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PHILOSOPHY IN THE MID-CENTURY

A Survey

edited by

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I

Logic and Philosophy of Science

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LA PHILOSOPHIE AU MILIEU DU VINGTIÈME SIÈCLE

Chroniques

par les soins de

RAYMOND KLIBANSKY
McGill University, Montréal

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Logique et Philosophie des Sciences

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QUANTUM PHYSICS AND PHILOSOPHY

CAUSALITY AND COMPLEMENTARITY

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THE significance of physical science for philosophy does not merely lie in the steady increase of our experience of inanimate matter, but above all in the opportunity of testing the foundation and scope of some of our most elementary concepts. Notwithstanding refinements of terminology due to accumulation of experimental evidence and developments of theoretical conceptions, all account of physical experience is, of course, ultimately based on common language, adapted to orientation in our surroundings and to tracing relationships between cause and effect. Indeed, Galileo's program—to base the description of physical phenomena on measurable quantities—has afforded a solid foundation for the ordering of an ever larger field of experience.

In Newtonian mechanics, where the state of a system of material bodies is defined by their instantaneous positions and velocities, it proved possible, by the well-known simple principles, to derive, solely from the knowledge of the state of the system at a given time and of the forces acting upon the bodies, the state of the system at any other time. A description of this kind, which evidently represents an ideal form of causal relationships, expressed by the notion of *determinism*, was found to have still wider scope. Thus, in the account of electromagnetic phenomena, in which we have to consider a propagation of forces with finite velocities, a deterministic description could be upheld by including in the definition of the state not only the positions and velocities of the charged bodies, but also the direction and intensity of the electric and magnetic forces at every point of space at a given time.

The situation in such respects was not essentially changed by the recognition, embodied in the notion of *relativity*, of the extent

to which the description of physical phenomena depends on the reference frame chosen by the observer. We are here concerned with a most fruitful development which has made it possible to formulate physical laws common to all observers and to link phenomena which hitherto appeared uncorrelated. Although in this formulation use is made of mathematical abstractions such as a four-dimensional non-Euclidean metric, the physical interpretation for each observer rests on the usual separation between space and time, and maintains the deterministic character of the description. Since, moreover, as stressed by Einstein, the space-time coordination of different observers never implies reversal of what may be termed the causal sequence of events, relativity theory has not only widened the scope, but also strengthened the foundation of the deterministic account, characteristic of the imposing edifice generally referred to as classical physics.

A new epoch in physical science was inaugurated, however, by Planck's discovery of the *elementary quantum of action*, which revealed a feature of *wholeness* inherent in atomic processes, going far beyond the ancient idea of the limited divisibility of matter. Indeed, it became clear that the pictorial description of classical physical theories represents an idealization valid only for phenomena in the analysis of which all actions involved are sufficiently large to permit the neglect of the quantum. While this condition is amply fulfilled in phenomena on the ordinary scale, we meet in experimental evidence concerning atomic particles with regularities of a novel type, incompatible with deterministic analysis. These quantal laws determine the peculiar stability and reactions of atomic systems, and are thus ultimately responsible for the properties of matter on which our means of observation depend.

The problem with which physicists were confronted was therefore to develop a rational generalization of classical physics, which would permit the harmonious incorporation of the quantum of action. After a preliminary exploration of the experimental evidence by more primitive methods, this difficult task was eventually accomplished by the introduction of appropriate mathematical abstractions. Thus, in the quantal formalism, the quantities by which the state of a physical system is ordinarily defined are replaced by symbolic operators subjected to a non-commutative algorism involving Planck's constant. This procedure prevents a fixation of such quantities to the extent which would be required for the deterministic description of classical physics, but allows us to determine their spectral distribution as revealed by evidence about atomic processes. In conformity with the non-pictorial character of the formalism, its physical interpretation finds expression in laws, of an essentially statistical type, pertaining to observations obtained under given experimental conditions.

Notwithstanding the power of quantum mechanics as a means of ordering an immense amount of evidence regarding atomic phenomena, its departure from accustomed demands of causal explanation has naturally given rise to the question whether we are here concerned with an exhaustive description of experience. The answer to this question evidently calls for a closer examination of the conditions for the unambiguous use of the concepts of classical physics in the analysis of atomic phenomena. The decisive point is to recognize that the description of the experimental arrangement and the recording of observations must be given in plain language, suitably refined by the usual physical terminology. This is a simple logical demand, since by the word 'experiment' we can only mean a procedure regarding which we are able to communicate to others what we have done and what we have learnt.

In actual experimental arrangements, the fulfilment of such requirements is secured by the use, as measuring instruments, of rigid bodies sufficiently heavy to allow a completely classical account of their relative positions and velocities. In this connection, it is also essential to remember that all unambiguous information concerning atomic objects is derived from the permanent marks—such as a spot on a photographic plate, caused by the impact of an electron—left on the bodies which define the experimental conditions. Far from involving any special intricacy, the irreversible amplification effects on which the recording of the presence of atomic objects rests rather remind us of the essential irreversibility inherent in the very concept of observation. The description of atomic phenomena has in these respects a perfectly objective character, in the sense that no explicit reference is made to any individual observer and that therefore, with proper regard to relativistic exigencies, no ambiguity is involved in the communication of information.

As regards all such points, the observation problem of quantum physics in no way differs from the classical physical approach. The essentially new feature in the analysis of quantum phenomena is, however, the introduction of a *fundamental distinction between the measuring apparatus and the objects under investigation*. This is a direct consequence of the necessity of accounting for the

functions of the measuring instruments in purely classical terms, excluding in principle any regard to the quantum of action. On their side, the quantal features of the phenomenon are revealed in the information about the atomic objects derived from the observations. While, within the scope of classical physics, the interaction between object and apparatus can be neglected or, if necessary, compensated for, in quantum physics this interaction thus forms an inseparable part of the phenomenon. Accordingly, the unambiguous account of proper quantum phenomena must, in principle, include a description of all relevant features of the experimental arrangement.

The very fact that repetition of the same experiment, defined on the lines described, in general yields different recordings pertaining to the object, immediately implies that a comprehensive account of experience in this field must be expressed by statistical laws. It need hardly be stressed that we are not concerned here with an analogy to the familiar recourse to statistics in the description of physical systems of too complicated a structure to make practicable the complete definition of their state necessary for a deterministic account. In the case of quantum phenomena, the unlimited divisibility of events implied in such an account is, in principle, excluded by the requirement to specify the experimental conditions. Indeed, the feature of wholeness typical of proper quantum phenomena finds its logical expression in the circumstance that any attempt at a well-defined subdivision would demand a change in the experimental arrangement incompatible with the definition of the phenomena under investigation.

Within the scope of classical physics, all characteristic properties of a given object can in principle be ascertained by a single experimental arrangement, although in practice various arrangements are often convenient for the study of different aspects of the phenomena. In fact, data obtained in such a way simply supplement each other and can be combined into a consistent picture of the behaviour of the object under investigation. In quantum physics, however, evidence about atomic objects obtained by different experimental arrangements exhibits a novel kind of complementary relationship. Indeed, it must be recognized that such evidence which appears contradictory when combination into a single picture is attempted, exhausts all conceivable knowledge about the object. Far from restricting our efforts to put questions to nature in the form of experiments, the notion of *complementarity* simply characterizes the answers we can receive by such inquiry, whenever the interaction between the measuring instruments and the objects forms an integral part of the phenomena.

Although, of course, the classical description of the experimental arrangement and the irreversibility of the recordings concerning the atomic objects ensure a sequence of cause and effect conforming with elementary demands of causality, the irrevocable abandonment of the ideal of determinism finds striking expression in the complementary relationship governing the unambiguous use of the fundamental concepts on whose unrestricted combination the classical physical description rests. Indeed, the ascertaining of the presence of an atomic particle in a limited space-time domain demands an experimental arrangement involving a transfer of momentum and energy to bodies such as fixed scales and synchronized clocks, which cannot be included in the description of their functioning, if these bodies are to fulfil the role of defining the reference frame. Conversely, any strict application of the laws of conservation of momentum and energy to atomic processes implies, in principle, a renunciation of detailed space-time coordination of the particles.

These circumstances find quantitative expression in Heisenberg's indeterminacy relations which specify the reciprocal latitude for the fixation, in quantum mechanics, of kinematical and dynamical variables required for the definition of the state of a system in classical mechanics. In fact, the limited commutability of the symbols by which such variables are represented in the quantal formalism corresponds to the mutual exclusion of the experimental arrangements required for their unambiguous definition. In this context, we are of course not concerned with a restriction as to the accuracy of measurements, but with a limitation of the well-defined application of space-time concepts and dynamical conservation laws, entailed by the necessary distinction between measuring instruments and atomic objects.

In the treatment of atomic problems, actual calculations are most conveniently carried out with the help of a Schrödinger state function, from which the statistical laws governing observations obtainable under specified conditions can be deduced by definite mathematical operations. It must be recognized, however, that we are here dealing with a purely symbolic procedure, the unambiguous physical interpretation of which in the last resort requires a reference to a complete experimental arrangement. Disregard of this point has sometimes led to confusion, and in

particular the use of phrases like " disturbance of phenomena by observation " or " creation of physical attributes of objects by measurements " is hardly compatible with common language and practical definition.

In this connection, the question has even been raised whether recourse to multivalued logics is needed for a more appropriate representation of the situation. From the preceding argumentation it will appear, however, that all departures from common language and ordinary logic are entirely avoided by reserving the word ' phenomenon ' solely for reference to unambiguously communicable information, in the account of which the word ' measurement ' is used in its plain meaning of standardized comparison. Such caution in the choice of terminology is especially important in the exploration of a new field of experience, where information cannot be comprehended in the familiar frame which in classical physics found such unrestricted applicability.

It is against this background that quantum mechanics may be seen to fulfil all demands on rational explanation with respect to consistency and completeness. Thus, the emphasis on permanent recordings under well-defined experimental conditions as the basis for a consistent interpretation of the quantal formalism corresponds to the presupposition, implicit in the classical physical account, that every step of the causal sequence of events in principle allows of verification. Moreover, a completeness of description like that aimed at in classical physics is provided by the possibility of taking every conceivable experimental arrangement into account.

Such argumentation does of course not imply that, in atomic physics, we have no more to learn as regards experimental evidence and the mathematical tools appropriate to its comprehension. In fact, it seems likely that the introduction of still further abstractions into the formalism will be required to account for the novel features revealed by the exploration of atomic processes of very high energy. The decisive point, however, is that in this connection there is no question of reverting to a mode of description which fulfils to a higher degree the accustomed demands regarding pictorial representation of the relationship between cause and effect.

The very fact that quantum regularities exclude analysis on classical lines necessitates, as we have seen, in the account of experience a logical distinction between measuring instruments and atomic objects, which in principle prevents comprehensive deterministic description. Summarizing, it may be stressed that, far from involving any arbitrary renunciation of the ideal of causality, the wider frame of complementarity directly expresses our position as regards the account of fundamental properties of matter presupposed in classical physical description, but outside its scope.

Notwithstanding all difference in the typical situations to which the notions of relativity and complementarity apply, they present in epistemological respects far-reaching similarities. Indeed, in both cases we are concerned with the exploration of harmonies which cannot be comprehended in the pictorial conceptions adapted to the account of more limited fields of physical experience. Still, the decisive point is that in neither case does the appropriate widening of our conceptual framework imply any appeal to the observing subject, which would hinder unambiguous communication of experience. In relativistic argumentation, such objectivity is secured by due regard to the dependence of the phenomena on the reference frame of the observer, while in complementary description all subjectivity is avoided by proper attention to the circumstances required for the well-defined use of elementary physical concepts.

In general philosophical perspective, it is significant that, as regards analysis and synthesis in other fields of knowledge, we are confronted with situations reminding us of the situation in quantum physics. Thus, the integrity of living organisms and the characteristics of conscious individuals and human cultures present features of wholeness, the account of which implies a typical complementary mode of description.[1] Owing to the diversified use of the rich vocabulary available for communication of experience in those wider fields, and above all to the varying interpretations, in philosophical literature, of the concept of causality, the aim of such comparisons has sometimes been misunderstood. However, the gradual development of an appropriate terminology for the description of the simpler situation in physical science indicates that we are not dealing with more or less vague analogies, but with clear examples of logical relations which, in different contexts, are met with in wider fields.

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[1] Cf. N. Bohr, *Atomic Physics and Human Knowledge*, John Wiley and Sons, Inc., New York 1958.

BHIOLOGY AND PILOSOPHY

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1. Introduction. The chapter "Philosophie biologique" in the *Chronique* of the war years 1939-1945 mainly deals with evolution, but also with finalism (not only in evolution, but also in ontogeny). The survey of the post-war years 1946-1948 deals with evolution only. No doubt the author, Piveteau [1], considers it as the most essential characteristic of life that it is a historical process. As according to this trend of thought the theory of evolution permeates the whole philosophy of biology, the latter is especially concerned with the general aspects of evolution.

According to many other modern biologists, however, the study of evolution is not the only biological subscience dealing with essential characteristics and aspects of life; in their opinion there are a number of equally important subsciences of biology.

The majority of these are based on such phenomena as form, organ function, form development, the building up of organisms out of cells and tissues, variability, heredity, speciation, relation to environment, biocenotical relations, distribution, behaviour, historical development, abnormality and illness, relation of body to psyche, etc. The number of subsciences concerned with the empirical biological phenomena, the so-called *empirisms*, mentioned in this list, is greater than that of the subsciences dealing with the historical development of life only. Their number and demarcation depend on the number of contingent 'empirisms' recognized. It is a question of the philosophy of biology whether there are many of these or whether they can be reduced to a small number, perhaps to form and function only.

Of much greater interest for the philosophy of biology are two other elements of these subsciences: the methods and the ideas applied. The term 'idea' is in the following used in the sense of Meyer-Abich as applied by him to the logic of morphology. These 'ideas', being general tendencies of thought applicable in biology as a natural science, act, as it were, as a compass needle pointing in the general direction in which our investigations are to proceed. When applied, these 'ideas' are the forms in which we have to mould the results of our investigations; they include the following: the 'ideas' of type or system, quantity, causality (as used in physics and chemistry as well as in the historical sciences), historical development, teleology, organism, individuality and essence (van der Klaauw [2] p. 25 sq.; [3] p. 236 sq.). In these questions, too, the kind of 'ideas' admitted and their demarcation depend on our philosophical insight.

There are great differences between the various subsciences of biology as to 'empirisms', methods and 'ideas'. To give a few significant examples of such differences: The subscience of systematics is characterized by the 'ideas' of type and/or historical development (genealogical sequence); in principle, it may use all 'empirisms' (form, function, cellular characters, variability, heredity, relation to environment, distribution, behaviour, etc.). The field of a young subscience is as a rule given by an 'empirism', scientifically elaborated into a set of 'ideas'; these may differ in character, being either merely heuristic or final. At a certain stage of development, some subsciences are split up into further subsciences in accordance with the 'ideas' applied, as for instance in the case of the subsciences based on the 'empirism' *form*: systematics, morphology, physiology of form, cytology, genetics, etc.

Thus the subsciences of biology are not absolutely separated. A number of subsciences are based on the same 'empirism', such as that of *form*. A number of subsciences tend to be guided by the same 'idea' (as is the case with the principle of causality as used in causal morphology, physiology, ethology, etc.), thus affording the possibility of a synthesis. Other subsciences synthesize two or more 'empirisms'; functional anatomy is a case in point.

2. The present state of the philosophy of biology. We find to-day philosophical enquiries into the various biological sciences rather than a general philosophy of biology. These enquiries have been based upon the main prevailing systems of philosophy; their implications have been worked out in the various subsciences of biology. Until now, this has not led to satisfactory results: to a large extent, the critical analysis of the philosophical presuppositions of modern biology is a task which remains to be carried out.

In this situation, we have to proceed on the basis of the given scientific material and try to draw attention to the different philosophical attitudes adopted towards it. In the first place, this can be done with regard to those concepts, methods, 'ideas', etc., which are used in more than one subscience and therefore have a more general character; in the second place, with regard to the syntheses of different biological subsciences; and in the third place, with regard to the various subsciences and their special concepts.

The *Bibliographia biotheoretica* [4] lists more than one thousand titles a year, of which a smaller part concerns mathematical biology, while the larger part bears on the philosophical and logical aspects of the biological subsciences. It is evident, therefore, that in the few pages at our disposal it is impossible to give more than a cursory review of the subject. Moreover, the difficulty of finding in a short time competent collaborators for so wide a field, made it impracticable to provide more than a short outline of some aspects of the subject.

3. Philosophy of biology based upon the major philosophical systems of the time. Each of the major philosophical schools of the day—for instance Thomist philosophy, dialectical thought, materialism, positivism, existentialism—has given rise to a special philosophy of biology. We confine ourselves to the following:

(a) *Thomism* (Professor P. H. van Laer, University of Leiden). The Thomist conception of life and man has made its impact felt above all on the discussion of the following three problems: the difference between living and non-living matter; the difference between animal and man; and the question of evolution, especially that of man. Thomist philosophy maintains that the living creature has a distinctive character which manifests itself in an organized unity and in an immanent purposiveness or finality. This latter exhibits itself in a co-ordination of the causal factors existing in the living creature, such as to result in the development and the preservation of the individual and the propagation of the species. This Thomist conception has been developed in a number of publications in the post-war years (Ballauff [5]; Bruna [6]; Brunner [7]; Carles [8]; Grégoire [9]; Jolivet [10]; Koren [11]; Marcozzi [12, 13]; Schubert-Soldern [14]; Seitz [15]; Siegmund [16]; Vignon [17]; Wenzl [18]). The purposeful co-ordination of the efficient causal factors finds its explanation in an intelligent mind, so that from the purposiveness of things in the world a Maker can be inferred (see also van Laer [19]; Vignon [20]). The typical immanent unity of living substances is also explained by the Aristotelian-Thomist doctrine of hylomorphism (see also Jeuken [21]).

Thomism holds that man has a completely distinctive character which manifests itself in the specific human activities of the intellect and the will. These are fundamentally different from the cognitive and appetitive functions of animals (Marcozzi [12]; Meyknecht [22]; de Montpellier [23]; Siegmund [24, 25]).

A theistic-finalistic theory of evolution is upheld, which in the case of macro-evolution is expressed in terms of a creative interference as regards the emergence of new 'typical forms' or new 'organization-types'; or in terms of a directed evolution by which inborn potencies are gradually realized (Conrad-Martius [26]; Conrad-Martius & Emmerich [27]; Descoqs [28]; Marcozzi [12, 13]; Niedermeyer [29]). A special problem of evolution is that of man, to which a number of philosophical as well as theological monographs and books have been devoted (De Fraine [30]; Marcozzi, [31*a*], Flick [31*b*], and Lennerz [31*c*]). According to Teilhard de Chardin [32], the purpose and explanation of the evolution of the vegetable and animal world lies in man; the purpose of the evolution of mankind lies in the gradual achievement, on the part of human individuals, of a complex unity manifesting the harmony of its members and directed towards God.

(b) *Mechanism, vitalism, holism, philosophy of the 'cosmonomic idea'* (Professor A. MEYER-ABICH, University of Hamburg; Professor J. LEVER, Free University, Amsterdam). No books treating of the general theory of mechanism, vitalism and holism have appeared during the period under review (the last book on holism by Meyer-Abich appeared in 1948 [33]). We mention only a paper by Meyer-Abich [34] on organisms as holisms, treating of autonomous biological causality. However, these theories, especially mechanism and holism, underlie a number of theoretical papers concerning the various subsciences of biology.

A general philosophy of distinctive character, originating in the orthodox-protestant circle of the Free University at Amsterdam, is the philosophy of the cosmonomic idea (Dooyeweerd [35, 36, 37]). It has distinct consequences for the philosophy of the biological sciences. According to this structure-theory, reality *shows* a number of 'irreducible created modal aspects' (arithmetical, geometrical, physical, biotical, psychical, logical, etc.), but reality *consists* only of 'totality-structures' (inanimate things, plants, animals, men), showing various of the modal aspects mentioned. Within the higher 'totality-structures' there occur 'individuality-structures', which are intermingled. The 'totality-structure' of higher animals shows three intermingled 'individuality-structures', that of the physico-chemical substratum, that of the typical-biotical processes and that of the typical-psychical behaviour; in plants this third 'individuality-structure' is lacking. Within each 'totality-structure' the highest 'individuality-structure' is predominant and induces changes in the lower 'individuality-structures', the proper laws of the latter not being altered in principle. This philosophy of the 'cosmonomic idea' in its application to biology maintains that material processes strictly follow physico-chemical rules, but rejects the view of mechanism that all phenomena in living organisms are physico-chemically determined. It holds the view that living organisms show an irreducible private nature, but rejects the vital substance or metaphysical vital force postulated by neovitalism; it lays stress on the unity of 'totality-structure', but denies the possibility, affirmed by holism, of a direct or indirect reduction of all phenomena to the psychical aspects. In elaborating this philosophy in the various biological subsciences, members of this circle (Lever & Dooyeweerd [38]; Lever [39, 40], working along the lines of Diemer [41*a-c*]) have emphasized that in systematics every aspect of the organisms demands our attention in characterizing the species, but that the most pregnant feature of animals is their behaviour, that is, the highest 'individuality-structure'.

4. *General concepts, methods, 'ideas', etc.* (Mr. P. SMIT, University of Leiden). In biology some concepts are restricted to one or to a very few subsciences (such as race, species, morphogenetic field, gene, biocenosis, etc.). On the other hand, others are used in a number of subsciences; they have a broader and more general value (form, function, cause, etc.). Of these general concepts we deal with the following:

(a) *Individuality.* Jeuken [42] treats the problems surrounding the concepts of 'individual' and 'individuality'. 'Individual' does not mean 'indivisible'. A number of biologists (Haeckel, von Bertalanffy, Driesch, Bergson), starting from a different philosophical standpoint, agree on a number of characters included in the notion of individuality, such as subsistence, unity and totality, tendency towards a closed system and the impossibility of a full definition. Jeuken himself gives the following definition of individuality: the tendency of the single organism towards undivided subsisting totality. His definition of an individual is: a being is an individual in the measure in which this tendency is realized.

(b) *Complementarity.* Meyer-Abich [43] deals with the principle of complementarity in biology. He illustrates his views on the complementarity of form and function, of internal relations and external world-relations, and of heredity and adaptation. Complementarity does not imply contradiction but it implies contrast; it results from the scientific methods applied. The philosophical implication of complementarity is that there is no universal system of reality. Complementarity is nothing but the logic of uncertainty. All this means metaphysically, according to Meyer-Abich [43], that reality as a whole is a source of freedom, of creative evolution and of self-responsibility. The notion of complementarity has also been discussed by Raven [44].

5. *Syntheses between different biological subsciences.* It will suffice to draw attention to a paper by von Ubisch [45] on the syntheses of genetics and cytology, of selection theory and genetics and of causal morphology and genetics.

6. *The philosophic content of the various subsciences of biology.* A most promising way to attain a broad general insight into the philo-

sophy of modern biology will no doubt be to investigate the philosophic basis and background of the various biological subsciences. As we have said already, the critical analysis of these fields, especially of their philosophical foundations, requires a thorough grasp of modern biological research; to a large extent, this investigation has still to be carried out.

In this section, too, we can give only a very brief review of a limited number of the many subsciences of biology which are studied nowadays.

(A) *Systematics* (Dr. K. BLOCH, Stuttgart). The philosophic problems related to systematic biology can be arranged in a number of groups, four of which will be mentioned here:

(i) *The unity of methods in systematics.* Practically all systematists believe in the unity of the methods used in systematics, independently of the organisms to which they have to be applied. It is possible to hold that systematics applied to animals should differ from that applied to plants, owing to the difference in character of the organization shown by plants and animals (Andréanszky [46]).

(ii) *Nominalistic and realistic tendencies.* It has recently been recognized that positivist, nominalistic ways of thought do not lead to further results. At the same time, an anti-darwinistic tendency has developed in systematics. A third tendency of distinctly realistic strain is taking shape, especially in some European schools.

(iii) *The realistic character of systematic categories.* The so-called individuals and the species are real. It may be asked, however, whether higher systematic categories are real or not, and in case they are real, what the character of that reality is. A number of important remarks have been made on this matter. The cause of the difficulty in recognizing the ontological reality of systematic categories is said to lie in the concept of reality taken in a narrow, subjective sense (Danser [47]). According to this view, the natural system has physical reality: there is a systematic hierarchy not only in the methodological sense, but also in the ontological sense. This reality has been understood only in a purely metaphysical sense by Buxbaum [48], Troll [49], Remane [50] and others, without any possibility of recognizing it distinctly. On the other hand, Bloch [51] has pointed out that a kind of material realism should be able to accommodate the reality of individuals as well as that of systematic categories in the same sense. It has also been held that there is an ontological hierarchy of systematic classes, the reality of which is not affected by the logical preparation of systematics; a problem arises here, however, in the case of a genus comprising a single species only (Gregg [52]). A broad survey and a penetrating critical review of all these problems has been given shortly after the period 1949-1955 by Bloch [53].

(iv) *Concepts, methods, etc.*

Infra-specific categories. There is much confusion in this field, and much has been done to clarify the situation. A new definition of the notion of a subspecies based on philosophical considerations has been formulated (Edwards [54]). This notion, which is applicable to certain organisms, needs precise statement, especially of its criteria (Fox [55]).

Superspecies (' *Artenkreis* '). This category, as a succession of species with a common paleontological origin, has been rejected, as being an evolutionary process from the root of a cladogenesis (Cain [56]).

Systematic type. The type of a species is generally considered as the normal individual, ' normal ' taken as the best or optimal specimen, as the mean specimen, etc. The type of a higher category is as a rule the first species of that higher category which has been described. On the other hand, the type of a higher category has been indicated to be the purely ancestral form, the characters of which have been inferred from the distribution of homologous similarities within the system (Remane [50]). Speaking of a type of all the systematic categories, smaller and larger, it has been said that the characters of any type necessarily comprise the diagnostical characters of the group concerned as well as primitive characters which are not realized in every subordinated group and consequently are not diagnostical. Every individual organism is a representative of a hierarchy of graduated morphological types. This conclusion is also valuable for the first species of any higher morphological group in its historic origin. Every type is four-dimensional in the sense of being a temporal dynamic form, time being included as the fourth dimension by the characteristic ontogenetic transformations of the type-form (ontogenetic-growing-type) (Kälin [57]).

(B) *Causal morphology* (Professor Chr. P. RAVEN, University of Utrecht). A number of questions of philosophical significance have been treated and developed:

(i) *' Ideas '.* The theoretical aspect of morphogenesis has led to a philosophical interpretation based on various empirical facts. The ' idea ' is that of causality.

Waddington [58] has treated developmental occurrence according to its genetic definiteness. Von Ubisch [59, 60] considers the activation of genes as depending on the position of the nuclei in relation to certain gradients. Moment [61, 62] gives an electrical theory of growth and differentiation. Turing [63] has propounded theoretical considerations of the chemical processes underlying morphogenesis. Tyler [64] has given a conception of the developmental processes founded on immunology.

We can consider the conception of the field structure as a structural idea in developmental processes, as it has been developed in a biological field theory by Gurwitsch [65].

Several aspects are treated by a number of authors in the Leiden symposium [66] and the Strasbourg symposium [67].

(ii) *Concepts, methods, etc.* The notion of specificity as it manifests itself in ontogeny has been treated by Weiss [68]. He has given [69, 70] a comprehensive survey of the methods to be used in causal morphology.

(iii) *The significance of causal morphology for other subsciences.* The significance of causal morphology for the notion of homology has been studied by Baltzer [71], and for the theory of evolution by Dalcq [72].

(C) *Animal psychology and animal ethology* (Dr. J. A. BIERENS DE HAAN, Amsterdam). In the science of the behaviour of animals two main schools can be distinguished: the subjective-psychological and the objective-ethological. They differ in the 'empirisms' they employ owing to a difference of opinion about the field of the science dealing with these phenomena on the one hand, and on the other hand, about the subject of biology, its methods and problems as a natural science.

As an example of the subjective-psychological school, we mention Bierens de Haan [73, 74]. The subjective or psychic phenomena, which we know in ourselves to be immaterial and non-spatial (for example: sensations and perceptions, feelings and emotions, desires, conations and memories), are acknowledged to be the determining factors in the actions of animals. Though we recognize these phenomena directly only in ourselves, Bierens de Haan thinks we have a right to assume them in the case of animals. Further he holds that these phenomena in animals can also be recognized by us. He bases his belief in the occurrence of psychic phenomena in animals on the seven features which McDougall enumerated some time ago as proofs for psychic definiteness of behaviour: the spontaneity of the act, its persistence when the original cause has ceased, its variability with regard to the achievement of an aim, the termination of an act when the aim has been reached, the preparations for a future act, the improvement of it in repetition, and the totality of the behaviour, in contrast to the limitedness of the reflex. In accordance with these features, descending from the highest animals to protozoa, he thinks that the existence of psychic phenomena in all animals is proved by their actions, and that their presence can be inferred from the actions observed. Starting from this, Bierens de Haan discusses the central problem of animal psychology, namely, that of animal-instinct, which he considers to be an innate psychic structure, which couples a certain knowledge (cognition) to a certain feeling (affection), and this again to a certain striving (conation), evoking a certain action, which is the outward form of appearance of this instinct-binding. He also discusses the problem of the intelligence of animals in its various forms, which he takes as their ability to reconstruct innate instincts in view of the acquired experience. Finally, animal comprehension is discussed, which he considers to be a grasp of the mutual relations of essential elements in a situation with respect to a pursued aim, which relations can have the character of space, time or causality. In this way a system of animal psychology is consistently built up from the psychological formulation of the notion of instinct.

As a typical example of the objective-ethological school, we may refer to Tinbergen [75]. Ethology can be considered as a physiology of behaviour, and so ultimately as a part of physiology in the broad sense. Subjective phenomena are not to be recognized objectively in animals, and are therefore rejected by him as elements of explanation, though their existence is not denied. Nor does he deny the purposefulness of animal behaviour, but, being a physiologist, he has to look only for physical causes. The aim of ethology, then, is to reduce the objectively observed animal conduct to nerve- and sense-physiological phenomena. In contrast to the psychologist who accepts observations and feelings as causes of reactions to stimuli, Tinbergen thinks, considering the dependency shown by innate reactions on those stimuli acting as signals, that there must be a special neuro-sensorial mechanism in the animal. It is this mechanism which evokes the reaction and is responsible for the selective sensitiveness which the animal shows for a special combination of observation-signals. He calls this, following Lorenz, the "innate releasing mechanism". He considers instinct to be a nervous mechanism which is sensitive to certain impulses of an internal or external nature, and responds to them with co-ordinated movements. Like Lorenz he separates instinctive behaviour into (i) 'appetitive behaviour', which is characterized by variability, plasticity and purposefulness, and (ii) a stereotyped motoric pattern, 'the consummatory act' which is the most conspicuous part of the act. Thus we have a variably conative behaviour and a fixed action, two components of a completely different character. The investigations of ethologists have mainly been directed to the innate behaviour of animals and have neglected their learning and intelligence. Tinbergen acknowledges that learning is hard to define from an objective standpoint. He considers it to be a central nervous process, which under the influence of the outside world brings about more or less permanent changes in the innate behaviour mechanisms.

(D) *Phylogeny* (Professor C. J. van der Klaauw; Dr. P. Smit, University of Leiden; Professor J. Lever, Free University, Amsterdam). Phylogeny, as the biological subscience of evolution and of the origin of subspecies as well as of phyla, contains a number of problems which can be separated according to the interpretation given to a number of general biological questions. In principle, we may find for each 'empirism' a special interpretation of these general questions. The answer given to these questions depends on the general philosophical attitude of the author. The answer given to one question determines the answers given to others.

These questions, which may also be put in phylogeny, are the following six: (i) Does the thing in question occur or not: does phylogeny occur in general? does it occur of species only, or perhaps also of phyla? (ii) What is it and what is its scientific definition: what is phylogeny? what is macro-evolution and micro-evolution? what can be called 'new' in development? (iii) What is the character of the thing: is phylogeny orthogenetic, progressive or regressive? is the degree of adaptation reached complete or insufficient? (iv) What has caused it: what is the cause or are the causes of phylogeny? (v) In what way has it come into existence: the genealogy- or the pedigree-question. (vi) What is its direction and what is its significance: what is the final form of an orthogenetic development? what is its biological significance with regard to its proper place in a biocenosis?

(i) *The occurrence and absence of phylogeny in groups of different systematic value.* Phylogeny is accepted by practically all biologists nowadays. Its necessity has been denied, in the period under review, by Heribert Nilsson [76].

(ii) *What is phylogeny?* In modern times this is especially the question of micro-evolution and macro-evolution, of speciation and the origin of higher systematic groups. As to the question of what can be called 'new' in development, Meyer-Abich [77] expresses the view that we can only speak of 'origin' in the case of the development of types (archetypes) with new characters; this is not the case in species which arise through the splitting up of the original archetype.

(iii) *The character of phylogeny.* This character is expressed by orthogenesis, by progressive and regressive evolution. It is also dependent on the degree of adaptation attained. As to the unadapted species which, according to Small [78], are destroyed in a certain geological period owing to innate instability, this author is of the opinion that their number shows a more or less constant relation to the number of newly developing species; at least in the groups studied by him.

(iv) *The cause or causes of phylogeny.* On this question the leading scientific and philosophical theories diverge.

In the field of theoretical biology we are faced with the problem as to whether phylogeny originates in natural selection, mutation, hybridization or type-synthesis. It may be a co-operation of two or more of these factors, in which case we may ask which is the most important. Neo-Darwinians advance the co-operation between natural selection, as the major cause, and mutation, as the minor cause of evolution (Dobzhansky [79]; Rensch [80]; Simpson [81, 82]). Has natural selection only a canalizing influence by eliminating certain variations or does it also cause new qualities? Considering type-synthesis as the cause of phylogeny, Meyer-Abich [77] develops the view that two or more archetypes can, by means of holobiosis in the form of a complete melting together, build a new archetype. The new archetype shows a number of new characters and is richer in potentialities than the original forms.

In a philosophical sense the problem of the cause or causes of phylogeny amounts to the question whether an accidental combination of factors from outside automatically acts selectively upon a great number of produced characteristics, or whether the cause lies in a psychic factor which works from the inside. Meyer-Abich [77] holds the former to be biologically incorrect. He assumes an active creating force; this creating, planning activity of organisms is one of the causes or is the primary cause of phylogenetic development.

On a philosophico-theological level the problem of the cause or causes of phylogeny appears as the question of creation. Within the doctrine developed in orthodox-protestant groups, and based on the faith in creation by a personal God, three forms can be distinguished: (1) the fundamentalist belief in the creation of reality as a whole, the fossils included, some thousands of years ago; (2) the doctrine of a creation recurring many times in the course of the billions of years of the world's history; these acts of creation can be dated and localized, and produce radically new things, either 'totality-structures' (as e.g. the vertebrates) or new aspects (life, psyche) (Conrad-Martius [26]; Kuhn [83]; Ramm [84]); (3) the theory of an all-embracing act with which the personal God in the beginning has created this reality in its total structural character and has placed it in time. Under God's continuous, but fundamentally imperceptible direction, the various aspects of this created reality have, in the course of world history, manifested themselves in a process of evolution, of which man formed the aim and biological end (Diemer [41*b*-*c*]; Lever [40]). In Neoscholasticism (Thomism) views similar to those mentioned under (2) and (3) have been developed, as we have seen above.

(v) *Genealogy or the question of pedigree.* This is the question whether genealogy conforms to a genealogical tree, branched or non-branched.

It is also the question whether there are non-branched so-called orthogenetic lines in which a rectilinear development occurs through a series of gradually changing and successive forms. According to Neo-Darwinians, these orthogenetic lines are rare and limited to very few cases in which there are limited possibilities of evolution; they may occur during short geological periods (Simpson [81, 82]). According to Darwinism, they need no active, spontaneous inner cause for their explanation.

The archetypes of Meyer-Abich [77], by a series of splits, show a discontinuous, spontaneous origin of new characters.

According to Small [78], a monopodial phylogenetic development can result in the fact that we find an accumulation of those genera and species which show an innate capacity for permanence by remaining in the living condition from their origin up to a much later period, or even up to the present time. Small regards numerically divergent end-products as being due to modifications superimposed upon the normal rules-within-limits during their previous history.

(vi) *The aim or the end of evolution.* This is the question whether there is a real orthogenesis developing in a certain direction with a certain aim. The aim has been considered to be a more complicated stage, a more and more perfected psychic life (see also Huxley and Hardy [85]).

Another question is that of the biological significance of phylogenetic development. In Darwinism it is the question of the use, in the evolution of living beings, of those characters which are of significance in the struggle for life, in which only the most highly adapted survive.

Still another question concerning the significance of a phylogenetic development is that of related and co-ordinated, parallel development of two or more groups of living beings. Leppik [86] considers the phylogenetic development of the flower types which must run parallel to that of the insects which play a part in the pollination of these flowers, and thus to the phylogenetic development of the instinctive behaviour of these insects. To deepen our insight, we need a comparison of the typological classification of ecological characters with the systematic classification based on the phylogeny of these living beings.

BIBLIOGRAPHY

Andréanszky, G., [46] *Essai sur un système phylogénétique des groupements végétaux*, Ann. hist. nat. Mus. hung. V, 175-186 (1954).

Ballauff, T., [5] *Das Problem des Lebendigen*, Bonn 1949.

BALTZER, F., [71] *Entwicklungsphysiologische Betrachtungen über Probleme der Homologie und Evolution*, Revue suisse zool. **57**, 451-477 (1950).

Bibliographia biotheoretica, [4] 1925/29, 1930/34, 1935/39, 1940/44, 1945/49, 1950/54 (Leiden).

BIERENS DE HAAN, J. A., [73] *Animal Psychology: its Nature and its Problems*, London 1948.

—— [74] *Psicologia degli animali*, Milano 1951.

BLOCH, K., [51] *Zur Frage der Realität der sog. Typen in der biologischen Systematik*, Acta biotheor. **10**, 1-10 (1952).

—— [53] *Zur Theorie der naturwissenschaftlichen Systematik*, Bibl. biotheor. **7** (1956).

BRUNA, M. A., [6] *Philosophie der organische natuur. Oud en nieuw denken over het leven*, Antwerpen & Nijmegen 1947.

BRUNNER, A., [7] *Die Grundfragen der Philosophie*, Freiburg i. B. 1949.

BUXBAUM, F., [48] *Grundlagen und Methoden einer Erneuerung der Systematik der höheren Pflanzen. Die Forderung dynamischer Systematik im Bereich der Blütenpflanzen*, Wien 1951.

CAIN, A. J., [56] *Not the Superspecies*, System. Zool. 4, 143-144 (1955).

CARLES, J., [8] *Unité et vie, Esquisse d'une biophilosophie*, Paris 1946.

CONRAD-MARTIUS, H., [26] *Abstammungslehre*, 2. Aufl., München 1949.

CONRAD-MARTIUS, H., & EMMERICH, C., [27] *Das Lebendige. Die Endlichkeit der Welt. Der Mensch*, München 1951.

DALCQ, A. M., [72] *L'apport de l'embryologie causale au problème de l'évolution*, Portug. acta biol., Ser. A, 367-400 (1951).

DANSER, B. H., [47] *A Theory of Systematics*, Bibl. biotheor. **4**, 117-180 (1950).

DE FRAINE, J., [30] *De bijbel en het ontstaan van de mens*, Antwerpen 1953.

DESCOQS, P., [28] *Autour de la crise du transformisme*, Paris 1944.

DIEMER, J. H., [41*a*] *Over biotypen van Anopheles maculipennis Meigen, in het bijzonder in Westelijk Nederland; een taxonomisch onderzoek*, Diss., Univ. Leiden 1935.

—— [41*b*] *Natuur en wonder*, Philosophia Reformata S/9, 100-128 (1943/44).

—— [41*c*] *Natuur en wonder*, Org. Chr. Ver. Nat. en Geneesk. in Nederland, 53-92 (1944).

DOBZHANSKY, T., [79] *Genetics and the Origin of Species*, 3rd ed., New York 1951.

DOOYEWEERD, H., [35] *De wijsbegeerte der wetsidee*, I-III, Amsterdam 1935-1936.

—— [36] *Het substantiebegrip in de moderne natuurphilosophie en de theorie van het enkaptisch structuurgeheel*, Philosophia Reformata **15**, 66-139 (1950).

—— [37] *A New Critique of Theoretical Thought*, 4 vols., Philadelphia & Amsterdam 1953-1957.

EDWARDS, J. G., [54] *A New Approach to Intraspecific Categories*, System. Zool. **3**, 1-20 (1954).

EHRENBERG, R., *Metabiologie*, Heidelberg 1950.

FLICK, M., [31*b*] *L'origine del corpo del primo uomo alla luce della filosofia cristiana e della teologia*, Gregorianum **29**, 392-416 (1948).

FOX, R. M., [55] *On Subspecies*, System. Zool. 4, 93-95 (1955).

GREGG, I. R., [52] *The Language of Taxonomy: an Application of Symbolic Logic to the Study of Classificatory Systems*, New York 1954.

GRÉGOIRE, F., [9] *Note sur la philosophie de l'organisme*, Louvain 1948.

GURWITSCH, A., [65] *Une théorie du champ biologique cellulaire*, Bibl. biotheor. **2** (1947).

HUXLEY, J., & HARDY, A. C., [85] *Evolution as a Process*, New York 1954.

JEUKEN, M., [21] *Hylemorphisme en biologie*, Studia Catholica **28**, 115-129 (1953).

—— [42] *The Concept of 'Individual' in Biology*, Acta biotheor. **10**, 57-86 (1952).

JOLIVET, R., [10] *Traité de philosophie*, I, Paris 1949.

KÄLIN, J., [57] *Zur Systematik und evolutiven Deutung der höheren Primaten*, Experientia **11**, 1-17 (1955).

KLAAUW, C. J. van der, [2] *Kritische Bemerkungen über das System der Biologie von Lubosch*, Tijdschr. Ned. Dierk. Vergg. 3e ser. **3**, 9-36 (1932).

—— [3] *Zur Aufteilung der Ökologie in Autökologie und Synökologie im Lichte der Ideen als Grundlage der Systematik der zoologischen Disziplinen*, Acta biotheor. **2**, 195-241 (1936).

KOREN, H. J., [11] *An Introduction to the Philosophy of Animate Matter*, St. Louis (Mo.) & London 1955.

KUHN, O., [83] *Die Deszendenztheorie. Grundlegung der Ganzheitsbiologie*, 2. Aufl., München 1951.

LAER, P. H. van, [19] *Philosophico-Scientific Problems*, Pittsburgh 1953.

Leiden symposium: [66] *De Morphogenetica*, Folia biotheor. **3** (1948).

LENNERZ, H., [31*c*] *Quid theologo dicendum de Polygenismo?*, Gregorianum **29**, 417-434 (1948).

LEPPIK, E. E., [86] *Some Viewpoints on the Origin and Evolution of Flowering Plants*, Acta biotheor. **11**, 45-56 (1955).

LEVER, J., [39] *Het soortbegrip en de levende structuren*, Openbare les., Loosduinen 1950.

—— [40] *Creatie en evolutie*, Wageningen 1956.

LEVER, J., & DOOYEWEERD, H., [38] *Rondom het biologisch soortbegrip*, Philosophia Reformata **13**, 119-138 (1948); **14**, 6-32 (1949); **15**, 1-23 (1950).

MARCOZZI, V., [12] *La vita e l'uomo*, Milano 1946.

—— [13] *Evoluzione o creazione?*, Milano 1948.

—— [31*a*] *Poligenesi ed evoluzione nelle origini dell'uomo*, Gregorianum **29**, 343-391 (1948).

MEYER-ABICH, A., [33] *Naturphilosophie auf neuen Wegen*, Stuttgart 1948.

—— [34] *Organismen als Holismen*, Acta biotheor. **11**, 85-106 (1955).

—— [43] *The Principle of Complementarity in Biology*, Acta biotheor. **11**, 57-74 (1955).

—— [77] *Beiträge zur Theorie der Evolution der Organismen: 2, Typensynthese durch Holobiose*, Bibl. biotheor. **5** (1950).

MEYKNECHT, J., [22] *Hebben dieren intelligentie?*, Leiden 1947.

MOMENT, G. B., [61] *A Theory of Differentiation*, Growth **16**, 231-242 (1952).

—— [62] *A Theory of Growth Limitation*, Amer. Nat. **57**, 139-153 (1953).

MONTPELLIER, G. de, [23] *Conduites intelligentes et psychisme chez l'animal et chez l'homme*, Louvain & Paris 1946.

NIEDERMEYER, A., [29] *Philosophische Propädeutik der Medizin*, Wien 1955.

NILSSON, H., [76] *Synthetische Artbildung. Grundlinien einer exakten Biologie*, Lund 1952.

PIVETEAU, J., [1] *Philosophie biologique*, Actual. scient. indust. **1089**, 81-89 (Paris 1950); **1105**, 155-159 (Paris 1950).

RAMM, B., [84] *The Christian View of Science and Scripture*, Grand Rapids (Mich.) 1954.
RAVEN, C. P., [44] *Über die Idee einer mehrfachen Komplementarität und ihre Anwendung auf die Wissenschaftslehre*, Synthese 7, 321-333 (1948/49).
REMANE, A., [50] *Die Grundlagen des natürlichen Systems der vergleichenden Anatomie und der Phylogenetik: I. Theoretische Morphologie und Systematik*, Leipzig 1952.
RENSCH, B., [80] *Neuere Probleme der Abstammungslehre. Die transspezifische Evolution*, 2. Aufl., Stuttgart 1954.
SCHUBERT-SOLDERN, R., [14] *Philosophie des Lebendigen*, Graz & Wien 1951.
SEITZ, L., [15] *Die Wirkungseinheit des Lebens*, Berlin & München 1950.
SIEGMUND, G., [16] *Auf der Spur des Lebensgeheimnisses*, Philos. Jahrb. **57**, 22-69; 171-241 (1947).
—— [24] *Tier und Mensch*, Fulda 1949.
—— [25] *Der Mensch in seinem Dasein. Philosophische Anthropologie*, Freiburg i. B. 1953.
SIMPSON, G. G., [81] *Rythme et modalités de l'évolution* (trad. par P. de Saint-Seine), Paris 1950.
—— [82] *Zeitmasse und Ablaufformen der Evolution* (übers. von G. Heberer), Göttingen 1951.
SMALL, J., [78] *Quantitative Evolution: 15, Numerical Evolution*, Acta biotheor. **9**, 1-40 (1949).
Strasbourg symposium, [67] Année biologique, 3me série, **26** (1950).
TEILHARD DE CHARDIN, P., [32] *Le phénomène humain*, Paris 1955.
TINBERGEN, N., [75] *The Study of Instinct*, Oxford 1951.
TROLL, W., [49] *Wesen und Aufgabe der Biosystematik in ontologischer Beleuchtung*, Philos. Jahrb. **61**, 1-27 (1951).
TURING, A. M., [63] *The Chemical Basis of Morphogenesis*, Phil. Trans., Ser. B, **237**, 37-72 (1952).
TYLER, A., [64] Growth **10** (Suppl. 6th Sympos.), 7-19 (1946).
UBISCH, L. von, [45] *Biologische Synthesen*, Acta biotheor. **9**, 115-134 (1950).
—— [59] *Das Zuordnungsproblem*, Münster 1951.
—— [60] *Entwicklungsprobleme*, 3 Tle., Jena 1953.
VIGNON, P., [17] *Science et métaphysique thomistes de la vie*, Paris 1946.
—— [20] *Au souffle de l'esprit créateur*, Paris 1946.
WADDINGTON, C. H., [58] *Organisers and Genes*, Cambridge 1947.
WEISS, P., [68] *The Problem of Specificity in Growth and Development*, Yale J. Biol. Med. **19**, 235-278 (1947).
—— [69] *Perspectives in the Field of Morphogenesis*, Quart. Rev. Biol. **25**, 177-198 (1950).
—— [70] *Some Introductory Remarks on the Cellular Basis of Differentiation*, J. Embryol. Exp. Morph. **1**, 181-211 (Oxford 1953).
WENZL, A., [18] *Materie und Leben als Probleme der Naturphilosophie*, Stuttgart 1949.

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References to the Bibliographies are included only in those cases in which the names do not appear in the text itself.

In the absence of a standardized transliteration, Russian names are given in the form in which they are quoted.