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Paweł Grieb

THE ORGANIZATION OF BIOLOGICAL MATTER AND THE PROCESS OF EVOLUTION

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ABSTRACT

The theory of biological evolution by natural selection and the theory of levels of biological organization are general concepts intended to enable understanding of the existence of biological matter defined as living organisms that reproduce sexually. These two theories were formulated independently of each other, but later their integration was postulated. This study is an attempt to implement such a postulate. The starting point is the statement that both theories concern the way in which biological matter composed of individuals constituting populations exists. The theory of biological organization is intended to explain the functioning of organisms by maintaining homeostasis (relative independence from the environment) during the life cycle, while the theory of evolution concerns the changes that populations undergo in response to a changing environment.

Keywords: Theory of biological evolution, biological organization, biological matter, living organisms.

The theory of biological evolution by natural selection and the theory of levels of biological organization are general concepts intended to enable understanding of the existence of biological matter defined as living organisms that reproduce sexually. These two theories were formulated independently of each other, but later their integration was postulated. This study is an attempt to implement such a postulate. The starting point is the statement that both theories concern the way in which biological matter composed of individuals constituting populations exists. The theory of biological organization is intended to explain the functioning of organisms by maintaining homeostasis (relative independence from the environment) during the life cycle, while the theory of evolution concerns the changes that populations undergo in response to a changing environment. These theories therefore cover processes occurring in other periods of time; this is, respectively, the life time of an individual (ontogeny) and the time during which a population of organisms changes by adapting its genetic structure to changes that have occurred in the environment. Since both describe and explain two different aspects of the same phenomenon, an attempt was made to formulate the assumptions of the theory of levels of biological organization in such a way that evolution by natural selection resulted from them as a result of a specific way of organizing biological matter. For this purpose, it was assumed that the two basic levels of biological organization are the organism and the population of organisms constituting its gene pool. The organism is an integrin, i.e. a self-organizing system with the ability to accumulate negentropy. There are three subintegrins in the organism: genotype, epigenotype and phenotype, responsible for various aspects of its operation during ontogeny. The functions of the genotype are to transmit “plans and tools” for the ontogeny process to descendants of zygotes, and at the same time to accumulate random variability. The epigenotype is a structure that organizes the flow of matter and energy through the body temporally and spatially during the life cycle. The phenotype, on the other hand, is a boundary structure constituting a “bridge” between the organism and its environment, fulfilling the key function of filtration and recognition of the nature of environmental impacts on the organism. These interactions, referred to as biological stimuli, have two components: information and energy. From the organism’s point of view, the recognition of the information component of the stimulus by the phenotype leads to an increase in negentropy, while the energy component, if not eliminated by the phenotype, causes its decrease. The persistence of a population of organisms in a changing environment requires continuous improvement of adaptation, defined as the ability to effectively conduct ontogeny. The essence of the concept of adaptation understood in this way is an adequate response to biological stimuli consisting in the elimination of their energy components (passive adaptation) and the recognition of information components (active adaptation). The outlined integration of the theory of evolution by natural selection with the theory of levels of organization of biological matter has two important consequences. First of all, we see that the process of evolution by natural selection is the result of the special structure of biological matter that enables adaptation to changing environmental conditions. Secondly, it becomes obvious to us that evolution is always associated with progress, because it is aimed at increasing the degree of adaptation of a population of organisms to a changing environment.

I. INTRODUCTION

According to some biology theorists,[1] the theory of evolution needs to be supplemented with a theory of levels of biological organization. However, before accepting this point of view, let us try to define the premises and reasons why such a synthesis of two general biological theoretical concepts is justified and desirable.

The theory of biological evolution, or more specifically the theory of natural selection, is a particular theory of evolution that applies to sexually reproducing organisms. The process of evolution by natural selection is a process that takes place in a particular way. In this approach, the theory of evolution is a theory whose task is to explain the processes of transformation of biological matter, and more specifically of sexually reproducing organisms and species composed of them, which take place over time counted in multiples of the life cycle of organisms. The phenomena explained (e.g. the genesis of adaptations) "happen" over generations. On the other hand, the theory of biological organization describes the way of organization existing at a given time, or—if the feature of organization is a structure whose properties become understandable or gain value over time (such as feedbacks that "happen" over time)—on a shorter time scale, within the life cycle of an organism. This difference alone suggests a crucial question: Are the theory of evolution and the theory of levels of organization theories of the same type, are equivalent theories, or is one primary to the other, or are both secondary to some more primary theory from which they should result as consequences?

The importance of this question becomes even more understandable if we consider that the theory of biological organization is a theory concerning self-organizing systems (organisms), whose essence of functioning consists in maintaining homeostasis, relative independence from the environment, and thus in implementing a conservative strategy. It is true that a form of natural selection, called stabilizing selection,[2] also seems to be (apparently) the implementation of a conservative strategy; however, the whole process of evolution is in fact a process of intergenerational change, the accumulation and expression of these changes, and stabilizing selection is also in fact

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[1] See e.g.: A. Urbanek, *Rewolucja naukowa w biologii* [A Scientific Revolution in Biology], Warszawa 1973; G.G. Simpson, *This View of Life. The World of an Evolutionist*, New York 1964.

[2] One of the most eminent creators of the theory of stabilizing selection, I. I. Schmalhauzen, said on this subject in a lecture delivered at the 15th International Zoological Congress in London in 1958 [quoted after I. I. Szmalhauzen, *Czynniki ewolucji. Teoria doboru stabilizującego* [Factors of Evolution. Theory of Stabilizing Selection], Warsaw 1975, chapter VI. Supplements, p. 512]: "Natural selection can take many forms and lead to different outcomes. I have proposed two basic forms of natural selection: 1) a driving form of selection, based on the selective superiority (under given conditions) of certain deviations, and 2) a stabilizing form of selection, based on the selective superiority of an established form over all deviations from it [...] The second [form of selection—stabilizing selection], although present in the Darwinian notion of the conservation role of selection (under fixed conditions of existence), leads to very important transformations, which neither Darwin nor later researchers distinguished. Only recently has the progressive role of stabilizing selection been noticed by [...] Schmalhauzen and then Waddington."

the accumulation and expression of phenomenologically only conservative changes.

The question posed above is of such a fundamental nature that at first glance it can be assumed that the answer to it has the rank of an axiomatic solution. After all, we are dealing here with two basic philosophical categories, matter and its structure on the one hand, and the form of matter motion on the other. Biological evolution is a form of existence of a certain type of biological organization, so the theory of levels of biological organization and the theory of evolution by natural selection must describe and explain two aspects of the same phenomenon, the biological life of sexually reproducing organisms, constituting a total unity.

If we start from such premises, we can try to formulate a theory of levels of biological organization in such a way that evolution by natural selection would result as a consequence of the way biological matter is organized. At the same time, we may be tempted to check whether the theory of evolution by natural selection describes and explains the process of evolution in such a way that from the very way of evolution of biological matter results, as a consequence, the formation of biological forms and levels of organization. Such a program is very extensive and this study is intended only to outline the starting point for the integration of the theory of evolution and the theory of biological organization as two compatible theories describing two aspects of one and the same—in fact—phenomenon, which is biological life in its intra- and supra-generational dimensions.

Before we move on to further considerations, a note on how concepts are presented. In many cases, it will be necessary to give new meaning to concepts from other particular theories (for example, phenotype, epigenotype, etc.). Adapting existing concepts is easier than creating new ones; it can also be expected that redefined but familiar concepts will be easier to assimilate. The new meaning of concepts taken from other theories is always explained in detail.

2. CONCEPTS OF LEVELS OF BIOLOGICAL ORGANIZATION

The theory of biological evolution faces the task of explaining the genesis of the diversity of life forms and their phylogeny, i.e. the sequence over time. Depending on the adopted theoretical premises, the essence of the evolution process was perceived either in changes in the frequency of genes from generation to generation, or in the genesis of adaptations understood in one way or another.[3] However, while the essence of the evolutionary process

[3] This issue was analyzed by Czesław Nowiński, *Pojęcie doboru naturalnego* [The Concept of Natural Selection], in: *Ewolucja biologiczna. Szkice teoretyczne i metodologiczne* [Biological Evolution. Theoretical and Methodological Studies], Cz. Nowiński (ed.), Ossolineum, Wrocław 1974, pp. 39–124.

has been perceived in various ways, the essence of the phenomenon of biological evolution has always and invariably been the variability of living forms over many generations, leading through phylogenetic ranks and trees to an organized and interrelated diversity of living forms. Thus, the scope of the theory of evolution as a theory explaining the transformation of living forms in time measured by many generations is obvious. By contrast, the scope of the theory of levels of biological organization is somewhat less clear.

The existing "theories" of biological organization are in fact classifications of levels of biological organization. We can say that these are concepts of a taxonomic nature, a kind of key to identifying cells as opposed to, for example, organs or subcellular organelles. They are mostly based on morphological criteria, distinguishing the molecular, macromolecular, cellular, organismal, population, biocenotic, etc. level of organization.[4] Classification systems of this type necessarily reduce biological matter to a linear, one-dimensional system, which is unreliable in view of the complexity of biological organization.

In this context, some proposals going in directions other than "morphological taxonomy" are noteworthy. Stanislaus S. Szwarc[5] distinguished only four levels of biological organization: metabolic, organismal, population and biogeocenotic, thereby freeing himself from morphological criteria and emphasizing functional (physiological) criteria. Cyril M. Zawadski[6] proposed not a linear, but a "matrix," two-dimensional system of classifying the levels of organization of living matter, distinguishing a primary series of levels of biological organization supplemented by appropriate structural degrees of organization of each of these primary systems. Such solutions make it possible to avoid many inconsistencies and shortcomings that morphological (linear) classification systems are burdened with. Still, they are not satisfactory, because the relationship between the organization of organic matter and the process of evolution is not obvious.

To find such a connection, the theory of levels of biological organization cannot be understood merely as a more or less accurate system of classifying these levels. The task of theory is not to describe but to explain a particular aspect of reality; in the task of explaining reality, classifications must play a subservient role. So, if we talk about the theory of levels of organization, we need to define what aspects of biological reality such a theory is supposed to explain.

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[4] E.g. C. L. Posser, *Levels of Biological Organization and their Physiological Significance*, in: *Ideas in Modern Biology*, A. Moore (ed.), XVI Int. Congr. Zool. Proc. V. 6, Garden City, New York 1965, p. 357; E.P. Odum, *Fundamentals of Ecology*, W. B. Saunders Co., Philadelphia 1959.

[5] С. С. Шварц [S. S. Schwartz], *Стратегия жизни* [Strategy of Life], Природа, 1967, v. 8.

[6] К.М. Завадский [K. M. Zawadskij], *Основные формы организации жизни и их подразделения* [Basic Forms of the Organization of Life and their Directions], in: *Философские проблемы современной биологии*, Москва-Ленинград 1966.

Let us assume that such a theory aims to explain how particular levels of biological organization function, and what interactions and interdependencies exist between them. To that extent, the theory of levels of organization should simply explain how organisms, populations, and species exist in the environment. Based on these premises, it would be necessary to try to show that evolution by natural selection is a consequence of the organization of biological matter, and at the same time—the mode of existence of this matter.

As a starting point for an attempt to consider biological organization and its evolution as two aspects of the same—in fact—phenomenon, I propose to assume that there are only two levels of organization of biological matter, namely the organism and the population. Such a division was proposed by Kazimierz Petrusewicz,[7] and its justification is worth quoting.

The carriers of life are individuals. Although some manifestations of life functions can be found in isolated tissues or cells placed in a suitable artificial environment, only the organism is capable of independent life in the natural environment. So only the individual is the whole, the organism for which all the attributes of biological life are proper. However, individuals, especially those that reproduce sexually,[8] are mortal, and lifespan longer than one generation is made possible only by the functioning of the population. Both genetically and ecologically, a population is not just the sum of its individuals. The laws governing the genotype of a population are qualitatively different from the laws governing the genotypes of individuals; the organization of a population shapes the functions of its individuals, etc. Thus, both the organism and the population are integrons in Jacob's[9] sense, and the laws used to describe and explain the phenomena occurring within each of them are autonomous laws.

From the point of view of the process of evolution by natural selection, it seems reasonable to distinguish the individual and the population as the two basic levels of organization. The process of evolution is an intergenerational process, because not individual organisms undergo evolution during their

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[7] K. Petrusewicz, *Organizm, populacja, gatunek* [Organism, Population, Species], Warszawa 1978.

[8] The issue of the death of an individual as a biological necessity is complex. Let us consider two problems related to the role of the population as the subject of the evolutionary process. First, it is sometimes mistakenly assumed that unicellular organisms that reproduce by division are (theoretically) immortal, and that the death of an individual is an evolutionary invention, having become a biological necessity at the time of the emergence of sex. However, at the moment of division, the parent individual ceases to exist, which is equivalent to death. In fact, the "invention" of evolution coupled with the emergence of sex (and more precisely with the emergence of sex cells) is only the corpse, the presence of which in common thinking is an inseparable attribute of death. Secondly, all individuals, even those that are "theoretically" immortal (e.g. multicellular organisms that reproduce by budding, i.e. maintaining the continuity of the parent's existence) are individually mortal, even as a result of "misfortune." The duration of life on a multi-generational scale is therefore always conditioned by the existence of a population; however, this fact is most obvious in the case of sexually reproducing organisms.

[9] F. Jacob, *La logique du vivant. Une histoire de l'hérédité*, Gallimard, Paris 1970.

lives, but a population of organisms that can exchange genetic material with each other. On the other hand, the mechanism of natural selection consists in differential survival and reproduction of individuals—carriers of particular genotypes and genes. Evolution, like the life of an individual and the functioning of a population, takes place in the organism-environment system, whereby for a given organism and for a given population the environment is the totality of external factors, biotic and abiotic.[10]

If we agree with the thesis that the division into only two levels of biological organization, organismal and population, reflects the objective characteristics of the subject of the process of evolution by natural selection, then we can expect that the analysis of the structure of these levels and processes characteristic of each of them, as well as the relationships occurring between them, and also between them and the environment, can be a starting point for the integration of the theory of levels of organization and the theory of evolution.

3. THE STRUCTURE OF THE ORGANISM

The organism can be defined as a structure capable of living in natural conditions. In the case of sexually reproducing organisms, and we limit our considerations to these, the life cycle (ontogenesis of an individual) is the implementation of a sequence of biological processes and developmental forms initiated at the moment of fertilization with the creation of a zygote, and completed at the moment of birth and upbringing (bringing to adulthood) offspring, and loss of reproductive capacity.[11] The life cycle that leads to reproduction is controlled by the genetic program, which is realized in the course of interactions between the organism and the environment. Assuming that the implementation of ontogenesis is the basic attribute of the organism, we can attempt to analyze the processes that make up it, and the interactions between the organism and the environment that occur during it.

The ontogenesis of an organism is the creation of new information.[12] This process can be described as the accumulation of negentropy. At the same time, development processes are processes that require the collection of useful energy from the environment, which is used to maintain the processes of rebuilding the internal structure and actively responding to envi-

[10] It is worth emphasizing that for a given organism the presence of other organisms of the same species (i.e. forming a population) is an element of the environment. On the other hand, a population does not have a population of the same species in its environment, constituting in itself the subject of the evolutionary process.

[11] M.V. Volkenstein, D. S. Cherniavskii, *Information and Biology*, Journal of Social and Biological Structures, 1978, 1, p. 95.

[12] Ibidem, p. 380.

ronmental stimuli. As a result of interactions between the organism and the environment, there is an orderly flow of matter and energy through the organism, which is a system relatively thermodynamically isolated from the environment.

Within the integron of the organism, we can distinguish three subintegrons, none of which exist independently from the others, but each has a specific structure and function. The genotype is responsible for storing and transmitting the genetic program to the offspring. The implementation of this program in the course of ontogenesis is the epigeneotype. A specialized product of the epigeneotype is the phenotype, which is the boundary structure of the organism and is its effector in interactions with the environment. Let us analyze the structure, function and interactions within and between each of these subintegrons.

The fundamental role of DNA as a carrier of hereditary information seems to be irrefutably proven. However, the sequence of nucleotides in DNA, which we can call a structural genotype, does not contain all the hereditary information passed on to descendants. At least two additional information carriers: enzymatic systems (proteins) ensuring a controlled course of metabolic processes from the very beginning (i.e. from the zygote level) and membrane structures whose spatial arrangement ensures an orderly separation of the intracellular environment (competence) must also be hereditary. Both of these systems, which are complementary, but at the same time necessary elements of hereditary information, can be defined as a functional genotype. His role cannot be overestimated. As Jakob wrote, “only the intact cell is capable of growing and reproducing itself, because only it has both the program and the way to use it, the plans and the tools necessary to execute them.”

The genotype is therefore a subintegron of the organism’s integron, whose function is to transmit to the progeny zygotes the “plans and tools” of the ontogenesis process. With the formation of the zygote, ontogenetic processes are launched and the functional genotype is transformed into an epigenotype, i.e. a structure whose task is to organize the flow of matter and energy through the organism in time and space, serving the purpose of the life cycle. Thus, the meaning attributed to this term in this study differs significantly from its original meaning.[13] In the currently accepted sense, the

[13] The concept of epigenotype was introduced by Conrad H. Waddington (*The Strategy of the Genes*, George Allen and Unwin, London 1957, as well as earlier works). The need to introduce this concept resulted from the discovery of regulatory genes, i.e. genes that do not have to encode the structure of proteins, but are used to control the function (expression) of structural genes. Regulatory genes did not fit into the classical definitions of Mendelian genetics (gene = hereditary trait) or genetic-molecular (gene = polypeptide chain). Therefore, the set of regulatory genes came to be referred to as the epigenotype. Such an approach, exemplified by Ernst Mayr (*Animal Species and Evolution*, Cambridge MA 1963), is a manifestation of excessive attention paid to the biological role of the DNA structure itself as a "memory of the biological order” *per se*. DNA is only a carrier of information, not a tool for its selective activation. For this reason, it may be assumed that the con-

epigenotype is the expression of information contained in the structural genotype, the implementation of the inherited ontogenetic plan. It is a set of macromolecular structures ensuring a timely and spatially ordered flow of matter and energy through the organism. It contains the same basic components as the functional genotype and arises from the interactions between the structural genotype, the functional genotype and the environment that provides the developing organism with matter and energy. During development, the epigenotype replaces the functional genotype, taking over from it the function of selective activation of the information contained in the structural genotype.

The third subintegron that is part of the organism is the phenotype. And also in this case, our understanding of this concept differs significantly from its traditional meaning, which includes the complete implementation of the genetic program in a given individual, i.e. both epigenotype and phenotype in the currently accepted sense. The term phenotype is understood here as the boundary structure that constitutes the "bridge" between the organism and its environment. It is a product of the epigenotype, but its distinction as a separate subintegron is supported by the fact that it performs an extremely important function of filtration and selection of environmental impacts on the body. A closer characterization of the phenotype in the above approach requires consideration of the nature of the links between the organism and the environment.

4. BIOLOGICAL STIMULI

By the term of a biological stimulus we mean any influence of the environment on the organism. This definition is so general that one may doubt its usefulness. However, if we consider all the influences of the environment on the organism from the point of view of the effects of a given influence on the course of the ontogenesis process, we will notice that, in fact, the variety of these influences comes down to two general types. One type, referred to as informational stimuli, will cause the accumulation of negentropy, while the other type—energy stimuli—will cause the dissipation of negentropy.

Let us assume that the genetically programmed desire to reproduce is a basic property of organisms, determining the course of ontogenesis. The

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cept of epigenotype already in its original meaning contains implicit references also to the "tools for implementing the plan" contained in DNA. In the glossary at the end of his book, Mayr defines the epigenotype as the totality of the developmental system; it includes all interactions between genes leading to a phenotype. On the other hand, he defines the concept of phenotype as the totality of the characteristics of an individual (its appearance) resulting from the interaction between the genotype and the environment. Thus, in some points, Mayr's definitions come close to the definitions proposed in the present work. This coincidence may be accidental, but it may also result from the need to adapt the conceptual apparatus to the structure of the phenomenon of biological life.

correct course of ontogenesis is, in turn, related to the creation of information, so informational stimuli will be conducive, or even create conditions for the correct course of the life cycle. On the other hand, energy stimuli will disturb or even prevent the proper implementation of the individual's development program.

Let us try to prove the thesis that all the extremely diverse effects of the environment on organisms can be classified into one of these two categories. First, let's consider whether there are any interactions that are neutral to organisms. Any material or energetic interaction causes a change in the state of the organism. This change may be insignificant, it may only concern the phenotype that suppresses, absorbs or diffuses this interaction. Were it not for the properties of the phenotype that made it possible to neutralize a given effect, its impact on the epigenotype would probably be very significant. The indifference of the organism to certain energy stimuli is therefore secondary to the properties of the phenotype, the boundary structure of the organism, which, as a result of each interaction of this type, is subject to a change of state consisting in the reduction of negentropy. After all, the phenotype is part of the organism. This reasoning leads to the conclusion that there is no influence of the environment on the organism, which does not exert any influence on it.

Secondly, let us consider whether any influence of the environment on the organism, which does not have negative effects on the process of ontogenesis, is an informational influence. This issue seems doubtful. For example, the assimilation of matter and energy does not appear to be an informational interaction. However, we must take into account the fact that the assimilation of matter and energy is not an autonomous process in relation to the organism, but it is a process that occurs as a result of the organism's recognition of the "information content" of a given element of the environment. In this approach, nutrition, for example, is an active process, it is a manifestation of an adequate (informatively effective, leading to increased negentropy) the body's response to an environmental stimulus (the appearance of food). Such a stimulus is thus informative. Similarly, photosynthesis is only seemingly a passive process. In fact, the absorption of light radiation by photosynthetic pigments is not only energy absorption, but also an informational signal, activating a number of internal, epigenotypic processes occurring in the photosynthetic organism (e.g. transport of products and substrates of photosynthesis, thermoregulation, etc.). Without the participation of these processes, the activation of which is not caused by the energetic impact of light, but is the result of reading the informative nature of the light stimulus, the effects of photosynthesis processes would not be beneficial for the organism.

Let us now return to the issue of the structure and function of the phenotype and the impact of informational stimuli. We can adopt a general rule that informational stimuli cause an adequate reaction of the organism. The adequacy of the reaction can be defined as such action of the organism in a given environment, which results in an increase in negentropy and the resulting undisturbed continuation of the ontogenesis process. A long catalogue of elementary and complex adequate reactions can be compiled, from maintaining the enzyme proteins of organisms in a native and active state, to thermoregulation processes, from food assimilation to avoidance of harmful environmental conditions and natural enemies, etc.

A special mechanism of adequate organism's reactions is this triggered not directly by stimuli coming from the environment, but caused by interactions with the receptors of the state of the organism's internal environment. We can define this phenomenon as the internalization of biological stimuli. Its appearance occurred as a result of evolution as one of the manifestations of the morphophysiological complication of organisms. In each case, the adequate reaction of the organism caused by an informational biological stimulus has a characteristic structure, which consists of: recognizing the meaning of the stimulus, i.e. information creation, transferring this information to epigenotypic structures, its processing and integration, and activation of effectors implementing the organism's response.

The recognition of the nature of the stimulus, i.e. the creation of information, is a process taking place at the phenotype level. The phenotype is a specialized product of the epigenotype, whose task is to protect the organism against the harmful effects of the environment and to recognize the informative nature of these interactions. On the one hand, the phenotype acts as a "protective filter," eliminating harmful effects as far as possible. This role is played, for example, by the integuments of the body (membranes and cell walls in single-celled organisms, animal skin, etc.). On the other hand, the phenotype recognizes the informative nature of stimuli. Receptors, specialized phenotypic structures whose biological function is the creation of information in response to stimulation, serve this purpose.

In the literature on the subject, the view was expressed[14] that biological stimuli are themselves carriers of information, that they have two components, information and energy, and therefore have a double character. This position does not seem appropriate. The impact of the environment on the organism is itself information only in the thermodynamic sense, as a certain specific state distinguished at a given point in space-time. However, this is not biological information. Considering the information carried by a biological stimulus in isolation from the organism on which the stimulus acts is a move without sense. Taking this fact into account, it is more reasonable

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[14] A. Przybylski, *Aspekt energetyczny i informacyjny bodźca biologicznego i jego implikacje ewolucyjne* [An Energetic and Informational Aspect of Biological Stimulus and Its Evolutionary Implications], in: *Ewolucja biologiczna* [Biological Evolution], Cz. Nowiński (ed.), Ossolineum, Wrocław 1974, pp. 159–207.

to assume that biological information is created in the phenotype as a result of interaction with its receptor systems. Organisms clearly differ from each other in the phenotypic dependencies of recognizing the informational nature of stimuli. The proverbial example here is the difference between a dog and a man. Olfactory stimuli that are of significant information to the dog may be imperceptible to the human (that is, filtered by the phenotype).

5. THE CONCEPT OF ADAPTATION

The above considerations show that a biological stimulus as such has no informational value, but from the point of view of its impact on a given organism, it has an informative character (leading to an increase in negentropy) or an energetic one (leading to its decrease). The energetic or informative nature of a biological stimulus can therefore only be assessed a posteriori by evaluating the effects it has had on the organism. It is obvious that not only representatives of different species, but also different individuals of the same species have different abilities to filter energy interactions, as well as to receive and react to informational impulses. Differentiation of responses to a given type of biological stimuli, which can be characterized by the concept of adequacy of the organism's response to biological stimuli, can be used to construct an objective definition of adaptation. The concept of adaptation has always been a source of significant difficulties in constructing evolutionary theories. A requirement of the theory of natural selection is that the selection mechanism should prefer individuals that are better adapted or have a higher degree or greater adaptability. It is therefore about such a construction of the notion of adaptation that would allow for a quantitative, at least in a model conceptual approach, evaluation of evolutionary prospects and chances of an individual exposed to natural selection.

The above-formulated concepts of epigenotype and phenotype, as well as the double—energetic and informative—nature of biological stimuli, "quanta" of the environment's impact on organisms, can be used to construct a concept of adaptation in such a way as to avoid a number of contradictions that the current definitions of adaptation are burdened with. Well, we can assume that the ontogeny of an individual is a sequence of genetically determined developmental forms. Each of these forms corresponds to a specific state of the system (organism). In order for the development of an organism to be beneficial from the point of view of the evolutionary process, i.e. ontogenesis completed with reproduction, the developing organism must be located in an appropriate, favorable environment. In other words, the organism must be "matched" to the environment in the sense that the effects of this environment on the organism will either be recognized as informative stimuli or filtered by the phenotype.

Each environment affects organisms in a characteristic way. As a model, a given environment can be characterized by a statistical distribution of interactions (i.e. biological stimuli) that will reach the organism located in this environment. More (better) adapted organisms will be able to recognize the informative nature of more biological stimuli, or recognize the informative nature of more relevant stimuli than less (less) adapted organisms. At the same time, the degree of adaptation must be assessed not only on the basis of the ability to recognize the informational nature of stimuli, but also on the basis of the degree of adequacy (response effectiveness) to the recognized informational stimulus. By the degree of response adequacy, we understand the assessment of the organism's response pattern to a stimulus from the point of view of an evolutionarily beneficial effect, the dimension of which is the increase in negentropy. Thus, adaptation would be determined by the ability to adequately respond to environmental stimuli, and the recognition of the informative nature of the stimulus would be a necessary condition for an increase in adequate response.

There is also another aspect of adaptation, related to the degree of protection of the organism against energy stimuli. In contrast to adaptation understood as an adequate response to informational stimuli, which can be described as active adaptation, adaptation by increasing the body's resistance to energy impacts can be described as passive adaptation. Whereas active adaptation is determined by the joint action of epigenotype and phenotype, passive adaptation is largely determined by the structure of the phenotype.

6. THE STRUCTURE OF THE EVOLUTIONARY PROCESS

Not only the degree of adaptation determines how natural selection works, but natural selection is the creative factor in evolution. Reductionist (genetic-population) theories of evolution placed special emphasis on considering adaptation not as a cause, but as a result of natural selection.[15] In the next stage of the development of evolutionism, the issue of the genesis of adaptations came to the fore.[16] The great difficulties faced by researchers in constructing various variations and modifications of the theory of evolution by natural selection largely resulted from the fact that the notion of adaptation, seemingly intuitively understandable, was extremely difficult to formalize, quantify, or even strictly define. The idea of making the degree of

[15] See e.g. M. Lerner, *The Concept of Natural Selection. A Centennial View*, Proceedings of the American Philosophical Society, 1959, 103 (2), pp. 173–182.

[16] See e. g. J. S. Huxley, *Evolution. The Modern Synthesis*, George Allen and Unwin, London 1963.

adaptation dependent on specific characteristics of the organism—the ability to recognize information stimuli and adequately respond to them, as well as the ability to eliminate the harmful effects of energy stimuli—proposed above is an attempt to go beyond the previously used terms in order to find a common denominator for the fact that—regardless on the structure of organisms and the nature of the environment in which they live—within each population there are organisms that are more or less adapted (adapted), and therefore have appropriately differentiated evolutionary perspectives.

A specific type of environmental impact on organisms (i.e. biological stimuli) are mutations, changes in genetic material that occur accidentally under the influence of environmental energy interactions. Thus, mutagenic interactions are a specific type of biological stimuli of an energetic nature, which are not stopped by the phenotype, but (in their pure form) do not have a harmful effect on the epigenotype, but only limit their impact to the modification of the genotype structure. Mutations are usually harmful to the ontogenesis of an organism, and explaining the mechanism that causes a random sequence of single harmful changes in genetic material to lead to any far-reaching changes of an adaptive nature after a sufficiently long time is not a simple problem and has not yet found a satisfactory solution. Using the conceptual apparatus introduced above, the process of transformation of single harmful mutations into changes of an adaptive nature should be presented not as a uniform phenomenon, but taking place at various levels corresponding to the subintegrons that make up the organism. The mechanisms of genotype and supragenotypic evolution, and in particular the role of natural selection in the process of evolution at each of these levels, are different.

Evolution at the genotype level is a change in the genetic structure of a population over generations. It is a change in the frequency of genes (mainly a change in the frequency of the ability to synthesize individual proteins or polypeptides) in the organisms that make up the population. It is a complex process resulting from the interaction of at least four factors. These are: mutations, internal selection, gene exchange between individuals in the process of reproduction and natural selection. Mutations are a source of variation that is random and usually harmful. The first phase of verification of variability induced by random mutations is the selection of embryos, called internal selection.[17] It is worth emphasizing that the death of organisms in the early stages of ontogenesis (death of the embryo in the early stages of development) as a result of mutual maladjustment of parental genotypes or as a result of the loss of certain extremely important genes, is caused not by the influence of the environment, but only by "construction errors" of the organism. Hence, the term "internal selection" seems to be extremely accurate here. There is not enough data yet to assess the im-

[17] L. Whyte, *Internal Factors in Evolution*, Travistock Publ., London 1965.

portance of the inner section for evolutionary processes, but it is potentially very large. In this way, genotypes potentially capable of ontogenesis are initially selected. Only genotypes internally organized in a correct way, ensuring such a degree of adaptation of the organism that enables the implementation of the program of ontogenesis in given environmental conditions, are able to produce epigenotypes and phenotypes, and reproduce, and thus be subject to the action of natural selection.

Organisms that carry certain genes and gene combinations may be better adapted to their environment. They will then be favored by natural selection. It should be remembered that the features of an organism determining its adaptation to the environment, i.e. the adequacy of its response to biological stimuli, are almost never determined by single genes, but only by the complex interdependencies between the genotype and epigenotype, encompassing extensive sets of genes interacting with each other and involving complex mechanisms regulating the expression of these genes. In addition, the genotype is redundant in relation to gene expression in the process of ontogenesis. As a result, the evolution of the genotype is only indirectly the result of natural selection. Mutations, internal selection and the exchange of genes between individuals in a population through sexual reproduction play a much larger role here. The latter process allows the accumulation of lethal and sublethal genes not in the homozygous form (which would not effectively guarantee ontogenesis), but in the heterozygous form. In this way, genotypes capable of ontogenesis (internally balanced) contain a "baggage" of genetic variability, which can be a starting point for further accumulation of variability. This may result in the emergence of more adaptive epigenotypic and phenotypic forms in the future. It is difficult to overestimate the evolutionary role of the redundancy of genetic material and gene exchange between individuals in a population, if one takes into account the fact that changes in the epigenotype or phenotype of an adaptive nature may occur as a result of the activation of a whole set of previously inactive genes, each of which has been changed by mutations taking place accidentally at different times, becoming per se harmful or even lethal in the homozygous state. The processes of regulating the expression of sets of genes in such a way that they have an adaptive significance, despite the fact that each single altered gene is harmful, can be defined as the essence of the evolutionary process at the epigenotype level.

Due to the fact that evolution is a process of transformations of sets of genes, considering it as a process based on changes in the frequency of genes in a population is wrong. Since individuals, not genes, evolve by natural selection, changes in the genetic pool of a population reflect and perpetuate the result of natural selection, which is the selection of epigenotypes and phenotypes. They are only one of the conditions for the evolutionary process to take place, but they are not its essence.

Natural selection consists in differential survival and reproduction of individuals with different degrees of adaptation. In a given environment, a different degree of adaptation entails a differentiation of chances for ontogeny to be completed to the end (that is, until the offspring is produced). As we mentioned before, there are two ways to increase the degree of adaptation: active adaptation, consisting in increasing the ability to recognize information stimuli and the ability to respond to them, and passive adaptation, consisting in increasing the body's resistance to energy stimuli. A common feature of both these types of adaptation is increasing the relative independence of the organism's ontogenesis from environmental influences.

In accordance with the previously adopted assumption that the pursuit of reproduction is the basic property of every living organism, strengthening the relative independence of the organism from environmental influences, increasing the chance of passing hereditary material to the next generation, can be considered a basic condition for evolutionary success. An increase in the degree of adaptation of an organism to the environment entails an increase in the above-mentioned relative independence of ontogenesis, and the processes underlying these changes concern the transformation of the structure and function of the epigenotype and phenotype. For this reason, we can talk about the evolution of epigenotype and phenotype as determined by the action of natural selection (and other previously mentioned mechanisms) changes in the structure and function of the organism, which occur only within the framework determined by the structure of the genotype.

Unlike genotype evolution, in which mutations and gene exchanges play a fundamental role in the process of sexual reproduction, evolutionary changes in epigenotype and phenotype are largely determined by the action of natural selection. Both single mutations (usually harmful in the homozygous form) and internal selection (which eliminates genotypes without environmental influences) play a minor role in supragenotypic evolution. Appropriate "management" of the genetic material can lead to a far-reaching independence of the vitality of the organisms in the population from the genetic structure of the population. Examples of such independence are given by Mayr. The interdependencies between genes and the regulation of their actions during ontogenesis, taking place through feedback between epigenotype and genotype, can even lead to a significant decoupling of supragenotypic evolution (mainly the result of natural selection) and genotypic evolution (mainly the result of mutation and internal selection).

Caused primarily by mutations and initially controlled by internal selection, the evolution of the genotype is expressed by the selection of internally balanced, and thus ontogeny capable, gene configurations. On the other hand, supra-genotypic evolution leads to an increase in the degree of adaptation of organisms to the environment, in the sense defined previously. Supragenotypic evolution at both levels (epigenotype and phenotype) can proceed in two basic directions. One of them leads to increasing active adaptation, the other—to increasing passive adaptation. These directions are largely mutually exclusive.

Evolution that increases the degree of passive adaptation consists in increasing the degree of independence of the organism from environmental influences through changes in the phenotype that favor the elimination of energy stimuli, and changes in the epigenotype leading to increased fertility. This type of evolution is often associated with morphophysiological regression and leads to a loss of evolutionary plasticity. However, from the point of view of changes in the degree of adaptation of organisms to their specific environment, such evolution is a progressive process, if progress is defined as an increase in adaptation.

Evolution that increases the degree of active adaptation leads to an increase in the degree of independence of ontogenesis from environmental influences through such changes in the phenotype that enable the reception of a larger range of informational stimuli. It must be accompanied by transformations of the structure and function of the epigenotype enabling a more adequate response to informational stimuli. This type of evolution leads to morphophysiological progress.

7. CONCLUSIONS

An outline of such an approach to the phenomenon of biological evolution has been presented above in which the evolutionary process is understood as a process resulting from the way biological matter is organized. So it would be a synthesis of the theory of biological evolution (the theory of natural selection) and the theory of levels of biological organization. At the same time, the intention was to construct a methodologically correct theory—in such a way that theorems and conclusions could be derived from its axioms, which would then be subject to verification by comparing them with natural phenomena. Of course, it is difficult to comprehensively examine a theory in the first outline, especially when it is not known whether the conceptual apparatus used will be accepted at all. Nevertheless, I would like to conclude by pointing out some potential possibilities in this regard.

It seems that the presented set of concepts can be used to construct a "deductive" theory of biological evolution in a sense, i.e. a theory in which not the course of the evolution process itself (whose final, actual shape depends to a large extent on the occurrence of random phenomena), but its general laws and limitations could be deduced from accepted "axioms" about the basic characteristics and attributes of the phenomenon of life. It is worth noting that, starting from a few elementary concepts and theorems (including the definition of ontogenesis as a process leading to reproduction, determination of the energetic and informational nature of biological stimuli, and adaptation as the ability to conduct ontogenesis in a given environment), we can try to derive a theoretical system that—at least at first glance, it avoids some of the contradictions oppressing the existing theories of evolution.

The issue of evolutionary progress is an example. If we adopt morphophysiological criteria to assess the directions of evolutionary changes, we must conclude that evolution is sometimes progressive, and sometimes, on the contrary, regressive. However, from the very essence of natural selection as a process in which in a certain type of competition: "better" individuals "win"—it follows that evolution by natural selection should always be progressive. In this respect, within the framework of the approach proposed above, we obtain a correspondence between intuition and the theorem of the theory: evolution is always progressive, because it always leads to an increase in adaptation.

It should be remembered, however, that evolutionary progress and its dimension, which is the increase in adaptation, are concepts referring to a specific, unchanging environment, characterized by a specific frequency distribution of biological stimuli of specific types. When the characteristics of the environment change, the degree of adaptation of organisms to the environment also changes. Then, at the same time, the direction of natural selection changes, and the consequences may be different, because in this case they depend on the genetic structure of the population and the adaptive plasticity of specific individuals. This plasticity determines the possibility of maintaining relative independence of ontogenesis from the environment in a situation where its characteristics change.

Epigenotype evolution and phenotype evolution are interdependent processes. Probably there cannot be a simultaneous process of increasing the degree of active and passive evolution. However, there is no space in this outline to analyze the relationships between the genetic structure of the population and the evolutionary prospects of the species, as well as to address the issues of processes occurring at the supra-organismal level (population, biocenosis, etc.). An important feature of the presented theoretical concept is its openness, the possibility of extending its scope towards more complex levels of biological organization.

In conclusion, it is worth re-emphasizing the fact that—regardless of the conceptual apparatus used and formulated definitions, the accuracy of which can only be assessed in retrospect—the essence of the current approach is the recognition that the organization of biological matter and the process of its evolutionary transformations are two inseparable and clearly mutually interrelated aspects of the phenomenon of biological life.

ABOUT THE AUTHOR — Professor of medical sciences (medical biology), affiliation: M. Mossakowski Institute of Experimental and Clinical Medicine of the Polish Academy of Sciences in Warsaw. Author or co-author of 180 works in the field of experimental and clinical medicine, supervisor of 8 doctoral theses. Areas of research interests: animal models of oncological and neurological diseases; design and testing of drugs and therapies for selected ophthalmological, cancer and neurological diseases; medical applications of magnetic resonance methods.

E-mail: pgrieb@op.pl