Aromorphoses in Biological and Social Evolution: Some General Rules for Biological and Social Forms of Macroevolution

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ABSTRACT

The comparison between biological and social macroevolution is a very important (though insufficiently studied) subject whose analysis renders new significant possibilities to comprehend the processes, trends, mechanisms, and peculiarities of each of the two types of macroevolution. Of course, there are a few rather important (and very understandable) differences between them; however, it appears possible to identify a number of fundamental similarities. One may single out at least three fundamental sets of factors determining those similarities. First of all, those similarities stem from the fact that in both cases we are dealing with very complex non-equilibrium (but rather stable) systems whose principles of functioning and evolution are described by the General Systems' Theory, as well as by a number of cybernetic principles and laws.

Secondly, in both cases we do not deal with isolated systems; in both cases we deal with a complex interaction between systems of organic systems and external environment, whereas the reaction of systems to external challenges can be described in terms of certain general principles (that, however, express themselves rather differently within the biological reality, on the one hand, and within the social reality, on the other).

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Thirdly, it is necessary to mention a direct 'genetic' link between the two types of macroevolution and their mutual influence.

It is important to emphasize that the very similarity of the principles and regularities of the two types of macroevolution does not imply their identity. Rather significant similarities are frequently accompanied by enormous differences. For example, genomes of the chimpanzees and the humans are very similar – with differences constituting just a few per cent; however, there are enormous differences with respect to intellectual and social differences of the chimpanzees and the humans hidden behind the apparently 'insignificant' difference between the two genomes.

Thus, in certain respects it appears reasonable to consider the biological and social macroevolution as a single macroevolutionary process. This implies the necessity to comprehend the general laws and regularities that describe this process, though their manifestations may display significant variations depending on properties of a concrete evolving entity (biological, or social one). An important notion that may contribute to the improvement of the operationalization level as regards the comparison between the two types of macroevolution is the one that we suggested some time ago – the ***social aromorphosis*** *(that was developed as a counterpart to the notion of biological aromorphosis well established within Russian evolutionary biology). We regard social aromorphosis as a rare qualitative macrochange that increases in a very significant way complexity, adaptability, and mutual influence of the social systems, that opens new possibilities for social macrodevelopment. In our paper we discuss a number of regularities that describe biological and social macroevolution and that employ the notions of social and biological aromorphosis such as ones of the module evolution (or the evolutionary 'block assemblage'), 'payment for arogenic progress' etc.*

INTRODUCTION

The discussions among the evolutionists on the possibilities and limits of the application of the Darwinian theory to the study of social evolution have been going for more than a century and a half (on the recent discussions see *e.g.*, Hallpike 1986; Pomper and Shaw 2002; Mesoudi, Whiten and Laland 2006; Aunger 2006; Barkow 2006; Blackmore 2006; Mulder, McElreath, and Schroeder

2006; Borsboom 2006; Bridgeman 2006; Cronk 2006; Dennett and McKay 2006; Fuentes 2006; Kelly *et al.* 2006; Kincaid 2006; Knudsen and Hodgson 2006; Lyman 2006; Mende and Wermke 2006; O'Brien 2006; Pagel 2006; Read 2006; Reader 2006; Sopher 2006; Tehrani 2006; Wimsatt 2006). We have already analyzed some approaches connected with the comparison between biological and social evolution; we have also expressed our own position on this point (Grinin and Korotayev 2007, 2009; Grinin, Markov, and Korotayev 2008: 145–152). Unfortunately, in most cases we observe an excessive polarization of positions, some of which imply an almost total rejection of the Darwinian theory applicability to the study of social evolution (see *e.g.*, Hallpike 1986), whereas the opposite camp insists that the cultural evolution demonstrates all the key Darwinian evolutionary traits and that is why the structure of the research in cultural evolution should share all the fundamental traits of the structure of the research in biological evolution (Mesoudi, Whiten, and Laland 2006). We believe that we need now somehow different approaches that are more constructive and more congruent with current trend toward interdisciplinary science.

At the present-day level of scientific development we need such approaches that allow seeing macroevolution at a transdisciplinary scale, such approaches that both secure the operationalization of the employed terminology and theoretical statements, and do not reduce one form of the macroevolution to another[1]. In other words, the activities aimed at the unification of the research tools with respect to various types of macroevolution should not be mechanical. In this article we try to present some of such research tools that can help to work out such approaches that could be common for both biological and social macroevolution.

In this article we discuss a group of ‘rules’ and ‘laws’ that can be applied to the both types of macroevolution. In the meantime we try to demonstrate not only similarities in those rules, but also significant differences that we confront when applying them to biological evolution, on the one hand, and social evolution, on the other.

When we speak about macroevolutionary rules, we imply that they do not denote any sorts of rigid functional dependencies and relationships that must be observed in all the phenomena of a given class; they rather denote some principles or trends that tend to be supported empirically and that, consequently, allow to provide more adequate explanations for complex processes and phenomena, which would be accounted for in a worse or less complete way if those rules were not taken into account (see also *e.g.*, Chernykh 1986).

We denote as a **scientific** law a certain statement (that can be expressed both verbally and mathematically), which is produced on the basis of generalization of a set of phenomena of a certain class on the basis of common approach, logic and rules of interpretation and which maintain that something will take place (or will not take place) in this or that degree of completeness under rigorously identified conditions (see *e.g.,* Grinin 2006; Grinin and Korotayev 2007, 2009; Grinin, Markov, and Korotayev 2008: 8–9).

All the analyzed rules are connected with the transition of biological and social systems to new qualitative levels or with 'newness' (see *e.g.*, Rautian 2006; Nikolis and Prigozhin 1979, 2003; Eygen and Vinkler 1979; Ebeling, Engel', and Faystel' 2001; Prigozhin 2002; Glensdorf and Prigozhin 2003; Prigozhin and Stengers 2003; Ebeling 2004).

We have presented a more or less complete system of evolutionary rules, laws, and principles in our monograph (Grinin, Markov, and Korotayev 2008, 2009). In this article we single out first of all those rules and laws of macroevolution that are connected with the most important evolutionary changes (as regards the increase in proximate and ultimate potential and advantages of biological and social taxa) that (following a number of biologists) we denote as **aromorphoses**.

BIOLOGICAL AND SOCIAL AROMORPHOSES

Thus, one of the important terms that we use in this article is *aromorphosis*. The aromorphosis is understood by Russian biologists along the lines suggested by Severtsov (Severtsov A. N. 1939, 1967). As any broad biological generalization, the notion of 'aromorphosis' remains a bit vague; it appears difficult to define it in a perfectly rigorous and unequivocal way. Initially, aromorphosis was understood as such a direction of evolution, within which the **biological flourishing** of a group is achieved through **morphophysiological progress** *(Ibid.)*, whereas the 'biological flourishing' of a group can be estimated using such measures as levels of achieved diversity, biomass, and numbers. As regards 'morphophysiological progress', Severtsov assigned this role to the increase in energy of vital functions. However, later such an 'energy-centered' approach was criticized as too one-sided (Tatarinov 1976). Shmal'gauzen (1969) emphasized the importance of such a criterion (or symptom) of aromorphosis as the **growth of organization complexity** that is tightly connected with the **expansion of conditions of existence and increase in their complexity**.

The importance of 'ecological' component of aromorphosis (expansion of adaptive zones and conditions of existence) has been underlined by a number of researchers. As a result a few quite reasonable definitions of the aromorphosis have been proposed, for example:

1. '*Aromorphosis is an expansion of living conditions connected with an increase in complexity of organization and vital functions*' *(Ibid.).*

2. '*Aromorphosis is an increase in the organization level that makes it possible for aromorphic organisms to exist in more diverse environments in comparison with their ancestors; this makes it possible for an aromorphic taxon to expand its adaptive zone*' (Severtsov A. S. 2007: 30–31).

Among classical examples of major biological aromorphoses one could mention the emergence of the eukaryotic cell (see *e.g.*, Shopf 1981), the transition from unicellular organisms to multicellular ones (that took place more than once in many lines of unicellular eukaryotic organisms [see *e.g.*, Walentein 1981: 149]), the transition of plants, arthropoda, and vertebrates to life on dry land (see *e.g.*, Walentein 1981), origins of mammals from theriodonts (Tatarinov 1976), origins of *Homo sapiens sapiens* etc.

The process of aromorphosis formation is called *arogenesis* that is rather close to *anagenesis* in the sense in which this term was originally proposed by Rensch (1959: 281–308; see also Dobzhansky *et al.* 1977; Futuyma 1986: 286 etc.).

The notion of 'aromorphosis' (or its analogue) does not appear to have been worked out with respect to social evolution. We believe that the adaptation of this notion for the theory of social evolution could be an important step forward for the development of this theory itself, and for the general theory of macroevolution. We tend to agree with Claessen's proposal to consider macroevolution as 'the process by which structural reorganization is affected through time, eventually producing a form or structure which is qualitatively different from the ancestral form' (Claessen 2000b: 2). Though this definition belongs to Voget (1975: 862), yet this was Claessen who supports this definition most systematically in the realm of sociocultural anthropology (Claessen and van de Velde 1982: 11ff.; 1985: 6ff.; 1987: 1; Claessen 1989: 234; 2000a; Claessen and Oosten 1996; see also *e.g.*, Collins 1988: 12–13; Sanderson 2007). If we base ourselves on this definition, then we can interpret *social* macroevolution as a process of structural reorganization of societies and institutions, as a result of which we observe the formation of such a structure that is qualitatively different from the ancestral structure and that usually gives to a respective society some advantage in its interaction with natural and social environments in the present or in the future.

However, it appears difficult to understand the general course of macroevolution and the evolutionary potential of various structural reorganizations without certain analytical tools, including appropriate classifications. Unfortunately, the research on social and cultural evolution lacks such classifications almost entirely. We believe that the introduction of the notion of social aromorphosis may contribute to the development of such typologies and classifications; thus, we believe that it may contribute to the transformation of social evolutionism into a truly 'scientific activity of finding nomothetic explanations for the occurrence of… structural changes' (to use Claessen's [2000b: 2] phrase; one may also compare this with Ervin László's idea that the application of 'evolution' as the basic notion opens the way toward the rapprochement of sciences [see *e.g.*, László 1977]).

The social aromorphosis can be defined as a universal / widely diffused social innovation that raises social systems' complexity, adaptability, integrity, and interconnectedness (see Grinin and Kortayev 2007, 2009; Grinin, Markov, and Korotayev 2008).

Social aromorphoses lead to the following results:

a) significant increases in social complexity and the societies' abilities to change their natural and social environments, to raise carrying capacity, as well as the degree of their stability against changes in their environments;

b) more rapid developmentary changes (including borrowings) that do not destroy social system;

c) the increase in the degree of intersocietal integration, formation of special stable supersystems (civilizations, various alliances etc.) and suprasocietal zones, special suprasocietal spheres that do not belong to any particular society;

d) more rapid evolution toward the formation of supercomplex maximum supersystems (world-systems, the World System, and, finally, the humankind as a single system) in whose framework each particular social system (while remaining autonomous) becomes a component of such a supersystem and develops within it through specialization, the intersystem functional differentiation.

Within the process of social macroevolution, a certain role is played by aromorphoses of all levels; yet, we believe that an especially important role is played by aromorphoses possessing characteristics (c) and (d), as they belong to aromorphoses of the highest type that influenced not only the historical fate of particular societies, but also the course of historical process as a whole.

As examples of social aromorphoses of the highest type one can mention:

- formation of the egalitarian food-sharing system among the early humans that increased the human adaptability to natural environments and stability of human communities in the most significant way;
- origins of early systems of social kinship that created a universally convenient system of social structuration;
- transition to food production that led to an immense artificial increase in the quantities of useful (for humans) biomass;
- introduction of developed irrigation systems that established an economic basis for early civilizations and states;
- formation of cities (the further urbanization process also included many important arogenic sociocultural changes);
- development of the social division of labor that secured the elaboration of crafts, trade, administration, and culture;
- state formation that led to a qualitative transformation of all the social, ethnic, and political processes;

- invention of writing that served as a basis for the revolution in information processing technologies involving the development of elaborate administrative systems, literature, science;
- transition to iron metallurgy;
- formation of world religions that made it possible to draw together culturally, ideologically, and ethnically hundreds of previously alien peoples and societies;
- invention of book-printing that triggered the second information revolution;
- formation of science of a new type – mathematically-based science that lead to a radical increase in productive innovations;
- formation of developed market systems that laid the basis for the industrial revolution;
- invention of computer technologies.

Each of those aromorphoses had a number of various (and frequently very evolutionary important) consequences that generally contributed to the increase in the potential of respective societies as regards carrying capacity of their territories and stability of their systems.

There are some important similarities between the evolutionary algorithms of biological and social aromorphoses. Thus, it has been noticed that the basis of aromorphosis

> is usually formed by some partial evolutionary change that... creates significant advantages for an organism, puts it in favorite conditions for reproduction, multiplies its numbers and its changeability…, thus accelerating the speed of its further evolution. In those favorable conditions, the total restructurization of the whole organization takes place afterwards (Shmal'gauzen 1969: 410; see also Severtsov A. S. 1987: 64–76).

And then, in the course of adaptive radiation those changes in organization diffuse more or less widely (frequently with significant variations).

A similar pattern is observed within social macroevolution. An example is the invention of iron metallurgy. As is well known, the iron production was practiced sporadically already in the 3rd millennium BCE; however, the regular production of low-grade steel actually began in the mid 2nd millennium BCE somewhere in Asia Minor (see *e.g.*, Chubarov 1991: 109) within the Hittite kingdom that guarded its monopoly. However, the very technology of iron production was still rather primitive and it did not secure to its owner any overwhelming advantages. The fall of the Hittite Kingdom led to the end of this monopoly and made it possible for the iron production technology to diffuse (Grakhov 1977: 17; Brey and Tramp 1990: 82; Giorgadze 2000: 122–123; Dyakonov 2004: 400). One could observe a process that was similar to what is called 'adaptive radiation' in biology. In the first half of the 1st millennium BCE the technologies of iron production and processing (yet, with some significant variations connected, among other things, with different types of ores and fuels) diffused within the whole of the Middle East and most of Europe, and then throughout the whole Afroeurasian world-system (Chubarov 1991: 109, 114; Grakhov 1977: 21; Kolosovskaya and Shkunaev 1988: 211–212; Davis 2005: 61; Zlatkovskaya 1971: 47). Diffusion of the iron industry led to revolutionary changes in different spheres of life: one could observe a significant progress in plough agriculture (and consequently in the agrarian system as a whole); an intensive development of crafts; the transformation of barbarian societies into civilizations; the formation of new types of armies (that is, the mass ones armed with relatively cheap but effective iron weapons); the emergence of significantly more developed systems of taxation (and, hence, information collection and processing systems) that were necessary to support those armies.

There are both significant similarities and significant differences between biological and social macroevolution; their analysis goes out of the scope of the present article (this analysis has been undertaken by us earlier: Grinin and Korotayev 2007, 2009; Grinin, Markov, and Korotayev 2008). It appears sufficient to mention one such difference that seems to be the most fundamental: the biological evolution is predominantly additive/cumulative, whereas the social evolution is predominantly displacing. In this regard the difference between social and biological aromorphoses is similar to the difference between the overall patterns of both types of macroevolution: the development of biological aromorphoses tends to contribute to the increase in biodiversity, whereas the diffusion of social aromorphoses tends (but just tends!) to lead to the replacement of more simple social forms with more complex ones. Thus, with the diffusion of iron technologies all the societies that confronted this diffusion had to borrow this technology, otherwise they risked to be absorbed or destroyed by those societies that possessed this technology.

Let us consider now what can be regarded as main criteria of biological aromorphosis, and whether those criteria fit social aromorphoses. By now the following criteria have been suggested:

1) the growth of organization level (increase in organization complexity) that is frequently accompanied by the growth of the 'general energy of vital functions' – a **morphophysiological** or **structural-functional** criterion;

2) the expansion of conditions of existence, the increase in independence of the organism from the fluctuations of external environments (in historical perspective this corresponds more or less to the expansion of the adaptive zone) – an **ecological** criterion;

3) 'biolological flourishing', or 'biological progress' that is achieved, according to A. N. Severtsov, through the first two points. The extent of biological progress can be estimated taking into consideration increases in morphophysiological, taxonomic, and ecological diversity, in numbers of organisms, and the overall biomass of the respective group. Due to biological progress, one can observe a wide diffusion of traits acquired by an aromorphic taxon – a **biological** criterion.

It is clear that all those criteria are not quite rigorous, and criteria 2 and 3 can be only applied in retrospect.

On the other hand, all the three criteria are quite applicable to many social aromorphoses. One can take as an example the creation of irrigation systems that secured a basis for civilizations, states (and their analogues) in the valleys of large rivers first in the Middle East (since the 4th millennium BCE), and then in some other regions (in the 3rd and 2nd millennia BCE). It is well known that this basis secured a vigorous demographic growth and a qualitative growth of complexity of social systems (Criterion 1).

The irrigation secured the development of extensive food storage, as well as systems of social exchange and (to a certain extent) social insurance. All these expanded the conditions of existence, increased radically the degree of independence of social organisms from the fluctuations of external ecological (and even social) environments (Criterion 2). The very fact of rather long periods of existence of Middle Eastern (and other irrigation-based) civilizations (as well as some states of this group) can be regarded as evidence for this.

Finally, on the basis of the two above-mentioned points we can observe an undeniable flourishing and expansion of irrigation civilization (Criterion 3) that may be estimated with a number of objective criteria: for example, through the growth of cultural-economic diversity of social units and formations (such as various temple, town, and trade communities), through population growth, and the increase in the size of territory controlled by polities of a new, aromorphic type.

As regards the social aromorphosis, one may add an important criterion (note that it is also applicable to the biological aromorphosis, yet at a more restricted scale, as the latter can only diffuse widely within a certain taxon, but not outside it, though it is not possible to exclude entirely the possibility of existence of a special type of supra-taxon aromorphoses that may be denoted as ecosystem aromorphoses). This criterion may be denoted as a criterion of diffusion (degree of **expandability**, and, hence, **adaptability**), that is the capability to borrow aromorphic innovations and to use them in new conditions[2]. With respect to many social aromorphoses this criterion sometimes becomes the most important (as we could see above with respect to the borrowing of technologies of iron-making). The wider an aromorphosis' capability to proliferate and adapt to various conditions, the weaker the competitive capabilities of those societies that rejected it or failed to borrow it. Thus, this feature of social aromorphoses produces a trend toward the convergence of various lines of social macroevolution and gives to social macroevolution certain features of a displacing process. In contrast, in biological macroevolution, though aromorphoses can diffuse rather widely so that this diffusion can produce a new phylum or subphylum (take, for example, such an aromorphosis as the emergence of the vertebral column), however, this does not lead to the displacement of other phyla/subphyla that are not capable for such a modification (and have no ‘need’ for it).

THE RULE OF AROMORPHOSIS

As the role of aromorphoses in the evolution of biosphere is very important, some scientists prefer to speak about the 'rule of progressive evolution', or the 'rule of aromorphosis'. According to A. S. Rautian (1988: 103), an aromorphosis is usually accompanied by penetration into a previously inaccessible adaptive zone and formation of a new adaptive zone through a radical reorganization of relationship with the earlier exploited environmental factors. The systematic nature and mutual coordination of progressive changes increases the general organizational superiority of an aromorphosis owner over the environment, that make it possible to use the environmental factors in a more diverse, active, and selective way. The organizational superiority is the most important precondition for the elaboration of a specific adaptation to the environmental factors based on the growth of vital capacity rather than fertility (Shmal'gauzen 1939, 1968).

Yet, as we have seen above, the role of social aromorphoses in social macroevolution is not less important. That is why it appears possible to speak about a single **rule of aromorphosis** (biological and social) in macroevolution that may be rendered as follows: *in the course of macroevolutionary process from time to time one may observe within particular groups of systems such potentially significant changes (innovations) that turn out ultimately (but not immediately) to secure a radical qualitative reorganization of large groups of (biological or social) organisms, as a result of which the following is observed:* 1) *the emergence of an opportunity to exploit new adaptive zones and previously unexploited resources (or a radical expansion of exploitation of old zones and resources);* 2) *the increase in organisms' resilience;* 3) *the growth of the level of organization of the respective system;* 4) *organisms acquire other potentially important evolutionary advantages. Those transformations lead to the 'flourishing' of respective groups and further evolutionary progress; in social macroevolution they also lead to the acceleration of development and the increase in the degree of suprasocietal integration.*

It seems possible to agree with the statement that the aromorphosis is a transformation that is qualitative with respect to its consequences but that is not accompanied by qualitatively specific evolution forms (Rautian 2006). Putting this in a different way, the statement that the aromorphosis has no specificity is only true with respect to mechanisms of its emergence and primary fixation, but not with respect to its evolutionary consequences.

Timofeev-Ressovsky, Vorontsov, and Yablokov maintain the following:

> Thus, there is no doubt that there are sufficient grounds to subdivide all the adaptations into two major types according to their wideness and their evolutionary potential: [1] particular adaptations that lead to specialization, and [2] general adaptations that lead to the expansion of the evolutionary potential of a group and to transition to new adaptive zones. It is not easy to draw a clear line between those two extreme types, but such a 'blurriness' of borders stems naturally from the complexity and diversity of natural conditions (Timofeev-Ressovsky, Vorontsov, and Yablokov 1969: 253).

It remains for us to add that the above mentioned 'general adaptations' are just **aromorphoses**.

Further we shall consider in more details *some mechanisms and rules of formation and diffusion of aromorphoses in the biological and social world.* Unfortunately, we do not have enough space to consider such important rules, as, for example, the **rule of aromorphic 'relay-race'** (connected with the point that the same group of biological or social organisms cannot always be the evolutionary leader, to create continuously chains of aromorphoses), or the **rule of special (exceptional) conditions for the emergence of aromorphoses** (for a detailed analysis of them see Grinin, Markov, and Korotayev 2008, 2009). The last rule is based on the point that primary, direct transition to an aromorphosis occurs in 'narrow places' (that is within a very limited number of systems), whereas the emergence of an aromorphosis needs a very large diversity of interacting systems. However, within a huge variety of forms just very few combine within themselves in the given moment of time all the conditions (frequently including unique ones) that are necessary for an aromorphic transformation. Ernst Mayr suggests many interesting ideas (and even calculations) regarding this point (Mayr 1974: 403–411).

RULES CONNECTED WITH THE AROMORPHOSIS FORMATION MECHANISM

1. Principle that organs' functions change in evolution

The principle that organs' functions change was first spelled out by Dorn in 1875. An important point (on which this principle is based) is that all the organs of biological organisms (or, at least complex organisms) are multifunctional[3].

The principles of change of functions and polyfunctionality of organs are tightly connected with the notion of 'preadaptation', that is predisposition, the presence of certain opportunities (organs, functions) to settle new ecological zones. That is, many organs have some real but weakly used functions, which in future (in changed environment) may increase their significance; in addition to that the polyfunctionality implies that in the future an organ may start performing such a function that does not exist at present, but that is similar in some important points with the already existing functions; that is producing the so-called 'preadaptation effect'. The notion of 'preadaptation' was proposed more than a century ago, but it was not easily accepted by the academic community and was a subject of rather vivid discussions (see *e.g.*, Georgievsky 1974). The settlement of any new environment by any type of organisms is only realizable if those organisms have such features that make it possible for them to survive in that new environment. It is very important that such features must form before that start of the settling of the new environment (these are such features that are called *preadaptive*) (Iordansky 2001: 125–130, 350; see also Huxley 1943: 449–457).

As was pointed out by Grant (1991: ch. 34), preadaptation makes it possible to bypass morphological limitations in a rather economic way. When a new function becomes needed, it turns out to be easier to modify for this purpose an already existing organ rather than to 'create' a new one. Thus, Grant emphasizes that in the evolutionary process major morphological changes occur 'along the least resistance lines'. According to Timofeev-Ressovsky, Vorontsov, and Yablokov, those ontogenetic differentiations that have been realized and have an adaptive potential may come out to an evolutionary arena of a larger scale involving new phyla through the phylogenetic processes. According to them, a clear example of this sort is represented by the haemoglobin that serves as an oxygen carrier in many groups of animals. Haemoglobin is likely to have emerged in addition to a few other similar compounds, it was used as an oxygen carrier within a number of taxa until it turned out to be the most effective oxygen transporter that made it possible for a few groups of vertebrates to settle very diverse adaptive zones (Timofeev-Ressovsky, Vorontsov, and Yablokov 1969: 263). We would like to add that the case of hemoglobin is also a good illustration for the rule of delayed aromorphosis that will be discussed in more detail below.

Due to preadaptations, within the process of biological evolution some organs and other components of the organism can change their main functions with the change of environments. Within such situations a functional role of a certain organ may grow substantially. A classical example of preadaptation is provided by the presence of a special type of fins in *Crossopterygii*. The construction of the extremities that is typical for land-based tetrapods emerged around 360–370 million BP in the late Devonian period in animals that practiced a fully water-based way of life (the first tetrapods – descendants of *Crossopterygii* – such as *Ichthyostega*, *Acanthostega* and some other similar forms). It was considerably later (in the Carboniferous period) that the first tetrapods capable to live on the land emerged. Thus, the lag between the formation of the tetrapod extremity and the beginning of its use was as long as 20–30 million years. Though the extremities of the first tetrapods were used to move in the water, their construction turned out to be 'preadapted' for life on the land, which up to a considerable extent secured the successful colonization of the land ecological zones by the tetrapods (see *e.g.*, Long and Gordon 2004).

Something similar may be detected within the social macroevolution. In the Ancient Period, as well as in the Middle Ages the growth of large scale land ownership against the background of declining state organization tended to lead to the so-called 'feudalization', to the appropriation of state resources and power over population by local magnates, to the replacement of state power by the power of local magnates. In bureaucratic states (such as medieval China) the growth of land possessions of high officials meant that they became less dependent on the central power and used their own powers for their self-enrichment. Such a process tended to lead to an actual 'privatization' of the state, the decline of the level of life of the commoner population, and, finally, to a political-demographic collapse (naturally, in combination with a number of other factors [see *e.g.*, Korotayev, Malkov, and Khalturina 2006b]). That is why the Chinese state tended to counteract the growth of such land ownership; and usually it was strong when the private land ownership (especially by high officials and local magnates) was very strictly limited. Hence, within the above described conditions of a centralized agrarian state the large-scale private ownership did not have many positive functions which it had in democratic industrial and postindustrial states. The private property acquires such positive qualities and functions within certain evolutionary types of social systems. In totalitarian or superbureaucratic societies even in the context of industrial production principle, the large-scale private property may have the above described negative functions that lead to the 'privatization of the state' (and we could observe this directly in Yeltsin's Russia). The same can be said about some types of monetary private property that in the Ancient period and Middle Ages were frequently parasitic, exploiting ruthlessly the population through usury and tax-farming. It is not accidental at all that due to those parasitic characteristics many religions stigmatized large scale/monetary private property opposing to it the labor property of commoners (let us recollect that the communist ideas have religious roots). It was only the restriction of interest rates, the expansion of opportunities to use monetary capital in order to increase the real production and mass trade, that led to the situation when monetary private property acquired many positive and important 'progressive' functions that look today as being inherent primordially in this institution; whereas the idea of primordial 'progressiveness' of private property makes it difficult to understand complex dynamics of functional development of private property and the reasons why most states tried to restrict it (see Grinin 1999 for more details).

Thus, according to the law of the functions' mobility (or functions' change) formulated by one of the authors of the present article, *within the overall system one may observe the change of number of functions, their hierarchy, quality, volume, and other characteristics of function realization* (*Ibid.*). In other words some functions performed by a certain social institution may be insignificant or unused (that is in a sort of social preadaptation) for a long period of time; but under certain conditions their presence could turn out to be extremely important. Later this function may become leading or even the main.

In general, the idea that aromorphoses are in some way prepared, that there are some latent prerequisites for future aromorphoses, seems to be even more important as regards social evolution than with respect to biological evolution. One can recollect the 'preadaptation' of the Greek *polis*, or medieval Italian republics with respect to the development of civil arts that gave birth to the creation of a great culture (including the Renaissance one). Or take the hidden potential (preadaptation) of Protestantism to facilitate a rapid development of capitalism discovered by Max Weber (2002[1904]). It was further shown (see *e.g.*, Korotayev, Malkov, and Khalturina 2006a) that the positive influence of Protestantism on the genesis of capitalism and modernization is connected with the point that Protestants (unlike Catholics) regarded the reading of the Bible as an extremely important duty of any Christian; though it is perfectly clear that the spiritual leaders of Protestantism instructed their followers to read the Bible for religious reasons (and, of course, not in order to promote economic growth). However, as the level of literacy and education among the Protestants turned out to be significantly higher than among the Catholics (as well as the followers of other confessions) who had no religious stimulus to become literate (see *e.g.*, Malerb 1997: 139–157), this turned out to be very important for the development of capitalism in the protestant countries (see Korotayev, Malkov, and Khalturina 2006a for more details).

It also appears reasonable to mention here that biology has the notion of constitutional preadaptation that actually unites morpho-functional and genetic-ecological aspects of preadaptation (Iordansky 2001), that is, a whole set of various peculiarities and adaptations that are ultimately capable to change the way of life of representatives of a given taxon. Actually, for their realization constitutional preadaptations need some impulse, event, key mutations. In this respect constitutional preadaptation is tightly connected with the notion of key aromorphosis that finalizes a set of changes giving a vigorous impulse to further transformations. It is not surprising that Iordansky (*Ibid.*: 133) cites as an example of constitutional preadaptation the tetrapods' ancestors – *Crossopterygii* (whose coming out to the land became a major aromorphosis).

The notion of constitutional preadaptation appears to be rather relevant for social macroevolution, especially for those cases when we observe special and even unique conditions (an example of England that in the 18th century possessed such peculiarities that made the industrial revolution possible is rather salient in this regard).

2. Rule of delayed aromorphosis

Some economists distinguish between ‘inventions’ and ‘innovations’, defining as innovations those inventions that have been actually introduced into economic systems and produced actual economic effect (see *e.g.*, Schumpeter 1926). It is not infrequent that in order that such innovations could be realized we should have a whole set of various inventions whose combining into a system could produce a vigorous economic effect. The same way, biologists-evolutionists distinguish between biological ‘inventions’ and biological ‘innovations’. The biological ‘invention’ corresponds to the emergence of a new trait as a result of some genetic change and its further fixation within a population under the influence of natural selection or genetic drift. The biological ‘innovation’ corresponds to the achievement of biological progress (the growth of diversity, numbers, biomass, role in the biosphere) based on the given ‘invention’ (Erwin and Krakauer 2004).

A number of evolutionary changes (including minor aromorphoses) can continue the formation of a certain system for a rather long time, preparing conditions for a major aromorphosis. Sometimes many necessary conditions for such an aromorphosis have already emerged, the key morphophysiological changes have already taken place, but there are no sufficient conditions for their wide proliferation (that is, for the achievement of biological progress). Thus, it is well known that mammals had emerged long before the moment when this group started to occupy a dominant position within the land ecosystems. The mammals emerged in the late Triassic period (c. 220 million BP), whereas their vigorous expansion and adaptive radiation only took place in the Cenozoic (since 65 million BP), that is in this case the time distance between the ‘invention’ and ‘innovation’ was much more than 100 million years (numerous new findings provide evidence on a high diversity of Mesozoic [and, especially, Cretaceous] mammals; however, in general, mammals remained a 'subordinate' group that evolved 'in the shadow' of the dominant group of the reptiles). There appear to have been a considerable number of 'delayed aromorphoses' at the early stages of the evolution of life. Thus, according to discovered biomarkers (remains of organic molecules that are typical for the eukaryotes), the first eukaryotes emerged c. 2.7 billion BP; however, they started playing a noticeable role in marine biocenoses not earlier than 1.9–1.5 billion BP. Their diffusion might have been restricted initially by low concentrations of oxygen in the atmosphere and hydrosphere; though some evidence suggests that by the moment of the emergence of the first eukaryotes the atmosphere and hydrosphere might have been oxygenized quite significantly (Rozanov 2003). The first multicellular animals appear to have emerged c. 1.5 billion BP; however, their wide diffusion in the ocean only began c. 0.6 billion BP (in the Ediacaran period of the Proterozoic era) (Fedonkin 2006).

In social evolution for long periods of time, many inventions do not play the role that they start playing in other circumstances. It appears sufficient to recollect that gunpowder and the compass did not make a revolution within the Chinese civilization. They did it within the European civilization, and then within the World System. We may also return to the above mentioned example of the emergence of the cotton industry in England that triggered the beginning of the industrial breakthrough (the second phase of the Industrial Revolution) and the transition to the industrial production (first in England, and later – within the World System as a whole); one should mention that by that time machines had existed for centuries (whereas the simplest ones had existed for millennia). Even the history of the steam engine was as deep as a century and a half by that time. There were some sufficiently mechanized branches of industry (like some branches of mining industry, for example [see Grinin 2003 for details]). The cotton industry also existed since quite a long time (whereas in India it existed for many centuries). There were also such important preconditions as patent law, developed private property etc.; however, the system first lacked an effective loom though there was a great need due to a very high demand for cotton textile. When it appeared (as John Kay's shuttle loom) in the 1730s, the system confronted the absence of an effecting spinning wheel (and the spinners lagged far behind the weavers, which hindered greatly the technological process as a whole). When more than 30 years later the famous spinning jenny was invented, one could observe the emergence of that very previously lacking element whose emergence was able to transform a delayed aromorphosis into an actual one. In subsequent years the cotton industry developed so vigorously that already 20 years later one could observe the emergence of a fully mechanized branch of industry based on the use of water energy and soon afterwards the energy of steam (subsequently one could also observe the formation of more and more new mechanized industrial branches).

As regards the causes of the long periods of time during which many biological and social aromorphoses failed to proliferate to any considerable degree, one should take into consideration the point, that evolutionary promising and effective aromorphoses were frequently not quite successful and promising within concrete circumstances of their emergence. It was rather often when an opposite pattern was observed.

Even when an evolutionary promising form already existed, there was usually necessary a long ‘incubation period’ and **special conditions,** in order that this form could prove its unusual effectiveness.

3. Key aromorphosis rule

This rule is rather tightly connected with the previous one, as it accounts for one of the possible causes of ‘delays’ in the aromorphoses' formation. The notion of ‘key aromorphoses’ was suggested by N. N. Iordansky (1977, 2001) to account for the mechanism that directs consecutive acquisitions of a complex set of mutually coordinated features within the phylogenesis. According to Iordansky, the key aromorphosis is a morphophysiological trait whose formation, first of all, has an important significance for its owner by itself, and, secondly, alters in a significant way the relationships between its functional subsystems, which opens on the basis of previous organization a new perspective direction of specialization and new opportunities for the functioning and evolution of subsystems (Rautian 1988).

A clear example of the key aromorphosis is provided by the energization of the lung respiration through the optimization of the air absorption into the lungs – a transformation that opened the way to the emergence of reptiles from their amphibian ancestors. This morphophysiological transformation made it possible to take from the skin the function of respiratory metabolism. In its turn, this made it possible to make the skin dry and keratinizing so that it could serve for the mechanical and hydroisolating protection of the organism. The venous blood lost the function of the oxygen transportation from the skin to the heart, and this made it possible to divide the venous blood stream and the arterial blood stream; finally, this paved the way for the emergence of the four-chamber heart. The notion of key aromorphosis emphasizes the role of some new traits in the realization of the organism's hidden evolutionary potential whose actualization was hardly possible (or just impossible) prior to the emergence of the key aromorphosis. The specificity of the key aromorphosis is connected with the far reaching consequences of its emergence for its owner (Rautian 1988).

One can find a very considerable number of key aromorphoses in social evolution. It makes sense to subdivide them according to their rank as well as according to their potential for creating form. Note also that in some cases (when objective conditions ‘demand’ a certain innovation) concrete time and locations of its emergence do not play any decisive role. Thus, if the spinning jenny had not been invented, the industrial revolution would have still occurred on the basis of some other mechanized spinning wheel. The same way one would expect emergence of some other steam engine instead of Watt's one. If not Columbus, America would have soon been discovered by someone else. Thus, the further ‘physiognomy of events’ (to use Plekhanov's expression [Plekhanov 1956]) would have been quite similar (though, of course, it would not have been entirely the same). We deal with a rather different situation when we confront the emergence of world religions, as their essence, organization, cult, and ideology are very tightly connected with the personalities of their founders, recorded texts of sacred scriptures, and concrete events. All these usually gave an emerging religion a rather special form and character that could not be easily changed in future (and, actually, some traits could not be changed at all). It is evident that the religion founded by some person other than Muhammad[4] in the early 7th century (if it had become a world religion) would have had another shape, different ethical norms, it would have had a different connection with politics, different organization principles etc. In this respect, each such event is analogous to the emergence of a new major taxon in biology.

No doubt, the discovery of the use of fire at the dawn of human history, the transition to agriculture, the invention of metallurgy (note that for all the cases above we do not know names of the inventors), the transition to statehood (and some of its analogues) etc. also included some key innovations that launched these major social aromorphoses that transformed the whole life of people. We know much more details with respect to key aromorphoses of modern history, for example, the ones that secured the Great Geographic Discoveries (such as, for example, fore-and-aft sail that made it possible to navigate forward with a cross-wind). We can also indicate with a considerable degree of accuracy the key aromorphoses of the age of the industrial revolution in England in the 18th century.

With respect to both social and biological macroevolution it is frequently difficult to identify the key aromorphosis within a group of them. However, as within social macroevolution (in contrast with biological macroevolution) an immense role is played by the conscious activities of people (including activities of concrete significant personalities). It is not infrequent that a role of the creator of such an integrating 'aromorphosis' is played by an outstanding personality. Thus, the key aromorphosis rule has significant peculiarities with respect to social macroevolution (for the analysis of the personality role in social macroevolution and in the historical process, the causes of fluctuations of this role as regards different situations, epochs and social systems see *e.g.*, Grinin 1997, 2006, 2008; Korotayev 1999, 2003: 116–144). In many cases this was an outstanding personality that was capable of giving to an institution, invention, organization, state, idea etc. a certain form, to create a new organization, ideology, to concentrate efforts of many people etc.

Important consequences of a key aromorphosis emergence (within both biological and social macroevolution) are as follows: a) its wide diffusion[5]; b) prevalence of respective aromorphic structures in certain conditions; c) further gradual perfection of an aromorphic system.

4. Rule of 'block assemblage' in evolution

When a system reaches a certain level of sophistication and maturity, it may start to be used as a whole within the process of evolution (as a single unit, a single block). In the process of adaptations and specialization, this block experiences an adjustment for the needs of a particular (biological or social) organism. In the course of divergence (of species from their common ancestor) the systems of respiration, circulation of blood, heart, system of reproduction (or, with respect to social evolution, say, subsystem of taxation, or military subsystem) are copied (inherited) with local variations from species to species, from taxon to taxon (this may be accompanied by partial ameliorations; and if this is a real aromorphosis, with time its significance tends to increase rather than decrease). In social evolution (with achievement of a certain level of maturity) there could be the copying (as a whole) of religions, systems of law and administration, technological, monetary, and other systems. This makes it possible to speak about the evolutionary 'block assemblage', which implies the use of already 'tested' blocks, subsystems, units for the formation of new systems (organisms). Such a 'block assemblage' accelerates strongly the evolution speed. The block assemblage principle manifests itself in the following:

- At the molecular-genetic level it manifests itself in the origins on new genes and genes' networks through the recombination of the already existing DNA fragments that have been already 'approved' by natural selection (Ratner 1992; Gillespi *et al.* 1986).
- It is also manifested with the emergence of aromorphoses through the following pattern: 'the multiplication of same-type modules – differentiation and division of functions between them'. The classical examples are the emergence of multicellular organisms, the evolution of metameric (that is, consisting of the same-type segments – metameres) animals, coloniality. In social evolution we can observe a rather close similarity in this respect when we are dealing, for example, with the formation of multicommunity societies from the monocommunity one with subsequent differentiation and the division of functions between different communities belonging to one society. This process could produce simple chiefdoms and later complex chiefdoms (consisting of simple ones) as well as their analogues (see *e.g.*, Carneiro 1970, 1998).
- This principle also manifests itself in course of aromorphoses based on the integration of symbiotic complexes. The most important aromorphosis of this type is the emergence of the eukaryotic cell that can be regarded as a result of the development of integrative processes in the community of prokaryotes

(Markov and Kulikov 2005). In social evolution one could find here an analogue in the early city that can be regarded as a symbiosis of a few different heterogeneous complexes, subsystems, and relationships (the royal palace, temple, citadel, popular assembly etc.). Another salient example is provided here by the formation of the developed market system that can be regarded as a complex heterarchical structure that comprises heterogeneous producers of heterogeneous commodities and supports their reproduction.

One of the first authors of the idea of the block assemblage principle (as well as the idea of natural selection) seems to be Empedocles (490–430 BCE) who believed that animals were 'assembled' in a random way out of finished components (legs, heads etc.), whereas the effectively acting combinations survived while ineffectively acting ones died (Asmus 2001).

At present a number of scientists discuss the 'block principle' in biological evolution (see *e.g.*, Krasilov 1984: 11; Ratner *et al.* 1985: 245; Chaikovsky 2003: 283); yet almost nobody seems to apply this principle to the social evolution.

The block-assemblage principle of the formation of new subsystems, systems, and groups is rather universal. It is manifested not only with the formation of new species and communities, but also with the transformation of the already existing ones. Both biological and social systems can borrow from each other separate 'inventions' and new structural elements.

For example, one can widely find among the prokaryotes the ability of 'natural transformation' – to absorb a DNA out of the external environment and to build it in the prokaryotic organism's genome, which leads immediately to the transformation of its phenotype.

Horizontal exchange of genes makes many useful 'inventions' literally a common property within communities of microbes. Precisely this picture is observed in the communities of planktonic microbes with respect to the genes of proteorhodopsins (albumens that make it possible to utilize partly the sun light energy). In contrast with those albumens that take part in the performance of real photosynthesis, proteorhodopsins do not need the 'help' of many other specialized albumens for their effective work, that is why in order to acquire a useful function it is sufficient for the microorganisms to borrow a single gene (Frigaard *et al.* 2006).

A special version of the manifestation of the rule of 'block' assemblage is represented by complex borrowings of whole gene systems. On the one hand, such events occur much more rarely; on the other hand, their consequences tend to be much more significant. A special and rather widespread (and what is the most important – very important just for arogenic direction of biological macroevolution) of 'new element borrowing' is the emergence of symbiotic systems, which could lead sometimes to the transformation of a few different organisms into a new single organism. The role of such systems is often underestimated, but in reality all the functioning of the modern biosphere is based just on such systems. We could mention here as examples the land plants (that would not have achieved their evolutionary success without their symbiosis with the nitrogen-fixing bacteria and mycorrhiza fungi, as well as without cooperation with pollinating insects), herbivorous animals (both insects and vertebrates who are not able to digest the most widespread types of plant food without their symbiosis with specialized microorganisms; whereas this is the processing of the plant food that is the main ecological, biospheric role of the animals!). Among the complex biological organisms (in contrast with human societies) large-scale 'borrowings' (in the form of the borrowing of the alien genetic material) occur extremely rarely, but these are such borrowings with which many very important aromorphoses are connected.

In the same way we can consider those aromorphoses that are based on special 'symbioses' of complex organisms with mobile genetic elements (MGE), such as viruses, as well as transposons and retrotransposons (that cannot be transmitted horizontally as freely as viruses; yet, sometimes such a transmission still takes place). In this case, quite a long time may pass between the acquisition of some MGE and its 'involvement' into the formation of a new aromorphic organism structure. One can mention the following as examples:

1) emergence of the system of the restoration of the end parts of the chromosomes (telomeres) that plays a key role in the cells' differentiation and the regulation of the life span among the eukaryotes (this system is based on the mechanism of the synthesis of DNA fragments on the basis of RNA-matrix that was borrowed by complex organisms from the retrotransposons);

2) formation of the adaptive immunity system whose key components (RAG-ablumens performing the V-(D)-J recombination) descend from ferments typical for transposons. V-(D)-J recombination is a process, as a result of which we observe in lymphocytes the formation of genes of antibodies (protective albumens through the combining of genetic 'billets' – ready-made blocks of three types (V, D, and J). As we see, the 'block assemblage' principle is manifested here too. In this case it is used for the creation through the combinatory way of millions of various antibodies from a relatively small number (several hundred) of initial blocks.

History and social macroevolution attest a great number of evolutionary block assemblage, when one could observe wholesale borrowings of religions, and religious organizations, writing system, systems of political organization and law, military organization etc.

RULES CONNECTED WITH SPECIAL CHARACTERISTICS OF ENVIRONMENT THAT IS NECESSARY

FOR THE AROMORPHOSES' EMERGENCE

Sufficient diversity rule

The aromorphoses are frequently delayed, they are rare, the aromorphic evolution follows a relay-race pattern. Thus, the emergence of a new branch of arogenic evolution, a new arogenic direction, needs a certain evolutionary environment. In particular, it is usually necessary that the niches accessible for the given (low) level of evolution are filled (that is, there is a sufficient diversity at this level). The non-arogenic types of transformations are by definition more widespread in evolution. This is connected with one of the phylogenetic rules of Cope (1904), according to which the group raises its taxonomic diversity prior to its extinction[6].

The diversity in nature and society is supported by various mechanisms. For example, there is an ecological principle, according to which the predators tend to support the diversity of their prey. If a certain type of prey becomes too numerous it is eaten first of all until the balance is restored (Kouen 1982: 57)[7]. The same effect may be produced by pathogens causing epidemics among the most numerous species.

As regards social systems, one may recollect the principal way of market optimization: if a certain commodity is scarce (and, hence, its production and marketing are very profitable), more and more capital is moved to this sphere until the commodity's scarcity is eliminated, profits come down to a normal level, after which excessive capital will move to another sphere of another commodity's scarcity (and, hence, very high profitability). Note that such mechanisms do not only support diversity, they also increase it. In addition, the certain phases of respective cycles may be accompanied by crises that could become an important source of innovations and even aromorphoses.

Aromorphoses need to be supported by an objective necessity to look for new ways of development. When the niches are filled in more and more, the competition increases and intensifies the ‘search’ for a breakthrough, for a new aromorphosis.

Within biological evolution ‘the rule of sufficient diversity’ has some additional aspects:

1) Due to ecological coherence of the biosphere, the emergence of a new aromorphic group frequently implies the following necessary condition: the presence of sufficient diversity of other organisms that could serve as food for a new group and create certain conditions for reproduction etc. For example, the coming of the vertebrates from the ocean to the land would have been impossible if there had not been a sufficient diversity of plants and anthropoda. Many scientists suggest the presence of positive feedbacks between the number of existing species and the speed of the emergence of new species (Emerson and Kolm 2005; Erwin 2005; Markov and Korotayev 2007b). In particular, the emergence of new species and the growth of diversity lead to the formation of new niches that can be filled in by a subsequent ‘generation’ of new species. We would suggest to denote the accumulating effect of the growth of the number of new taxa in conjunction with the emergence / change of taxa connected with them as a ‘diversity multiplicator’.

2) The realization of the ‘block-assemblage principle’ needs a sufficient diversity of ‘blocks’. For example, the emergence of the eukaryotic cell from a community of prokaryotes would have been impossible if the prokaryotes had not been sufficiently diversed by that time. One can trace a similar regularity in social

evolution. For example, the emergence of developed market systems is impossible without a high degree of diversity of producers. Even to a more considerable extent this is manifested in the search for technical solutions, as the invention of new machines always implies a sufficient diversity of materials, components (including finished units and blocks), technologies.

3) As the evolutionary innovations usually emerge through the way of 'trial and error', the current level of biodiversity and variability (number of 'trials') should correlate positively with the frequency of the emergence of innovations (including the aromorphic ones).

4) Note that relationships between the diversity and the level of intraspecific and interspecific competition are very complex and ambiguous[8].

The competition is considered to be an important precondition for the effectiveness of directed selection. It is believed that with a weak level of competition the adaptations are perfected by the selection not to the maximum level, but rather to some satisfactory level, after which the intensity of selection substantially decreases (see *e.g.*, Iordansky 2001: 134). In general, the average level of the fitness of a population with respect to its environment never reaches its theoretical maximum, whereas this level decreases with the change of environment (Berdnikov 1990: 23). We believe that these ideas can be formulated as a separate rule – for example, as a **rule of the dependence of the selection effectiveness on the degree of intergroup competition**. First of all, this rule explains why the aromorphosis realization needs a sufficient diversity, with the increase in which (*ceteris paribus*) the probability of aromorphoses increases (because the search for the responses to the changing environment in conditions of a tough competition is going in many different directions, including the search for new adaptive zones). Secondly, this rule can be well applied to social macroevolution. For example, in the absence of external enemies an army tends to degenerate[9]; in the absence of competition producers do not strive after the improvement of the production parameters (to decrease the production costs, to improve the quality). Thirdly, it is connected with the adaptive compromise principle (for more details see Grinin, Markov, and Korotayev 2008).

DIVERSITY GROWTH RULE

As has been already mentioned, the fact that biological evolution is a predominantly additive process, whereas social evolution is (to a very considerable extent) a displacing process is expressed rather distinctly in the historical dynamics of diversity. One of the most important regularities of biological evolution is the growth of biodiversity. Sometimes this regularity is regarded as a law (Alexeev 1998). In social evolution an analogous trend (that is, the accelerating growth of the diversity of social organisms) is traced in most respects up to the 19th century; however, within the 19th century this trend was changed (in most respects) with the opposite trend – toward the decrease of diversity of societies[10].

However, with such a conclusion it appears important to distinguish diversity parameters at the levels of higher taxa and the levels of lower taxa. In particular, one can single out social 'taxa' of a higher level (corresponding to families, orders, and even classes and phyla in biology), such as tribes, chiefdoms, states that consist of lower-order taxa[11]. With the development of more aromorphic taxa (for example, with the transition of complex chiefdoms and their analogues into states) the number of lower-order taxa within less aromorphic higher-order taxa might have decreased. In other words, the number of higher order taxa tended to grow up to the 19th century (whereas the number of lower order taxa of some archaic types of social organisms is likely to have started decreasing some time before that).

Within social macroevolution the emergence of a new aromorphic taxon usually tended to lead in the very long run to the decline of diversity within older taxa (*e.g.*, within the chiefdom taxon after the formation of a taxon of the states), whereas within a new taxon the diversity tended to increase. Yet, the older taxa themselves could coexist with the new ones for many millennia.

Indeed, for example, the formation of simple chiefdoms (and their analogues) did not lead to the disappearance of simple independent communities, the emergence of complex chiefdoms (and their analogues) did not lead immediately to the disappearance of simple chifdoms; the formation of early states (and their analogues) did not lead to the extinction of simple chiefdoms, the formation of early states (and their analogues) did not result in the disappearance of chiefdoms and independent communities, the emergence of developed states (and their analogues) did not lead to the disappearance of independent communities, chiefdoms, early states, and their analogues. Even the formation of the first mature states in the 18th and early 19th centuries did not result in the immediate extinction of all independent communities, simple and complex chiefdoms, early and developed states, and their analogues.

As a result, the diversity of political systems (with respect to the higher-order taxa) reached its maximum in the 19th century when one could observe the coexistence of *all* the above mentioned political forms. What is more, in this period the maximum diversity could be observed as regards not only political parameters, but all the other parameters of sociocultural systems. For example, by the mid 19th century one could observe the maximum diversity of economic forms with the simultaneous coexistence of numerous types of non-specialized nomadic hunter-gatherers, specialized sedentary foragers, early extensive agriculturalists, nomadic pastoralists, societies specializing in trade and/or various crafts, developed intensive agriculturalists, and the first industrial societies. We could also see, for example, the maximum diversity of religious forms (the coexistence of very diverse animistic, totemistic, fetishistic, shamanistic, polytheist etc. religions, in addition to numerous denominations and sects of the world and syncretic religions).

The systematic decline of the diversity of political, social, economic etc. forms/taxa only began since the mid 19th century, when according to this indicator the social macroevolution became radically different from the biological macroevolution[12].

Yet, in social evolution one can also observe the growth of diversity in certain respects; however, it is achieved in a way that is different from the one observed with respect to biological evolution: through the differentiation of institutions, relationships, social groups, the growth of the diversity of specializations within one profession, the increase in the diversity of information, in the nomenclatures of various artifacts. This trend can be denoted as the **growth of the diversity of results of human activities.** There is no doubt that this growth is very considerable, and its speed is accelerating. In the meantime, as has already been mentioned, in social evolution of recent decades we observe a constant strong opposite trend toward the replacement and unification (of cultures, languages, religions, economic systems, institutions, tastes). It is clear that at present the globalization processes lead to the decrease of ethic and cultural diversity.

The growth of diversity of forms leads directly to the growth of probability of the emergence of new aromorphoses. Timofeev-Ressovsky, Vorontsov, and Yablokov maintain that such a growth leads in general to the growth of complexity of the biosphere as a whole and, consequently, to the growth of complexity of relationships of every group of organisms with its environment (Timofeev-Ressovsky, Vorontsov, and Yablokov 1969: 282). New perspective taxa acquired sooner or later special aromorphic characteristics that made it possible to use those evolutionary advantages on a wider scale. Thus, though such wide-range arogenic adaptations were very rare, their frequency tended to increase with the diversity accumulation, because the dense competitive environment generated more frequently extraordinary responses to ordinary challenges.

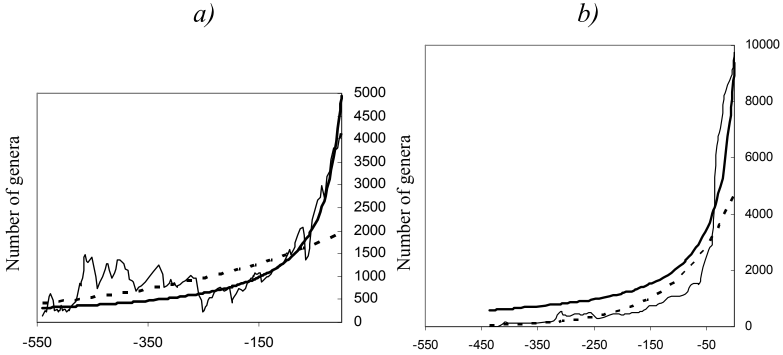

Fig. 1. The growth of diversity (the numbers of genera) of the marine *(a)* and continental *(b)* organisms during the Phanerozoic (542–0 mln years BP)

X-axis indicates time in mln years BP. Broken lines indicate exponential trends, solid lines indicate hyperbolic trends (for more details see Markov and Korotayev 2007a, 2008, 2009; Grinin, Markov, and Korotayev 2008: Appendix 5)

THE RULE OF 'PAYMENT' FOR THE AROMORPHIC PROGRESS (IN PLACE OF CONCLUSION)

The emergence of major aromorphoses takes place against the background of extinctions and unsuccessful evolutionary 'attempts' of many organisms (societies) and groups.

In particular,

> as is demonstrated by the paleontological chronicle, only a few relatively small groups get from one adaptive zone to another. This transition is usually conducted with a great (evolutionary) speed, whereas many groups die out in inter-zone spaces without reaching new optimal adaptive zones. Yet, even a single branch, having found itself in a new adaptive zone, starts a new period of allogenesis[13] (Timofeev-Ressovsky, Vorontsov, and Yablokov 1969: 224).

Speaking about social evolution, one may mention that it should not be compared with a wide ladder along which all the societies should move independently in the same upward direction; it should be rather compared with an extremely complex labyrinth, an arogenic way out of which can be found without borrowings only by a very few societies (yet, even such societies may only find independently a part of this way, whereas no society has managed to find the whole of this way entirely without borrowings from the other societies). In other words, the evolution of a concrete society cannot be usually regarded as a small-scale repetition of the main line of the arogenic evolutionary development. This can only be done with respect to a very few of them, only for certain parts of their history (and always with very considerable reservations). The point is that throughout most of human history the evolutionary breakthrough to a new level could only happen at the expense of extinction, stagnation, movement sideways of many other societies.

One can trace here a certain similarity with biological evolution. One may recall numerous (but finally unsuccessful) 'attempts' of prokaryotes to become multicellular; and not less numerous (but successful on a few occasions) similar attempts on the part of eukaryotes. During the periods of mass extinctions one could observe a sort of 'preliminary selection' of more resilient taxa. This also means that extinct taxa clear the evolutionary space for new potential leaders who get better starting conditions than they did before the extinctions.

Thus, we believe that, on the one hand, the emergence of perspective morphological forms, institutions, relationships is accounted for by internal characteristics of biological and social organisms; however, on the other hand, this could be regarded as a result of the presence of a sufficient number of other forms whose evolutionary 'successes' and 'failures' have paved way for the emergence of a 'successful' version.

NOTES

[1] Sometimes this is done using such 'common denominators' as energy or entropy (see *e.g.*, Chaisson 2001, 2005, 2006; on the analysis of such an approach see Spier 2005). A search of such a 'denominator' is very important, as it could indicate some common fundamental characteristics of all the forms of the matter. Yet, it appears rather dangerous to exaggerate its potential for the understanding of specific features of each type of macroevolution and their driving forces.

[2] It is very clear, however, that with respect to social evolution the adaptability criterion has its limitations.

[3] Social institutions are also usually polyfunctional.

[4] Naturally, we discuss here the reconstructions of some students of Islam, and not the beliefs of the Muslims themselves.

[5] To use Teilhard de Chardin's words (Teilhard de Chardin 1987), what looked at the beginning as a lucky event or way to survive could be transformed into a tool of progress and conquest.

[6] Shishkin emphasizes that the growth of diversity is observed not only prior to extinctions of groups, but also with the *growth of the speed of evolution*. Both cases can be reduced to the situation, within which the change of conditions of existence makes the sustainable reproduction of the former organization impossible; and this stimulates the search for the stabilizing version (Shishkin 1988: 168–169). This point appears to provide a partial explanation for the explosive growth of diversity in certain periods, as here we seem to observe positive feedbacks of the first and second orders when the accelerating speed of evolution provokes the growth of diversity, whereas the growth of diversity accelerates the speed of evolution (among other things through the emergence of aromorphoses and innovations, allomorphoses and specializations).

[7] The above mentioned diversity of 'blocks' can also arise due to different causes, including the diversification of similar components of a system (for example, the divergence of functions of duplicated genes, specialization of polyps in *Siphonophora*).

[8] For example, in isolated islands ecological systems are usually much poorer in comparison with continental ones; in this case a weak interspecific competition may contribute to the development of imbalanced one-sided adaptations,

to the emergence of aberrant, bizarre forms (one could mention as examples such widespread phenomena as 'island gigantism' and 'island dwarfism'). The intraspecific competition stimulates the growth of variability (the intraspecific diversity) and contributes to the speciation (that is, the increase in the diversity of species). In this case, the growth of diversity is the result of intraspecific competition and, theoretically, it can contribute to the decrease of this competition (that, most likely, will be very short-term). A sharp interspecific competition (for example, in saturated ecological systems with numerous diverse species) may have an opposite effect; that is, it may limit the growth of intraspecific and interspecific diversity. However, aromorphoses tend to occur more frequently just in saturated diverse communities rather than in communities with low diversity. This can be seen, for example, when we compare the speed of progressive evolution of vertebrates in different parts of the world: usually, this speed is higher in those parts of the world where we find a higher biological diversity.

[9] It is not coincidental that defeats lead to military (as well as political, social etc.) reforms more frequently than victories.

[10] In social evolution one could observe a long-term trend toward the growth of societies' sizes, whereas this growth was not only due to the increase in population of particular polities caused by natural demographic growth; it was also due to the unification, integration and incorporation of smaller societies into larger ones. This way thousands of independent agrarian communities could be united into one state, hundreds of small ethnic groups with their particular languages could get merged into one nation with one language, dozens and hundreds of small states could be conquered by one empire. One may also recollect how many local religions disappeared with the expansion of the world religions. Yet, up till the 19th century, say, the disappearance of particular local religions did not lead to the decrease of religious diversity. Indeed, if predators eat 50 % (or even 90 %) of individual prey animals in each of species of artiodactyls, this will not result in any decrease of the specific diversity of artiodactyls. The same way, prior to the 19th century, the replacement of local religions by the world religions does not appear to have led to the decrease of the 'generic diversity' of local religions. Though the diffusion of world religions led to the extinction of many **particular** animistic, totemistic, shamanistic religions, we have absolutely no evidence on the extinction of any **'genus'** of such religions (*e.g.*, animism, totemism, or shamanism).

[11] For example, chiefdoms could be simple, complex, and supercomplex; they could be ruled by a single chief, or by two (sacred and secular) chiefs; they could have very different economic foundations; thus, depending on criteria, one can easily identify dozens of chiefdoms' 'genera' (and hundreds of chiefdoms' species).

[12] Note that we observe simultaneously a real accelerating decrease of biodiversity (though in the same time human activities lead to the increase in diversity of a small number of species of domestic plants and animals).

[13] Note that Timofeev-Ressovsky and his colleagues discuss here adaptive radiation or cladogenesis, that is, the direction (rather than level) of evolutionary changes. – *L. G., A. M., A. K.*

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