Non-randomness of Genetic Mutations: Some Philosophical Implications

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The task of both scientists and philosophers is to doubt, question the supposed truth and challenge scientific claims. This article meets the task of challenging evolutionary theory's (neo-Darwinian) claims of the random nature of genetic mutations. The neo-Darwinists' theory of biological evolution views the transformation of living forms through stages of random mutations and non-random natural selection. Mutations are, by the definition of randomness, not caused by or aimed at the benefit of the organisms in which they occur. However, some experiments question the randomness of mutations claiming their non-random nature, and conceptual analysis points to the ambiguity of the concept of randomness and the notion of usefulness. In addition, it is not justified to apply the conceptual and methodological toolkit from physics in biology (except in molecular biology), because biology has its own domain with corresponding special concepts, principles and methodology. Harmonisation of the conceptual meanings indicates that the nature of non-random mutation process confirmed the specific economy of biological evolution. The evolutionary implication of the non-random nature of mutation process presumes a world in which the occurrence of biological diversity is highly probable.

Key words: biology, benefit concept, evolution, mutation economy, mutations, non-randomness

Karl Marx: »Die Philosophen haben die Welt nur verschieden interpretiert; es kommt aber darauf an, sie zu verändern«.[1]

Jerry Fodor: »Biologist have changed neo-Darwinism in many ways; the point now is to subvert it«.[2]

INTRODUCTION

It has been generally accepted that the theory of biological evolution is related to a process of emergence of quantity and quality diversification from a few or even one form (LUCA); however, there is a dispute concerning the principle underlying and governing these changes. Evolutionary experts are in a unanimous agreement when it comes to interpreting the properties of the causal relationship responsible for the evolutionary processes, as well as concerning the very nature of the principle governing evolution. Previously, I also thought that the evolutionary story sounded quite logical and irrefutable, but after insight into the results of experimental biology, which sometimes show a different nature of the structure of the theory of evolution, I began to doubt. Despite the explanatory power of the neo-Darwinian theory of evolution, I find the explanation of the evolutionary processes, more specifically the nature of genetic mutations, unacceptable. An additional confusion stems from the issue of determining the nature of genetic mutations from the vaguely defined concepts of randomness and non-randomness, and as Mayr[3] notes, in evolutionary biology most of the progress is achieved by the introduction of new concepts, or the improvements of existing concepts. The next step in this dilemma arose from a decision regarding the position of biology both inside and outside the system of science: if someone thinks, as I do, that biology is real but an independent science with its own domain, specific principles, concepts and methodology, than it is not possible to profit from using the principles, concepts and methodology of physical science in biology.

Therefore, this article briefly presents the neo-Darwinian view of the theory of evolution, and then examines some conceptual issues (concepts of mutation, randomness and non-randomness). Thereafter, the paper brings some experimental results that are contrary to the canonical view of the nature of genetic

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[1] E. BLOCH. 1959. *Das Prinzip Hoffnung, Band I, Weltveränderung oder Elf Thesen von Marx über Feuerbach.* Suhrkamp Verlag Frankfurt am Mein , Frankfurt am Mein. XI these, p. 124: »Philosophers have hitherto only interpreted the world in various ways; the point is to change it«.

[2] J. FODOR and M. PIATTELLI-PALMARINI. 2010. *What Darwin got wrong.* Farrar, Straus and Giroux, New York. p. 20.

[3] E. MAYR. 1982. *The Growth of Biological Thought. Diversity, Evolution and Inheritance.* Cambridge, Massachusetts and London, England, The Belknap Press of Harvard University Press. p. 23.

mutations. Experiments indicate the relativity of the concept of benefit and specific nature of mutation economy, so this article discusses that concepts assuming that the explanation of the nature of genetic change can be misinterpreted because of the vagueness of terms used. The meaning of concepts in biology is different from that in physics and the meaning of terms should be matched with the area in which they are used. Thus, consistent concepts bring a significantly different view of the principle of evolutionary change.

1. CANONICAL VIEW

Darwin and the neo-Darwinists view the process of evolution by natural selection in two stages:

1) a genetic mutation further leads to variation;

2) natural selection favours the survival of the individuals with specific genetic combinations.

A two-stage approach to the explanation of evolutionary changes implies essentially different natures of its components. The first component is the occurrence of genetic variability or genetic mutation representing a discontinuity of the hereditary information and is designated as *random*. The second component of evolutionary changes is the process of natural selection by which some genotypes are non-randomly favoured. Actually, it is not the genes that are exposed to natural selection; rather it is entire organisms and populations, so that the selection is active at the level of phenotypes rather than genotypes.[4] Natural selection means a differential survival and reproduction of newly formed individuals. It is precisely how Sober[5], somewhat more generally, defines the nature of non-randomness:

> »However, when the different possibilities have drastic unequal probabilities, the process is not a random one«.

Because natural selection involves unequal probabilities, it will be safe to say that it is not a random process. The non-randomness of the process of natural selection is by no means disputable since different possibilities (variations) do not have the same or similar probability of survival and reproduction, with some of the possibilities being entirely ruled out.[6] More specifically, different organisms have different degrees of probability of survival and reproduction. Mayr[7] warns of the unsuitability of the term selection and suggests that a

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[4] Many candidates tend to place evolutionary unit: genes, organisms, populations and species.

[5] E. SOBER, 2000, o. c. p. 37.

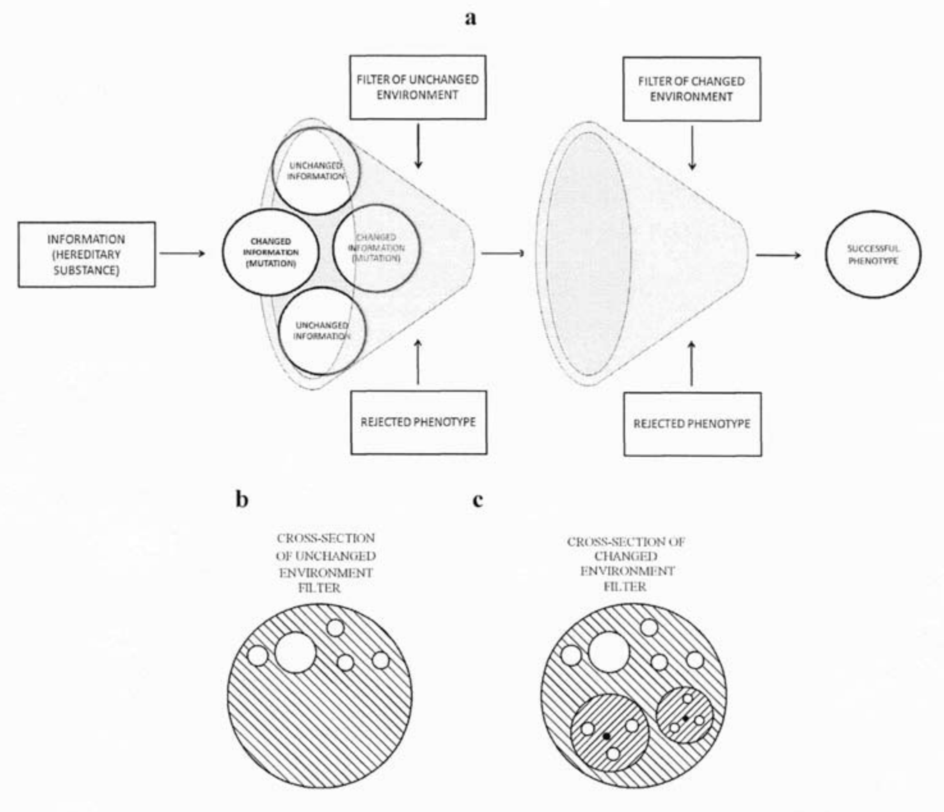
[6] Ibidem.

[7] E. MAYR, 1988. *Toward a New Philosophy of Biology: Observations of an Evolutionist*. Cambridge, Harvard University Press. p. 564.

more suitable term – non-targeted elimination - should be introduced, showing more precisely the absence from nature of a selecting force. Mayr views these two components as a combination of chance and anti-chance, by which adaptability and goal-directedness are imparted to evolution. Directedness, as well as certain tendencies of evolution, should not be confused with orthogenetic series[8], since selection itself involves certain directional trends.

The diagram in Figure 1 shows a simplified canonical view of evolutionary pattern, facilitating a research into the logical and causal relation between the transfer of hereditary information and adaptation-reproduction results which mean a benefit for a successful phenotype or damage to an unsuccessful one.

Figure 1



The left side of the Figure 1a shows a hereditary substance which carries information concerning the building of a phenotype. Such information mainly

[8] Like nomogenesis (L. Berg), aristogenesis (H. F. Osborne) and omega principle (T. de Chardin).

consists of unchanged contents, but sometimes mutations occur, changing the original information to a greater or lesser extent; however, not in response to the needs of the organism in question, but merely copying mistakes during the replication on the genetic material. It should be noted Crick's *central dogma* by which the fundamental function of the genetic material controls the synthesis of proteins, and the direction of information is one-way, only from the nucleic acid to protein (or something else, but it is not possible to transfer information from protein to nucleic acids). This article is without prejudice to the evolutionary importance of Crick's central dogma, though Crick's dogma can be overridden according to the evolutionary importance from two directions. First, the incompleteness due to cytoplasmic inheritance[9], and second the directional adaptive changes or enormous adaptive potentials[10]. Anyway, the aggregate of information composed of original, changed and mixed information first reaches a rougher filter (left southpaw-Figure 1b, whose white circles represent the space of passage of hereditary substance) which checks whether the forwarded information is suited to the unchanged structure of the environment. Sober[11] maintains that the modification of frequency of diverse genotypes can also be explained by non-mutation models, as the system of mating or migration. Mayr[12] completely attributes the factor of genetic variability to chance, whether the variability has been caused by mutation, recombination (by breaking up and rejoining of the parental chromosomes), or by genetic drift. If you do not question the belief in the principle of causality, then the knowledge of causal connection is the assumption of knowledge of evolutionary phenomena. It is not problematic to determine the conditions under which nothing will change, the problem is to determine the conditions under which something will change. For example, Newton's dynamics of motion involves the principle of equilibrium in which the state changes (acceleration, deceleration and change of direction) to import the balance of power disturbances. Similarly, there is the example of the principle under which the genetic equilibrium will not change: in the absence of perturbation factors alleles frequencies at locus remain unchanged and there is no variation and no possibility of evolution. Evolution requires the perturbation factors, with numerous candidates[13]: selection, mutation, meiosis, migration, genetic

9 R. H. TAMARIN. *Principles of Genetics*. Boston, WCB McGraw-Hill, 1999; D. FUTUYMA, 1986. *Evolutionary Biology*. Sunderland, Massachusetts. Sinauer Associates, Inc.

10 L. PERFEITO, L. FERNANDES, C. MOTA and I. GORDO, 2007. Adaptive Mutations in Bacteria: High Rate and Small Effects, *Science*, 317: 813-815

11 E. SOBER, 2000. *Philosophy of Biology*. Boulder, Colorado: Westview Press.

12 E. MAYR, 1976, o.c. p. 9.

13 P. THOMPSON, 2007. Formalisations of Evolutionary Biology. In: Matthen M. i Stephens, C. (eds.), *Philosophy of Biology*. Amsterdam, Elsevier.

drift, and often ignored anatomical-physiological effects and environmental constraints[14].

Genetic differences participate in the production of various phenotypes forming numerous morphological properties (with respect to both quantity and quality), physiological properties, cytological structures (e.g. the number of chromosomes), pigmentation, etc., in which an additional difficulty is caused by the research and study of phenotype variations since genetic and non-genetic causes cannot be easily distinguished and separated. The concepts of genetic variation and genetic mutations are not synonymous, and it is sometimes not entirely clear how genetic mutation is to be defined. Mayr[15] speaks of a conceptual confusion in the meaning of genetic mutation as interpreted by T.H. Morgan and De Vries.

Changes in gene frequency may be brought about by different causes; apart from the selection, there is mutation, recombination, migration, pattern of mating and genetic drift. All these factors may simultaneously contribute towards changes in gene frequency, but it is the genetic mutation that results in a new value with respect to quality upon which all of the above causes of change in gene frequency are based. It is the genetic mutation that creates new individual genes and it is believed that there is no law controlling the direction of mutations. Population genetics and evolutionary biology see mutation as a statistical category which, by re-forming hereditary information concerning the building of a phenotype and its behaviour, re-structures life forms regardless of potential benefit (survival-adaptation and reproduction). This still remains to be researched on a model facilitating an observation of evolutionary entities and their complex interrelations

A completely invariable structure of the environment represents a simplified idealisation since such an environment does not exist: it is really the elements of the environment that change extremely slowly, like universal physical laws in the form, for example, of existence and size of the gravitational force responsible for various symmetrical relations of living forms or atomic-molecular properties determining numerous quantity and quality relations within organisms. The constant rate of oxygen and other gases in the atmosphere within geological time, falls into this category, i.e. can be regarded as a relatively unchangeable structure of the environment. By the absence of cataclysmic occurrences which would affect this, the relatively invariable structure of the environment, the hereditary substance containing

[14] R. FALK, 2007. Genetic Analysis. In: Matthen M. i Stephens, C. (eds.), *Philosophy of Biology*. Amsterdam, Elsevier.

[15] E. MAYR, 1997. This is biology: the science of the living world. Cambridge, Massachusetts and London, England, The Belknap Press of Harvard University Press, p. 68.: »1) A sudden change in the genetic substance» and 2) evolutionary change immediately resulting in a new species«.

an unchanged information in creating a phenotype, passes the first selection filter relatively easily. Constant or relatively constant structures of the environment favour the unchanged information, or changed in the form of structures which could even better utilise the given parameters, e.g. symmetrical patterns or an improvement in the utilisation of mixture of atmospheric gases. Nonetheless, any information disregarding or violating the basic laws of such constant structures could not be admitted any further. Mutations carrying the changed information concerning the building of a phenotypes in the event of collision with relatively constant environmental structures would come to a halt upon reaching the first filter. Such mutations are lethal and imply the rejection of genetically proposed instructions concerning the building of a modified phenotype. It could be said that a non-correspondence of the organism structure to its environment in crucial points of form would mean that such an organism would be eliminated. Mutations which are not in collision with constant structures represented by this filter may come across yet another environmental selection filter whose structure changes more rapidly (the right southpaw-Figure 1c, whose smaller rotational plates more frequently alter the conditions permitting the passage of various mutations) as an example consider climatic changes and the related changes in food resources. This filter is capable of stopping and rejecting some changed bits of information, but it can also let them go through, thus creating a new, more successful phenotype. The second selection filter can, under changed conditions, stop some of the so far successful constant gene instructions, finding their phenotypes not to be sufficiently well adapted.

2. CONCEPTUAL ISSUES

Genetic mutations are frequently attributed as anomalous by nature; they are considered to be »erroneous or faulty« DNA replications. The phenomenon of mutation rate, proved by various experimental methods, establishes an average mutation rate on the basis of DNA pairs per cell division in monocellular organisms or per gamete in »higher« organisms respectively. It therefore follows that we are by no means dealing with an anomaly of any kind, should anomaly be defined as an event which is subject to no law, regularity or pattern, but rather with a constant and predictable process with determined average values. The possibility of determining the mutation rate further proves a logical relation between the mutation occurrences and the »normal« transfer of hereditary material (whose information is not subject to change) onto new generations, i.e. it demonstrates a regularity of such occurrences. The model illustrated in Fig. 1 shows logical and causal relations of the transfer of essentially different hereditary information concerning the building of a phenotype and its evolutionary fate. The logical relation, i.e. the regularity of the process, is clear, since without the transfer of hereditary information there can be no creation of phenotype, regardless of the ultimate evolutionary outcome. A causal relation of the occurrence of successful phenotypes may be viewed in a similar way because we always deal with a regular sequence leading from mutation towards successful or unsuccessful phenotypes. A different sequence of events would be impossible to imagine, therefore allowing us to establish a constant common occurrence of mutations and successful phenotypes. What is necessary, however, is to identify and separate the causes underlying the dispersion of results of mutations characterised as beneficial, harmful, or neutral. An intuitive idea emerging in the process would require the relation of a particular specific mutation or a more complex mutation entity and its benefits for the organism to be determined. Since the idea of one gene carrying one trait[16] has been long abandoned, it is necessary to understand that mutation in itself by no means represents a primary source of phenotypic variations. Therefore, although mutation ultimately remains the main source of all genetic variation, the main source of phenotypic variation is much richer in content (different genetic and non-genetic variation, epistasis, slight variations in the regulation of genes or timing of activation of those genes, even as the result of the same genes of gene complexes). Such a mutation entity on its way to phenotypic realisation produces some of the aforementioned results (useful, harmful and neutral). In terms of category, it is by no means easy to determine the properties of such results: a beneficial mutation means that such a phenotype has some, if only minimal advantages over other phenotypes of the same population, ensuring also other advantages in utilising the resources of the ecological niche and reproduction. Such a phenotype is more suitable and better adapted. The mutation, whose effect may be designated as harmful, results in a phenotype which is either totally incapable of survival and reproduction (the so-called lethal mutation) or has, by its properties, a reduced chance of survival and reproduction in comparison to other phenotypes of the same population. Neutral mutations are those which cannot be identified as resulting in any phenotypic changes in the selection competition, i.e. as resulting in any determined physiological effect. By category determination the ultimate results of the relation between mutation events and the selection process are defined, however, it says nothing about actual relations between particular mutation entities and the ultimate outcomes of evolutionary processes.

The concept of randomness, in its broadest definition, sees various possibilities as having the same or similar degree of probability. Figuratively speaking,

[16] So-called *beanbag concept,* according to Mendelian compared the genetic content of population to a bag of colored beans. Mayr thinks that considering genes as independent units is meaningless from the physiological and the evolutionary viewpoint (J. FODOR and M. PIATTELLI-PALMARINI, 2010, p. 25.)

randomness can most easily (though inaccurately) be compared to a game of lottery in which every ticket has an equal probability of winning. A more precise comparison, however, may utilise the time of the semi-disintegration of a chemical element half of whose atoms will certainly disintegrate, but which atoms they will be and why these particular atoms cannot be determined with any certainty since all of the atoms have an equal probability of disintegration in a given time – if this is really true, it could be confirmed by one of the lives of Schrödinger's cat. It has been universally accepted that randomness of mutation processes means that their very occurrence is not dictated by the benefit of the organism in question. Sober[17] says that: »Mutations are said to be 'random' in that they do not arise because they would be beneficial to the organism in which they occur«. Wright[18] similarly defines the concept of random mutation: »By the neo-Darwinian definition, a mutation is random if it is unrelated to the metabolic function of the gene and if it occurs at a rate that is undirected by specific selective conditions of the environment«. Addressing the same issue, Mayr[19] claims that:

> »There is no connection between the molecular event and its potential significance - neither the underlying molecular phenomena nor the mechanical motions involved in some of these processes are related to their biological effects«.

Sober allows for the possibility of physical events resulting in a higher probability of particular mutations: »There may be physical reasons why a given mutagen-radiation, for example – has a higher probability of producing one mutation than some other«, while Tamarin[20] thinks that: »... we note that we view mutation as a process that occurs randomly, not because a cell 'needs' a particular mutation«.

Furthermore, Tamarin points out that randomness of mutations does not mean that the occurrence of different mutations has an equal degree of probability.

3. BIOLOGICAL FACTS

Mutation is the primary source of all genetic variation. It is only on the basis of mutation that all other causes of genetic variation can be added. But what is mutation? By introducing the concept of mutation into biology, De

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17 E. SOBER, o.c., p. 37.

18 B. E. WRIGHT. 2000. A Biochemical Mechanism for Nonrandom Mutations and Evolution. *Journal of Bacteriology*, Vol. 182, No. 11, p. 2995.

19 E. MAYR, 1982., p. 58.

20 R. H. TAMARIN, 1999, p. 489.

Vries[21] wanted to identify and designate a process by which a new species is created, more specifically a process of a sudden change in phenotype. The term *mutation* was equally used as the process and its result, as well as for describing changes in both genotype and phenotype. With the development of genetics the term became exclusively reserved for the area of genetics, but not unarguably. Mayr[22] mentions mutation being defined by some authors as: »...any error in gene replication« or »Anything that could interfere with the normal process of gene replication might result in a mutation«. Others maintain that there is a separate gene unit of mutation, designating it by the term *muton.* In regards to mutation, Futuyma[23] claims the following: »Mutations are of many kinds, and their variety appears still to be growing as more molecular information comes to light«. By this Futuyma apparently means several types of mutation (point mutation: a substitution of one base pair for another; frameshift mutation: the deletion of insertion of a single base changes the reading frame; back mutation: reversion of a mutant allele to the original form). Contemporary genetics[24] speaks of mutation as: »... both the process by which a gene (or chromosome) changes structurally and the end result of that process«.

Of course, different phenotypes may be the result of the same genes or gene complexes (differential gene regulation), also. Anyway, mutation is undoubtedly a factor fundamentally important to evolutionary changes, but what are mutations caused by? Although the laboratory research by induced mutations have resulted in the discovery of numerous mutagene factors, e.g. chemical, physical, or radiation, mutation may also spontaneously occur as an erroneous DNA replication which has been claimed to have no connection whatsoever with its biological effect.

Contrary to this, Cowan[25] claims that:

> »It is possible that microbiology may provide the evidence that Lamarck's followers have been seeking, for a microbial population (a strain) that acquires a property in a new environment may retain it for some time when transferred back to the old, though a re-adaptation may sometimes occur within five generations«.

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[21] H. De VRIES, 1901. *Die Mutationstheorie.* Leipzig.

[22] E. MAYR, 1982. *The Growth of Biological Thought. Diversity, Evolution and Inheritance.* Cambridge, Massachusetts and London, England, The Belknap Press of Harvard University Press, p. 804.

[23] D. FUTUYMA, 1986, p. 65.

[24] R. H. TAMARIN, 1999, p. 466.

[25] S. T. COWAN, 1962. The Microbial Species-A Macromyth? *Symp. Soc. Gen. Microbial.,* 12 (*Microbial Classification*), 433-455, p. 439.

Cowan is not alone in such claims, Cairns[26] claims that mutations to be occurring because the cells need them, calling such occurrences directed mutation or adaptive mutation. Apart from Cairns' paper, which was based on research conducted on *E. coli* involving genes which did not allow the use of lactosis as a source of energy, Tamarin[27] mentions that similar results have been obtained by other scientists utilising other organisms and different genes. Hall[28] seems to share this opinion by claiming that some experimental results can be interpreted in corroboration of an allegation that individual organisms are capable of adaptively changing their genomes in response to variable environmental conditions while passing on the acquired properties to their offspring, as Lamarck had thought. Furthermore, the hypothesis about the non-random nature of gene mutations should by no means be confused with teleological interpretations of the nature of movable gene elements, *transposons*, by which, allegedly[29], the evolutionary suitability of certain bacteria can be improved. These gene elements are sometimes described as seemingly non-functional, representing really strategic reserves which in future could be used for meeting the newly created needs requirements. Also, Wright[30] recently describes the biochemical mechanism for non-random mutation and evolution that were predicted by mathematicians. Wright writes similarly to Mayr (see footnote 16) about the meaning of the concept of random or spontaneous mutation: »In a scientific context, the word spontaneous is meaningless. Every event is preceded, and dependent upon, innumerable known and unknown prior events and circumstances«. Wright[31] argues that the causes, in this case of mutations, sometimes are non-random: »...hypermutation resulting from derepression (derepression is a mechanism which occurs in response to starvation for an essential substrate or for an end product that represses its own synthesis by feedback inhibition, A/N) is localized as a direct consequence of a specific response to environmental challenge«. This approach is clearly contrary to anti-Darwinist view because of the direct influence of environment. In support of this thesis is Salvini-Plawen and Mayr's[32] evidence of independent evolution of the eye on at least 40, very different species.

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[26] J. CAIRNS, J. OVERBAUGH, and S. MILLER, 1988. The origin of mutants. *Nature* 335, /001014/145.

[27] R. H. TAMARIN, o.c.

[28] B. G. HULL, 1988. Adaptive Evolution that Requires Multiple Spontaneous Mutations. *Genetics*, 120: 887-897.

[29] R. H. TAMARIN, o.c.

[30] B. E. WRIGHT. 2000. A Biochemical Mechanism for Nonrandom Mutations and Evolution. *Journal of Bacteriology*, 182: 2993-3001.

[31] Ibid, p. 2995.

[32] L. V. SALVINI-PLAWEN and E. MAYR. 1977. On the Evolution of Photoreceptors and Eyes. *Evolutionary Biology*, 10: 207-263.

At the end of this chapter, it is important to mention that Dobzhansky[33] also considers that the most serious objection to the neo-Darwinist version of the theory of evolution arises precisely from the accepting nature of genetic mutations as random and that it is difficult to see how mutation and selection can add up to the formation of beautifully balanced organs as eyes.

4. RELATIVITY OF BENEFIT CONCEPT

Natural selection is not a random process because different possibilities (variations) do not have the same or similar probability of survival and reproduction, i.e. different phenotypes have different degrees of probability of survival and reproduction[34]. Natural selection is like a filter which admits into existence only variations capable of adapting in the given existing geological, climatic and environmental system. It is precisely due to their being different that some variations have a probability of survival, which serves to corroborate the hypothesis that natural selection is not random, i.e. does not happen by chance. In the course of adaptation, more suitable characteristics seem to be occurring increasingly frequently, while the less suitable ones are becoming rare, resulting in the survival of only those organisms possessing more suitable properties. Adaptation is one of the basic features of evolution despite all the differences and disagreement concerning the extent of its influence upon the direction of evolutionary processes. Nevertheless, no one doubts the existence of adaptation trends which represent a clear interrelation between inanimate and living nature. The strength of the concept of adaptation can be corroborated by the fact that it is sometimes used to define life itself, thus Dawkins[35] says: »Living things ... they are adaptively complex«. In the same paper Dawkins points out the adaptive complexity by employing a crucial criterion for the definition of life, claiming that explaining the phenomenon of adaptation is the basic issue to be resolved by any theory of biological evolution. Namely, from all possible ways of arranging the total number of atoms in some living organisms,[36] only a very small number of combinations would constitute automata that work to keep themselves into being and multiply similar products. The process of adaptation takes place under the pressure of selection by the evolutionary modification of organism properties in order to achieve an efficient functioning, i.e. increasing suitability in a certain con-

[33] T. DOBZHANSKY. 1950. The genetic basis of evolution. *Scientific American*, 182: 32-41.
[34] A. ROSENBERG and D. McSHEA, 2008. *Philosophy of Biology: A Contemporary Introduction*. New York, Routledge.
[35] R. DAWKINS, 1998. Universal Darwinism. In D. L. HULL and M. RUSE (eds.): *The Philosophy of Biology, 15-38*. New York: Oxford University Press Inc, p. 17.
[36] For example, human body which contains 10^{27}.

text of relations between the organism, population and the environment. It is precisely due to the fact that biological processes take place in time and within a space characterised by the variable properties of the environment that a substantial determination of usefulness or harmfulness of particular mutation becomes virtually impossible. Colbourne, Constantin, Dobell and Fehres[37] says:

> »Mutations that are not meant an advantage, or even been opposing it, may become desirable in the new environment. In this situation, mutations provide a selective advantage in the new environment«.

Therefore the same mutations may be beneficial or harmful. The environment with its changeable geological, physical, climatic and ecological properties does not direct the adaptation process, but compares all the available phenotypic forms with the currently existing possibilities of survival. General conditions of the environment constitute a peculiar mould into which the available forms may or may not fit. A more frequent and complete correspondence in structure between the organisms and the environment increases the chances of survival, and organisms cumulate an increased quantity of information of their surroundings. A change in the mould constantly requires new variations of living forms capable of fitting into the existing available moulds. Vollmer[38] compares adaptation with the concept of representation as an indication of an environment resembling a horse's hoof representing a prairie or a fish fin symbolising water and the laws of hydrodynamics. Does this mean that better adapted organisms have an advantage over less adapted ones when it comes to survival? The answer to this question is not as simple as it appears; namely an imaginary perfectly adapted phenotype would require a partner in the form of an unchangeable mould in an ideal environment which is not possible in the physical world. Such a phenotype would »waste« numerous generations of its species in order to achieve no more than an ephemeral perfection which would shortly be condemned to stagnation, because of its excessive adaptation, or, more likely, extinction. In biological terms a perfect adaptation taken as an absolute suitability to a particular ecological niche means an obvious setback; what is more useful is the production of optimum solutions for an adaptation with a relation to the environment as open and independent as possible. The specific nature of the concept of ideal adaptation in the domain of biology actually implies variability and tolerance, and mutations can act in favour of such a type of adaptation, but also against it. An ideal and complete adaptation in the conditions of a constantly changing

[37] H. COLBOURNE, B. CONSTANTIN, D. DOBELLl and C. FEHRES, 2007. *Inquiry into Biology*. Toronto, McGraw-Hill Ryerson Ltd, p. 117.

[38] G. VOLLMER, 1984. Mesocosm and objective knowledge. In: Wuketits, F. M.(ed.), *Concept and Approaches in Evolutionary Epistemology*. Dodrecht, D. Reidel.

world is not only unnecessary: it is also undesirable, even harmful, because an absolute correspondence in structure between the organism and its environment could be only attained for a negligibly short sequence of time. It is much more beneficial for the organism to produce merely »sufficiently good« adaptation, capable of ensuring its survival. Mutation stimulated variability and adaptation process cannot be evaluated in terms of usefulness/harmfulness in any other way but by comparison to the conditions of the environment. The fixed goal of successful survival has no concrete predetermined constants: its values are open and variable. What is suitable and useful in one situation does not have to be so in a different situation and *vice versa*. It is sometimes precisely the so-called harmful mutations that represent an advantage, as in the following extreme case: haemoglobin in its heterozygote form in human population is known to cause sickle-cell anaemia, whereas in a malaria-infested environment it protects such individuals[39]. How is it then possible to characterise a causal relation between a particular mutation and its effect, reducing it to a phenotype? The specific position of a particular mutation in relation to time and space determines its designation as either useful or harmful, it is therefore obvious that the concepts of usefulness and harmfulness in terms of mutations and evolutionary fate cannot be substantially, but rather relatively defined. I should also mention a statement about the randomness of mutations by advocating independent occurrences of variations with regard to the needs of an organism in conditions of a given environment, i.e. claiming that mutation bears no impact on the organism in its entirety. Conversely, the relation between the genotype and phenotype constitutes a relation of a complex system of expression interaction of hereditary units, genes, the given environment, organism development, population and the computer science concept of *developmental noise*. The course of development is not completely determined even by the joint action of genotype and the environment because, according to Waddington[40], the epigenetic process is a system of channels (canalisation or capacitor[41]) varying in *depth*, rendering it impossible to be disturbed in one part, while in the other segments it changes in various degrees, depending upon the conditions of the environment. The direction of development of a particular cell does not exclusively depend upon the genetic instruction of that cell, nor does it depend on the conditions of the environment, but on the condition and status of the adjacent cells. Fodor and Piattelli-Palmarini writes:

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[39] M. D. GRMEK, 1989. *Bolesti u osvit zapadne civilizacije*. Zagreb, Globus.

[40] C. H. WADINGTON, 1957. *The Strategy of the Genes*. London, Allen and Unwin.

[41] J. FODOR and M. PIATTELLI-PALMARINI. 2010. *What Darwin got wrong.* Farrar, Straus and Giroux, New York. p. 39.

> »...the sorts of cases reported here do not suggest an adaptationist treatment; in consequence, they were largely forgotten until the emergence of epigenetic revived an interest in Waddington's experiment«.[42]

For example, in *Drosophile,* certain sexual cells can, regardless of their developmental instruction, be transformed into legs and antennae, depending on the choice of the adjacent cells. Therefore, should a substantial definition of the relation between the occurrence of mutation and evolutionary outcomes be rendered impossible and replaced by a relative one, how could we claim that a particular mutation is purely random if its effect is useful within the limits of a certain place and time, while in another it could prove harmful for the organism? How is it possible to know that an occurrence of a specific mutation does not depend on its usefulness for the organism when it cannot be unambiguously determined what is beneficial and what is harmful for a particular organism? The solution lies in the relativity of the definition of the concepts of usefulness/harmfulness, but also in the specific nature of the mutation economy.

5. SPECIFIC NATURE OF MUTATION ECONOMY

Mutation is a concept whose nature has to be defined with respect to the organism, population and the environment. The property of usefulness or harmfulness can only be determined in relation to the comprehensive and concrete conditions of the environment, where upon it might be possible to reflect upon whether discussing the random nature of mutation made sense at all. I believe that the nature of mutations can be explained as non-randomness, entirely compatible with the economy of nature. Population genetics and evolution choose to look upon mutation processes as a statistical category creating new forms of life or participating in their formation, depending on how they understand the principle of evolutionary changes. Describing the relations between a particular specific mutation and its usefulness or harmfulness is nothing but an inappropriate isolation of a mutation process from its complexity from which it is inseparable, otherwise the same mutation could be claimed to be both useful and harmful (e.g. the above quoted radical example of the occurrence of haemoglobin in its heterozygotic form in humans). The occurrence of a specific mutation is directly related to its usefulness for the organism in question. However, variable conditions of the environment, the factor of time and space, as well as its occurrence within the complex of other mutations, frequently cause confusion. Continual occurrence of mutation complexes makes it possible to identify and isolate specific mutations

[42] J. FODOR and M. PIATTELLI-PALMARINI, 2010, o.c. p. 61.

necessary for the organism at a specific actual point in time and place with its specific requirements. Potentially useful and harmful mutations co-occur within the mutation complex in order to respond to all possible challenges as dictated by the time and space, whereby specific mutations are isolated, depending on the current needs. Any response of the organism or environment structures is necessarily temporary, as is the adaptation. It is therefore naive to demand that merely an isolated occurrence of a specific mutation in a successful phenotype containing an adaptation novelty should be declared as pertaining to the indispensable nature of mutation. The fact that large cats catch their prey with a success ratio of 1:9 does not mean that all unsuccessful attempts could be declared useless for the organisms of these animals. All attempts at hunt, whether successful or not, constitute a statistical whole, similar to the mutation effects, both successful and unsuccessful, for a particular organism. A particular mutation is not an entity – a mutation complex represents an entity, in very much the same way as a population or a species, and not an individual organism, constitutes an evolutionary entity. **Mutation complex** is an entity which behaves as a whole, despite the existence of an internal structure, very similar to the atom. Furthermore, what should be understood is the specific nature of the economy of mutation processes which departs from other scientific fields, as for example physics, chemistry, even the economy of biological processes pertaining to a different level. Physical laws impose upon atoms in a stable condition an existence at the lowest energy stages which can be changed only discontinuously, whereas chemical laws govern chemical bonds between atoms based on the electron exchange at the least possible loss of energy. A similar thing happens in the area of economy of forming living organisms, utilising the smallest possible number of atoms in creating a gene, which is capable of ensuring an orderly and lawful behaviour in accordance with statistical physics[43]. The most economical (the best arranged) status of metabolical processes has a high degree of usefulness in which entropy is the lowest, so that out of the total quantity of solar energy contained in a molecule of glucose, an organism can utilise almost one half.[44] An electron assuming the orbit requiring the lowest level of energy, chemical bonds between atoms at the lowest possible loss of energy, as well as the economy of glucoses oxidation, all represent phenomena essentially differing from the nature of mutation processes and evolution. Physical, chemical, and, to an extent, physical-chemical laws in living organisms are general, universal laws which, by definition, are not limited by a specific time or space, but are valid everywhere and at all times (they are symmetrical). Such laws are the subject of nomothetical sciences. Living organisms are different in nature:

[43] E. SCHRÖDINGER, 1944, *What is life?* Cambridge, UK, Cambridge University Press.

[44] For example, in humans the efficiency is 44%.

apart from their compliance with general and universal laws, they necessarily dwell in a particular time and space as historical entities as well, and therefore need to be individually studied. Specific processes unfolding in living organisms do not in any way violate physical or chemical laws, but cannot be reduced to them, predicted or integrally explained by them. Sober[45] remarks that biologists most frequently avoid the use of the word law due to the fact that biology is only partially a nomothetical science, while to a certain extent it is also historical. Similar views about the structure of biological science can be found in Rosenberg[46], Rosenberg and McShea[47], Mayr[48] and others.

This is precisely why there exists a different nature of economical processes in the inanimate and the living worlds, particularly when it comes to evolution and mutation-phenotypic logical and causal relations. The economy of the mutation-phenotypic relation, according to which mutation is viewed as occurring for the benefit of the organism, can be compared to Malthus'[49] economy of procreating seemingly overabundant offspring in accordance with the astounding force of life. Similarly, an abundant and incessant »rain« of changed information contained in the hereditary substance is by no means random or accidental: it serves to enable a new item of information to occasionally emerge, up to that moment perhaps neutral or harmful, which in the specific newly created conditions of the environment would build such a phenotype structure as would be capable of ensuring an advantage in the changed conditions. The economy of mutation processes is therefore no less thrifty or economical than other economies: it spends the least possible energy in producing new forms. What superficially may seem as prodigality and extravagance is really a readiness to re-form, in accordance with the occurrence of very diverse ecological niches. The model as illustrated in Fig. 1 shows that it is most economical to have a permanent divergence of hereditary information in order to be able to pass on the instructions concerning the building of a phenotype through variable plates of the selection filter. An additional reason, frequently causing confusion concerning the nature of the economy of mutation processes, is the Western economic reasoning restricted by a paradigm of transformation of all things into commodities with a shareholding type of ownership and governed by a principle of attaining the most benefit and gaining the highest profit in the shortest time possible and at the least expense.

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45 E. SOBER, o.c.

46 A. ROSENBERG, 1994. *Instrumental Biology or the Disunity of Science*. Chicago, Chicago University Press.; A. ROSENBERG, 1985. *The Structure of Biological Science*. New York, Cambridge University Press.

47 A. ROSENBERG and D. McSHEA, 2008. D. 2008. *Philosophy of Biology: A Contemporary Introduction*. New York, Routledge.

48 E. MAYR. 2004. *What Makes Biology Unique?: Considerations on the autonomy of a scientific discipline*. Cambridge, Cambridge University Press.

49 T. MALTHUS, *An Essay on the Principle of Population*, published 1789.

6. CONJECTURE

According to the neo-Darwinist version theory of evolution, the transforming of living species happens by the principle of random mutation events and non-random natural selection. Mutations are attributed to a nature of randomness by claiming that they do not occur to benefit particular organisms. This statement is corroborated by the existence of a large number of harmful mutations and only a small number of useful ones. Since living organisms and populations are not subject to nomothetical laws but require a historical study in real conditions of space and time, it becomes obvious that concepts of usefulness and harmfulness of particular mutations cannot be substantially, but only relatively defined. What is useful in one situation may not be so in another, which is why it is impossible to establish whether a mutation has occurred for the benefit of the organism, nor is it possible to say whether or not it is random. It is only in relation to the environment that a mutation can be called useful or harmful. A possible solution to the problem of defining mutation in terms of usefulness or harmfulness may lie in an idea which takes mutation complexes (rather than individual mutations) as an evolutionary entity participating, together with natural selection, in the evolutionary transforming of living species. Mutations occur for the benefit of organisms, and it is its occurrence within the complex of other mutations that causes confusion. Another reason for talking about a random nature of genetic mutations stems from failing to understand the specific economy of the mutation-phenotype relation. Due to environmental conditions continuously changing, mutation events produce an abundant rain of variations which constantly examine the current conditions of the environment. The mutation complex is bound to produce a wide range of instructions concerning the building of a phenotype instead of strict directions, since an ideal biological adaptation implies openness, variability and tolerance. Continuous occurrence of a mutation complex ensures the isolation of a specific required mutation, depending on the needs of the organism, population and the circumstances of environment. It is possible to say that mutations are consequently occur for the benefit of organisms; however, the economy of mutation processes is not comparable to the economy of physics, chemistry or biological processes pertaining to a different level. Evolutionary implications of the hypothesis according to which mutation events are non-random in nature indicate that nature is arranged and finally tuned towards order, complexity and the advent of life. In nature thus conceived, the mutation-phenotype relation is nothing more than a physical analogy of the electron path, assuming its position in orbit in accordance with the physical laws to which it is subject. The idea of the non-random nature of mutation processes presupposes a world in which the occurrence of life diversity is highly probable.

Tonći Kokić

Neslučajna narav genetičkih mutacija: Neke filozofske implikacije

Sažetak

Zadatak podjednako znanstvenika i filozofa je da sumnjaju, dovode u pitanje pretpostavljene istine i pokušavaju osporiti znanstvene tvrdnje. Ovaj rad ispunjava taj zadatak iskušavanjem tvrdnje (neo-darwinističke) teorije evolucije o slučajnoj naravi genskih mutacija. Neo-darwinistička inačica teorije biološke evolucije vidi preoblikovanje živih oblika kroz stadije slučajne mutacije i neslučajnog prirodnog odabira. Prema definiciji slučajnosti mutacije nisu prouzročene niti imaju cilj u dobrobiti organizma u kojem se pojavljuju. Ipak, neki pokusi dovode u pitanje slučajnost mutacija tvrdeći njihovu neslučajnu narav, a pojmovna analiza ukazuje na dvosmislenosti pojmova slučajnosti i korisnosti. Uz to, nije opravdana primjena pojmovnih i metodoloških alata fizike u biologiji (osim u molekularnoj biologiji), koja ima vlastito područje s posebnim pojmovima, načelima i metodologijom. Usklađivanje pojmovnog značenja ukazuje da je neslučajna narav mutacijskog procesa posvjedočena specifičnom ekonomijom biološke evolucije. Implikacija neslučajne naravi mutacijskog procesa pretpostavlja svijet u kojem je postanak biološke raznolikosti vrlo vjerojatan.

Ključne riječi: biologija, pojam dobrobiti, evolucija, mutacijska ekonomija, mutacije, neslučajnost

Inherentni ateizam kapitalizma

Napredni kapitalistički sustav je inherentno ateistički. Bezbožan je u svojoj konkretnoj materijalnoj praksi, kao i u vrijednostima i vjerovanjima koja su mu implicitna, ma koliko pojedini njeni pobornici pobožno dokazivali suprotno. Kao takav, on je ateistički na sve pogrešne načine, dok su Marx i Nietszche ateisti na uglavnom ispravan način. Nije vjerojatno da će društvo pakiranog ispunjenja, upravljane želje, menadžerske politike i konzumerističke ekonomije doprijeti do te dubine na kojoj bi se teološka pitanja uopće mogla propisno postaviti, baš kao što odbacuje politička i moralna pitanja koja u sebi imaju bilo kakve dubine. Koji bi, pobogu, bio smisao Boga u takvom uređenju, osim kao ideološke legitimacije, duhovne nostalgije ili sredstva osobnog ispetljavanja iz svijeta lišenog vrijednosti?

Jedno od mjesta na kojima su takozvane duhovne vrijednosti, istjerane s lica brutalno pragmatičnog kapitalizma, našle utočište jest New Age, koji je upravo onakva karikatura duhovnog za kakvu bi se i očekivalo da će je stvoriti materijalistička kultura. Otprilike kao što ljudi kamena srca plaču na srcedrpateljnu glazbu, tako su oni koji ne bi prepoznali istinsku duhovnu vrijednost ni da im padne u krilo skloni vidjeti duhovno kao sablasno, eterično i ezoterično. To je, usput rečeno, ono što je Marx imao na umu kad je pisao o »duši svijeta bez srca, duhu bezdušnih prilika«. Pod time je mislio da je konvencionalna religija jedina vrsta srca kakvu svijet bez srca može zamisliti, po prilici kao što je posramljujuće prostački humor jedina vrsta komedije koju ljudi lišeni humora mogu cijeniti. Religija koju napada Marx odaje upravo onakvo sentimentalno, bestjelesno shvaćanje duhovnog kakvo bi se i očekivalo od trezvenih materijalista.

Terry Eagleton, *Razum, vjera i revolucija. Refleksije o raspravi oko Boga*, Preveo Dinko Telećan, Zagreb, Ljevak, 2010, 46-47.