10

Biological and Social Phases of Big History: Similarities and Differences of Evolutionary Principles and Mechanisms

Leonid E. Grinin, Andrey V. Korotayev,
Alexander V. Markov

Abstract

Comparison of biological and social macro-evolution is a very important issue, but it has been studied insufficiently. Yet, analysis suggests new promising possibilities to deepen our understanding of the course, trends, mechanisms and peculiarities of the biological and social phases of Big History. This article analyzes similarities and differences between two phases of Big History at various levels and in various aspects. It compares biological and social organisms, mechanisms of evolutionary selection, transitions to qualitatively new states, processes of key information transmission, and fixation of acquired characteristics. It also considers a number of pre-adaptations that contributed to the transformation of Big History's biological phase into its social phase and analyzes some lines of such a transformation.

Introductory Remarks

In this article, we continue our analysis of similarities and differences between social and biological evolution, which makes it the continuation of an article that we published in the previous issue of *Evolution* (Grinin, Markov, and Korotayev 2011). Since the comparison of biological and social evolution is an important but (unfortunately) understudied subject, we shall re-state a few of the salient points from our previous article.

We are still at the stage of a vigorous discussion about the applicability of Darwinian evolutionary theory to social/cultural evolution. Unfortunately, we all are mostly dealing with a polarization of views. On the one hand, we confront a total rejection of Darwin's theory of social evolution (see, *e.g.*, Hallpike 1986). On the other, we deal with those who stress that cultural evolution demonstrates all the key Darwinian evolutionary characteristics (Mesoudi, Whiten, and Laland 2006).

Evolution: A Big History Perspective 2011 158–198

We believe that, instead of following the outdated objectivist principle of 'either – or', we should concentrate on the search for methods that could allow us to apply achievements of biological evolutionary science to social evolution and *vice versa*. In other words, we should concentrate on the search for productive generalizations and analogies for analysis of evolutionary mechanisms. The Big History approach aims for inclusion of all mega-evolution within a single paradigm (this paradigm is discussed in Grinin, Carneiro *et al.* 2011). Hence, this approach provides an effective means to address the above-mentioned task.

As is known, not only systems evolve, but mechanisms of evolution evolve too (see more on this in Section 3). This concept also appears rather fruitful as regards the development of Big History itself. Let us consider some of the parameters and examples that we might consider.

Each sequential phase of Big History is accompanied by the emergence of new evolutionary mechanisms; therefore, certain prerequisites and preadaptations can be detected within the previous phase. So, development of new mechanisms of evolution does not imply invalidation of evolutionary mechanisms that were active during previous phases. As a result, one can observe the emergence of a complex system of interaction of forces and mechanisms determining the evolution of new forms. Biological organisms operate in the framework of certain physical, chemical and geological laws (see Kutter's contribution on this topic and also on the comparison between physical and biological evolution).

Likewise, the behaviors of social systems and people have certain biological limitations. New forms of evolution that determine Big History transition into a new phase may result from activities going in different directions. Some evolutionary forms that are similar in principle may emerge not only at a breakthrough point, but may also result in a deadend – from the overall view of Big History. For example, the emergence of social forms of life took place in many phyla and classes – bacteria, insects, birds and mammals. Additionally, among insects, we can find rather high forms of socialization (see, *e.g.*, Reznikova 2011; Ryabko and Reznikova 2009; Robson and Traniello 2002). Despite the common trajectory and interrelation of social behaviors by these various life forms, there has been a large overall difference in the impact that each has had on the Earth.

What is more, as regards information transmission mechanisms, it appears possible to speak about certain 'evolutionary freaks'. Some of those mechanisms (in particular, the horizontal exchange of genetic information) were spread rather widely in the biological evolution of simple organisms but were later discarded (or transformed into highly specialized mechanisms, *e.g.,* sexual reproduction) among more complex organisms. Today, they are mostly confined to the simplest forms of life. We mean the horizontal exchange of genetic information (genes) among microorganisms, which makes many useful genetic 'inventions' literally a sort of 'commons' of microbe communities. Among the bacteria, the horizontal transmission of genes contributes to the fast development of antibiotic resistance (*e.g.*, Markov and Naymark 2009).

For the present article, the following turns out to be important: The horizontal exchange of genetic information (in its general function) is distantly similar to those forms of information exchange that became extremely important for social evolution – the direct borrowing of innovations and their introduction into social life. Hence, principles and mechanisms that appear of marginal relevance at a certain phase of Big History may turn out to be extremely important in a later phase.[1]

These parallels suggest that analysis of similarities and differences between the mechanisms of evolution may help us to understand the general principles of mega-evolution[2] and Big History in a much fuller way. They may also help us to better understand their driving forces and supra-phase mechanisms (mechanisms that operate in two or more phases of Big History). Our first article was devoted to the analysis of one such mechanism – *aromorphosis* (Grinin, Markov, and Korotayev 2011; also Grinin and Korotayev 2008, 2009a, 2009b; Grinin, Markov, and Korotayev 2009a, 2009b).

Let us return now to a comparison of biological and social evolution. It is important to describe similarities and differences between these two types of macro-evolution – at various levels and in various aspects. This is necessary because such comparisons tend to be deformed by conceptual extremes[3] and tend to be incomplete. These limitations are true even in respect of the above-mentioned paper by Mesoudi, Whiten and Laland (2006), as well as a rather thorough monograph by Christopher Hallpike (1986), *Principles of Social Evolution*. There, Hallpike offers a fairly complete analysis of similarities and differences between social and biological organisms, but does not provide a clear and systematic comparison between social and biological evolution.

---

[1] Note that in the biological macroevolution the 'borrowing' is found mostly at lower levels of the biological evolution, whereas it is found much less frequently at higher levels. The opposite situation is observed in social macroevolution – in general, the older the society, the lower its borrowing rate (incidentally, this accounts to a considerable extent for a low rate of change in the majority of ancient societies).

[2] We denote as *mega*evolution all the process of evolution throughout the whole of Big History, whereas we denote as *macro*evolution the process of evolution during one of its particular phase.

[3] This is typical, for example, for a very interesting and controversial article by Mesoudi, Whiten, and Laland *Towards a Unified Science of Cultural Evolution* (2006), where we clearly deal with an attempt to impose the Darwinian methodology on the study of social evolution. The importance of the above-mentioned differences (including such fundamental differences as the absence in social evolution of a clear distinction between genotype and phenotype) is downplayed by a statement that those differences are either illusory or unimportant (*Ibid.:* 345). Such an approach also reduces the value of a rather interesting methodology that they propose.

Section 1. Biological and Social Organisms: A Comparison at Various Levels of Evolution

There are a few important and understandable differences between biological and social macro-evolution, nonetheless, it is possible to identify a number of fundamental similarities. One may single out at least three basic sets of shared factors.

- First of all, there are similarities that stem from very complex, non-equilibrium, but stable systems whose principles of function and evolution are described by General Systems Theory, as well as by a number of cybernetic principles and laws.
- Secondly, we are not dealing with isolated systems but with a complex interaction between organisms and their external environment. As a result, the reaction of systems to external challenges can be described in terms of general principles that express themselves within a biological reality and a social reality.
- Thirdly, it is necessary to mention a direct 'genetic' link between the two types of macro-evolution and their mutual influence.

It is important to emphasize that similarity between the two types of macro-evolution does not imply commonality. Rather significant similarities are frequently accompanied by enormous differences. For example, the genomes of chimpanzees and the humans are 98 per cent similar. However, there are enormous intellectual and social differences between chimpanzees and humans that arise from the apparently 'insignificant' variations between the two genomes.[4]

It appears reasonable to continue the comparison between the two types of macro-evolution on the basis of the analysis used by Hallpike, who singles out the following **similarities between social and biological organisms** (Hallpike 1986: 33):

1. 'The institutions of societies are interrelated in a manner analogous to the organs of the body, and preserve their continuity despite changes of individual membership, just as individual cells are renewed in organs.'
2. 'There is a specialization of organic functions analogous to the social division of labor.'

---

[4] It appears appropriate to mention that the genomes of the humans and the chimpanzees differ by ten major genome reorganizations. A few years ago it turned out to be possible to sequence the genome of the rhesus macaque (a special issue of the *Science* was devoted to this subject; see in particular Rhesus Macaque... 2007). This is the third primate genome that was sequenced (after the human and chimpanzee genomes). Up to that moment, when detecting differences between the genomes of the humans and the chimpanzees, specialist could not determine which of those differences emerged in the human evolutionary line, and which appeared in the evolutionary line of the chimpanzees. The reading of the rhesus macaque genome substantially facilitated this task. The comparison with the macaque genome allowed detecting that three of those differences happened in the human evolutionary line, whereas the other seven occurred in the evolutionary line of the chimpanzees (see Markov and Naymark 2009 for more detail).

3. 'In both cases self-maintenance and feedback processes occur.'

4. 'There are adaptive responses to the physical environment.'

5. 'In organisms we find the transmission of matter, energy, and information analogous to trade, communication, *etc.,* in societies.'

According to Hallpike, **societies are unlike organisms in the following respects** (Hallpike 1986: 33–34):

1. 'They are not physical entities at all, since their individual members are linked by information bonds, not by those of a purely physical nature.'

2. 'Societies are not clearly bounded, *e.g.,* two societies may be distinct politically, but not culturally or religiously.'

3. 'Societies do not reproduce, so that cultural transmission from generation to generation is indistinguishable from general processes of self-maintenance.'[5]

4. 'Societies are capable of metamorphosis to a degree only found in organic phylogeny.'

5. 'The individual members of a society, unlike cells, are capable of acting with purpose and foresight, and of learning from experience.'

6. 'Structure and function are far less closely related in societies than in organisms.'

Hallpike also comes to the sound conclusion that similarities between social and biological organisms are in general determined by similarities in organization and structure (we would say similarities between different types of systems). As a result, Hallpike believes that one can use certain analogies when institutions can be represented as similar to some organs. In this way, cells may be regarded as similar to individuals; central government similar to the brain, and so on. Spencer (1898) and Durkheim (1991 [1893]) are important representatives of this tradition.[6] Hallpike also has sufficient grounds to add Alfred Radcliffe-Brown and Talcott Parsons.

When comparing biological species and societies, Hallpike (1986: 34) singles out the following similarities:

1. 'Species, like societies, do not reproduce.'

2. 'Both have phylogenies and metamorphosis.'

3. 'Both are composed of competing individuals.'

He also singles out the following difference: '*Unlike* species, however, societies are organized systems, whereas species are simply collections of individual organisms' (*Ibid.*).

---

[5] However, there are cases when societies create new societies rather similar (with basically the same 'memotype') to the 'maternal' ones, for example, with the establishment of settler colonies. See the next section for more information on the differences in ways of information transmission.

[6] See also Heylighen's (2011) contribution to the first issue of the Almanac.

Further, Hallpike tries to demonstrate that, because of such differences between biological and social organisms,[7] the very idea of natural selection does not appear to be very productive with respect to social evolution. We believe that his proofs are not very convincing, although they make some sense in certain respects. In addition, his analysis is concentrated mostly at the level of an individual organism and an individual society. He hardly moves at the supra-organism level (though he, of course, discusses the evolution of species). We believe that with this, Hallpike (notwithstanding his desire to demonstrate the sterility of the application of Darwinian theory to social evolution) involuntarily amplifies the effect of similarity between biological and social evolution, because the analogy between the biological organism and society (as Hallpike admits himself) is rather salient indeed.

On the other hand, Hallpike does not take into account the point in social evolution where a few substantially new supra-socium levels of development emerge. We contend that it is very important to consider not only evolution at the level of a society but also at the level above individual societies, as well as the point at which both levels are interconnected. The supra-organism level is very important, as regards biological evolution (but, perhaps, less so in respect to social evolution). Thus, it might be more productive to compare societies with ecosystems rather than with organisms or species. However, this would demand the development of special methods, as in this case it would be necessary to consider the society not as a social organism, but as a part of a wider system, which includes the natural and social environment.[8]

We identify the following differences between the social and biological evolution.

A. At the Level of an Individual Society and an Individual Biological Organism

1. As Hallpike (1986: 33) notes, societies are capable of such rapid evolutionary metamorphoses that they were not observed in the pre-human organic world. However, social systems are not only capable to change and transform, they are also capable to borrow innovations and new elements.

2. They may be also transformed consciously and with a certain purpose. Such characteristics are absent in natural biological evolution in any form.

3. In the process of social evolution the same social organism may experience radical transformation more than once.

---

[7] Because the systems of transmission of traits within biological and social systems are rather different; because of the higher degree of complexity of social systems, and so on.

[8] See Lekevičius 2009, 2011 for more detail on the problems of the evolution of ecosystems. Note that one of those articles, in addition, contains a discussion of analogies between the evolution of ecosystems and the evolution of capitalist society.

4. Key information transmission differs significantly in biological and social evolution (we shall consider this point in more detail in the next Section).

5. In biological evolution, the acquired characteristics are not inherited; thus, they do no not influence the biological evolution that proceeds very slowly. This point will be also considered in more detail in the next section.

6. It appears very important to note that, though biological and social organisms are significantly (actually 'systemically') similar, they are radically different in their capabilities to evolve. The biological organism does not evolve by itself; evolution may only take place at a higher level (population, species, *etc.*), whereas social evolution can often well be traced at the level of an individual social organism. What is more, it is frequently possible to trace the evolution of particular institutions and subsystems within a social organism.

B. As Regards the Results of Social/Natural Selection

1. Biological evolution is more additive (cumulative) than substitutive; put in another way: 'the new is added to the old'. In contrast, social evolution (especially during the two recent centuries) is more substitutive than additive: 'the new replaces the old' (Grinin, Markov, and Korotayev 2008, 2011).

2. Since social evolution is different from biological evolution, in respect of mechanisms of emergence, fixation and diffusion of evolutionary breakthroughs (aromorphoses), this leads to long-term restructuring in size and complexity of social organisms. It is important to note that, in contrast to biological evolution, where some growth of complexity is also observed, such social reorganization becomes continuous. In recent decades, societies that do not experience a constant and significant evolution look inadequate and risk extinction. In addition, size of societies (and systems of societies) tends to grow constantly through more and more tightly integrative links (this trend has become especially salient in recent millennia), whereas the trend towards increase in the size of biological organisms in nature is rather limited and far from general.

3. Within social evolution, we observe the formation of special suprasocietal systems that also tend to grow in size. This can be regarded as one of the results of social evolution and serves as a method of aromorphosis fixation and diffusion.

C. At Supra-organic (Suprasocietal) Level

As a result of the above-mentioned differences, within the process of social evolution, we observe the formation of two types of special suprasocietal systems: A) amalgamations of societies with varieties of complexity that have analogies to biological evolution; B) emergence of elements and systems that do not belong to any society, in particular that lack many analogies to biological evolution.

Naturally, type B needs a special comment. The first type of supra-organic amalgamation is rather typical not only for social but also for biological evolution.[9] However, within biological evolution, amalgamations of organisms with more than one level of organization[10] are usually very unstable and are especially unstable among highly organized animals.[11] Within social evolution, we observe the emergence of more and more levels: from groups of small sociums to humankind as a whole. Of course, it makes sense to recollect analogies with social animals: social insects, primates and so on. Neither should we forget to compare society with the individual biological organism but also with groups of organisms bound by cooperative relationships. Such groups are widely present among bacteria and even among viruses.

It should be noted that modern biologists have developed well respected theories that account for the emergence of intragroup cooperation and altruism, including competition, kin selection, group selection and so on (see, *e.g.*, Reeve and Hölldobler 2007). However, it is not clear if societies should be really compared with groups of organisms rather than individual organisms, whether we should not consider societies within the system of numerous intersocietal links?

In any case, it is clear that the level of analysis is very important for comparison of biological and social evolution. Which systems should be compared? Such analogies are more frequent when society (the social organism) is compared to a biological organism or species. However, in many cases, it may turn out to be more productive to compare societies with other levels of the biota's system organization: with populations, ecosystems and communities, with particular structural elements or blocks of communities (*e.g.,* with particular fragments of trophic networks or with particular symbiotic complexes), with colonies (with respect to colonial organisms), or finally – and this is the closest analogy – with groups of highly organized animals (cetaceans, primates, and other social mammals or termites, ants, bees and other social insects).

Thus, here we are confronting a rather complex and hardly studied methodological problem: which levels of biological and social processes are most congruent? What are the levels whose comparison could produce the most interesting results? In general, it seems clear that such an approach should not be a mechanical equation of 'social organism = biological organism' at all times and

---

[9] There is, however, a major difference: any large enough society usually consists of a whole hierarchy of social systems (*e.g.,* with respect to a typical agrarian empire these would be: nuclear family – extended family – clan community – village community – primary district – secondary district – province), so that it can hardly be compared with a single biological organism (though both systems can still be compared functionally, as is correctly noted by Hallpike [1986]).

[10] We could mention various flocks and packs of animals as examples of such amalgamations with one level of organization.

[11] More complex superorganic amalgamations may be found in the biological evolution among less complex organisms. This trend seems to be opposite to what is observed in the social evolution, though, say, village communities in more complex societies tend to be less complex than in more simple ones (see, *e.g.*, Korotayev 1995; 2003: 75–90; Korotayev *et al.* 2000, 2011).

in every situation. The comparisons should be operational and instrumental. That means that we should choose the scale and level of social and biological phenomena, forms and processes that are adequate for their respective tasks.

We would say again that sometimes it is more appropriate to compare an individual biological organism with a society, whereas in other cases it could well be more appropriate to compare a society with a community (of, say, ants or bees), a colony, a population or a species. We believe that the issue of the 'presence' of the social ontogenesis (and its comparison with the biological ontogenesis) should be studied in this framework (Grinin, Markov, and Korotayev 2008: ch. 6 for more detail). However, there are some cases when it seems more appropriate to compare social ontogenesis with biological phylogenesis. Hence, different scales and types of scientific problems need special approaches. This subject will be discussed further in the subsequent section of the present article.

Section 2. Similarities and Differences at the Level of Evolutionary Mechanisms

1. Biological and Social Aromorphoses

In certain respects, it appears reasonable to consider biological and social macro-evolution as a single macro-evolutionary 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). We believe that many similarities and differences in laws and driving forces in the biological and social phases of Big History can be comprehended more effectively if we apply the concepts of biological and social aromorphosis. As our contribution to the first issue of the *Evolution* Almanac (Grinin, Markov, and Korotayev 2011) was devoted to aromorphoses and their regularities, in our present article we shall restrict ourselves to a summary of some principal concepts.

Aromorphosis is understood by Russian biologists along the lines suggested by Alexey 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. As a result, a few quite reasonable definitions of aromorphosis have been proposed, for example:

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

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

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

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

The concept of aromorphosis (or its analogue) does not appear to have been worked out with respect to social macro-evolution. We believe that the adaptation of this notion for the theory of social macro-evolution could be an important step forward for the development of this theory itself, and for the general theory of macro-evolution.

The matter is, 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 completely. 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. Moreover, one may also compare this with Ervin László's idea that the application of 'evolution' as the basic notion opens the way toward the rapprochement of sciences (see, *e.g.*, László 1977).

The social aromorphosis can be defined as a universal / widely diffused social innovation that raises social systems' complexity, adaptability, integrity and interconnectedness (Grinin and Korotayev 2007a, 2009b; Grinin, Markov, and Korotayev 2008). Social aromorphoses lead to the following results:

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

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

c) increase in the degree of intersocietal integration, formation of special stable super-systems (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 super-complex maximum super-systems (world-systems, the World System and, finally, humankind as a single system), in whose framework each particular social system (while remaining autonomous) becomes a component of such a super-system and develops within it, through specialization, inter-system functional differentiation.

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

- 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;
- state formation that led to a qualitative transformation of all 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 and science;
- transition to iron metallurgy;
- formation of developed market systems that laid the basis for the industrial revolution;
- invention of computer technologies.

Each of these aromorphoses had a number of important consequences that contributed to an increase in the potential of success for the adopting societies for increasing the carrying capacity of their territories and heightening the stability of their systems. Often these aromorphoses were of evolutionary importance too.

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

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

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

A similar pattern is observed within social macro-evolution. An example is the invention of iron metallurgy. Iron production was practiced sporadically in the 3rd millennium BCE, but regular production of low-grade steel began in the mid-2nd millennium BCE in Asia Minor (see, *e.g.*, Chubarov 1991: 109) within the Hittite kingdom, which guarded its monopoly. Diffusion of iron technology led to revolutionary changes in different spheres of life: one can observe a significant progress in plough agriculture and consequently in the agrarian system as a whole (Grinin and Korotayev 2006); an intensive development of crafts; the transformation of barbarian societies into civilizations; the formation of new types of militaries that were made up of massed forces armed with relatively cheap but effective iron weapons; the emergence of significantly more developed systems of taxation as well as information collection and processing systems that were necessary to support those armies.

In this regard, the difference between social and biological aromorphoses is similar to the difference between the overall patterns of both types of macroevolution:[12] the development of biological aromorphoses tends to contribute to an increase in biodiversity, whereas the diffusion of social aromorphoses tends (but just tends!) to lead to the replacement of more simple social forms with more complex ones. Thus, with the diffusion of iron technologies, all the societies that confronted this diffusion had to borrow iron technology, otherwise they risked being absorbed or destroyed by those societies that possessed it.

The application of the notion of biological and social aromorphosis has helped us to detect a number of regularities and rules that are common for biological and social evolution – 'payment for the arogenic progress', 'special conditions for the aromorphosis emergence', and so on. Such rules and regularities are similar for both biological and social phases of Big History. However, as they have been already considered in detail in our contribution to the first issue of this Almanac, we shall not analyze them in the present article.

2. On the Peculiarities of Key Information Transmission at Various Phases of Big History

Replication on the basis of the matrix principle is a fundamental feature of all forms of life (see, *e.g.*, Timofeev-Ressovsky *et al.* 1969: 15–16). However, the process of such replication cannot be conducted with a 100 per cent accuracy; hence, the replication of a complete genome without any errors is virtually impossible. That is why the emergence of practically any new biological organism is accompanied by random change in genes (*i.e.*, mutations). However, a significant change of the genotype occurs extremely rarely. Yet, the role of mutations in biological evolution is extremely important and very well known, because the mutations are one of the main sources providing 'raw materials' for evolution (see *Ibid.*: 72).[13]

However, it is important to emphasize that the number of distortions by which transmission of information is accompanied from generation to generation within social evolution (especially in complex societies) is orders of magnitude higher than that observed within biological evolution. There are grounds

---

[12] The biological evolution is predominantly additive/cumulative, whereas the social evolution is predominantly displacing (see above).

[13] However, there is also an opinion that the importance of mutations for evolution has been exaggerated, whereas the main source of new genetic material for major morphobiological reorganizations was provided by the gene duplication (see, *e.g.*, Shatalkin 2005: 30). The gene duplication may indeed be a source of new material; yet the studies that try to prove that the morphobiological reorganizations are, first of all, results of duplications have been conducted just for 15 years, and at the moment we are rather dealing with accumulation of data in this field, that is why we still prefer to keep to the classical point of view on the role of mutation in the process of biological evolution.

to maintain that the role of such 'distortions' in social macro-evolution tends to increase (in addition to conscious and purposeful alteration of cultural information). In the meantime, it appears that we observe just the opposite within biological macro-evolution. For example, among viruses and some bacteria, mutational variability is constantly necessary for their mere survival; on the other hand, in complex biological organisms, it is necessary only up to a very limited extent.

Within social evolution, some unconscious distortion of transmitted cultural information always takes place, which may be regarded to some extent as analogous to biological mutations.[14] This, by itself, may lead to certain socio-evolutionary shifts (Korotayev 1997, 2003; Grinin and Korotayev 2007b, 2009b). However, the conscious directed alteration of the information by its carriers is significantly more important. Though many are still sure that 'history never teaches anything to anybody', already the elites of many complex agrarian societies quite often tried to take into account errors made by their predecessors and to modify the 'socio-cultural genotype' accordingly in order to avoid them in future.

One may recollect, for example, the conscious alteration of the social position of the military elite by the founders of the Sung dynasty in China (960–1279 CE), in order to prevent the military coups that jeopardized the political stability of their predecessors (Wright 2001). Similarly, there was the conscious and purposeful replacement of traditional military systems with the modernized military systems of Western Europe by Peter the Great in Russia and Muhammad Ali in Egypt (see, *e.g.*, Grinin 2006a; Grinin and Korotayev 2009c, 2009d).

Thus, the major part of fixed socio-cultural alterations (supported by social selection) emerge not as a result of 'random errors of copying' (though, of course, such random errors do exist), but as a result of purposeful alteration of respective memes. Such 'mutations' are directional from the very beginning and do not seem to have any anologues in natural biological evolution.

3. On the Inheritance of Acquired Characteristics

The other (and perhaps even more important) difference is that, in the process of biological (but not social) evolution, the acquired characteristics are not inherited.[15] That is why socio-evolutionary changes are accumulated much faster than biologically useful changes of phenotype determined by mutation processes.

---

[14] Close results are arrived at by Dawkins (1993) in his theory of the 'evolution of memes'.

[15] As one of the differences between social and biological evolution is connected with the absence in the former of clear equivalents of genotype and phenotype (see, *e.g.*, Mesoudi, Whiten, and Laland 2006: 344–345), it appears quite evident that the expressions 'sociocultural genotype' and 'sociocultural phenotype' should be regarded as metaphors rather than as exact scientific terms.

Thus, because the acquired characteristics do not influence biological evolution, biological evolutionary processes go extremely slowly (in comparison with social evolution). On the other hand, within social evolution, the acquired characteristics can be inherited, and, hence, social evolution goes 'according to Lamarck' rather than 'according to Darwin'. This point has been noted many times by a number of evolutionists (see, *e.g.*, Mesoudi, Whiten, and Laland 2006: 345–346). Consequently, social evolution proceeds much faster. In addition, as social evolution tended to go more and more 'according to Lamarck', it became more and more Lamarckian rather than Darwinian, which was one of the main factors for the acceleration of social evolution.

Still, it appears necessary to mention that in some rare cases one can observe the inheritance of acquired characteristics in complex biological organisms (Zhivotovsky 2002a). For example, somatic mutations may well be inherited in plants both with vegetative and sexual reproduction. In animals, viruses can insert themselves into the genome of gametes – subsequently the offspring inherit quite an 'acquired characteristic', the virus infection. The ability to inherit acquired characteristics is found in many plant-eating insects, in which specialized symbiotic bacteria live. Biochemical and ecological characteristics of such symbiotic complexes are determined up to a very large extent by bacteria (see, *e.g.*, Dunbar *et al.* 2007).

The possibility of inheritance of acquired characteristics through special particles (pangenes) was proposed by Darwin (1883) himself. Within the genomes of complex biological organisms one can find a very large number of retropseudogenes and even working copies of genes that emerged as a result of the 'copying' of genetic information from RNA molecules to the chromosome with special enzymes (such genes are characterized by the absence of introns). Thus, in biological evolution, one may observe the 'copying' into the genome of information on the structure of mature matrix RNA. Because the alternative splicing is quite a controlled process, regulated by the cell and subject of intermediate influence of external conditions (see, *e.g.,* Lareau *et al.* 2007), mature mRNA may actually carry some (albeit rather incomplete and fragmentary) information on 'acquired phenotypic characteristics', and this information may be transmitted to the genome of the germ line.

The impossibility of genetic inheritance 'according to Lamarck' postulated by the Synthetic Theory of Evolution is because the mechanism of reverse translation does not appear to have emerged. That is why there is no way for changes that occur in an organism during its lifetime, at the level of proteins, can be recorded back into the genome.[16] On the other hand, at present, we know

---

[16] On the other hand, there is a hypothesis that such a mechanism may have existed at the earliest phases of biological evolution. What is more, scientists have experimentally obtained RNA molecules that can perform certain stages of reverse translation (Nashimoto 2001).

that the phenotype at the cellular level is determined not only by proteins, but also by a great variety of functional RNAs, whereas intravital changes of those molecules may well be written into the genome because here the mechanism of reverse transcription exists and is rather widely spread in biological organisms (including complex organisms). Hence, the point is not that within the biological evolution the 'Lamarckian' inheritance is totally impossible; rather the point is that such an inheritance is rather disadvantageous in most cases (see also Steele *et al.* 2002; Zhivotovsky 2002b). Consequently, such an inheritance is not usually an important mechanism of evolution (and, especially, of arogenic evolution).

For example, it is evident that the hereditary fixation of adaptive modifications ('modification genocopying') is disadvantageous in many cases. Note that this includes those very consequences of the organ exercise whose inheritance played such an important role in Lamarck's theory. In order for an adaptive modification to appear, we should observe first a genetically determined capability for such a modification (*e.g.,* the muscles' ability to grow as a result of exercise or the lymphocytes' ability to develop immunity against new pathogens). However, if such a genetically determined ability has appeared, the firm fixation in the genotype (the *genocopying*) of only one of many possible versions of the final state of the trait (*e.g.,* a precise size of a muscle or an immunity toward a specific pathogene) will not be a progressive evolutionary change; it will be a degenerative evolutionary change, accompanied by a decrease of the organic complexity and a loss of one of the ontogenetic regulatory circuits. In biological evolution, such events take place rather frequently, but this is not the arogenic evolutionary pathway.

Within social evolution, there is no significant difference in the inheritance mechanisms between those traits that have been inherited from 'ancestral' societies and the ones that have been acquired throughout the history of existence of a given society. There could be some insignificant difference as regards the firmness of the fixation of the respective alterations, the easiness of their acceptance, and so on, but it is impossible to say that acquired social characteristics are transmitted to new generations with significantly more difficulties (especially in complex societies).

A serious obstacle for the operation of the 'Lamarckian' mechanism can be seen in traditionalism, which holds negative attitudes toward innovation and glorifies everything inherited from ancestors. This was very typical for simple traditional societies. However, such attitudes have weakened in a significant way in modern complex social systems.[17] This might be connected with the de-

---

[17] On the other hand, we observe another trend in connection with some sorts of regulation mechanisms. One should not think that the only evolutionary mechanism in social evolution is a conscious change of existing objects. There is also an opposite trend that may be denoted as institutionaliza-

velopment of the means, methods and technologies of forecasting, which is the conscious evaluation of innovation. Forecasting makes those characteristics that might be considered dangerous or disadvantageous by traditionalists to become acceptable in a society, in particular: (1) a very low precision of the 'memotype' replication (the memotype concept will be dicussed in more detail below) and (2) 'Lamarckian' inheritance.

4. On the Nature of Hereditary Variation

Hereditary variation is a key issue in the theory of evolution. This is the issue, around which the main discussions between representatives of various schools of evolutionary thought (classical Darwinism, Synthetic Theory of Evolution, Orthogenesis, Nomogenesis, Neolamarckism and so on) are concentrated. *Variation is the main material basis of evolution; its character, mechanisms, factor, and emergence rates determine to a very high extent the character of the evolutionary process*. These mechanisms of variation are one of the most fundamental areas of difference between biological and social evolution.[18]

Starting with Darwin, biologists have based their evolutionary theories on the idea that hereditary variation is basically 'indeterminate' or undirected, that is, random. However, as we have noted, within biological evolution, one can still detect a trend toward a decrease of andomness, both in mutational and recombinational variation. In some sense, this trend continues into social evolution, where variation is even less random and more directed.[19]

---

tion. In many cases certain relationships are fixed by customs or laws in order to avoid excessive variation/equivocality that may often be harmful for a social system. For example, one could observe the development of rather rigid marriage institutions, various legal codes and constitutions that can be only altered with significant difficulties (that are usually consciously established by respective norms aimed at the provision of the stability of respective codes and constitutions). In this respect the trend toward the canalization of changes may be also traced in the social macroevolution.

[18] It appears that this is relevant not only for the biological and social phases of Big History, but also to all its preceding phases.

[19] When we make such comparisons, we compare genotype with that totality of sociocultural information (it may be denoted as 'memotype'), which is transmitted from generation to generation and determines main characteristics of social systems. In social systems, in addition to biological generations, parents and children, we find other types of continuity (that could be sometimes even more important) like institutional and legal continuity whose role increases constantly. That is, we observe the growth of the importance of information transmission in the framework of institutions, corporations, organizations, and so on, that is conducted not between biological generations (from parents to children), but, say, from an experienced worker to an inexperienced one, or from a teacher to a pupil. In addition the emergence of external information carriers (in form of books, electronic records, and so on) allows conducting a distance transmission of information without any direct contact between respective people, which, incidentally, contributes to the growth of the sociocultural evolution rate. Actually, as a result, in complex social systems the number of information transmission channels grows by orders of magnitude (especially with the emergence of external information carriers). In some sense, this growth already starts with the development of social life among the animals.

As mentioned above, there are significant differences between biological and social evolution in regard to the accuracy of copying (reproduction of replicators), because in general the precision of copying of genes (and, correspondingly, periods of their existence in a recognizable form) exceeds by orders of magnitude values of analogous indicators for memes. That is why ‘memetics’ (in contrast with genetics) has to deal with a much lower precision of replication and with a much higher speed of mutagenesis, though some replicators (memes) may have rather long periods of life.

For example, according to some recent estimates, roots of some most widely used words may be preserved in a recognizable form for about 10,000 (and even more) years of linguistic evolution (Pagel *et al.* 2007). Another example can be provided by ‘long-lived’ folklore-mythological motifs that can survive for dozens thousand years (see, e.g., Korotayev and Khaltourina 2011; Berezkin 2007; Korotayev 2006; Korotayev *et al.* 2006). The same can be said about a very long life of some technical methods, for example, the production of stone tools. However, it makes sense to distinguish between various types of information transmission, depending on the number of copies in which the information is stored and reproduced (as well as the forms of that reproduction).

There could be situations in which there is just a single carrier of important information. An ancient engineer could take his secrets of construction to the grave so that nobody could continue his techniques any more. There are lots of historical facts known to us from just one source; and if, in the process of transmission, there was distortion of the initial text, this could affect our current knowledge of the past. Those unique ancient books that disappeared in fire did not let us know the important information contained in them, and so on. These are examples of distortion or loss of information by functioning social systems.

It seems appropriate here to recollect the **information irreplaceability principle (Lyapunov principle)**. According to this principle, information that has entirely disappeared cannot be reconstructed in its entirety – what can be replaced are portions of information coming from a common source (see Rautian 1988a, 1988b). We confront a different case when we deal with information that is used by numerous carriers (as in the case of the use of a mass language). In such cases, changes in a living language should not be always regarded as information distortion; we should rather speak about some drift in the use of linguistic matrices and patterns (similar to gene drift in populations), because language carriers may well know older forms, but prefer new ones. One may even observe the coexistence of persons using differently linguistic forms and lexemes (similarly within one population there could be different phenotypes). However, with time, some forms win the competition and language changes.

When we speak about the accuracy of transmission of biological information, it is necessary to take into account that biological evolution has worked out rather effective molecular mechanisms that allow for sharply reduced precision of DNA replication when necessary (for example, *SOS-response* among bacteria).

For some primitive biological objects, such as viruses, too high a precision of replication can even be lethal; in order to successfully go through their life cycles they *need very low precision of replication* or, in other words, a very high rate of mutation (*mutagenesis*). For such organisms, evolutionary changes turn out to be necessary components of their everyday life! (Vignuzzi *et al.* 2005)

Generally, though, in biological evolution, replication accuracy increases rather than decreases with the growth of the organismal complexity. In this sense, the reduction of precision that is observed in the transition from biological to social evolution looks as if this were a 'step backward'. However, this observation is rather superficial, as it does not take into account the nature of those errors that emerge in the process of replication, notably the degree of their randomness/directionality.

Within biological systems, replication errors are basically random. Taking into consideration the decrease of randomness, this may be interpreted in the following way: Nature has not developed any biological mechanisms that allow us to forecast results of concrete genetic changes and to plan them. Though a cell (for example, a lymphocyte) may 'know' in advance that, in order to achieve a needed result, it should alter some particular part of the genome, it, however, lacks mechanisms that would allow it to forecast results of a concrete genetic alteration.[20] That is why, in the framework of biological evolution, the acceleration of adaptatio-genesis through a radical reduction of the precision of replication is a very expensive and risky strategy that can be afforded only by very primitive forms of life. The situation changes radically if the replication 'errors' become not random, but actually purposeful, based on forecast of the possible results of concrete changes introduced into the 'memotype' of a social system.

The presence of 'directed mutations' (in addition to undirected ones) **radically distinguishes the process of 'mutational variation' in the evolution of memes from what is observed within the evolution of genes, where ALL the mutations are basically undirected.**

That is why we believe that the difference between biological and social evolution in respect to randomness/directionality of hereditary variation is more fundamental than the differences in precision of replicator copying or mutation rate. In the process of 'sociocultural mutagenesis', the element of randomness is significantly smaller, because people possess the ability (albeit limited) to foresee results of certain concrete 'mutations'. That is why human creativity (say, in development of new judicial laws or new technologies) may differ qualitatively from the 'creativity' of biological evolution – especially, as regards the effectiveness and the speed with which the respective results are achieved.

On the other hand, one should not exaggerate the role of conscious planning in relation to social innovation. Random search, trial and error remains very im-

---

[20] Such a mechanism (in the form of scientific methods and genetic engineering) was finally developed in the course of sociocultural evolution; this mechanism, however, could still hardly be called perfect.

portant in social evolution (Grinin 1997, 2006b, 2007a, 2011a; Korotayev 2003), although there has been a clear decreasing trend in randomness in recent centuries (see, *e.g.*, Korotayev 1999, 2003, 2004; Korotayev, Malkov, and Khaltourina 2006; Grinin 1997, 2007a, 2009a). Thus, it is not sufficient just to have respective challenges in order that serious transformations could take place. Most societies 'respond' to new problems in old, habitual, tested and familiar ways, as they choose – not from a set of hypothetical alternatives – but from a set of accessible alternatives (Van Parijs 1981: 51). In other words, they use actually known measures instead of potential ones (Claessen 1989). In these situations, their behavior is often quite similar to that of social animals. Naturally, not all such 'responses' are effective. As a result, many societies perish, disappear or lose their independence (Grinin 2011a).

For example, after the Roman regiments were withdrawn from Britain in 410 CE, the Britons (Romanized British Celts) sought protection from the raids of their Irish and Scottish neighbors. They invited Saxons to defend them in return for plots of land in Britain. Actually, this was a variation of the very well-known Roman method 'to use barbarians to fight barbarians'. However, the Saxons, after they had seen the Britons military weakness, stopped obeying local authorities and became masters of the country (together with Angles and Jutes). In this way, the Britons, notwithstanding their fierce and long resistance, were partly evicted, partly destroyed and partly enslaved. As a result, barbarian Anglo-Saxon states were found in place of the state of the Britons (Blair 1966: 149–168; Chadwick 1987: 71; Philippov 1990: 77).

If we take into account general historical contexts, we see that an extremely small fraction of all responses to various challenges turned out to be capable of becoming sources for system aromorphoses. This implies that most societies turned out to be incapable to move to new qualitative levels: They did not have the necessary potential for change, their construction had certain 'defects', the system might have been too rigid to transform easily, or some necessary conditions were lacking, and so on (Grinin 2011a, 2011b; Grinin and Korotayev 2009e).

5. The Ability to Borrow and the Horizontal Exchange of Genetic Information

These facts illustrate a rather strange situation. There are similarities in biological and social evolution, such as the transmission of information, variability, community complexity, *etc.* However, these similarities occur at the lower stages of biological evolution (involving simple biological organisms), whereas they are absent in higher stages of biological evolution (involving complex biological organisms).[21]

---

[21] We do not have a full explanation of this phenomenon, but one may think about the application to the macro- and even megaevolution of **the law of the negation of the negation**, which in this

One of the main differences between social and biological evolution is the ability of social systems to not just change and transform, but also to borrow new elements. However, in this respect, social evolution resembles the biological processes that prevailed during the epoch of the 'prokaryotic biosphere' (and those processes continue up to the present among prokaryotes and monocellular eukaryotes). Among the prokaryotes, we find the ability to 'transform naturally' – to absorb DNA from the environment and to insert it into their genome, which leads to an immediate transformation of the phenotype. There is also, of course, a significant difference between this biological and social analogue: in society the borrowings are usually made consciously.

Horizontal gene transfer produces many useful genetic 'inventions', a sort of commons for microbe communities. For example, communities of marine planktonic microbes use the genes of proteorhodopsins – proteins that allow them to partly utilize sunlight. In contrast to the proteins that participate in real photosynthesis, proteorhodopsins do not need the help of many other specialized proteins. Thus, in order to acquire a useful function, it is sufficient for a microorganism to borrow a single gene (Frigaard *et al.* 2006).

Complex borrowing of entire gene systems is observed much less frequently, but when they occur, they have more significant consequences. An original and wide-spread version of such 'borrowing' results in the emergence of symbiotic systems, which sometimes actually leads to the formation of a new organism out of several other organisms. The role of such systems is often underestimated, but all functioning of the modern biosphere is based on them.

There are many examples. *Terrestrial plants* would not have been able to achieve evolutionary success without symbiosis with mycorrhizal fungi and nitrogen-fixing bacteria. *Herbivorous animals,* both insects and vertebrates, are unable to digest plant food without symbiosis with specialized microorganisms. Indeed, the principle ecological, biospheric role of animals is precisely to process plant food!

In highly complex biological organisms, in contrast to social organisms and human societies, large-scale 'borrowings' in the form of symbiotic relations or alien genetic material **rarely take place, but many of the most important aromorphoses are connected just with them.**

6. Analogues of 'Suprasocietal Institutions' in Biological Evolution

Let us come back to the question: Are there analogues of such structures in the evolution of the biosphere? The answer will depend on the level of the bio-

---

case may be interpreted in the following way: '*From a free borrowing of information to its rigid isolation and canalization, and then again to its free (but now conscious) borrowing'. 'From contraposition of biological (genetic) and social mechanisms of evolution (within the process of anthropogenesis and sociogenesis) to genetic evolution controlled by the humans.'*

sphere's system organization. Society is frequently compared with biological organisms, but – in this case – we are comparing supra-societal amalgamations with supra-organic systems: populations, species, ecosystems, groups of social animals, and so on. However, this is probably not quite an appropriate scale of analysis, so we need to compare suprasocietal institutions of a global scale (like the United Nations) with biological objects of immeasurably smaller scale, *e.g.,* with particular 'casts' of the ant family.[22]

At any scale, it is difficult to find good analogies to the formation of supra-societal institutions within biological evolution. This becomes even more evident if we compare societies, not with organisms, but with supra-organic biological systems (*e.g.,* populations or species). Although those biological systems (like societies) can amalgamate into systems of a higher order (ecosystems or the biosphere), these higher-order systems are not centralized but are weakly integrated – nothing like supra-societal institutions as the World Health Organization, UNESCO, or even a complex tribal confederation with its own supra-tribal regulation organs. For example, one can observe the formation of rather complex links between species in ecosystems; certain key species may produce a decisive influence on other species in the community, but this does not result in the formation of any 'supra-species institutions'.

On the one hand, it is possible to see in this comparison one of the fundamental differences between social and biological macro-evolution. On the other hand, some biological analogues of 'suprasocietal institutions' did emerge. In the Holocene (the last 10,000 years, starting with the Agrarian Revolution), human societies developed suprasocietal institutions. In the course of the socio-biological evolution of the resulting 'anthroposphere', we observe a parallel growth in the integration of humankind and integration and coordination of evolutionary changes of biological populations, species and ecosystems. In other words, the development of the global human community (the World System) may be regarded as a factor of integration of biological evolution at its upper level.

Thus, social and biological evolution are related processes that supplement and maintain each other. Indeed, there is a tendency toward their fusion into a single complex process, one leading to the development of an 'anthropo-biosphere'. In this respect, it appears to be possible to speak about the co-evolution of biological and social development.

7. On the Role of Selection in Biological and Social Evolution

The role of selection in social evolution differs significantly from the one in biological evolution. In the biological world, the main source of stable, herita-

---

[22] On the other hand, a large anthill or termitary may well be compared with a large village community.

ble innovations (mutational and recombinational variation) is characterized by a high degree of randomness and unpredictability. Although, of course, it is also necessary to take into consideration all the above-mentioned qualifications about the means of optimization. In this situation, 'post factum selection', the selection among the deviations that have already emerged and have found their realization in the phenotype, becomes the only way to give the process a certain directionality (in this case – to secure the additive character of changes).

In the social world, the main sources of heritable innovations are not random errors of copying and reproduction but conscious and purposeful correction and alteration of memes. However, such purposefulness is unable to foresee not only all the consequences of its actions but even the near consequences. That is why intentional actions may appear random. Throughout human history, failures of some societies have been a sort of payment for the success of others (what we denote as 'a rule of payment for the arogenic progress'), from which the role of selection in the search for successful aromorphic variants acquires an especially important meaning (Grinin, Markov, and Korotayev 2011; Grinin 1997, 2007a; Grinin and Korotayev 2009b). Societies frequently confront such situations when an old system does not work. Those who do not change or look for more effective means perish.

Selection at the gene/meme level plays a less important role in social evolution than it does in biological evolution. However, selection in social evolution takes place not so much at the level of memes but more **at the level of organizations, institutions and social systems**. At the level of inter-societal competition, until recently, social selection acted in an especially tough way: 'the victor gets more or everything; the defeated may lose himself' (Grinin 2003, 2004, 2009a, 2009b, 2010, 2011a, 2011b). So, this is a selection mechanism that is rather different from the one found in biological evolution.

One more important aspect of social selection that is absent in biological evolution is the struggle for the selection of a certain model (model of reforms, model of unification, ideological model) at the level of individual societies, as well as at the inter-societal level. Everywhere, we can observe the selection of leaders, models, courses, central positions and so on. The decisive advantage could be rather different in different cases. In some cases, this could be a very capable and talented leader; in others this could be an advantageous geographic position; in still other situations this could be just a lucky contingency.

Thus, although we are dealing with rather different mechanisms of selection in biological and social evolution, their roles are very important in both cases. Still, within biological evolution, selection process is more important, because there is no alternative, whereas such an alternative exists within social evolution.

Section 3. Some Preconditions of the Transition from Biological to Social Macro-evolution

1. Social Evolution as a Logical Result of the Development of Adaptiogenesis Mechanisms

In addition to what has been already said about the organic links between biological and social evolution, one should consider another aspect of adaptiogenesis. The process of adaptation that constitutes the principal contents of biological evolution may proceed at different levels: 1) the organism structure; 2) its behavior; 3) structure and behavior of a socium as a superorganic amalgamation.

At all those levels, one may observe the transition from primary, primitive and slow methods of adaptiogenesis based on random mutations, recombination and selection to more progressive, effective and rapid ways of evolutionary change. **Not only organisms, species and societies evolve; mechanisms of** evolution evolve too. The general direction of this evolutionary movement may be characterized as a trend to the reduction of the role of random processes and the growth of systematic controlled processes. The initial and primary evolutionary algorithm is the random search, the trial-and-error method. However, at all levels of adaptiogenesis, one may observe a gradual development of such mechanisms that decrease the role of randomness and, thus, optimize this algorithm; though it appears impossible to exclude entirely an element of randomness either from biological or from social evolution.

1) The organism structure level. Even at the basic level of biochemistry, physiology and morphology, many forms of life have developed ways of adaptiogenesis that are faster and more effective than the random search conducted according to the scheme of 'random mutations + selection'. One of these mechanisms is regulation of the mutagenesis rate, depending on available conditions: under favorable conditions, the mutagenesis rate is low; in unfavorable conditions it increases (Grinin, Markov, and Korotayev 2008: ch. 6, §6.8).

It is also appropriate to mention epigenetic changes of hereditary material that are transmitted to a number of generations, in particular parental genomic imprinting that became especially developed in the most complex organisms, such as mammals and flowering plants (Jablonka and Lamb 1999). Imprinting is actually a sort of purposeful manipulation of hereditary properties of offspring. With the maturation of male and female gametes, certain parts of the genome are marked in a special way, for example through methylation. The methylation of DNA is not a chaotic process but is regulated by complex molecular systems. What is especially important is that methylation of particular nucleotides increases the probability of their mutating. Thus, through the methylation (or non-methylation) of particular nucleotides, the cell can in principle regulate the probability of their mutation (Vanyushin 2004).

Another example of the purposeful change of hereditary information is provided by the development of adaptive (acquired) immunity through combining genetic blocks, subsequent somatic hypermutation, and clonal selection. Both the combining of DNA fragments (V-(D)-J recombination) and hyper-mutation are processes that are only partly random. In other words, the limits of randomness in this case are rather accurately demarcated (Grinin, Markov, and Korotayev 2008: ch. 4, §4.2.4). The combination of DNA fragments is conducted from a precisely defined set and the hyper-mutation takes place at a rather accurately demarcated part of a gene, while the selection of lymphocyte clones makes the whole process unequivocally directional. As a result, the final outcome of such a 'sequence of random events' turns out to be quite deterministic.

Such a mechanism may be designated as '**optimized** random search'.[23] Note that in the case of the acquired immunity, from a 'technical' point of view, the achieved result may well be transmitted to the offspring, for example, via the mechanism of reverse transcription and transmission of the genetic material from lymphocytes to gametes through endogenous retroviruses (Steele *et al.* 2002). However, this does not happen, because it is more advantageous to transmit not a concrete immunity to a particular pathogen to the offspring but a universal capability to develop immunity against any pathogen.

In general, such mechanisms of purposeful genome alteration do not have a universal presence in biological organisms, and the overwhelming majority of mutations take place in a quite random way.

Biologists rarely consider that assortative (selective) mating, mediated sometimes through extremely complex mechanisms of mate-choice, is nothing but an extremely effective mechanism for management of recombinational variation. However, in the real biological world, absolutely unselective, random mating is hardly ever observed. Indeed, random mating is a scientific abstraction, like an 'ideal gas', or an 'absolutely dark body'. With growth in the level of organization of biological organisms, the complexity and effectiveness of mate-choice also grew, whereas the recombinational variation became less random as a result.

2) Level of individual behavior. One can trace the transition from predominantly hereditary and genetically determined behavioral patterns to more flexible learning-based ones. As we saw above, in the case of immunity, it was more advantageous to transmit to the offspring a universal capability to 'learn'

---

[23] In this way, a more flexible reaction to unknown situations develops; this may be compared with multifunctional institutions in human societies that while remaining apparently the same institutions may allow social systems to behave differently in different situations, whereas respective institutions would experience certain changes with the change of situations. Thus, army may be relatively small during the time of peace, and then it would grow sharply in size as a result of mobilization, whereas its functions also substantially change. The same can be said about the flexibility of the family, the village community and many other social groups and institutions.

instead of a rigidly determined means of resistance to a particular pathogen. In an analogous way, in the general course of evolution, it has turned out to be more advantageous to transmit the ability to learn rather than to transmit rigidly fixed behavioral stereotypes.[24] No doubt, the emergence of the capability to learn is a major aromorphosis, though it is very stretched over time. Even unicellular organisms have some inchoate abilities to learn (sensitization, habituation), let alone such highly organized animals as ants or bees.

3) Biological socium level (social adaptiogenesis). A wide variety of living organisms – from bacteria to mammals – lead a social way of life. The socium as a whole has certain system characteristics that can be more or less adaptive (Popov 2006). Here, we also observe the transition from rigidly genetically determined forms of social relationships to more flexible versions, within which a social system may adequately (adaptively) react to changes in its environment. For example, the size of subsidiary colonies of an anthill may change in a reasonable, that is, adaptive way, depending on resource availability (Zakharov 1978: 49). However, in general, for all the pre-human forms of life, such possibilities are limited. The human development of the ability to evolve socially, which implies the possibility of an almost limitless change in the structure of social systems, appears to be a natural (though qualitatively higher) continuation of this evolutionary trend.

2. One of the 'Preadaptations' that Facilitated the Transition from Biological to Social Evolution

The issue of how biological evolution transformed into social evolution is among the most important questions of Big History and Evolutionary Studies. What 'preadaptations' were needed for the transition from biological to social evolution? This is a very complex subject. And here we shall restrict ourselves to consideration of just one of those preconditions.

Social macro-evolution became possible due to the emergence of an uniquely human ability denoted as 'ultra-sociality' (Boyd and Richerson 1996). This is only found among humans and designates the ability to change their social organization radically and almost limitlessly in response to internal and external challenges. Only humans are capable of forming collectivities that could be entirely different as regards their structure, their traditions, their norms of behavior, their modes of subsistence, their systems of intragroup relationships, their family types, *etc.*

---

[24] It appears necessary to note that in both cases the ability to learn does not replace entirely the genetically determined concrete adaptations; the former is added to the latter. In the immunity system of higher organisms, the system of innate immunity is preserved in addition to a new system of adaptive (acquired throughout the life) immunity; similarly, in the behavior of higher animals, behavioral patterns developed throughout the life through the learning are combined with innate genetically determined behavioral traits.

Whatever the complexity of the collectivities of non-human primates, they do not have such flexibility. Each species usually has only one type of social organization; some cultural differences are observed, but they are incomparable with the ones observed in *Homo sapiens sapiens*. Yet, some animals possess a limited ability to adaptively change the structure of their socium. For example, in disadvantageous circumstances, one may observe growth in the rigidity of social hierarchy (the 'power vertical'), whereas the relationships become more egalitarian under more favorable conditions. Sometimes the transition to a social way of life occurs during unfavorable conditions, whereas the same animals may return to solitary life with improvement of conditions (Popov 2006). Those adaptive modifications of social structure in animal communities are still significantly inferior in their scale to what is observed in human societies; in addition, among other animals, they are characterized by a much higher degree of predictability.

The emergence of ultra-sociality was a natural result of the preceding *co-development of intellect and social relations* among our ancestors. The progressive development of the brain and intellectual capacities in primates is inseparably linked with a social way of life – with the necessity to predict actions of other members of their group, to manipulate them, to learn from them, to achieve an optimum combination of altruism and egoism in their behavior. At present, this is the point of view of the majority of primatologists (*e.g.*, Byrne and Whiten 1988; Byrne and Bates 2007).

The idea that the primates intellect developed first of all for, say, effective search for fruit (the 'ecological intellect hypothesis') does not now have many supporters. It cannot explain why primates need such a large brain, if many other animals, such as squirrels, perfectly manage similar tasks, though their brain remains small. In contrast, the 'social intellect hypothesis' is supported by facts. Scientists have detected a significant positive correlation between brain size in primates and the size of their social groups (Dunbar 2003). It is necessary to note that primates (in contrast to the majority of other social animals) know all the members of their group 'by sight' and have particular relationships with each of them. There are grounds to maintain that individualized pair relationships are the most intellectually 'resource-intensive' (Dunbar and Shultz 2007).

A positive feedback appears to have existed between the development of a social intellect and the growth of complexity in social relationships of hominids.[25] Those individuals that managed to achieve a higher status within a social hierarchy, due to a higher intellect or a better ability to foresee actions of others, left more numerous offspring, which in turn led to the general intellectual growth of the socium. As a result, in subsequent generations, in order to move

---

[25] This social intellect is also called the 'Machiavellian intellect', *e.g.*, Byrne and Whiten 1988.

up the social ladder, it was necessary for individuals to possess an even more developed social intellect, and so on.

Interesting experimental facts have been recently obtained. They indicate that intellectual abilities of a 'social' character, which allow for resolution of social tasks, developed in our ancestors earlier in comparison with the intellectual capabilities of the other types (*e.g.,* the ones that allow to solve 'physical' and instrumental tasks) (Herrmann *et al.* 2007).

In order to function effectively in a complex, constantly changing socio-cultural environment, our pre-human ancestors had to develop intellectual abilities of a rather concrete type: abilities of effective communication, learning and – most importantly – of understanding not only actions, but also thoughts and desires of members of their groups (Vygotsky 1978). It is quite evident that abilities of this kind should become apparent in early childhood, in the period of active learning and social adaptation. There are two alternative hypotheses about possible mechanisms in the evolutionary development of these social abilities.

The first hypothesis suggests that they emerged as a result of the uniform development of the intellect as a whole (*general intelligence hypothesis*). The second suggests that this was the directed development of specific socially-oriented abilities, whereas all the other abilities (such as abilities to think logically, to detect cause-and-effect links in the physical world, and so on) developed later, as something additional and secondary. This is called the *cultural intelligence hypothesis* (Barkow *et al.* 1992; Shettleworth 1998; Herrmann *et al.* 2007).

At first glance, the *general intelligence hypothesis* looks more plausible, but, it is also possible to provide evidence in support of the *cultural intelligence hypothesis*. For example, it is known that specific intellectual abilities develop locally in many animals, but their overall intellectual level does not grow (or grows insignificantly). One can mention, for example, the birds' unique orientation abilities (Shettleworth 1998). Special experiments have been conducted in order to test these hypotheses.

The experiments were based on the following reasoning: If the *cultural intelligence hypothesis* is true, then there should be an age in the individual development of humans when we are not different in our 'physical' intellect from the apes, even though we are already far above them in our 'cultural-social' intellect. Experiments have confirmed the *cultural intellect hypothesis*: it turns out that 2.5 year old children have the same level of development as adult chimpanzees and orangutans in respect to solving physical tasks (spatial, quantitative, detection of cause-and-effect relationships, and so on), but they are significantly superior as regards the effectiveness with which they solve tasks of a social nature, such as those connected with the prediction of others' actions, communication, learning, and so on (Herrmann *et al.* 2007).

In general, present-day anthropological data suggests the following:

1) The development of social relationships and intellectual abilities in the higher primates (in general) and the hominids (in particular) proceeded within a single evolutionary process that was accelerated by the above-mentioned positive feedback;

2) This process tended to lead to the growth of complexity and flexibility of social relationships. Thus, the development of ultra-sociality and the ability to evolve socially within one of the groups of primates was a natural and logical result of the development of a trend that started among the primates long before the emergence of *Homo sapiens sapiens*.

Afterword. The Formation of Social Evolution's Own Mechanisms

The transition from the biological to social phase of Big History was a very complex process that we do not quite understand even now. *Within this transition it appears possible to speak about a phase change of a few subtypes of macro-evolution: the biological type of macro-evolution was first transformed into the biological-social type, then the biological-social type was transformed into the social-biological type; and, finally, the latter was transformed into the social type of macro-evolution already in the framework of the unequivocally human society* (see Grinin and Korotayev 2009b: ch. 1 for more details).

In the course of anthropogenesis, biological macro-evolution was transformed into bio-social evolution. The discoveries of recent decades have moved the dating of the emergence of our species deep in the past to about 200,000 BP.[26] However, the borderline around 50,000 – 40,000 BP still retains an immense importance. This is the point from which we can speak with a complete confidence about humans of a contemporary cultural type, in particular about the presence of full-fledged languages, as well as 'really human' culture (*e.g.*, Bar-Yosef and Vandermeersch 1993: 94). There is, of course, some hypothesis that human language appeared long before 50,000 – 40,000 BP. Although this is contested by other scientists, everybody agrees that by 40,000 BP language existed wherever humans lived (*e.g.*, Holden 1998: 1455).

Richard Klein, an anthropologist from Stanford University proposes the following hypothesis to explain the gap between the emergence of anatomically modern *Homo sapiens sapiens* and the emergence of language and cultural artifacts that took place much later. According to Klein, the modern brain is a result of rapid genetic changes. He hypothesizes that such changes took place around 50,000 BP, pointing out that the affluence of cultural artifacts starts just after

---

[26] See, *e.g.*, Stringer 1990; Bar-Yosef and Vandermeersch 1993; Pääbo 1995; Gibbons 1997; Holden 1998; Culotta 1999; Kaufman 1999; White *et al.* 2003; Lambert 1991; Zhdanko 1999; Klima 2003: 206.

that date, as well as the migration of anatomically modern humans out of Africa (see Zimmer 2003: 41ff.). Thus, the emergence of *Homo sapiens sapiens* did not automatically result in social macro-evolution proper.

We believe that the evolutionary driving forces were still mostly biological when modern humans first emerged, but that the social forces gradually increased their importance and prevailed over the biological ones at a certain point. Naturally, this was a rather prolonged process, within which the breakthrough point could hardly be identified. We contend that the social component became dominant after 50,000 – 40,000 BP. However, it did not become absolutely dominant, as biological adaptation and physical anthropological transformation continued in many important ways. The point is that they did not disappear, but their role significantly decreased.[27]

This transition to modern human society is sometimes denoted as the *Upper Paleolithic Revolution*. If we use the title of the book by Mellars and Stringer (1989), we may call this radical transformation: *The Human Revolution*. Thus, starting with the Upper Paleolithic Revolution, we may speak about *the transition from socio-biological evolution to social evolution*, a process that was finalized by the Agrarian Revolution.

There were not many major aromorphoses in the hunter-gatherer epoch (Grinin 2006b, 2009a), which is why the overall rates of socio-evolutionary processes were slow and their directionality rather vague. *Such a type of social macro-evolution may be denoted as socio-natural.* As a result of a system of inter-related aromorphoses connected with the agrarian revolution, one could observe the transition to the socio-historical type of macro-evolution. As a result of this, social macro-evolution changed its algorithm in a rather significant way, resulting in modification of certain evolutionary laws. We shall consider below how the significance of laws of evolution and the process of social macro-evolution changed as a result of the Agrarian Revolution.

Main factors of social change in foraging societies were the result of adaptation to new and various environments – from the deserts of Australia to the pack ice of the Arctic. This was only possible through the modification of socio-cultural systems. This made it possible for humans to people most of the world's landmass, to create an enormous variety of tools and crafts, as well as social and other institutions. Effective adaptations let people not only survive, but also live ‘comfortable’ lives that Sahlins (1972) called the *original affluent society*. The character of human relations with their environment varied significantly,

---

[27] There are sufficient grounds to maintain that the biological evolution of the humans did not stop 200–150,000 BP; it did not stop either after the Upper Paleolithic Revolution (see, *e.g.*, Alexeev 1984: 345–346; 1986: 137–145; Yaryghin *et al.* 1999, vol. 2: 165; Borinskaya 2005; Borinskaya and Korotayev 2007). Thus, the above-mentioned factor must have played some role in the biosociocultural evolution of *Homo sapiens sapiens*.

but generally these were ones of human adaptation to the natural world (see, *e.g.*, Leonova and Nesmeyanov 1993; see also Grinin 2006b: 82–83).

In the agrarian epoch, the character of those inter-relations changed significantly through the transition to much more conscious and effective change of the environments at a rather wide scale (irrigation, clearing of forests, plowing of steppes, soil fertilization, construction of cities, roads and so on). Natural forces (animal, wind and water energy) started to be used on a much wider scale (earlier humans actively used only fire). Natural raw materials started to be transformed into entirely new products (metals, fabrics, ceramics, glass).

Thus, within social evolution process a more and more significant role started to be played by peculiarly social factors that (in contrast with natural factors) are connected to conscious goal-setting and goal-achieving. Gradually, with economic-technological progress, the growth of surplus accumulation capacities, as well as general cultural complexity of social systems, their evolution became almost purely social. As a result, the 'vector' of evolutionary selection turned out to be directed toward societal capabilities to adapt to social (rather than natural) environments, which implies the capacity to compete with neighboring social systems in economic, military, commercial, cultural, ideological and other spheres.

Finally, we would like to mention the following important changes in the 'algorithm' of social evolution:

- *The start of the mechanism for resource accumulation.*

In the tens of thousands of years of the human foraging epoch, long-term material resource accumulation was relatively insignificant when compared to subsequent epochs. There was, of course, a certain amount of accumulation, of knowledge, traditions and technologies, albeit at a limited scale. This accumulation took place not in every society, but was observed on the global stage and was due to the overall demographic growth, increase in numbers of social systems, emergence of new tools, products, *etc.* There was practically no special accumulation sector prior to the Agrarian Revolution[28] (see in particular Artzrouni and Komlos 1985; Grinin 2007b).

In many cases, people could produce more than they actually needed, and sometimes even so-called 'original affluent societies' could emerge (Sahlins 1972). For example, with respect to the gatherers of sago in New Guinea, people would spend a minor part of their time securing food for themselves, whereas they would spend the rest of the time at other activities and leisure (Shnirel'man 1983, 1989). The impossibility to accumulate and/or the absence of the desire to accumulate slowed down development, which contrib-

---

[28] With a possible exception of some highly specialized hunters (usually of large aquatic animals), gatherers, and fishers – for example, some social systems described ethnographically for the North-Western Coast of America (see, *e.g.*, Averkieva 1978; Shnirelman 1986).

uted to the slow speed of social evolution (Grinin 2006b, 2009a). *In simple social systems of agriculturalists and pastoralists, the emergence of the possibility (and, later, the desire) to accumulate led to numerous transformations in the spheres of functional differentiation, distribution, social stratification, exchange, trade, development of property relationships, increasing political complexity and so on.*

- *Strengthening of the ability of social systems to change.*

Agrarian societies turned out to be more capable of serious social transformations than hunter-gatherers, while complex agrarian societies turned out to be much more capable of such transformations than simple agriculturalist and pastoralist systems. The growth of social systems' ability to change provides a vivid demonstration of the main difference between social and biological evolution – that humans were capable of consciously transforming their social systems, with preconceived goals.

- *Intersocietal contacts become the leading factor of social evolution.*

The importance of various contacts increased sharply, and this contributed to a more active adaptation of social systems to their environments. The growth of the role of contacts dramatically raised the importance of external social driving forces (Grinin 1997–2001 [1997/2: 23]; 2007a: 177). Note that this had an enormous importance for the development of the World System and for humankind as a whole. Military and other interactions stimulated improvements in administration, defense, culture, technology and so on. All this contributed to development of a single global process involving numerous societies and peoples.

It is also appropriate to note that the growth of societal size is not only due to natural demographic growth, but is more importantly due to the integration and unification of social systems. Thus, external contact factors become most important with respect to societal evolution.

References

Alexeev V. P. 1984. *Formation of the Mankind.* Moscow: Politizdat. *In Russian* (Алексеев В. П. *Становление человечества*. М.: Политиздат).

Alexeev V. P. 1986. *Ethnogenesis*. Moscow: Vysshaya shkola. *In Russian* (Алексеев В. П. *Этногенез*. М.: Высшая школа).

Artzrouni M., and Komlos J. 1985. Population Growth through History and the Escape from the Malthusian Trap: A Homeostatic Simulation Model. *Genus* 41(3–4): 21–39.

Averkieva Yu. P. 1978. The Indians of the Northwest Coast of the North America (the Tlingit). *The North American Indians* / Ed. by Yu. P. Averkieva, pp. 318–360. Moscow: Progress. *In Russian* (Аверкиева Ю. П. Индейцы северо-западного побережья Северной Америки (Тлинкиты). *Североамериканские индейцы* / Ред. Ю. П. Аверкиева, с. 318–360. М.: Прогресс).

Barkow J. H., Cosmides L., and Tooby J. (Eds.) 1992. *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*. New York, NY: Oxford University Press.

Bar-Yosef O., and Vandermeersch B. 1993. Modern Humans in the Levant. *Scientific American* April: 94–100.

Berezkin Yu. E. 2007. *Myths Populate America. Areal Allocation of Folk Motive and Early Migration to the New World*. Moscow: OGI. *In Russian* (Березкин Ю. Е. *Мифы заселяют Америку. Ареальное распределение фольклорных мотивов и ранние миграции в Новый Свет*. М.: ОГИ).

Blair P. H. 1966. *Roman Britain and Early England 55 B.C. – A.D. 871*. New York – London: W. W. Norton and Company.

Borinskaya S. A. 2005. The Role of Genetic Factors in Social Evolution. *History and Complexity Studies: Methodology of the Study* / Ed. by S. Yu. Malkov and A. V. Korotayev, pp. 62–75. Moscow: KomKniga/URSS. *In Russian* (Боринская С. А. Роль генетических факторов в социальной эволюции. *История и синергетика: Методология исследования* / Ред. С. Ю. Малков, А. В. Коротаев, с. 63–75. М.: КомКнига/ URSS).

Borinskaya S. A., and Korotayev A. V. 2007. Genes, Peoples and Sociocultural Evolution. *History and Mathematics: The Analysis and Modeling of Sociohistorical Processes* / Ed. by S. Yu. Malkov, L. E. Grinin, and A. V. Korotayev, pp. 232–242. Moscow: KomKniga/URSS. *In Russian* (Боринская С. А., Коротаев А. В. 2007. Гены, народы и социокультурная эволюция. *История и Математика: анализ и моделирование социально-исторических процессов* / Ред. С. Ю. Малков, Л. Е. Гринин, А. В. Коротаев, с. 232–242. М.: КомКнига/ URSS).

Boyd R., and Richerson P. J. 1996. Why Culture is Common, but Cultural Evolution is Rare. *Proceedings of the British Academy* 88: 77–93.

Byrne R. W., and Bates L. A. 2007. Sociality, Evolution, and Cognition. *Current Biology* 17(16): R714−R723.

Byrne R. W., and Whiten A. (Eds.) 1988. *Machiavellian Intelligence*. Oxford: Oxford University Press.

Chadwick N. 1987. *The Celts*. London: Penguin.

Chubarov V. V. 1991. Middle Eastern Locomotive: Development Pace of Technique and Technology in the Ancient World. *The Archaic Society: The Main Problems of Development Sociology* / Ed. by A. V. Korotayev and V. V. Chubarov. Vol. 1, pp. 92–135. Moscow: Institute for History, Academy of Sciences, USSR. *In Russian* (Чубаров В. В. Ближневосточный локомотив: Темпы развития техники и технологии в древнем мире. *Архаическое общество: Узловые проблемы социологии развития* / Ред. А. В. Коротаев, В. В. Чубаров. Т. 1, с. 92–135. М.: Ин-т истории АН СССР).

Claessen H. J. M. 1989. Evolutionism in Development. *Vienne Contributions to Ethnology and Anthropology* 5: 231–247.

Claessen H. J. M. 2000. Problems, Paradoxes, and Prospects of Evolutionism. *Alternatives of Social Evolution* / Ed. by N. N. Kradin, A. V. Korotayev, D. M. Bondarenko, V. de Munck, and P. K. Wason, pp. 1–11. Vladivostok: FEB RAS.

Culotta E. 1999. A New Human Ancestor? *Science* 284: 572–573.

Darwin C. 1883. *The Variation of Animals and Plants under Domestication.* 2nd ed., rev. New York: D. Appleton.

Dawkins R. 1993. *Selfish Gene.* Moscow: Mir. *In Russian* (Докинз Р. *Эгоистичный ген*. М.: Мир).

Dobzhansky T., Ayala F. J., Stebbins G. L., and Valentine J. W. 1977. *Evolution*. San Francisco, CA: W. H. Freeman.

Dunbar H. E., Wilson A. C. C., Ferguson N. R., and Moran N. A. 2007. Aphid Thermal Tolerance is Governed by a Point Mutation in Bacterial Symbionts. *PLoS Biology* 5(5): e96.

Dunbar R. I. M. 2003. The Social Brain: Mind, Language, and Society in Evolutionary Perspective. *Annual Review of Anthropology* 32(1): 163–181.

Dunbar R. I. M., and Shultz S. 2007. Evolution in the Social Brain. *Science* 317: 1344–1347.

Durkheim E. 1991 [1893]. *On Social Division of Labor. A Sociological Method.* Moscow: Nauka. *In Russian* (Дюркгейм Э. *О разделении общественного труда. Метод социологии.* М.: Наука).

Frigaard N.-U., Martinez A., Mincer T. J., and DeLong E. F. 2006. Proteorhodopsin Lateral Gene Transfer between Marine Planktonic Bacteria and Archaea. *Nature* 439: 847–850.

Futuyma D. J. 1986. *Evolutionary Biology*. 2nd ed. Sunderland, MA: Sinauer Associates.

Gibbons A. Y. 1997. Chromosome Shows that Adam was an African. *Science* 278: 804–805.

Grinin L. E. 1997. Formations and Civilizations. Chapter 2. *Filosofia i obschestvo* 2: 5–89. *In Russian* (Гринин Л. Е. Формации и цивилизации. Глава 2. *Философия и общество* 2: 5–89).

Grinin L. E. 1997–2001. *Formations and Civilizations.* [The book was published in the Journal *Filosofia i obschestvo* in 1997–2001]. *In Russian* (Гринин Л. Е. *Формации и цивилизации.* [Книга печаталась в журнале *Философия и общество* с 1997 по 2001 г.]).

Grinin L. E. 2003. The Early State and Its Analogues. *Social Evolution & History* 2(1): 131–176.

Grinin L. E. 2004. Early State and Democracy. *The Early State, Its Alternatives and Analogues* / Ed. by L. E. Grinin, R. L. Carneiro, D. M. Bondarenko, N. N. Kradin, and A. V. Korotayev, pp. 419–463. Volgograd: Uchitel.

Grinin L. E. 2006a. The Transformation of the Egypt State System in the 19th – Early 20th Centuries: From Developed State to the Mature one. In *Egypt, Near East and Global World* / Ed. by A. P. Logunov, pp. 123–132. Moscow: Krankes. *In Russian* (Гринин Л. Е. Трансформация государственной системы Египта в XIX – начале

XX вв.: от развитого государства к зрелому. *Египет, Ближний Восток и глобальный мир* / Ред. А. П. Логунов, с. 123–132. М.: Кранкэс).

Grinin L. E. 2006b. *Productive Forces and Historical Process*. 3rd ed. Moscow: KomKniga. *In Russian* (Гринин Л. Е. *Производительные силы и исторический процесс.* Изд. 3-е. М.: КомКнига).

Grinin L. E. 2007a. The Problems of Analysis of Driving Forces of Historical Development, Social Progress and Social Evolution. *Philosophy of History: Problems and Prospects* / Yu. I. Semenov, I. A. Gobozov, and L. E. Grinin, pp. 148–247. Moscow: KomKniga/URSS. *In Russian* (Гринин Л. Е. Проблемы анализа движущих сил исторического развития, общественного прогресса и социальной эволюции. *Философия истории: проблемы и перспективы* / Ю. И. Семенов, И. А. Гобозов, Л. Е. Гринин, с. 148–247. М.: КомКнига/URSS).

Grinin L. E. 2007b. Production Revolutions as the Most Important Thresholds of History. *The Man and Nature: Confrontation and Harmony* / Ed. by E. S. Kulpin, pp. 191–221. Series 'Socionatural history. Genesis of Natural and Societal Crises in Russia'. Moscow: Publishing Analytical Centre 'Energy'). *In Russian* (Гринин Л. Е. Производственные революции как важнейшие рубежи истории. *Человек и природа: противостояние и гармония* / Ред. Э. С. Кульпин, с. 191–221. Серия «Социоестественная история. Генезис кризисов природы и общества в России». М.: Издательско-аналитический центр «Энергия»).

Grinin L. E. 2009a. *State and Historical Process. Political Cut of Historical Process*. 2nd ed. Moscow: LIBROCOM. *In Russian* (Гринин Л. Е. *Государство и исторический процесс: Политический срез исторического процесса.* Изд-е 2-е. М.: ЛИБРОКОМ).

Grinin L. E. 2009b. The Pathways of Politogenesis and Models of the Early State Formation. *Social Evolution & History* 8(1): 92–132.

Grinin L. E. 2010. *State and Historical Process. The Evolution of the Statehood: From an Early to a Mature State*. 2nd ed. Moscow: LIBROCOM. *In Russian* (Гринин Л. Е. *Государство и исторический процесс: От раннего государства к зрелому.* Изд. 2-е. М.: ЛИБРОКОМ).

Grinin L. E. 2011a. *State and Historical Process. The Epoch of the State Formation.* Moscow: Izdatelstvo LKI. *In Russian* (Гринин Л. Е. *Государство и исторический процесс: Эпоха формирования государства: Общий контекст социальной эволюции при образовании государства.* Изд. 2-е. М.: Изд-во ЛКИ).

Grinin L. E. 2011b. *The Evolution of Statehood: From Early States to Global Society.* Saarbücken: Lambert Academic Publishing.

Grinin L. E., Carneiro R. L., Korotayev A. V., and Spier F. (Eds.) 2011. *Evolution: Cosmic, Biological, and Social*. Volgograd: Uchitel.

Grinin L. E., and Korotayev A. V. 2006. Political Development of the World System: A Formal Quantitative Analysis. *History & Mathematics: Historical Dynamics and Development of Complex Societies* / Ed. by P. Turchin, L. E. Grinin, V. C. de Munck, and A. V. Korotayev, pp. 63–114. Moscow: KomKniga.

Grinin L. E., and Korotayev A. V. 2007a. Political Development of the World System: A Formal Quantitative Analysis. *History and Mathematics. Macrohistorical Dynamics of the Society and State* / Ed. by S. Yu. Malkov, L. E. Grinin, and A. V. Korotayev, pp. 49–101. Moscow: KomKniga. *In Russian* (Гринин Л. Е., Коротаев А. В. Политическое развитие Мир-Системы: формальный и количественный анализ. *История и Математика: макроисторическая динамика общества и государства* / Ред. С. Ю. Малков, Л. Е. Гринин, А. В. Коротаев, с. 49–101. М.: КомКнига).

Grinin L. E., and Korotayev A. V. 2007b. Social Macroevolution and Historical Process. *Filosofia i obschestvo* 2: 19–66; 3: 5–48; 4: 17–50. *In Russian* (Гринин Л. Е., Коротаев А. В. Социальная макроэволюция и исторический процесс. *Философия и общество* 2: 19–66; 3: 5–76; 4: 17–50).

Grinin L. E., and Korotayev A. V. 2008. Macroevolution and the World-System: New Facets of Conceptualization. *Istoriya i sovremennost* 1: 3–31. *In Russian* (Гринин Л. Е., Коротаев А. В. Макроэволюция и Мир-Система: новые грани концептуализации. *История и современность* 1: 3–31).

Grinin L. E., and Korotayev A. V. 2009a. Social Macroevolution: Growth of the World System Integrity and a System of Phase Transitions. *World Futures* 65(7): 477–506.

Grinin L. E., and Korotayev A. V. 2009b. *Social Macroevolution. Genesis and Transformations of the World System.* Moscow: LIBROKOM. *In Russian* (Гринин Л. Е., Коротаев А. В. *Социальная макроэволюция: Генезис и трансформации Мир-Системы.* М.: ЛИБРОКОМ).

Grinin L. E., and Korotayev A. V. 2009c. On Some Peculiarities of Social-Political Development of Ottoman Egypt (the 16th – 18th Centuries). *Vostok (Oriens)* 1: 46–62. *In Russian* (Гринин Л. Е., Коротаев А. В. О некоторых особенностях социально-политического развития османского Египта (XVI–XVIII вв.). *Восток* 1: 46–62).

Grinin L. E., and Korotayev A. V. 2009d. On the Typological Characteristics of Statehood of Ottoman Egypt (the 16th – 19th Centuries). *Vostok* 3: 35–51. *In Russian* (Гринин Л. Е., Коротаев А. В. О типологических характеристиках государственности в османском Египте XVI–XIX вв. (К постановке проблемы). *Восток* 3: 35–51).

Grinin L. E., and Korotayev A. V. 2009e. The Epoch of the Initial Politogenesis. *Social Evolution & History* 8(1): 52–91.

Grinin, L. E., Markov, A. V., and Korotayev, A. V. 2008. *Macroevolution in Wildlife and Society*. Moscow: LKI. *In Russian* (Гринин Л. Е., Марков А. В., Коротаев А. В. *Макроэволюция в живой природе и обществе*. М.: ЛКИ).

Grinin L. E., Markov A. V., and Korotayev A. V. 2009a. Aromorphoses in Biological and Social Evolution: Some General Rules for Biological and Social Forms of Macroevolution. *Social Evolution & History* 8(2): 6–50.

Grinin L. E., Markov A. V., and Korotayev A. V. 2009b. Aromorphoses in Wildlife and Society: An Experience of Comparing Biological and Social Forms of Macroevolution. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, A. V. Markov, and A. V. Korotayev, pp. 176–225. LIBROCOM). *In Russian* (Гринин Л. Е., Марков А. В., Коротаев А. В. Ароморфозы в живой природе и обществе: опыт сравнения биологической и социальной форм макроэволюции. *Эволюция: космическая,* *биологическая, социальная* / Ред. Л. Е. Гринин, А. В. Марков, А. В. Коротаев, с. 176–225. М.: ЛИБРОКОМ).

Grinin L. E., Markov A. V., and Korotayev A. V. 2011. Biological and Social Aromorphoses: A Comparison between Two Forms of Macroevolution. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 162–211. Volgograd: Uchitel.

Hallpike C. R. 1986. *Principles of Social Evolution.* Oxford: Clarendon.

Herrmann E., Call J., Hernàndez-Lloreda M. V., Hare B., and Tomasello M. 2007. Humans have Evolved Specialized Skills of Social Cognition: The Cultural Intelligence Hypothesis. *Science* 317: 360–366.

Heylighen F. 2011. Conceptions of a Global Brain: An Historical Review. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 274–289. Volgograd: Uchitel.

Holden C. 1998. No Last Word on Language Origins. *Science* 282: 1455–1458.

Jablonka E., and Lamb M. J. 1999. *Epigenetic Inheritance and Evolution: Lamarckian Dimension.* Oxford: Oxford University Press.

Kaufman D. 1999. *Archeological Perspectives on the Origins of Modern Humans. A View from Levant.* Westport, CT: Bergin & Garvey.

Klima B. 2003. The Period of *Homo Sapiens* of Modern Type till the Beginning of Food Production (Producing Economy): Overall Review (Except the Art). *History of Humanity.* Vol 1. *Prehistoric Period and the Origins of Civilization* / Ed. by Z. Ya. De Laat, pp. 198–207. Moscow: UNESCO. *In Russian* (Клима Б. Период *человека разумного* современного вида до начала производства пищи (производящего хозяйства): общий обзор (за исключением искусства). *История Человечества*. Т. 1. *Доисторические времена и начала цивилизации* / Ред. З. Я. Де Лаат, с. 198–207. М.: ЮНЕСКО).

Korotayev A. V. 1995. Mountains and Democracy: An Introduction. *Alternative Pathways to Early State* / Ed. by N. N. Kradin, and V. A. Lynsha, pp. 60–74. Vladivostok: Dal'nauka.

Korotayev A. V. 1997. *The Sabaean Essays. Some General Tendencies and Factors of Evolution of the Sabaean Civilization.* Moscow: Vostochnaya literatura. *In Russian* (Коротаев А. В. *Сабейские этюды. Некоторые общие тенденции и факторы эволюции сабейской цивилизации.* М.: Вост. лит-ра).

Korotayev A. V. 1999. Objective Sociological Laws and a Subjective Factor. *Vremya mira* 1: 204–233. *In Russian* (Коротаев А. В. Объективные социологические законы и субъективный фактор. *Время мира* 1: 204–233).

Korotayev A. V. 2003. *Social Evolution: Factors, Laws, Tendencies.* Moscow: Vostochnaya literatura. *In Russian* (Коротаев А. В. *Социальная эволюция: факторы, закономерности, тенденции*. М.: Восточная литература).

Korotayev A. V. 2004. *World Religions and Social Evolution of the Old World Oikumene Civilizations: A Cross-cultural Perspective.* Lewiston, NY: The Edwin Mellen Press.

Korotayev A. V. 2006. 'Midwest-Amazonian' Folklore-Mythological Parallels? *Acta Americana* 14(1): 5–24.

Korotayev A., Berezkin Yu., Kozmin A., and Arkhipova A. 2006. Return of the White Raven: Postdiluvial Reconnaissance Motif A2234.1.1 Reconsidered. *Journal of American Folklore* 119: 472–520.

Korotayev A., Kradin N., de Munck V., and Lynsha V. 2000. Alternatives of Social Evolution: Introductory Notes. *Alternatives of Social Evolution* / Ed. by N. N. Kradin, A. V. Korotayev, D. M. Bondarenko, V. de Munck, and P. K. Wason, pp. 12–51. Vladivostok: FEB RAS.

Korotayev A., Kradin N., de Munck V., and Lynsha V. 2011. Alternatives of Social Evolution: Introductory Notes. *Alternatives of Social Evolution* / Ed. by N. N. Kradin, A. V. Korotayev, and D. M. Bondarenko. 2nd ed., pp. 12–51. Saarbücken: Lambert Academic Publishing.

Korotayev A., and Khaltourina D. 2011. *Myths and Genes.* Moscow: LENAND/URSS. *In Russian* (Коротаев А. В., Халтурина Д. А. *Мифы и гены.* М.: ЛЕНАНД/URSS).

Korotayev A., Malkov A., and Khaltourina D. 2006. *Introduction to Social Macrodynamics: Compact Macromodels of the World System Growth.* Moscow: KomKniga/URSS.

Lambert D. 1991. *The Prehistoric Man. The Guide-book of Cambridge.* Leningrad: Nedra. *In Russian* (Ламберт Д. *Доисторический человек. Кембриджский путеводитель.* Л.: Недра).

Lareau L. F., Inada M., Green R. E., Wengrod J. C., and Brenner S. E. 2007. Unproductive Splicing of SR Genes Associated with Highly Conserved and Ultraconserved DNA Elements. *Nature* 446: 926–929.

László E. (Ed.) 1977. *Goals for Mankind. A Report to the Club of Rome on the New Horizons of Global Community.* New York, NY: Dutton.

Lekevičius E. 2009. On Some Analogues between Ecosystems' Evolution and Economical Development: From A. Smith and Ch. Darwin to the Newest Ideas. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, A. V. Markov, and A. V. Korotayev, pp. 226–259. Moscow: LIBROKOM. *In Russian* (Лекявичюс Э. О некоторых аналогиях между эволюцией экосистем и развитием экономики: от А. Смита и Ч. Дарвина до новейших идей. *Эволюция: космическая, биологическая, социальная* / Ред. Л. Е. Гринин, А. В. Марков, А. В. Коротаев, с. 226–259. М.: ЛИБРОКОМ).

Lekevičius E. 2011. Ecological Darwinism or Preliminary Answers to Some Crucial though Seldom Asked Questions. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 101–121. Volgograd: Uchitel.

Leonova N. B., and Nesmeyanov S. A. (Eds.) 1993. *The Problems of the Ancient Societies' Paleoecology.* Moscow: Russian Open Unversity. *In Russian* (Леонова Н. Б., Несмеянов С. А. (Ред.) *Проблемы палеоэкологии древних обществ.* М.: Российский открытый университет).

Markov A. V., and Naymark E. B. 2009. On Some Newest Achievements of Evolutionary Biology. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, A. V. Markov, and A. V. Korotayev, pp. 306–363. Moscow: LIBROCOM. *In Russian* (Марков А. В., Наймарк Е. Б. О некоторых новейших достижениях эволюционной биологии. *Эволюция: космическая, биологическая, социальная* / Ред. Л. Е. Гринин, А. В. Марков, А. В. Коротаев, с. 306–363. М.: ЛИБРОКОМ).

Mellars P., and Stringer C. (Eds.) 1989. *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*. Princeton, NJ: Princeton University Press.

Mesoudi A., Whiten A., and Laland K. 2006. Towards a Unified Science of Cultural Evolution. *Behavioral and Brain Sciences* 29: 329–383.

Nashimoto M. 2001. The RNA/Protein Symmetry Hypothesis: Experimental Support for Reverse Translation of Primitive Proteins. *Journal of Theoretical Biology* 209: 181−187.

Pääbo S. 1995. The Y-Chromosome and the Origin of All of Us (Men). *Science* 268: 1141–1142.

Pagel M., Atkinson Q. D., and Meade A. 2007. Frequency of Word-Use Predicts Rates of Lexical Evolution throughout Indo-European History. *Nature* 449: 717–720.

Philippov I. S. 1990. The Emergence of Feudalism in Western Europe. *History of the Middle Ages* / Ed. by Z. V. Udaltsova, S. P. Karpov, vol. 1, pp. 42–84. Moscow: Vysshaya skola. *In Russian* (Филиппов И. С. Возникновение феодального строя в Западной Европе. *История средних веков* / Ред. З. В. Удальцова, С. П. Карпов, т. 1, с. 42–84. М.: Высшая школа).

Popov S. V. 2006. The Problem of Adaptation in Social Structure Studies. *Jurnal obschey biologii* 67(5): 335–343. *In Russian* (Попов С. В. Проблема адаптивности при исследовании социальных структур. *Журнал общей биологии* 67(5): 335–343).

Rautian A. S. 1988a. Paleontology as a Source of the Data on Evolutionary Laws and Factors. *Modern Paleontology* / Ed. by V. V. Menner, and V. P. Makridin, vol. 2, pp. 76–118. Moscow: Nedra. *In Russian* (Раутиан А. С. Палеонтология как источник сведений о закономерностях и факторах эволюции. *Современная палеонтология* / Ред. В. В. Меннер, В. П. Макридин, т. 2, с. 76–118. М.: Недра).

Rautian A. S. 1988b. Dictionary of Terms and Subjects. *Modern Paleontology* / Ed. by V. V. Menner, and V. P. Makridin, vol. 2, pp. 356–372. Moscow: Nedra. *In Russian* (Раутиан А. С. Словарь терминов и наименований. *Современная палеонтология* / Ред. В. В. Меннер, В. П. Макридин, т. 2, с. 356–372. М.: Недра).

Reeve H. K., Hölldobler B. 2007. The Emergence of a Superorganism through Intergroup Competition. *Proceedings of the National Academy of Sciences of the USA* 104(23): 9736−9740.

Rensch B. 1959. *Evolution above the Species Level*. London: Methuen.

Reznikova Zh. 2011. Evolutionary and Behavioural Aspects of Altruism in Animal Communities: Is there Room for Intelligence? *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 162–211. Volgograd: Uchitel.

Rhesus Macaque Genome Sequencing and Analysis Consortium. 2007. Evolutionary and Biomedical Insights from the Rhesus Macaque Genome. *Science* 316: 222–234.

Robson S. K., and Traniello J. F. A. 2002. Transient Division of Labour and Behavioral Specialization in the Ant. *Formica schaufussi*. *Naturwissenschaften* 89: 128–131.

Ryabko B., and Reznikova Zh. 2009. The Use of Ideas of Information Theory for Studying 'Language' and Intelligence in Ants. *Entropy* 11(4): 836–853.

Sahlins M. D. 1972. *Stone Age Economics*. New York: Aldine de Gruyter.

Severtsov A. N. 1939. *Morphological Laws of Evolution.* Moscow – Leningrad: Academy of Sciences USSR. *In Russian* (Северцов А. Н. *Морфологические закономерности эволюции*. М. – Л.: АН СССР).

Severtsov A. N. 1967. *The Major Trend of Evolutionary Process.* 3^{d} ed. Moscow: Moscow University. *In Russian* (Северцов А. Н. *Главные направления эволюционного процесса*. 3-е изд. М.: Московский ун-т).

Severtsov A. S. 1987. Criteria and Conditions for Appearance of Aromorphic Organization. *Evolution and Biocenotic Crises* / Ed. by L. P. Tatarinov, and A. P. Rasnitsyn, pp. 64–76. Moscow: Nauka. *In Russian* (Северцов А. С. Критерии и условия возникновения ароморфной организации. *Эволюция и биоценотические кризисы* / Ред. Л. П. Татаринов, А. П. Расницын, с. 64–76. М.: Наука).

Severtsov A. S. 2007. Aromorphosis Formation. *Materials of the Conference 'Modern Problems of Biological Evolution'* / Ed. by A. S. Rubtsov, and I. Yu. Samokhina, pp. 30–31. Moscow: State Darwinian Museum. *In Russian* (Северцов А. С. Становление ароморфоза. *Материал конференции «Современные проблемы биологической эволюции»* / Ред. А. С. Рубцов, И. Ю. Самохина, с. 30–31. М.: Изд-во Государственного Дарвиновского музея).

Shatalkin A. I. 2005. Molecular Phylogenies – Revolutionary Breakthrough in Systematics. *Evolutionary Factors of Forming Animal World* / Ed. by E. I. Vorobyeva and B. R. Striganova, pp. 30–42. Moscow: KMK. *In Russian* (Шаталкин А. И. Молекулярные филогении – революционный прорыв в систематике. *Эволюционные факторы формирования разнообразия животного мира* / Ред. Э. И. Воробьева, Б. Р. Стриганова, с. 30−42. М.: КМК).

Shettleworth S. J. 1998. *Cognition, Evolution, and Behavior.* New York, NY: Oxford University Press.

Shmal'gauzen I. I. 1969. *Darwinism Problems.* Leningrad: Nauka. *In Russian* (Шмальгаузен И. И. *Проблемы дарвинизма.* Л.: Наука).

Shnirel'man V. A. 1983. Gatherers of Sago. *Voprosy istorii* 11: 182–187. *In Russian* (Шнирельман В. А. Собиратели саго. *Вопросы истории* 11: 182–187).

Shnirel'man V. A. 1986. Late Primitive Community of Farmer-Breeders and Advanced Hunters, Fishers and Gatherers. *The History of Primitive Society. The Epoch of* *the Primitive Tribal Community* / Ed. by Yu. V. Bromley, pp. 236–426. Moscow: Nauka. *In Russian* (Шнирельман В. А. Позднепервобытная община земледельцев-скотоводов и высших охотников, рыболовов и собирателей. *История первобытного общества. Эпоха первобытной родовой общины* / Ред. Ю. В. Бромлей, с. 236–426. М.: Наука).

Shnirel'man V. A. 1989. *Emergence of Producing Economy*. Moscow: Nauka. *In Russian* (Шнирельман В. А. *Возникновение производящего хозяйства*. М.: Наука).

Shopf J. W. 1981. Evolution of the First Cells. *Evolution* (the translation of a special issue of *Scientific American*) / Ed. by E. Mayr, F. Ayala, R. Dickerson *et al.*, pp. 109–148. Moscow: Mir. *In Russian* (Шопф Дж. У. Эволюция первых клеток. *Эволюция* (перевод тематического выпуска журнала *Scientific American*) / Ред. Э. Майр, Ф. Айала, Р. Дикерсон и др., с. 109–148. М.: Мир).

Spencer H. 1898. Principles of Sociology. *Complete Works.* Vol. 1. St. Petersburg: T-vo I. D. Sytina, Otd. N. A. Rubakina. *In Russian* (Спенсер Г. Основания социологии. *Соч.* Т. 1. СПб.: Т-во И. Д. Сытина, Отд. Н. А. Рубакина).

Steele E., Lindley R., and Blanden R. 2002. *What if Lamark is Wright? Immunogenetics and Evolution.* Moscow: Mir. *In Russian* (Стил Э., Линдли Р., Бланден Р. *Что, если Ламарк прав? Иммуногенетика и эволюция.* М.: Мир).

Stringer C. B. 1990. The Emergence of Modern Humans. *Scientific American* December: 68–74.

Tatarinov L. P. 1976. *Morphological Evolution of Theriodonts and General Questions of Phylogenetics.* Moscow: Nauka. *In Russian* (Татаринов Л. П. *Морфологическая эволюция териодонтов и общие вопросы филогенетики.* М.: Наука).

Timofeev-Ressovsky N. V., Vorontsov N. N., and Yablokov A. V. 1969. *Brief Essay on Evolution Theory.* Moscow: Nauka. *In Russian* (Тимофеев-Ресовский Н. В., Воронцов Н. Н., Яблоков А. В. *Краткий очерк теории эволюции.* М.: Наука).

Valentine J. 1981. Evolution of Multicellular Plants and Animals. *Evolution* (the translation of a special issue of *Scientific American*) / Ed. by E. Mayr, F. Ayala, R. Dickerson *et al.*, pp. 149–172. Moscow: Mir. *In Russian* (Валентайн Дж. Эволюция многоклеточных растений и животных. *Эволюция* (перевод тематического выпуска журнала *Scientific American*) / Ред. Э. Майр, Ф. Айала, Р. Дикерсон и др., с. 149–172. М.: Мир).

Van Parijs P. 1981. *Evolutionary Explanation in the Social Sciences: An Emerging Paradigm*. Totowa, NY: Rowman and Littlefield.

Vanyushin B. F. 2004. Materialization of Epigenetics, or Little Changes and their Big Consequences. *Himiya i zhizn* 2: 32–37. *In Russian* (Ванюшин Б. Ф. Материализация эпигенетики, или Небольшие изменения с большими последствиями. *Химия и жизнь* 2: 32–37).

Vignuzzi M., Stone J. K., Arnold J. J., Cameron C. E., and Andino R. 2005. Quasispecies Diversity Determines Pathogenesis through Cooperative Interactions in a Viral Population. *Nature* 439: 344–348.

Vygotsky L. S. 1978. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

White T. D., Asfaw B., DeGusta D., Gillbert H., Richards G. D., Suwa G., and Howell F. C. 2003. Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature* 423: 742–747.

Wright D. C. 2001. *The History of China*. Westport, CT: Greenwood.

Yaryghin V. N., Vasilyeva V. I. ***et al.*** **1999.** *Biology*. Moscow: Vysshaya shkola. *In Russian* (Ярыгин В. Н., Васильева В. И. и др. *Биология*. М.: Высшая школа).

Zakharov A. A. 1978. *Ants, Family, Colony*. Moscow: Nauka. *In Russian* (Захаров А. А. *Муравей, семья, колония*. М.: Наука. URL: http://evolution.powernet.ru/library/marav.htm).

Zhdanko A. V. 1999. Letter to the Editors. Remarks on Primordial History (Modern Data of Paleontology and Paleoarchaeology about Emergence of *Homo sapiens*. *Filosophia i obschestvo* 5: 175–177. *In Russian* (Жданко А. В. Письмо в редакцию. Заметки о первобытной истории (современные данные палеоантропологии и палеоархеологии о возникновении *Homo sapiens*). *Философия и общество* 5: 175–177).

Zhivotovsky L. A. 2002a. On Inheritance of Acquired Characteristics. *Materials of Academic Genetic Conference. February 26–27, 2002*, pp. 110–119. Moscow: Timiryazev Agricultural Academy. *In Russian* (Животовский Л. А. О наследовании приобретенных признаков. *Материалы научной генетической конференции. 26−27 февраля 2002 г.*, с. 110−119. М.: Изд-во Московской сельскохозяйственной академии им. К. А. Тимирязева).

Zhivotovsky L. A. 2002b. A Model of the Early Evolution of Soma-to-Germline Feedback. *Journal of Theoretical Biology* 216: 51–57.

Zimmer C. 2003. Great Mysteries of Human Evolution. *Discover* 24(9): 34–44.