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Origin of Species by Means of Adaptation, or the Struggle for Life by "Active" and "Passive Darwinism"

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Abstract

According to Modern Synthesis: a) The origin of species is associated with natural selection; and b) The material sources of biological variations are random mutations of DNA and chromosomes, a part of which may be useful at adaptation to the new environment. If this were the case, then we would already know the mechanisms of adaptation and the origin of the species. It is generally accepted that the origin of species is a very slow process. However, it‘s turned out that sometimes under the effect of external factors evolutionary processes can dramatically accelerate, as has happened in the case of Anolis carolinens is living on Islands off the Florida coast. Using anoles as an example, we tried to illustrate the possibilities of origin of species by adapting to a new habitat based on Darwin's gemmules (DGs). Currently, the material sources of biological variations are considered the changes only at the level of DNA. It is this point of view that seems to us an obstacle in comprehending the mechanisms of the origin of species. Therefore, in order to get out of this deadlock, it is proposed to review our attitude to DGs. Perhaps the DGs are the additional material sources of biological variation and they appear in response to the external environment. But at the same time, DGs are not the material basis of Mendelian heredity, and this fact is not in doubt.

Keywords: Origin of species; Adaptation; Anolis carolinensis; Darwin's gemmules; Heterochromatin regions; Noncoding DNAs; Cell thermoregulation; Chromocenters

Introduction

The mechanisms of the origin of species proposed by Darwin and Modern synthesis, under all their undoubted merits, do not answer many questions. Currently the origin of species is associated with mutation of the gene(s) and natural selection. The biological variation is usually associated with the changes at the level of DNA. Without challenging the merits of such an approach, we offer, to revise the old hypothesis of Darwin‘s gemmules, based in his theory of pangenesis. The fact is that the possibility of origination of species only on the basis of random mutations at the gene level is not proved yet. As it is known Darwin supposed that the gemmules are the material sources of biological variation and they appear in response to the external environment. According to Modern Synthesis the material sources of biological variations on the basis of which new species arise are random mutations of DNA and chromosomes (duplications, polyploidy, structural rearrangements such as deletion, insertion, substitution etc.), a part of which may be useful at adaptation to the new environment. In other words, the adaptation idea is perceived mainly in the context of changes in the sequences of nucleotides in DNA. It is generally accepted that the origin of species is a very slow process and therefore it cannot be observed directly in Nature. However, it‘s turned out that sometimes under the effect of external factors evolutionary processes can dramatically accelerate, as has happened in the case of *Anolis carolinensis* living on Islands off the Florida coast. Using anoles as an example, we would like to illustrate the possibilities of origin of species by adapting to a new habitat (living) based on Darwin's gemmules. We suppose that, possibly, Darwin‘s gemmules (DGs) are additional sources of biological variability (except for random mutations), based on which new adaptive forms or functions (adaptation) appear. However, their impacts on individual development are implemented through epigenetic changes in the genome. If such epigenetic changes contribute to the survival of individuals in the new environment, then over time they may result to 'persistent' developmental changes in genome. As it is known Darwin proposed that cells not only are able to grow by means of cell division but are also capable of 'throwing off' gemmules - minute informative molecules - that are self-replicating and circulating. These gemmules circulate throughout the organism, penetrate other nascent cells and modify their subsequent development. The cells gave off minute hereditary particles (gemmules) that congregated in the sperm and ova to be transferred to offspring. There they aggregated to recreate the same structures from which they were derived in the parent *[1]*. Unfortunately, our knowledge about gemmules since Darwin‘s time is not changed significantly. In fact, the idea of Darwin about gemmules was simple: all parts of an organism issue small particles throughout the individual‘s life. Travelling by way of some unspecified bodily fluid, gemmules accumulate in an individual‘s sex organ. Upon mating, parental gemmules blend, thereby producing additional sources of variation. If such phenomena occur in Nature, then we have right to expect from DGs the same, that the author of the theory of pangenesis has expected-gemmules are the material sources of biological variability in the population with all the ensuing consequences for heredity, individual development and evolution.

For these years a number of publications on this topic have appeared *[2-5]*, which convinced us to come back to this problem. Thus, we have seen that the genetic and organismic evolutions are disproportionate. Really, a human and chimpanzees are identical in 99% of their genes *[40]*, but belong to different families. The striking phenotypic differences between chimpanzees and present-day humans cannot be fully explained by an approximately 5% DNA sequence divergence (counting indels) *[41]*, in particular considering that mice and rats exhibit relatively small phenotypic differences and yet are much more diverged in their sequence *[5]*. There is a growing consensus that changes in behavior or activity may be the initial catalyst for the development of new phenotypes, and that this plasticity-induced change can precede the more gradual process of genetic adaptation *[6-11]*. However, not everybody share this point of view. For example, Kuzawa *[12]* argues: We now know that cells do indeed harbor hereditary material - DNA - which they obtain from the gametes, but rarely do the gametes obtain extra-nuclear DNA. Interacting with the environment can induce phenotypic change in structures, but there is no evidence that this changes the genome in those cells or that somatic mutations are transferred to sperm or egg'.

Prerequisites for a return to Darwin's ideas

The fact that since the publication of Darwin's "Origin" has been published, despite the efforts of numerous scientists, including the author himself, has not been able to find out the mechanisms of the origin of the species, says a lot. It seems highly probable to us that, perhaps, one more important element is missing here, without which adaptation does not arise, and, ultimately, species. According to Modern Synthesis: a) the origin of species is associated with natural selection; and b) the material sources of biological variations are random mutations of DNA and chromosomes, a part of which may be useful at adaptation to the new environment. If things were like that, then we would already know the mechanisms of adaptation and the origin of the species, which is not in reality. Currently, the material sources of biological variations are considered the changes at the level of DNA. This point of view - random changes only at the DNA level - seems to us an obstacle in clarifying the mechanisms of species origin. Therefore, in order to get out of this impasse, it may be useful to return once more to Darwin's ideas. Namely, to reconsider our attitude to Darwin's gemmules and agree with the classic that perhaps gemmules are the material sources of biological variation and they appear in response to the external environment. But at the same time, always remember that DGs are not the material basis of Mendelian heredity and this fact is not subject to any doubt. Perhaps, two types of gemmules should be conditionally distinguished: Darwin's gemmules, which are responsible for heredity in the understanding of Darwin himself, and adaptive gemmules (AGs), which, we believe, are produced in addition to DGs in response to the new external environment. In the case of anoles, AGs are substances for gene transcription to synthesize the additional amount of proteins and/or RNAs necessary for increasing the size and stickiness of pads of green anoles (see below). These AGs in a certain period of embryonic development of fetus are cumulated in the cytoplasm of oocytes. After fertilization, these AGs act as gene transcription factors to recreate the same structures from which they were derived in the parent. Obviously, in response to the effects of the new environment, DGs (unless of course they really exist in Nature) are produced in both the paternal and the maternal organism. However, we believe that only mothers have gemmules of adaptive value, since DGs can persist only in the oocyte cytoplasm. If our hypothesis is correct, then DGs accumulated in oocytes only at the certain stage of its embryonic development in a mother's womb. As far as it is known, from all cells of fetus only oocytes cease mitotic divisions and stay in the same condition before sexual maturity. That is why it can be expected that substances, including gemmules, produced by fetus's could be conserved in oocyte cytoplasm. In mature male germ cells cytoplasmic material is practically absent; thereby, the presence of gemmules in those cells is not expected. Unlike the production of spermatozoa in males, which only begins at puberty, the production of ova in females begins before birth and is completed only after fertilization. During fetal development primordial germ cells undergo repetitive mitotic division and produce many larger cells - oogonia. These undergo mitosis and form primary oocytes, which remain at prophase of this stage until just before ovulation. Primary oocytes are enclosed by a layer cells and form structure known as primordial follicles. The role of primordial follicles is apparently the same as of Sertoli cells. However, we assume that unlike Sertoli cells the dense layer of follicle cells has one more important function: they prevent oocyte cytoplasm penetration by the products of vital activity of specialized cells, tissues and organs of both fetus's and maternal organism. In other words, starting with meiosis prophase I the flux of gemmules in oocyte cytoplasm ceases, as since that time they have been isolated from the influence of other cells by a permanent layer of primordial follicles. All that creates a unique situation: oocytes become the only cells in a body of multicellular organism where hypothetical gemmules of fetus could be conserved. If so, then AGs could be represented as one of the forms of cytoplasmic determinants, switching on genes at different stages of embryogenesis. With the help of AGs different genes are activated in cells from different layers (ectoderm, mesoderm, and endoderm), so that different gene products are formed. That is why it is assumed that AGs are already present in the unfertilized egg cytoplasm and these cytoplasmic determinants play a role in directing embryonic development (for details see *[13,14]*.

The Essence of the Proposed Hypothesis

The essence of our hypothesis is illustrated by the example of anoles. It is turned out that sometimes under the influence of external factors, the evolutionary processes can dramatically accelerate, as happened in the case of green anoles (*Anolis carolinensis*), lizards - dart anoles living on islands off the Florida coast. Recently, scientists have witnessed record quick evolutionary changes among American lizards *[15]*. Literally within a few years the habits and structure of these reptiles has undergone significant restructuring. Thus, in the 1950s, from Cuba to Florida was brought other species of lizards - brown anoles (Anolissagrei).Then the anoles-aliens began to settle in the islands and squeeze lizards-aboriginal. Scientists observed this process for about 15 years, during which managed to turn about 20 generations of lizards. It is turned out that during the observation period pads on the toe pads of green anoles began larger and sticky, and they began to dwell in the upper part of the trees. According to the researchers, if the human height was changed with the same speed, then after 20 generations of American men (average height is 175 cm) would be similar to the NBA basketball players (average height is 193 cm). We suppose that the case of anoles provides scientists with a rare opportunity to test the Darwin's hypothesis of gemmules.

According to our hypothesis, the origin of species by adaptation is schematically looks like this:

a) A change in the physicochemical and biotic conditions of the habitat of the species;
b) Strengthening or increasing existing structures or functions by intensifying the activity of already functioning genes or mobilizing "silent" genes necessary for adaptation of an organism to new living conditions. In the case of anoles, such intensification has led to the fact that pads of green anoles began larger and sticky;
c) Merging of new biochemically highly active chromatin sites into chromocenters to remove excess heat outside the cell nucleus to preserve temperature homeostasis in the cells;
d) The production of gemmules as a result of the response of the organism to a new environment. However, it is difficult to say whether gemmules pass from the mother to the fetus (the Weismann barrier) or the fetus itself, along with the maternal organism, reacting to environmental influences, produce DGs. One way or another, gemmules accumulate in the cytoplasm of oocytes;
e) The transmission of gemmules from the cytoplasm of oocytes to the zygote during fertilization;
f) The use of AGs by the fetus during ontogenesis to recreate the same structures and functions from which they were derived; with time these epigenetic changes in chromatin can result in translocation of these dense regions from one chromosome to another, there by changing the former harmonious structure of the species karyo type, which can lead to its reproductive isolation using meiotic mechanisms with all the ensuing consequences (for details see *[13-19]*). By the struggle for life by "active" and "passive Darwinism" we mean that perhaps the basic idea of Darwinism on the origin of species by means of natural selection needs some refinement. This thought we found from Steven Rose, who wrote that 'the key feature of Darwinism as it is conventionally understood is that it is the external world, the environment, which is constantly setting organisms challenges to their survival. If they meet the challenge, they survive and breed, and their progeny prosper, if they fail, their line diminishes and eventually ceases. It was at this rather passive concept of natural selection that Popper's criticism was aimed. He argued instead for what he called 'active Darwinism', which conceives of the living organisms as helping to determine its own fate by itself challenging and modifying its environment to meet its own needs' *[20]*. If we apply this idea in our context, then attracting the idea of DGs will lead us to what Karl Popper demanded, namely 'active Darwinism'. Really central to Darwin's thoughts about heredity was the idea of blending inheritance, i.e. the merging of parental differences in the off spring of bisexual reproduction; according to Robert Olby this was the most unfortunate of the assumptions underlying Darwin's mechanism of evolution *[21]*. The recognition of the two types of Darwinism presupposes the existence of a material bases corresponding to them. In this case, the material basis for 'passive Darwinism' is changes at the DNA level, and DGs for 'active Darwinism'. In this case, species occur through adaptation using both "active" and "passive Darwinism". Perhaps in the face of gemmules we found what Darwin unsuccessfully searched for - a source of organismic variability, on the basis of which species occur. Despite the impeccability as a logical construction, Darwin's hypothesis on gemmules still does not have direct experimental support. We have already written about possible methods of experimental verification of the hypothesis *[13,14]*.

Discussion

Currently the idea of biological variation is usually associated with the changes at the level of DNA. While a tremendous amount of variation has been revealed at the DNA, a satisfactory explanation of the adaptation and origin of species is still lacking. It is not at all clear whether adaptive evolution makes use of the kind of genetic diversity that is now known to be so common. Population genetic theory leads to conflicting conclusions about the forces operating on the variation, and it appears that current theory is inadequate to cope with the data *[22]*. Our long-term studies of human populations permanently living in extreme climatic conditions show that *Homo sapiens, H. sapiens* can adapt even without the involvement of gene parts of genome. Thus, for example, the human populations can adapt to cold and high-altitude hypoxia by changing the amount of chromosomal Q-heterochromatin regions (Q-HRs), which consist mainly of highly repeated sequences of DNA, not capable to encode proteins and enzymes known in the science. In particular it is turned out that chromosomal Q-HRs is distributed in human genome not accidentally. Specifically: a) The amount of chromosomal Q-HRs in human population genome depends on climate and geographical conditions of permanent residence and not their ethnic and racial peculiarities. The largest amount of chromosomal Q-HRs is found in the genome of populations living in low altitude subequatorial Africa and India, and the least - in Northern Siberia aborigines, as well as indigenous people of Tien-Shan,

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Pamir and Ethiopian high altitudes *[23-29]*; b) Individuals capable of successfully adapting themselves to the extreme high-altitude climate (e.g. mountaineers) and newcomers of the Far North (e.g. oil industry workers of the Jamal peninsula of polar Eastern Siberia) are characterized by extremely low amounts of chromosomal Q-HRs in their genome *[30,31]*.These data show that there is connection between the amount of chromosomal Q-heterochromatin in human genome and his adaptability to some physical environmental conditions *[32]*. This example is notable for the fact that all this happened for very short period of time (several millennia) and H. sapiens remained a single tropical biological species. We have already given experimental evidence of how the wide variability of chromosomal Q-HRs in the genome form adaptive phenotypes at the level of the whole organism and what are their consequences in normal and pathological conditions *[33]*. In other words, we showed the possibility of adapting to different climatic and geographical conditions without involving structural genes. If this is the case, then why should we exclude other possibilities, namely the occurrence of adaptation based on DGs, as an additional third source of biological variability? The germ cell lineage carries the fragile link between one generation and the next, and so is of central importance for the survival and evolution of living organisms *[34]*. The main genetic problem of embryonic development is differentiation. At present time, theories of differentiation at gene level can be considered refuted. Indeed, genomes of all cells are identical. As a rule, control of differentiation is carried out on a transcriptional level: differentiated cells produce various numbers of mRNAs. Regulation on the other levels, less connected to a primary activity of genes, is also possible. However, the exact mechanism of such control of higher eukaryotes is not determined. Therefore, we believe that differentiation is not just a matter of genes and cortex and cytoplasm interacting with each other but also of the DGs of one generation controlling those of the next generation during the very early development. Cytoplasmic control is of enormous importance in early development. Evidence for the importance of the cytoplasm accumulated in the late 19th century. Numerous examples are now known of the effects of the cytoplasm on the nucleus. Classic experiments of Hörstadius and Spemann established that the unequal distribution of materials in the egg cytoplasm plays a role in directing embryonic development. They were named ‘cytoplasmic determinants’*[35]*. However, those hypothetical cytoplasmic determinants are not identified yet and still elude sophisticated methods and machines of science. There are sensitive time windows during early development where environmental cues can program persistent epigenetic modifications, which are generally assumed to mediate these gene-environment interactions. The fact that the DGs accumulated only in oocytes are transmitted to the offspring, apparently, is a deep biological sense. In fact, if in a fertilized oocyte met DGs from both parents, there would be a serious failure in the development of a fetus. It is not difficult to imagine that to the quantitative and qualitative composition of DGs in germ cells will undoubtedly have effect by gender, age, weight, height, food composition, environment features and the history of the individual development of parents. Therefore, the collision of biological parents past through DGs can create chaos in the already complicated process, which is the individual development. Thus, we suppose that only the maternal organisms DGs, as a source of organismic variability, participates in origin of species.

It's still unclear how new adaptive forms and functions are gained and transmitted to descendants? There is an opinion that ‘The gene does not create form and function’*[38]*. We are of the opinion that with the appearance of the sexual mode of reproduction the role of genes in the origin of species has decreased *[13,14,36,37]*. In any case, none has been able to prove that new adaptive forms, body plans or new species have appeared due to random mutations of the gene(s). In other words genes for eukaryote organisms did not show themselves as bridges between the outer and internal environments. DG would suit for this role, if they really exist in Nature.In this case, it can be expected that adaptation, and subsequently the origin of the species, can be based on the variability of genes, noncoding DNAs and DGs. When asked why natural selection did not find a place in our hypothesis, we answer with the words of Stephen J Gould that ‘Natural selection is, first of all, a theory about adaptation to changing local environments, not a statement about “improvement” or “progress” in any global sense’. In addition, now few people doubt that natural selection is not the only mechanism that can explain the origin of species. ‘What Darwin called natural selection is actually a process of elimination. The progenitors of the next generation are those individuals among their parents' off spring who survived owing to luck or the possession of characteristics that made them particularly well adapted or the prevailing environmental conditions. All their siblings were eliminated by the process of natural selection. Herbert Spencer, when saying that natural selection is nothing but "the survival of the fittest”, was indeed quite right. Natural selection is a process of elimination, and Darwin adopted Spencer's metaphor in his later work’ *[39]*. And finally, the concept of the origin of species by means of natural selection is the first scientific theory to explain the possible mechanism of evolution without involving supernatural forces. Science owes this theory to the expulsion of vitalism from biology and the beginning of scientific research based on the natural causes of evolution. If Darwin’s hypothesis about the existence of gemmules is confirmed in the future, this would leave even less space for proponents of orthogenesis, creationism and open the way to experimental evolution.

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I apologize to that authors whose works are not cited or are cited only through reviews. The reason for this is only the space limitations of the publication.

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