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Biological and Social Aromorphoses: A Comparison between Two Forms of Macroevolution^{*}

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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 on 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; Auger 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 2007a, 2009a; 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.

The human need to comprehend the world in its unity seems to have appeared with the very development of abstract thinking. As regards evolutionary ideas with respect to the general order of the world transformation, they can be found

^{*} This research has been supported by the following Programs of the Presidium of the Russian Academy of Sciences: 'Biodiversity and Dynamics of Gene Pools' and 'Origins of Biosphere and Evolution of Geobiological Systems. Subprogram 2'.

in philosophical constructions of Ancient India or Greece (see, *e.g.*, Vorontsov 1999). However, the first ideas of scientific approach to evolution only emerged in the 18th century. In the 19th century the evolutionary ideas became a component of scientific thinking. As they were supported by an impressive body of empirical evidence, they were gradually established in geology, cosmology, and, in a virtually parallel manner in biology and social sciences, producing a mutual influence. In the last decades of the 19th century the idea of evolution (accompanied by the one of progress) as a general course of development of nature and society (and the matter in general) became one of the major components of science and philosophy. This idea made it possible to see the picture of the development of the world as a whole. However, such approaches were based on rather naïve belief in the linearity of development and universality of general laws, in the overall complete concordance between nature and knowledge (see, *e.g.*, Bunzl 1997: 105). That is why the evolutionism of the positivist philosophy soon stopped satisfying the fast developing science and began to be rejected together with the idea of uninterrupted progress (Parsons 2000: 44).

However, the evolutionary concepts did not die; the academic community returned to them at a new level of scientific knowledge and actively developed them (and not only in biology, but also in sociology and cultural anthropology).¹ In recent decades a considerable number of authors tried to connect biological and social evolution; yet, in general, evolutionism develops quite independently in biology and social sciences (note that it is developed much more actively and effectively in biology). In most cases those biologists and sociologists who study the evolution do not know that many problems and ideas are rather similar in the both realms. Authors of this article have found this with their own experience, when solutions discovered in one realm turned out to be applicable in the other. That is why we believe that it is highly desirable to create a general field of evolutionary studies (see the Introduction to this Almanac for more detail).

Yet, at the present-day level of scientific development we need such approaches that allow considering 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 macroevolution to another.² In other words, the activities aimed at the unification of

¹ Evolutionary ideas have been also developed rather actively with respect to non-biological natural systems; however, we do not consider this aspect in the present article. Yet, this point is treated in the Introduction to the present issue of the Almanac.

² 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; see also his contribution to the present issue of the Almanac). 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, there is some risk to exaggerate its potential for the understanding of specific features of each type of macroevolution and their driving forces.

the research tools with respect to various types of macroevolution should not be mechanical. In this article we try to present some 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 encounter 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 2007a, 2009a; 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 'novelty' (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). 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**

success of a group is achieved through **morphophysiological progress** (Severtsov A. N. 1939, 1967), whereas the ‘biological success’ of a group can be estimated using such measures as levels of achieved diversity, biomass, and abundance. As regards ‘morphophysiological progress’, Severtsov defined it as the increase in energy of vital functions. However, later such an ‘energy-centered’ approach was criticized as too limited (Tatarinov 1976). Shmal'gauzen (1969) emphasized the importance of such a criterion (or symptom) of aromorphosis as the **growth of organismal 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 environmental conditions) 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* (Shmal'gauzen 1969: 409).

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).

In the meantime we do not find it reasonable to identify ‘aromorphosis’ with ‘evolutionary progress’ (Davitashvili 1972: 10). The notion of evolutionary progress is much wider than arogenic changes, though aromorphosis constitute a major component of evolutionary progress. On the other hand, we are not ready to agree with the statement of Timofeev-Ressovsky *et al.* (1969: 226–228) that if the evolutionary regress is accompanied by the movement to a new adaptive zone due to the acquisition by the respective group of some new characteristics, then we can extend the notion of aromorphosis (or arogenesis in terminology of Timofeev-Ressovsky *et al.* [1969: 224]) to the regressive phenomena.

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 different lineages of unicellular eukaryotic organisms [see, *e.g.*, Walentein 1981: 149]), the transition of plants, arthropods, 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; Futuyama 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 2000: 2).³ Though this definition belongs to Voget (1975: 862), yet it was Claessen who supported this definition most systematically in the realm of sociocultural anthropology (Claessen and van de Velde 1982: 11ff.; 1985: 6ff.; 1987: 1; Claessen 1989: 234; Claessen and Oosten 1996 *etc.*; see also, *e.g.*, Collins 1988: 12–13; Sanderson 2007; Bondarenko, Grinin, and Korotayev 2002, 2011 in this volume). 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 (see Grinin and Korotayev 2009a).

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 [2000: 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]).

Thus, we believe that the use of some important theoretical achievements of biological macroevolutionary theory (including some of its terms) in the field of the study of social evolution (this naturally implies the necessity to take into account the specific features of social evolution) may be rather productive (for some experience of such borrowings see, *e.g.*, Korotayev 1997, 2003; Grinin and Korotayev 2007b, 2008a, 2008b, 2009a, 2009b, 2009c; Grinin, Markov, and Korotayev 2008).⁴ Such an approach is quite justified, as it is quite typical for social

³ It seems necessary to emphasize that, though Claessen and Voget speak about the evolution as a whole, their definition is still more applicable to macroevolution, whereas its applicability to microevolution (and, especially, to biological microevolution) seems to be rather limited.

⁴ As well as the other way round. It appears appropriate at this point to recollect that Charles Darwin borrowed a number of important notions for his theory from social sciences, in particular

sciences (that are reaching their maturity significantly later than the natural ones) to borrow from natural sciences – from geology to complexity studies. And if a social science lacks a convenient term, why not to take it from a more developed science?

In the process of our work aimed at the adaptation of some biological terms to the description of socioevolutionary phenomena it has been found out that such an approach is rather productive as regards the comparison between various aspects of social and biological macroevolution. On the other hand, the opposite influence is also possible. For example, the hyperbolic growth models designed initially for the mathematical description of the social macroevolution turned out to be well applicable to the description of the biological evolution (see, *e.g.*, Markov and Korotayev 2007, 2008, 2009). In addition to this, as has already been mentioned above, quite a few ideas that have been developed by us with respect to the social evolution have turned out to be applicable to the biological evolution (we can mention as an example the rule of special/exceptional conditions for the emergence of aromorphoses, where we just substituted ‘newness/novelty’ with ‘aromorphosis’; the same is true for the ‘rule of the arogenic relay-race’).

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

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 developmental 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, see note 5) 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.

from theories of Thomas Malthus and Herbert Spencer (see, *e.g.*, Mayr 1981: 18–19). Darwin himself points out that the struggle for survival is Malthus doctrine spread to both realms of animals and plants (Darwin 1991: 23). See also Lekevičius 2009.

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, which made it possible to finalize the formation of the World System in its main Afroeurasian borders;⁵

⁵ *World-system* is a maximum system of human societies, beyond whose borders no significant contacts/interactions (between parts of the given world-system and parts of the other world-systems) exist. This implies that there could be some contacts between societies of the given world-system and societies of the other world-systems, but this contacts should be insignificant; that is even after a long time such contacts do not lead to any significant changes within the respective systems (see Grinin and Korotayev 2009a for more detail). For example, early travels of Scandinavians to the New World (and even their settlement there) did not alter in any significant way the social macroevolution of either Europe or Americas (see, e.g., Slezkin 1983: 16). For example, with respect to the 15th century one may speak about the American, Australian, Afroeurasian, and some other (smaller) world-systems. We denote as the **World System** a world-system that emerged between the 10th and 8th millennia BCE in West Asia, and then, through a series of expansions/incorporations developed into the Afroeurasian world-system (= the World System). The Modern World System (that actually encompasses the whole world) emerged as a result of the expansion of this very system, and that is why, following Andre Gunder Frank (1990, 1993; Frank and Gills 1993) we denote it as the main world-system, that is, as the World System. One can use as a formal justification for the designation of this world-system as the World System the point that in the recent millennia it encompassed more than a half of the world population. Note that we also find it appropriate to speak about biological world-systems, which we define as

- 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 the innovation production;
- formation of developed market systems that laid basis for the industrial revolution;
- invention of computer technologies, *etc.*

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, stability of their systems and so on.

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 particular evolutionary change that... creates significant advantages for an organism, puts it in favorite conditions for reproduction, multiplies its numbers and its variability..., thus accelerating the speed of its further evolution. In those favorable conditions, the total restructuring of the whole organization takes place afterwards' (Shmal'gauzen 1969: 410; see also Severtsov A. S. 1987: 64–76). And then, in 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. Take, *e.g.*, 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

flora and fauna of those landmasses that have contacts within themselves (such contacts could be episodic; but they should be sufficient for the exchange of main bioevolutionary innovations) but lack such contacts with the ones of the other landmasses. For example, it seems possible to speak about such biological world-systems as North-American-Afroeurasian, South American (that had existed before South America was connected with North America), or Sahul (New-Guinea-Australian) ones (see Grinin, Markov, and Korotayev 2008; Markov and Korotayev 2008).

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, *etc.*

There are both significant similarities and significant differences between biological and social macroevolution; their analysis goes beyond the scope of the present article (this analysis has been undertaken by us earlier: Grinin and Korotayev 2007a, 2009a; Grinin, Markov, and Korotayev 2008, 2009a, 2009b). 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,⁶ 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) ‘biological success’, 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 morphophysi-

⁶ Quantitative characteristics of biodiversity are displayed in Fig. 1.

ological, taxonomic, and ecological diversity, in abundance 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 quite clear that all those criteria are not quite rigorous, and Criteria 2 and 3 can be only applied in retrospective.

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 an 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.⁷ With respect to many social aromorphoses this criterion sometimes becomes the most important (as we could see above as regards 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

⁷ It is very clear, however, that with reference to social evolution the adaptability criterion has its limitations.

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 aromorphoses 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).

Returning to the classification of qualitative changes in the framework of biological macroevolution, it should be mentioned that in cases when Criterion 2 is not applicable to the given evolutionary shift (the development occurs within the limits of an old adaptive zone, or the adaptive zone is changed without its expansion), it appears more appropriate to speak about the *allomorphosis*;⁸ the contraction of adaptive zone (including those cases when it is accompanied by the development of sometimes complex and perfect, but partial adaptations) is denoted as *ecological specialization*. For those evolutionary events that satisfy Criterion 2, but not Criterion 1 (the expansion of adaptive zone without increase in organization complexity) the term *epektomorphosis* has been suggested (Iordansky 2001). One can mention following examples of epektomorphoses: the development of skin respiration in amphibians, the development of the shell in mollusks, the development of the special axial skeleton and musculature in snakes (*Ibid.*: 361).⁹ As regards the biological progress (Criterion 3), it may be achieved in a number of non-arogenic ways, including morpho-physiological regress (decrease in organismal complexity), ecological specialization, allomorphosis, epektomorphosis, *etc.* (Shmal'gauzen 1939, 1969; Matveev 1967; Severtsov A. S. 1987; Iordansky 2001; Timofeev-Ressovsky *et al.* 1969, *etc.*).

Phenomena of a partial social progress accompanied by antiprogressive and regressive (involving the decrease of societal complexity) shifts are not rare in social macroevolution. Thus, a collapse of a large empire can lead to a progress in the development of local institutions, to the formation of local feudal states and dynasties, to the growth of cities, *etc.*, for which one can easily find many examples in the history of Western Europe, Russia, as well as in certain periods of Chinese history.

Numerous examples of evolutionary transformations satisfying Criteria 1 and 2 (but not 3) can be observed in periods of formation of new major taxa. For example, in the course of mammalization (that is the formation of mammal

⁸ Quite wide-spread changes of specialization of foragers (*e.g.*, change of the focus on hunting to the focus on gathering), as well as, *e.g.*, transition from extensive plant cultivation to extensive animal husbandry (and *vice versa*) could serve as examples of 'social allomorphoses'.

⁹ Within social macroevolution one can mention as an example a high level of development of some crafts in some communities of simple agriculturalists that did not lead to any significant growth of the overall complexity of respective social systems.

traits) many groups of theriodont reptiles acquired progressive ‘mammalian’ traits in a parallel way, which was accompanied by the expansion of their potential adaptive zone; however, only one of those lines realized fully its potential and became aromorphic giving birth to mammals (Tatarinov 1976).

Such examples can be also found with respect to social macroevolution. Thus, in the period when the complexity of late primitive societies increased, one could observe the intensification of politogenetic processes, as a result of which societies of different types acquired similar traits that enhanced functional differentiation and social stratification, alienation of power from the majority of population and its concentration by certain groups, as well as the expansion of the possibilities of societal administration. There were many types of such complex societies, but only one line managed to realize fully the respective potential and became aromorphic giving birth to the state formation process (see Grinin and Korotayev 2009a, 2009b; Grinin 2009 for more detail).

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 Rautian (1988a: 103; see also 1988b), 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 previously 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 makes 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 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.

As regards mechanisms of emergence of major aromorphoses, we believe they should be analyzed in two aspects.

The first is the aspect of general evolutionary context. An evolutionarily perspective aromorphic 'model' emerges as one of many types of qualitative change in the process of reaction to changing conditions and more complex tasks. In this respect both evolutionarily pass-through transformations and evolutionary blind-alleys (if they led to important changes and solutions of pressing evolutionary tasks) can be regarded as somehow equivalent at a certain level of analysis. This provides an additional explanation for the difficulty of differentiation between such notions as *aromorphosis*, *allomorphosis*, *epektomorphosis*, *etc.*, as all of them designate versions of evolutionary solutions in answer to changing conditions and circumstances, and there is no 'Berlin wall' between the respective types of evolutionary solutions. In other words, there is no fatality in the way to new aromorphoses; there is only an objective need to 'find an answer' to changing conditions, new problems and challenges.

The second is the aspect of exceptionality (see below the rule of exceptional conditions for the emergence of an aromorphosis). Only one of many concrete changes (models) turns out to be sufficiently perspective and universal when it proves its competitive advantages and starts to gradually diffuse, be borrowed and transmitted. The reasons for such exceptionality should be studied specially for every particular case. However, the general answer why some major aromorphic transformation was realized could sound as follows: *it took place as one of many reactions to environmental, resource, structural, factor changes (or any other substantial changes)*. Yet, in different taxa and in different societies the reaction to the growing complexity of tasks (changing conditions) was very different with respect both to its contents and to its evolutionary perspectiveness. Only some of many models turned out to be evolutionarily perspective. However, their advantages did not manifest themselves immediately, and for a long time different models could compete among themselves.

Hence, 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 modes of evolution (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.¹⁰ 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 detail *some mechanisms and rules of formation and diffusion of aromorphoses in the biological and social world*.

Rules Connected with the Aromorphoses’ Characteristics

1. Rule of the aromorphic ‘relay-race’

The same group of organisms or societies cannot remain permanently the evolutionary leader that constantly gives birth to a chain of aromorphoses. Aromorphic potentialities are limited by numerous circumstances, including the structure of the organism (society) itself, environmental conditions, degree of specialization, *etc.* It is evident that ‘indeterminately continuous and directed adaptation progress is impossible due to the fact that such a progress is accompanied by a conflict between the stability (the acquired level of adaptation) and the freedom of creativity (perspectives of future adaptation)’ (Rautian 1988a: 104).

Any direction of adaptation can become exhausted due to the accumulation of inadaptivity burden (as any adaptation constitutes a sort of trade-off, see below for more detail). This is sometimes denoted as a ‘blind alley of specialization’. Finally this usually leads to decline, *i.e.* biological regress (decrease of diversity, abundance, biomass). However, later the situation sometimes changed, leading to a new cycle of adaptation (progressive specialization) in a similar direction, ‘whose initial stages are naturally characterized by a lower level of specialization in comparison to the latest phases of a previous cycle’ (Rautian 1988a: 100).

As regards social evolution, this idea may be connected with the cycles of growth and disintegration of empires and civilizations; within those cycles one may observe firstly a certain ‘regression’ toward simpler social systems with subsequent increase in their complexity (that could sometimes reach a level that was significantly higher than the one attested during the peak of a previous cycle (see, *e.g.*, Kul'pin 1990; Grinin 1997–2001, 2003a; Korotayev, Malkov, and Khalturina 2006b; Korotayev and Khaltourina 2006). Well-known cycles of centralization – decentralization/feudalization of the early states sometimes

¹⁰ According to them, *e.g.*, internal skeleton of vertebrates, external skeleton of arthropoda, or development of vascular system can serve as examples of such adaptations (Timofeev-Ressovsky *et al.* 1969: 252).

ended with the emergence of centralized states of a new more developed type (see, e.g., Grinin 2007a, 2007b, 2007c, 2009; Grinin and Korotayev 2007a).

This suggests the following important conclusions: a) aromorphoses that increase the level of system complexity emerge in new taxa, societies (or in the same societies, but on the basis of new political structures); b) however, those systems are not entirely alien within the macroevolutionary arogenic line. Within biological evolution new leaders are always direct descendants of those groups from whom they have inherited the previous aromorphic traits, whereas in social evolution we can only speak about a certain degree of continuity and succession. This way, one can observe the emergence of a sort of aromorphic ‘relay-race’ from some systems to others, from one level of organization to another, which makes it possible to trace a sort of trajectories of major aromorphic changes. For example, in Europe, the transition from the Middle Ages to the Modern Age (even if we only take into account technological and commercial aspects of this process) began in Northern Italy, from where the ‘relay-race’ passed to Portugal and Spain that made the main contribution to the Great Geographic Discoveries (yet, not without help and direction on the part of Genoese seamen and bankers), whereas a part of their achievements was acquired by Germany. Then, as a result of Reformation that began in Germany and the influx of the New World gold, the Netherlands became the avant-garde part of the World System, whereas later the ‘baton was picked up’ by Britain (where the Industrial Revolution began). Britain occupied the leading positions for many decades until the ‘baton was picked up’ by the USA. Note that at every stage one could observe important aromorphoses based on the previous achievements.

Thus, the rule of the aromorphic relay-race that we have proposed indicates that a chain of major aromorphoses emerges due to succession of various taxa and societies with a rather complex evolutionary trajectory that is far from a strait line; within this trajectory one can observe constant fluctuations, regressions, zigzags. As a result, the trajectory of the aromorphic ‘relay-race’ can be only traced retrospectively. Such a composite ‘relay-race’ evolutionary trajectory may well be denoted as an arogenic line of evolution. However, it is important to take into account the point that the above-mentioned rule confirms an important conclusion by Rautian (1988a, 2006); according to him, the arogenesis as a specific form of evolution (as is interpreted by Takhtadgyan [1966]) that leads directly (without any modus change) to an aromorphoses turns out to be theoretically impossible; such aromorphoses can never emerge. ‘The necessity to change specialization directions implies a risk of extinction in the way to aromorphosis’ (Rautian 1988a: 104).

2. Rule of rarity of major aromorphoses

The impossibility of the arogenesis as a straight continuous line of changes accounts for the rarity of aromorphoses as a sort of interruptions of graduality. Actually, the more important the aromorphosis, the more rarely it is observed. On the other hand, the rarity of emergence of aromorphoses only emphasizes the evolutionary importance of major aromorphoses. In general, we can maintain that the more important the aromorphosis is, the lower the probability of its occurrence is.¹¹ The rarity of major aromorphoses, on the one hand, and a certain rapidity and suddenness of changes caused by them, on the other hand, produced some vagueness regarding the point whether the aromorphosis should be understood as a relatively brief phylogenetic event, or it should be regarded as a prolonged process even at the geological time scale (Rautian 2006). We believe that (both biological and social) aromorphoses can be considered (depending on the respective context) in the both aspects. In certain places some major changes can occur relatively quickly; yet, the formation of the whole necessary chain of evolutionary arogenic changes and the wide proliferation of the respective ‘innovation’ need a long time. For example, in some areas of West Asia the primary transition to agriculture occurred quite rapidly (within a few centuries); however, the improvement and diffusion of primary agricultural technologies took a few millennia that we include in the total period of agricultural revolution (10 000–5 500 BP [Grinin 2003a; Grinin and Korotayev 2009b]). This dualism is directly connected with **the rule of delayed aromorphosis** that will be considered below.

The rule of the rarity of major aromorphoses correlates with **the rule of inversed relationship between a taxon's rank and the frequency of the emergence of such taxa in phylogenesis**, that is trivial in some sense, as within almost any natural set of any objects one can observe a negative correlation between the size (scale, importance) of certain objects and their number: the number of large animals is always smaller than the number of small animals; the number of great writers is always smaller than the number of mediocre ones, *etc.* This is even more clear with respect to taxa of different ranks. Thus, the number of genera can never be higher than the number of species, whatever sample we use; consequently, the frequency of the emergence of new genera is always lower than the frequency of the emergence of new species.

Thus, major aromorphoses are very rare, which emphasizes their status of the most important evolutionary events, each of which gave birth to a whole chain of diverse transformations that in their turn led to new changes; thus, in the framework of one major aromorphosis we can observe a great number of

¹¹ However, the significance of this rule gradually diminishes with respect to social (and, possibly, also biological macroevolution) due to the acceleration of the macroevolution's speed, as well as due to another rule – the rule of the growth of new aromorphoses probability (see Grinin, Markov, and Korotayev 2008 for more detail).

other changes with various degrees of importance. Take, for example, the Industrial Revolution of the 18th and 19th centuries. It was connected with immense transformations in transportation, communications, finance, education, demographic processes (including migrations), modern nation and state formation, *etc.* (see in particular Grinin 2003a, 2007c).

In the biological evolution aromorphoses only emerge in very few phylogenetic branches. However, in any given moment of geological history in biosphere one could observe a certain number of aromorphic groups, which testify for the typicality of aromorphoses for the evolution of biota as a whole (Rautian 1988a).

3. The rule of special (exceptional) conditions for the emergence of aromorphoses

Primary direct transition to the aromorphoses occurs (figuratively speaking) in ‘narrow places’ (for a very limited number of systems).¹² However, this should not be interpreted in the sense that aromorphoses emerge in isolated systems. On the contrary, the emergence of aromorphoses need a great diversity of interacting systems (see below). We mean that in the given moment among many forms only very few combine within themselves all the conditions (some of which are often unique) that are necessary for an aromorphic transformation.¹³ Mayr (1974: 403–411) suggests a number of interesting ideas and calculations regarding this point.

Consider, for example, the primary transition to agriculture. Independent invention of agriculture (whatever species were domesticated) only took place in particular zones (see, *e.g.*, Deopik 1977: 15 with respect to South-East Asia). In other words, this needed very special natural conditions. In order to stimulate people to move from foraging to agriculture powerful factors were necessary, and there is no unanimity with respect to those factors. Even more so, special circumstances were necessary in order that agriculture could become an impor-

¹² In consequent periods, in the process of adaptive radiation in biological macroevolution and in the process of innovation diffusion in social macroevolution, aromorphic changes become more wide-spread.

¹³ It appears necessary to underline that, within the present context, the determinative ‘exceptional’ (with respect to conditions that are necessary for emergence and full-scale realization of aromorphoses) has two aspects, or even two degrees. The first is the very rarity of the appearance of respective structural and/or other changes that are necessary for the emergence of an aromorphosis. However, a certain combination of ‘exceptional’ conditions is frequently also necessary for the emergence of many non-aromorphic adaptations. However, allomorphic, degenerative, *etc.* changes do not imply the exceptionality of the second degree, that is the exceptionality of evolutionary results. Indeed, such changes should have a progressive potential and allow at the same time to raise in the subsequent period the level of taxa organization, to expand conditions of their existence and to increase the degree of the organism’s independence from the fluctuations of external conditions. Thus, one may say in a figurative way that we are dealing in such cases with exceptional conditions “squared”, that is with rare conditions for the changes themselves coupled with the rarity of evolutionary qualitative consequences.

tant (and not just marginal) sector of primitive economy. Yet, among all the domesticated species a special role in the aromorphic evolution was played by the cultivation of cereals.

Consequently, the degree of uniqueness of the required natural and social conditions becomes even higher. Hence, it is not surprising that, though many hunter-gatherers knew technologies of plant cultivation and many other ‘secrets’ of agriculture (including irrigation) (see, *e.g.*, Kabo 1980, 1986; Shnirel'man 1989), there was a great distance from this knowledge to the actual transition to agriculture. Many scientists suggest that the cereal agriculture emerged first in certain highland zones with suitable microclimate and high diversity of respective plants.¹⁴ Note here the hypothesis that was proposed quite long ago (*e.g.*, Shnirel'man 1989: 273); according to this hypothesis, the most ancient agriculture emerged in such mountainous zones where there was a periphery of natural habitats of wild ancestors of the domesticates, as it was this periphery where a need in agriculture was felt in an especially acute form. It was also suggested that in such places climatic fluctuations pushed people not only to gather plants, but also to try to support their reproduction through the creation of favorable conditions (Mellart 1982: 128).

Thus, the primary transition to agriculture needed the concurrence of time, place, various contingent factors, favorable social characteristics, presence of individuals with certain personal qualities, *etc.*; that is a rather large number of conditions should have been satisfied, which illustrates the validity of the above mentioned evolutionary rule, according to which special circumstances are necessary in order that an aromorphosis could emerge. In the meantime it is important to emphasize that West Asia was not isolated, in the respective age it was a relatively highly developed region tightly connected with its neighbors (see Grinin and Korotayev 2009a for more detail).

This makes it possible to arrive at a conclusion, which is very important for the study of the both types of macroevolution (though it seems a bit more relevant for social macroevolution): in order that a major aromorphosis could emerge, a ‘wide scene of action’ is necessary. We will clarify this point using as an example the Industrial Revolution in the 18th century England. There are a lot of discussions why the Industrial Revolution started in England. Dozens of explanations have been proposed, and each of them is true in some respect. Below we shall sum up various views, including ones of the authors of the present article (Grinin 2003b: 345–346). As is always observed with the start of a major aromorphosis, one can find in this case a unique combination of internal and external factors, as well as peculiarities of the previous development of the respective society.

¹⁴ This seems to have occurred ‘only in certain zones – highland arid areas with warm a subtropical climate that create abundance of natural microzones in a relatively small territory and possess a very reach flora, including wild cereals’ (Gulyaev 1972: 50–51).

In particular, one can mention a relatively small degree of the prevalence of serfdom in England and its early abolition; less rigid social barriers, including the possibility for the nobility to engage into commerce, as well as the possibility for rich commoners to become ‘gentlemen’; high level of development of private property and legal relationships (including effective legal guarantees of private property inviolability); a fortunate (without a civil war) reformation of the religious subsystem, *etc.*; the favorable external market conditions of the previous centuries (amplified by the well-known inflationary processes of the 16th century – the so-called ‘Price Revolution’¹⁵). One should also mention the optimum proportions of territory and population. The insular geographic position and respective external security were also very important. There is no doubt that Britain also benefited from the European wars (as highly qualified staff from various European countries moved to this country) and geographic discoveries. The possibility for ‘excessive’ population to move to colonies gave an early impetus for the development of labor-saving technologies. Finally, one should note an immense role of English political revolutions that ultimately transformed the English political system into a constitutional monarchy, which provided favorable political conditions for the development of capitalism. England managed to defeat its main competitor – the Netherlands.

Hence, by the 18th century England managed to solve main internal and external problems, and this way to secure conditions for the start of unprecedented breakthrough. Naturally, one can single out among those factors more and less important, determined and random ones. Yet, in this case it is important for us that, in order that this particular aromorphosis could emerge in the respective particular time and place, a unique combination of many circumstances and causes was necessary.

However, we would like to maintain once again that the emergence of significant social aromorphoses needs a certain social scale (that is much larger than the scale of an individual society – this is often the scale of the World System) and a high ‘species diversity’ of certain social forms (see, *e.g.*, Grinin 1997a, 1997b, 2003a)¹⁶ (see below ‘the rule of sufficient diversity’). The emergence of the primary system of machine production in the English cotton industry in 1730–1760 with subsequent development of systems of steam engines was determined, on the one hand, by the general level of development, integrity and needs of Europe and the World System as a whole; on the other hand, it was determined by unique peculiarities of the preceding history of Great Britain

¹⁵ See Grinin, Korotayev, and Malkov 2008 for more detail.

¹⁶ At this point it appears appropriate to notice that in biology (in macroevolutionary theory, in ecology, *etc.*) **diversity** is one of the key indicators, which is an object of intensive attention on the part of biologists, whereas in sociology the idea of **diversity** is used, unfortunately, much less frequently, especially as regards its quantitative analysis. In the meantime, one can find here many possibilities for the development of many important parts of the theory of social evolution and macroevolution.

(see Grinin 2003a: 139–140 for more detail) and some events that might look rather accidental with respect to the formation of machine industry. Note among them the prohibition to import to Britain Indian, Chinese, and Persian cotton print textiles. This was a usual protectionist measure that was taken under the pressure of the producers of wool textiles (Mantu 1937: 160). In this age a lot of such measures were taken in various European countries; yet, usually they did not have any revolutionary consequences. As the respective law was passed after a serious struggle (and, hence, there were some chances for it not to pass at all; thus, we are dealing here just with a contingency), one may ask a question: how would the machine mode of production have emerged, if the above-mentioned law had not been passed? We believe that in this case the transition to the new mode of production might have taken significantly more time; this transition might even have taken place in another country (*e.g.*, in Belgium). However, there was a very high probability that such an aromorphosis would have emerged (see McNeill 1990 for interesting comments regarding this point). Thus, the prohibition to import textiles played a role of fortunate contingency.

However, the fact that a usual protectionist measure performed the trigger function within the process of formation and development of the new production function, is accounted for by the point that both the World System as a whole and England as its rather developed but semiperipheral part (note that the semiperiphery is precisely the zone where aromorphic changes are most likely) were ready for such a breakthrough. The early capitalist system and industrial production principle had already emerged (see, *e.g.*, Grinin 2003a: 123–138; 2007c: 73–78), colonial empires had formed, and the world trade had developed in a rather vigorous way (as a result of which Europe found itself flooded with Indian textiles). One should also take into account the presence of a very serious technological progress. In particular, by the late 18th century there was a 150-year history of the steam engine (see, *e.g.*, Mantu 1937: 264).

That is why in some sense one may maintain that the emergence of a new social aromorphic trait **is always a result of synthesis of suprasocietal (civilizational, regional, world-system, or even panhuman) scale of development and peculiarities of the society that produced the respective innovation.**

As regards biological macroevolution, we have already noticed above (for example) the situation when within the ‘mammalization’ process many groups of reptiles independently acquired progressive ‘mammalian’ characteristics, which was accompanied by the expansion of their potential adaptive zone; yet, only one of those lines was capable to realize fully its potentialities and became aromorphic, giving birth to the mammals (Tatarinov 1976). As is well known, in the subsequent epochs mammals populated immense spaces of land and ocean. However, the whole process from the first steps made by some groups of reptiles toward ‘mammalization’ (Late Permian, 270–250 million years BP) till the occupation by the mammals of dominant positions in the terrestrial ecosystems (Early Cainozoic, 65–55 million BP) needed a rather long time – *c.* 200 million years.

Other aromorphic transformations ('arthropodization' – emergence of arthropods, 'ornitization' – emergence of birds, 'angiospermization' – emergence of angiosperms, as well as hominization, sapientization, *etc.*) occurred in a similar manner. In all those cases aromorphic transformations (that were realized each in a single evolutionary line) were prepared and directed by long parallel development of many lineages, as well as by concomitant development of corresponding ecosystems and the biosphere as a whole.

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 of complex organisms) are multifunctional.¹⁷ A. N. Severtsov (1939) described a system of moduses of organogenesis that was based on two categories of facts that are observed objectively in nature: 1) all the organs are multifunctional; 2) any function may experience a quantitative change. We do not know a single monofunctional organ in any biological organism; what is more, the number of known functions for any organ tends to increase with its more profound study (see also Timofeev-Ressovsky *et al.* 1969).

However, notwithstanding the intensive study of organogenesis undertaken by Severtsov and his school, the full and definitive analysis of this issue is still absent. More than 15 moduses of organogenesis are known; for example, Timofeev-Ressovsky *et al.* (1969: 216) mention (on the basis of research conducted by other scientists) the following moduses: change of functions, substitution of organs (Kleinenberg 1886), expansion of functions (Plate 1912), physiological substitution (Fedotov 1927), reduction of the number of functions, intensification of functions, substitution of functions (Severtsov A. N. 1935), oligomerization and polymerization of homodynamic and homonomous organs (Dogel' 1954), heterobathmy (Takhtadgyan 1959), compensation and uneven rates of transformation of organs (Vorontsov 1961).

The principle 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' (or exaptation) was proposed more than a century ago, but it was not easily accepted by

¹⁷ Social institutions usually are also polyfunctional.

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 necessary, 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 haemoglobin 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 Sarcopterygii. The construction of the limbs 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 Sarcopterygii – 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 limb and the beginning of its use on land was as long as 20–30 million years. Though the limbs 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 terrestrial ecological niches 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 capitals 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 detail).

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, a quantitative change, and other characteristics of function realization* (Grinin 1999). 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. Thus the private property's function to secure the extended industrial production through the private interest (that was either absent or weakly manifested in the preindustrial societies) became one of the most important functions of the private property institution in the conditions of the industrial production principle and within a certain type of the states. One more clear example can be provided by weakly functional administrative borders between the republics of the USSR that played a purely administrative role and could be arbitrarily changed at any time. Naturally, the crossing of those borders went unnoticed for the Soviet citizens. However, the importance of those borders grew dramatically after the break-down of the USSR, after which the crossing of those borders became a complex and difficult operation, while any attempts to change those borders get across the principle of their 'invulnerability'.¹⁸

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 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 morphofunctional and genetic-ecological aspects of preadaptation (Iordansky 2001), that is, a whole set of various peculiarities and adaptations that are ultimately capable to change

¹⁸ Similar metamorphoses took place with respect to the borders between colonies belonging to one state after those colonies became independent.

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 (Iordansky 2001: 133) cites as an example of constitutional preadaptation the tetrapods' ancestors – Sarcopterygii (see the example above).

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 interval 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 groups of 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 Neoproterozoic era) (Fedonkin 2006).

In social evolution for long periods of time many inventions do not play either the role that they start playing in other circumstances. It appears sufficient to recollect that gunpowder and 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 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 2003a for details]). The cotton industry also existed for 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 in it 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 aromorphoses 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 after 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 1988a).

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 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 (*Ibid.*).

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 form creating potential. 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 Co-

lumbus, America would have soon been discovered by someone else. Thus, the further 'physiognomy of events' (to use Plekhanov's [Plekhanov 1956]) would have been quite similar (though, of course, it would not have been entirely similar). 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 Muhammad¹⁹ 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. Thus, in particular, while interpreting the above-mentioned example, it may be said that, if the reptiles' ancestors had not 'learned to breath with their breast' (and continued, like frogs, to pump air to their lungs through the expansions and contractions of their oral cavities), no reptiles would ever emerge.

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/innovations 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 one) 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 1997b, 2006, 2008;

¹⁹ Naturally, we discuss here the reconstructions of some students of Islam, and not the beliefs of the Muslims themselves.

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,²⁰ b) prevalence of respective aromorphic structures in certain conditions; c) further gradual perfection of an aromorphic system.

4. Rule of ‘block assemblage’ (modularity) in evolution

When a system reaches a certain level of sophistication and maturity, it may start being used as a whole within the process of evolution (as a single unit, a single block). In process of adaptations and specialization this block experiences a sort of adjustment for the needs of a particular (biological or social) organism. In 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) *etc.* 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 (after reaching 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 of new genes and gene 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

²⁰ To use Teilhard de Chardin's words (1987), what looked at the beginning as a lucky event or way to survive could be transformed into a tool of progress and conquest.

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 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 (c. 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 discusses 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.

Krasilov (1984: 11) notes that ‘evolution seems to use the block assemblage technology’. ‘Principle of self-organization of proteins and RNA reflects stages of block substructures’ formation’ (Ratner *et al.* 1985: 245). ‘The new is almost always created through the combining of previous blocks; new blocks emerge very rarely’ (Chaikovsky 2003: 283).²¹

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 DNA from the 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

²¹ See also Haitun 2005: 92–96, 102–103.

of proteorhodopsins (proteins that make it possible to utilize partly the sun light energy). In contrast with those proteins that take part in the performance of real photosynthesis, proteorhodopsins do not need the 'help' of many other specialized proteins 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 wide-spread (and especially important for arogenic direction of biological macroevolution) kind of 'new element borrowing' is the emergence of symbiotic systems, which could lead sometimes to the transformation of several different organisms into a new single organism. The role of such systems is often underestimated, but in reality all the functioning of 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 (neither insects nor vertebrates are able to digest the most wide-spread types of plant food without their symbiosis with specialized microorganisms; whereas it is the processing of the plant food that is the main ecological, biospheric role of 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 cell 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 proteins performing the V-(D)-J recombination) descend from enzymes 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 proteins) 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.*

5. Rule of non-specialized ancestor

For the emergence of an aromorphosis (*i.e.*, an evolutionary transition to a qualitatively higher complexity level) any excessive specialization usually turns out to be an insurmountable obstacle. *Ceteris paribus*, less specialized, more flexible forms evolve easier. With respect to biological evolution this idea was formulated in the late 19th century by Cope. It is known as the rule of descent from non-specialized ancestors; according to this rule, new major groups do not descend from the most specialized representatives of the ancestor groups – they descend from comparatively weakly specialized ones (see Markov and Naymark 1998 for more detail on this rule).²²

This rule is also applicable to social macroevolution. Thus, we could see above that the transition to the cultivation of cereals needed the combination of various natural conditions, which by itself hindered a narrow specialization (that is why it is hardly surprising that specialized hunters, gatherers, and fishers usually tended not to move to agriculture, as they were highly successful in their ecological zones). The integrated agricultural economy (unifying plant cultivation and animal husbandry) turned out to be much more evolutionarily perspective than both the specialized (usually nomadic) animal husbandry and pure plant cultivation (see, *e.g.*, Onischuk 1995). In a similar way, new types of pre-machine industries usually emerged not in highly specialized cities (with strong positions of guilds), but rather outside the city walls (see Grinin 2003a for more detail).

²² Vorontsov believes that this rule has been excessively absolutized, and that even stenoecic organisms (that is, organisms that can only exist in particular environmental conditions) are capable of giving birth to new directions. From his point of view, the stenoecicity is achieved by specialization of only some part of the system of organs, whereas some other subsystems of this system remain weakly specialized, and that is why (when conditions change) they may turn to be more appropriate for a transformation in another direction (Vorontsov 1999: 596–597). This observation seems to be quite reasonable; however, even having taken Vorontsov's idea into account, we should maintain that, in any case, the transition to qualitatively new forms is connected just with unspecialized forms and organs.

Rules Connected with Special Characteristics of Environment that is Necessary for the Aromorphoses' Emergence

1. 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) evolutionary level are filled (that is, there is a sufficient diversity at this level). The non-arogenic types of transformations are by definition more wide-spread 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.²³

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).²⁴ 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,

²³ 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).

²⁴ 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 polyyps in Siphonophorae).

the competition increases and the ‘search’ for a breakthrough, for a new aromorphosis intensifies.

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, 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 arthropods. Many scientists suggest the presence of positive feedback 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 multiplier’.

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 diverse 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 ‘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.²⁵

²⁵ 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 wide-spread 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 spe-

The competition is considered to be an important precondition for the effectiveness of directed selection. It is believed that with a low 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 think 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 aramorphosis realization needs a sufficient diversity, with the increase in which (*ceteris paribus*) the probability of aramorphoses 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;²⁶ 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), *etc.* Thirdly, it is connected with the adaptive compromise principle (for more detail see Grinin, Markov, and Korotayev 2008).

2. 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 so-cieties.²⁷

cies) may have an opposite effect; that is, it may limit the growth if intra- and interspecific diversity. However, aramorphoses 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.

²⁶ It is not coincidental that defeats lead to military (as well as political, social, *etc.*) reforms more frequently than victories.

²⁷ 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 *etc.* One may also recollect how many local religions disappeared

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.²⁸ 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 co-exist 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 chiefdoms; 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 system (with respect to the higher-order taxa) reached its maximum in the 19th century when one could observe the co-existence of *all* the above mentioned political forms. What is more, in this period the maximum diversity could be observed as regards not only political

with the expansion of the world religions. Yet, up to 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 *etc.* religions, we have absolutely no evidence on the extinction of any '**genus**' of such religions (*e.g.*, animism, totemism, or shamanism).

²⁸ 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 *etc.*; thus, depending on criteria, one can easily identify dozens of chiefdoms' 'genera' (and hundreds of chiefdoms' species).

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), and so on.

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.²⁹

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 *etc.* This trend can be denoted as the **growth of the diversity of human activities' results**. 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 *etc.*). It is clear that at present the globalization processes lead to the decrease of ethnic 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. Formation of major aromorphoses occurs against the background of extinction and evolutionary failures of numerous biological and social systems.

²⁹ 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).

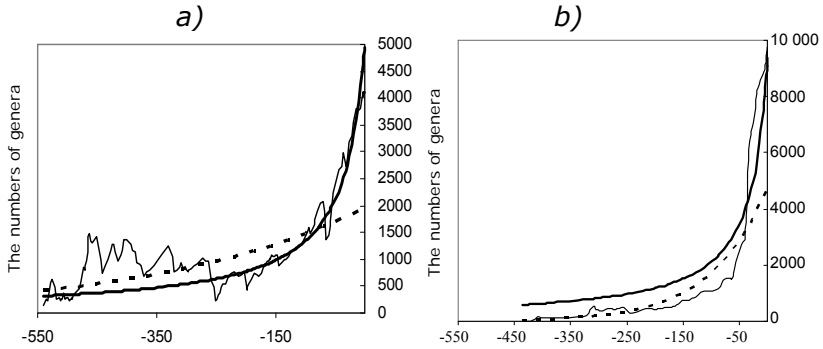


Fig. 1. The growth of diversity (the numbers of genera) of the marine (a) and continental (b) organisms during the Phanerozoic (542–0 mln years BP)

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

The Rule of ‘Payment’ for the Aromorphic Progress (Instead of a 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 not numerous groups get from one adaptive zone to another. This transition is usually conducted with a great (evolutionary) speed, whereas many groups die out in interzone 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 allogenesi³⁰ (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

³⁰ 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.*

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 the 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.

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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 (both biological and societal) organisms 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).

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 intellectual and social differences between the chimpanzees and the humans that arise from the apparently 'insignificant' difference between the two genomes.

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.*