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The Formation of Genetic Memory at Various Stages of the Evolution of the Earth

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Abstract

In geochemical, biological, technical, and civilizational systems, evolutionary events occur that bring systems to fundamentally new levels of complexity. The value of systems for the evolution of the Earth as a whole is growing. A physical mechanism and a carrier of genetic memory spontaneously arise, which makes it possible to reproduce complex structures against the background of their destruction by elemental forces. It is shown that genetic memory arises and is preserved according to similar scenarios in the most diverse systems.

Keywords: Evolution, Physical Mechanism, Genetic Memory, Genetic Code

Problem Formulation

Based on the ideas of quantum physics and physical chemistry, the mechanism of self-development of the model world, consisting of a set of amino acids, nitrogen bases, ATP molecules, and a neutral medium, was clarified [1]. If such a world is an open nonequilibrium system, then it spontaneously evolves. In it, under the influence of thermal motion, polypeptides and polynucleotides arise. Mutual correspondence is established between the emerging biopolymer texts by the forces of intermolecular interaction. This allows complex structures to recur over time, despite their constant destruction by thermal motion. We suggest calling the mechanism of memorization of complex structures **the genetic memory of evolution**.

A part of the genetic memory of the biological evolution is the genetic code, that is, a table of degenerate correspondence between codons and amino acids of proteins.

In the model world, each amino acid corresponded to a single nucleotide [1]. This could lead only to a very poor composition of polypeptides: four nucleotides encode texts of only four amino acids. In the real chemical world, long four-letter polypeptide texts played a decisive role. Even a single molecule of an amino acid with a complex radical significantly affects the biochemical processes in living matter. If the alphabet of four amino acids included amino acids with complex radicals, then they could become enzymes, under the influence of which the simple genetic code was converted into a modern code.

The idea of the similarity of evolutionary scenarios and the existence of a common evolutionary law for the entire material world was verified [2]. This idea was expressed by academician E.M. Galimov [3,4]. This assumption was tested on complex processes in the noosphere, up to the evolutionary formation of national, imperial and civilizational ideologies [2]. On the model of the ecological system, it was shown that an attempt to forcibly subjugate all civilizations to a single ideology is deadly for mankind [5].

We propose to trace how the material and spiritual world of planet Earth, moving along the stages of evolutionary development, creates and destroys the carriers of its genetic memory. It is argued that one of the conditions for sustainable life of structures valuable to evolution is the mechanism of destruction, that is, their death [6].

In order to fulfill the task, we recall the concept of evolution, as well as the details of the formation of genetic memory in the world of amino acids and nitrogen bases [3].

Evolution Concept

If an open nonequilibrium system consists of suitable objects and is in suitable conditions, then the process of ordering and complication takes place spontaneously in it [3,4]. This is the process of constructing complex structures from simple ones through their random collisions and manifestations of attractive-repulsive forces [7]. Only such a process will we call evolution. The meaning of this process is the construction of objects that more effectively affect themselves and the environment than the original objects. The unconscious goal of the evolutionary process is the transformation of an open nonequilibrium system into a new object, capable of entering into the processes of attraction-repulsion with other objects in order to further complicate the world. Thus, the goal of any stage of evolution is the further evolution of the world until the emergence of an object capable of understanding the laws of Nature for the prosperity of Nature itself. This object is Humanity. In it, Nature is trying to realize

itself, however, so far not too successfully. Nevertheless, we do not lose hope of success, since we have already partially realized the evolutionary potentials of Nature.

The Picture of the Formation of the Simplest Genetic Code in the World of Amino Acids and Nitrogen Bases

In the model world, the amino acid component can linearly develop completely independently, without paying attention to the presence of nitrogen bases [1]. The autocatalytic process of the formation of peptide bonds between amino acid molecules and peptide fragments can lead to the emergence of polypeptide texts of almost any length. However, these texts can be completely useless in terms of impact on themselves and the world around them. For example, the text AAAAAAA may occur, where A = alanine. Remembering and reproducing such texts is pointless from an evolutionary point of view. A careful examination of the physical interactions of the radicals of amino acid residues in the formation and destruction of peptide bonds showed [8,9] that simple texts tend to die out quickly under the influence of thermal motion, and complex texts tend to build up and accumulate. So at the lowest level of organization of the organic world, the mechanism of natural selection according to Darwin appears, however this is not a mechanism of evolution, but a mechanism of linear development.

The mechanism of evolution is a mechanism for creating and maintaining new valuable structures in history. In the world, the presence of nitrogen bases contributes to this [1]. A randomly generated complex polypeptide structure acts on a single nucleotide or on a fragment of a polynucleotide. For a relatively short time, attractive-repulsive forces collect complementary nucleotide structures on the surface of a complex polypeptide. A temporary complex arises in which the polypeptide acts as a catalyst for addition reactions for nucleotides. A complex nucleotide text appears. This text is not random, it strictly corresponds to the structure of the polypeptide. After thermal destruction of the complex, the initial polypeptide and polynucleotide of a fixed structure remain in the world. This structure is now the matrix on which, according to the key-lock rule, the products of the destruction of polypeptides are collected. So a new copy of the original polypeptide is synthesized and then separated. The released polynucleotide is now genetic memory for reproducing the original polypeptide text.

We notice that in this model world a rule has been revealed: randomly arising complex structures of one chemical class are repeated in history only due to the organization of their genetic information in a completely different chemical class.

Next, we will check with some examples whether this rule is implemented in other complex systems. We turn to examples from the biosphere, technosphere and noosphere.

Compartmentation as A Stage of the Evolutionary Process in the Chemical World

The described model chemical world can be quite adequate to the world of the early Earth with the finished Ocean. However, such a world does not have significant evolutionary perspectives. It is capable of only slowly linearly developing up to polymer structures resembling modern biopolymers. But this did not create the conditions for the transition of complex molecules to the discharge of living matter. For this, more complex physical conditions were needed on planet Earth and, most importantly, a rich chemical composition capable of evolutionarily developing under the influence of polypeptides [10]. In the framework of the scientific program "Evolution" of the Presidium of the Russian Academy of Sciences, it was suggested that the primary conditions for further evolution were created in micropores of weathered rocks on the shore of the Ocean. A tidal wave filled such pores with sea water containing future biopolymers along with ancient lipids. Low tide time ensured the synthesis of an independent lipid membrane. Such synthesis proceeded under the control of complex polypeptides present in a drop of water. At the same time, the complexity of polypeptides and their associated polynucleotides continued to increase in this fluid, up to the appearance of enzymes and their corresponding entries in the texts of DNA molecules. The next tidal wave carried out a free-floating drop of living matter protected by the lipid membrane.

Such an open nonequilibrium chemical system was a new stage in the evolution of the Earth. A drop protected by a permeable shell concentrated and retained a rich set of complex products from the previous stage of evolution. Such a drop was able to draw nutrients from the Ocean and convert them into the set of necessary amino acids with the help of enzymes.

We believe that in the current Ocean, the process of spontaneous emergence of complex polypeptides with random structures continues. But now this evolutionary process is prevented due to unleashing protein-hungry living unicellular and multicellular organisms. Thus, the memory of the primitive evolutionary scenario is now destroyed and irretrievably lost. However, in unicellular organisms, the synthesis of complex polynucleotides, which are genetic memory for complex enzymes that help the growth and division of living cells, proceeds more efficiently. So, a living cell writes to its DNA memory the entire evolutionary history of its origin and the instruction for its future reproduction. This memory carrier itself has nothing to do with the ordinary vital manifestations of a cell, except for the processes of doubling the DNA strand itself during cell division.

Now let's try to formulate a general evolutionary rule for the existence of genetic memory:

Genetic memory is formed simultaneously with the accidental occurrence of a new product valuable for evolution; however such a memory is stored in a separate structure, well protected from destruction.

The high security of the modern carrier of biological memory is confirmed by the experience of paleobiology and criminalistics. A living organism dies, but its DNA molecules remain available for research, identification, and even for a brief revival in the case of a simple organism.

Multicellular Life as the Most Protected Product of the Evolution of Living Matter

Let us repeat the thesis from the definition of evolution:

The unconscious goal of the evolutionary process is the transformation of an open nonequilibrium system into a new object, capable of entering into the processes of attraction-repulsion with other objects in order to further complicate the material world.

We can afford an essential detail. Before using a previously created object in a new evolutionary process, this object should be carefully preserved. Otherwise there will be nothing to use, and evolution will not take place.

A single cell is exposed to many dangers. It can be burned by ultraviolet radiation of the Sun, it can be oxidized by free oxygen, it can be frozen, it can be eaten by more deftly arranged cell. With this in mind, individual cells gathered in random conglomerates, adhered to each other. Some of the cellular associates revealed successful properties, and then the process of natural selection fixed such objects. However, a real evolutionary step occurred only after a significant historical time. A linear development was required so that as a result of the variability of protein structures and the corresponding DNA molecules, a reproduction program for a successful team was built.

Let us summarize the interim history of the living matter of the Earth. We may refer to a definition from materialistic philosophy: Life is a form of existence of protein bodies. We agree, but not completely. In the early Ocean, protein structures existed and developed. However this substance cannot be called living matter. The very existence of polypeptides was very poor. In order not to be completely disassembled into the starting amino acids, a polypeptide had to look for a happy meeting with the corresponding polynucleotide, which could float on the other side of the world. Then might spring up a carrier of genetic memory for this polypeptide, and the original polypeptide could die with full consciousness of the work done: it gave rise to the reproduction of the same complex structures. Compartmentation was a crucial evolutionary step, since genetic memory for a particular set of protein bodies has become encapsulated in the cell body. Now, a drop of living matter swam in the Ocean along with its genetic memory, with clear instructions for self-reproduction. This allowed the processes of cell reproduction to accelerate sharply against the background of their continuous death, Death [6]. We propose to supplement the definition from materialistic philosophy:

Life is a self-reproducing form of the existence of protein bodies in close interaction with the carrier of their own genetic memory.

Following the logic of Fukuyama, we could say that the emergence of multicellular organisms is the end of the history of living matter. Nature has not created anything more complex than the multicellular organism of the species Homo sapiens. The news in the history of organisms consisted only in the isolation of gametes with its single function - to direct the process of reproduction of the organism against the death of the same organisms. By trial and error, Nature has found a way to preserve successful organisms. Nature divided the carrier of genetic memory into two parts and hid the halves in the nuclei of different cells. The process of reproduction slowed down somewhat, but the offspring became viable, since there is little chance of simultaneous damage to two different cells before they accidentally meet.

The historical process of evolution of living matter did not end there, and we, like Fukuyama, would be mistaken with the end of history. In accordance with the general law of evolution, complex organisms have become the building material for a new stage of evolution. The forces of attraction and repulsion between organisms were revealed and associates of natural objects of a new level of complexity appeared. Our task is to find and describe the mechanisms of genetic memory formation for new stages of evolution.

Symbiosis as the Simplest Form of Association of Organisms

In symbiosis, a multicellular organism, when combined with another organism, receives some benefit and survives better under adverse conditions. Often another organism is more prosperous. Organisms in such a compound do not mix their genomes. Therefore, under favorable conditions, symbiosis breaks up, and each of the partners leaves with its own genome and with its own protein life. Where is the storage medium that, when the conditions worsen, again recognizes a suitable partner? This is the whole biochemical mechanics of each of the partners, which is adapted to effective interaction at the time of a chance meeting. The genetic memory of a symbiotic object is not built in an act of evolution, it is a random gift to all partners during their evolutionary development.

Let us examine with examples how this is consistent with the definition of evolution.

Lichens

The algae drying out from waterlessness is carried by the wind and accidentally stumbles upon a mushroom starving in harsh conditions. It eats the already dying cells of algae, but provides living cells with moisture accumulated in itself. Algae cells are illuminated by the Sun, synthesize sugar, which is used to build new cells and feed the fungus. Both organisms are pleased with themselves and with each other. A colony appears in which both organisms reproduce independently, thanks to the conditions created by them for each other.

The combination of two objects into a more complex object occurs when the algae accidentally sticks to the fungus. In fat years, when the environment becomes moist and well-lit, the algae will quickly grow and stick to the fungus.

There are no significant changes in the structures of the two combined objects. However, a substantial streamlining of the material world takes place, a new structure with outstanding vitality appears (lichen lives in the harsh conditions of the Arctic for up to 4000 years), and the release of some fungal products into the environment contributes to the formation of scarce Arctic soils. This efficiency of a new natural object fits well with the concept of evolution.

Ecosystem

On the basis of the extended Lotty – Volterra model, a computer simulation of processes in the forest-herbivore-predator-hunter ecosystem was performed [5]. It is shown that on the basis of this model processes in the system of countries with different political and economic organizations can be analyzed. Different countries can be named as follows: Resource Exporters, Predators, Hunters. It was found out that the fate of such a system substantially depends on the diversity among Predators, Victims and Resources. An ecological disaster can occur in the system if only one species of Herbivores is included in it and if one species of Predators eats them all. In this extreme case, only one forecast is possible - All Predators will quickly die of hunger, and the Hunters will have nothing to do there. A system is in dynamic equilibrium if its Flora and Fauna are very diverse. By Flora we mean a system of non-aggressive countries similar to Slavic countries, and by Fauna we mean a system of liberal robbers of foreign Resources, as well as Hunters for foreign finance. A catastrophe can happen in the political ecosystem if all Slavic countries are persuaded to become liberal democracies. Then they will liberally allow the experienced colonialists to plunder their resources in order to unite all values in one exchange mechanism. And since the exchange mechanism works only on financial gears, experienced Hunters will take all the values into their own hands. The process of

exchanging universal values will stop forever, since the Herbivores now do not own their Resources, and the Predators do not know how to turn Resources into Finance. Finance hunters could feed all members of the ecosystem from their dimensionless Reserve system, but no one can feed on finances.

The total genetic memory is composed of the memory of all members of the Fauna and Flora. Each member has a strong self-preservation instinct or mentality based on the historical memory of animals or peoples. Under suitable conditions, instincts or mentalities provide mutual attraction of natural objects. The predator dog has long teamed up with the hunter to facilitate the extraction of meat. Ukraine, industrialized by Russia, is passionately glued to the EU predator. Even more passionately, it sticks to the US hunter in search of protection from the brutal RF. In catastrophes, sharp repulsions arise: animals flee from a burning forest or from someone else's epizootic. Pre-war alliances break up after the war. However, based on this experience, instincts and mentalities are enriched. We remember the past grandeur of the British, Russian, Soviet empires. Therefore, timid attraction now arises with the formation of the British Commonwealth, the European Union, and the Eurasian Economic Union. From this we can draw a particular conclusion that is consistent with the concept of evolution:

Any evolutionary process does not pass without a trace, even if the products of evolution decay when conditions change. Recording the history of evolution on material carriers facilitates the repetition of evolutionary processes in the future, even if the pathologization of the original objects occurred during the decay of a complex object.

The tactical goal of evolution is to create a new object that more effectively affects its own and the outside world. The strategic goal is to prepare the product of evolution for further complication. The spontaneous formation of ecosystems and complex political systems fits well into this concept. Archaic Forest after the appearance of birds, bark beetle eaters, gained the opportunity to successfully develop and significantly influence all processes in the biosphere. The unification of different peoples around one attractive mentality creates a new successful civilization, significantly affecting neighboring civilizations. Such a successful civilization in the past turned out to be Russian civilization, looking for Truth and Justice. As a result, developed countries were forced to move toward socialism.

Unfortunately, the symbioses of macroscopic objects are prone to decay under the influence of external conditions. In contrast, an animal cell contains many organelles living for the benefit of the whole cell. In ancient times, these mitachondria and vacuoles were eaten by independent single-celled creatures. Being eaten by a predator cell, they turned out to be useful to this cell and integrated into its biochemical cycles. The complicated cell began to breathe more freely and turned out to be the most successful material for further evolution. The genomes of the original organisms did not disappear anywhere, but the scenario of the exact reproduction of the most complex cell architecture arose and was remembered.

In macroscopic symbioses, the genetic memory of a complex object is not so densely concentrated, but distributed in their subsystems. Therefore, with the breakdown of symbiosis, former partners are exposed to their habitats. This creates a risk of pathologization of one of the partners. This eliminates the exact recreation of the symbiotic object when restoring the former conditions. Ukraine suffered such pathologization after its separation from the Soviet empire. This resolutely impedes its entry into a new version of the empire, the Eurasian Economic Union.

Evolutionary Processes in the Noosphere

The biological stage of the evolution of the Earth rested against the natural limit of the complexity of living matter. The exception is viruses that create and store their genetic memory in their structures and in the structures of the animal cells that generated them [11]. With the help of viruses, there is a horizontal exchange of genetic memory between different biological species. However, this does not lead to the appearance of new species on Earth. The fate of mutated species is governed by natural selection, but not by evolutionary mechanisms.

The appearance of the species Homo sapiens provided the beginning of a new stage in the evolution of the Earth. A characteristic feature of this stage is a new location of evolutionary processes. All of them are localized in the mental apparatus of families, tribes, ethnic groups, political nations, civilizations. Genetic memory is also stored there, allowing people to stably reproduce technical and social inventions. We give examples of such inventions, new evolutionary objects.

The Emergence of New Technical Facilities

The need for a new invention is the realization of an unresolved technical problem. Inventive thought is very economical, as is evolution itself. The various available technical means are selected and their successful combination is found. The path to its achievement is laid in the memory of the inventor, which allows him to recreate the invented.

Primitive man learned to use a stick or stone to get a small beast. He learned to tear a liana from a tree and use it like a rope. However, you can't feed a primitive family with a carcass of a small beast. Need more weighty carcass. It's dangerous to approach a large beast with a stick or stone. Problem. In search of a solution, the inventor groped for the idea of connecting a stone and a stick with the help of a vine. It turned out a stone ax, with which you can already attack the boar. If the experiment is successful, the inventor remembers the image of the ax and the technique of its manufacture.

The genetic memory of the "ax" object arises and is stored separately from the object itself and from the world of sticks, stones and vines. An essential feature of this stage of evolution is a new mechanism for the transfer of genetic memory into the historical future. This mechanism is almost completely divorced from the process of reproducing successful evolutionary objects. Now these are oral stories about the technology of manufacturing useful tools. And in the future, these are paper storages of extensive technical documentation, according to which a new generation of engineers and workers will be able to assemble useful tools from suitable parts, such as a motorboat (boat + engine from a weaving factory + Archimedes screw), as an airplane (the same initial components + wings from windmill).

The Emergence of New Social Objects

Ethnic groups and peoples living in the neighborhood are able to realize that they will become more successful in their external environment if they form a single political nation. The genetic memory of a new object arises and is stored in the merged mentalities of ethnic groups and nationalities. This memory is passed orally to future generations in the form of historical and religious myths.

The genetic memory of a political nation may be subject to corruption. Memory is partially erased, religious myths are subject to an alien influence. A nation can weaken and disappear. Salvation may come from typography. Vernadsky paid special attention to this factor. The genetic memory of the nation is moving into a new mighty tool, in national literature.

However, the danger of corruption does not disappear. Let us compare the historical experience of the two countries with the imperial mentality, Russia and Poland, the heirs of the unique ancient Slavic mentality. Both countries entered the historical European arena as independent entities when the evolutionary merger of the Slavic mentality with the Orthodox ideology of the Byzantine Empire took place. Over time, this most important component of the Polish mentality was replaced by the ideology of Catholicism. The result is known. Russia has managed to create a dynamically stable empire, reviving independently after historical failures. Poland only dreams of creating an empire "from sea to sea", but always remains only a province within any other empire. Now it is the economic province of the European Union and the financial province of the United States.

Conclusion

With the evolution of the Earth, the memory of evolutionary processes also evolves. It seems interesting and important for Earth sciences to organize an interdisciplinary study of this phenomenon in order to predict the next stage of evolution. It also seems that this new stage will be the close unity of the Homo sapiens species with the entire biosphere for the sake of their successful impact on all spheres of the Earth. This was thought by V.I. Vernadsky, when he calculated the amount of entropy production in geological processes, in living matter and in the activity of mankind. These three fractions of the total entropy production turned out to be the same, which poses a threat to the health of the Earth [12].

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