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ENERGY HUNGRY AND THE PROBLEM OF PROGRESS IN THE EVOLUTION OF THE BIOLOGICAL SYSTEMS

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"*Biological organisation and evolution are consequences of the flow of energy through matter*"
Ronald Fox, 1988

Abstract. The analysis of the current situation concerning the progress in the biological evolution shows the presence of a deadlock. The true cause of this situation lies in the reductionist-individualist manner of approach. The way out of this deadlock is possible only by changing this point of view. This can be made by approaching evolution through the hierarchical organisation of the biological systems and by considering the antientropic character of these systems. From this point of view it results that there are no preferential trends of increasing or decreasing the structural complexity along the evolution; it exists just the intrinsic tendency of the biological systems to maximise the input, of energy, which is done in various ways within the hierarchy of the systems. Globally, the increase of the biodiversity and of the biomass is the essential way of progress. The biological progress consists in achieving this trend that allows the preservation, prosperity and differentiation of the living forms and, at the same time, the moving off of the biosphere from the state of thermodynamic equilibrium.

Résumé. L'analyse de la situation actuelle au sujet du progrès dans l'évolution biologique montre la présence d'une impasse. La cause vraie de cette situation se situe de la façon reductionist-individualiste de l'approche. La sortie de cette impasse est possible seulement en changeant ce point de vue. Ceci peut être fait en approchant l'évolution par l'organisation hiérarchique des systèmes biologiques et en considérant le caractère antientropique de ces systèmes. De ce point de vue on résulte qu'il n'y a aucune tendance préférentielle d'augmenter ou de diminuer la complexité structurale le long de l'évolution; il existe même la tendance intrinsèque des systèmes biologiques de maximiser l'entrée, de l'énergie, qui est faite dans diverses manières dans la hiérarchie des systèmes. Globalement, l'augmentation de la biodiversité et de la biomasse est la manière essentielle du progrès. Le progrès biologique consiste en réalisant cette tendance qui permet la conservation, la prospérité et la différentiation des formes de vie et, en même temps, d'écarter la biosphère de l'état d'équilibre thermo-dynamique.

Key words: biodiversity, biological progress, biological thermodynamics.

INTRODUCTION

The problem of progress in the biological evolution appeared simultaneously with Lamarck's (ever first) theory of evolution formulated in "Philosophie zoologique" (1809). He considered that a trait of the living things is their intrinsic tendency towards improvement.

Although this idea was rejected from Darwin onwards, it represented the spark that lighted a spread dispute around the complex issue on the existence of a progressive trend in the evolution of the living world.

The problem has been and still is debated at different levels by historians, philosophers, biologists of the most varied profiles. This debate is excellently presented in the book "Evolutionary Progress" (1988) edited by M. H. Nitecki (who has also contributed to it), which includes papers of highly competent authors both in the philosophy and history of the problems, and in the empirical research.

This paper presents several significant opinions on the notion of progress and the criteria proposed for the assessment of this progress, followed by a critical analysis of the current state of the issue of progress in the biological evolution. I will try to approach the issue from the position of the hierarchical organisation of the biological systems.

The basic idea of this approach is that from the thermodynamic point of view the biological systems at any level of organisation, from the individual organisms to the biosphere, are in the third state (Laszlo, 1987; Botnariuc, 2003), therefore, they display a tendency to move off from the first state (thermodynamic equilibrium), process that requires a continuous input of energy into the system.

The increase of this input (by increasing the intake of energy) and the efficiency of energy utilisation becomes the basic factor for the evolution of the biological systems at any level of organisation.

I. THE NOTION OF PROGRESS AND ITS CRITERIA

Initially, the term of progress, of progressive evolution, was used to express the general idea of evolution of the living world, from the single cell organisms to the most evolved plants and animals. Although all the phases of evolution of the life coexist currently, it was shown that they appeared gradually, from the most simple organisms (bacteria) to the most evolved forms of life that exist nowadays.

As we will see later on, other notions appeared gradually, intending either to replace or just to clarify their content, ending in a complete rejection of the idea of progress in the biological evolution.

The notion of progress has an axiological character, which requires criteria allowing the evaluation and measurement of the evolutive changes. Ayala (1988), defined the progress as a "systematic change in a feature belonging to all members of a sequence in such a way that posterior members of the sequence exhibit an improvement of that feature. More simply, it can be defined as directional change toward the better." (p. 78). Also Ayala (1977, 1988), proposed several criteria to assess the "better" from the above definition: increased level of genetic information, increased number of individuals and species, increased global biomass, expansion of the overall rate of energy flow.

Schmalhausen (1968), considered the increase of the complexity and adaptability of the organisms as essential criteria.

Dobzhansky (1989), stated that there are no generally accepted criteria which to assess the progress. He suggested four different criteria: increased structural complexity of the organisms, build up of the genetic information, independency and ability to dominate the environment, development of the nervous systems and the sense organs and, finally, the development of self conscience and abstract thinking, criteria that can be applied to animals only.

The main difficulty in applying the criteria proposed by the above mentioned authors is the lack of measuring methods. This made some authors such as Ayala (1988), for instance, to consider that "It may be properly questioned whether anything is gained by speaking of evolutionary progress rather than of evolutionary advancement or of directional change" (p. 94). Later on Ayala showed the shortcoming of this criterion – the lack of axiological value.

Severtsov (1949) had a major contribution in understanding the progress in biological evolution. He noted two biological processes distinct by their content: biological progress and morphophysiologic progress.

The biological progress consists in the development of adaptations that lead to the prosperity of that species. Three features of the species are considered to be characteristic to the biological progress: the increase in the number of individuals, the increase of the areal, the differentiation of new forms within the old ones, therefore taxa divergence.

The three features characteristic to the biological progress can be achieved on various morphophysiologic ways: aromorphosis – structural-functional changes that increase the energy level of that organism's activity. There are nodal moments in the process of evolution that lead to the occurrence of higher taxa. Some examples of aromorphosis in vertebrates: the appearance of Gnathostomata by the transformation of a branchial arch into mandibular arch thus allowing active feeding that increases by the transformation of scales into teeth. This is how the shift from passive to active feeding was done. The appearance in fish of the ventral air-bladder that became the lung of the tetrapods; the appearance of limbs with fingers, the transformation of the heart leading to the separation of the artery and venous blood stream etc. Zavadsky (1961) presents several aromorphoses in plants: the appearance of new organs in the higher plants – conducting tubules, leaves, flowers, seeds etc. The examples above clearly show that aromorphoses are adaptations with a very general, even universal character.

Idio-adaptations, consequence of aromorphoses, are the second way of the biologic progress. These are lower amplitude changes, adaptations to the local, particular, conditions, such as the protective colours and shapes, the dentition specialised for different ways of feeding, as well as extreme specialisations such as adaptation to the life in caverns or in the abyss.

The third way of the biological progress is represented by the coenogeneses, characteristic to the embryos, to the larval stages, which are adaptations to the conditions of that particular environment that disappear once that stage of the individual development has passed.

The fourth way of the biological progress is very significant, according to Severtsov: organ degeneration due major changes in the life environment – transition to the sedentary or parasitic life. The conclusion of Severtsov is significant. The 1949 edition of his full work states that: "the four directions of phylogenesis have the same value by the fact that they all lead to biologic progress, that is to victory in the struggle for existence" (vol.5, p. 492). "Through each of these four ways of evolution the number of individuals of a given species increases, its areal expands and the species divides into new systematic groups (subspecies, species, genera etc.)" (p. 493). In other words, that which many times is labelled as regress, regressive evolution etc., is one of the ways in which the biologic progress is achieved. For the first time one noticed the fact that phenomena at the individual level, with seemingly adverse effects for a particular organism, may have a positive effect at a higher level – the level of species and of that species' relations with other species in the struggle for existence, in the struggle with the ecosystem it belongs to. Although the paper has been published in German in 1931, this idea with a deep significance passed unobserved.

I think this is the place to reveal the criteria proposed by Ayala (1977, 1988) to assess the "better" from the definition of the progress mentioned earlier. All these criteria, concern processes at levels superior to the level of the individual, same as those mentioned by Severtsov in the notion of biological progress.

Huxley (1956), developed a concept rather similar to the one of Severtsov. Using the terminology of Rensch (1947) he shows that the biological progress is achieved through two main ways: anagenesis (equivalent to the aromorphoses) and cladogenesis (equivalent to the idio-adaptations) to which Huxley added a third way, the stasigenesis, represented by persisting types, the so-called living fossils.

Concerning the criteria assessing the progress, Huxley considered that progress can be limited or unlimited. Man is the highest stage un the single line of unlimited progress, therefore the progress of all groups must by evaluated only by comparison with the man. The limitation of the progressive evolution on other evolutionary lines is due to the morphophysiological features of those particular animals. The anthropocentrical character of Huxley's conception on the biological progress is obvious.

Mayr (1998) rejects the existence of a progressive trend: "There simply is no indication in the history of life of any universal trend to or capacity for evolutionary progress. Where seeming progress is found, it is simply a byproduct of changes effected by natural selection." (p. 198).

More recently, Mayr (2001), seems to have changed position. Although he states that there is no knowledge of any genetic mechanism generating the trend toward progress: "However, one can also define progress purely empirically as the achievement of something that is somehow better, more efficient and more successful than what preceded it" (p. 214). He cites several examples such as the symbiosis that led to the appearance of the eukaryotes, multicellular organisms, endothermy, the development of the nervous system, the care for offsprings, which he considers "highly progressive". He regards all these traits as being strictly individual and concludes that "the summation of all these steps is evolutionary progress" (p. 215). The conclusion of the examination is that "The survivors of this selection process have been proven to be superior to those that were eliminated. The end product of all successful so-called armeraces can be considered to be examples of progress." (p. 216).

Futuyma (1988), separates the notion of trend from the notion of progress: "A trend may be described objectively as a directional shift over time", while "progress, in contrast, implies betterment, which requires a value judgement of what "better" might mean" (p. 691)

Concerning the idea of the existence of a global trend in the evolution of life, such as the increase of complexity of the living things or the increase of the functional efficiency, Futuyma remarks that there is no way to measure these trends. Therefore, "It is probably safe to say that no uniform trends can be discerned in the history of evolution. For every proposed trend, exceptions can be cited" (p. 694).

While the various kinds of trends are objective realities (except the existence of some global trends), Futuyma considers that: "Progress usually implies directional movement toward a goal, which in turn implies foresight. None of the mechanisms of evolution has foresight, and process of evolution cannot have a goal" (p. 700). Besides, there are no objective criteria to evaluate improvement in the evolutional process: "By no objective standard can we say that amphibians are superior to fishes or human to frogs" (p. 701).

Maynard Smith (1988) stated that: "the concept of progress has a bad name in evolutionary biology", statement that he repeated in the book he published together with Szatmary (1995) in a subchapter bearing a significant title, “The fallacy of progress” (p. 4). There are multiple reasons to reject the idea of progress: the difficulty to define the notion and, maybe to define the possibility of measurement. Maynard Smith (1988) said that there is the wish to measure progress by the degree of morphological complexity and suggests evaluating complexity by the number of cell types and by the amount of coding DNA. In the 1995 paper reverting on this issue, he stated that: “there is no reason why evolution by natural selection leads to an increase in complexity, if that is what we mean by progress” (p. 4). However, on the next page he states that although progress is not an universal law of evolution, “…common sense suggests that at least some lineages have become more complex” and leaving the idea of the number of cell types, he proposes a single criterion – the amount of coding DNA in the genome structure, although this indicator too, doesn’t yield satisfactory results.

I think this is the right place to insist of the idea of the existence of an isomorphism between the biological and the technological evolution, both processes being directed toward increasing the structural complexity (Zavadsky, 1970; Mayr, 2001). I think that the idea of isomorphism between the two is correct, but as it is conceived it only reflects a facet and not the essence of the processes. Mayr gives the example of the motorcar whose structure became considerably complicated from the early models to the current ones. I think that no motorcar producer complicated their structure just for the sake of increasing their complexity. The real trend was and is to save fuel and to increase the efficiency of utilisation. The structural complexity is just the means to achieve this trend.

Similar trends take place in the biological evolution too. The real teleonomy in this process consists in the development of the same organisation that leads to increased energy inputs into the system and to increased efficiency in allocating and using it.

Given the (even partial) adoption of increasing complexity as criterion of progress in the biological evolution, the reverse of this idea emerged – the reduction of complexity, the simplification of organisation on some evolutional lines (the classical example – parasites) would represent the regress, a regressive evolution. As we shall later see, this idea too is not according to reality.

It is interesting to mention that the isomorphism between the biological and technical evolutions may also be observed under this aspect, of the structural simplification, which yields, however, an opposite conclusion to that of the biologists. Continuing the example of motorcars, electric cars emerged lately, a *progressive step by structural simplification*, accompanied, however, by increased complexity of the electric and electronic installations of functioning and control. As we shall see further on the same phenomenon also takes place in the biological evolution: simplification under certain aspects is accompanied by increased complexity under other aspects. The essence of both processes is the increased energy efficiency which in biology means the survival and prosperity of a given species, therefore progress.

The evolution of Gould’s opinion is significant in order to assess the current situation concerning the progress in biological evolution. In 1988 he considered that “Progress is a bad example of a crucial generality that we must pursue – the study of directional change in history” (p. 319). The notion of progress is criticised for its anthropomorphic character and he suggests replacing this term by the “operational” notion of directionality.

In "Full House" (1996) Gould gives up categorically the notion of progress and doesn't mention directionality either. In this paper, the analysis of the biological progress is based on several important ideas.

- Life, that appeared through bacteria, beings with a minimal level of organisation (complexity) compatible with life, can only evolve in the direction of increased complexity. The reality shows that indeed, bacteria did not evolve toward more complex forms, but on the other hand, same as in the more complex groups that appeared later, the trend toward increased complexity is not more frequent than the trend toward simplifying the structure, and even on the contrary, it is observed in a very low number of evolutional lines. The structural simplification of many parasites suggests this idea although, as Gould admitted without comments, their often very complex biological cycle contradicts it. Therefore, according to Gould, the increased complexity can not be a criterion of progress, and where such increase was observed it was due to the aleatory course of the process and not to active directions.
- Natural selection only determines adaptation to local changes in the conditions of living: "Natural selection can only produce adaptation to immediately surrounding (and changing) environments" (p. 139).
- The rule of randomness: "the vaunted progress of life really *random motion away from small beginnings, not directed impetus toward inherently advantageous complexity*" (p. 173) (author's underlining). "Thus, and with powerful irony, the most venerable evidence for general progress – the increasing complexity of the most complex – becomes a passive consequence of growth in a system with no directional bias whatever in the motion of its components" (p. 173).
- Dominance of the regressive trend, of structural simplification in the biological evolution

The conclusion of this, quite brief, presentation of the currently dominating situation in the approach of the progress in the biological evolution, may be expressed in just one word – discouraging: the lack of objective criteria to define progress, the lack of methods for the quantitative assessment of the involved processes (increasing or decreasing structural complexity). The criterion of "better" proposed by Ayala to define progress, also accepted by Mayr, without mentioning the entity to which it referred, and only increases the confusion.

It seems that the whole situation is in a deadlock, conclusion reached by two authors who studied closely the issue of progress. Ayala (1988) reached a conclusion of discouraging pessimism: "If the term "progress" were to be completely obliterated from scientific discourse I would be quite pleased, but it seems to me unlikely to happen" (p. 94). The position of Gould is similar. He rejects categorically the existence of a progressive trend in the biological evolution, of a directionality of progress.

I think that the main cause of this critical situation is the reductionist individualism in approaching this issue. All changes (the increase or decrease of the complexity - structural first of all) are evaluated only related to their value to the life of the individual. It would be so if the movement (toward increasing or decreasing complexity) would take place in an ecological void. As we shall further see, reality shows us something else.

The internal constraints specific to the individual organisms may limit the possible ways of action of the natural selection and/or select a certain direction of this action by which the ecosystem controls the direction and extent of evolution. I will demonstrate this idea by an example.

Two large groups of organisms dominate currently the biosphere – bacteria and insects. What do these two groups have in common? First, they didn't produce anything new on the "vertical", but they have both generated an uncommon diversity on the "horizontal"; this was done on two different ways resulting from the intrinsic constraints that determined the direction in which natural selection acted. In eubacteria, the rigid cell wall doesn't allow the increase in size and phagotrophy, which led to external digestion and to the extreme development of the metabolic adaptability. A similar phenomenon can be observed in insects. The rigid (chitinous) external skeleton doesn't allow the growth in size or the development of the nervous system and of the internal structure in general, same as the tracheal respiration, incompatible with the large size of the animal. The evolution of this group went toward the direction of the morphophysiological diversification, the group being represented by millions of species.

It is obvious that these intrinsic features of the bacteria and insects influenced the direction of action of the natural selection.

An important difference must be highlighted between these two groups of outstanding stability of the structural type. The insects surpassed it by the evolution of social life organisation exceeding thus the very limited individual capacity.

Reverting to the ideas of Gould on the subject of progress, I think that the idea according to which natural selection develops adaptations only to the immediately surrounding environments reflects just part of the reality. Of course, adaptations cannot appear to factors of no connection to the organisms, but there are adaptations of a very general character, such as photosynthesis, phagotrophy, gnathostomy, free oxygen respiration etc., Severtsov's aromorphoses in general, that open new and wide ways for the progressive evolution of species.

Gould's statement that the trend of simplifying the structures, the so-called regressive evolution, predominates over the increase of complexity doesn't reflect reality. The classical example is that of the parasites, such as the parasitic worms that lack a range of digestive, sense or locomotion organs. Gould admits that the large complexity of the biological cycle of many parasites contradicts the idea of predominance of the regressive trend, but leaves the problem without comments.

It is noteworthy that there are free animals with a simplified structure similar to the parasites, such as the lack of mouth, of the digestive tract, of the anus, of the locomotion organs. A whole phylum, Pogonophora (Ivanov, 1960) and its two classes, Vestimentifera and Pogonophora s. str., is in this situation. The common trait of these animals with the parasites is that their available source of feed (energy) does not require the mentioned organs. The Pogonophora of both classes live in symbiosis with bacteria, close to the vents on the ocean bottom (Vestimentifera) and close to the methane sources (Pogonophora s. str.). The phylum is represented by about 15 species of Vestimentifera and over 100 of Pogonophora s. str. This phylum is the best proof that the simplification of the individual structures can result in the prosperity of the particular species.

Noteworthy is that Pogonophora are not the only animals adapted to life close to vents or on the ocean bottom. Complex ecosystems with hundreds of species of molluscs, crustaceans and fish form in these places, living directly or indirectly on bacteria as primary source of energy, some of their organs, particularly the digestive ones, displaying various degrees of regression (Malakhov, 1997).

Animals with manner of life and structure resembling to those of the Pogonophora are known to live in other environments too, such as the marine silt and the sediments from the salt swamps, both reducing media (Cavanaugh, 1983).

In connection with the idea of predominance of the trend of structural complexity simplification over its increase, one may miss the fact that most times the change of the environment and/or of the way of life leading to the simplification or even disappearance of some structures is accompanied by increased complexity in other traits or processes which are meant to fulfil the same functions under the new environmental conditions or to fulfil new functions required by this environment. The essence of these changes at the individual level is the same: the use of available sources of energy, which allows the population to live and possibly to prosper in the given ecosystem.

Following are some examples showing the decrease in complexity accompanied by its increase.

- The comparison of a single freeliving cell organism with a cell from a metazoan shows that "…even the more typical metazoan cells seem to be less complex on average, than typical freeliving cells" (McShea, 2001, p. 27). On the other hand we should notice that new structures form in a cell integrated in a pluricellular organism, related to the function of the cell in the life of the organism – liver, muscular, nervous cells etc.
- The origin of the animals from Pogonophora phylum, known as fossils from the Carboniferous, has not yet been clarified. Their internal morphology is, on the one hand, simplified similar to the parasitic worms but, on the other hand, both structurally and functionally, it appears much more complex (Ivanov, 1960, Malakhov et al., 1996, Malakhov, 1997). The cells of their trophosoma are populated by bacteria which split when they become mature and become feed source for the host. The bacterial metabolism is different in the two classes: in the Vestimentifera, the bacteria oxidise H_2S and use the produced energy to synthesise the organic substances they need, while in the Pogonophora s. str., the bacteria oxidise the methane released from the cracks in the ocean bottom. Obviously, the decrease in some organs' complexity is accompanied by the increase in other organs' complexity.
- A last example refers to Cetacaea. Although their exact origin is not clear, it is known that they appeared from terrestrial mammalians during the Eocene, some 55 million years ago. Their transition to the aquatic environment simplified some structures and made others to disappear, while other structures increased in complexity and new structures formed. Examples of simplified or disappeared structures: the hair, salivary glands, skin glands and the hind limbs have disappeared, while the pelvis is disappearing. At the same time, some structures gained in their complexity and new structures formed: chemoreception, changes in the hearing apparatus, increased complexity of the stomach, which consists of 3-14 compartments, the development of a mechanism that stores air making thus possible diving for over one hour, change of the dental apparatus by the formation of baleens in Misticetae, the metabolic adaptation to salt water drinking, development of echolocation.

To conclude this brief review of the current opinions on the progress in the biological evolution we stop on a new point of view based on the analysis of the role of animals in the evolution of the biosphere, view that shares a lot of optimism in solving the problem and opens new horizons of investigation. This change is due to

D. Por, who approached the progress in evolution in his book "Animal Achievement. A Unifying Theory of Zoology" (1994), followed by several concentrated lectures (1996, 2000, 2003).

In approaching the problem, Por delimits categorically both from the reductionism, dogmatism and catastrophism of the, still dominating, Neo-Darwinism, and from all the idealist conceptions.

Por starts from the idea that the biosphere is an open and dissipative thermodynamic system in which structures evolve that consume increasing amounts of energy and whose content of information is also increasing. The whole process of biosphere evolution is directed by the natural selection starting from the biochemical molecular level up to the phylum. It runs fast due to the positive feedback. Once the animals appeared "the speed of the energetic processes within the biosphere and implicitly that of the evolution itself increased considerably" (1994, p. 31).

What characterises the activity of animals, the "animality" in Por's terminology? "The essence of animality in the biospheric context is aggressive consumption of live organisms, sensory capacity to detect the food resources, mechanical means to approach the prey and liberty to move among different environments in search of food. Improvement in these capacities is the yardstick of progressive animal evolution. The trend to progressively improve "animality" is however far from universal in the animal kingdom." ….."Many branches of animal world diverged into specialised side alleys, for instance progressively improving adaptation for sedentary or to parasitic life styles". (2003, p. 31).

Animal diversification led to the development of complex trophic networks with long trophic cycles, accelerating matter recycling. An important moment in this process is the transition of many animals to the consumption of vegetal food (cellulose) done by symbiosis with anaerobe bacteria. The "harpactic" activity (term proposed by Por for the predatory character of animals) throughout all cycles of the trophic cycles led to the development of defence mechanisms in plants and animals: physical, chemical, behavioural.

The increased energy inputs by biosphere expansion both due to the terrestrial vegetation and to the increased rhythm of recycling due to animal activity led, on the one hand, to a considerable increase of the global biomass and, on the other hand, to a more stable balancing of atmosphere composition, in which the CO_2 consumed by plants, with O_2 release, is restituted through animal respiration.

The appearance of the vertebrates with thermoregulation (birds and mammalians) - the largest energy consumers – represented a new qualitative stage in biosphere evolution. If the birds, with their whole morphology and physiology strictly specialised for flying, are a dead end of evolution, the mammalians, man included, are the most recent peak of this evolution. Once man appeared, Por considers, the process of evolution ended (2003, p. 38).

The essential problem is whether a certain general trend can be discerned in the evolution of life. If yes, than what is its progressive character, what are the criteria to evaluate it and what are the forces, causes driving this process?

The answer to these problems, in my opinion, is the original contribution to the analysis and solving of the problem of progress in the biological evolution.

In the Introduction to the 1994 book, a general characterisation of the evolutionary process in animals is given: "…animal life evolved progressively to ever-increasing level of complexity and keener behaviour" (p. 9). This progressive character is the result of a given trend: "the biosphere has expanded, thickened and became more complexly structured as a general trend of organisation of matter of living planet Gaia" (1994, p. 325).

On the same page we also find the answer to the issue of the criteria and factors of the evolution process: "The objective criterion is without doubt the improved "animality": the improvement of animals, their increased range and capacity to fulfil their role as global energy traders."… "The driving force of zoological progress is basically ecological: the expansion and melioration of the energetic progresses in the biosphere."

Some observations on Por's conception:

1. The problem of natural selection. As Por says, natural selection drives the whole evolution process from the molecular level to the phylum. The species holds the main place within this process: "What day-by-day environmental fluctuations do in selecting among species, large-scale convulsions did in selecting among classes and phyla." (1994, p. 212).

Also, as Por showed, a trend of increasing structural complexity exists in animal evolution.

I had two observations concerning these two ideas, which complete them. First, natural selection is an emerging feature of the ecosystem – resulting from the interaction between the populations and the abiotic factors within the ecosystem. The direction of action of the natural selection is adaptation of each population of the ecosystem to its structure and functioning (constraints). The individuals composing the populations stand for the mechanism of action of the natural selection because they are the only entities with metabolism, capable therefore of material and energy exchange with the environment.

If this is how thing are, then there can be no trend of structural-functional increasing or decreasing of the organisms, but just a trend given by the ecosystem, of maximising the inputs and minimising the energy expenditure in the activity of each organism; this is done by any means, either by increasing the complexity, or by structural simplification, or many times by blending these two trends, if this leads to the improvement of the energy budget, ensuring the success of survival and reproduction in the given population.

Second, if we take into account the hierarchical structure of the biological systems, then we observe that natural selection acts on several levels and the levels of this action are different many times, even contradictory on diffrent levels. A useful feature for species survival in the given ecosystem may have adverse, even fatal consequences on the composing individuals. I will only mention several categories of facts:

- Adult aphagia in ord. Ephemeroptera and in fam. Chironomidae (ord. Diptera), including several thousands species
- Hypertely in many invertebrate and vertebrate species
- Reduction of some essential organs in many parasites as in many sedentary animals

If despite the reduction, or even disappearance of some vital organs the prosperity of those species is provided for, then can be deny the progressive effect of their evolution?

Of course, as Por says, selection at the species level also reflects at the class and phylum levels. Although, due to the lateral exchange of the genetic information the possibility of the monophylectic origin of the large taxa is questioned, making abstraction of this idea, we can say that the taxa belonging to a class or phylum have in their genome part of the common inheritance, but that each taxon component of a phylum has its own way of evolution. This is the consequence of the fact that the evolution of life is neither a unilinear process, such as a marathon (Por's comparison) nor an anthropocentric process, but that it runs on multiple and divergent ways, ways that represent history, more precisely the assembly of preconditions to the current situation, history during which changes in genome structure occur.

I will only give one example, that of the human species. One of the preconditions was the adaptations to the arboreal life of the primates of origin: displacement of the eyes in front (convergence with that of all carnivorous mammalians and birds), allowing stereoscopy necessary to assess correctly the distance; prehensile structure of the limbs, opposability of the tow, the use of hands to gather food and even an early use of tools, the use of hind limbs for support. These features were preconditions for the transit to life in the open land of the savannah, where the tall grasses with large carnivorous animals (another precondition) imposed the biped posture that allowed the detection of these carnivorous animals; this freed the hands, with all subsequent consequences. This evolution also involved changes in the genetic fund structure.

If on our planet this trajectory of evolution of life and appearance of the human species was inevitable and necessary, as Por says, it is hard to me to imagine the possibility of a replicate on another planet of our solar system, let alone into another solar system. This is one of the reasons why I can not agree with Por's optimism on the future of mankind evolution and role: "Humanity is bound to produce breakthrough in the energy capture and transformation on the globe, both by transgenic increase in the primary production and by liberation of new energy sources like hydrogen burning and "clean" atomic fusion"…."The humans … will survive and dominate the globe until it will start to be engulfed by the red giant-turned sun. By then we shall have already colonised space." (2003, p. 38).

In conclusion of the discussion to this issue, I mention the opinion of Budyco (1984) based on own investigations and on the analysis of an abundant literature. "When investigating biosphere evolution one has to consider that the area of life (interval of the physical and chemical conditions that make the existence of organisms possible) is very narrow compared to the variability of these conditions on the celestial bodies. This area is even narrower for different species of concrete organisms and for their groups." (459). Because "… the external factors of biosphere evolution act on it independently of the existence of life on Earth, biosphere preservation for billion of years and its long progressive development, as it can be seen, are events whose possibility is very low. Hence the quite null perspective of discovering extraterrestrial life or civilisations." (459).

I think that both positions, optimist and pessimist, have a strong speculative character for now. However, with a cool judgement, the current evolution of biosphere ad the role of mankind in this process has no sign to justify the optimism. On the contrary, global phenomena such as climate warming, pollution of all life environments, excessive exploitation of the biological resource and not only, cause a dramatic reduction of the biodiversity, slowing thus down the displacement from the state of thermodynamic equilibrium; furthermore, the expansion of deserts shows the reversal of this trend on wide areas: closing in on the state of thermodynamic equilibrium (Botnariuc, 2005).

2. In the evolution of animality, excellently presented by Por, that highlights the increase of energy consumption and the speeding up of all ecological flows, I think that another side should also be reflected: the evolution of the harpactic activity inevitably led to the *qualitative* evolution of energy through the development of the higher nervous activity and of animal thinking, ending eventually with the use of "tools" to get food by birds and mammalians, primates particularly.

3. The harpactic activity, the "animality" appeared much long before the appearance of the actual animals. Arhaebacteria are the first organisms able to catch food (phagotrophy). The proof is the symbiosis with cyanobacteria. Besides, numerous protist until not long ago classified as Protozoa, from amoeba to infusorians, eat living food. These activities that precede much the appearance of the actual animals, considerably increase the ecological and evolutional amplitude and role of the harpactic function in time and space.

II. INCREASE OF THE ENERGY INPUTS AND OF THE ENERGY EFFICIENCY – FUNDAMENTAL TREND IN THE EVOLUTION OF THE BIOLOGICAL SYSTEMS

As shown before, thermodynamically, the biological systems are in the third state, in other words they tend to distance from the first state (thermodynamic equilibrium) provided the availability of increased energy inputs into the system, which is done through the increase in biodiversity. This trend appeared together with the first living things. Until now, we do not know how life emerged on Earth, but we know that this event took place 3.85 billion years ago (this figure is contested – for instance, Moorbath (2005) sustains that the oldest certain bacterial fossils come from Gunflint formations in Ontario, Canada, 1.9 billion years ago) and that it was preceded by a long chemical evolution, which was proved experimentally (Fox, 1988). We also know that the first beings that appeared were bacteria, the only components of the biosphere for over 2 billion years. Much of this period, Earth's atmosphere was completely or almost completely devoid of oxygen and therefore bacteria have been anaerobe for a long period of time. The efficiency of the anaerobe metabolism is much less efficient than the efficiency of the aerobe metabolism: from the same amount of glucose a 19-fold higher amount of biomass forms under aerobe conditions than under anaerobe conditions, which is very important because biomass is the energy source for other organisms. Under the conditions of the anaerobe atmosphere bacteria started to bind the free nitrogen, which is indispensable to protein synthesis.

A first qualitative change in the biosphere energetics, event that we can consider as a first ecological revolution, occurred when the oxygenic photosynthesis appeared. It must be said that anaerobic photosynthesising prokaryotes existed before this event. This was the anoxygenic photosynthesis, in which H_2S was the source of H to reduce CO_2. It is essential to note that the oxygen was used in the metabolic processes and therefore it was not released in the environment; besides, the hydrogen source was limited.

The radical change occurred when the oxygenic photosynthesizing cyanobacteria appeared, in which H is produced by water photolysis – unlimited source, and the O_2 is released into the environment. Cyanobacteria deposits, the so-called stromatolite, are known as fossils in rocks of about 3 billion years ago; they are currently forming in oversaturated waters in hot climate areas. The onset of the oxygenic photosynthesis had numerous and profound consequences on the subsequent evolution of the entire ecosphere.

Thus, the oxygen concentration increased gradually both in the water and the atmosphere, therefore there was an increasing influx of energy into the ecosphere. The process was, however, very slow: the current concentration was achieved about in the time of the Cambrian, taking therefore about 3 billion years. Because oxygen was toxic for the anaerobic prokaryotes they either started to withdraw in anaerobe environments, or began to develop mechanisms to neutralise oxygen toxicity to adapt to aerobic conditions. The accumulation of biomass was increasingly active and therefore the solar energy was retained in the synthesised biomass.

Structural changes also appeared in the cyanobacteria with important physiological and ecological implications. Thus, besides monocellular species filamentous species appeared – the first supraindividual organisations. Furthermore, cellular differentiations occurred within the filament: akynetic cells – cells that are resistant to some abiotic factors (such as temperature, for instance) and heterocysts – cells with thick walls that prevent oxygen penetration making thus possible nitrogenase activity and thus molecular nitrogen binding that diffuses thereafter throughout all the filament cells. This is a first structural feature that marks colony integrality.

Meanwhile, another radical change occurred in the evolution of biodiversity, the appearance of the monocellular eukaryotes by symbiosis between Arhaebacteria able to perform phagotrophy and photosynthesising cyanobacteria. The oldest eukaryote fossils have about 1.5 billion years. The paleochemical analyses reveal the presence of sterols that are characteristic to eukaryote membranes in geological formations aged 2.7 billion years (Knoll, 1999). The appearance of eukaryotes brought about several important innovations: for the first time complete cells appear, with the nucleus included in a membrane that encloses the nuclear chromosomes. The eukaryote cell has specialised organelles: mitochondria that perform respiration and chloroplasts that perform photosynthesis. Although a large number of monocellular eukaryotes have asexed replication, for the first time the sexual process appears, which is an important innovation. The eukaryotes have a polyphyletic origin due to the symbiosis between various Arhaebacteria with various cyanobacteria.

All these innovations brought profound changes within the biosphere energetics. First, the energy input increased due to the significant increase of the biodiversity; this was done on two ways: the diversity of symbiont combinations, on the one hand and their diversity due to the genetic recombination resulting from the sexual process, on the other hand.

Second, energy efficiency increased, also on two ways: the efficiency of the aerobe metabolism that draws more energy from the food on the one hand and the active nutrition (phagotrophy) on the other hand.

These phenomena had important ecological consequences: the establishment of the first trophic cycles due to phagotrophy (harpactic activity), which activated matter recycling and increased the speed of biomass accumulation – source of energy and factor accelerating energy flow and life evolution.

The monocellular eukaryotes were the most evolved group for hundreds of million of years, until just before the Cambrian when, in a quite (geologically) short period, as Gould (1996) said, an "explosion" of the metazoars produced: all present phyla appeared, as well quite a lot phyla that disappeared meanwhile. No doubt, the

Cambrian explosion was the result of a long process, but those organisms, with no skeleton, left no traces.

How can this sudden flourishing of the forms of life be explained, several billion years from their appearance and after an extremely slow evolution? The appearance of multicellular organisms was the result of an increased energy input into the biosphere, phenomenon that was possible with the increased atmospheric oxygen concentration. Close to the Cambrian this concentration closed the current level making thus possible the existence and diversification of life (Knoll and Carroll, 1999; Knoll, 2003).

Biodiversity and its increase throughout the entire hierarchy of the biologic systems was and remains the most important way for energy input into the system, distancing thus the global system from the state of thermodynamic equilibrium.

Ways of biodiversity increase

- Mutational and phenotypic variability
- Genetic recombination due to the sexual process
- Lateral genetic transfer
- Endosymbiosis
- Intrapopulational diversity – by age, size, gender, behaviour, food, defence
- Interpopulational diversity due to the different activity of each species' populations in different ecosystems
- Speciation, in all its phases – appearance of new breeds, subspecies, species. Species diversification on a trophic level leads to species diversification of all subsequent levels (Watt, 1968).
- Odum (1983) revealed the stabilising role of the functional redundancy of the primary producers in ecosystem functioning. To this role it must be added, however, the fact that the food (biomass) resulted from the primary production differs *qualitatively* from one species top another. Food diversity is a significant stimulus to increase consumer biodiversity, thus the energy inputs in the trophic cycles on all trophic levels, increasing thus consistently the energy inputs into the biosphere.

The manner of increasing the energy inputs and efficiency of utilisation differs in the biological systems of different levels depending on several factors such as: the position in system hierarchy and in phylogeny, the conditions of the abiotic environment, organism size, manner of feeding, position in trophic cycles, reproduction strategy.

We shall present briefly the diverse ways of energy input increase at the individual, populational and ecosystemic levels.

At the individual level. The individual organisms function according to the principle of maximal energy input and minimal energy and time expenditure. This is done on different ways:

- Development of morphophysiological features and their specialisation for various functions leading to higher levels and to higher efficiency of the organism, as a whole. Phagotrophy and later gnathostomy, made feeding an active process with increased energy efficiency. These transformations were correlated with other transformations such as pulmonary respiration, separation of the venous and arterial blood flows, development of homeothermy, increased independence from the variation of some abiotic factors.

- An original way of increasing the energy inputs can be observed in some groups of animals, which is the coupling of functions that are energetically essential – respiration and nutrition. This phenomenon can be observed in the filtrating organisms: branchiopods, molluscs - lamellibranchiates, in many sedentary animals and generally in those animals in which respiration and food capture are done by the same organ, the legs in the case of branchiopods. Because respiration is a continuous process, so did feeding become.

At the populational level. New ways of increasing energy inputs appeared: ecological diversification of the ontogenic stages – the polymorphism and polyphenism of these stages, which leads to the diversification of the consumed food, to the regulation of the offspring number according to the available food sources, to the social hierarchy that settles priorities in the access to food.

The appearance and evolution of sociality in the invertebrates and vertebrates increased consistently the energy input. The schools by age of many fish species and of many other vertebrates allow a quicker spotting of the food and a better defence. Pack hunting, organised in many carnivores – wild dogs, hyena, wolves, allows a more efficient hunt of large herbivores. Furthermore, in some species the food is split with those individuals that remained at "home" – the sick or the females with cubs.

In the invertebrates, sociality peaked in two insect orders, the Isoptera (termites) and the Hymenoptera (particularly in bees and ants). Their social organisation allows them to bypass their individual capacities. Some of these insects (Termitidae among the termites and Attini tribe of the ants) are actually doing farm work growing fungi as food source. In other species the interindividual collaboration allows them to catch much larger animals, inaccessible to the isolated individuals.

At the ecosystemic level. A large scale ecological revolution, in biosphere energetics included, took place when the terrestrial vegetation appeared in the Silurian and developed thereafter rapidly so that the trees appeared in the Devonian (Valentine, 1977). This event determined a strong increase of energy input throughout the biosphere. The mineral sources from the continent surface began to be used, which caused all the bio-geo-chemical cycles to transform. This revolution was quickly followed by an explosive development of insects.

Biodiversity, essential mechanism of energy input increase, speeds its increase by positive feedback. I can not express in a better way the functioning of this mechanism than citing Ayala (1988): "The greater the number of species, the greater the number of environments that are created for the new species to exploit. Once there were plants, animals could come into existence, and the animals themselves sustain large numbers of species of other animals that prey on them, as well as of parasites and symbionts" (p. 87).

III. ENERGY ALLOCATION

Within the structure of the trophic cycles, each population is both a consumer of energy from sources available and accessible to it, and a producer of biomass – source of energy for other consumers. This activity, characteristic to each population, is its specific message (information) toward the ecosystem, which "assesses" the compatibility of these activities with the structure and functioning of the whole ecosystem. This is the process of natural selection, emergent process of the ecosystem, which determines the direction and intensity of a population's activity and evolution within the limits allowed by the intrinsic features of the component individuals.

Within this context, the essential strategy of any population, result of the natural selection, is to keep it within the integrator ecosystem. In achieving this strategy the allocation of the energy input differently for the various functions is a major factor.

There are two essential functions of the individuals of a population: a) individual surviving, with all the functions related to food tracking, eating, processing and assimilation, that is energy extraction and to defence and, b) reproduction that ensures the survival and maintenance of the population.

Wilson (1975) presents the results presented by researchers on the time and energy budget allocated by vertebrates to the different functions. The investigations conducted on 4 species of fish, 6 species of amphibians, 3 species of reptiles, 7 species of birds and 7 species of mammals showed that foraging ranks first as energy allocation in most species followed by reproduction, including all the pre- and postreproductive behaviours.

Of course, the reported data are too few to be generalised, even in the vertebrates only, let alone in all animals and plants.

The facts show that energy allocation varies very much according to several factors such as the position in the trophic cycles, the reproduction strategy (r or K), the way of life (sedentary, parasitic) and the abiotic and biologic environment. Thus, the species with r strategy of reproduction, most situated at the basis of the trophic cycles (all prokaryotes, the protist, and many metazoars) lack efficient defence mechanisms and therefore their catch by various predators is not selective, which is why they allocate most of the energy to reproduction, to the production of an as large as possible number of offspring ensuring thus the survival of that particular species.

Most plants are species with r strategy of reproduction and their source of energy is provided by photosynthesis. Many plants have efficient means of defence, either physical (thorns or prickles) or chemical (toxicity), which are efficient against their main enemies that might endanger the existence of the population (Botnariuc, 2003). The plants use the energy mainly for organism survival and secondly for reproduction.

The priority of energy allocation for individual survival is clearly observed in special circumstances. For instance, in the Danube floodplain, when the spring floods are higher and longer, the reed (*Thypha latifolia*) spends much of the rhizomes energy to reach water surface, to grow and restore the energy deposits from the rhizomes. During such years it does not blooms and doesn't make seeds because the rhizome deposits are not enough for this energy-craving function (Botnariuc, 1963).

Such facts show us that energy allocation depends not only on the mentioned factors, but also on accidental phenomena in the biologic cycle of those particular organisms. All these variations change the ratio of the energy budget of the particular organisms, parameters whose value can be determined quantitatively both at the individual and populational level.

Conclusions

The analysis of the current state in the problem of progress in the biological evolution shows the presence of a critical situation. The real cause of this situation lies in the individualist-reductionist manner of approach of the whole problem which, with just a few exceptions, dominates the thinking of the biologists.

It is possible to exit this stalemate by switching to systemic thinking, considering the energetics of the biological systems throughout the entire hierarchy, from the individual organisms to the biosphere. As shown in this paper there are some encouraging signs, too. But these attempts to overcome the dominant dogmatism are kept under silence. It is another kind of tacit veto and this is due to a wrong policy of thinking.

In this paper I only tried to show that the approach of the biological evolution considering the structure and hierarchic relations of the biological systems and of their anti-entropic character with their tendency to distance from the state of thermodynamic equilibrium, is the way out of the deadlock.

There is no preferential trend of the biological evolution in the direction of increasing or decreasing complexity, just the tendency to maximise the amount of energy input into the system, which is done by different means at all levels from the individual to the ecosystem throughout the biosphere. Irrespective whether the structure of the organisms composing the population, as well as the structure of their biological cycle, is simpler or more complex but it allows the maintenance and prosperity of the population in the given ecosystem by efficient participation in the ecological flows and meeting of its material and energy requirements, such population (species) is progressing.

At the global level, the increase of biodiversity is the most efficient means to increase the energy inputs and therefore to distance from the state of thermodynamic equilibrium.

Energy capture and allocation for the different functions of the individuals, and of the population, are processes that can be evaluated quantitatively and they are a basis to assess the progress in the biologic evolution.

The human species, by its intraspecific relations, by its destructive behaviour in relation with the entire biosphere, by the lack of self control, by its all activity, disorganises the biosphere, undermining the basis of its very existence. Its evolution is no longer biological. Such a species can no longer be used as standard to assess the biologic progress.

FOAMEA DE ENERGIE ȘI PROBLEMA PROGRESULUI ÎN EVOLUȚIA SISTEMELOR BIOLOGICE

REZUMAT

Examinarea părerilor privind problema progresului în evoluția biologică arată o situație critică, mergând până la negarea existenței oricărei tendințe progresive.

Cauza generală a acestei situații stă în modul de abordare a problemei, în gândirea individualistă, reducționistă.

Unii autori admit existența unei tendințe evolutive spre „mai bine“ fără a preciza la cine se referă acest „mai bine“ și în ce constă. În majoritatea cazurilor „binele“ sau „răul“ se referă la individ.

Se consideră că un neajuns major în acceptarea ideii de progres este lipsa de criterii de evaluare și a unor modalități de măsurare a acestei tendințe evolutive, atunci când este admisă.

Unii autori propun anumite criterii în aprecierea unei tendințe evolutive, ca de pildă creșterea complexității structurale sau comparația evoluției animalelor cu specia umană, luată drept etalon.

Este evident că toate aceste propuneri sunt consecințele modului unilateral, reducționist de abordare a problemei.

Există și unele încercări de a depăși acest dogmatism, dar ele nu sunt luate în seamă, fiind trecute sub tăcere.

Ieșirea din impas necesită schimbarea modului de abordare a problemei prin acceptarea concepției sistematice privind organizarea, funcționarea și evoluția biologică, cea de creștere a energiei captate, fie pe calea creșterii sau a simplificării structurale (de obicei ambele procese sunt combinate) care asigură evoluția și prosperitatea speciei.

Specia umană nu poate fi luată drept etalon pentru că evoluția ei nu mai este un proces biologic, iar activitatea ei duce la scăderea biodiversității și la apariția tendinței biosferei de apropiere de starea de echilibru termodinamic.

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