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An Evolutionary Model for the Neoproterozoic (Ediacaran)-Phanerozoic Biosphere

Part Two—Exploitation of Terrestrial Environments

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Abstract

Adaptations introduced through the progressive development of the various phyla through geologic time are either directly or indirectly the result of their competition with each other. Evolutionary transformations of the archetype, or fundamental structure, including its systems and organs, from which a natural group of animals or plants are assumed to have evolved, is the product of long and directed selection that can span millions of years. Aromorphosis (one of the main trends in biological evolution characterized by increased organization without narrow specialization) has favored the groups with the most successful archetypes (original pattern or model for later related individuals and groups, e.g., bilaterally symmetrical groups and the vertebrates). Throughout the Phanerozoic, dominant groups suppress those less successfully developed groups by closing their pathways to progressive development.

Keywords

Super-Aromorphoses, Vertebrate Evolution, Terra-Biosphere, Noosphere

1. Introduction

Influence of the Biosphere on the Land and the Hydrosphere

A major evolutionary event of the Carboniferous was the flourishing of the amphibians, which had appeared by the end of the Devonian, representing a remarkable stage in the development of living organisms. Their introduction was the beginning of the assimilation of land by tetrapods, a progressive group of vertebrates, which occupied the completely new continental environment. The development of the tetrapods, which later played a very important role in the progressive development of life on Earth, was the most characteristic feature of the archetypes of this super-aromorphosis. However, the appearance of the amphibians at that time in the development of life on Earth did not bring significant changes to the general characteristics of the hydrosphere. At the same time, the origin of amphibians was a significant indicator of the higher level of development of biospheric relations, especially in the marine neritic zone. The competing phylogenetic groups were forced to assimilate all of the diversity of the strongly differentiated neritic biotope. The progress of some groups of fish to the littoral and sublittoral zones, ultimately led to the "exit" of the vertebrates to the land that would create new conditions for the origin of tetrapods that possessed new archetypes and opened, in principle, new avenues for the further progressive development of life. The Elpistostegalia, large sarcopterygian fishes, exhibit features of organization that are found later in the tetrapods, suggesting an ancestral relationship [1] [2]. With the beginning of the Mesozoic, the hydrosphere began to exert a strong influence on the terrestrial biosphere, which by this time, was already well developed. Powerful competition between phylogenetic groups on the land attests to the fact that some of these groups started to assimilate marine biotopes. If plesiosaurs were specialized marine predators having pinniped-like limbs, and came out on the land only for reproduction, then the ichthyosaurs had already completely lost any connection with the land. Ichthyosaurs and plesiosaurs appeared in the Triassic, but both became extinct almost at the end of the Cretaceous [1] [2]. One significant and contributing cause of the extinction of marine vertebrates that had thrived during almost the entire Mesozoic was competition from advanced sharks that appeared in the Jurassic, especially the Galeomorphs, active predators with a body length up to 20 meters, and a highly developed brain, larger than that of their ancestors. The ratio of brain size to body weight in carnivorous sharks and advanced skates is even higher than that of many birds and mammals. As brain size increased, convolutions similar to those of advanced mammals appeared on both the cerebrum and the cerebellum [2].

The peculiarities of the phylogeny of the crocodiles provide insight into competition among organisms in the Mesozoic hydrosphere. These terrestrial, fresh water and marine predators are the only surviving archosaurs, but they are a thriving group in the present hydrosphere. Crocodiles follow an amphibian life style, and with the peculiarities of their archetypes, they have become the most adapted large predators to the neritic-shore biotope of tropics and subtropics, which they have occupied since the Mesozoic. A peculiar near shore "crocodile barrier" appeared, which could not be overcome by the large predators either from the land or sea. Apparently, the crocodiles also played a distinct role in the disappearance of the plesiosaurs, which broke the "crocodile barrier" for reproductive purposes, although sharks restricted plesiosaur distribution to the deeper marine biotopes.

Extremely specialized archosaurs adapted for active flight appeared in the Late Triassic and lived in the near shore environment. The earliest forms fed on insects, and the latest forms were fish-eaters that reached large sizes (15 m in wing-span and 70 kg in weight) [1] [2]. Pterosaurs exercised a limited influence on the development of the hydrosphere, and by the end of the Cretaceous, they were restricted by the birds, representing a noticeably higher step of development. The birds exercised strong and diverse pressure on marine organisms providing their contribution to the evolution of the hydrosphere.

From the middle of the Paleogene (beginning of the Oligocene), the hydrosphere received a new contribution from the biosphere of the land. This event originated from one of the more developed groups of the animal world—the placental mammalians represented by the cetaceans. The cetaceans are unusual members of the modern marine fauna that apparently evolved from the carnivorous Condylarthra. Cetaceans are highly specialized marine carnivorous or herbivorous forms, some of whom reach gigantic size—more than 30 m [3]. Throughout their phylogeny, this group experienced a major reconstruction of the archetypes that actively developed social relationships. The general organizational progress achieved by mammals allowed significant improvement of their central nervous system. These animals possess an extremely well developed system of acoustic communication and echo sounding. By the middle Miocene, whales had become highly specialized marine animals. By 30 my, their brain had attained sizes, and a degree of surface crenulation, that approximated the brains of advanced hominids [2]. The brain weight compared to body weight of some recent species exceeds that of the human brain (**Figure 1**).

Success of the whales was enhanced by the avenues available to them as representatives of the mammals, particularly the rapid, progressive development of their brains. Whales quickly occupied the top of the food chain and became socially organized predators that drove back the sharks and had practically no other competitors. Exclusive cetacean abilities include those of sperm whales that can dive to a depth of more than one km while hunting, a feat unique among the inhabitants of the modern seas that probably reflects their high brain development (**Figure 1**).

2. Biosphere of the Land (Terra-Biosphere)

By the end of the Silurian, the level of the development of the biological world had reached such a high degree that organisms, such as plants and insects, were capable of the conquest of new terrestrial zones of habitation significantly different from the physio-chemical conditions of the hydrosphere. Gravitation acts completely on the land and strongly influences the particular morpho-physiological characteristics of a particular organism. Life in a gaseous environment, where there are sharp and rapid changes of temperature, requires special adaptations. The terrestrial environment is characterized by an extremely wide range of conditions that exert pressure on biosystems to explore new and

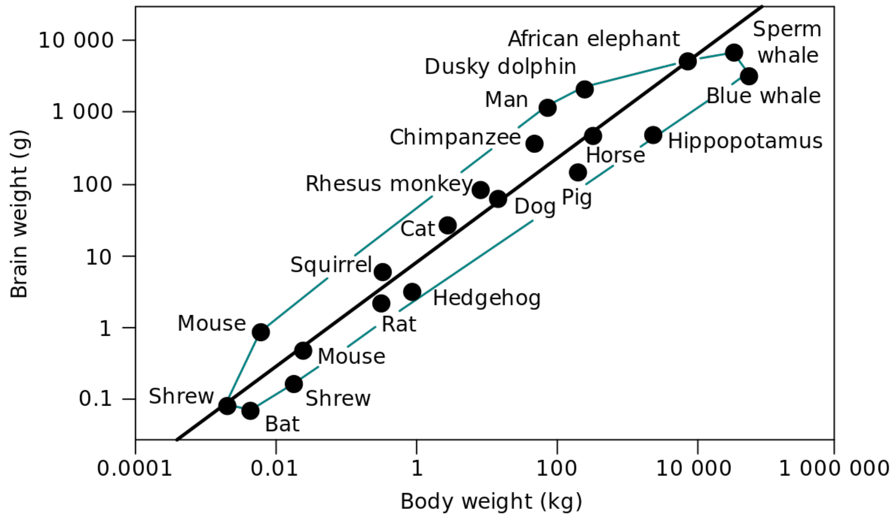

Figure 1. Comparison of brain weight versus body weight in selected modern vertebrates (source: https://commons.wikimedia.org/wiki/Main_Page).

unique possibilities for progressive development. The unique conditions of terrestrial habitation determine the origin of new and isolated biospheric systems with close hydrospheric interaction. Leonov [4] noted that the developmental directions for marine organisms and terrestrial organisms have been significantly different. Consequently, the development of each of these groups must be considered, analyzed separately, and independently, and then correlated and compared. The definition of the "natural stage" of that development can have real meaning only through understanding the separate evolutionary paths followed by each of these groups [4].

The wide diversity of physio-chemical conditions on the land resulted in great differentiation of its biosphere as stable biosystems became broadly and comprehensively adapted to local environments. However, with clearly internal biological interactions and mutual dependence, neither limited by a trophic connection, the biosystems achieved unique complexity and variety. The amount of material, energetic, and informative exchange between the components of the biosystems increased significantly on land, and promoted their spatial mobility.

The origin of the terrestrial biosphere began with the "expansion" of plants onto land, which occurred at the end of the Silurian, approximately 420 my ago. This event was the culmination of the preceding developmental trends of both an organic and inorganic nature. It was preceded by soil formation reflecting both organic (bacteria, cyanides) and inorganic (climate, particulate minerals) interaction. However, success required the proper level of the development among the organisms. Psilophytaleans, with a stalk and primitive conductive system, made the initial step onto land. The arrival of plants onto the land was accompanied by the first arthropods, myriapods, followed by arachnids and apterous insects. More than 50 my later, in the Late Devonian, crossopterygians (precursors of amphibians) arose, or rather crawled, onto the land, whereas the atmosphere was dominated by the insects.

The origin and development of angiosperms at the beginning of the Cretaceous, 130 my ago, was also an important event in the development of the terrestrial biosphere. From the Late Cretaceous into the Cenozoic, the angiosperms became a dominant component of terrestrial vegetation. They contributed to the success of many groups of animals, including insects, birds, mammals and eventually, humans.

3. Insects

Arthropods are exoskeletal bilaterals occupying the terrestrial environment. The most numerous arthropods are the insects, represented by approximately 30 million modern species. Insects apparently moved onto land in the Devonian, where they occupied almost all biotopes, including the atmosphere. Their distribution indicates that the insects were quick to reach a significant level of development of their central nervous system and brain. However, even the most advanced insect groups, such as the hymenopterans, could not achieve the level of development found in the crustaceans. Pressure from higher levels of progressively developed vertebrate groups that also inhabited the land turned out to be a significantly stronger influence on the arthropods than they had experienced in the hydrosphere. Furthermore, the powerful influence of the vertebrates (competition for the food resources and pressure of predators) directed the evolution of insects in other directions.

The general developmental strategy of the more advanced insect groups (hymenopterans) involved the formation of social structures in which every member of the society performed strictly defined duties, and could not exist independently outside the system. Such a strategy for the development of the group is not compatible with the direction of progressive evolution, which requires improvement of the central nervous system and brain of every individual, ultimately increasing the developmental level of the group.

An interesting ecological development is illustrated by the origin of the social insects that is connected with the aromorphosis of the birds and insectivore placentals, their main predators, which evolved during the end of the Cretaceous and into the beginning of the Paleogene. The appearance of birds and insectivore placentals resulted in sharply decreased numbers of insects during this time interval [5]. Other more successful groups of insects (hymenopterans) responded to this pressure by evolving in the direction of the formation of social societies (ants, bees and others) that were collectively organized and based on the improvement of care for their descendants.

4. Di-Biosphere Amphibia

Land vertebrates differ considerably because of their significant and sustained progressive development. This group exhibits successive steps in the transition of the organization of the groups from amphibians to mammals, which occupy the upper levels of the trophic pyramid (**Figure 2**). After their major expansion in the Carboniferous and Permian, the amphibians relinquished their position to the reptiles, a more advanced group. The reptiles followed the same pattern in the Mesozoic, followed by the mammals, the most highly developed group of animals, in the Cenozoic. Mammals are characterized by intensive metabolism, differentiation of the tooth system, highly developed sensory organs, and improvements in both thermoregulation, reproduction, and most importantly, the most highly developed nervous system, especially the brain. All of these attributes contributed to a significant expansion of the mammalian habitat and the development of new biotas.

The Devonian-Carboniferous super-aromorphosis is marked by the origin of tetrapods, which evolved from the amphibians, and made their first appearance at the end of the Devonian (**Figure 2**). The most progressive groups of vertebrates began the occupation and dominance of the completely new environment—extensive continental masses with subaerial exposure. The development of land use by the vertebrates started from the evolutionary transformations of the fishes. Sarcopterygian fishes living at the water-land interface were adaptable to the occupation of the marginal parts of the complex terrestrial environment, which required greater intellective abilities. Dominance of entire biosphere by the amphibians is the time of a separated existence of the hydrosphere and terra-biosphere. That period ended in the Triassic, which saw the flourishing of the reptiles. Most extant amphibians exhibit different stages of their life cycle in either water or on land. Because success in these environments requires completely different and often incompatible characteristics, there is only a narrow zone of habitation at the boundary of water and land, and this feature characterizes the archetype of amphibians.

The significantly differentiated terrestrial environment also predetermined the significantly more diverse terra-biosphere. Tetrapod limbs possessed the important potential for complicated movements that required the essential development of the nervous system and brain. Tetrapod movement required complete ossification of the skeleton, differentiation of the spinal column, intensification of lumbar limbs, strengthening of the connections with the axial skeleton, and the development and differentiation of muscles.

From the point of view of the development of animals, the possibility of the wide and effective application of telereceptors, *i.e.,* some type of enhanced visual capability, was an important step in the occupation of the land. The ability to see prey or predator from a significant distance allowed an organism to plan and effect responsive actions in advance, depending on the specific behaviors of the victim or hunter. This ability provided a precise and essential influence on the development of the nervous system, especially the brain. An increase in relative brain size, mainly of the anterior cerebellum, was characteristic of the tetrapods. The accumulation of nerve cells, which in mammals are distributed in the outer cortex of the large cerebral hemispheres, appeared and increased in the anterior brain of amphibians, reptiles and birds [1] [2] [6] [7] [8].

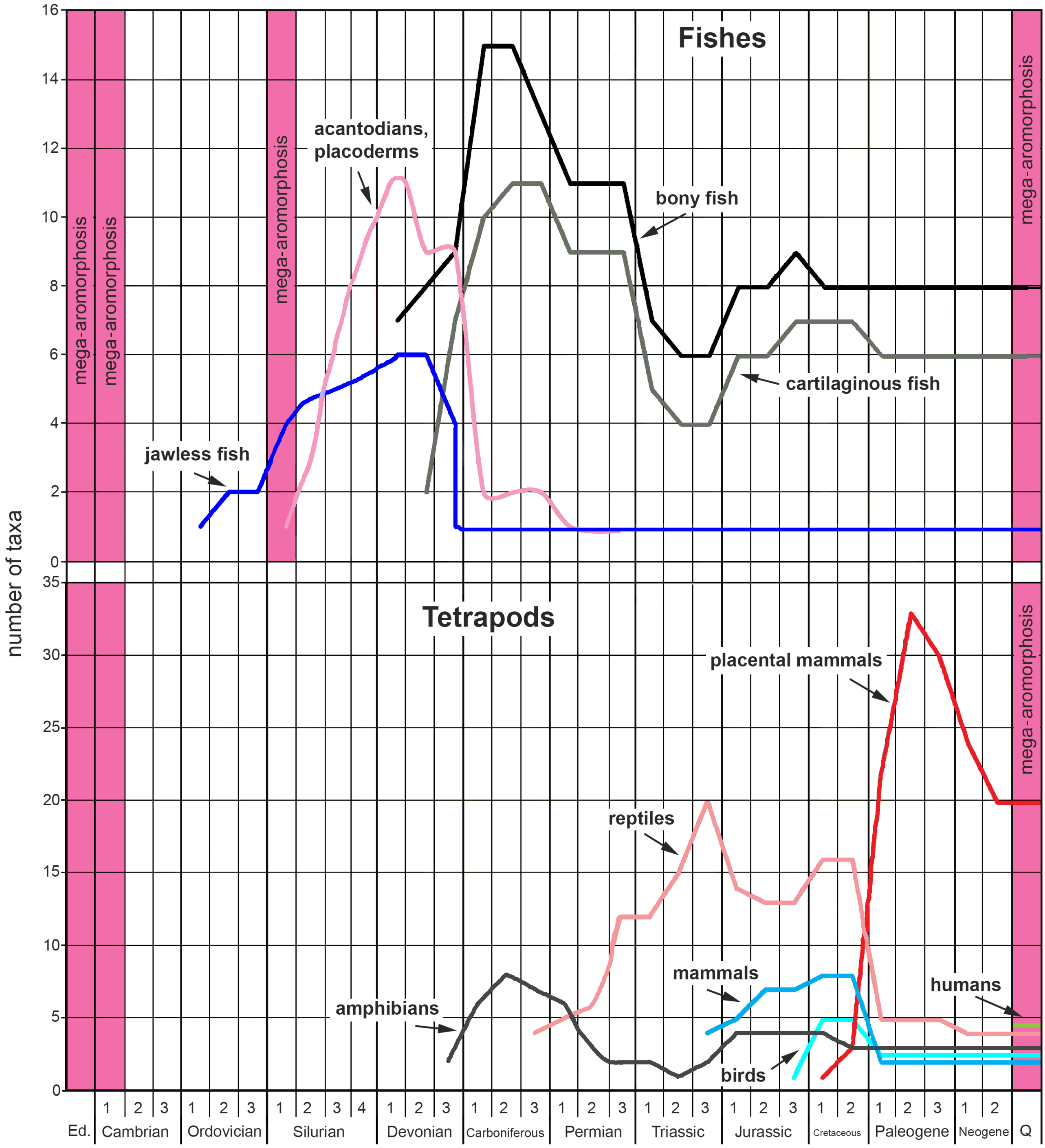

Figure 2. Development of dominant groups of fishes and tetrapods throughout the Phanerozoic. Ed.—Ediacaran Stage, Q—Quaternary.

5. Carboniferous-Permian Super-Aromorphosis: Biosphere of Reptiles

A new qualitative shift, which ended domination by the amphibians, occurred in the evolution of the biosphere of the land during the Late Carboniferous and Early Permian. Several branches, the Eosuchia, Squamata, and Thecodontia, that differ in their level of development, appeared simultaneously within the reptiles. The Carboniferous-Permian super-aromorphosis of the terra-biosphere is reflected in groups, such as the Squamata and Thecodontia. Many amphibian groups were driven from their biotopes and disappear simultaneously with the appearance of these reptile groups. Squamates, with an especially advanced development, settled in all environments, except the aerial one, although there were gliding forms [1] [2] [9]. As noted by Carroll [2], the skeleton of the earlier amniotes (Amniota) stiffened more rigidly than in most other Paleozoic amphibians. Judging by the proportions of their limbs, they were also quicker, and their system of muscle receptors was more perfect and effective than that of the amphibians. The success of the reptiles, according to Carroll [2], was their further development of locomotive coordination. Furthermore, the higher development of their nervous system, and especially the brain, was the fundamental basis for all the advantages of their super-aromorphosis.

The formation of the main features of the reptile archetype as a land animal was completed by the end of the Permian (**Figure 2**). Advanced reptiles in which one or two temporal windows formed in the skull, and that significantly simplified the development of the brain (in its frontal areas), appeared at the Carboniferous-Permian boundary. The appearance of windows in the previously solid skull significantly enhanced the evolutionary opportunities for transformation and improvement of the brain, particularly an increase in its size. Significant development of the brain was necessary for the successful adaptation by the reptiles to the initially under populated terrestrial environment, and later to competition within the class. An explosive adaptive radiation of the reptiles marked the Permian-Triassic boundary, and initiated a general biospheric reconstruction in which reptiles occupied most terrestrial biotopes. Concurrently, many groups of reptiles again occupied the hydrosphere, and also expanded into the aerial environment, so it can be said that the group controlled the biosphere. By the Late Jurassic, dinosaurs had forced out many other groups of reptiles from their earlier dominant positions in the biosphere. Further development of tetrapods in the direction of progressive evolution led to the appearance of a new group—the placental mammals, whose domination marked the introduction of a new stage in the evolutionary development of the biosphere: the biosphere of the mammals and birds.

6. Biosphere of the Mammals and Birds

New groups arose in the Triassic with more progressive adaptations: lower mammals by the end of the Triassic, birds by the end of the Jurassic, coincident with the domination of archosaurs, particularly, pterosaurs, crocodiles and dinosaurs (**Figure 2**). The development of homothermia and a higher level of brain function allowed these groups to pursue both day-and-night activities. In the first stages of these important evolutionary developments, the new groups still occupied a subordinate position, but by the end of the Cretaceous, they had become dominant, especially the birds. Although birds appeared significantly later than the mammals, their faster rate of development in the Mesozoic allowed them to compete effectively with the mammals. Paradoxically, the specialization of birds to flight closed the path to their greater progressive development. This limitation is clearly expressed in the undeveloped ventricles of the brain in birds. As a result, the functions of the brain in birds that were similar to those in mammals developed less fully. Thus, birds as a group exhibit less intelligence compared to the mammals.

The appearance of the placental mammals by the end of the Cretaceous produced a general reconstruction of the biosphere. Their great advantage was the improvement of higher nervous activity, which effectively used all of the newly acquired capabilities of the mammals. Characteristics and abilities, such as the use of individual experience, and consistent reaction to specific situations experienced in the competition with groups similar to themselves, depend on the degree of the organization of the brain. The success achieved by mammals in their development relied on the perfection of memory that was capable of storing individual experiences [10] [11]. The adaptations made by mammals, such as homothermia, provided not only the ability for day-and-night activity, but also led to the domination of the biotopes, of which the vertebrates had previously taken control, but also led to their assimilation of new and large regions that had cold climates. Development of the ability for prolonged memory radically expanded the opportunities for higher mental activities by the placental mammals. This development rapidly led to the appearance of primates, which anticipated the appearance of a completely new phenomenon—the noosphere: literally, "mind-sphere," a term that was coined by Édouard Le Roy, the French philosopher, who had attended Valdimir Vernadsky's geochemistry lectures in Paris at the Sorbonne in 1924 together with Teilhard de Chardin, the Jesuit paleontologist. Vernadsky [12] adopted the term as his own to depict the stage of the biosphere characterized by the preponderance of human activity.

Eutherians and other mammals attained such perfection that reptiles were forced out of almost all the continental biotopes that formed the basic components of the biosphere of the land (terra-biosphere). The expansion of eutherians was not limited to the land. They moved into the hydrosphere, e.g., whales in world's oceans occupy the top of the food pyramid.

The appearance of primates is directly connected with the expansion of the placentals. The Late Paleogene-Early Neogene (Late Oligocene-Early Miocene) was a time of the origin of the most highly developed phylogenetic groups characterized by the appearance of qualitatively new perfection of the brain. Vision and hearing in primates became highly perfected, and their limbs acquired the ability to make complex and narrow movements, a development that made them radically different from the cetaceans. The presence of social relationships is recorded extensively in the intraspecific relations of primates [2] [13]. However, the development of the brain of primates at the early stages of their evolution lagged behind that of the whales [1] [2] [7] [8].

Humans evolved from the group Archonta (from the Latin-*archonta*-supreme), and most curiously, from its most unspecialized ancestors—the primates (Primates), for whom an arboral style was characteristic [9]. Their eating habits required well-developed spatial orientation and acrobatic motion through trees. In advanced pentadactyle limbs, the first finger opposed to the rest of fingers, significantly expanding their potential abilities. These features are a particular necessity for insectivores and omnivorous primates. Their use of complex movements contributed to the development of their nervous system and brain, with a resulting increase in volume that is characteristic of primates. The evolution of primates also involved improvement of vision and hearing, but a weak of sense of smell. High levels of social communication and interaction are a characteristic of primates [2] [13]. The recorded specializations within the phylogenetic development of primates illustrates their quick and radical rise above the general developmental levels within the animal world and contributed to their conquest of new ecological niches.

The appearance of animals with brain development equivalent to that of the Cetacea comprises a stage not only for the hydrosphere, but for the entire biosphere. It is interesting to note that the anthropoids actually lagged behind the whales in their brain development [2] [7] [8]. This relationship may possibly reflect greater competition in the biosphere of the land that did not allow them the same opportunity exploited by whales in the aquatories. The hominids experienced strong competitive pressure from other groups of mammals occupying the biosphere of the land, and especially from predators among that group, that undoubtedly delayed their early success.

The brain of primates achieved high development of the informative process, expressed complex differentiation, and the group developed limbs that acquired the ability to make complex and narrow movements, which contrasts radically with the cetaceans. An essential characteristic of the primate brain is its ability to accumulate information from the environment, process it, keep, and promptly accept decisions corresponding to specific situations, *i.e.,* actions that correspond to accumulated individual experiences. Further successful development of the hominids was connected not only with development of an advanced brain leading to a highly specialized group, but also with the transmutation of their limbs into a unique organ—hands—capable of intricate manipulations and the ability to construct tools. It has been noted that the education of a hand to perform complex movements directly contributes to the development of the brain. The absence of such an organ as the hand in whales has been an insurmountable barrier to the further development of their brain to a level comparable with the development of the brain in hominids.

7. Mega-Aromorphosis of the Noosphere

The peculiarities of the evolution of hominids predetermined the origin of the mega-aromorphosis that occurred in the Quaternary, expressed by the formation of the noosphere, the highest stage of evolution of the biosphere to this point in the time continuum [12]. The improvement of the brain at this particular stage of primate evolution has led to the origin of speech, the principle means of communication promoting the process of labor activities. The first speaking centers in the brain were already established by the appearance of *Homo habilis*—"skillful man," approximately 2 my ago. However, it is unlikely that this level of hominid development can be considered as the origination of the noosphere. Features of the speaking centers are noted also in anthropoid primates. The appearance of modern humans, *Homo sapiens*, occurred about 40 - 35 thousand years ago in the Late Paleolithic [2] [13]. That species was distributed across the territory encompassing southeastern Europe, northern Africa and western Asia. From those areas, the recent human-type radiated throughout the world forming enormous cultural historic provinces: European periglacial, Mediterranean-African, southern African, Indo-Himalayan, Siberia-Mongolian, and Malaysian [14]. This time is characterized by the widening and assimilation of new territories by ancient humans, increasing the size of their population, and their new achievements in technology, including of the manufacture of tools.

However, the establishment of the noosphere should be placed at the moment of the sharp increase of the size of the population of humans on the Earth, which occurred in the interval of 10 - 15 thousand years ago. The appearance of the alphabet in the centers of ancient civilizations (Egypt, Mesopotamia, and India) is also assigned to that time interval [14]. The appearance of a vocabulary separated the early stone-age humans from later groups, and led to the rudiments of the noosphere.

Apparently, this period is also characterized by the transformation of *Homo sapiens neanderthalensis* [15] [16] into what is considered the modern human (*n.b.* the current Paleobiology Database recognizes *H. neanderthalensis*, while the National Center for Biotechnology Information (NCBI) database recognizes *H. s. neanderthalensis*). One interesting feature of this development is the transformation of the brain in recent humans to a smaller volume compared to that of Neanderthal man—1400 cm^3 compared to 1500 cm^3 [2] [13].

A very specific feature of the noosphere is the origin and development of ideas and a technosphere (part of the environment on Earth, where techno-diversity extends its influence into the biosphere) subordinate to it. Ideas imply understanding in a very wide sense, spreading and experiencing competition and selection. However, the present development of the noosphere provides the alphabet and means to spread mass information. The noosphere through the technosphere renders an increasing influence on biospheric processes. The powerful influence of the factors of human activities is that they have begun to streamline the biospheric processes, which in turn, are beginning to violate the equilibrium of important biospheric relationships. The realization of such a danger is one of the urgent problems of today's society. Precisely, the characteristics of hominid evolution will predetermine the origin of the next mega-aromorphosis as expressed in the formation of the noosphere, which is highest stage of evolution of the biosphere.

The study of the phylogenies of large groups of vertebrates and their interactions in the process of their evolution allows one to understand the general picture of the transformation of the Phanerozoic biosphere. Such study can help to reveal the internal characteristics of the development of groups that represent the progressive stream of evolution, view its interaction with various existing groups, and understand the transformation of the entire biosphere. For **Figure 2**, data of Cherepanov and Ivanov [9] were used and one can see that the successfully developed dominant groups (cartilaginous and bony fish, reptiles, and to a lesser degree, the amphibians) have two well-expressed periods of adaptive radiation. The second period expressed a qualitative shift in the development of the groups. The placentals are still experiencing only the first wave of radiation. In the evolution of other groups, only the first wave of radiation was actually developed, because competition pressure from more successful phyla did not allow a second wave of the radiation. For example, the pressure of the reptiles noticeably depressed the second wave of radiation for the amphibians. The powerful competition from the placentals led to a sharp decline of the reptiles and lower mammals. It should be recognized that the decrease of an adaptive segment usually reflects internal competition. The appearance of a plateau in the development of a group indicates that it occupied a subordinate, but constant place in the biosphere. Thus, placentals form the upper layer of the evolutionary transformations of the biosphere, which suppresses the development of groups from the lower layers by limiting their ability to evolve further.

Competing relationships inside a vertebrate group are easily seen in their aquatic representatives. The appearance of cartilaginous and bony fish suppressed the development of jawless vertebrates, and caused the total extinction of the acanthodians and placoderms. Those groups could not withstand the competition from the cartilaginous and bony fish. Some tetrapods, the ichthyopterigians and pterosaurians, actually developed on land, but returned again to aquatic environments, where they exerted pronounced influence and competition on the aquatic fauna. Cetaceans and odobenidians (placentals) occupied the top of the food pyramid and exerted strong competitive pressure on other aquatic groups.

These fundamental evolutionary improvements in the structure of an organism are reflected in the systematics of animal taxonomy. However, new taxa are proposed not to change existing systematics, but to provide a more precise picture of the evolution of the various phylogenetic groups and the entire biosphere. The progressive changes have enormous significance not only for the vertebrate phyla, but also exert a powerful influence on the evolution of the entire biosphere and reflect its progressive development. The degree of the development of the nervous system, especially the brain, defines the level of evolutionary progress of a group, which is reflected in their corresponding taxonomic assignment [17] [18].

8. Conclusions

The general development of dominant groups is expressed by an increase of organization of a separate organism-individual. It predetermined the appearance of humans and the noosphere. Dominant groups force out and suppress groups less successfully developed by limiting their path to progressive development. These relationships create the basis for the structure of the biosphere and influence the transformations of the structure of its main biotopes. The change of the dominant groups stimulates general biospheric reconstructions and results in stages of increased organization of the biosphere that predetermined the origin of the noosphere.

The main stages of this progression began with the improvement of the morpho-functional adaptation of a particular organism, and later by the development of a qualitatively new organ—the brain—regulating all functions of the organism by using informational processes. With the origin and development of the brain, informational processes became isolated. As the brain functions improved and developed, its connected central nervous system and telereceptors contributed unequally to promote the general direction of the evolution in all living organisms (the cerebral stage of the development). The establishment of superiority in specific groups was dominated in turn by the protometazoan, protobilateral, cerebral and noospheric aromorphoses through the Neoproterozoic/Ediacaran (Vendian)-Phanerozoic evolutionary history. That history was one of unlimited progress in the evolutionary transformation of the biosphere. This transformation is especially noticeable in the tetrapods. In particular, the influence of placental mammals on the evolutionary transformations of the biosphere is significantly more powerful and diverse than the influence on the biosphere by any other group during its acme. The appearance of the noosphere is marked by the undivided domination of one species—humans.

A decrease of brain volume must indicate significant internal qualitative improvements of its informative processes that are clearly expressed in the explosive growth of the human population, its global spread, and the formation of the noosphere. These circumstances may require the establishment of a new species: *Homo eusapiens* [17].

Self-awareness by humans of their unity and place in nature allowed them to comprehend the higher truths of their existence and role in the world, e.g., a new level of development of life. It was realized that changing relationships reigned in the society, similar to the spirit of Darwin's [19] struggle for existence, and prepared the conditions for the recognition and development of a system of truths, which corresponded to new conditions associated with the evolution of living, and which assumes that humanity is completely responsible for its own existence. The urgent need for the transformation to new and positive relations has been enhanced by the increasing power of human responsibilities, in which they accept their sometimes destructive nature within the framework of Darwinian natural selection. This transformation will direct understanding by humanity of the necessity of substituting dominant negative relations among people for positive connections and the recognition of the inherent worth of each individual. This, in turn, will promote significantly more rational use of human resources and encourage the expression of all positive qualities of each human. This non-alternative way of survival and development of groups of people, and indeed, the entirety of humanity, has become more necessary and pressing. A system of spiritual and moral truths, the Word, must be the fundamental principle driving the relationships between people and their groups: state, legal, and cultural [18].

Positive relations between people will recognize the value in each human and are the most rational development of society. Unity secures survival and encourages flourishing of all society, and each human as an individual. This concept leads to development and recognition of inherent worth and uniqueness of each individual contributing to the development of the biosphere. A qualitatively increased level of material independence allows humanity to move toward a different sphere—the spiritual, which relies only on purely informative processes. There is no longer a material power based on the struggle for survival. An improvement in appreciation for the spiritual and moral becomes the main line of the evolutionary process, which humanity must identify to develop the material sphere. The hope for the improvement of the material sphere beyond the spiritual and moral is non-adaptive development. It transcends the level of the struggle for the existence by decreasing the change in the previous step of the evolutionary process [18].

Authors' Note

Professor A. V. Popov is an internationally known paleontologist, and for many years Chairman of the Paleontology Department, St. Petersburg State University, Russia. He published numerous scientific papers over his career that spanned more than half a century, but all were in the Russian language. This paper, part 2 of An Evolutionary Model for the Neoproterozoic (Ediacaran)-Phanerozoic Biosphere, represents the culmination of his thoughts on the procession of life through geologic time, and his second paper in English. His co-authors are pleased to have played a small role in translating and editing this paper for dissemination to Dr. Popov's friends, colleagues and other students of the biosphere.

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