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Historical Stages in the Formation of the Scientific Knowledge System in a Theoretical and Methodological Context

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Abstract--Current tendencies question the role of science in modern society, force returning to the processes of formation of the scientific paradigm. The latter was complex and nonlinear, and the formation of scientific principles of cognition was their natural result. Throughout human history, the knowledge about the objective world has been acquired and used in various, historically necessary forms – both in the methodology of cognition and in the method of systematization, which was determined by the level of their accumulation. The accumulation of knowledge took place in different ways: in the process of direct practical activity, on the basis of supposedly “foreign” contemplation and as a result of conscious influence on an object of study (experiment) with their different “specific weight” at different historical stages. As for the systematization, the need for which was determined by systemic nature of an object of knowledge and the social nature of knowledge, throughout the history of mankind its forms differed considerably, but, in the end, were reduced to three main ones. The article presents the results of a comprehensive study of the historical development of the scientific paradigm as a natural dialectical change of its specific stages with appropriate systematization of knowledge caused by the growth of knowledge and development of research methods (cognition in practice, “external” contemplation, experiment followed by theoretical model).

Keywords---cognition, cultural clichés, history of science, mythology, paradigmatic significance, philosophy, socio-cultural, systematics.

Introduction

Today, at the beginning of the 21st century, global changes in the development of human civilisation, associated with the rapid growth of productive forces and, consequently, the amount of knowledge, are accompanied, in particular, by a revision of fundamental ideas about the role and place of science. The general tendency is a kind of shift of science from the central positions of worldview and the actual refusal to recognise succession in the development of knowledge. Assumptions are made about the beginning of the stage of “end” of the undivided dominance of the basic mental, ideological and cultural clichés of “classical science”, i.e. what could be called a scientific paradigm. These hypotheses are consistent with the conclusions of critics of the scientific worldview – such as [Guenon \(2008\)](#); [Heidegger \(2003\)](#); [Krushanov & Mamchur \(2011\)](#); [Spengler \(1993\)](#); [Eliade \(1994\)](#); [Jung \(1991\)](#). The latter argue that science as a normative body loses its fundamental importance in solving social, cultural, ideological and historical issues, and therefore there is the necessity for a new interpretation of the essence, functions, boundaries and logic of the evolution of science-based on those paradigmatic shifts in historical consciousness, which continue throughout the development of civilisation.

Conceptually, it is widespread to associate obtaining, systematising and using knowledge about the surrounding reality with science. However, not every knowledge is a science – a special branch of human activity, specifically aimed at finding, systematising and applying information about reality. Such reality can consist of physical, biological, technical objects, mental and social processes, in particular in thought processes. It is worth noting that science is a historically recent phenomenon in human life. At the same time, it could not have arisen without a certain system of information about nature and society, and therefore human began to use and subdue the substances and forces of nature long before the emergence of science, using other, “pre-scientific” forms of knowledge. Science itself was the result of social development, the formation of the scientific paradigm of world domination was a complex and long historical process, which today, due to the emergence of new ideas about the role of science in society, is of great interest ([Byesov, 2005](#); [Vereshchahina-Biliavska et al., 2021](#)).

The problem of formation and development of scientific knowledge is often presented in the form of quantitative growth of information about nature, technical devices and society, without taking into account the specifics of scientific knowledge, different from any other. At the same time, there were other views, according to which not only social development but also intellectual evolution was characterised by stages, which was largely decisive for social change. [Komte \(1899\)](#), the first thinker in the history of philosophy – the founder of positivism, who had a basic technical education, took a fundamentally new approach to understanding and interpreting a number of scientific problems. He identified three forms of human thinking. In the first – theological, people explain all phenomena by the action of supernatural forces. In the second – metaphysical,

phenomena are interpreted as the result of certain “causes” that destroy religious ideas, preparing the formation of the third form – positive, which motivates everything scientifically. These considerations, in accordance with the specific realities of today, are the result of conjecture but not scientific analysis.

The reasons for the nature of knowledge, its historical evolution, obviously, should be sought in the way of obtaining and organising knowledge in society. Knowledge of nature, technical devices and social phenomena exist as much as humans. At the same time, the social nature of knowledge, which is more definite, the higher their quantitative growth for society as a whole, and differentiation in relation to the individual, requires more clear and effective organisation into a certain system. The aim of the article is to determine the stages of formation of scientific knowledge, highlighting the general nature of the processes of their acquisition and systematisation that eventually led to the formation of a modern scientific paradigm, which is the information basis of human life. The study is based on an analysis of the literature on the historical development of scientific thought and critical use of the achievements of the history of science. Its methodology is based on the synthesis of principles and methods of cognition – general scientific, special-historical and interdisciplinary. The methodological basis of the work was the principles of objectivity, systematics and dialectical understanding of the historical process. The authors used historical-genetic and comparative approaches in the work. Among the general scientific methods, it is also worth noting the method of logical-theoretical analysis and the evolutionary method (Dwijayanti et al., 2017; Srivastava & Mishra, 2016).

Formation of the system of social knowledge

The systemic nature of social knowledge at each stage of development is determined by two factors. First, it must be borne in mind that knowledge of the environment is a more or less complete and accurate ideal reflection of the latter, which is in fact not a simple set of individual objects and phenomena but an internally connected system. Therefore, its adequate reflection should also be with systemic nature. Secondly, it is important to keep in mind that knowledge through its social existence presupposes the “fragmentation” of the available volume “in the minds” of individuals. Therefore, the integrity of knowledge can be ensured only by its systemic nature. This applies to all forms of knowledge, and to the greatest extent – scientific knowledge, the paradigmatic formation of which is of particular interest (Piattelli, 1989; Brennan et al., 2008).

In this context, a common understanding of the first historical stage of the formation of systems of social knowledge is extremely important. It is during this period that both the appearance of its pre-scientific equivalents and the formation of scientific ideas can be traced. In the historical literature, the first stage of formation and development of scientific knowledge is associated with “traditional communities”, or the period of development of socio-economic, political structures, cultural and spiritual systems of the “Ancient World”, whose detailed characteristics are widely presented in modern scientific literature (Astratova & Rushchitskaya, 2016; Guenon, 2008; Gaidenko, 2009; Granin, 2017; Prasolov et al., 2018). The traditional communities of the “Ancient World” are considered to be civilisations, the main feature of which is the recognition of the central place in

the basis of all socio-cultural and political institutions in mythological and religious systems. A significant component of traditional society was “mythology”, which defined the system of views. In it, individual things, beings, events, natural and social phenomena were connected by a plurality of plots, which were elements of a general myth, or the development of its individual aspects as a whole, and provided a certain system of unified ideas about the world (Spier, R. 2002; Pollock, 1988).

The limited knowledge and duration of the existence of “traditional communities” in virtually unchanged form led to the belief that the “true” idea cannot be “new”, and in general the truth was not considered a product of human reason. It seemed to exist independently of an individual, so the only thing that needed to be done was to try to master it. Thus, the true idea belonged to all who were able to comprehend it. Accordingly, the mythological principle emerged and existed as a powerful tradition, binding on all members of primitive society without exception (Baturin, 2018; Suleymanli, 2021). Consistent study of the preserved complex of material artefacts, written sources allows concluding that in traditional communities, technical and practical activities that required certain rational skills (reminiscent of certain elements of the modern scientific approach), also had irrational, including magical, components. Each civilisation of the Ancient World had its own varieties of the foundations of the traditional sciences that emerged. This was explained both by a set of natural-geographical, economic features, and the specifics of thinking, a set of specific factors in the life of individual peoples, the realities of a certain period in their history. Some knowledge gained in the field of mathematics, astronomy, medicine was transmitted within the higher castes on the principle of exclusive affiliation (from senior to junior in age and rank) (McGrane & Maul, 2020; Wahl, 2018).

For a long time the knowledge formed in this way was stored almost in a “frozen” form. The training was based on the principle of transmitting ready-made deterministic algorithms based on the predetermination of cause and effect. The closed nature of knowledge transfer within professional and social groups led to a model where the place of the individual was occupied by a collective generalised custodian (Ancient Egypt). In general, the knowledge of ancient civilisations was applied; differences between exact and approximate solutions of problems were not considered fundamental – any solution was acceptable if it led to the desired result (Rätsep et al., 2016; Fairweather, 1976). The first elements of scientific knowledge were achievements in the field of mathematics. The earliest known mathematical texts left two great civilisations of antiquity – Egypt and Mesopotamia, where the first mathematical problems were solved, the solution of which required everyday life. Arithmetic appeared, geometry developed significantly. Mathematics as a scientific discipline originated in ancient Greece, where the methodology of mathematics was created, which was based on the deductive method (Prasolov et al., 2018).

Elements of scientific data that were formed were included in the general mythological system – astrology, numerology. The objective realities of the development of society show that knowledge about the environment has never existed and cannot exist as a conglomeration of disparate information, it must be integral. Systematisation of knowledge in general is a condition for their

accumulation and social functioning, regardless of how it is carried out. In general, system can be understood as the organisation of knowledge put in order based on certain theoretical features, and more generally – a certain worldview paradigm (Sajganova, 2005; Bronnikova, 2016; Baturin, 2018). Replenishment of knowledge about the world around always involves two stages: obtaining data directly from the surrounding reality and bringing them into a certain system. During the accumulation of knowledge, the way to achieve both was historically determined. In different periods, obtaining data directly from the environment occurred with the predominance of one of three factors. First, information in the process of life or practice was obtained through direct operation of objects. Second, “remote” observation of data and other processes (contemplation) was carried out. Third, there was a continued targeted impact on studied objects to obtain information about them – an experiment (Sarkar, 2014; de & Gatesy, 2007).

Systematisation of knowledge

Based on the information thus obtained, knowledge was systematised and organised into a holistic system, where the quantitative characteristics of knowledge played an extremely important role. Initially, systematisation was carried out by “imposing” on the natural environment in its ideal reflection as the organisational principle of those systemic connections that were known to humanity in the immediate area of its existence, and later – in the form of social connections. In its developed form, this kind of system, based on the image as a source element, was called mythology. The next step was the philosophy that on the basis of seemingly a priori elements – categories – perfectly constructed the world in the form of a more or less integral system of certain fragments, and those a kind of construction “superimposed” on reality as a certain picture. However, only in the third, scientific, stage – the reflection of the world with the achievement of a sufficiently high level of knowledge – in fact, this world in all its diversity became the basis for generalisations in systematically related concepts. Therefore, the formation of the scientific paradigm has come a long way in historical development, beginning with mythology.

Mythology, as a way of obtaining and organising information about the world, could not in principle – due to the small amount of rational data – be completely based on them. Given the small amount of knowledge, to obtain a holistic picture of the world in general or one or another of its “subsystems” in particular, people were forced, along with rational information, to use “mythological” data, which generally formed a bizarre picture. This is the “theoretical concept” guided by a human in practice. The created picture of the world was the closer to reality, the more everyday things concerned, but it was invariably reflected in all human activities. With regard to the problems of development and functioning of technology, the mythological “model of the world” inevitably foresaw an irrational – from the present point of view – component of almost any technology. Seeking to achieve a goal, a person did actions, not only determined by his direct life experience but also those that stemmed from more general ideas about the surrounding objects and their interaction, determined by the experience of society – both real and imaginary. This means that human actions, in particular, were

not – again according to modern ideas – rational, naturally necessary to achieve this goal but also included irrational components.

Human acted so not because he hoped to enlist the help of “higher powers”, but because, in his view, the world was just that. Certain actions were included in a set of practically useful technological techniques that led to a given goal, despite the lack of a sufficiently deep understanding of the processes that took place. Human has steadily expanded his rational knowledge of the world, replacing insufficient links with magical ideas, which sometimes reflected the true but unknown picture of the world, gradually increasing the amount of objective information. At a certain stage of human development, the idea of a higher being, which stood above the real world, is introduced into the spiritual-religious paradigm. It also created faith in a certain unity of the world. In the future, it becomes a methodological basis in the process of forming a new way of obtaining and organising knowledge about the world – philosophy, the principles of which were originally developed within the religious form of consciousness (Baturin, 2010). Over time, the general idea of the unity of the world allowed philosophy to abandon the emphasis on the “action of divine forces” and develop new methods of cognition. There is a more detailed understanding of the specific information revealed in the various phenomena belonging to different systems of images. The isolation of a number of such features allowed assuming the presence of certain communities of structures and elements, as well as a certain isomorphism of the laws to which they are subject, respectively, organising a systematic generalisation of existing data.

Stages of development of the cognition process

In ancient times, the gradual development of civilisation captured the emergence of a number of ideas, which within the mythological paradigm involved the use of certain elements of the scientific approach. This was most convincingly manifested in mathematics (Euclid's “Principles”) and, in some cases, in the natural sciences. In the field of mechanics, Archimedes established a number of laws of statics and hydrostatics, which became the basis for further improvement of the knowledge system and later became part of the scientific picture of the world (Czejten, 2014). In the period under discussion, the most promising system of knowledge formation is philosophy, which presented the world in the form of a certain combination of a limited number of source elements. The perfect reflection of these elements, the principles of their combination were philosophical categories. Aristotle (1983) believed that in philosophy categories play the role of universal definitions through which the mind knows things. Categories, as basic structural elements, do not have clearly defined definitions, ideas about them are formed on the basis of experience intuitively and develop in the process of application to specific phenomena. It is the system of categories that formed the basis of the general structure of knowledge (Rozin, 2006).

Due to the use of the basic method of philosophy, which consisted of superimposing on the real but unknown laws of nature of others, formulated speculatively but in such a way that the results obtained quite satisfactorily coincided with real events – the phenomenological approach. However, in the process of expanding the amount of knowledge, the real state of affairs deviated

from the theory, and this required a complication of the system. A classic example is the geocentric system of Ptolemy's world. In its simplest form, it made it possible to describe the visible motion of the Sun, Moon, and stars fairly accurately, but it made inadmissible failures when it came to the planets. That is why within the originally simple system were invented very complex laws of planetary motion (which included the so-called epicycles and deferents). Gradually, under the influence of the expansion of general knowledge about the world, the structure of philosophy changed. Later, these changes became the subject of a comprehensive analysis by scientists. Thus, in the first half of the 19th century representative of German classical philosophy F.V. Schelling (1936) drew attention to the complexity of the processes that took place. He believed that philosophy found “completion in two basic sciences that complemented each other and demanded each other, despite their opposite in principle and direction”, namely, in transcendental philosophy and natural philosophy. Philosophy in the form of natural philosophy included all the leading knowledge of its time and in this capacity played an important role in the generalisation of knowledge about the world, contributing to the formation of scientific methods.

However, the development of the scientific paradigm was controversial. Within the framework of natural philosophy, new phenomena of reality were discovered, new methods of research were created, at the same time in the formation of the general picture of the world, its separate spheres, the use of ideas of transcendental philosophy continued. In the Middle Ages, this was most evident in alchemy. Due to the fact that the use of chemical processes has always played an important role in society, the authors consider it appropriate to highlight their applied aspect. Human already at the “initial” stage accumulates experience in the application of various types of chemical processes, based on long-term practical experience. For example, the use of fire gradually became an integral part of life. It was used for cooking, sintering, and later for fusion, metal reduction, tanning, fermentation, rot, and so on. In the Hellenistic era, numerous knowledge in these fields, such as the Egyptian priests, brought a kind of theoretical basis in the form of the doctrine of the four elements – the elements, which marked the beginning of such a natural philosophical system as alchemy. This theory was based on Aristotle's idea that everything around is formed of four primitive elements, combined in pairs on the principle of opposite: fire – water, earth – air (Redgrouv, 2019; Rokhmistrov, 2002; Trosheva, 2002).

Alchemy, as was noted, received the highest development in the Middle Ages. The practical activities of alchemists – attempts to create an “elixir of immortality” and a “philosopher's stone” that turns metals into gold – have made a great contribution to the development of science. Mendeleev (1949), believed “Science owes the first accurate collection of alchemical data. Only thanks to the stock of information collected by alchemists, it was possible to begin real scientific studies of chemical phenomena.” At the same time, during the accumulation of knowledge, the philosophical system, within which the alchemists operated, became a brake on knowledge. In the 18th century theoretical and practical realities led to the “Rubicon” – the decline and degeneration of alchemy. Accordingly, the ideas of natural philosophy have lost their significance (Granin, 2017). This does not mean that the efforts of scientific thought had no prospects. According to Schelling (1936), whose idea seems to be noteworthy, the second

part of the philosophy remained, on which certain “universal systems” of knowledge were based that objectively contributed to the creation of new systems over the centuries. Each new system, at certain intervals, provided the basis for further progress in the knowledge of the world. A wide range of tasks was solved, favourable for filling the “treasury of knowledge”, which laid the foundation for scientific knowledge of the world.

Representatives of philosophical thought led to a temporal correspondence of general theoretical ideas and the available amount of knowledge. Later, everything was repeated, and the next system came into conflict with the accumulated experience. The format and depth of the contradictions programmed the creation of new “systems” that did not meet the objective goal and gradually turned into a kind of “mind game”. In the process of increasing the amount of knowledge and establishing the relationship between them, there was a growing need to organise a scientific system of knowledge about the world, which was formed over time. The formation of a scientific attitude to the world was accompanied by the emergence of individual sciences with their subject and, accordingly, – a new system of obtaining and organising data on the surrounding reality. The basic foundations for the formation of science as an open system of knowledge were created, which did not limit the solution of the problems that arose to predetermined limits and in principle proceeded from the relativity and incompleteness of the known truths.

Formation of a scientific paradigm

Historical processes show that science is not a holistic and complete phenomenon, which is based on the foundation of defining algorithms. Any science in its development strives for this, and the scientific paradigm leads to starting points through the multiplicity of crossed and paradoxical paths. Accordingly, a special methodological analysis is needed to compare the different stages of historical development of science. In this context, the authors consider it appropriate to focus on the three stages of obtaining and organising knowledge, the general characteristics of which are presented above. All stages are united by a set of approaches: the first, practical – obtaining knowledge from the world around, and the second, theoretical – constructing on the basis of the acquired knowledge of a system, a generalised, ideal model of the world, its elements or aspects. These stages have a significant difference in the relationship between theoretical and practical. If at the stage of mythology the theoretical model is formed, first of all, on the basis of the knowledge received in the course of practical activity, the philosophical system, generally, develops on the basis of “abstract” observations. In scientific activity, the main method of knowledge accumulation is the conscious influence for this purpose on the objects of the real world, or experiment. In this way, science combines both the experimental study of objects of reality and their theoretical study, which no longer relates directly to an object, but to its theoretical model. In science, the division of theoretical and experimental knowledge – two sides of a single holistic process – has been brought to its logical conclusion.

The objective necessity of theoretical (abstract) research is explained, first of all, by the complexity of “coverage” of any object of study and its potential interrelations with other objects. The American mathematician, one of the

founders of cybernetics and the theory of artificial intelligence, emphasised that abstraction is the replacement of the part of the universe under consideration by a certain model, a model similar but with a simpler structure. The theoretical study of any object involves its replacement, based on the information obtained, a simplified model of an object, designed to cover the basic elements and relationships in a particular case. The impossibility of complete identification of a model with the existing object is accompanied by a discrepancy between theoretical and experimental data. Hence, in the results of theoretical research there are both truth and error. Errors and oversights present in any study can provoke fundamental inconsistencies. In this context, it should be noted that “the laws formulated within the theory relate, in essence, not to empirical reality, but to reality as it is presented by an idealised object ohm ”, therefore, it is impossible to ensure their full compliance (Rozin, 2005). In the process of further cognition, a new cycle of research emerges with the creation of an object model in which existing truths develop and delusions are eliminated. The new model repeats the cycles of the previous reality, and such a process of comprehending the truth in science has no limits.

It is possible to ensure the greatest correspondence of an object model both based on the experience of studying reality and using analysis and processing of the obtained information. The result of such work is, first, a system of specific knowledge about the surrounding reality; secondly, methodological ideas, which are a “collection” of ideas about the similarity of the laws in force. The first are sufficiently fully formalised in the form of a system of sciences, the latter are systematised partly as defined patterns of quantitative changes (e.g., mathematics), partly in the form of less specific methodological “laws” in logic, dialectics, general systems theory, synergetics. The realities of social development show that the laws that describe the movement of systems of different nature have significant formal similarities. Mathematical modelling is based on the possibility of studying various phenomena on the basis of the same mathematical description. Thus, it is possible to describe an electric oscillating circuit and a spring pendulum by the same equations. These equations can be used to determine other processes in various systems.

Modern achievements suggest that if science knew the basic laws of motion of matter, their mathematical expressions would describe all the phenomena of nature and social life. However, humanity does not know all the basic laws, and every step in the study of nature is always just an approximation to the truth. An infinite number of relationships between real-world objects must also be taken into account, which may never allow the description of the motion of a real object to be limited by mathematical laws. Nevertheless, the generalisation of the multiplicity of individual cases has developed in science the ability to qualitatively assess phenomena, in particular postulates, taken for granted, without a proof (axiomatic method). In addition, science has in its arsenal methodological techniques aimed at a generalised understanding of the information obtained experimentally, which is used in the process of building a theoretical model and planning experiments. All this is a scientific paradigm formed as a result of a long and complex path of development of human knowledge.

Conclusion

Thus, the acquisition and use of knowledge about the objective world was carried out by society in various, historically necessary forms. These forms – mythological, philosophical and scientific, displacing each other in accordance with the quantitative changes in the accumulation of knowledge, provided both the possibility of practical activities of society and the formation of generalised ideas about the world. The main role in this context is played by science. Science as a social phenomenon did not arise out of nowhere. It became a natural result of historically previous forms of knowledge that contributed to the development of the necessary elements of the scientific paradigm. And now it is science that has taken on the function of providing society with a system of necessary knowledge. At the present stage of development of civilisation, science does not disappear, it changes its qualitative – paradigmatic significance. There is a change in the understanding of the “nature” of modern science, which involves its rethinking. And this also implies the need to cover the history of science at the level of its basic sources in the global historical context.

It is necessary to rethink and take into account the whole set of prerequisites for its emergence and correlate it with the previous factors regarding the emergence of science: worldview, religious, mythological, philosophical. Therefore, in the authors' view, the reasoning about the reduction of the role of science, which naturally develops as a special cognitive process as a result of long and profound historical transformations, is too pessimistic. Naturally, it can be assumed that science, like previous forms of obtaining and organising knowledge, will one day give way to other, as yet unknown forms. However, today, despite a number of serious problems in development, scientific knowledge does not lose its fundamental position. Freed from the influence of the rudiments of past systems, science retains its social significance. Convincing proof of this is not only new scientific discoveries that sometimes radically change the perception of the world, but also the increasing role of science in the formation of a new production system, its active transformation into a direct productive force of society.

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