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Organon 1, 165-185

1964

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# THE HISTORY OF THE CLASSIFICATION OF SCIENCES

## GENERAL REMARKS. VARIOUS PRINCIPLES OF CLASSIFICATION

The classification of sciences pictures the mutual bond between sciences, that is the structure of the whole of science. Every classification of sciences is based on these or other principles whose premises show the bond between sciences. Such a bond is of the most various kind and is defined by: 1) the subject of the science and the objective relations existing between the subjects of various sciences; 2) the method and the conditions of recognition of the said science's subject; 3) the aims which are the cause of the science's development and for which science is destined.

From the point of view of gnosiology these principles are divided into objective, when the bond between sciences derives from the bond between the objects of research, and subjective, when the features of the human mind are taken as a base.

From the point of view of methodology these principles are divided according to how the bond between sciences is understood as an external one when sciences are considered in a definite order or as an internal, organic one, when they are consistently derived and developed from one another. In the first case we have the principle of coordination: its scheme is: A|B|C a.s.f. In the second case we have the principle of subordination and its scheme is: A...B...C... a.s.f. The letters here represent the particular sciences, the vertical lines shows the sharp division between sciences, and the dots — their mutual penetration.

From the logical point of view the principles are divided in accordance with what aspect of the general bond of sciences is taken into consideration when the characteristic of the original and of the final point of the general row of sciences is made. In this way we have two principles governing the location of sciences in order of: diminishing generalization — from the general to the particular, and rising concreteness — from the abstract to the concrete. In reciprocal opposition these

two principles formed the premises for the most popular in the XIXth century non-Marxist classifications of sciences worked out by Comte (1st principle) and by Spencer (2nd principle). Both of them were starting from the principle of coordination. For the principle of subordination on the contrary it is of importance to take into consideration the aspects of the general bond between sciences which is the foundation of the principle of development from a simple form to a complex one, from a low to a higher one, from an "undeveloped cell" to a "developed body". Consideration is turned here chiefly to the fact, which is entirely ignored by the coordination principle, namely to the common points and to the mutual penetration of the particular sciences.

It is also possible to separate other aspects of the general bond of sciences and to formulate other appropriate principles (for instance from an empirical description to a theoretical explanation or from theory to practice a.s.f.).

But the essential is not what aspects of the general bond of sciences are considered in this or that classification, but the manner in which they are treated: in opposing the separated aspect to all others, that is subordinate to the one which is the foundation of the whole given system, or in their mutual union, their mutual dependence being clearly explained: the derivative from the main ones, the inessential from the essential a.s.f. with no artificial dependence of all aspects of the universal bond of sciences from the one selected by the author, without their dissolution in this one. The first case is characteristic of the formal or artificial classifications, the second one — of the dialectic or natural classifications.

This last one does not separate the various aspects of the general mutual bond between sciences, but examines them as an expression of: 1) the progress of our knowledge from the general law to its particular symptoms, or from general law of all evolution to the particular laws of nature and of society, which corresponds to the principle from the general to the particular; 2) the transition of our knowledge from one aspect of the subject to the entirety of all its aspects, to which a corresponding principle is: from the abstract to the concrete; 3) the reflection in our mind of the evolution of the object from simple to complex, from a lower to a higher one, which is in accordance with the law of evolution. This last one includes also the progress of our knowledge, equally from the general to the particular as well as from the abstract to the concrete.

The dialectic-materialistic principles which are at the base of the Marxist classification of sciences presume the indissolubility of the principle of objectivity and of the principle of evolution (or subordination). The gnosiological, methodological (dialectic) and logical aspects of the general bonds between sciences are apparent here in their inter-

nal unity, as various moments of the whole consideration of this problem, which are not contradictory, but are mutually dependent. The assertion that the classification of sciences reflects the bond between the objects of these sciences expresses the fundamental premise of the materialistic theory of knowledge.

The assertion that the sciences go over into one another and are being developed, the higher from the lower ones, showing the transition and the evolution of the objects themselves, expresses the fundamental premise of the dialectic method with its principle of the historical development.

The logical foundations of the coordination principle are formed by the theses of formal logic, in particular by its requirements that the parts of the division exclude each other. This is possible provided the sciences are strictly separated from each other and have only external common points.

The logical foundations of the subordination principle are the premises of the Marxist dialectic logic, which in the first place takes into consideration the evolution of ideas and their transition from one into the other, where the ideas of the division between sciences are excluded, as well as violent division lines between them.

The coordination principle allows for the external combination of the various aspects of the general bond of sciences. The result is a classification table of sciences, different from the lineal row based on the consideration of only one aspect of that bond. Such is for instance the Cournot system, which is a combination of both these systems.

Some other forms of classification are also possible, especially such where not two but three or more aspects of the general bond of sciences are taken into consideration. All these systems are based on the principle of coordination.

A special case is when we observe the division (in two or three parts) combined with a ramification of the general row of classified objects. In these conditions the lineal row as well as a table based on it cannot be applied. The division (into A and non A) is taking place also in formal classification of sciences, when the parts of the division are placed in an external relation, for instance in the transition from more general notions to the more particular ones (the so called Tree of Porphyry). The division (ramification) of a row in the dialectic classification of sciences shows the ramification of an uniform entirety on contradictory aspects, forms or development trends as is the case in the division of living nature into plants and animals.

An essential role especially in natural sciences is played by two problems reciprocally connected: the classification of sciences when the bond between sciences is analysed in a logical cross-section from the point of view of the internal structure of knowledge, of the internal

relation of its component parts and the periodization of the history of science, when the bond between sciences is analysed in a historical cross-section, from the point of view of the historical origin of knowledge, of a successive formation, one after another, of its separate domains.

The bond between these two problems may be understood when we consider that the Marxist dialectic logic is a generalization of the history of the whole human thought, that it brings into light the laws of its development, while the classification of sciences presents only the effects or the results attained by sciences themselves in their mutual connection. To arrive at a valid result from the logical point of view of how are related among themselves the various aspects of knowledge and in what order they ought to be located, it should be analysed historically how they came into being and how they were developed one after the other and how they influenced each other. Such an approach we see in d'Alembert and even more distinctly in Saint-Simon and Comte in their division of the whole history of knowledge into three stages which are gradually attained by various sciences and which are forming an encyclopaedic row. However in Comte especially we have much artificiality. Such a conception reached a full development only in the works of Engels, freed by him of all artificiality and formulated in a true scientific form.

With Engels the classification of sciences is firmly based on periodization of the history of sciences and the logical analysis is done strictly in accordance with the whole character of the development of scientific knowledge.

The whole history of the problem under consideration may be divided into three basic stages, which correspond to: 1) the unramified ancient science, the Middle Ages partly included; 2) the differentiation of sciences in the XVth — XVIIIth centuries (an analytical ramifaction of sciences into different branches); 3) the beginning of their integration in the XIXth century (a synthetic revival of an uniform system of knowledge by means of uniting sciences that have been heretofore divided). At each of these historical stages the problems of the mutual bond between sciences were put and solved differently.

At the first stage we have philosophy embracing all realms of sciences, which had no time yet to acquire definite forms and to become independent and had to be developed under its patronage. At the second stage when sciences began to be differentiated from the previously uniform science and so one science after another began to be separated (first came mathematics, mechanics, astronomy, then physics and chemistry, further biology and geology, finally came anthropology, psychology and social sciences). The third stage is characterized by a trend towards a synthesis of sciences, to their integration. This

trend had a dialectic character, it was based on the effects of the preceding differentiation of knowledge, showing the necessity to bring the particular sciences to their internal unity. This trend was moreover stimulated by the lasting process of science differentiation, beginning with the formation of chemical atomic theory and especially through the discovery of the law of conservation and transformation of energy.

The newly discovered domains of science (the mechanical theory of heat, the kinetic theory of gases, astrophysics, physical chemistry and especially electrochemistry and chemical thermodynamics, biochemistry, biophysics and many others) have appeared at the joining points of sciences that were previously separated (mechanics and physics, physics and astronomy, chemistry and physics, biology and chemistry and physics, geology and chemistry a.s.f.). They have filled the apparently existing previously empty spaces between sciences and fostered a synthetic union among the particular disciplines in one uniform system, realizing directly their synthesis. In this way both contradictory trends of scientific development, the differentiation of sciences and their integration have proved to be penetrating each other and forming a dialectic unity.

This dialectic character of the development of science has been especially apparent in the relation between philosophy and other particular sciences. In the middle of the XIXth century the necessity of their close contact became quite obvious, showing the complete baselessness of the old philosophy of nature and popular in that time positivism. Not a dissolution of philosophy in particular sciences or *vice versa*, and not a separation was needed, but their organic alliance: philosophy should contribute to the particular sciences a general method of scientific knowledge, show the road to scientific research and a general theory of knowledge, and the particular sciences should contribute to philosophy the concrete material for the elaboration of the method and general theory of knowledge in order to have them further enriched.

Such synthesis of philosophy with particular (natural) sciences has been advanced by Herzen showing the road to a general synthesis of sciences. Such a synthesis was for the first time realized by Marx on the basis of a dialectic and historical materialism; it has been concretely realized by Engels in his classification of sciences.

Philosophy has kept now for itself the sphere of dialectics (sciences about the most general laws of nature, of society and of logic sciences dealing with the specific laws of thinking). The rest has been absorbed by the remaining sciences concerning nature (natural sciences) and society (history). Thus in the general system of knowledge the place for philosophy has been clearly defined. This system embraced philo-

sophy and the other sciences. It was in accord with the trend of knowledge: from the general (general laws of all development) to the particular (particular laws that were the subject of other separate sciences, natural and social).

## THE THREE STAGES OF DEVELOPMENT OF THE PROBLEM OF SCIENCE CLASSIFICATION

The three basic stages of scientific development: the universal philosophic science of antiquity; the differentiation of sciences in modern times (since the Renaissance period to the end of the XVIIIth century); their integration in the XIXth and XXth centuries, form the general background of the problem which is the subject of our study. This problem at each of the above stages has been solved in a different manner.

I. In the first of the above stages we have as a rule the division of the uniform science or philosophy into different branches, whose unity has been defined by the fact that all of them were parts of an uniform science.

The idea of science classification was born in the countries of the ancient East simultaneously with the birth of sciences. Ancient thinkers (Aristotle and others) have formed the embryos of all subsequent classification of sciences and their principles, among others the division of the whole knowledge (according to its subject) into three main domains: nature (physics), society (ethics) and thinking (logic), as in general in ancient philosophy the embryos of all later aspects of philosophy were born. In the Middle Ages thinkers of the near and middle East developed further the ideas of Antiquity, preserving them for future generations. On the contrary, theology and scholasticism that were dominating in the West took only the superficial form of Aristotle's ideas, destroying its living materialistic content. This is why when studying the various kinds of science classification it is insufficient to deal only with their scheme, with their external expression, but it is necessary to study their internal meaning which is to be found in the particular sciences and also in their general grouping. The general evolution of this problem may be examined in the form of a comparative analysis of the systems of ancient thinkers (Plato, Democritus, Epicurus and others) with those of the Middle Ages (Avicenna, Arabian thinkers, scholastics, Roger Bacon, David the Invincible and others).

II. The leading principle of the second stage is the coordination of sciences fully in conformity with the general analytical character of the whole science of that time. The problem of science classification arises because the uniform philosophy begins to desintegrate into a number of strictly separated sciences such as: mathematics, astronomy a.s.f. The task of bringing these sciences together, even if only into an external

union between them, so as to preserve their uniformity, has been attained by having them included in a general system. The analytical method that had been dominant at that time led to the general character of science classification, it could be realised only by means of superficial combination of sciences.

At the beginning (in connection with the development of the idea of humanism in the Renaissance period) science dealing with mankind and with its peculiarities replaced the old medieval scholasticism and in accord with this trend we have the origin of the principle of the classification of sciences, which in these conditions played a very progressive role. It took into account such distinctive marks of the human intellect as memory (with history as its correspondent), imagination (poetry) and intellect (philosophy). It was a big step forward in comparison with what was offered by theology and scholasticism with their division of "secular" knowledge into the seven "liberal arts".

The subjective principle advanced by Huarte has been developed by Francis Bacon who divided the whole knowledge into: 1) history, 2) poetry and 3) philosophy. An identical division has been made at the beginning of our era by a Chinese librarian Tsin Su. Hobbes who systematized Bacon's learning endeavoured to put together the subjective principle with the objective one. Being a mechanician Hobbes considered the mathematical method as universal and put geometry at the head of all deductive sciences with physics at the head of all inductive sciences. With Hobbes we see a nucleus of the principle of having all sciences classified from the abstract to the concrete, from the quantitative definition of a subject to a qualitative, which may be allegedly reduced to a quantitative one.

Descartes, whose general mechanical philosophy embraced in his conception of the world some elements of historicism, was developing the principle of classification based on the properties of the object of knowledge. Lémery advanced a metaphysical division of nature into three kingdoms (minerals, plants and animals) with a corresponding division of science. The classical division into logic, physics and ethics (Gassendi) or into physics, practice and logic (Locke) has been restored. Atomistic ideas suggested the possibility of degrees of complexity of matter (molecules in Gassendi, "groups" of primitive particles in Boyle). It was favourable to the development of an objective principle. In the XVIIIth century this principle has been developed further by Lomonossov and Kozielsky who came near to the Gassendi's idea.

On the contrary the French encyclopaedists (Diderot and d'Alembert) accepted the principles and scheme of Bacon, changing it in some details only. The comparative analysis of the systems of Bacon and Hobbes and of the French encyclopaedists permits us to bring to light the general evolution of the subjective principle in the direction of

a less consistent application and combining it with the objective principle (Hobbes) or a more consistent application (Diderot and d'Alembert). The division of the whole of knowledge into three basic parts (nature, society and thinking) is in the XVIIth century replaced by a more detailed division.

In England John Wilkins was building a classification of sciences taking as a starting point not the particular sciences but some elementary figures and notions. By combining them (coordination) he was forming complex matters and notions with aid of special means and demonstrated the relations existing between notions by establishing their common elements. In this way Wilkins instead of dividing phenomena, separated from each other, advanced the exposure of their mutual alliance. His method however in its content was strictly analytical, based on the coordination principle.

The transition to the third stage (the first three quarters of the XIXth century) includes two principally different trends:

1) The first trend is the preservation of principles which appeared and became dominant in the preceding stage. They were based on the general principle of coordination and were therefore contradictory to the main trend of the scientific development of the XIXth century. This problem has in principle two solutions:

a) The first formal solution is based on the coordination principle from the general to the particular (in the order of diminishing generality). In France it had conditions favourable to its development in the beginning and in the middle of the XIXth century. Saint-Simon was the first to advance quite distinctly the objective principle of classification in accord with the transition of phenomena from more simple and general to more complex and detailed. It corresponded to the succession in the research of phenomena in the history of sciences. The Saint-Simon system had some elements of dialectic that were the product of a man of genius (for instance the unity of the stability and of changeability in nature expressed in the notions of "hardness" and the "liquidity of bodies"). Comte took over and systematized the ideas of his master, but gave them an exagerated and banal character. He distinguished six fundamental (theoretical, abstract) sciences, forming an encyclopaedic row of the hierarchy of sciences: mathematics, astronomy, physics, chemistry, physiology, sociology (the mechanics of earthly bodies was put together with mathematics, and psychology — with physiology).

Comte was unaware of the historical notion of nature. According to him only the knowledge of nature by man had a historical character. The effect was the connection of two methodological problems of the classification of sciences and periodization of the history of sciences. The Comte law of the three stage development of knowledge (the theological, the metaphysical, and the positive) is artificial. It was

however necessary because of the superiority of knowledge over belief, of science over religion. This "law" reflects the general vulgar evolutionary conception of Comte, according to which the transition occurs only gradually: the second stage is an intermediary one between the first and the third, it effaces the basic contradiction between the initial and the final stages (theological and scientific).

At the base of Comte system we have the principle of coordination: sciences are located according to their diminishing: generality, simplicity and mutual independence of the phenomena under research. A comparative analysis of the Saint-Simon and Comte systems shows the lack of originality of the second when compared to the first. Only sociology, which was not considered by Saint-Simon as a separate science, got its independent place in Comte in his row of sciences.

The importance of Comte system consists in this: the really basic sciences have been set apart to which correspond (with mathematics excluded) either the basic forms of motion of matter in nature, or a social form of motion (it being a subject of sociology), and these sciences have been brought into a regular, though only an external union between themselves, and have been placed in such an order in which they have been developing one after another. That is why the Comte system was historically and logically a premise and a preparation for a classification of sciences based on the subordination principle, as analysis is a preparation and a premise to synthesis.

The Ampère system was much more artificial. It was based on four points of view from which each subject may be examined. The principle of coordination is here developed due to the fact that these points of view exist thanks to the combination in pairs of the following factors: either a description of phenomena or a search after their laws; an examination of a subject either from the side which is obviously visible or from the side which is hidden.

Systems that were more simple, more near to the really existing sciences, especially to natural sciences, have been worked out by Geoffroy Saint-Hilaire (*fils*) and by d'Halloy. By combining two different aspects of an analysis of unity of science Cournot worked out a table of sciences where the principle of coordination is even more sharply defined than in a lineal row: here the cut-off coordinated (horizontal) reflects the grouping of sciences according to the method of research or to the use of the subject, and the one in the row (the vertical coordinated) according to the character of the object itself.

The growth of importance of the coordination principle appears namely when the idea of development contradictory to this principle penetrates with special force into natural sciences and into social sciences (the middle of the XIXth century).

b) The second formal solution of this problem of science classification

with the principle of coordination as a base from abstract to concrete (with abstractiveness successively diminishing) became popular in the middle of the XIXth century and in the following decades in England. Here the predecessors of Spencer were: Coleridge, the author of the purely empirical system, Bentham who worked out a very artificial construction, Whewell with his system of induction and with his division of sciences into formal (astronomy), mechanical and mechanical-chemical (physics), analytical (chemistry), analytical-classifying (mineralogy), classifying (botany and zoology, which together with organic sciences were included in biology) and geology. Mill and Spencer criticizing Comte reserved a place for psychology in the row of sciences. Spencer rejected the notion of Comte that every science may be divided in two parts — an abstract and a concrete, asserting that all sciences may be divided into completely abstract (logic and mathematics) and completely concrete (astronomy, geology, biology, psychology and sociology), and intermediary abstract-concrete (mechanics, physics and chemistry).

These groups are sharply divided while within these groups we have a gradual transition from sciences to other sciences in spirit of vulgar evolutionism. By introducing the idea of evolution to concrete sciences Spencer rejected it in relation to the two remaining groups of sciences; he did not approve either a union of sciences classification (logical factor) with the history of world knowledge.

The external contradiction of the Comte and Spencer systems (with their common methodological base, i.e. the principle of coordination) was partly due to the fact that they understood differently the abstract and the concrete taking no consideration of their full meaning.

Bain made an endeavour to reconcile the Comte and Spencer systems. Adhering to the Comte principles he tried to enlarge his scheme by adding logic (at the beginning of the file) and psychology (replacing sociology). A comparative analysis of the systems of Mill, Bain and Spencer shows that they started from the same basis, with differences in details for instance in such questions as: should astronomy be separated or not, if so, should it be placed at the beginning of the row next to mathematics (Mill, Comte) or after chemistry and before zoology (Spencer). Should psychology be set apart or not (Comte) and if so should it be separated from sociology (Mill, Spencer) or should it replace sociology (Bain) a.s.f. Alike a comparative analysis of the systems of Comte and Bain demonstrates their common basis as to the main division of sciences into theoretical (abstract), descriptive and practical.

2) The other direction for transition to the third stage was the inauguration of an essential modification of these principles which came into existence during the second stage which means the beginning of the change of coordination principle by the principle of subordination, which was in accordance with the general character of science in the

XIXth century and in accordance with the idea of development and with the universal unity of natural phenomena. Here we have also two solutions:

a) The first solution has been worked out by Kant, Schelling and especially Hegel. The subordination principle was here based on an idealistic foundation as a principle of the evolution of spirit (but not of nature). Instead of the dual division which was popular in the formal classification of sciences Hegel suggested a threefold division which corresponded to the general trend of his philosophical system, divided into logic, philosophy of nature and philosophy of spirit, and the second part was divided into mechanism (mechanics and astronomy), chemism (physics and chemistry), and organism (biology).

With all its artificiality this system reflected the idea of nature's evolution from its lower grades to higher, till finally the thinking spirit has been created. The idealism of Hegel led to a vulgar distortion of his dialectic conception.

b) The second solution of subordination development with an approach to a theoretical synthesis of knowledge was reached in Russia on a materialistic basis by Herzen and Tchernyshevsky, while their predecessors (Viellansky, Pavlov, Maksymovitch and others) were not yet prepared to break away wholly from the idealistic philosophy of nature.

To arrive at the realization of a synthesis of sciences it was in the middle of the XIXth century absolutely necessary to remove the division imposed by positivists between philosophy and natural sciences (this was the way of Herzen) and to set aside the division between natural and humane sciences, especially social sciences and this was the way of Tchernyshevsky. For Herzen the necessity and the possibility of a union of philosophy and natural sciences was derived through the indivisibility of the empirical and theoretical factors of knowledge: historicism in the understanding of nature was for him united organically with historicism in the understanding of the development of the knowledge of nature, which gave a deep methodological foundation for the realization of a synthesis of sciences. The same is the case of Tchernyshevsky who, as before him Bielinsky and later Antonovitch criticized the restricted notions of Comte, while Pisarev to the contrary supported the erronous historical conception of Comte and Mikhaylovsky, a sociologist and populist was stubborn in his support in Russia of the positivism of Comte.

III. The third stage was fully reflected in the works of the authors of Marxist philosophy. Marx and Engels based their synthesis of sciences on the dialectic-materialistic method that has been formulated by them, taking as basis a critical analysis of the whole valuable work of their predecessors (Hegel, Saint-Simon and French materialists) and

especially the attempts to realize an encyclopaedic generalisation of contemporary science. The works of Russian progressive thinkers were mostly unknown to Marx and Engels.

Marx and Engels overcame the restriction of the two extreme conceptions (Hegel's idealism and Saint-Simon's metaphysicism) preserving and critically elaborating everything that had been there of value (Hegel's dialectics, the materialism of French thinkers). The results were entirely new dialectic-materialistic principles of classification which combined organically two fundamental factors: the objective approach and the principle of subordination (that is the principle of evolution).

Marx discovered the fundamental principles of materialistic dialectics as the most universal laws of nature, of society and of thinking evolution. Thus the foundations of a general theoretical synthesis of sciences have been laid. It included before all the three main domains of knowledge: those dealing with nature, with society and with thinking, and the solution of two problems (they were the subject of the work of Russian materialists of the XIXth century) dealing with the relation of philosophy to natural sciences, and of natural sciences to social sciences. Marx reached a solution taking as basis the unity of the world, that is the mutual union of natural and social phenomena. The place for applied sciences has been defined in the general system of knowledge; they are a link uniting natural and social sciences, being located on the contact point between them. An important role was played here by historical materialism which was the source of a general method for all social sciences.

The creation of Marxist classification of sciences by Engels was preceded by his thorough studies on the discoveries of natural sciences in the middle of the XIXth century which fostered the discovery of an internal bond between the phenomena of nature that is between sciences dealing with lifeless nature (sciences dealing with energy, atomic theory) and with living nature (Darwinism, the theory of cell). But no key has been found to solve the problems concerning all domains of nature in general, i.e. a key demonstrating the unity of nature living and lifeless. Among others it was due to the fact that the real transition from lifeless to living nature has not yet been discovered.

The discovery of Engels which took place on May 30th, 1873, consisted in the fact that in one notion "the form of motion", one for all domains of nature, he embraced all kinds of energy appearing in lifeless nature as well as in life (the biological form of motion). Hence all sciences are forming one single row: mechanics... chemistry... biology... just as the forms of motion follow one after the other, pass one into the other and develop — the higher forms from the lower ones, the complex from the

simple. In this manner the notion of the forms of motion in Engels' comprehension is broader than the notion of energy or of life.

The original classification of sciences based on different forms of motion of matter has been enlarged by Engels in several directions: in the first place he has proved that the succession of the forms of motion corresponds in the evolution of nature itself as well as in history of science to the succession of birth and of transition to higher stages of the development. The coincidence of the historical and logical factors in the knowledge of nature and equally in the very evolution of nature leads to the solution of two methodological problems: to the classification of sciences and to the periodization of the history of sciences.

A further development of classification was directed by Engels to the consideration of the material bearers (substrata) of the various forms of motion. In a general way motion is a form of the existence of the matter, therefore each separate form of motion should have a separate, corresponding to this form, specific material bearer whose manner of existence (and of it only) is a given form of motion. More and more complex form of motion should therefore have a corresponding row of non continuous material creations, that is the process of matter becoming more complicated from simple, lower kinds to more complex, higher. Thus sciences dealing with energy (in the sphere of inorganic nature) and of life came in contact with science dealing with the structure of matter (atomic theory). Historically atomism took its origin in the idea of the divisibility of matter and of its differentiation into diverse non-continuous forms of various dimensions.

In defining the bearers of the particular forms of motion (mass for mechanical motion, particles for physical motion, atoms for chemical and proteins for biological) Engels obtained, as it seemed, the total convergence between the row of the forms of motion of matter becoming more and more complicated with the general row of their bearers which were coming into being one from another when the division of the original matter took place.

And yet the hypothesis of the existence of "ether particles" as those presupposed bearers of lighting and electrical phenomena was in disaccord with the whole system as it was presumed that these "particles" being physical bodies should have their origin in the division of atoms into smaller parts. It was therefore understood that if physics dealing with these particles was following chemistry in the general row of sciences, then physics of "ether" should precede chemistry, and chemistry would be "encircled" by physics. This premise has been confirmed in the XXth century due to the new subatoms (nuclear and quantum) physics.

A big complication in the new scheme of classification of sciences was brought by the recognition of the division into two parts of the line

of development of nature primarily into lifeless and living nature. It became apparent as soon as Engels put the question of the existence of a constant transition between developed objects of one or other domain of nature, for instance between meteorite and man.

The rapid development of natural sciences in the eighties of the XIXth century and the discordance that came to light on many points between the accepted classification of sciences and the real relations in nature, and especially between all forms of motion and their materialistic bearers, the smallest of which were not yet discovered, brought Engels to the conclusion that his work was getting old.

Accepting subordination as the basic principle (the development from lower to higher, from simple to complex) Engels has not confined himself to this one principle, but added to it other figures of the same subordination principle (evolution); so philosophy represented by materialistic dialectics was put by him in the first place of the general row of sciences, because it analyses the most general principles of all development, while other sciences deal only with such or other detailed principles of nature, society or thinking. The principle of subordination: from general to particular was here applied. Engels put also mathematics before mechanics, as it deals not with any concrete form of matter motion, but is an abstract, separated quantitative form of natural phenomena. Thus here the principle of subordination: from abstract to concrete has been applied.

The ideas of Marxist classification of sciences have been taken by Engels as a foundation for his work *Dialectics of Nature,* which however he did not complete. In it he foretold brilliantly the mutual union of sciences — anticipation which was later confirmed by further development of science.

## THE MOST RECENT DEVELOPMENT OF THE CLASSIFICATION OF SCIENCES

Turning to an analysis of the modern development of this problem we may distinguish two principal trends of this process:

1) The non-Marxist systems at the end of the XIXth and in the XXth century.

While the Marxist classification of sciences became an expression of the third stage of the progressive development of the whole problem the non-Marxist thought went a step back even in relation to the level which it had reached in the middle of the XIXth century. It was not even able to advance any new generalizing idea or a new principle which would bring it to the synthesis of sciences at the end of the XIXth and during the XXth century. Here we see the general downfall of the non-Marxist theoretical thought in the new historical epoch.

At the end of the XIXth century we can clearly see the idealistic trend in the work on the classification of sciences which was directly bound with the crisis in natural sciences that was just beginning and with the deepening of the ideological struggle caused by the transition of capitalism to imperialism. At the base of the classification of sciences we still see as a rule the general principle of coordination and it is strengthened even more by the fact that it is applied to combine the more detailed principles among themselves in order to complicate still more the whole system of sciences. Such an example we have in the system of F. H. Giddings, an American sociologist. This system is characterized by formalism and by a peculiar "constructivism". From the gnosiological point of view we have a distinct turn in the direction of a subjective idealism, especially in Machists. Pearson in his *Grammar of Science* endeavours to deal with the general scheme of the non--continuity of matter which in reality was a real starting point in building the classification of sciences on an objective foundation.

The Machist, positivistic system of sciences takes it origin chiefly from the Comte system. It is subject however to some criticism: from "the right" by the adherents of the religious world outlook; Carpenter tells that the Comte system is in principle a "vicious circle". The same we see in France where the evolution from the Comte system to the Machist scheme of H. Poincaré, Naville and others took place. Naville rejected the objective principle corresponding to the Comte system and advances a subjective principle which is an expression of man's spiritual activity. According to Naville the subject of a science is not the phenomena of the real world, but "problems" which arise while research dealing with these phenomena is being done. Hence we have a classification based on answers to questions "what is real" (historical sciences based on facts) and "what is good" (the rules of conduct).

In Germany systems of sciences having an eclectic and mostly a positivistic character were advanced by Dühring, Erdmann, Wundt and others; in Bohemia — by Masaryk. The division of sciences into formal and real was here advocated. Wundt included in the first — mathematics, and in the second — natural sciences and sciences dealing with spirit. Eclecticism has been manifested in the attempts to unite the principles of Comte with those of Spencer. The work on this problem has been done from the posifion of neokantism. Windelband and Rickert (the Freiburg school) adhered to the idealistic basis of metaphysical discord between sciences dealing with nature (whose phenomena were subject to some rules) and dealing with society (the history of events was considered to be a chaos of incidents). Rickert rejected the Wundt ideas that psychology may become such a basis for the second group of sciences, as mechanics is for natural sciences. H. Cohen, E. Cassirer, P. Natorp (the Marburg school) gave to the

classification of sciences an *à priori* direction: they considered the problem to introduce unity to diversity with the aid of a notion constructed mathematically: hence mathematics became the main science.

Machists and energeticists have built their classification of sciences on the negation of a specifism of social phenomena, considering them only as complex biophysical phenomena (Avenarius, Mach) or as energetic, biophysical phenomena (Ostwald). By dividing all sciences according to the principles of energeticism into three classes: mathematics (fundamental sciences), energetics (physical sciences), biology, Ostwald has built his "pyramid of sciences". At its base is the principle of coordination and Ostwald (like Tchyzov) considered transitional sciences (physical chemistry) as an application of this principle, seeing here a simple combination of two kinds of energy.

A formal approach to this problem has found its expression in putting to the front one aspect of the general union of sciences (corresponding to the world phenomena) and in considering it as main and deciding. Such is the geographic direction which is considering as the chief bond the spatial bond of matter and of phenomena (E. Tchyzov, L. Mietchnikov and L. Berg in Russia and A. Hettner and F. Ratzel in Germany).

Characteristic traits of all these directions are: an evident epigonism, the backward step to the stage of the problem development which was attained in the XIXth century: the inability to include all domains of science from one single point of view and especially the total inability of a theoretical thought of idealists when they attempted to reflect the novelties offered us by science.

If the coordination principle has been outlived already in the middle of the XIXth century thanks to the great discoveries of natural sciences, not to mention social sciences, it became an obvious anachronism at the turn of the XIXth and XXth centuries. And yet the adherents of this principle made further useless efforts to press it into the new sciences, which required to accept the evolution principle and could not be reconciled with the coordination principle.

And even in this case the idea of evolution and of transition of various domains of science, of one into another, found its way into the domain of classification of sciences and many authors endeavoured to reconcile it with the old idea of a sharp division between sciences.

The idea of coordination and the principles of coordination were especially popular in Russia (M. Troitsky, G. Grot and others). With Grot the idea of evolution is reflected in the division of sciences into: non organic, organic and superorganic. He gives a characteristic of his scheme as a fusion of the positivistic Comte method and the evolutionary point of view of Spencer. Much more progressive and containing some new ideas was the scheme of I. Potchesky. He tried to present the principle of development (evolution) of nature and the disunion (rami-

fication) of the development line, which was inherent. In accord with his idea he built a "cone of sciences" where not only the objective foundation of the system of sciences, but also the factor of knowledge was considered.

In connection with "neopositivism" (the Vienna circle) becoming popular in the West a classification of sciences has been worked out on a logic-positivistic foundation. A typical case is here the geometric principle of coordination by P. Oppenheim (Germany), the effect being that the real union and the transition between modern sciences has not been taken into consideration. The author started from several antitheses, like: nature — spirit. Accepting the contradictions: typical-individual and concrete-abstract the author has built on this foundation a "square of sciences" which was supposed to contain not only all sciences, but also all their methodological cross-sections.

A Syrian scientist J. Mouhasseb attempted to construct a system of sciences on the foundation of a symbolic scheme: passing from a simple object (for instance a mathematical object) to a more complex one (for instance a mechanical object) we add, according to the author, a certain magnitude (quantity) to the starting point, what permits us to symbolize the whole process of complications of objects (according to learning about them) independently of their nature.

In France and in Switzerland neopositivism in the above domain is represented among others by Meyerson. Piaget starting from the psychological trend and coming near to materialism tried to develop genetic epistemology in contradiction to the usual static point of view on human knowledge. He reaches as a result the cyclical scheme, which takes into consideration the transition from subject to object and *vice versa*. Piaget indicates that classification of sciences has the tendency to a natural conclusion, which in his opinion is realized in psychosociology (in the study of the subject itself) in individual and social aspects. His system is assuming therefore the character of a "circle of sciences".

Ph. Frank considers the problem of classification when analysing the mutual relations between philosophy and the particular sciences. A binding link between them is "the philosophy of science". The whole knowledge (including science, philosophy and common sense) is represented by Frank in the form of a circle whose tearing leads to the formation of two "ends", one scientific and the other philosophic. The starting premises and the solution itself of the problem of the unity of sciences is given by the author in a purely positivistic cross-section. Bergmann (U.S.) considers the same problems from the position of logical positivism; he is not concerned with broad generalisations and thinks such a problem is entirely superfluous, but turns his whole attention to detailed phenomena. He dissolves the general factor (philosophy) in particular sciences. A similar position is taken by A. J. Ayer.

The most reactionary trends in the above domain were represented by philosophic currents directly bound up with religious ideology: holism (Smuts, A. Meyer-Abich), neospiritualism (A. Reymond), neothomism (J. Maritain).

Holists attempted to put in the centre of the system spirit life according to their principal idealistic conception. They denied each possibility of a reduction (or a union) of this factor from higher to lower and accepted an opposite motion, from lower to higher. Their whole system of sciences was therefore built not on a system from simple to complex, from lower to higher, but just the opposite. Such principle even before the birth of holism has been criticized by Timiriaziev as being anti-scientific and antihistoric.

A. Reymond, a Swiss spiritualist has been critical "from the right" to the early subjective-idealistic systems of sciences and as foundation he took the formulation of judgements and tried to introduce here "the principle of functional immutability", which apparently replaced the content of a form of thinking (notions, judgements) reflecting the real bonds of the subjects of the external world. By means of this principle Reymond endeavoured to break the sharp division between sciences that was introduced by Comte and tried to express the relativity, the mobility of the boundaries between sciences, as one of the most important marks of modern science. He attained only a pure relativism and formalism.

J. Maritain, the author of neothomism started from the premise that there are three grades of abstraction: 1) "physics" (in a broad meaning of this word, that is natural sciences) has to do with the subject which cannot exist without matter and cannot be understood without it; 2) mathematics has to do with subjects which cannot exist without matter, but which can be understood without it; 3) supernatural knowledge (metaphysics) has to do with subjects which may be understood and may exist without matter; we have here the notions "God" and "pure spirits" and other general abstract notions. On the basis of this differentiation Maritain builds his system of sciences.

After the second world war the influence of neothomism became considerable especially on science and its systematization. In connection with this influence we have an intensification of the current of objective idealism (together with its "metaphysics" and with "ontology") at the cost of neopositivism and subjective idealism in general. Hartmann for instance deals from this position with the reciprocal relations and bonds between sciences. Schneider, a West German philosopher, in his work *Philosophy and the Particular Sciences* (1955) has shown that, taken the philosophic subjectivism and agnosticism as basis, the bond between philosophy and particular sciences is impossible.

Neothomism and the Roman-Catholic church made efforts to utilize

for their purposes the problem of the systematization of sciences. Pope Pius XII wrote about the three tools of truth (science, philosophy and revelation), of which revelation in his view is the highest and the two others should be subordinated to it. The same has been written by neothomists (Gilson and his pupil de Wulf for instance have built a three stage pyramid: at the bottom particular sciences, general or philosophical in the middle, theology at the top).

At the XI International Philosophic Congress (Brussels 1955) there were attempts to substantiate the theory of sciences together with the classification of sciences from the position of objective idealism (Ysaye) and neothomism (Aebi, Brinkmann). Trying from the religious point of view (or approaching the religious) to explain the general problem of scientific methodology and the mutual relations between their various aspects, as well as the problem of the particular groups of sciences (for instance mathematical, technological and others) Aebi built a scheme of the general system of sciences which terminated in "full life", "sanctity", which in his view is the final goal of man's existence, as if crowning the "natural" system of sciences.

From the theological position a classification of sciences has been given by van Laer, a Dutch philosopher and expert in natural sciences. The author is dividing sciences according to their "material" and formal objects. The first one includes "God" as a separate subject. In this way the principle, apparently "objective" is exposed in reality as purely artificial, subordinated to a religious ideology.

A special place is taken by the mathematical-logical studies in the domain of the structure of sciences, the structure of scientific knowledge (for instance Bertalanffy) which are closely connected with the classification of sciences and are used for its logical foundation from the position of this or other philosophy. Its purpose is to find out an issue from the chaos of the various trends which are not included in one point of view, often entirely empirical, descriptive, which exist in the contemporary science of the West.

The theoretical thought however that is dominating in the capitalistic countries is entirely unable to lead science out of this chaos, which is devoid of order and unity.

2) The Marxist classification of sciences subsequent to Engels.

Although Lenin did not study this problem, he developed it and enriched the fundamental premises of materialistic dialectics which later became the basis of the modern Marxist classification of sciences. In his work *Materialism and Empiriocriticism* Lenin has shown the way in which the objective principle of science should be elaborated, and how the effects of the latest revolution in natural sciences, especially in the domain of the knowledge of the structure of matter, should be

generalized. In his *Philosophic Notes* [1] and his work *Once More About the Trade Unions* Lenin worked out the principles of Marxist dialectical logic which can be directly applied to the problem of the classification of sciences. With full force Lenin advanced the demand for an objective approach, rejecting every kind of subjectivism. Of great importance are his suggestions as to the necessity of preserving the unity between the historical and logical factors, of taking into consideration the disunion of the unity into contradictory parts, of considering the transition and the bond of phenomena and the cooperation of theory with practice.

In the first years of the Soviet rule in Russia the idea of Marxist classification of sciences did not yet come to the surface. Some systems whose authors were adhering in some way to the schemes and principles of the usual formal classification (B. Gustchin, W. Ivanovsky and others) became popular. The works of Timiriaziev were an exception. They were based on a broad historical-revolutionary principle and approached the Marxist classification of sciences. In 1925 Engels' *Dialectics of Nature* was published, containing his classification of sciences.

A big stimulus for a further elaboration of this problem were Lenin's *Philosophic Notes* [2] published in 1930. And yet the first attempts to base the classification of sciences on the ideas of Marx, Engels and Lenin had an unfortunate end, as the authors based their works practically on the position of mechanism. A characteristic example we have with E. Somov. Quite adversely and from a position near to Hegelianism these problems have been put and solved by W. Roshitchin.

Studies of the order of the particular sciences in the general system of sciences and the definition of their subjects preceded the solution of the whole problem. So for instance N. Siemionov studied the boundaries between physics and chemistry from the viewpoint of the definition of sciences by Engels. The classification of natural sciences has been elaborated by C. Shmidt, who started from Lenin's assertion dealing with the movement of knowledge from living observation to abstractive thought and from it to practice. Shmidt has studied especially the boundaries between natural sciences and technology demonstrating that these boundaries dividing them are gradually being effaced. The general idea of Marxist classification was formulated by E. Barkash and S. Turetsky.

In many works we have a dogmatic approach to the idea of Engels trying to uphold his scheme although in science many changes have occurred. In other works however (E. Kolman, M. Rutkievich, W. Bukanovsky and others) the necessity was stressed to make some changes in the concrete scheme of Engels, especially in the art dealing with

[1] *Философские тетради.*
[2] *Философские тетради.*

subatomic physics, observing however the general dialectical-materialist principles of Engels.

Some of the authors (Strumilin and others) have worked out the idea of a cyclic character of the general system of sciences. A trial of classification of sciences from the materialist-dialectical position has been undertaken also by a Yugoslav scholar N. Milonkovič.

The author of the present report is studying ever since 1945 the problems here discussed in their historic and logical crosssections. His chief attention is devoted to the Marxist elaboration of the classification of sciences. This is a question however which transgresses the frame of the present report.