 below).

Thus, there is a fundamental evolutionary problem: has this process (of cognition and creation of new world) some finality or not? The hypothesis on the basis of some of my previous works (1993, 1994, 1997) is the following: if perceptual possibility of the biosphere organisms is limited by its physical boundaries then the process dies out gradually and the system begins to resemble separated adjusted living machine (meanwhile the external cosmic conditions are constant). If the life is able to go abroad the perceptual space of traditional scales or dimensionalities, for example, abroad the planet, then the above process of creation of new world may be unlimited along the physical time. Note, the spatial limitation for the biosphere means that living organisms are not able to interact with either objects which are placed farther (deeper, etc) some accessible for organisms physical boundaries. Thus, expansion of interaction to other scales (and to dimensionalities as well) of the environment can lead to the evolution of biosphere and to origin of new biological forms.

If the expansion of interaction isn't possible then there is some resource restrictions for the processes of both physical evolution and cognition as well because the environment for continuum of living organisms can't be anyone but must provide suitable conditions for life. In particular, it is some temperature diapason: the environment can't be too warm and has to be not too cold. Therefore, G_{max} has to have some final power (it is the consequence that the density of energy flow passing through surroundings has to have some upper limit) and fundamental niche has to have maximal multidimensional volume. The such requirements allow to understand better possible ways of life propagation along Cosmos (see http://bio.nagaokaut.ac.jp/~matsuno/echo/abstracts/levchenk.html).

For non living object the energy flows lead to destruction of the object and, thus, to maximal possible level of its entropy as a rule but in the case of living organism the "correct" management allows to support some necessary level of order in the biosystem (Shroedinger, 1955). We can see here the genetic relations between both the nature cognition processes and processes of management of flows of energy providing life processes. This may be interpreted as the environment, nature "contains" information about every step and path how to use different kinds of energy and, thus, how to go to higher level of the life organization. Then, in this context, life is the "correct" management by energy flows to survive; evolution of the life is both: 1) the finding of new ways for getting of energy and 2) the improving of above management. This process is going under control of surroundings but is modifying the surroundings which is being occupied by the life. One of results of that is the parts of this surroundings are being included gradually into living systems. Hence, the final (i.e. without any evolution) condition of some part of Universe containing the life (which is not able to further evolution) may be a good-organized secluded system.

3 Effective Evolutionary Ways

In order to evolve some ideas which were formulated in previous sections it would be interesting to find out what are peculiarities which evolutionary ways have?

It was said that the biosphere is understood here as some biosystem which developed under the effect of external influences. The evolution of biosphere and other biological systems can be discussed as permanent acquiring of new possibilities to correctly function in order to survive. An biosystem may find new possibilities independently but may also use either informational messages from other biosystems. The result of evolution is that every surviving biosystem is able to realize necessary, concrete sequences of actions – **behavioural algorithms** – in reply on different classes of situations along its life (ontogenesis) to avoid negative conditions or to use either resources (including new ones) which are actually necessary for survival. Just accumulation of the algorithms (for example genetical algorithms but not some abstract "information") by biological systems of memory is real result of evolution. So, the nonmaterial algorithms which

accomplish different kinds of preserving reactions (self-preservation, preservation of an population, for instance) materialize in concrete biological forms. In figurative language, the process of life resembles in some sense an movement along algorithmic "kabalistic" rules (in the meaning of preset system of sequences of signs) to some "golden sections" of the perceptual world; then the evolution is the process of revealing of new behavioural algorithms under the stipulation that "karma" of the life is that to live. To be engaged with science (or arts) may be regarded as one of forms of collective perceptions of the informational messages from external world.

As since the surroundings is changeable along the evolution of biosphere, the life (i.e. organisms of different biological forms in this context) has to able not only to find new behavioural algorithms but also to forget some algorithms to evolve further. But this forgetting must not be too fast because then complication of the life isn't possible. The optimal regime of evolution is oscillation of surroundings conditions (Rautian, 1988; Levchenko, Menshutkin, 1988; Essin, Levchenko, http://kal-el.ugr.es/macrophylon/intro.html). Thus, many of above algorithms and sequences of actions are optimal ones temporarily only. The evolution of genetical algorithms demonstrates good examples of the such regularities and mechanisms of algorithmic evolution.

We could see above that the evolution of biosphere demonstrates the increasing of energy flow which the biosphere uses. What is the way of the such increasing?

Let the flow of energy passing through some biosystem is P(T) at time T:

$$P(T) = P_0 + \int_0^T R(t')\,dt' \qquad (7)$$

where P_0 is initial energy flow at t = 0 and it is some constant which is > or = 0 in general case, R(t) = dp(t)/dt is the rate of changes of energy flow along time, $\int$ is integral (of 0 to T here). To simplify the formulas we shall suppose in the further $P_0 \cong 0$.

The total of all changes for energy flow along the evolutionary trajectory from t = 0 to t = T is:

$$Q(T) = Q_0 + \int_0^T |R(t')|\,dt' , \qquad (8)$$

where $Q_0 \cong 0$. Different evolutionary ways between the same points needs different energy costs. The efficacy f(T) of some evolutionary way for some biosystem may be described as the following relation:

$$f(T) = \frac{P(T)}{Q(T)} = \frac{\int_0^T R(t')\,dt'}{\int_0^T |R(t')|\,dt'} \qquad (9)$$

Obviously, P(T) < Q(T) and f(T) ≤ 1.

As it was shown earlier (Schroedinger, 1955; see about that also Levchenko, 1993, 1997) the prolonged decreasing of energy flow passing through a biosystem leads to destruction and death of the system. Therefore, in the case of any single biosystem inside some physical system any negative values of dp(t)/dt have to be quite brief and not too strong ones. The maximal time for any interruption depends on the

capacity of internal compensative energy resources which were collected during previous period of the biosystem life.

The competition between different biosystems leads to only the such biosystems survive which have had the biggest values of f(T) along evolutionary trajectory in each moment of time. Therefore:

$$P(T) = \int_0^T R(t')\,dt' \rightarrow \max \quad \text{and} \quad Q(T) = \int_0^T |R(t')|\,dt' \rightarrow \min, \tag{10}$$

Hence, we come to the following conclusion: the evolutionary ways of biosystems under competition strive to be optimal one. It isn't difficult to see that Q(T) demonstrates the known so called "principle of minimal actions": the total of changes of energy flow have to be minimal one along evolutionary way (note, that we discuss here the case of biosystems which don't swap effectively by energy). Here is just the consequence of competition between individuals. It may be interesting also that above principle being applied to producing of entropy gives us the important law of nonequilibrium thermodynamics which is applicable to many sorts of biological systems (Nicolis, Prigogine, 1977).

The above eqs. 7, 8, 9, 10 describe the situations when the survived biosystems are "ideal" during an interruption, i.e. they search and certainly find new sources of energy (see section 1). Of course, the formulas conforms with the known rule of evolutionary biology that the best evolutionary way is the such when a biosystem is able to fast adaptations.

Thus, we come to a little strange result: the life uses optimal evolutionary ways for physical evolution and, hence, optimal (in this energy context) behavioural reactions in every moment of evolutionary time. That conforms with both the interruption model and the population approach (when behaviour of population doesn't reiterate the behaviour of simple sum of individuals but has own characteristic regularities). The above "correct" behavioural reactions being memorized create a systems of behavioural algorithms which are different for different periods of the evolution. But these algorithms are certainly not optimal in cybernetic context, for example has no minimal length. Only Earth's biosphere being a secluded biosystem without competition with somebody has more freedom not to go along the most optimal way.

4 Autocanalization of Cognition

The discussion in the previous sections permits to reveal the following consequences:

1. The physical evolution of biosphere is the increasing of energetic flow through it.

2. This evolution is going along optimal ways (in energy context) on all levels of the life organization although separated individuals may use sometimes not only optimal ways.

3. The life of biosystems (i.e. separated organisms, ecosystems, biosphere) is supported by behavioural algorithms which help for these systems to get necessary resources (at the first, the energy) from external world and to preserve their structures under some classes of conditions. The evolution is improvement of management by energy flow.

4. These algorithms are produced by natural selection of correct reactions along evolution and they are being remembered by different systems of biological memory. The creation of new algorithms (and, thus, new specific models of reality) is the process of the nature cognition by life.

All this leads us to almost obvious thought: the living systems resemble some cybernetic machines solving one main task that is self-preservation; there are also other tasks connected with preservation of population, for example, the care about posterity. These cybernetic machines are able to heuristic behaviour in the case of unknown situation and, therefore they are able to cognition. The evolution is producing different intermediate types of these machines (organisms, ecosystems). The way of the evolution begins from some primitive biological machines of embryosphere (Levchenko, 1993, 1997) and brings to the stage when they

are more adapted and more predicted for some classes of external conditions. Different biological machines may use different resources (sometimes fully) nevertheless the summary effect of the evolution is the increasing of energetic flow through the biosphere along its history. Every new step of biological evolution needs new licenses for new biological forms (old forms continue to use traditional for them licenses). That is impossible without appearance of new ecosystems and modifications of local and global conditions on the planet: temperature diapason, water regimen, atmospheric and soil compositions. The rate of biological evolution cannot to be too fast (simultaneously for all living forms at least) because the rate is limited by geophysical processes of the biosphere, by modifications of environments for the life (Vernadsky, 1989; Lovelock, 1991). This means that biosphere is controlling the process of both the biological evolution and the nature cognition by the actually living biological machines of different levels of organization. The biosphere evolution was going under stipulation of autocanalization. The life is modifying surroundings and studied it again and again.

The systems of biological memory (at the first, genetical) and the "surroundings memory" (irreversible modifications of surroundings) promote to be the situation that some the surviving biological forms are "trained" by the nature (and know it) more than their ancestors. This circumstance give the ground to formulate **the principle of self-development of cognition**: the nature (on the Earth at least) canalizes the cognition process by the such way that the total of knowledge of all actual living systems is growing and the process doesn't end.

It is clear that the main laws of the nature (for example, the main physical ones) existed before the origin of the species *Homo sapiens* and, obviously, the information about them and the others wanders around all living organisms always. But every species of organisms (or – on another language – of biological machines) is able to perceive only some restricted part of this information being arrived to them; the man happens to be the most developed receiver of the information during all the history of biosphere. Why? The fundamental (potential) niche of this species may occupy in principle almost any conditions on the planet and even abroad it because the man can use different inventions to create necessary for him local surroundings. Nevertheless, every human population has own peculiarities of fundamental niches, the capacity of which is determined by the total of actual "constructive" knowledge of this population. Not only some experience results but also intuitive conjectures about arrangement and organization of the real physical world create the world of possibilities in minds and these possibilities may be used in appropriate moment. So, the possible becomes to be the real as was written by M. Heidegger (1960).

The development of human civilization demonstrates the extremely fast widening, expansion of fundamental and realized niches of man as a result of reasonable activity but not as genetical modifications which were characteristic for previous evolution. After either widening of fundamental niche the realization niche of man may expand gradually also.

The man was created by the biosphere only on the latest stage of evolution in Cenozoic because, probably, the biosphere was already good developed biological machine which guarantees relative stable surroundings for men. Besides, the possibilities to further rise of energetic flow through the biosphere were, it seems, exhausted. The man break off some feedbacks with the biosphere because he is able to find and use non traditional resources (for example, fire) uncontrolled by biosphere in order to build own surroundings in a local region. This is one of consequences of reasonable activity; all this becomes to be almost unlimited after the appearance of new systems of memory and the means of communications between men. There are human languages, literature and books, libraries and INTERNET at last which allow to use great amount of collective knowledge to search unknown yet regularities of the nature and exploit them for well-being and an further broadening of both fundamental and realized niches. Every individual may now receive great surplus non vitally necessary information simply by means of communication and he can use during his life not only individual or/and evolutionary genetical experience. Learning the micro-levels and macro-levels (Cosmos) of the nature the man leaves the perceptual boundaries of the biosphere and, thereupon, creates possibilities to leave the physical boundaries of it.

As soon as the mind has understood that something exists also abroad of visible and tangible boundaries the power of biosphere under all life on the Earth was finished. New laws of ultra-rate evolution begins to work on the planet. Not only energy and resources confine the rate of evolution now but the rate of distribution of new knowledge which changes the traits of man populations and other elements of biosphere.

One of the simple models of the such new type of evolution when ideas “infect” the man population may be the model of bacterial infection. By using appropriate ideology a cultural system sets the social hierarchy and, therefore, specific filters and contexts for informational messages. It is not difficult to see that this system plays a role of the immunology system too. The human history demonstrates that the ideologies which don't imply cognition (and, thus, modifications of fundamental niche and social hierarchies) perish under pressure of competition of others of the developing civilizations.

If to suppose that ideas play a role of mutations then some peculiarities of the such process may be investigated by means the simulation which is described on the site http://kal-el.ugr.es/macrophylon/intro.html by Kirill Essin and Vladimir Levchenko. Different aspects of modeling need a special discussion that isn’t the topic of this article where the attempt to design some general regularities of the evolution is made.

5 Ultra-rate Evolution of the Modern Biosphere as Result of Anticipatory Activity. Evaluation Experiment

New stage of evolution of the biosphere is characterized by extremely fast expansion of one species – *Homo sapiens* – to all places of Earth which are accessible for life. The level of development of the human population grows together with the increasing of utilization of different resources, in particular, energy. Every new step of the development is caused by appearance of new ways of exploitation of the nature, for example, there was inventions of new agricultures during pre-technical era (Rindos, 1984, 1985). Any other species are being forced out by men, the biodiversity is decreased, new relations between species arise, the biosphere is in crisis state. In fact, we are eye-witnesses of ultra-rate evolution of the biosphere. This situation is a consequence of either deliberate or non deliberate activities of men in direction of creation of new realized niches for themselves by means of essential changes of natural surroundings. This is possible because the man has the such intellect which allows to him to be super universal among all other species.

The philosophy of the previous section 4 permits to come to the reasoning that new knowledge, new ideas broaden fundamental niches of human population; the realized niches expand into new spheres thereupon too. Therefore it is interesting to estimate the possible rate of producing of the new knowledge (i.e. the such informational messages which alter evolutionary trajectories of biosystems perceiving the messages) and the rate of propagation of new ideas in the some human population as well.

We shall describe a simple model within a frameworks of which either individual is able with some probability to produce some informational message. The message may be propagated to other individuals who may either delete this message or multiply and pass it to one or more other individuals. Every process of propagation from some the first “producer” may either die out or develop as chain reaction.

Let D_i characterises a propagation of informational message which belongs to some class of knowledge **i** (for instance, to some concrete field of science) and it is the coefficient of multiplication (or of reproduction) for this message. D_i gives the relation of quantity of the messages after one step of multiplication to the quantity of messages before the multiplication. The standard participant of the process is the such who perceives the message, reproduces it and sends this message further. D_i isn't integer and may be either >1 or < 1. Let Δt_i is the average time interval of the signal propagation for class **i** between participants. Obviously, the number of steps during the propagation is $m_i=t/\Delta t_i$ where t is physical time. Let I_a is actual average full number of accidental informational connections from a participant to other ones. At last, let n_i to be the ratio of individuals, who are able to perceive and resend the messages of the class **i**, to the full number of population which Δt_i is considered by us. Of course, if some groups of individuals, for example, use different languages or they are spatially separate then we have different human populations.

The quantity D_i is proportional to $I_a n_i$ at the initial steps of the process of propagation and if the quantity $D_i > 1$ then number of participants N will be risen very quickly as $\sim D_i^{mi}$ along the time on the preamble stages of process. Later, on the stage of saturation, this increasing have to be slower because any individual who participates in the propagation more than one time in the same moment of time has not to be taken into

consideration for the calculation of N. But in order to estimate roughly the upper limit of N before saturation it is enough to take

$$N_{mi} \sim D_i^{mi}. \quad (11)$$

The linear rate of the such "informational detonation" is not more than m_i in simple case (in contrast to nuclear detonation where the effect of rising of density plays big role).

Obviously, that n_i can be expressed as

$$n_i = a_i r_i \quad (12)$$

where $a_i < 1$ is the coefficient of perception for informational messages; it characterizes the such population part the members of which have necessary mentality to perceive the informational messages of class **i**. The coefficient $r_i < 1$ characterizes process of the message resending.

It is natural to suppose that a_i is proportional to value of informational message V which will be written as V_i here (see the section 2). It is important to note that V_i is here just an **a priori value of informational message**; this value is evaluated by participants on the ground of own previous experience and intelligence about other individuals (or even of rumours concerning somebody). Remember also that V_i characterizes here only a evolutionary important within class **i** parts of general informational flow but not any information which can promote self-preservation in every current moment of time (the consideration of propagation for everyday informational flows which flows which support biological existence, can change realized niches but not fundamental niche needs some other assumptions).

It is known that the development of either mentality isn't possible without intercourse, communication between individuals. Therefore the number of individuals in population who are able to perceive the informational messages of a class **i** in the reason of they have appropriate mentality have to be proportional to the full number of connections between every such individual and others. Moreover, it is necessary to take into account the connections with not only actually living participants of process but also with previous generations i.e. ancestors who provide actual individuals with both the suitable physiological organisation of their organisms and with experience in the form of achievements of culture, of science and of technology as well. Then,

$$a_i \sim V_i(I_a + I_p) \quad (13)$$

where I_p is the number of connections with previous generations in the units of I_a. The way of estimation of I_p may be a comparison of quantities of vitally significant information which were received from actual generation and previous generations (see section 2).

The alike reasoning leads also to the conclusion that

$$r_i \sim V_i \quad (14)$$

because the desire to impart either news to somebody depends on the actual value of the news (this has the corresponding reflection in Gospel in the known sentence about beads and pigs). Thus, if to join all these evaluations and to remember that they were made for the case of infinite space, ideal participants and population which has some unrestricted number, then it is not difficult to get that

$$D_i \sim V_i^2 (I_a^2 + I_a I_p) \quad (15a)$$

or

$$D_i < d_i V_i^2 (I_a^2 + I_a I_p). \quad (15b)$$

Moreover:

$$N_{mi} \sim (d_i V_i^2 (I_a^2 + I_a I_p))^{mi} \quad (16)$$

where d_i is some coefficient which is depended on the features of both concrete population (number, abilities to perception and resending of informational messages) and peculiarities of propagation of informational messages of some class **i** (extinction, distortion, size of the informational message etc) as well.

It is interesting that a priori value of either informational message V_i influences on D_i and N_{mi} quite violently. This means that the rate of propagation of any information which is surmised a priori as significant (including harmful rumours and romantic dreams even) may be very fast. Note also that the $I_a^2 < I_a I_p$ for developed society which has many traditions because $I_a < I_p$ in this case. If d_i is too small (the case of primitive animals, for example) and, thus, $d_i V_i^2 (I_a^2 + I_a I_p) < 1$, then the propagation of informational messages between them is almost impossible. The origin of men or, more exactly, of an human population has happened when some developed language for communication arises and, thus, results of individual experiment of separated primates may be accumulated by this population (by way of stories, of books etc) along its history. As a result of that I_p grows. This process and its beginning which had happened when $d_i V_i^2 (I_a^2 + I_a I_p)$ becomes to be > 1 resemble the chain reaction in nuclear physics and don't need great physiological reorganisations of brain of primates.

The production of really new information (i.e. new ideas, "mental mutations") and sending of it to other individuals of some population may be expressed on the basis of alike to above reasoning as

$$P_i \sim g_i V_i N \quad (17)$$

where P_i is the rate of producing of new information in some unit of time, N is the number of the population. The parameter V_i is included in this formula from the same reasoning as it was for r_i in the case of the propagation (this can be interpreted also as a giving new ideas from the so called "world of ideas"). At last, $g_i < 1$ is the coefficient which characterizes a part of individuals in population who are able to the creative activity in some class of knowledge **i**. This part is proportional to $V_i(I_a + I_p)$ likewise it was for a_i above (the including of V_i signifies here that this model uses the following hypothesis of behaviour: any creative activity have to be stimulated by some motives about its supposed significance). If to summarize we can get that

$$P_i \sim V_i^2 N(I_a + I_p) \quad (18a)$$

or, taking into a consideration non ideality of the process participants:

$$P_i < p_i V_i^2 N(I_a + I_p) \quad (18b)$$

where p_i is some coefficient which characterizes concrete population and its surroundings.

Let $W_i = P_i D_i$ to be the value which is here named as "**creative power**" and which was repeatedly described in metaphoric poetry language, for example by F. Holderlin (1946) and S. George (1958). Note that W_i concerns some class of knowledge **i** only and this parameter describes not a single individual but a groups of individuals inside some human sub-population (for example, a scientific school or an art community). This approach reflects the thought that an idea begins to live ("chain reaction" has begun) when it exists within more than one mind, by other words when the intuitive reasoning is verbalized and suitable to be reproduced to other individuals. If $W_i > 1$ then the population are able to produce new knowledge of class **i**. The propagation of the such knowledge within the sub-population is going very fast according to exponential law,

so the change of fundamental niche happens instantly in fact. The process of expansion of realized niche is predetermined by local ecological license.

Hence, as a result of above argumentation in this section we come to the following equations:

$$D_i < d_i V_i^2 (I_a^2 + I_a I_p), \quad (19)$$

$$P_i < p_i V_i^2 N(I_a + I_p) \quad (20)$$

and

$$W_i = P_i D_i \quad (21)$$

If $W_i > 1$ ($P_i > 1$ and $D_i > 1$) the ultra-rate evolution has to occur and new informational message of class **i** produced by either individual of a population is being disseminated within the population very quickly. If $W_i < 1$ ($P_i < 1$ and $D_i < 1$) then the ultra-rate evolution is impossible. There are also other interesting cases, for example, the class of events when $W_i \sim 1$, $P_i \sim 1$ and $D_i \sim 1$ but they are not discussed within a framework of this article.

Along the evolution, the rate E_i of expansion of fundamental niche of a population depends on appearance of new possibilities to exploit surroundings. One of important cases is just $P_i > 1$ and $D_i > 1$. It is naturally to suppose that the capacity of fundamental niche of a population grows together with origin of either new evolutionary inventions including the such "mental" ones which are described in this case. Here is two ways for that (every of them has own rate): either the mechanical extension of the capacity of fundamental niche or the increase of dimensionality of the space of the fundamental niche. For the first way $E_i \sim P_i$, for the second one the rate of growing of dimensionality of the fundamental niche $X_i \sim P_i$ (inside some space of infinite dimensionality). Therefore, the capacity of fundamental niche within the space of "traditional" dimensionality (i.e. before the rise of new dimension) doesn't grow necessarily. In order to make clear what it mean in biological and evolutionary aspects remember the subdivision of evolutionary processes on so called "important" changes and adoptive ones. Both very essential, fast evolutionary changes of organisms which lead to the origin of new macro-taxa as well as adoptive changes on species level are described in different evolutionary theories. In particular, they are correspondingly named as ana-genesis and clado-genesis – by Huxley'(1963) and Rensch'(1960) terms in speciation context, – or aro-morphosis and ideo-adaptation – in Russian tradition by A.N.Severtsov' (1945) terms in context of morpho-functional progress. It is not difficult to see, the appearance of new dimension of fundamental niche means ana-genesis, the growing of the fundamental niche capacity within a framework of traditional dimensionality means clado-genesis.

Of course, the eqs. 19, 20, 21 were worked out under quite rough assumptions and hypotheses. For example they doesn't describe the changes of parameters along the evolution. Nevertheless, these formulas demonstrate extremely high evolutionary role of the cognition activity which leads to the creation of a priori models of reality. The such dependence on the modelling of future isn't specific trait of the ultra-rate evolution (it is the property of the life to predict some situation in order to survive) but here this is more clearly. Thus, an adaptation leads to cognition and the evolution is originated from not only the past but also from the future (more exactly – from a model of the future); the time becomes indeed to be Heidegger's "gap" ("the time is a gap") i.e. a duration but not a point between the past and the future. So, cognitive evolution is an anticipatory evolution in the sense of R.Risen (1985) and D.Dubois (1997, 1998).

The above eqs. 19, 20, 21 demonstrate also that the society may produce and distribute very fast not only useful but also harmful destructive ideas if they look to be attractive. Destructive ideas may lead to extinction of some human populations or its sub-populations. Thus, the natural selections of both ideas and mentalities is happening during the ultra-rate evolution. The studies of different cases for different values of parameters need special discussion and, moreover, more precise definitions. Therefore only two simplest cases is described below for some class **i**. The first is the creation and propagation of really new ideas by

"young" society without big baggage of knowledge and traditions. The second case concerns well developed society. For the first case I_a is more than I_p , for the second one I_a is much less than I_p. Then for the first case we have:

$$P_i < p_i V_i^2 N I_a \quad (P_i > 1 \text{ and } D_i > 1), \tag{22a}$$

and for the second:

$$P_i < p_i V_i^2 N I_p \ (P_i > 1 \text{ and } D_i > 1). \tag{22b}$$

$I_p > I_a$ means that a well developed society which keeps knowledge has more potential possibilities for further development of ideas from class **i** than new, "young" society but in any case this mechanism can work only if $D_i > 1$ (where $D_i < d_i V_i^2 (I_a^2 + I_a I_p)$ – see above). These formulas equally with conditions $P_i > 1$ and $D_i > 1$ gives in principle a broad spectrum of different ways of ultra-rate evolution (they are not discussed in this article).

The ultra-rate evolution on the modern stage of development of the biosphere may be not necessarily an evolution when energy flow which is being used by civilization grows. The knowledge may in principle allow now to expand both fundamental and realized niches of man beyond of the visual and tangible boundaries of the planet and, hence, don't disturb the environment of other existing organisms of biosphere.

Hence, new regularities of the ultra-rate evolution on Earth connect now with not only energy aspects of the life but with informational exchange between men as well. Meanwhile just the man can continue the evolution process but on informational phase now. The such new way permits in principle to preserve actual living forms of organisms on the planet and to reach some optimal functioning of the "traditional" biosphere machine and new human civilization. But the men must understand that now they themselves have to govern the life of the biosphere because the time when it was selfregulation system is finished.

6 Conclusion

The physical evolution of biosphere is the increasing of energetic flow through it. This increasing is the consequence of perfection of photosynthetic possibilities of plant communities and of all biosphere system. The interruption mechanism (see section 1) of the physical evolution plays main role before the origin of man.

The life of any biosystems (i.e. separated organisms, ecosystems, biosphere) is supported by behavioural algorithms which promote these systems to get necessary resources from external world and to preserve own structures under some classes of conditions, in other words, which help to quasi forecast a future. The ecosystems and biosphere which are adapting themselves to surroundings use optimal evolutionary ways for physical evolution and, hence, optimal (in the energy context) behavioural reactions in every moment of evolutionary time. The "correct" behavioural reactions being memorized by structures of these biosystems create "libraries" of their behavioural algorithms. Thus, these biosystems are cybernetic machines and that conforms with both the interruption model and the population approach. In this context, the evolution of the life is improvement of management by usable energy flow to survive on every level of the life organization. The creation of new algorithms (and, thus, new specific models of reality to forecast the conditions of surroundings) is the process of the nature cognition by life.

All this allows to believe some predetermination for the physical evolution of biosphere and, hence, to use the term "development" for the biosphere evolution. This process is going under control of surroundings but is modifying the surroundings which is being occupied by the life. These features of the process are expressed as auto-canalization approach to the biosphere evolution.

On the last stages of the biosphere evolution the informational exchange between different organisms is helping them to use resources of surroundings, begins to play more and more risen role for the physical evolution of the biosphere. The modern stage of evolution of the biosphere is characterized by extremely

fast expansion of one species – *Homo sapiens* – to all places of Earth which are accessible for life. The level of development of the human population grows together with the increasing of utilization of different resources, in particular, energy. Every new step of the development is caused by appearance of new ways of exploitation of the nature by men. New regularities of the ultra-rate evolution on Earth are connected now with not only energy aspects of the life but with informational exchange between men as well. This exchange leads to training of the individuals to new ways of survival and, therefore, to modifications of ecological niches of human sub-populations and ecological licenses of all biosphere. The consideration of mechanisms of both producing of new information in human community and dissemination of this information gives the following: the intensity and the rates of these processes depend strongly (as square function) on a priori evaluations of values of current information by members of every human population. Thus, the evolutionary modifications of the modern biosphere are interconnected not only with slow "traditional" physical evolution but with very fast cognitive anticipatory evolution. Just the man can continue the biosphere evolution process but on informational phase now. The such new way permits in principle to preserve actual living forms of organisms on the planet and to reach some optimal functioning of the "traditional" biosphere machine and new human civilization.

The inferences of this article leads also to the following progression of reasoning: the living systems being cybernetic machines are solving main tasks of self-preservation and preservation of population; these cybernetic machines are able to heuristic behaviour in the case of unknown situation and, therefore they are able to cognition; the evolution is producing different intermediate types of these machines (organisms, ecosystems). Thus, one of many responses to the known question "what is the life?" may be the such: any biosystem has anticipatory behaviour and the life is the substance which is able to predict own future.

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