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ON THE DEVELOPMENT OF THE GREATEST UNIFYING THEORIES IN BIOLOGY

Till the present time there has been no coherent concept of development of the most general and unifying biological theories. In monographs as well as in popular publications, a view is repeated which is internally contradictory. It is stressed, that since 1859 the biological sciences have developed within theoretic teleological systems which assumed as their general thesis the invariability in time of living organisms. At that time the publication of Ch. Darwin's work *On the Origin of Species* became a revolution in all respects. On the other hand, the concept of „invariability", and that of „evolution" are represented as two competing theories which existed already in antiquity but one of them became dominating in result of a gradual accumulation of science. The formation of the theory of evolution would be — in this way — an exclusively cumulative quantitative process. The latter point of view seems to dominate owing to the incessant efforts of many historiographers to increase the number of pre-darwinistic evolutionists. In consequence, evolutionism became a concept which had its prominent followers already in the Greek philosophy and even earlier, in the Chinese cosmogony, and since the time of the Renaissance it is confessed more and more clearly by many distinguished scientists. The idea of invariability and of creation of species — which persisted however till the second half of the 19th century — may be explained as a sign of concession and opportunism of naturalists to the dogmas of theologians which were supported only by a few authorities in biology (Linné, Cuvier, L. Agassiz).

In the present paper theories will be presented which are the consequences of the following points of view:

1. Interesting concepts of variability and of the natural development of the living nature (together with Lamarck's theory) were promulgated till the time of Darwin. They never constituted, however, a consequent and gradually developing current which would seriously influence the progress of biological investigations. They were always

on the margin of science and — what is more important — they had neither genetical nor logical bonds with Darwin's theory of evolution, which had really initiated the evolution.

2. Till the second half of the 19th century, the development of biological research occurred in the limits of the static, teleological and — consequently theological — theoretical systems. For centuries those concepts were conditioned by the state of sciences and in this way determined the normal (regular) stage of development of science. It means that the main trends of the progress in general theories of the living nature lead over the concept of Aristotle, Linné, Cuvier — to Darwin.

3. The progress in the biological unifying theories was accomplished — before all — as result of scientific revolutions.

The problem of regularity of development of science in the course of centuries, and especially the role of revolution in this process, found lately an interesting interpretation in the monograph of T. S. Kuhn: *The Structure of Scientific Revolutions* (1962)[1]. Kuhn concluded his concept on the ground of analysis of development of physical sciences (mostly physics, astronomy, with references to the facts of biology), assuming that the regularities stated by him are typical for the other natural sciences as well. The leading idea of Kuhn is the postulation, that the development of the separate disciplines does not occur gradually but consists of a sequence of periods of cumulative concentration of knowledge and scientific revolutions. The latter are mile-stones on the way of progress. The base of Kuhn's concept is the concept of "paradigm": "Universally recognized scientific achievements that for a time provided model problems and solutions to a community of practitioners"[2]. The appearance of paradigm characterizes an advanced degree of development of the given branch of science. It is preceded by a period of preparadigm, in which different partial competing theories exist which sometimes are semi-scientific. As examples of paradigms in physics, Kuhn indicates — among others — the mechanics of Newton and the relativity theory of Einstein. Those paradigms performed real scientific revolutions having altered not only the views on the most fundamental phenomena of nature, but transforming the scientific problems and methodology as well. According to Kuhn, the revolutionary qualitative character of those transformations is the more evident as the paradigm is never a supplement or a logical development of the old paradigm. The relativistic mechanics kept the validity of classical mechanics — although in a much restricted form — but Einstein conferred to mass, space and time quite different meanings from the Newtonian ones.

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[1] *International Encyclopedia of Unified Science.*, vol. II/2, Foundation of the Unity of Science, Chicago, London, Toronto 1962.

[2] Kuhn, *op. cit.*, p. X.

Besides the great revolutions, Kuhn distinguished paradigms on a more restricted scale as *e.g.* discovery of oxygen or of X-rays which performed revolutions of a much more narrow range, which did not alter immediately the most general rules of a given science. A new paradigm initiates — according to Kuhn — a period of normal science *i.e.* of cumulative development of research-work. The research activity in this situation resembles the solving of puzzles: it is admitted that the problem is solvable after finding a definite key and that its solution should be in agreement with general rules. This may occur, because the paradigm is the essential and methodological ground not only for research, but also of the whole educational process. In the period of normal science, anomalies begin to accumulate, corresponding to facts of different cathegories, which cannot be explained on the ground of the paradigm, existing actually. Initially an inclination appears to explain them within the limits of the dominating paradigm or with slight theoretical concessions. However, when the number of anomalies gradually increases, controversive theories begin to appear and the period of crisis approaches. Next, controversies of different kinds reveal themselves and involve the concentration of research on a definite line. This situation leads to the formation of a theory and subsequently to a scientific revolution. The new theories become a paradigm of the subsequent period of normal science. It seems that the way of development of the natural science disciplines — as postulated by Kuhn — may be helpful as the starting point for a precise determination and for the development of theses formulated previously, which concern the most general theories of the living nature.

The pre-Aristotle period would exactly correspond to the preparadigmatic stage, considering the state of biological science which was not put in order into one scientific system and embraced a number of controversive and competing doctrines. The works and research of Aristotle in the field of biology, together with his theory of stability of forms and of the dynamics of life, would correspond to the idea of paradigm.

The ideas of Aristotle dominated in biological sciences for over two thousand years. Nevertheless, this period had not exactly the character of a "normal" science in the understanding of Kuhn.

Till 1859 the view was generally accepted, that the fundamental feature of living forms is their invariability in time. Every general biological hypothesis of an explicative character could not reach beyond the boundaries of a teleological, and in consequence theological interpretation. The ideas of Aristotle dominated in the fundamental points. Other factors, which initially constituted the paradigm of the Stagirite (*e.g.* the principles of the biological classification, views on the process of propagation) underwent transformations or were postponed as *e.g.* the belief in selfreproduction, in the organic origin of fossil forms. Aristotle's concepts of matter and form were also not maintained.

In this process of transformation of the Aristotle's paradigm, a number of partial scientific revolutions took place; the most important concerned the principles of biological classification and the theory of the static structure of nature; Linné described nearly 9000 plant species and over 4000 animal species and indicated in this way, for the first time on a huge material, to what assembly of organisms corresponds the range of species. The general approbation of the Linné's principles of nomenclature and of the hierarchic classification created stable foundations for their subsequent determination by other taxonomists. Linné assumed in his theory of the static structure of nature, that the species determined by him or by other taxonomists — according to the same principles as Linné — are fundamental and invariable in time, "bricks" of nature derived from the originally created forms. The problem formulated in this way presented grounds for verification *i.e.* for a correct solution which was given by Ch. Darwin. Before this occured, a typical crisis situation arose which supports the postulation of Kuhn, that revealing of anomalies — even serious ones — fails so long to involve the rejection of the dominating paradigm, as long as a new theory having the character of a scientific revolution does not appear. Since the beginning of the 18th century, a number of doubtless facts — controversive to the idea of invariability of species — began to accumulate. This led to a serious crisis already in the beginning of the 19th century. The crisis was accompanied by formation of various theories which aimed at annihilating the new controversies by correcting the dominating paradigm. Those were *e.g.* the theory of catastrophies, by which Cuvier tried to reconcile his own paleontological findings with the thesis of invariability and of creation of species, or with the J. B. Lamarck's theory of evolution, which rejected the paradigm of invariability of nature but preserved its teleological character. Indeed, a long time before the work of Ch. Darwin, the image of the living nature ceased to be comprehensible, but the dogma of stability of species remained still valid.

The revolution evoked by the work: *On the Origin of Species* corresponded to all the attributes of a paradigm. Darwin's theory of evolution changed the image of the world as seen by science, it changed the view on methodology of biological research and created new, quite unknown problems in many fields. The views of Darwin on the process of evolution and on its agents, being deprived of teleology, were not a logical development of the existing paradigm and failed to refer to the theories of the "predarwinistic" evolutionists. Darwin introduced a number of new concepts, *e.g.* the struggle for life, natural selection, or — keeping the old names — gave a quite new meaning to such notions as variability, adaptation, natural systems, or species.

The views represented above have been formulated already in the communication read at the XIth International Congress of the History of Science in Warsaw [3], which evoked a discussion, not free of polemical statements. Its character was in some degree due to simplifications, which can hardly be avoided in a short congress communication. The present, more extensive justification of the theses which were put forward, seems all the more necessary.

The essential proof of a real scientific revolution is the transformation of the most fundamental ideas. In the case of change of their structure (of logical status), the successive theories would be logically incommensurable *i.e.* qualitatively different.

Species is considered as one of the most fundamental concepts of biology. The categorial character of this idea — it was always an indispensable element of all the dominating theories of living nature — as well as the transformations of its structure, are expressed in the monograph of Cz. Nowiński and L. Kuźnicki *On the Development of the Species Concept* [4]. Accentuation of those important statements which found no sufficient argumentation in the present literature, is due to the working method applied by the authors. The regularity of development of the concept of species has been established after a historical analysis of the whole role performed by this concept in the biological practice, as well as in the theories of the living nature, since the time of Aristotle to Darwin.

For illustration of the transformation range of the concept of species, it is necessary — before all — to define what is essentially its categorial (theoretical) character.

The terms: "theory" and "theoretical" are applied here not in the meaning opposing the cognition activity to the practical action, nor in the meaning of documented and reliable statements, in contrast to conjectural theses probable only in part. The meaning of those terms is associated with the explicative function of natural sciences.

The theoretical theses are in this meaning univocal with the explicative ones. Describing facts, we answer the question: what are they like? explaining them we answer the question: why do they occur? The inclination to explain facts is peculiar to the human cognition in its entire historical development. The forms, however, in which investigators of different epochs of history tried to achieve the explanation of the general phenomena of living nature are various.

The considerations of Aristotle had a teleological character. His definitions and classifications had to serve the explanation of dynamics and of the structure of living nature, constituted of eternal forms. Linné

[3] L. Kuźnicki: *The Structure of Scientific Revolutions in Biology* (in press).

[4] *O rozwoju pojęcia gatunku.* Warszawa 1965, PWN, pp. 294 (in Polish).

referred to the eternal structure of nature which arose as a result of creation of different species, when he wished to explain the natural entities in nature. Darwin explained the formation of species, as comparatively stable forms, adapted to their life conditions, by the action of natural agents and the mechanism of natural selection. In all those cases, the explanation of natural phenomena was of a different character, but we always had to do with the "explaining function" of cognition and in this broad meaning we may speak of the theory of Aristotle, of the theory of Linné and of Darwin's theory.

The types of theories which embraced the perception of species were different (teleological of Aristotle, structural and theological of Linné, causal and developmental of Darwin) but all the constructions of the species concept were connected invariably with an attempt at answering the questions: 1. Why do stable forms occur simultaneously with the vivid variability and fugitiveness of individuals, so characteristic for the living nature? 2. Why does nature present assemblies of forms (populations) sharply distinguished from one another, despite a "certain" link of all its creatures? 3. Why are organisms so purposeful, in the meaning of coordination between their functioning and the abiotic and biotic conditions of life and also in the "harmony" of organs and the mutual agreement of their functions?

It is characteristic, that all dominating and unifying biological theories tried to include the answer to the above questions into the concept of species. This constitutes the categorial character of the concept of species, explaining its key-position.

The great transformations of the concept of species in Darwin's theory may be best understood in the following examples. According to the concept of Linné each concrete species was created in the same manner, represented a separate form (*hiatus*), differed from other species by a specific assembly of morphological characters and was isolated physiologically (sexually). In contrast to this, Darwin's dynamic concept of species as a form of adaptation equilibrium and as morphological and physiological differentiation (to which the process of evolutionary transformations is directed) occurs according to the theory of natural selection. The concrete species, presenting the "realization" of this scheme in nature, may be very near to the "pure" model (as it is the case in the majority of species) but they may also deviate from it, because they are at a given moment at different stages of evolutionary advancement.

The transformation of the logical status of the concept of species in Darwin's theory involves changes in the ratio of the meaning function to the designate function (ratio of content and range of the species concept).

In the 18th century *i.e.* in the period of establishing the modern concept of species, the leading biological discipline was systematic, and the general theory of nature was in the first place a rationalization of actual practice of determining species and other taxonomic units, as well as a generalization of results of taxonomic research. No doubt that the main problem of Linné's theory of the structure of nature was performing the functions of a classification system. The general connections in nature, embraced in its theses, expressed in a general manner the order of nature, whereas its concrete reproduction was the task of systematicians who determined species and constructed the classification system. Those conditions are essentially changed in the concept of Darvin. His theory aims its critical point against the thesis of the species creation and in its positive content is not adjusted to the requirements and tasks of taxonomy, but it is orientated towards "the other more general branches of the natural history".

Consequently, if Linné's theory was essentially the metatheory of the classification system, Darwin's theory performs only the secondary function of metatheory of the classification system.

A characteristic regularity of the development of the concept of species may be perceived from the assembly of those historical changes. Initially, the determination of species exerts an essential influence upon the meaning of the species concept. The classical concept of Linné may serve as a characteristic example in which species — as a form morphologically specific and distinguished — is linked with the practice of determination of species in systematics. However in the 19th century, when the range of knowledge of the associations in nature extends powerfully and the idea of evolution gains the general approval in the second half of the century — the concept of species is formed not so much under the influence of determination of species, as under that of the knowledge about the associations in nature and, especially, about the facts concerning development. The trends of the meaning function of the species concept and those of determining species, have been diverging for a long time. The meaning of the species concept is determined by the theory of evolution, whereas the determination of species proceeds in taxonomy according to the tracks made in the period of domination of the static concept. In the 20th century the knowledge of the general connections in nature and the species concept — which was determined by it — begin to exert influence upon the reconstruction of the taxonomic work, similarly as the meaning formed the determination in the past time.

The theory of Darwin presented a qualitative change of the dominating paradigm, and it was not a logical continuation of the former concepts of evolution. This may be clearly demonstrated on the concept of species.

Assuming the species concept as the first rate problem in the biological system is a common characteristic feature of the views of Aristotle, Linné, Cuvier and Darwin. Scientists who confessed the idea of variability of the living nature (in the 18th and the first half of the 19th century) were as a rule opposed to this view. This tendency found its full expression in the theory of evolution of Lamarck who considered the concept of species as indispensable for reasons of classification — but deprived of any correspondent in nature. Consequently Lamarck was the author of the first general theory of nature in which the species concept was fully deprived of any categorical character. In this way, the logical incommensurability of this theory with that of Darwin is evident, even if the other essential differences are not taken into consideration.

In the biological sciences, the idea of evolution found a full approval more or less 20 years after the publication of the work *On the Origin of Species.* — This did not amount to the general acceptation of the theory of the natural selection. The discussion about the factors and mechanisms of evolution became gradually more and more violent and led on the break of the 19th and 20th centuries to a situation which reminds the preparadigm period although it had also a crisis character. There was no dominating theory, while numerous neo-lamarckistic neo--darwinistic, mutationistic and other theories arose. They all were controversive and competing. This situation persisted up to 1930, when the first attempts to escape the impasse appeared. The works of R. A. Fisher, J. B. S. Haldane and S. Wright initiated tendecies to a gradual formation of a "synthetic theory" or a "synthetic evolutionism". This theory integrated into one entity some competing and seemingly contradictory concepts. It based on Darwin's theory of natural selection, introducing some correction into this concept. After a long-lasting crisis, a new paradigm failed to appear, but a "renaissance of darwinism" occured, as it is called in biological literature. The turning-point in this process was the adoption of the rules of Mendel's genetics to the population phenomena and the indication of the key-role of natural selection and of the evolution phenomena by means of mathematic calculations. The role of the pioneer works in this field of R. A. Fisher, J. B. S. Haldane and S. Wright should be considered only as a "small" paradigmatic alteration. The main bulk of Darwin's theory remained unimpared. The synthetic theory was formed — first of all — as a result of a subsequent cumulation of science in which many scholars participated. The most essential codifying role however, was performed by the monographs of Th. Dobzhansky, J. S. Huxley, E. Mayer, G. G. Simpson and I. I. Schmalhausen.

In the post-darwinistic period, the regularities of the most unifying biological theories deviate considerably from the scheme suggested by

Kuhn (paradigm, normal science, paradigm, normal science *etc.*). Should this speak against his concept or reduce its applicability to the physical sciences only? An answer to this question may only be indirect, by pointing out what it means as a function of this type of synthesis. It seems that the most adequate way would be to determine the regularities established by Kuhn as a model type in the knowledge of science. Models, as shown by Beckner [5] in the case of biological theories (postulating that it holds true for all the fields of science), besides their psychological and heuristic values, perform important logical functions as well. It should be of course defined, what meaning is attributed to the concept of model, that it might not become a sort of waste matter basket into which the beyond-logical scientific operations are placed without restriction.

The model of Kuhn should be understood as a manner of explaining the specific intrinsic mechanism of development of the scientific disciplines by finding the common regularities in their historical development. For sake of this explanation, the model contains some simplifying postulations which in some cases may prove to be wrong. This is the inevitable consequence of idealization. Nevertheless, the deviations from the postulated regularities — as it is the case with the development of the theory of evolution — do not restrict its value. In the case of Kuhn's model its logical functions beyond explanation (they should not be confused with the heuristic ones) seem to be more essential than the explanation functions. First of all, the successful simplifications, without naive reducing of such a complex process as the development of different branches of science, should be pointed out. May be still more essential is the introduction of a uniform apparatus of theoretical concepts (paradigm, normal science) with a simultaneous indication of principles of analysing their adequacy (the logical incommensurabilities of successive paradigms). This makes possible the synchronous and asynchronous comparison of development of different branches of science. It enables also to detect the interpretation controversies by means of logical operations. The model of Kuhn proved to be very useful for affirmation of conclusions concerning the development of the general theories of the living nature as postulated in the introduction. Its application introduced much clarity into the problem.

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[5] M. Beckner: *The Biological Way of Thought.* Columbia Univ. Press, New York, 1959, p. 200.