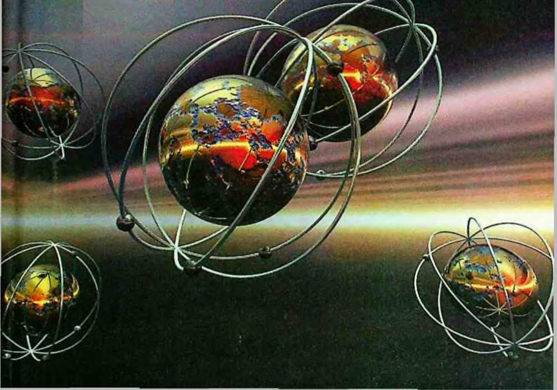
M.Sh. Khasanov, V.F. Petrova

History and Philosophy of SCIENCE

TEXTBOOK



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The textbook *History and Philosophy of Science* introduces the reader to the history and philosophy of science; it traces their development, discusses their acute problems as well as the principles and methods of scientific inquiry. Additionally, the textbook deals with such topics as the structure and models of development of science within culture, the scientific revolutions, empirical and theoretical levels of science. The textbook is based on the writings of philosophers of science from Kazakhstan and abroad.

The material of the textbook is designed as the aid during the preparation for lectures and seminars, or completing the assignments for the "Student's Independent Work" and revision prior the mid-term and end-term evaluations as well as the final examinations.

The textbook is aimed at Master's students and university faculty members.

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TABLE OF CONTENTS

CHAPTER 1
History and Philosophy of Science: Content, Object, and Research Questions

1.1 Subject Matter of Philosophy of Science.

History and philosophy of science as independent branches of scholarly inquiry have been existing since the second half of the 19th century. Such great scientists as Hermann von Helmholtz, Pierre Duhem, Ernst Mach, Karl Pearson, and Jules Henri Poincare are often named as the founders. The very term "philosophy of science" was first coined by Eugen Karl Dühring.

As it was developing as a relatively autonomous and complex branch of philosophy, the term "philosophy of science" have been presided and the scope of its subject matter has been specified. There is scholarly consensus that central problem of philosophy of science concerns the establishment of the criteria of validity and reliability of scientific theories. Philosophy of science also deals with the place and role of science in the social life. However, as to the subject matter of philosophy of science, there have been considerable debate. For example, the subject matter of philosophy of science may be understood as metascience, i.e. science of science policy concerning an ideal model of science. Alternatively, it may be regarded as a socio-psychological study of science or analysis of the ethical issues of research practices.

Definition of the subject matter of philosophy of science is even more complicated by the fact that there are philosophies of particular sciences, such as philosophy of mathematics, of physics, of law, and so forth. Their emergence is a consequence of narrowing of inquiry via focusing on a particular branch of science. Moreover, the question remains about the relationship between general philosophy of science and philosophy of particular sciences.

Although philosophy of science sees itself mainly as a study of science, its principles and goals, it is still not universally recognized as a coherent branch of philosophy for a number of reasons. Firstly, it is the nature of science per se as its subject - given that its development may result in both achievements and crises - as well as the features of deductive, empirical and humanitarian scholarly inquiries. Secondly, it is about the method of solving the problems of epistemological nature; the type of questions being asked and the way they are dealt with by philosophy of science depends both on the state of knowledge itself and on the specific philosophical methodological (epistemological) bias of a researcher. In other words, within philosophy of science, science itself is not only the subject of philosophical reflection, but also the space where philosophical debates are being conducted.

The task of philosophy of science is to define the principles of rational research behavior. Such principles, when followed, ensure acquirement of some knowledge about the reality in its entirety. Philosophy of science shall also provide science with theoretical bases for rational actions. At the same time, philosophy of science reveals new difficulties of scientific inquiry and limitations of scientific knowledge.

Science is the object of study in history, sociology, economics, psychology, ethics, and finally science of science. However, among them, history and philosophy of science occupy a special place.

Philosophy of science studies general laws and patterns of scientific inquiry and knowledge. Science is regarded as a systematic enterprise that builds and organizes knowledge in its historical form within changing sociocultural contexts. In other words, this branch of philosophy tries to answer the following basic questions. What is scientific knowledge? What are the principles of its organization and functioning? What is science in terms production and accumulation of knowledge? How are various disciplines of science formed and developed, how do they differ from each other and how are they interrelated? It is important to bear in mind, however, that this list of questions raised by philosophy of science is by no means exhaustive.

Generally, philosophy of science is regarded as a field of philosophy that studies scientific methods that shall be applied to put forward hypotheses and formulate theories that would be operate with facts as well as the premises scientific research shall be based on so that scientists may have the evidence of validity of their vision of how the world functions.

Special attention in philosophy of science is paid to studying the nature of scientific inquiry, primarily to the human ability to proceed from observing particular natural phenomena to developing universal propositions about the world. Its task is to determine the criteria of usable hypotheses, or for a right choice between numerous theories explaining the same phenomenon. Philosophy of science studies the very process of emerging and changing of scientific theories.

Philosophy of science closely related to the other branches of philosophy, namely metaphysics (general vision of the world), epistemology (theory of knowledge), and semiotics (analysis of the methods of communication and information). In other words, philosophy cannot be considered as an intellectual guardian of a scientific order; rather, it provides the tools to explain the meaning of practical application of scientific knowledge.

In order to reveal the general laws that govern development of scientific knowledge, philosophy of science must be based on the material history of particular scientific disciplines. It develops certain hypotheses and models of gaining and accumulating of knowledge testing them against a particular historical reality. This is how close interrelation between philosophy and history of science may be explained.

Philosophy of science has always been dealing with the structure and dynamics of knowledge in particular scientific disciplines. At the same time, it also compares different scientific disciplines to determine the universal laws of their development.

Thus, history of science and philosophy of science study the same subject using different approach. Science delivers facts about the world (in this case, the world of science), philosophy deals with criteria and assessments, concepts and values. Philosophy explains the language that science uses to construct its arguments, reveals the principles on which they are based, and helps to understand the direction of scientific inquiry.

1.2 The Debate on the Role of Science in Societies: "Scientism" vs "Anti-scientism"

The scientific and technological revolution, which unfolded in the second half of the 20th century, gave rise not only to numerous problems and challenges, but also revived the hope that these problems and challenges will be solved with the help of new science and new technology. Such a worldview is known as "scientism" (from Latin scienlia - science) or "technicism". The "scientism" and "technicism", in their cybernetic-, genetic"- computer-centric varieties, laid in the foundation of the concepts of" industrial", "post-industrial", and "information society" that throughout the 1950s-1980s succeeded each other on the ideological arena. This pan-scientism was nothing but the reincarnation of the "rationalism" characterized by the faith in "reason".

In certain sense, the faith in scientific and technical reason, or "functional rationality" - the term was coined by prominent sociologists and philosophers Max Weber and Emile Durkheim - was even more profound in the 20th century than during the classical period of the reign of "rationalism". The impact of scientific and technical mind on social lives was thought as direct and comprehensive. In the 1950s and 1960s, - due to high economic conjuncture - the concept of "universal welfare society" based on the principles of "rational efficiency" emerged and gained its momentum.

Popular Western authors of that time such as Walt Whitman Rostow and Daniel Bell promised the "welfare state" that would rely specifically on rising scientific and technical reason, which would have almost ultimate power, on "rationally" and "scientifically" managed growth, on improving education of masses. In other words, these were utopian visions rooted in "technicism" and "scientism" otherwise known as "technocratic" visions (Greek "kratos" authorities), i.e. the visions of a social order where the power rests with qualified scientific and technology elite consisting of specialists and experts. In other words, these were the variation of the unlimited power of scientific and technological reason.

The proponents of "scientism" and "technism" in the 1950s-1960s expected the "technocratic" era to establish itself by the 1970s-1980s. These prognoses proved to be unrealistic. Although the 1970s-1980s saw unprecedented scientific and technological achievements, increasing productivity and raising living standards, the challenges and discrepancies become more acute than ever bringing the humanity to the brink of probably the most dangerous crisis in its history. What is the status and influence of the current variation of "technicism" and "scientism", of their technocratic concepts and theories? They are still shared by a number of experts, although in rather modified format.

Here are a number of examples. Yoneji Masuda, in his *The Information Society as Post-industrial Society* (1980), developed a forecast of an information society, the elements of which, at least in their scientific, technical and organizational terms, had been already successfully built in Japan and other industrialized capitalist countries. Usually these kinds of writing contain the ideas and conclusions that are of considerable theoretical and practical interest. For example, Masuda - as well as the other authors who had been writing on the information society such as Daniel Bell, Alvin Tofler, and John Naisbitt - analyses the features of science and technology at the "information stage" of the development of social and economic systems, i.e. the conjunction of computer and communications technologies. Taking information as the primary basis for the contemporary scientific and technical activity, they show its advantages and specific features meaning that the information does not disappear when consumed and cannot be transmitted completely via exchange. In other words, it remains in the information system accessible for the user as something "indivisible". It is possible to make any sense out of it only if the information is sufficiently complete. Therefore, its quality increases with addition of new Information.

Indeed, societies where scientific, technical, productive, material and theoretical activities are relying on rapidly accumulated and reasonably used information, have at their disposal the resource of enormous importance that is "renewable", i.e. can be used multiple times and ways; can be improved and used swiftly for creation of new information systems. Thus, information has two important attributes: firstly, it is knowledge of a relatively new type that is suitable for further use; secondly, it is that kind of knowledge production, storage and use of which really becomes increasingly important for entire society that generates its integral technological and organizational structure.

Increasing role of information and information systems is a historical fact underlying the concepts of the "information society". Another factor is rapid and truly systemic impact "information mind" may have on production, management, and, ultimately social life in its entirety.

The contribution professional philosophers made into understanding of the problems of reason, technology, and science is worth special attention. Sometimes, it might have appeared rather obscure for an external observer, but quite often, it resulted in valuable and significant outcomes. Still, the worth of the non-Marxist philosophy of the 20th century, which may seem rather incomplete and not without contradictions and ambiguities, is to a large extent, in a rather promising search for a new holistic concept of man and human spirit that would include a new understanding of rationality in general as well as scientific and technological rationality in particular. The problem of science and technology has been, in other words, included into philosophical questioning of man's place in this world.

1.3 Internalist and Externalist Conceptions in History of Science

The proponents of these two approaches in history of science of the 20th century explained the emergence and development of scientific ideas and theories differently. Internalists – such as Koyre, Hall, Rossi - believed that science develops due to its internal factors such as objective logic of emergence and solution of scientific problems, evolution in scientific traditions, internally identified need to conduct experiment, to create new concepts, to formulate and solve new problems etc. Therefore, in the works of historians of science belonging to the internalist school of thought, history of science appears as a form of purely intellectual history, i.e. history of ideas that resembles Hegel's approach to the absolute spirit. Thus, for example, analyzing the scientific revolution of the 16th-17th centuries, Koyre sought to show that the root cause of that revolution was in rejection of the ancient concept of the ordered and finite "cosmos" and its replacement with the concept of homogeneous, isotropic and infinite "space". This conceptual shift, according to Koyre, resulted from particular philosophical and religious views of the late Middle Ages. Thus, internalists history of science states that socio-economic, cultural, and personal impact on science is limited; it can only slow down or speed up its evolution that is immanent in its nature.

On the other hand, being under the influence of Marxism, the externalism of Bernal, Haldane, Zilsel, and Needham - which had been established as an independent school of thought by the 1930s - insisted that socioeconomic factors have decisive impact on the development of science. Therefore, when studying history of science, the main task is to reconstruct the socio-cultural conditions (social orders) in which particular ideas and theories arose and developed. Hence, the scientific revolution of the 16^{th}-17^{th} centuries for externalist historian was the consequence of industrial mass production and emergence of capitalist relations. The major postulate is that science develops responding to the impact from the social environment where it is located. The debates between internalism and externalism had continued for several decades; however, by the end of the 1970s, most historians and philosophers of science agreed that the externalist approach described historic reality more accurately.

Thus, science exists in certain socio-cultural conditions and cannot be free from their impact. This became particularly obvious in the second half of the 20th century when new scientific branches and even new sciences began to emerge due to the strong demand for new types of weapons, computers or environmental protection. Nevertheless, the relationship between science and society shall not be oversimplified and trivialized; it would be rather premature to regard any scientific achievement as a mere fulfillment of industrial or political demand. There have been many instances when scientific development accrued due to some immanent processes within science itself.

- Self-checking
- Main topics of philosophy of science.
- The definition of science.
- Science as a form of knowledge and as a social institution.
- Science as a form of social consciousness and the productive force of society.
- Cummulativist and anti-cummulativist models of the dynamics of scientific knowledge.

CHAPTER 2
Philosophical Foundations of Science

2.1 Features of Scientific Inquiry

Unlike all the other types of cognitive activates, science is a process aimed at obtaining of new knowledge that would be objectively true and at revealing and formulating the laws of the physical world. Science is a creative activity, the result of which is knowledge brought into a larger coherent system based on certain principles. Like all the others, scientific knowledge is historical not universal "pure knowledge".

Cognition is a specific type of human endeavor aimed at understanding of the world around us and ourselves in the world. The main task of scientific inquiry is to reveal the objective laws including the natural laws, the social laws, and the laws of cognition and mind. Hence, research is aimed mainly at defining the essential properties of an object, its necessary characteristics and at expression thereof in a systematic abstract manner. Scientific inquiry strives to discover the existing relationships that are to be articulated in a form of the universal laws, otherwise it cannot be called "science" because the very notion of scientific inquiry presupposes discovery of the universal laws and understanding of the essence of the phenomena being studied.

The ultimate goal and the highest value of scientific knowledge is truth that is obtained primarily by the application of rational means and methods, but not without contemplation. Hence, the characteristic feature of scientific knowledge is its objectivity and elimination of subjectivity whenever possible. The task of science is to reflect the true objective picture of the phenomena it studies. At the same time, one must bear in mind that the active engagement of a researcher is the most important prerequisite for a scientific inquiry. This is impossible without critical attitude that prevents stagnation, dogmatism, and bias.

Science more than any other forms of cognition is about being implemented in practice, guiding the action, changing the reality, and managing the processes. The whole point of scientific inquiry can be expressed in the following maxim "know in order to foresee, foresee in order to act (Germ: *wissen, um vorauszusehen; voraussehen, um zu handeln*). The progress of obtaining scientific knowledge is about increasing the scope and depth of scientific foresight. This ability to foresee makes it possible to manage the processes. Thus, scientific knowledge makes it possible not only to foresee the future, but also to construct it.

Scientific inquiry, in its epistemological sense, is a complex process of production of knowledge that is integrated into a single dynamic system of concepts, theories, hypotheses, laws, and other ideal forms and codified in a language that could be a natural one, or, more often, an artificial language such as mathematical symbols or chemical formulas. Scientific knowledge not only fixes its elements but also continuously reproduces them on its own basis forming them in accordance with its own norms and principles. Throughout its history, periods of "normal science", when the established body of knowledge is being deepened and detailed, are interrupted by the periods of "revolutionary science", where discovery of "anomalies" leads to the changes in theories and laws and emergence of new paradigms. This continuous self-renewal of conceptual arsenal of science is an important indicator of the particular nature of the process as a scientific one.

Scientific inquiry often requires the application of such specific means as instruments and devises - so-called "scientific equipment"- that is often rather complex and expensive, for example synchrophasotrons, radio telescopes, rocket and space technology and others. In addition, science more than other types of cognition, is characterized by the use of intellectual means and methods to study its objects and itself such as logic, mathematical methods, dialectics, systemic analysis, speculation, simulation, and deduction as well as the other universal scholarly methods.

Scientific knowledge is gathered via obtaining the evidence that underpin validity of the findings and conclusions. At the same time, hypotheses, speculations, assumptions, and probabilistic judgments are all characteristic of scientific inquiry. That is why methodological competence of a researcher, his/her philosophical awareness, and the ability to apply scientific methods and principles correctly is vitally important.

The desire to study the natural world in order to foresee and manage the possible outcomes of its transformation is not unique for science, it is inherent in the other cognitive activities too that are integrated into practice and develops therein.

Because spontaneous empirical process of cognition may also result in obtaining the knowledge that would be objectively true, the question raises how to differentiate it from scientific inquiry. One can distinguish science from the other cognitive processes by making sure that the latter operates with the following integrated categories: object, means, product, methods and subject. The fact that science produces long-term predictions about future practices that go beyond the existing stereotypical patterns of thinking within everyday experience means that it deals with rather particular sets of objects and these objects cannot be reduced to everyday experience. Nonscientific knowledge reflects only those objects that have been already available via the experiences within a historic context. Science, on the other hand, may very well deal with the fragments of the reality that may be included into everyday practice only in distant future.

Due to the features of the objects studied by science, they cannot be conceived by using the ordinary means of cognition. Although science may use natural language, it is often inadequate to describe the objects it studies for a number of reasons. First, there is nothing in natural language that does not exist in life. In other words, natural language is suitable for the objects only within the current human experience while science goes far beyond. Secondly, the concepts of natural language are often unclear and ambiguous; their exact meaning most often can be only understood and confirmed within the discursive context having been formed historically amidst the everyday experience.

Science cannot do that because it mainly deals with the objects beyond the everyday experience. To describe the phenomena it studies, science seeks to keep its concepts and definitions as precise as possible. Along with specific languages, scientific inquiry requires a system of means applied to the object under study within the conditions built and controlled by the researcher. The means applied in industries are generally unsuitable for science since the objects of science and objects of production by industries are most often different in character. Hence, the need for special equipment and devises, such as measuring instruments, that enable scientists to study empirically these specific types of objects.

These features of the objects can also explain the main difference between the scientific knowledge as a product of deliberate scientific activity from the knowledge obtained spontaneously through everyday empirical cognition. The latter often lacks any systematization. It is rather a body of information, prescriptions, sequences and patterns of actions and behavior accumulated throughout history via everyday experiences. Its validity and reliability is established in its direct application in the actual situations in daily practice. As for scientific knowledge, its validity and reliability cannot be established this way as science deals with the objects beyond the productive activities in industries or everyday lives. Therefore, specific means are required to establish the truthfulness of scientific knowledge. Thus, "scientific knowledge" is the knowledge obtained through controlled experiments or deduced from the knowledge about the facts that has been previously established as accurate.

Furthermore, this means that deducibility makes it possible to transfer the truth from one fragment of knowledge to another, so that they become interconnected and systemically organized. Thus, we ensure coherence and validity that are characteristic for scientific knowledge and distinguish it from ordinary cognitive experiences. Thus, the nature of scientific inquiry makes scientific method the main feature that demarcates science from other activities.

The objects of ordinary knowledge are located in everyday experience, so are the methods through which such knowledge is acquired, and people rarely conceive them as specific methods. The situation is different in the case of scientific inquiry. Because science tends to study the objects that are relatively independent from the available types of productive activity or everyday experience, they are different in nature. Therefore, special qualification is a key requirement in science. To obtain such qualification a researcher must study and master all historically developed scientific means and methods. This not necessary, however, to gain everyday knowledge that is acquired through the process of socialization while an individual absorbs the culture and is engaged in various kinds of activities in a social context.

Apart from the means and methods, science presupposes certain values and motivations. All these shall stimulate search for knowledge in a pure scientific sense regardless its practicality. Otherwise, science will not fulfill its main function that is to overcome the limitations of experiences within the particular historical context. There are two basic values of science that explain such a quest for knowledge: the intrinsic value of the truth and the value of novelty

Constant accumulation of knowledge and special value placed on novelty are the two similarly important drivers in science. These values are manifested in the system of ideals and normative principles; for example, the prohibition of plagiarism and critical revision of the theoretical foundations that are the conditions for gaining the new knowledge. The values of science lay in the foundation of its ethos that scientists must share in order to pursue successfully any scientific inquiry. Great scientists left a significant mark in history not only because of their discoveries, but also because they are the role models for many generations as the pioneers devoted to search of the truth. These people often neglected their personal interests, self-serving motivations or any unscrupulousness pursuing their life in science.

The existence of science-specific normative principles and goals as well as science-specific means and methods requires the training of professional scientists. This leads to the "academic component of science", i.e. special organizations and institutions that educate and train the professionals for exercising scientific activities. In the course of such a training, future scientists not only gain special knowledge and master the methods of scientific work, they also learn about the main values of science, its ethical norms and principles.

Finally and the most importantly, science enables to learn about the objects and phenomena that are inaccessible through ordinary sensual cognition. A human being is able to establish objectively existing connection between the phenomena accessible through the senses and the phenomena that are inaccessible; for example, the relationship between electromagnetic waves and audible sound in the radio receiver, or between the movements of electrons and those visible traces they leave in the Wilson chamber. Understanding of this objectively existing relationship is how the empirically perceived is being transformed into the abstract.

This is why, while doing a scientific inquiry, when the changes occur in the sensuously perceived phenomena without apparent causes, researchers assume the existence of the phenomena that are not perceivable empirically. However, in order to prove their existence, to reveal the laws of their action and to use these laws, it is necessary that the researcher's activity would be inworked into a cause-effect relation connecting the observable and the unobservable. By managing this process and by producing the observable, which is based on the knowledge of the unobservable, the researcher proves the validity of this knowledge.

2.2 The Normative and Ontological Role of Philosophy in Science

Philosophy operates within certain established normative premises that can influence the process of scientific inquiry and its outcomes. For a scientist, his/her understanding of ontological fundamental characteristics of the universe is as important as the facts about the world in purely scientific sense. Philosophy also brings speculative and predictive aspects. It is to provide the ideas and principles, the value of which may be appreciated hundreds or even thousand years later. The ideas of ancient atomism and Hegelian dialectics are the vivid examples thereof.

The greatest influence philosophy makes on science is when fundamental theories are being constructed. Such influence can be both positive and negative depending on the philosophical ontological principles of a scientist. The influence philosophy makes on scientific inquiry as a specific kind of cognitive activity and the process of construction of scientific theories is that philosophical principles are applied as a selective tool while proceeding from a speculation to an inquiry of fundamental theoretical character.

Any use of philosophical principles and ideas implies their rethinking and development. Thus, one can argue that application of philosophical principles to scientific activities promotes further development of science, but also helps to deepen and strengthen philosophy in general as well as its particular ideas and principles.

Philosophy for science is a kind of the original premise or prerequisite that creates the necessary background. It influences the research process setting the qualitative assessment criteria of a particular hypothesis or theory, for analyzing and synthesizing the collected data, and for deriving scientific principles and laws. Philosophy provides the basis of criticism while a new scientific approach or paradigm is being formed; it is the driving force of scientific revolutions that change our understanding of the world; it is an orbiter of the values of scientific activities; it clarifies the nature of scientific knowledge and is about the very understanding of science.

Some scientists, namely Albert Einstein, occasionally resorted to philosophical interpretations. He realized that his theory of relativity, being such a general physical theory, could neither be created nor developed within the physics only without referring to philosophy.

Philosophy, in turn, is constantly enriched by natural and social sciences; it evolves while absorbing and synthesizing the factual knowledge and socio-historical experience. Scientific discoveries very often trigger comprehensive philosophical shifts changing the understanding of the problems that are far beyond science. Philosophical abstractions should be based on scientific facts. However, once emerged and widely disseminated, philosophical postulates very often make rather limiting influence on scientific inquiry determining how a scientist choses from many directions that are possible. Shifts in the accepted views lead to unexpected new outcomes that may become the source of new philosophical developments.

A wide variety of functions and principles of philosophy applied in science show that philosophy has a great influence on formation of scientific knowledge. All these functions are intermingled forming a single whole. The role philosophy plays in science is that of providing the epistemological and methodological foundations necessary for scientific inquiry. Philosophy operates with the established ideas and normative principles that can influence the process of gaining of scientific knowledge and its outcomes. A scientist is conditioned by his particular scientific worldview that is rooted in his experience gained through conducting the scientific research, but also the understanding of the fundamental characteristics of the physical world that are ontological by nature.

Science is rested on three main pillars. The first is the scientific worldview, the second is the ideals and normative principles, and the third is the philosophical justifications that helps to interlace them into culture in broader sense. Each of these components are worth a more detailed analysis.

The scientific worldview is an integral system of ideas about basic properties and laws of the physical world resulted from analysis and synthesis based on the fundamental scientific concepts and principles. Scientific worldview can be general, which includes the ideas of the physical reality in its entirety, namely about the nature, society and cognition, and that of natural science. The latter, depending on its object, may be physical, astronomical, chemical, biological, etc. Scientific worldview, in general sense, is the core element of the ontology of a particular scientific field that is prevailing in a particular historical context.

Each worldview is based on certain fundamental scientific theories. As the experience is being widened and empirical knowledge accumulated, one paradigm is replaced by the other. Thus, the natural scientific paradigm in general sense was initially "physical" based on the classical mechanics since the 17th century, then on the electrodynamics, and later on the quantum mechanics and the theory of relativity since the early 20th century. It has been increasingly synergetic in the course of the latest decades.

Finally, scientific worldview brings heuristic component in the process of constructing of fundamental scientific theories. They, in turn, are closely associated with the ontological premises contributing into their formation.

Ideals and norms of scientific inquiry are a set of definite conceptual, normative, methodological and other guidelines that are characteristic for science in particular historical contexts. Their main function is to organize and regulate the process of scientific research, to direct it , to make it more effective, to provide the means and determine the actions to achieve the results that would be factually true. For example, being transformed from the "classical" to the "non-classical" science, its ideals and norms changed radically. Importantly, these norms and principles are determined primarily by the object of inquiry and its properties and their content is always molded in a particular socio-cultural context.

The notion of the "paradigm" is a manifestation of the norms and ideals of science in their integral unity that prevails at a certain stage of historical development of science. It directs scientific inquiry being itself complex and value-oriented. Since it reflects commonly accepted and established patterns of intellectual activity that are dominant at a particular stage of the development of science, a paradigm is always historical. Most often philosophy and history of science distinguish between the "classical", "non-classical", and "post-non-classical" (contemporary) paradigms.

The concept of "philosophical foundations of science" expresses philosophical ideas and principles of a given science (scientific discipline, concept, etc.) that provide the most general guidelines for scientific inquiry. Along with justification of already acquired knowledge, philosophical foundations of science are heuristic, i.e. they contribute into construction of new theories, and methodological. As means of gaining and accumulating of new knowledge, they help the formation of new scientific methods.

- Self-checking
- Scientific and ordinary knowledge.
- Distinctive features of scientific acquisition of knowledge.
- The influence of the change of the type of culture on the standards of presentation of scientific knowledge.
- The interaction of science with other forms of non-materials activities of man.
- The worldview role of philosophy in the development of science.

CHAPTER 3
Functions of the History and Philosophy of Science

3.1 Main Functions

The history and philosophy of science have a number of functions.

Methodology is a doctrine of principles, methods of acquiring knowledge and transformation of the world. Each science uses its own methods of acquiring knowledge. Philosophy, too, formulates its own methods of acquiring knowledge. Currently, philosophy studies various forms and methods of acquiring knowledge. These include: analysis and synthesis, induction and deduction, hypothesis and theory, observation and experiment, analogy and modelling, the historical and the logical, verification and paradigm, etc. Accordingly, the methodological function is in the justification of the need for general principles and methods of acquiring knowledge about the world and taking into account the general principles of self-organisation and development of the world in the study of any particular objects of knowledge.

The logical-epistemological function of philosophy consists in the development of the philosophical method itself, its normative principles, and also in the logical-epistemological justification of certain conceptual and theoretical structures of scientific knowledge. The production of knowledge necessary for improving the elements of the universal method is combined with its application for the development of general scientific methods of acquiring knowledge such as the system approach, or the modeling method. The use of the principles of dialectics as logic in the construction of scientific theories means the inclusion of their logical or epistemological grounds. Although, notably, scientific disciplines do not specifically study the forms of thought, its laws and logical categories, they, however, are constantly faced with the need to develop logical and methodological tools that would allow them to temporarily "withdraw from" the object in the process of cognition in order to "approach" it, thereby enriching their true conception of it.

Scientific disciplines can not normally function and develop without relying on logic, epistemology and the general methodology of acquiring knowledge. This function is performed by dialectics as logic, for only dialectical thinking is able to adequately "grasp", reflect the ever changing world. Whereas general epistemology shows the possibility and need for an adequate scientific knowledge of the object, dialectics as logic together with other types of logic (formal, mathematical, fuzzy logic) contributes to the achievement of this level of adequacy. It develops the means for the most complete and accurate reflection of the developing and continuously changing essence of the object. Dialectics sets general guidelines for cognitive activity in various fields of theoretical natural science and social science, and the development of dialectical-logical principles of knowledge carried out in close unity with the generalisation of the latest achievements in the methodology of natural and social sciences gives practical significance to the general methodological function of philosophy.

The word "ontology" (from Greek *ontos* – substance as reality, *logos* – thought, teaching) has different meanings: 1) "the first philosophy" as the study of being, 2) the study of the supersensible world, and 3) the study of the world as a whole. Today, the ontological function of philosophy is understood as the ability of philosophy to describe the world by such categories as "being", "matter", "system", "determinism", "development", "necessity and chance", "possibility and reality", etc. Philosophy widely uses the achievements of all sciences to describe the world, seeks to make generalisations and, based on this, to raise new concepts to the level of universality.

The ontological function is, therefore, expressed in creating a philosophical view of the world. By creating a worldview, philosophy generalises the achievements of modern science. In creating a view of the world, as is already emphasised, the anthropic principle applies. In the centre of this view is man and his multifaceted relations with the world. Therefore, ontology is closely related to both axiology and anthropology. In creating a philosophical view of the world, the original premise of what the primary, original understanding of the world is becomes important. Therefore, the ontological view contains the original philosophical creed.

Social philosophy studies society as an integral organism, the interconnection and role of all its components (economy, politics, social structure, culture, etc.), the role of objective and subjective factors in the changes in and the developing of society, examines the problem of historical periods, stages of development of society, the emergence of global problems and prospects of human civilisation. The content of this branch of philosophy also implies the socio-cultural function of philosophy, which is to help man to comprehend the course of human history, to understand more deeply the contemporary state of society and the multifaceted interrelation between culture and individuality, to become aware of one's place in society and one's opportunities of self-development in the context of contemporary events.

One of the functions of philosophy is the cultural and educational function. Knowledge of philosophy, including the requirements for acquiring knowledge, contributes to the formation in an individual of such essential features of a cultured person as commitment to seeking the truth, beauty and good. Philosophy can protect an individual from the superficial framework of commonplace thinking; it makes dynamic the theoretical and empirical concepts of the natural, technical and social sciences and humanities with the aim of reflecting, as adequately as possible, the contradictory and changing essence of different phenomena. In other words, philosophy shapes an individual's high culture of thinking, sharpens his intellect, and develops the ability to adequately comprehend the world. One of the indicators of a high culture of thinking is the ability of the subject not to ignore or avoid cognitive contradictions, but to seek to resolve and overcome them actualising the available scientific information, philosophical categories and showing independence and nonstandard approaches. Dialectically developed thinking, by excluding formal logical contradictions, always aims to solve the real contradictions of the object and, along this way, reveals its own creative and antidogmatic nature. When confronted with the contradictions of reality, an individual begins to approach things with skepticism, which is the opposite to dogmatism.

Axiology (from Greek *axia* - value, worth, *logos* - teaching) is a study of the nature of values, of their place in real life and the structure of the world of values, i.e. the relationship between different values and their relationship with social and cultural factors and structure of personality. The axiological function is manifested in the justification of the proposition that man is the measure of all things, that all his actions, deeds, the results of discoveries, inventions, the creation of the world of objects, etc. must be evaluated from the point of view of the ethical categories of "good" and "evil". The 'what is good?' always remains relevant. The axiological function is in the determination of the orientation of any activity, in the formulation of a humanistic approach, in cognitive, scientific, technology, social, political, economic, cultural, environmental, and any other activity. Individuals live among other people. In terms of the principle of axiology, an individual is regarded as the highest value of the world, and all his actions, creations, consequences of his actions are evaluated from the standpoint of this humanistic paradigm. The axiological function is the development of an individual's system or framework of values. The most typical life-purpose personality orientations are: hedonism (the meaning of life is in pleasure), eudemonism (the meaning of life is in happiness), selfishness (personal interests come first), etc.

All these daily life individual moral orientations are associated with a deeper philosophical problem -- the problem of the meaning of life, death and immortality. Throughout its entire written history, mankind has sought to unravel the mystery of life and death. Science, art, religion, and philosophy seek, each in its own way, to find an answer to the question of the mystery of life and death.

Epistemology (from Greek *episteme* -- knowledge, *logos* -- teaching) is a study or theory of knowledge. The epistemological function is in the development of a general theory of knowledge, in the unravelling of levels of knowledge (e.g. the empirical, theoretical). Epistemology studies the forms of sensory acquisition of knowledge (sensations, perceptions, views, ideas), rational cognition or acquisition of knowledge (concepts, judgments, reasoning, inferences). Epistemology is important in describing the general principles of the relationship between the subject and the object of knowledge and the detection of objective limitations of the subject of cognition, in describing the contradictory ascent of knowledge from relative truth to absolute truth. At each stage of its development, philosophy sought to answer the question: what is truth? Currently, there are many answers to this question. This, again, depends on the initial philosophical axioms.

The most common definition of truth is this: truth is knowledge about the object of knowledge which adequately reflects the properties, attributes, structure, changes of the object. Truth is seen as something flexible. Truth is a process. Knowledge of the object of knowledge changes depending on new discoveries, new ways of describing the object of knowledge, new ways of testing our knowledge. It has been established that our knowledge contains misconceptions, which, for a number of reasons, are regarded as truth for a certain period of time.

As knowledge is expanded and refined, people get rid misconceptions without suspecting that some new ideas contain new misconceptions. The epistemological function has a heuristic aspect. Academician philosophers, by relying on scientific data and applying methods of knowledge acquisition that are inherent in philosophy, are capable of making independent discoveries, which, in turn, are included in the achievements of science.

The nature of the acquisition and consolidation of philosophical knowledge depends on the ability of philosophy as a system of knowledge to be transferred from one person to another and to inform the latter about its content. This is the information-communicative function of philosophy.

Philosophy as a body of knowledge about the most general principles of the relationship of man to the world is also a system of criteria for the valuation activity, where these principles perform the role of such criteria. Valuation activity, which depends on people's awareness of the criteria of optimality offered by philosophy, on the usefulness of a particular set of phenomena and actions, acts as a means of orienting these people in the world. In terms of axiology or theory of values, philosophy as a means of developing knowledge about values and as a carrier of this knowledge is capable of performing a value-oriented function.

The critical function within the framework of philosophy is carried out as an evaluation of what is happening in the world on the basis of the general ideas within philosophy about the norm and pathology of phenomena and processes of reality that surround man. The critical attitude of philosophy to what is negatively evaluated in spiritual and material life contributes to the development of measures aimed at overcoming something which does not suit an individual, which seems to him or her pathological and, therefore, worthy of transformation. The critical function of philosophy can manifest itself not only in people's relationship to the world, but can also be realised in the course of self-assessment of its own content by the professional community. As such, the critical function of philosophy can be realised both in terms of encouraging and driving the development of knowledge about the world and the renewal of the world as a whole, and in terms of improving the content of philosophy itself.

The integrating function shows that it generalises the knowledge accumulated by mankind, systematises and integrates it into a single system, develops the criteria for its hierarchy. This allows us to talk about the integrative function of philosophy in relation to knowledge.

In addition, philosophy formulates the most general principles of the world order, as well as the requirements for the relationship and attitude of man to the world, society and himself. By being assimilated in the course of education, becoming the property of different people, such principles provide them with the formation of positions similar in content, which facilitates the integration of the social community into a single whole. This is how another plan for the realisation of the integrating function of philosophy is manifested.

In close connection with these functions, philosophy is able to determine and advocate the interests of social strata and groups of society, that is to act as an ideology, to perform the ideological function. This function may have specific features depending on the interests of which social groups this philosophy expresses and we know that group interests can be progressive or reactionary. This determines on the orientation of the realisation of the ideological function, which is capable of exerting a great influence on the manifestation of other functions of philosophy. Reactionary ideologies are able to inhibit the development of philosophy, misshape and distort its content, degrade its social value, limit the scope of its application in practice.

Along with the functions mentioned above, philosophy also deals with forecasting and fulfills a predictive function. Many philosophers of the past acted as prophets by predicting the future. Some of their forecasts were utopian and far from reality, but sometimes the prophecies of individual prominent thinkers had a great level of accuracy. Of course, it is difficult to foresee the future, but the value of philosophers' warnings about imminent dangers, such as those generated by the thoughtless and predatory consumption of natural resources, is extremely high in terms of the rules that the world economy applies today as this poses the task of improving the rules and requirements governing the connections between society and nature with the aim of ensuring the survival of people.

There is another function of philosophy which is related to those described above -- the design function. In view of the fact that philosophy reveals the mechanisms and the most general trends of the evolution and development of nature, society and thinking and determines the requirements the observance of which ensures the functioning of these mechanisms and trends, it capable of becoming the basis for impact on the processes in nature and society. This impact should be properly organised in order to ensure its clear focus and to obtain certain results. Conceptual design of the social environment, e.g. in the context of land development, urban planning or construction of factories and factories requires the involvement of philosophy which, together with other sciences, is called upon to develop the most general principles and norms that make up the normative framework for the creation and functioning of objects used for the arrangement of the life conditions and activities of people in urban and other environments. Philosophy should play the same role in the arrangement of the economic environment as well. In a narrower sense, the design function of philosophy is realised in the formation of models of knowledge acquisition and practical activities. The consideration of the functions of philosophy is an illustration of its large-scale role in public life, in the arrangement of people's activities aimed at the acquisition of knowledge and transformation of the world.

- Self-Checking
- The cultural function of philosophy.
- Philosophy as a factor of social regulation.
- Science as a factor of and condition for rational management.
- The humanistic function of science.
- The ecological or environmental function of science.

CHAPTER 4
The Origin and Formation of Science in the Ancient World, the Middle Ages and the Renaissance

4.1 The Cultures of Egypt and Babylon: Mathematics and Astronomy

It can be concluded from the survived mathematical documents that the branches of mathematics concerned with the solution of economic problems were strongly developed in Ancient Egypt. The Rhind Papyrus (circa 2000 BC) begins with the promise to teach the reader about the perfect and thorough exploration of all things, understanding of their substance and knowledge of all mysteries. It explained to the government officials the art of computation with integers and fractions. They were expected to be able to solve a wide range of practical tasks, such as the distribution of wages between a known number of workers, the calculation of the amount of grain for a certain quantity of bread, the calculation of surfaces and volumes, etc. However, it seems that Ancient Egyptians did not go beyond solution of the first degree equations and the simplest quadratic equations. The entire content of the Ancient Egyptian mathematics which is known to us was aimed at the satisfaction of specific needs of material production and could not have had any serious relationship to philosophy.

The mathematics of Babylon, like Egyptian mathematics, was brought to life by the needs of production activities and was aimed to solve tasks related to irrigation, construction, accounting, property relations, time calculation, etc. The survived documents show that the Babylonians, by relying on the hexadecimal number system, were able to perform the four arithmetic operations, used tables of square roots, cubes and cube roots, sums of squares and cubes, degrees of a given number and were familiar with progression summation formulas. They reached spectacular results in numerical algebra. While the Babylonians had no knowledge of the algebraic symbols, solutions to mathematical problems were based on plans, problems were reduced to the uniform "normal" and then were solved according to the general rules, and the interpretation of the transformations of "equations" was not seen as related to the specific nature of the original data. They also dealt with problems involving solution of third degree equations and specific types of fourth, fifth and sixth degree equations.

If we compare the mathematical sciences of the Ancient Egypt and Babylon in terms of the way of thinking, it will not be difficult to determine the similarities in such their features as authoritarianism, lack of criticism, sticking to tradition, and extremely slow evolution of knowledge both in the fields of mythology, religion and philosophy alike.

4.2 Chinese Medicine

The ancient Chinese medical text Huangdi Niejing was recorded during the reign of the dynasty of the Spring and Autumn period (770-476 BC) and the Warring States period (475-221 BC), a few hundred years earlier than the works of the Greek physician Hippocrates, who lived in 446-377 BC and was considered the father of Western medicine. Huangdi Neijing can, therefore, be considered the oldest work on medicine in the world. It summarises the practical medical experience accumulated by previous generations of Chinese physicians, provides justification for the theoretical systematisation of China's traditional healing arts, and describes the basics of Chinese medicinal therapy, as well as acupuncture and cautery.

The Chinese surgeon and acupuncture expert Hua Tuo (112-207 AD) was the pioneer in the application of narcotics to achieve complete anesthesia during abdominal surgeries and other types of surgical interventions. During his bold surgeries Hua Tuo used for anesthesia his famous tea mix called Ma Fei. Approximately at the same time another Chinese physician Zhang Zhongjing (150-219 AD) wrote his work "Treatise on Cold Pathogenic and Miscellaneous Diseases" in which he described a specific method of dialectical diagnostics used in Chinese medicine which is still relevant today. This treatise was written during the lifetime of the Greco-Roman physician Galen of Pergamon (129-199 AD), who was the author of the fundamental and extensive work in the field of medicine, which remained a mandatory reading for Western physician until the end of the Middle Ages. Another significant milestone in the history of Chinese medicine was the publication by Li Shizhen of the *Compendium of materia medica Bencao Gangmu* in 1578. In total, over six thousand Chinese books on medicine, which describe different methods of treatment and which are still used by Chinese physicians as reference books, have survived to the present day.

Preventive medicine has always had a significant place in Chinese medicine. The idea of disease prevention was present at the very beginning of Ancient China's medical legacy that has survived to the present day. For example, one of the dialogues in the first chapter of the Huangdi Neijing deals with the question of how to maintain one's health. For this reason, hygiene measures and parasite control have always played an important role in Chinese history.

As early as during the Tang Dynasty (618-907 AD), Chinese physicians knew that leprosy is an infectious disease and infected people were isolated from healthy people. First smallpox vaccinations were not conducted by the English physician Edward Jenner (1749-1823), as is believed in the West. The method of smallpox inoculation was discovered in China and was probably first used there during the eleventh century and the serum taken from smallpox patients was given to healthy people as a means of prevention. In the 16th centur, the Chinese book called *The New Book on Vaccines Against Smallpox* (Douzhen xinfa), an innovative work in the field of immunology, was known in some countries of Europe and Asia.

As early as during the Qing Dynasty (221-26 BC) and Han (206 BC - 220 AD), China, Korea, Vietnam and Japan shared their knowledge in medicine and this practice later spread to the Arab worlds, Russia and Turkey. The *compendium of materia medica Bencao Gangmu* which was an authoritative source for medicinal therapy was translated into many languages, including Latin, Korean, Japanese, Russian, English and French and was widespread in the Western world.

4.3 Mathematics, Astronomy and Medicine in Ancient India

The discoveries in Ancient India in exact sciences influenced the development of Arab and Iranian-Persian science. The place of honor in the history of mathematics is occupied by the mathematician-astronomer Aryabhata (476–550 AD). He was aware of the meaning of Pi and proposed an original solution of the linear equation. In addition, it was in Ancient India where the numeral system became decimal (i.e. included a zero and used digits for the ten values). This system formed the basis of modern number system and arithmetic. Algebra was more developed, but the concepts of "figure", "sine", "root" originated in Ancient India.

Ancient Indian treatises on astronomy are an evidence of a very high level of development of this science in this part of the world. Independently from the Ancient Greek and Roman science, Aryabhata articulated the idea of the Earth's rotation around its axis, for which he was angrily condemned by the priests. The introduction of the decimal system contributed to accurate astronomical calculations, although Ancient Indians had no observatories or a telescope.

Ayurveda -- the science of longevity, which originated in ancient times -- is still treated with great respect in India. Among other things, Ancient Indian physicians studied the properties of herbs, the effect of climate on human health, etc. Great attention was paid to personal hygiene and diet. Surgery was also highly developed; we know about approximately three hundred types of surgeries that were mastered by Ancient Indian physicians and about 120 surgical instruments. The currently popular Tibetan medicine is based on the Ancient Indian science of Ayurveda

Ancient Indian physicians believed that the human body is based on the three main life substances: wind, bile and phlegm, which represent, respectively, movement (kinetic energy), fire and water. Indian medicine paid special attention to impact of the environment and heredity on the human body. There were also treatises on medical ethics.

Professional physicians from many different countries travelled to India to study. A number of Indian cities had universities which offered training in religious and philosophical texts, astronomy, astrology, mathematics, medicine and Sanskrit. The cultural tradition of this country was not particularly rational and Indian scientists were not interested in the logic of scientific knowledge, they were more concerned with the mysteries of the universe and the practical side of calculation, the arrangement of the calendar and spatial measurement.

4.4 Logic and Mathematics in Ancient Greece and Rome: the Historical, Cultural and Scientific Significance

We know that, at the initial stage of its development, the Greek civilisation borrowed many of its elements from the civilisations of the Ancient East.

The question of the relationship between mathematics and philosophy was first asked a long time ago. Aristotle, Bacon, Leonardo da Vinci -- many great minds of mankind concerned themselves with this issue and achieved outstanding results. This is not surprising as the basis for the interaction of philosophy with any science is the need to use the conceptual framework and terminology of philosophy to conduct research in a particular field; and, of all the exact sciences, mathematics, undoubtedly, is best suited for philosophical analysis (because of its abstract nature). Along with this, the progressive mathematisation of science has a great impact on philosophical thinking.

The history of science, mathematics and philosophy in particular, is traced back to the Ancient Greece of around the 6th century BC. Analysis of the history of Ancient Greek mathematics and philosophy should begin with the Milesian school, which laid the foundations of mathematics as a proof- and argument-based science.

The Milesian School was of the first Ancient Greek mathematical schools that had a significant impact on the development of philosophical ideas of the time. It existed in Ionia from the end of the 5th century to the 4th century BC. Its main representatives were Thales (circa 624-547 BC), Anaximander (circa 610-546 BC), and Anaximenes (circa 585-525 BC).

If we compare the early mathematical knowledge of the Greeks with the achievements of the Egyptians and the Babylonians, then it is hardly possible to doubt that ancient mathematicians were familiar with such elementary propositions as the equality of the angles at the base of an isosceles triangle, the authorship of which is attributed to Thales of Miletus. Nevertheless, the early Greek mathematics was qualitatively different from the mathematics of its predecessors.

Its distinctiveness is, first of all, in an attempt to systematically use the method of **proof**. Thales sought to prove what was empirically obtained and used, without proper justification, in Egyptian and Babylonian mathematics. Perhaps, during the period of the most intensive development of the culture of Egypt and Babylon and during the formation of the foundations of their knowledge, the presentation of certain mathematical propositions was accompanied by a justification presented in one form or another.

The Greeks introduced the **process of justification** as a necessary component of mathematical reality, proof was indeed a distinctive feature of their mathematics. Originally, the proof technique in early Greek mathematics, both in geometry and in arithmetic, was an attempt of providing a **clarity**. Specific varieties of such proof were proof with the help of pebbles in arithmetic and superposition in geometry. But the very fact of having evidence shows that mathematical knowledge is not perceived dogmatically, but in the process of reflection. This, in turn, reveals a critical mindset, the confidence (perhaps not always conscious) that by reflection one can establish the correctness or falsity of the proposition in question, the confidence in the power of the human mind.

The qualitative difference between the studies of Thales and his followers from pre-Greek mathematics is manifested not so much in the concrete content of the examined dependency, but rather in the new method of mathematical thinking. The Greeks took the source material from their predecessors, but used a new method of assimilation and application of this material. Distinctive features of their mathematical knowledge are **rationalism, criticism, and dynamism**.

The same features are also characteristic of the philosophical studies of the Milesian school. **A philosophical concept and a corpus of mathematical propositions** are formed by a thought process that is homogeneous in its general characteristics and is qualitatively different from the way of thinking of the previous era.

The emergence in Greek mathematics of the need for proof can be adequately explaned if one takes into account the influence of a world view on the development of mathematics. In this respect, the Greeks differ significantly from their predecessors. Their philosophical and mathematical inquiries demonstrate the faith in the power of the human mind, the critical attitude toward the achievements of their predecessors, and the dynamic way of thinking. The Greeks transformed the influence of the world view from a restraining factor of mathematical knowledge into a stimulating, effective force of progress in mathematics.

The game-changing effect of the fact that the justification took exactly the form of proof instead of stopping at empirical verification was the emergence of a new **worldview function of science**. Thales and his disciples adopted the mathematical achievements of their predecessors in order to meet technical needs, but science for them was something more than a tool for solving operational problems. Individual, most abstract elements of mathematics are entwined into the **natural-philosophical system** and here they serve as the opposites to mythological and religious beliefs. Empirical verifiability for the elements of the philosophical system was insufficient because of their common nature and the scarcity of the facts supporting them; whereas mathematical knowledge had, by that time, reached such a level of development that it became possible to establish logical connections between individual propositions. This form of justification was objectively acceptable for mathematical propositions.

Our studies of the Milesian school can indeed tell us that the active influence of one's worldview on the process of mathematical knowledge occurs only with radical changes in the social and economic conditions of society. Still the questions remain as to whether changes in the philosophical basis of society's life influences the development of mathematics, whether mathematical cognition depends on changes in the ideological orientation of one's worldview, and whether there is a reverse effect of mathematical knowledge on philosophical ideas. We can try to answer these questions by studying the legacy of the Pythagorean school.

Pythagoreanism as a philosophical movement that concerned itself with spiritual life emerged in the 6th century BC and went through several stages in its development throughout the entire history of Ancient Greece. The founder of the school was Pythagoras of Samos (circa 580-500 BC), but not a single line written by him has survived and it is not known whether he wrote down his thoughts at all. It is very difficult to establish which of the work attributed to this philosophical movement was authored by Pythagoras himself and which of it was done by his disciples. The records of the ancient Greek authors about him are contradictory; to some extent, the differences in the opinions of his work reflect the diversity of his teaching.

There are two components distinguished in Pythagoreanism: a practical component ("the Pythagorean way of life") and a theoretical component (a certain body of teachings or doctrines). In the religious teachings of the Pythagoreans, the priority was given to rituals, these were followed by the idea of achieving a certain state of mind and only then we see references to beliefs which allowed different interpretations. In comparison to other religious movements, the Pythagoreans had their own ideas about the nature and fate of the soul. The soul is a divine being, it is imprisoned in the body as punishment for sins. The ultimate goal of life is to free the soul from the corporal prison, to prevent it from entering into another body, which supposedly happens after death. The way to achieve this goal is the observation of a certain moral code, the "Pythagorean way of life". In the system of numerous prescriptions governing almost every step of life, a prominent place was given to music studies and scholarly inquiries.

The theoretical aspect of Pythagoreanism is closely related to its practical aspect. Pythagoreans regarded theoretical efforts as the best way of freeing the soul from the circle of births and tried to use their results to rationally justify the proposed doctrine.

For the Pythagoreans, the main objects of scientific knowledge were mathematical objects, primarily the natural number sequence (the famous "Number is the essence of all things" is an example). A prominent place was given to the study of the relationships between even and odd numbers. In the field of geometric knowledge, attention was focused on the most abstract dependencies. The Pythagoreans built a significant part of the plane geometry of rectangular figures; the highest achievement in this area was the general proof of the Pythagorean theorem, which was occasionally cited in Babylonian cuneiform texts some 1200 years before this event. Some sources even attribute such outstanding results as the construction of five regular polyhedra to the Pythagoreans.

For the Pythagoreans, numbers were the fundamental universal objects, to which they intended to reduce not only mathematical constructions, but also the whole diversity of reality. Physical, ethical, social and religious notions were viewed from the mathematical perspective. The science of numbers and other mathematical objects was given a fundamental place in the worldview system, that is, essentially, **mathematics was declared a philosophy**.

Pythagoras and his followers developed a **method of mathematical deduction** (the rules for the logical inference of consequences from initial propositions, or axioms) and achieved many valuable results in number theory. They were first in Greece to learn how to recognise the five planets (Mercury, Venus, Mars, Jupiter, and Saturn) and offered their system of the world in which the planets, the Sun, the Moon, and the spherical Earth revolve along the circular orbits around the "central fire". They also laid the foundation for the mathematical theory of musical harmony.

Euclid of Alexandria (the end of 4th - the beginning of the 3rd centuries BC) wrote thirteen books under the common title *The Elements*. They contain a presentation of important issues in number theory:

divisibility and the properties of prime numbers, summation of geometric progressions, the theory of incommensurate quantities, etc.

If we compare the mathematical studies of the early Pythagorean and Milesian schools, we can identify a number of significant differences. For example, mathematical objects were considered by the Pythagoreans as the primary essence of the world, that is, the very understanding of the nature of mathematical objects changed radically. Also, mathematics was transformed by the Pythagoreans into a religious component, into a means of purifying the soul and achieving immortality. And, finally, the Pythagoreans limit the field of mathematical objects to the most abstract types of elements and deliberately ignore the applications of mathematics for the solution of production problems. But what caused such global differences in the understanding of the nature of mathematical objects in schools that existed almost at the same time and apparently drew their wisdom from the same source -- the culture of the East? It must be said that Pythagoras, most likely, enjoyed the achievements of the Milesian school, since he, like Thales, demonstrated the main signs of mental activity that were different from the pre-Greek era; but the activities of these two schools in the field of mathematics were of a different nature.

Aristotle was among the first who tried to explain the reasons for the emergence of the Pythagorean concept of mathematics. He saw them within mathematics itself: "The so-called Pythagoreans, having engaged in mathematical sciences, first moved them forward and, having been educated from them, began to consider them the beginnings of all things". However, the Pythagoreans themselves undermined their fundamental principle that "Number is the essence of all things" by having discovered that the ratio of the diagonal to the side of a square is not expressed by integers.

The **Eleatic school** is quite an interesting topic for research as it is one of the oldest schools in the works of which **mathematics and philosophy** closely and multilaterally interact. The main representatives of the Eleatic school are thought to be Parmenides of Elea (late 6th century – 5th century BC) and Zeno of Elea (first half of the 5th century BC).

According to **Parmenides**, being is one, indivisible, immutable, timeless, and complete in itself, only being truly exists; multiplicity, variability, discontinuity, and fluidity are all the attributes of the imaginary.

Parmenides' teachings were defended against objections by his disciple, **Zeno**. The ancients attributed to him the forty proofs defending the doctrine of the unity of existence (against the multiplicity of things) and the five proofs of its motionlessness (against motion), of which only nine have survived.

The most famous has been Zenon's proof that objects are motionless; for example, motion does not exist on the grounds that the moving object must first go halfway before reaching the end, and in order to get to the half, you need to go half of that half, and so on.

From the common sense perspective, Zeno's arguments have paradoxical results, but they could not have been simply disregarded as groundless, because, both by form and substance, they satisfied the mathematical standards of his time. By breaking down Zeno's aporias into constituent parts and moving from conclusions to premises, we can reconstruct the initial propositions that he used as the basis of his concept. It is important to note that in the concept of the Eleatics, like in the pre-Zenon science, fundamental philosophical ideas relied heavily on mathematical principles, the main of which were represented by the following axioms:

- the sum of an infinitely large number of any even infinitesimal but extended quantities must be infinitely large;
- the sum of any even infinitely large number of non-extended quantities is always equal to zero and can never be a preset extended quantity.

It is exactly because of the close relationship between general philosophical concepts and fundamental mathematical concepts why Zenon's blow against philosophical views of his time had a significant impact on the system of mathematical knowledge.

A number of important mathematical constructions, which had been previously regarded as undoubtedly true, in Zenon's constructions looked contradictory. Zeno's reasoning resulted in the need to rethink such important methodological issues as the nature of infinity, the relationship between continuous and discontinuous, etc. His arguments drew the attention of mathematicians to the fragility of the foundation of their scientific activity and thus had a boosting effect on the progress of this science.

We should pay attention to the reverse relationship as well -- to the role of mathematics in the formation of Eleatic philosophy. For instance, it is established that Zeno's aporias are related to finding the sum of an infinite geometric progression.

Thanks, in large part, to the work of the Eleatics, the increase in the level of abstraction of mathematical knowledge was of great importance for the subsequent development of mathematics. This process was specifically manifested in the emergence of the concept of **indirect proof** ("by contradiction"), the characteristic feature of which is the proof of not the statement itself, but of the absurdity of its opposite. Thus, a step was taken towards the development of mathematics as a deductive science and certain prerequisites for its axiomatic construction were created.

As such, the philosophical reasoning and arguments of the Eleatics, on the one hand, gave a powerful impetus to a fundamentally new formulation of the most important methodological questions of mathematics, and on the other hand served as a source of the emergence of a qualitatively new form of justification of mathematical knowledge.

Zeno's arguments revealed the internal contradictions that were present in the mathematical theories existing at the time and the existence of mathematics was questioned. What ways were used to resolve the contradictions revealed by Zeno?

The simplest way out of this situation was the refusal of abstractions in favour of what can be directly verified with senses. This position was taken by the sophist **Protagoras of Abdera**. He believed that we can not imagine anything straight or circular in the sense that these terms are represented by geometry; in fact, a circle does touches a straight line at more than one point.

He believed that the following should be removed from mathematics as something irreal: the idea of an infinite number of things, because no one can count to infinity; infinite divisibility, because of its impracticability, etc. By this, mathematics can be made invulnerable against Zeno's reasoning, but theoretical mathematics is practically abolished. It was significantly more difficult to construct a system of fundamental mathematical propositions in which there would have been no place for the contradictions revealed by Zeno. This task was solved by **Democritus** who developed the concept of mathematical atomism.

Marx regarded Democritus as the first polymath thinker among the Greeks. Diogenes Laertius (3rd century AD) names 70 of his works that covered the problems of philosophy, logic, mathematics, cosmology, physics, biology, social life, psychology, ethics, pedagogy, philology, art, technology, etc. The introductory part of Democritus' scientific system was "canonics", in which the principles of atomistic philosophy were formulated and substantiated. It was followed by physics as the science of various manifestations of being and by ethics. Canonics was part of physics as the first section, while ethics was constructed as a product of physics.

Democritus' philosophy distinguishes the "truly existing" and that which exists only in "common opinion". Only atoms and the void were seen as truly existing. As truly existent, emptiness (non-being) is the same reality as atoms (being). The "Great Void" is infinite and contains everything that exists, it has neither top, nor bottom, nor edge, nor center, it makes matter discontinuous and its motion possible. Being is formed by countless tiny, qualitatively homogeneous basic particles that differ in external shapes, size, position and order, they are further indivisible due to the absolute hardness and absence of emptiness in them and "are indivisible in size". Atoms in themselves are characterized by constant movement the diversity of which is determined by the infinite variety of the shapes of atoms. The motion of atoms is eternal and is ultimately the cause of all changes in the world.

According to Democritus, the goal of scientific acquisition of knowledge is to reduce the observed phenomena to the realm of "true being" and explain them based on the general principles of atomism. This can be achieved through the joint activity of senses and reason. The content of the original philosophical principles and epistemological attitudes determined the basic features of his scientific method: a) to proceed from the individual for the purpose of knowledge acquisition; b) any object and phenomenon are decomposable to the simplest elements (analysis) and are explained on the basis of them (synthesis); c) to distinguish between existence "in truth" and "according to opinion"; d) the phenomena of reality are separate fragments of the ordered cosmos which emerged and functions as a result of the actions of purely mechanical causality.

Democritus' mathematics should be rightly seen as the first section of physics as such immediately following canonics. Atoms are indeed qualitatively homogeneous and their primary properties are of a quantitative nature. However, it would be wrong to interpret his teaching as a version of Pythagoreanism, because, although he retains the idea of domination of mathematical regularity in the world, he is critical of the a priori mathematical constructions of the Pythagoreans believing that numbers should not be the arbiters of nature, but should be extracted from it. Democritus revealed mathematical regularity from the phenomena of reality and, in this sense, he anticipated the ideas of mathematical natural science. He sees the first principles of material existence, to a great extent, as mathematical objects and, according to this, mathematics is assigned a prominent place in the worldview system as a science of the primary properties of things. However, the inclusion of mathematics in the foundation of the worldview system required its reorganization and bringing mathematics in line with the original philosophical propositions, with logic, epistemology, and the methodology of scientific research. The so created concept of mathematics, which is called the concept of mathematical atomism, turned out to be essentially different from the preceding concepts.

All Democritus' mathematical objects (bodies, planes, lines, points) are presented in certain material images. There are no ideal planes, lines, points in his teaching. The basic procedure of the mathematical atomism is the decomposition of geometric bodies into the thinnest leaves (planes), planes into the finest threads (lines), and lines into the smallest granules (atoms). Each atom has a small but nonzero value and is further indivisible. Now the length of the line is defined as the sum of the indivisible particles contained in it. The question of the relationship between lines on a plane and planes in a body is solved in a similar manner. The number of atoms in a finite volume of space is not infinite, although this number is so big that it is inaccessible to the senses. Therefore, the main difference between the teachings of Democritus and those discussed above is his denial of infinite divisibility. As such, he solves the problem of validity of theoretical constructions of mathematics without reducing them to sensually perceived images, as Protagoras did. For instance, Democritus' answer to Protagoras 'arguments about the tangency of a circle and a straight line could have been that feelings, being Protagoras' starting criterion, show to him that the more precise the drawing is, the smaller is the area of tangency; whereas, in fact, this area is so small that it does not lend itself to sensory analysis, but belongs to the realm of true knowledge.

Being guided by the propositions of mathematical atomism, Democritus conducted a series of concrete mathematical studies and achieved outstanding results (for example, the theory of mathematical perspective and projection). According to Archimedes, he also played an important role in the proof by Eudoxus of Cnidus of the theorems on the volume of a cone and a pyramid. It is impossible to say with certainty whether he used the methods of analysis of infinitesimals when solving this problem.

Another outstanding achievement of Democritus in mathematics was his idea of constructing theoretical mathematics as a system. In its initial form, it represented the idea of construction of the axiomatic system of mathematics, which was further developed in terms of methodology by Plato and was logically explained in great detail by Aristotle.

The works of **Plato** (427-347 BC) are a unique phenomenon in terms of development of a philosophical concept. He, on many occasions, expressed his views on mathematics which was always highly esteemed by him: without mathematical knowledge, no person, regardless of any natural traits, will be blessed. In his Ideal State, he intended to approve by law and convince those who intend to occupy high positions in the city to practice the science of numeration. Plato systematically and extensively used mathematical material, first in his *Meno* dialogue, where makes the main inference with the help of geometric proof. It is the inference made in this dialogue that knowledge is recollection which became the fundamental principle of Platonic epistemology.

Plato's ontology was influenced by mathematics to a significantly greater extent that his epistemology. Plato offered the following interpretation of the problem of the structure of material reality: the world of things, which is perceived through the senses, is not the world of the truly existing; things continually emerge and perish. The true being is the world of ideas that are incorporeal, insensitive, and act in relation to things as their causes and images according to which these things are created. Further, in addition to sensory objects and ideas, he establishes mathematical truths that differ from sensory objects in that they are eternal and motionless, and differ from ideas in that certain mathematical truths are similar to each other, while the idea is always one and the same.

According to Plato, as matter, the first principles are the great and the small; and as the essence, the first principle is the whole, because ideas (which are also numbers) are obtained from the big and the small through their adherence to the whole. The world perceivable through the senses, according to Plato, was created by God. The process of the construction of the cosmos is described in the Timaeus dialogue

According to Plato, mathematical sciences (arithmetic, geometry, astronomy, and harmony) are given to man by gods who created numbers, gave the idea of time and supported the need for exploring the universe. The original purpose of mathematics is to purify and revitalise the organ of the human soul, upset and blinded by other deeds, which is more important than a thousand eyes, because the truth is observed by it alone.

He was also dissatisfied by his contemporaries' understanding of the nature of mathematical objects. Mathematicians of the time considered the ideas of their science as a reflection of the actual relationships of reality and, along with abstract logical reasoning, often used sensory images and geometric constructions in their studies. Plato tried in every possible way to convince them that the objects of mathematics exist separately from the real world; therefore, it is wrong to resort to sensory evaluation when studying them.

As such, in the established systems of mathematical knowledge of the time, Plato distinguished only a speculative, deductively constructed component and assigned it with the right to be called mathematics. The history of mathematics is mystified, its theoretical branches are heavily opposed to the computing tools and techniques, and the scope of its application becomes extremely narrow. In such a distorted form, some real aspects of mathematical knowledge did indeed serve as one of the foundations for the construction of the system of Plato's objective idealism, because, after all, mathematics as such does not lead to idealism at all and, in order to build idealistic systems, it has to be substantially deformed.

Plato also developed some important methodological problems of mathematical knowledge: the axiomatic construction of mathematics, the study of relationships between mathematical methods and dialectics, and the analysis of the basic forms of mathematical knowledge. Thus, the process of proof necessarily links a group of proven propositions to a system which is based on certain unprovable propositions. Since the first elements of mathematical sciences are the essence of an assumption, this can raise doubts about the validity of all subsequent constructions. Plato thought such doubts to be unreasonable.

According to his explanation, although the mathematical sciences themselves use assumptions, they leave them in a state of motionless and can not provide them with any foundation, such assumptions acquire foundations through dialectics.

Criticism, which was applied by mathematicians against Plato's methodology and philosophical system, for all its importance, did not address the very foundations of his idealistic concept. To replace the methodology of mathematics developed by Plato with a more productive system, it was necessary to critically analyse his doctrine of ideas, the main parts of his philosophy and, consequently, his view of mathematics. This mission was assigned to Plato's disciple, Aristotle.

Aristotle (384-322 BC) is revered as the First Teacher and the greatest philosopher of Antiquity. The main problems of philosophy, logic, psychology, natural science, mechanics, politics, ethics, and aesthetics, raised by the science of ancient Greece, were thoroughly and comprehensively covered by Aristotle. Apparently, he did not make any specific studies in mathematics, but he subjected the most important aspects of mathematical knowledge to a profound philosophical analysis that served as the methodological basis for the work of many generations of mathematicians.

By the time of Aristotle, theoretical mathematics had gone a long way and had reached a high level of development. Continuing the tradition of philosophical analysis of mathematical knowledge, Aristotle posed the question of the need for putting in order the knowledge about the ways of assimilating science, about the purposeful development of the art of cognitive activity, which includes two main components: "education" and "scientific knowledge of the subject matter".

According to Aristotle, the initial stage of cognitive activity is learning, which is based on (some) already existing knowledge ... Mathematical sciences, and each of the other arts is acquired (precisely) in this way. To separate knowledge from ignorance, Aristotle proposes to analyse all those opinions that are expressed by some thinkers in this regard and to consider the difficulties that may have occurred. Such analysis should be carried out in order to answer four questions: what (a thing) is, why (it) is, does (it) exist and what (it) is.

The basic principle that determines the whole structure of the scientific knowledge of the subject matter is the principle of reducing everything to the beginnings (or first principles) and reproducing everything from the first principles. According to Aristotle, the universal process of producing knowledge from the first principles is proof. By proof he meant syllogism, which provides knowledge. The entire of Aristotle's *Organon* is dedicated to the presentation of the theory of knowledge by proof. The main provisions of this theory can be grouped into sections, each of which reveals one of the three main aspects of mathematics as a proving science: that in respect of which something is proved; that which is proved; and that on the basis of which something is proved. As such, Aristotle distinguished **the object, the subject (matter) and the means of proof**.

For Aristotle, the choice of the first principles is defining in the construction of a proving science; it is precisely the first principles that characterise science as a specific science and distinguish it from a number of other sciences. That which is proved can be interpreted very widely. On the one hand, it is an elementary proving syllogism and its inferences. The building of a proving science is constructed as a separate theory from these elementary processes. These same processes created a **science as a system of theories**. However, not any set of proofs forms a theory. To achieve this, it must meet certain requirements covering both the content of the propositions being proved and the relationships between them. Also, within the framework of a scientific theory, a number of auxiliary definitions are necessarily required; while these definitions are not primary, they serve to reveal the subject matter of the theory.

Archimedes (287-212 AD) worked in that area of mathematics which is now called the integral calculus. He proved theorems on areas of plane figures and body volumes, found an approximate value of the Pi (the ratio of the circumference to the diameter) with the accuracy of about 0.01%, calculated the surface area and volume of a sphere and some more complex bodies, etc. Archimedes discovered the fundamental law of hydrostatics presenting it in a form that can still be found in many textbooks: Any floating object displaces its own weight of fluid.

Mathematics in the ancient world and during the following historic periods was inextricably related to astronomy. During the Hellenistic period, astronomy became a strict quantitative discipline by having lost its natural-philosophical, cosmological properties.

Hipparchus of Rhodes (or Hipparchus of Nicaea) (circa 180-123 AD) was the first to use the method of adding several uniform circular motions, which had been proposed by the mathematician **Apollonius of Perga**, to describe complex uneven motions of celestial bodies. By using his model, he was the first to compile tables for calculating the moments of solar and lunar eclipses.

The mathematical description of astronomical phenomena reached its peak in the system of the Alexandrian astronomer and geographer **Claudius Ptolemy**. The geocentric theory of Ptolemy was based on Aristotle's ideas: the motionless Earth is in the center of the world and the planets and the Sun revolve around.

4.5 Science in Central Asia, the Near and Middle East in the Middle Ages

The spread and establishment of Christianity in the Roman Empire led to closing philosophical schools and academies and to the expulsion of philosophers and scholars who found shelter in the Middle East, particularly Syria and Iran, where, with the development of cities and urban life, philosophical schools and schools of thought, translation centers, libraries, and, eventually, academies, were emerging. In addition to philosophical and theological teachings, "Houses of Wisdom", religious and cultural centers of the time, studied medicine, mathematics, astronomy, and geography. Translations from Greek into the Syriac, Pahlavi, and Arabic languages of the works of outstanding thinkers of Antiquity were also produced here. The East preserved the ancient philosophical and scientific heritage for the West. With the formation of the Caliphate, cultural and scientific ties expanded, and scholarly research becomes more profound and goal-oriented. This was fully in line with the spirit of Muslim faith which had not yet become too rigid in the grip of dogmatism.

The translation movement was thriving in all the countries of the Caliphate. In the 9th century, its center was the House of Wisdom in the Syrian capital Baghdad, which was founded by the Caliph Harun al-Rashid. Arabic-speaking scholars were familiar with all main scholarly and philosophical works of the Greco-Roman world: the astronomy of Ptolemy, the works of Euclid and Archimedes, Hippocrates, Galen, Plato, Aristotle, Porphyry, and others.

Development of Mathematical Knowledge, Algebra. Medicine, Logic, and Other Sciences (al-Khwarizmi, al-Kindi, al-Farabi, Ibn Sina, and others).

The aspiration to knowledge through reason made in possible for the medieval Arab-Islamic culture to reach the full flowering of philosophical thought in two centuries, which made a milestone in the development of the culture of all mankind. The achievements of this thought were largely determined by the fact that philosophy was closely related to the activities of philosophers as scientists – they encouraged the birth and consolidation of the most advanced ideas in philosophy and philosophy, in its turn, promoted their search for knowledge. Thanks to **its union with science, philosophy** entered the realm of practice by bringing out thought from the field of pure speculation and revealing its relationships with life.

Both religious and secular philosophical knowledge was aimed at finding a reliable foundation, but there was a significant difference between them. Religious knowledge was guided by the other world; therefore, the knowledge of the earthly world played in it the supporting role of approaching the other world, while philosophical and scientific knowledge was directed at comprehending the earthly life, the natural world. The mathematician **al-Khwarizmi** (780-930) wrote about the goal of his mathematical treatise *The Compendious Book on Calculation by Completion and Balancing* that he compiled a short book containing simple and complex questions of arithmetic, for this is necessary for people in dividing their inheritance, drafting wills, dividing property and in court cases, in trade and all sorts of transactions, as well as in measuring land, building canals, in geometry and other such dealings.

The history of science of the Muslim East is the evidence of its interest in experimental knowledge and organisation of the practice of experimental observation. Although scholars were not fully financially secure, some rules provided funding for those studies that were of interest to them. There were even institutions similar to the modern research centers and scientific communities with sophisticated equipment such as Astronomical Observatory of **Nasir al-Dīn Tusi** (13th century) or the **Ulugh Beg** Observatory near Samarkand (15th century). The famous Housed of Wisdom were established in the 10th century. Arabic scholars had advanced knowledge in many fields: mathematics, astronomy, physics, optics, chemistry, medicine, etc. This contributed to the development of philosophy, to its development of the methodology of scientific knowledge, its mechanisms, and elements, as well as the place of experimental knowledge in it.

The great chemist of the time **Jabir ibn Hayyan** proclaimed experience as the basis of scientific research. According to him, the duty of those concerned with the sciences of physics and chemistry is to work hard and carry out experiments. Knowledge is acquired only through them.

Arabic-speaking philosophers made attempts to develop a single consistent theory of knowledge supplemented by the Sufi mystic gnosis, Zoroastrianism and Buddhist self-contemplation. This philosophy, as part of the Islamic culture, did not have its own previous stage, but, nevertheless, **in the period from the 9th to the 10th centuries, it formed as an independent discipline with its own range of problems and vision of the world.**

Abu Yūsuf Ya'qūb ibn 'Isḥāq aṣ-Ṣabbāḥ al-Kindī (800-879) was among the first in the medieval East to actively engage in translation of the works of ancient philosophers. He was the founder of the Arabic-speaking philosophy and earned the title of "the philosopher of the Arabs".

He is known as a physician, mathematician, astronomer, translator, and commentator of Aristotle's and Plato's heritage. Paying a due tribute to theology, al-Kindi, nevertheless, sharply criticised "narrow-minded people", i.e. extreme zealots of faith who, as he put it, trade in faith, but are themselves enemies of faith and truth. In opposition to Muslim theologians who denied the possibility of learning about life with the help of science and were satisfied with the revelations of the Holy Scripture, the "philosopher of the Arabs" considered human reason the only source and criterion of knowledge about reality. He distinguished knowledge acquired by the senses and reason. The knowledge through reason is accessible to humans only and it is built on evidence and proof. For him, as for Aristotle, philosophy is the basis and the ultimate point of the encyclopaedic scientific knowledge acquired by other sciences. Philosophy provides knowledge about the true nature of things. The most famous al-Kindi's works are *On First Philosophy, On the Quantity of Aristotle's Books and What is Required to Attain Philosophy,* and *That There are Separate Substances*. In these works, he is represented as a follower of Aristotle, a rationalist who opposes knowledge to faith, as polymath who widely uses the knowledge of the natural sciences, as well as the data and research methods of a corpus of mathematical sciences -- arithmetic, geometry, astrology, and harmony. Al-Kindi believed that harmony is present in everything, and most clearly it is found in sounds, in the structure of the Universe, and in human souls.

Al-Kindi was convinced that the world is knowable. He developed and provided justification for the concept of three levels of scientific knowledge: 1) logic and mathematics; 2) the natural sciences; and 3) metaphysics. Following Aristotle, he offers the most general definitions of being as matter, motion, space and time, and form. In the book entitled *That There are Separate Substances*, al-Kindi describes matter as the fundamental, determining substance, from which all things are made. The study of mind – noology – was given more attention by the Arab-Muslim Peripatetics compared to Aristotelianism. Al-Kindi was the first to engage in these studies. In his treatise *On the Intellect*, he presents a classification of the kinds of reason or mind, with references to Aristotle's *On the Soul*. The Aristotle of Stagira described four types of intellect: the first is active, it is constantly in motion; the second is potential and it belongs to the soul; the third is in transition from the potential state to the active state; and the fourth is the manifested (appearing from the soul) type of intellect. In other words, it is the mental activity of the subject which is directed outwards.

Al-Kindi's interpretation of the active mind is more profound than that of Aristotle. He expands and further elaborates the problem articulated by the First Teacher. Ibn Sina and al-Farabi followed suit and further developed this tradition. According to al-Kindi, the active intellect is the universal Logos which makes up the substance of the mind. A polymath and a free spirit, al-Kindi was convinced that for the seeker of truth, there is nothing greater than truth itself and indeed sought to know the truth. In doing so, he presented the views of the Ancient philosophers as well as his own views in the most careful and clear manner.

Abu Nasr Muhammad ibn Muhammad ibn Tarkhan ibn Uzlag al-Farabi (870-950) was an outstanding thinker, a follower of Aristotelianism, a native of the city of Farab (Otrar). He lived in the era when the Arab Caliphate strengthened the ideological authority of the Muslim faith, but in the Middle East urban life was flourishing, the economy was developing and the demand for scientific knowledge and philosophy was still great.

Al-Farabi started learning about sciences and philosophy in Baghdad. Like other philosophers of his time, he was also a physician, musician, poet, rhetorician, was thoroughly informed in the achievements of the natural sciences. But, above all, he was a philosopher and in this capacity rivalled not only al-Kindi, but Aristotle himself, whom he regarded as his teacher. Al-Farabi learned and critically reviewed the achievements of the Ancient philosophers, collected and organised the whole corpus of Aristotle's *Organon*, wrote comments to all his works and finalised the logical legacy of the Stagirite taking into account the latest achievements of science and the requirements of the medieval ideology. His achievements in the development of logic and music theory were so great that al-Farabi to this day is referred to as the "Second Teacher" (Al-Muallim Al-Thani), after Aristotle.

Al-Farabi's presents his ethical-social doctrine in several of treatises. He emphasises that the main goal of human activity is happiness. It can not be attained without knowledge and free will. Happiness is the goal of man. To achieve it, one needs knowledge, will and freedom. Will is related to sensory cognition and freedom is related to logical reasoning. Only together we can achieve happiness. In his *Treatise on the Principles of the Opinions of the Citizens of the Virtuous City*, al-Farabi, following Plato and Aristotle, offered his own model of an ideal state. He is convinced that it is easiest for people to achieve happiness and virtue within a particular city. Al-Farabi compares the classes inhabiting such a city state to parts of the human body: all the organs in the body are interrelated and help each other to maintain the health of the body. The emphasis is made on the ethical and moral problems of the human society. But the most valuable here is that al-Farabi was the first in the East to raise and try to solve issues of social life.

In this treatise, great attention is given to universal worldview issues, and the last chapters are dedicated to ethical and social problems. Al-Farabi presumes that the human mind is the manifestation of the rationalistic spirit of the deity, which calls to action, to distinguishing good from evil. The task of the state and society should be aimed at meeting the needs of man. To successfully solve this problem, a virtuous, reasonable, strong-willed, and enlightened person should be the head of the state. He must have both spiritual and secular authority, be virtuous, have a healthy body and spirit, and be wise. Such a learned ruler will create conditions for the spread of education and science, which will teach people to curb their irrepressible passions, to love and to be tolerant of others. He believed that a virtuous city is a city in which people unite for mutual help in the deeds by which true happiness is obtained.

In his classification of sciences, al-Farabi assigned the most important place to metaphysics as the divine science. He dedicated the first section in the classification of sciences to grammar, the science of languages. He emphasises here the universal nature of the laws governing the words of a language. The second section is dedicated to logic. For al-Farabi, logic is not merely a science, but an art akin to grammar. The relationship of logic to intellect and to the intelligible objects of intellect is the same as the relationship of grammar to language and words. Al-Farabi's logic is a science of proper reasoning, which is based on the laws of Aristotle's *Organon*. Logic precedes any type of knowledge and is used to acquire reliable knowledge and the measure of knowledge. The third section is about mathematics, by which he meant a number of sciences: arithmetic, geometry, optics, astronomy, and astrology. Notably, he distinguished applied and theoretical arithmetic and geometry, which is the evidence of the high level of differentiation of knowledge of his time. Al-Farabi placed the Earth in the centre of the Universe and believed that it has the shape of a sphere. His "Science of the Stars" covers astronomy, astrology and physical geography, i.e. the study of the inhabited and uninhabited parts of the Earth. The following sections are dedicated to music; the science of weights; the science of skilful building techniques, carpentry, etc., algebra as the science "on numerical tricks" which is shared by both arithmetic and geometry.

The fourth, final, section of the classification is comprised of two sciences: physics as a natural science dealing with the study of natural and artificial bodies; and metaphysics. In metaphysics, al-Farabi makes a clear distinction between ontology and epistemology and it is exactly here that he surpasses the Stagirite. His epistemology reveals the substance and the distinctive properties of things and phenomena based on logic, mathematics, and physics; whereas the main subject of study in ontology is God. Hence the title of metaphysics as the "divine science".

The Second Teacher's philosophical explanation of the issue of God is similar to the Neoplatonic Absolute. This allows al-Farabi to explain the emergence of the world: he distinguishes to kinds of being – things probably existing, which may or may not exist. Their existence requires external causes. The second kind of being (things) does not require any external cause, because their existence is absolutely necessary and the highest variety of such being is God. God is the beginning of the beginning, the first in existence. In God, the subject and the object are the same. God possesses absolute knowledge, will, omnipotence, he is incorporeal, one, indivisible, devoid of opposites, and is "a pure intelligible and pure intellect". In the process of emanation of God, the conditions for the evolution of various spheres of existence – the celestial and terrestrial elements, nature and man – are created consistently.

In the study of the soul (psychology), an active constituent component of which is intellect (the mind), al-Farabi identifies the active mind with eternally existing universals. And here his interpretation becomes similar to that of Plato and brings together two systems – Aristotelianism and Neoplatonism. Al-Farabi, in particular, considers the mind through such concepts as "soul", which he calls the "material mind". At the same time, he notes its ability to take universal forms and also distinguishes the "potential" and the "active" mind. This is Plato's realism which poses the eternal question of the theory of knowledge: **what is the source of the universal and necessary nature of our thinking?**

According to al-Farabi, the human soul is a substance which is completely different in nature from the body, but at the same time it depends on it. The body cannot function without the guidance of the soul. There is no reincarnation. The human soul (intellect) strives to know the essence of God. Kowledge is impossible without reliance on feelings. But at the sensory level, it is impossible to know either the essence of being, or the divine essence. This can only be achieved by reason or the mind which does not depend on the body and which al-Farabi divides into the **passive** (potential) mind which makes generalisations based on sensory data and images; and the **active** (actual) mind which does not depend on corporeality and materiality. The mind is a pure form capable of acting and comprehending what is outside it. The actual mind, enriched with acquired knowledge, acts comprehending the spiritual and cosmic forms and God as the highest form among them. The doctrine of the mind and intellect acquires an ontological and cosmological character. The "Second Teacher" merges together the Neoplatonic concept of emanation and the Aristotelian cosmological system.

Avicenna (Ibn Sina) (circa 980-1037) is known in the East at the "Prince of Physicians and Philosophers". This physician, jurist, astronomer, poet, musician and philosopher wrote more than 100 books and, like other Peripatetics was persecuted by orthodox adherents of Islam. What in the teachings of Avicenna made the theologians unhappy? He refuted the attacks of the orthodox theologians on philosophy insisting that the role of reason in knowledge is indisputable and further developed the ideas of Aristotelianism in metaphysics, epistemology, and logic; while in ontology he adhered to the concept of Neoplatonism rejecting the creation of the world in time.

The main philosophical work of Avicenna is *The Book of Healing* which covers the foundations of logic, physics, mathematics, and metaphysics. He regards all things as atemporal emanation of God.

Avicenna distinguishes theoretical (speculative) and practical knowledge. According to his classification of sciences, theoretical sciences are not directly related to human actions, but they help them in finding their place in this world. These sciences include the most supreme of sciences, metaphysics, i.e. the science of being as such and of what is beyond nature; the medium science is mathematics which represents a corpus of independent sciences (arithmetic, geometry, optics, astronomy, and music); and the lowest science is physics which is the science of nature. Practical sciences are ethics (the science of human behaviour), economics (the science of economic management), and politics (the science of management of the state and the people).

This classification is similar to that of Aristotle, but it takes into account the new realities. Avicenna's achievement here is that he highlighted the relationship between metaphysics, as the most general study of being and knowledge, and specific, specialised sciences. Like in Aristotelianism, he considered logic to be the measure of sciences and the foundation for philosophical or any other kind of knowledge.

Avicenna's philosophy is realistic and includes elements of mysticism and materialism. Ibn Sina was one of the founders of the Arabic Peripatetic movement, but his knowledge in the natural sciences is more profound and through compared to Aristotle. In his views, he is similar to the Ismailites, who had theocentric views and believed that the world is the creation of the divine mind, but not will, because God's will is subordinate to his mind and emerges from it. The world was created gradually, by way of emanation and it is material. Matter is eternal. Human soul is immortal and it is the spiritual form of the body. He believed that the intelligent soul is immortal. He explained the distinctive property of the incorporeality and immateriality of the intelligent soul through the immateriality of reason, i.e. **its ideal nature**. In other words, in his description of the ideal nature of thought, he distinguishes such functions of the human brain as the senses, the imagination, and dreams. These functions of the human mind demonstrate that man is not simply corporeal. What he wants to know is whether man can establish the existence of his substance without questioning that he exists in his substance? The level of development of man's soul makes him similar to angels and the substitute of God on the Earth. For Avicenna, as for Aristotle, God is the form of forms, the original cause. The most popular in the West was Avicenna's *Canon of Medicine* which, for many centuries, was used in European universities as the textbook on the theory and practice of medicine.

While Avicenna was renowned as the Prince of Philosophy in the eastern part of the Caliphate, the Prince of Philosophy of the Arab-speaking West was **Averroes of Cordoba** (Ibn Rushd) (12th century). He was a physician, a jurist, a theologian, an Arab Peripatetic whose treatises, rejected by Islamic theologians, have survived thanks to the Spanish Jews.

Like all Peripatetics, he provided arguments proving the dominant role of reason in acquiring knowledge. He insisted that God is not the original cause, but that he had co-existed with the world; therefore, he is as eternal as nature. The material world is eternal, infinite, but limited in space. Unlike Aristotle, who regarded God as the first cause, the form of forms, Averroes believed that the eternal, indestructible matter has always contained all forms and that it is not God who turns these potential forms into reality, but they manifest themselves in the process of the evolution of matter. Ibn Rushd rejected the idea of the immortality of the individual soul. The soul is feelings and memories acquired by man. It dies together with a particular individual.

By further developing this idea, Averroes distinguishes the passive and active mind. The passive mind is inseparable from a particular person, from his intellect. The active mind is by nature universal and one intellect and it is eternal. As such, the common mind of mankind is eternal, it is constantly developing and, from this perspective, it can be compared to the divine mind and is similar to it. The minds of different individuals is part of the universal mind of the entire mankind, is related to it, but it is finite. He completes the Arab falsafa (philosophy) which had a great impact on the development of the Medieval European philosophy, in particular, on Thomas Aquinas, Siger of Brabant, and others.

The works of the outstanding scholar al-Bruni describe dawn and dusk, high and low tide, rain, thunder, the Moon during the eclipse, precious stones, their properties, etc. But it was the actual work of scholars that led them to a deeper understanding of the significance of experience, to the use of a carefully prepared experiment. Examples of this are their experiments in physics, studies of the properties of minerals, studies of the pharmaceutical properties of plants and minerals, etc. Although experimental practice was not yet acknowledged as the main component of a scholar's research efforts, observation remained the dominant method of obtaining new knowledge and speculation was the main general characteristic of knowledge, the science of the Arab-Muslim East was experiencing a serious new trend that distinguished this science from Ancient science and brought scientific thought to a new level. Experimental practice provided additional support to the mind which was seeking a reliable foundation -- it was in the process of acquiring a methodological tool that strengthens the possibilities of the mind.

The Arab-Islamic philosophy also contributed to the flourishing of socio-political thought which marked one of the directions of its future development. **Ibn Khaldun** (1332-1406), who lived and worked in the Arab West, was, according to a number of researchers, a harbinger of sociology, although he had no influence on its formation and development. He became famous for his fundamental work *Kitāb al-'Ibar* or *Book of Lessons* (full title: *Book of Lessons, Record of Beginnings and Events in the History of the Arabs and the Berbers and Their Powerful Contemporaries*). The Introduction to this work – *Muqaddimah* (or *Prolegomena*) –itself represents an encyclopaedic work which reflected the cultural life of the Arab Middle Ages and the knowledge it possessed: the information about land and climate, the history of different peoples, the emergence and collapse of states, about agriculture, trades and crafts, about finance, sciences, arts, etc. He accompanies the description of the socio-economic and political life of the era with his analysis of society and the explanation of the principles of "social physics", the science of the nature of society.

The core of Ibn Khaldun's concept is the desire to reconcile the destiny of the state and civilisation with the changes in its economy. He demonstrates how, as a result of the surplus product in the community, primitive communal relations die out which is followed by the emergence and formation of a different type of relations which results in the establishment of a state. The distribution of the surplus product and eventually of part of the necessary product within it and in the interests of its apparatus leads to the stagnation of civilisation and to the death of this state. Ibn Khaldun's historical descriptions depict the life of civilisation and state as elements of the science of society and it is this quality of his work that puts him in line with such later European thinkers as Machiavelli, Vico, and Montesquieu.

4.6 The Distinctive Features of the Formation of Science During the Renaissance Era

Traditionally, the beginning of the first scientific revolution is counted from 1543 when the book of Nicolaus Copernicus (1473-1543) *On the Revolutions of the Celestial Spheres* was published. Using the achievements of mathematics and astronomy of his time, he presented his revolutionary views on the kinematics of the solar system as a a rigorous, convincing theory. It should be noted that during the time of Copernicus, astronomy did not yet possess methods that directly proved the revolution of the Earth around the Sun (such method was discovered almost two hundred years later).

According to the then traditional theory, the entire heliocentric system of the world is presented only as a way of calculating the visible celestial bodies, which has the same right to exist as the geocentric system of the universe of Claudius Ptolemy and Aristotle. The views of Copernicus regarding his new system of the world was completely different. His book contains theorems from planimetry and trigonometry (including spherical) necessary for the author to construct a theory of planetary motion based on the heliocentric system.

Nicolaus Copernicus presented a beautiful and convincing proof that the Earth has a spherical shape based on the arguments of ancient scholars and his own arguments. Only with the convex surface of the Earth, when moving along any meridian from north to south, the stars in the Southern Celestial Hemisphere rise above the horizon, and the stars in the Northern Celestial Hemisphere descend to the horizon or completely disappear beneath the horizon. But, as Copernicus correctly notes, only with the spherical shape of the Earth, movements at the same distance along different meridians correspond to identical changes in the heights of the celestial bodies above the horizon.

All works of Nicolass Copernicus were based on a single principle which was free from the prejudices of geocentrism and amazed the scientists of the time. This is the principle of relativity of mechanical motions, according to which any motion is relative. The concept of motion does not make sense unless a reference frame (coordinate system) in which it is being considered is selected.

The original views of Copernicus on the dimensions of the visible part of the Universe are also very interesting. According to him, the sky is immeasurably large in comparison with the Earth and is infinite in size; according to our feelings, the Earth compares to the sky as a point to the body, and as the finite to the infinite in size. From this, we can see that Copernicus had correct views on the size of the Universe, although he believed that the origin of the world and its development was caused by divine forces.

The Copernican theory shows that only the heliocentric system of the world provides a simple explanation for the fact that the magnitude of the direct and retrograde motion of Saturn in relation to the stars is smaller than that of Jupiter, and for Jupiter it is smaller than that for Mars, but the number of the alterations of direct to retrograde motions of Saturn per revolution is greater than that of Jupiter, and for Jupiter it is greater than than that for Mars. If the Sun and the Moon always move in the same direction among the stars from west to east, then the planets sometimes move in the opposite direction. The explanation provided by Copernicus for this interesting and mysterious phenomenon was absolutely correct. All this is explained by the fact that the Earth, in its motion around the Sun, catches up with and overtakes the outer planets – Mars, Jupiter, and Saturn (and the later discovered Uranus, Neptune, and Pluto), and itself in turn also is overtaken by the inner planets, Venus and Mercury, for the reason that they all have different angular velocities.

- Self-Checking
- The science of the Ancient East
- Ancient Greece and the cradle of science
- Scientific knowledge in the West during the Middle Ages
- The Science of Central Asia, Near and Middle East during the Middle Ages.
- The heliocentric system of the world.

CHAPTER 5

Modern European Science – the Classical Period of the Development of the History and Philosophy of Science

5.1 Philosophy as a Form of Reflection on the New Science: the rationalism and the idea of mathesis universalis of Rene Descartes; Empiricism of Francis Bacon.

Francis Bacon (1561-1626), the Italian physicist **Galileo Galilei** (1564 - 1642) and the English physician **William Harvey** (1578-1657), who recognised the necessity of the natural unity of practice and theory, are thought to be the founders of the modern science. In his main work *The New Organon* (1620), Francis Bacon proclaimed the principles of experimental and theoretical studies of nature. Galileo Galilei applied the experimental method in practice providing it with such modern features as constructing an idealised model of the real process, disregarding non-essential factors, numerous repetition of experiments, etc. He brought back to life Archimedes' mathematical approach to the study of natural phenomena, proclaiming, after Leonardo, that the great book of nature is written in the language of mathematics. He showed that a ball rolling along an ideally horizontal plane will continue its movement until the plane ends (this preceded the law of inertia). His discovery of the property of a body to maintain its speed helped him to explain why weights fall vertically on the revolving Earth, the wind does not constantly blow from east, and birds are not torn down against the revolution of the Earth (these are common arguments of the proponents of the motionless Earth). The history of the science of biology is traced back to 1628 when William Harvey published his book *On the Motion of the Heart and Blood*. The works of these great thinkers determined the formation of the methodology of acquisition of scientific knowledge in which theory and experiment are dialectically inseparable.

Knowledge of the world becomes the central theme of philosophising in the Modern Ages. All disputes are not about how to create a theory of the world or a theory of being, but about what a theory of knowledge can be. Philosophers pass the right of theoretical description of the world to physicists, chemists, and biologists, bur reserve the themes of **object and subject, subject matter and method, truth and error**. The central figures in the formation of the modern European theory of knowledge were **Rene Descartes, John Locke, David Hume, and Immanuel Kant**. The question of whether the world is knowable becomes the main subject of the scientific debate of the time.

In many respects, the interest in the construction of a philosophical theory of cognition was determined by the onset of a new era – the era of **scientific and technological revolution**. This era begins with the motto "Knowledge is Power" of Francis Bacon who opposed the speculative nature of the old philosophy stating that knowledge should be based on experience and expand man's power in his use of nature. At the same time, the Italian Galileo Galilei puts into practice the program of Pythagoras and Plato by creating mathematical natural science. The sphere of imperfect and variable matter is described with the help of perfect and invariable numbers and figures. At the heart of mathematical natural science is the experimental study of the properties of nature with a view of its mathematisation. The followers of Galileo **Isaac Newton, Gottfried Leibniz**, and others laid the foundation for the modern European science which is based on the adaptation of natural processes for mechanical devices.

The second important element of the philosophy of this period was the so called **Cartesian Paradigm** proposed by Rene Descartes, the author of the proposition "Cogito, ergo sum" (I think, therefore I am). This truth, which is most obvious of all, should, according to the French philosopher, justify other obvious evidence from which the rest of the knowledge can be derived. Like Francis Bacon, Rene Descartes seeks to overcome the legacy of speculative metaphysics which was abound with "unobservable substances" and "hidden qualities" that proliferated during the period of scholasticism. According to the Cartesian Paradigm, the philosopher begins his reasoning not with statements about the world, but with **obvious internal experience**, which was considered more reliable. The subject is transferred from the external world to the inner world of the thinking being. The philosophy of the Modern Ages was characterised by the struggle between two epistemological concepts: **rationalism and empiricism**.

Rationalism (from Latin – reason, mind) gives priority to logical foundations of science. Ideas (or thoughts and conceptions which are apparently inherent in man or constitute his innate abilities) are thought to be the primary source of knowledge. But rationalism is unable to answer the question of how these ideas can provide truth and accurate knowledge of the world and what guarantees the truth. The most outstanding representatives of rationalism of that time were **Rene Descartes, Benedict (Baruch) de Spinoza, Gottfried Leibniz**, and a number of other thinkers.

The other philosophical movement – **empiricism** (from Greek *empiria* – experience) argues that all knowledge is derived from experience and observation. At the same time, it remains unclear how scientific theories, laws and concepts, which cannot be obtained directly from experience and observations, emerge. The most outstanding representatives of this empiricism were **Francis Bacon, Thomas Hobbes and John Locke.**

The debate between the rationalists and sensualists was resolved by Immanuel Kant who proved that the source of man's propositions and statements about the world are not in his reason, mind or senses. According to Kant, the source of knowledge is the **active learning subject who synthetises the sensual content of sensations with rational forms**. Man does not learn about things in themselves, but only about phenomena describing them based on experience and specialised sciences. Natural scientists realized that reason only sees what it creates according to its own plan. As such, Kant concludes, it is not the subject that revolves around the object, but the object revolves around the subject. He also states that it is not metaphysics (the study of the principles of being) is the foundation of all sciences, but the **critical theory of knowledge** (the study of methods and categories of reason, the senses and the mind).

According to their understanding of the nature of cognitive attitude, an individual must impose significant methodological limitations on his efforts which are aimed at obtaining new knowledge. This ensures that he "turns" from an ordinary person into a **learning subject**. To become a learning subject is necessary in order to exclude as much as possible the negative influence of emotions, interests, past experience and attitudes that are inherent in each individual and are conditioned by his nature. They can not be destroyed, but procedural restraints can be put into effect. According to the general plan, the doctrine of method and the philosophical theory of cognition are aimed at achieving this goal.

Representatives of French Enlightenment denied the existence of the supernatural and explained nature proceeding from nature itself, based on data from experimental natural science whose base was much broader than that of the materialists of the 17th century: **biology, chemistry, and geology** were finally formed as independent scientific disciplines in the **18th** century. At the same time, the solution of the basic question of philosophy acquired new shades and aspects.

Relying on scientific data, French materialists further developed the theory of matter as the only reality which possesses an infinite variety of properties: the entire nature is in the state of constant motion and development – everything is perished in one form and is reborn in another (the universal fermentation in the Universe). All relationships between causes and actions in nature is dominated by the strictest necessity: nature in all its phenomena and manifestations operates necessarily. Through movement, the whole interacts with its parts, and the latter interacts with the whole. The universe is merely an immense chain of causes and effects, continuously flowing from each other. Material processes exclude any chance or purposefulness. Chance is merely subjective ignorance of causes.

In this regard, matter was thought to be made up of indivisible particles of a certain substance: for instance, **Holbach and Helvetius** called them atoms which have geometrically mechanical properties (density, length, gravity, inertia forces, and mobility); and **La Mettrie and Diderot** called them molecules, which, in addition to these properties, have extra sensitivity and inexhaustible inner strength.

The collision and merging of heterogenous elements creates a variety of forms of matter, while matter is internally active, it does not need an external engine and, therefore, **Diderot** argues, there is a transition from the inert molecule to the living molecule. He also claims that the first elements of the world are not mechanical atoms, but organic molecules that have sensory capacities. After having merged under favourable conditions, they produced animals and, with further changes in the external conditions, animals themselves also change (the actively functioning organs get bigger, the inactive ones become atrophied), and then these changes are inherited by the following generations (the idea of natural selection).

In their concepts of causality, French materialists identified it with necessity, and chance was characterised as subjective ignorance. Relying on the concept of causality, they came close to the theory of evolution; for example, La Mettrie, trying to answer the question of what causes the changes of the species of plants and animals, offered various ideas akin to the idea of natural selection. He among the first to offer a scientific explanation of the origin and evolution of life on earth: live embryos enter the ocean from the air; these embryos, under the influence of the sunlight when the ocean is drying up, are transformed into living beings. Then simple organisms and complex organisms (humans) emerge. He also substantiates the thesis about the origin of man from animals making an anatomical comparison of man and animals. Diderot's concept of the unity of matter and consciousness, which served as the basis for the rejection of the existence of the immortal soul, also relied on deterministic approaches.

The rejection of supersensible, a priori, innate knowledge and the justification of the possibility of constantly expanding and deepening knowledge are the main features of the theory of knowledge of French materialism. It is based on the rejection of agnosticism and Descartes' concept of innate ideas, on the consistent development of Lockean sensationalism: i.e. sensations that are the source of all knowledge occur as a result of the influence of the external world on the sense organs while inner experience and reflection are subordinate to it. Ideas are images of objects which cause sensations, the truth is the conformity of ideas about things to the things themselves and it is verified through experience and experiment. In this regard, reflection was understood by analogy with the physical reflection of light rays and the mind was interpreted as a simple ability to summarise sensory data. Observation, reflection and experiment are the main methods of acquiring knowledge.

The French Enlightenment had a profound effect on the development of the advanced philosophical, social and political thought of Europe, America and Asia. Philosophy and social and political theories of the French Enlightenment provided an ideological foundation for the French Bourgeoise Revolution of 1789 – 1794. These theories sought to find a solution to the problem of harmonious combination of personal and public interests in the process of changing the social environment and educating man. This being said, laws should contradict the natural qualities of man and these natural qualities and needs must be understood.

As such, the following chain emerged in the Enlightenment worldview: natural - reasonable - useful - good - lawful - knowable - feasible. At the same time, deviations, twists and turns away from natural progress due to ignorance are real in the historical process, but the return to the norm is also real and natural. Therefore, there are two parallel trends in the history of mankind: enlightenment - wisdom - good - progress - love for knowledge - free-thinking - atheism - the rule of reason - happiness and ignorance - stupidity - evil - stagnation - religious bigotry - political despotism - misfortune. Each element of the second chain is a deviation of a corresponding link of the first chain. And these chains operate in cycles.

The worldview of the representatives of the French Enlightenment, even taking into account the numerous dialectical insights in their views on nature and society, was generally metaphysical. They saw Newtonian mechanics as the ultimate conclusion about the fundamental foundations of natural and social being, the foundations which are absolutely identical under any conditions in all corners of the Universe.

With respect to nature, it meant that nature is constant and immutable: Holbach, for instance, offered a concept of natural cycles in which the sum of substances and elements is a constant. In public life, such constants were human nature, needs, the pursuit of happiness, the equality of all with respect to natural rights, dependence on the environment and the ability for the gradual, steady development of one's own mind.

In terms of knowledge, mechanicalism and metaphysics merged with the absolutisation of everyday experience: knowable is something that is observable and, therefore, can be expressed in mechanical models. Notably, chance was excluded from this approach and it was regarded from the perspective of materialistic fatalism as a minor cause capable of bringing about significant consequences.

As such, the Enlightenment, which saw itself as a new era, believed that the cure against all evils was in the dissemination of knowledge, had an optimistic view on the possibilities of social progress, and tried to make man aware of his own nature.

The English Lord Chancellor **Francis Bacon** (1561-1626) was the founder of the **empirical** (experimental) method of acquiring knowledge in European philosophy. Philosophy for him is the science of the real world which relies on experiential knowledge. According to Marx and Engels, Bacon was the founder of English materialism and all modern experimental science. Bacon believed that the the primary role in the acquisition of knowledge should be given to natural sciences which are based on observation and experimental data. The responsibility of the mind is to process this data and to systematise and find the cause and effect relationships between phenomena.

In his work **The Great Instauration**, the treatise **The New Organon**, and the utopia **The New Atlantis**, he presents the essence of his philosophy as the idea that knowledge based exclusively on experience and on the **inductive** method of knowledge acquisition which relies on it. But this approach alone is insufficient for the acquisition of reliable and comprehensive knowledge, as is insufficient is the use of the opposite, rational, method. The truth is in the middle. Using simple and clear examples, Bacon clarifies his position: **empiricists** are like ants, they only collect and use what has been collected; **rationalists** are like spiders spin webs out of themselves. The bee takes the middle course: it gathers its material from the flowers of the garden and of the field, but transforms and digests it by a power of its own. In his work *The New Organon*, Bacon concludes: "Not unlike this is the true business of philosophy". He sees himself as the bee who skillfully synthesises both methods and understands that "**Knowledge is Power**".

In his main work, the life-long project *The Great Restauration*, Bacon defines philosophy as a science about the real world the subject matter of which must be the objective reality comprehended through the senses. Sensual perception, together with experience and experiment, becomes the starting point of his "**new inductive method**" which is based on observation, analysis, comparison, and experiment. This is true induction which provides keys to interpretation.

Bacon says that in the process of acquisition of knowledge, man is faced with obstacles. These are the old theories and prejudices, the so called **idols**. In his concept of idols, Bacon distinguishes four types of false prejudices:

Idols of the Tribe are common to everyone, because we all tend to confuse our own nature with the nature of things. The reason for this is in natural causes (the level of intelligence, life experience, etc.).

Idols of the Cave are fallacies caused by individual factors (one's upbringing, blind submission to authority and the opinions of others…).

Idols of the Marketplace are fallacies of people caused by the incorrect interpretation of words or information (they are similar to miscommunication, gossip and market rumors).

Idols of the Theatre are the result of the wrong theories and dogmas that are accepted at face value.

Bacon believes that Idols of the Tribe and the Cave are "innate" (they are the result of natural, universal and individual properties of the human mind) and that Idols of the Marketplace and Theatre are acquired and socially conditioned.

According to Bacon, idols (false notions) are preconceived, obsessive ideas or fixations that interfere with the process of acquiring knowledge. They can and should be eradicated. For this purpose, he developed the method of acquisition of reliable knowledge.

In the early Modern Ages, there was no science as we understand science today. Working on The Great Instauratoin, Bacon, like his younger contemporary the French polymath Denis Diderot, dreamed of creating a single science from disparate parts of the scientific knowledge available at that time which would use **the universal method of acquiring knowledge** (induction) and would allow the researcher to obtain reliable knowledge in any field. And he succeeded: an inductive method formed the basis for the formation of modern science. With its help, for 400 years (until the emergence of a new, non-classical paradigm), all the main scientific achievements were obtained. And his efforts proved successful: the inductive method laid the foundation for the establishment of modern science. It had been used for almost 400 years (up until the emergence of the new, non-classical paradigm) for all major scientific achievements.

In this work Bacon also presented his own classification of sciences relying on such properties of the human mind as: **memory, imagination and reason**. Memory corresponds to the historical sciences, imagination to poetry, and reason corresponds to philosophy. Philosophy is the **science of God, nature, and man**. Man learns about each of the three elements of philosophy in different ways: nature is conceived through immediate sensory perception and experience; God is conceived through nature; and man himself is conceived through reflection (i.e., the direction of thought to itself).

5.2 Metaphysical Ontology: the Problem of Substance (Descartes, Spinoza, Leibniz, etc.)

Rene Descartes (1596-1650) was amount the founders of "new philosophy", the founder of **rationalism**, a polymath, and worked on the establishment of the Dutch Academy of Sciences. Unlike Bacon, who relied on experience and observation, Descartes preferred reason and self-knowledge. He presented the rationale for the idea of the guiding role of reason in knowledge in the works **The Rules for the Direction of the Mind, The Meditations on First Philosophy, The Principles of Philosophy, and The Discourse on the Method.**

One of the most important tasks that Descartes was committed to resolve was the justification of the reliability of knowledge. Like Bacon, he intended to develop a universal method of acquiring knowledge, which would allow the researcher to get a true idea of the substance and relations between objects. But unlike its predecessor, Descartes considered thoughts and concepts inherent in the mind from birth (the so-called "theory of innate ideas") to be the main source of knowledge. As the founder of modern rationalism, he was convinced that only his method, which is "based on evidence", gives accurate results and allows us to comprehend the truth.

In the search for reliable knowledge, reason should be guided by a number of rules that will not allow the one who uses them, to take the false for the true and, avoiding useless mental efforts, gradually increasing the level of knowledge, will lead to a true knowledge of all that he is able to comprehend. Briefly, Descartes' rules of method are as follows:

- do not take anything at face value ("Doubt Everything!");
- divide every problem of the inquiry into as many parts as is required for its resolution;
- thought must ascend to the truth gradually, step by step – from the simple to the complex; and
- always keep records of the conducted inquiry as fully as possible in order to be certain that nothing is missing.

As we can see, the starting point of Descartes' method is the thesis "Doubt Everything". For him, doubt is not an end in itself, but a means of getting rid of prejudices and false scientific assumptions, including those that have not been reliably verified, but are based on authority and are taken at face value as true.

Descartes believed that his method is necessary to determine the "**primary truth**" (substance), the true basis of the inquiry. Bacon, for instance, thought the "sensual reality" to be such primary truth. Descartes sees it in reason – the "**thinking Self**". He solidifies this proposition in his dictum "Cogito, ergo sum". This dictum was highly valued by Hegel who said that Descartes directed philosophy in a completely new direction, which began a new period of philosophy and that he proceeded from the requirement that **the thought should begin with itself.** Descartes believed that the **"Self" is the substance** (the true reality which one cannot doubt), the whole substance and nature of which is in thinking.

However, Descartes warned, even if the researcher fully complies with these recommendations, errors in scientific search cannot be avoided, since every scientist has his own opinion and opinions differ. That is why a true scientist questions all knowledge of the past gradually approaching reliable knowledge and using true reality (consciousness) as a starting point.

Descartes laid the foundations for analytical geometry, introduced the concepts of variable quantity and function, provided justification for the law of conservation of momentum, introduced the notion of reflex, explained the motion and formation of celestial bodies by the vortex motion of material particles. Descartes' fascination with the problems of the physics and mathematics of his time left a mark on his theoretical justification for the gradual "increment" of metaphysical knowledge. He believed that "new knowledge" can be obtained by using two methods – the **deductive-mathematical** and the **experimental-inductive**. But the main role in obtaining true knowledge belongs to **rational deduction,** when the researcher speculatively draws specific conclusions from general provisions.

As such the central concept of rationalistic metaphysics is the concept of substance.

However, from the perspective of **mechanics**, the "queen of sciences", which dominated science during the time of Descartes, it was impossible to explain what consciousness is, as well as to justify the interconnection of matter and consciousness. This is why Descartes advocated the doctrine of two different substances and acts as a **dualist**. He argues that the world has two primary, original principles – being and thinking. In other words, he recognises the existence of matter and consciousness (the thinking "Self"). He sees them as "imperfect substances" that do not depend on each other. The "perfect substances" (perfect being), according to Descartes, is only God, who is a sufficient cause of himself. In **The Principles of Philosophy**, he says that everything else for its existence requires the presence of God. Descartes' God is a "great watchmaker" whose function is that he, having established the laws of nature, let it follow its own flow and acts as a guarantor of the truth of knowledge.

As such, Descartes distinguishes two types of substances of which the world created by God is made up: the **material** and the **spiritual**. The most important attributes (properties) of the material substance are length, size and divisibility to infinity. Descartes' "material substance" is nature, where everything obeys mechanical laws that can be discovered with the help of the exact sciences -- mathematics and mechanics. The "spiritual substance" (thinking, reason, the thinking "Self") is indivisible. It inherently (beyond experience) possesses **innate ideas**. For example, the idea of God, the concept of time, space, numbers, figures, etc. In other words, the mind has natural ability to create ideas. It is the "innate ideas" that guarantee the truth of scientific knowledge.

Isaac Newton (1642-1727) completed the formation of classical physics of the Modern Ages. He is most famous for his work entitled **The Mathematical Principles of Natural Philosophy** (1687). At the beginning of the third book of his Principles, Newton formulates four rules of philosophical reasoning. These are methodological rules which should govern any scientific inquiry. According to Newton, nature is simple, and does not abound in superfluous causes of things, it is uniform. Therefore, based on sensory experience, it is possible to establish the basic natural properties of bodies, such as length, hardness, impermeability, and motion. All these properties can be derived from sensations using the inductive method. In his reasoning as a physicist and mathematician, Newton insists that **induction** is the only effective procedure for the formation of scientific judgments. He believes that since the judgments of experimental philosophy derived by general induction should be regarded as true or very close to the truth -- in spite of opposing hypotheses that can be imagined -- until other phenomena are discovered through which these judgments are either clarified or are classified as exceptions.

Newton's physics does not investigate substances but functions, it does not aim to find the essence of gravity, but is satisfied that gravity exists, and explains the motion of both celestial bodies and terrestrial objects. This is a **mechanistic** approach. The question of the **essence and substance of things** is put by Newton beyond the framework of "experimental philosophy". Newton says that, if a new hypothesis is proposed, it must be justified and verified by observable facts and experiments, the uncontrollable fabrication of metaphysical assumptions is not scientific.

Thomas Hobbes (1588-1679) Shares the sensualism of Francis Bacon and the rationalism of Descartes. In his arguments about "first" philosophy, he recognises the primacy of matter the accidents (properties) of which are movement, dormancy, colour, etc. But the most important for him are not ontological, but socio-political views, which are presented in the works **On the Citizen** and **Leviathan**.

In his views on the social order and the state, Hobbes proceeds from the so-called "natural state of man", who tends to harm himself by being selfish, vain, in short, far from perfect.

In his work **De Homine**, Hobbes provided justification for the fundamental thesis of the capitalist era: "**man is wolf to man**" (Homo homini lupus est), such is his nature. He describes this state of man as the right of everyone to everything, i.e. a war of all against all, in which there can certainly be no winners. He sees the way out of this situation in the formation of a society in which public authority is delegated to one or several people. Transferring to some of their rights to the government, a citizen should share responsibility for its actions. This responsibility is supported by a **social contract**. Hobbes hopes that the conclusion of a social contract between people will allow them to get out of the natural state of a war of all against all. The state should support this as a new form of relations between people.

The state must replace the laws of nature in relations between people with the laws of society that will limit their natural rights with civil law. Regarding the origin of the state, Thomas Hobbes declares that the state is the "**great Leviathan**" or mortal God, who emerges as a result of a mutual agreement amongst many people for their peace and common defense. According to Hobbes, it is necessary to obey state laws and state power unconditionally, regardless of the form of this power, be it absolutism (monarchy), aristocracy, or democracy.

As such, Hobbes is an advocate of a single, centralised state as a guarantor of preserving basic human rights: the right to life, property, and freedom.

Hobbes concludes that freedom and necessity are compatible; moreover, they presuppose each other, for this is God's will. In contemplating on freedom, he emphasises that we can talk only about natural (sanctified by God) freedom. By "freedom" he means the absence of external obstacles, that is approaches this problem not a from philosophical position, but only as a practical citizen.

Blaise Pascal (1623-1662) was an outstandign physicist, mathematician, Descartes' follower, and is known as the creator of the first prototype of modern computers. He, like Galileo, considered it necessary to demarcate (separate) scientific knowledge and religious faith. He believed that theological question are governed by the principle of the authority of Holy Scripture, whereas natural sciences must be ruled by reason. And wherever the mind rules, there must be progress. All sciences must develop, leaving to descendants a knowledge more perfect than that obtained earlier. Unlike the eternal divine truths, the products of the human mind constantly evolve. The unwillingness to accept scientific advancements and discoveries leads to results in stagnation and paralysis of progress.

In his work **Of the Geometrical Spirit**, Pascal argues that scientific evidence is convincing when it applies the geometric method. This method does not define and does not prove everything. It simply accepts only that what is clear and constant in the natural light. This scientific method is universal, but its use implies observance of three conditions:

- to observe the necessary rules of terms (definitions);
- do not take ambiguous terms without definition; and
- to use only the already known terms in definitions.
- соблюдать необходимые правила дефиниций (определений);

Pascal's Christian views are consonant with skepticism, which is manifested in his disbelief in the possibility of knowing the infinite. He believes that "man is only a reed, the weakest in nature, but he is a thinking reed". Man is created for thinking; all his dignity, all his merit and all his duty consists in orderly thought, and the order of his thought is to start with himself, with his Creator and his purpose. The scientist clearly lacks the depth of comprehension of this important problem -- the theologian in him won over the philosopher. Skeptically assessing the nature and thinking abilities of man, Pascal concludes that man is one of the weakest and most insignificant creatures in nature, a kind of a "**thinking reed**".

John Locke (1632-1704) was a follower of the empirical line in English philosophy presented by Bacon. He was a scientist, politician, and diplomat and the author of more than ten major treatises, which have been republished recently in 30 volumes. As Engels put it, after the "glorious" (bourgeois) revolution, Locke became known as a theorist of the compromise between the classes – the bourgeoisie and the nobility, the upper and lower classes.

Locke's presented his ontological and epistemological views expounded in the treatise **The Essay Concerning Human Understanding.** In his analysis of the possibilities of human knowledge, he criticises the Cartesian theory of "innate ideas", denies that the mind is initially filled with different notions and claims that at birth **the human soul is a blank sheet of paper (tabula rasa)**, on which life experiences write its letters.

Locke believes that prior to any investigation or study, we must explore the possibilities and limits of our knowledge. As he put it, he was seeking the truth and was always happy whenever and wherever it was coming from. But he also noted that the empirical experience, i.e. the impact of the objects of the surrounding world on man, plays the main role in gaining knowledge about the outside world and, therefore, the senses are the basis of all knowledge.

As a sensualist, he separates **internal** experience from **external** experience and distinguishes sensory ideas (obtained from external experience) and the emerging reflections (i.e. feelings resulting from the work of our souls). He calls these "ideas" simple, and defines the "general ideas" emerging in the process of thinking as a property of thought (soul).

By distinguishing the types of experience, Locke identifies ideas about primary and secondary qualities. He classifies both as ideas derived from external experience. He sees the difference between them in that the ideas of "primary qualities" exist objectively, since they appear under the influence of the external world, and the ideas of "secondary qualities" are subjective, depend on the reaction of our senses to the external world: these are perceptions of the smell, taste, colour of things, etc. The ideas of secondary qualities are the result of "contemplating" the data received from the outside world, they exist only in our minds, therefore their qualities always correspond to the action of "primary" qualities".

He states that all our knowledge is based on experience, from it ultimately originates, but reason should be our last judge and leader in everything. Locke restricts the role of reason in acquiring knowledge to simple empirical judgments. Having devoted, according to Voltaire, almost half his life to writing the history of the human soul (mind) and the limits of our cognitive abilities, Locke comes to the conclusion that knowledge will never be able to overcome all difficulties and resolve all issues, cognition is the perception of the consistency or inconsistency of ideas. Sensory cognition is more limited than other types of cognition.

Locke's social and political ideas differ substantially from those of Hobbes. He outlined them in his work **Two Treatises on Government**. According to Locke, the natural state of society is not a "**war of all against all**" (as is statement by Hobbes), but a **state of equality** in which one has no more than the other. This is a state of freedom, but not despotism. Personal freedom in a society can not be absolute. It, according to Locke, is limited by the "natural law" (natural rights) which expresses and protects the interests of the young, progressive bourgeoisie, the main class of capitalist society. This law applies to all, both rulers and subjects.

Locke elaborates this concept and argues that any legitimate government is based on the consent of the governed, and if the ruler does not observe the requirements of natural law, the subjects have the right to withdraw from the contract.

Locke's views on "natural law" and the social contract were more progressive than those of Hobbes. He supplemented them with the doctrine of the **separation of the three branches of power** (the legislative, executive and federative), thereby laying a conceptual foundation for the future democratic state.

Locke, as the production of a compromise between classes, found a way to balance the relationships and interconnections of various strata of society. He was the first among the representatives of the Modern Ages to scientifically substantiate the approaches to solving the problem of the legitimacy of power, considering the **natural state of society as a state of freedom and equality**. Human freedom can be limited only by the natural law, according to which no one has the right to restrict the other in his life, health, freedom or property, i.e. in "natural rights". But this is achievable, according to Locke, only when a number of conditions are fulfilled: the separation of the branches of power and the existence of a social contract between the ruler and the subjects which conditioned by respecting natural law. Locke wrote that all these socially important decisions reflect the trend of the time and they are all in a dialectical relationship, each stemming from the other and making sense only if the others are respected.

Locke was one of the most gifted and educated people of his time and accomplished his task as a scientist. He wrote an epitaph for himself, "Bred a scholar, he made his learning subservient only to the cause of truth. This thou will learn from his writings, which will show thee everything else concerning him, with greater truth, than the suspected praises of an epitaph".

Baruch (Benedict) Spinoza (1632-1677) was a mathematician, and a rationalist philosopher, a follower of Descartes. He developed the doctrine of the single universal cause of the world, the substance (God) whose attributes (inalienable properties) are thinking and nature, and modes (not very essential properties) are finite objects. According to Hegel, Spinoza maintained that only one substance is real, the attributes of which are thought and prevalence, or nature. Like the other rationalists of this time, he considers the thoughts and concepts inherent in the mind from birth to be the main source of knowledge. His teaching is based on the thesis that nothing exists, apart from the substance and modes. Spinoza's God is a phenomenon that is absolutely independent and free, he is the "**unfolding Nature**" and the cause of the world. This is pantheism.

He instated that there is nothing accidental either in Nature or in God, everything is preconditioned and strictly predetermined. He substantiates determinism as follows. Attributes, according to Spinoza, are essential characteristics, forms of action of God. They are infinite in quantity and the human mind is not able to detect everything. The most accessible to our understanding is **thinking** and **space**, which are independent and unconnected, but they express the single divine essence of nature.

Since the substance is infinite, one and indivisible, the connection between the attributes and modes, like the connection between the **creative nature** and the **created nature**, is rigidly preconditioned: there is nothing accidental in the world, "everything has its own cause, and only the substance has a cause in itself. In other words, the phenomena of these "two natures" have the cause-effect relations, and therefore the world is rigidly determined. Spinoza's determinism is **mechanistic** which was inline with the level of development of natural science of his time. He points to the external interconnection of phenomena explaining it by the presence of the single substance. But he also ignores the inner unity of opposing principles.

He managed overcome this shortcoming to a certain extent in his ethical concept of man's free will of man. In his main work **Ethics**, in the chapter entitled **God**, Spinoza presented a justification for the idea of freedom through the opposite concept -- necessity. Both concepts are comparable, because they coincide in God (the substance). Spinoza considers understanding of the substance, in which necessity merges with freedom, in the context of ethical problems. God is free in his accomplishments, he proceeds from his own need. Therefore, there is a necessity in nature, and the degree of man's freedom is determined by the degree of reasonable knowledge of this a state of things. In everyday life, our behavior depends on the instinct of self-preservation and its resulting affects t (joy, sadness and attraction). As **man** gets rid of them, he becomes free. Spinoza concludes that **freedom is a recognised necessity**. Freedom is in the unity of mind and will.

- Self-checking
- The problem of method in science.
- The distinctive features of the formation of natural science and the role the natural scientist in the Modern Ages.
- The influence of scientific thought on philosophy.
- The role of Newton's theory in the formation of the paradigm of modern natural science.
- Philosophy as a form of reflection on science.

CHAPTER 6

Basic Concepts, Movements and Schools of the Non-Classical and Post-Non-Classical Stage of the Development of History and Philosophy of Science

6.1 The Philosophy of Positivism: Comte, Spencer and Mill

By the end of the 19th century, the philosophy of modern times was unable to give answers to questions put forward by life. The French moralist philosopher Francois de La Rochefoucauld, in his assessment of the shallow skepticism and blind fanaticism in science, pointed to the place of philosophy in the system of sciences says that philosophy triumphs over the difficulties and sorrows of the past and the future, but the sorrows of the present triumph over it. This can be fully attributed to the situation in which the new European metaphysics found itself at the turn of the century.

At the beginning of the twentieth century, Europe witnessed the emergence of a philosophical movement that made another "revolution" in philosophy and was named **positivism** (by analogy with positive knowledge which is only available to specialised sciences that are of practical benefit to society). Representatives of this movement argued that the "old" philosophy is not scientific and is overly speculative. Therefore, it is necessary to make sure that the old philosophy, like the natural and exact sciences, be based only on reliable (tested by experience) knowledge and be of practical use. Philosophy should investigate only facts, get rid of any evaluative role, and be guided in research by the scientific tools and methods.

The main principles of this movement formulated by its founder Auguste Comte (1798-1857) in **The Course in Positive Philosophy** formed the basis for numerous positivist theories and concepts that appeared in the late 19th - early 20ht centuries. To a certain extent, positivism stems from the philosophy of the French Enlightenment of the 18th century. Like the polymaths of the Enlightenment, Comte proclaimed the cult of science and had an unlimited faith in its possibilities. He insisted that scientific methods of thought (including metaphysics) are applicable to an unlimited scope of the subject area. His classification of sciences can be regarded, in many respects, as the realisation of the philosophical maxims of the polymaths. He put sciences in the order which was based on a "natural hierarchy": Mathematics - Astronomy - Physics - Chemistry - Biology - Sociology. He believed that the term "philosophy" can be reserved for the "common" science, which reveals the relationships between these sciences. However, it should not have anything in common with traditional metaphysics, because they have different subject matters and methods of research.

By contrasting science to philosophy, Comte states that science is the source of positive, reliable knowledge which is applied in practice. Whereas philosophy, as a **general system of knowledge**, is not necessary for science. It is a "synthetic" science and must deal with the **generalisation of the achievements of the natural sciences**. He argued that every science is itself a philosophy. Hence, his maxim which was picked up by all the positivist, "Down with metaphysics, long live physics!", as well as his "Law of Three Stages" of evolution of human thought -- religious, metaphysical and scientific.

After Comte's death, the centre of positivist thought moved to England and is primarily associated with the name of the logician **John Stuart Mill** (1806-1873). In his book **A System of Logic, Ratiocinative and Inductive**, he developed **methods of inductive logic** earlier formulated by the founder of the English empiricism Francis Bacon. This is due to the fact that the **basic principle of empiricism** -- "all our knowledge derives from sensual experience, the senses" -- inevitably leads to the question of how the data of our observations is transferred to the form of those propositions, which are called "laws" in science. In his opinion, the is no fundamental difference between the empirical and theoretical propositions.

Mill criticised the mechanistic and physicalist interpretation of human behaviour which ignores his freedom and hence a possibility of moral choice. Being a utilitarian, Mill reasons that people derive benefit from everything and, therefore, should act morally, because moral actions are more beneficial than immoral actions.

The English philosopher and sociologist **Herbert Spencer** (1820-1903) is the author of several works: **First Principles, Principles of Psychology, Principles of Sociology, The Study of Sociology, Principles of Ethics**. He came to the idea of evolution in the biological world before Darwin and formulated the principles of natural selection and the struggle for survival in the natural world. Spencer applied the idea of evolution to all phenomena and processes in nature and society without exception -- from outer space, organic and inorganic nature to society. He can be called the founder of two perspectives in sociology: "**organicism**" and "**evolutionism**", which allowed scientists to consider social progress as a process of differentiation and integration of social phenomena.

Using these approaches, Spencer was among the first to develop a general theory of systems. Structural and functional and evolutionary analysis allowed him to discover a number of important features of the structure and functioning of social systems, such as the cycles of evolution and decay, integration and differentiation processes leading to the emergence of more complex types of society.

6.2 Empiricism, Sensualism and Rationalism of the Philosophy of Ernst Mach and his school.

The **second** historical form of positivism comprised of machism and empiriocriticism (Ernst Mach, Richard Avenarius and others). Empiriocriticism is a philosophical system of "pure experience", or critical empiricism, which seeks to limit philosophy to the presentation of experimental data completely rejecting any metaphysics in order to "develop natural conception of the world". From the perspective of machism, positivism addresses such problems as the nature of knowledge and experience; the problem of subject and object; the nature of the categories of "thing", "substance"; the nature of the basic "elements" of reality; the relationship of physical and psychological, and so on.

In their studies of these problems, the machists are consistent in their approach from the point of view of phenomenology, which indicates the proximity of positivism to David Hume's philosophy and George Berkeley's subjective idealism. They proposed the thesis of the "neutral" character of the "elements of the world". Machism claimed to have overcome the "metaphysical" contradiction of materialism and idealism, but in reality it occupied the positions of **subjective idealism** and **phenomenology**.

The problem of the relationship between abstract theoretical concepts and empirical data arises whenever the main categories in science are disrupted and the question arises as to whether the logical constructions of science are justified in experience. Such a question became topical in science at the turn of the 19th and 20th centuries, when a revolution took place in the field of natural science. A certain role in the discussion of the logical nature of the basic theoretical concepts of classical physics that were unfolding during this period was also played by the works of Ernst Mach. In his book **Mechanics** he criticises Newton's ideas about the absoluteness of space and time and tries to reveal the "logical content" of the concepts of mass, frame of reference, etc.

The discovery of the electron provided Mach and Avenarius with the basis for stating that "matter has disappeared". Thus, if the basic philosophical concept turned out to be fiction, with no basis in reality, then all previous metaphysical arguments about the matter were wrong, therefore science should be cleared of empty metaphysical abstractions. From this they inferred that " Empiriocriticism stands above materialism and idealism". From the standpoint of subjective idealism, Mach and Avenarius regard objects and the reality that surrounds us as "**complexes of human sensations**". Apparently, they came to this conclusion under the influence of the Lockean concept of primary and secondary qualities. The **mechanical**, formal division of qualities into objective and subjective led them to the erroneous conclusion that "the world is a complex of our sensations". The objects of the world have no colour, no weight, they are neither warmth nor cold. People perceive them as they are able to sense with their senses. However, the Machians did not take into account that the solution of this problem requires an answer to two questions: what is the source of the sensations and what is the mechanism of their formation.

The famous French mathematician and physicist **Henri Poincare** (1854-1912) was on a similar ground with empiriocriticism on a number of epistemological problems. In his 1905 book **The Value of Science**, he wrote that the progress in science challenges even the most established of its principles. For example, the discoveries of Einstein showed that the speed of light is independent of the speed of its source. Newton's Third Law "staggered" under the weight of the fact that the energy emitted by a radio transmitter has a rest mass and that there is no equivalence of action and reaction. It became clear that the Euclidean Geometry is not the only possible geometric system. All these inconsistencies had led to a crisis in physics at the end of the 19th century and beginning of the 20th century.

New scientific data that do not fit into the usual theoretical framework gave grounds to assert that the laws of nature should be understood as **conventions**, i.e. provisions adopted by agreement. The interpretation of a law, as a conditionally accepted provision, became the leading concept in Poincare's theory of cognition, which named "**conventionalism**". Poincare states that these conventions are works of the free activity of our spirit, which knows no obstacles in this field. Here it can assert, since it also prescribes.

6.3 Traditions and Innovations of Positivism and Rationalism: Structuralism, Hermeneutics, and Postpositivism (Ludwig Wittgenstein, Rudolf Carnap, Karl Popper, Thomas Kuhn, Imre Lakatos, Paul Feyerabend, and Michael Polanyi)

The **third** historical form of positivism is **neopositivism**. It is divided into two branches -- and **logical positivism analytical philosophy**.

Logical positivism emerged in the1920s. Its core centre was **The Vienna Circle**, whose members proposed a program of "scientific" philosophy. Its members were Moritz Schlick, Rudolf Carnap, Hans Reichenbach, Herbert Feigl, Otto Neurath, and Ernest Nagel. In England, its active proponents and advocates were A.J. Ayer and Gilbert Ryle. In Poland, its supporters set up the Lwów–Warsaw School of logicians headed by Alfred Tarski and Kazimierz Ajdukiewicz. The members of the Vienna Circle and its followers rejected the psychologism and biologism of the machians and adhered to the principle of non-empirical and analytical nature of the propositions of logic and mathematics.

The focus of their attention was at the problems of the sense and meaningfulness of empirical scientific propositions. They reject the conception of philosophy as a theory of knowledge and see it **as a type of activity aimed at the analysis of natural and artificial languages**. This philosophy should remove from science all discourse and pseudo-problem that have no sense in order to ensure the construction of ideal logical models of meaningful discourse. As an ideal tool for building a model of meaningful reasoning, they use the **apparatus of mathematical logic**.

In a broad sense, positivism makes an attempt to deny philosophy as a specific form of theoretical knowledge, it argues that all genuine theoretical and cognitive problems can be solved by means of "positive" specialised scientific thinking. However, positivism is not merely a substitution for philosophy with specific scientific thinking, nor is it a kind of primitive scientism. It acts as a philosophical doctrine exactly because it is trying to provide a theoretical evaluation for the possibility of solving "marginal" philosophical problems, instead of moving away from these problems and ignoring them.

All this is also true for **logical positivism** that is not merely reduced to substituting philosophical analysis of scientific knowledge with its formal logical analysis. Logical positivism aims to develop a concept of scientific knowledge in general, while neither formal logic, nor any other special scientific discipline studying knowledge make any such claims. But, since the above-mentioned concept of knowledge as a whole is formed on the basis of individual formal logical models, which are related to the study of particular aspects of knowledge, therefore, obviously, philosophical problems of knowledge cannot be solved from this perspective. Notably, however, logical positivists try, in a way, to philosophically canonise this limitation of the methods of individual science applied to the analysis of knowledge, maintaining that it is impossible in principle to find theoretical solutions for relevant philosophical problems.

The programme of logical positivism has offered a number of principles: the principle of verification; reduction of true theoretical propositions to experimental "data"; division of all meaningful scientific propositions into analytic and synthetic.

The principle of verification was developed by members of the Vienna Circle for experimental verification of statements to be true. In other words, a statement is scientifically meaningful only if it can be reduced to immediate sensory experience of and individual, to "atomic facts", or "protocol statements". The essence of the verification principle is in the identification of the observed and the real (real is what is observable), and truth is understood as the coincidence of statements with the immediate human experience.

For logical positivism, presuppositions of all knowledge are "events" and "facts", meaning by these sense data, which "exist within the subject's realm of consciousness". One of the distinctive characteristics of this movement was that it identified the object with the theory of object. This immediately excluded the problem of the existence of the objective world and led to the restriction of the scope of philosophical knowledge to the logical language analysis only.

The logical positivists saw the problem of development of the logic of science as the analysis of its language. They believed that its purpose was not only to replace the traditional **philosophical ontology, but also the traditional epistemology** (theory of knowledge). Logical positivists, obviously, attracted the attention of philosophers and other professionals, who were concerned with the methodology of science, to the issues of logical formalisation and facilitated the introduction into the study of the methodology of science of concepts and methods of modern mathematical logic, thereby seeking to implement their programme of broad logical analysis of the language of science.

But they, of course, failed to replace the philosophical analysis of scientific knowledge with the logic of science which is "strictly positive" and "free from all philosophical presuppositions". This is universally accepted in today's philosophical and methodological literature.

The proposed by logical positivists logical models of logical analysis of the language of science were by no means "without ground" in terms of philosophy. Claiming to have discovered some universal "method of analyses for the language of science," logical positivists were forced to proceed from a certain concept, use some way or another to establish the criterion of truth, the relation of the language of science to reality and other traditional methods. All these problems and the chosen methods of their solution, although they appeared when used by logical positivists in a form that was apparently very far from traditional philosophical epistemological formulations, were, in fact, of a philosophical nature. It is easy to see that the formulation and solution of many of these problems had very definite points of contact with and were similar to a number of positivist and phenomenalist concepts of traditional epistemology

We can say that logical positivism reached its "end" with the publication in the 1950s of a series of articles by one of the former members of the Vienna Circle Carl Hempel, that described the fundamental difficulties and even ambiguities associated with the very key concept of meaningfulness. These difficulties and ambiguities of the logical positivist concept of meaningfulness are beginning to be seen as part of another variety of neo-positivism -- analytic philosophy.

Analytic philosophy is not so much a "school" as it is a certain style of philosophical thinking implying the rigor and accuracy of the terminology used along with a careful attitude to broad philosophical generalisations. It is a separate intellectual "movement" within the boundaries of philosophical thought of the 20th century with the status of a specific metaphilosophical discipline. It is extremely diverse. Notably, many of the leading representatives of analytic philosophy, with the exception of the member of the Vienna Circle, at different stages of its development opposed positivism.

Representatives of analytic philosophy (George Moore, Ludwig Wittgenstein, John Wisdom, Gilbert Ryle, and John Austin) proceeded from the assumption that philosophy per se cannot carry any new information and maintained that it has to do only with the explanation of what science or experience tell us. From the standpoint of the subjective idealist theory of knowledge, which is traced back to David Hume, they complemented the methods of logical analysis with Bertrand Russell's doctrine of "logical atomism" and with the principle of verification. Representatives of Analytic Philosophy offered a basis for their own philosophical doctrine, according to which philosophy is not a theory and can only be considered as a discipline engaged in a "neutral" analytical work based on mathematical logic. "Philosophy aims at the logical clarification of thoughts" (Wittgenstein).

Ludwig Wittgenstein (1889-1951) in the work **The Tractatus Logico-Philosophicus** focuses analytic philosophy at the ideals of clarity, unambiguity and logical rigor inherent, in his opinion, in an ideal, logically perfect language. He reasoned that the world is revealed to man through language, therefore language is what philosophers should concern themselves with in the first place. It is a universal key to the solution of scientific problems. Language is capable of forming, on its own terms, views of the world. Being guided by these ideals, analysts studied not only the logical structure of language, but also its usage in ordinary, everyday contexts. They emphasised that everyday contexts of language should be taken into consideration, because the usage of language in **specific** "extrinsic" meanings (as is customary among philosophers) inevitably implies difficulties that cannot be solved in principle.

Wittgenstein believes that it is impossible to develop a strict definition of language or to see in it a set of symbols unambiguously related to their objects. Language is part of normal human activity, it is a form of life, a game played by arbitrary rules. It is all the more important to define the "metaphysics of language" which should study the formation of the real language of science and its functioning in not within the sphere of artificially constructed calculations, but in real life.

Representatives of analytic philosophy believed that logical semantic study of the language of science should be limited to the so-called "internal" questions, which it can answer, while remaining within the framework of the rules and tools of this language. But these rules and language tools cannot provide answers to the "external" questions, i.e. questions of whether there is something in the objective world conforming to them.

In the 1940s and the 1950s, the logical methods of analytic philosophy were replaced with linguistic methods, and these, in turn, refused to use mathematical methods and atomic theory. From that time on, analytic philosophy begins to revert to the **traditional philosophical problems** (A. Gritsianov) and, at the next stage of its evolution, concludes that metaphysics is not nonsense as it sets up a specific vision of the world.

Following the criticism, self-criticism and further evolution of neopositivism (i.e. logical positivism and analytic philosophy), the middle of the 20th century was when the fourth historical form of positivism – **postpositivism** -- emerged. For its representatives, Karl Popper, Thomas Kuhn, Imre Lakatos, Paul Feyerabend, and others, the demarcation of scientific knowledge from non-scientific knowledge is that scientific knowledge can in principle be refuted by empirical data. Therefore, any scientific knowledge is merely hypothetical in nature and is prone to error. This line of philosophy aims to study the development of scientific knowledge, rather than its structure (language, concepts). According to postpositivism, development of science is not strictly linear, but intermittent and goes through highs and lows, but the general trend is toward **growth and improvement of scientific knowledge**.

The English scientist **Karl Popper** (1902-1994), who developed the concept of the growth of knowledge, is considered to be one of the greatest philosophers of science of the 20th century. Speaking about the growth of knowledge, he was not referring to the accumulation of observations, but about a repeated overthrow of scientific theories and their replacement by better or more satisfactory ones. To prove his concept, he used the ideas of neo-Darwinism and the principle of emergent (evolutionary) development. As the necessary means of the growth of science he named language, formulation of the problem, the emergence of new problem situations, competing theories, and mutual criticism in the process of discussions.

The first work of Karl Popper **Logik der Forschung**, which was published in Vienna in 1934, covered questions of the philosophy of science. The English version of this book, published a quarter of a century later (1959) under the title **The Logic of Scientific Discovery**, became very popular and is now considered a classic in its field. The problems of the philosophy of science defined the content of such Karl Popper's works as **Conjectures and Refutations** (1963), **Objective Knowledge: An Evolutionary Approach** (1972), and **The Self and its Brain** (1977), co-authored with the Nobel Prize laureate in Physiology and Medicine, the English neurophysiologist John Eccles.

The place of the philosophy of quantum mechanics in Popper's philosophy of science is determined by the role played by this branch of physics in the philosophy of science. We know that the philosophy of quantum mechanics is one of the most developed sections of the philosophy of science. It is focused on discussing the issues of mathematical and conceptual methods of science. In his interpretation of quantum mechanics, Popper opposed the representatives of the Copenhagen School (Niels Bohr, Werner Heisenberg, Wolfgang Pauli, and, to a certain extent, Max Born and Paul Dirac). His position in this issue is close to that of Albert Einstein and Erwin Schrödinger.

The discussions in quantum mechanics determined his position on the question of the interrelation between philosophy and science. To distinguish one from the other, Popper introduces the concept of "demarcation". He recalls that, at that time, he was not interested in the question of when a theory is true, and not the question of when a theory is acceptable. He set himself a different task. He wanted to distinguish between science and pseudoscience being fully aware that science often makes mistakes and that pseudoscience can accidentally stumble upon the truth. To distinguish between them, he introduced the principle of **falsification** (from the Latin *falsus* - false, *facio* - do), which assumes fundamental refutability of any scientific statement. The introduction of this principle allowed Popper to finally solve the problem of **demarcation**, the separation of scientific knowledge from unscientific. Notably, unlike the logical positivists, he refused metaphysical statements not meaningless, but only as unscientific, because they do not rely on empirical facts.

Popper criticises Wittgenstein's concept, according to which only those proposals are scientific which are derived from "true observational propositions" or which may be verified (tested) with their help. Popper disagrees with him in that any theory which claims to being scientific must derive from experience. He believes that any scientific observation as such presupposes a theoretical setting, an initial hypothesis, because one cannot just observe without any preconditions. Accordingly, observation is always selective and targeted as it proceeds from a particular task and observes only what is needed to reach it.

In the preface to **The Logic of Scientific Discovery**, Popper describes his philosophy of science as that pertaining to cosmology – to learning about the world, including ourselves (and our knowledge) as part of this world. He says, "All science is cosmology, I believe, and for me the interest of philosophy, no less than of science, lies solely in the contributions which it has made to it". For Popper, the role of philosophy, not to a lesser extent than the role of science, is solely in the contribution that it makes in its development. His ideal is **"open science in open society"**, that supports freedom of criticism as the essence of scientific activity. And the openness of science also means the participation of scientists in philosophical discussions and in the development of what Popper calls "metaphysical research programs". Science will become an open system, if scientists respect philosophy and common sense. This, of course, does not imply that we should uncritically accept philosophical doctrines and tenets of common sense. He insists on seeing science as a dynamic process defining scientific knowledge as a process of introduction of new bold hypotheses and their subsequent refutation. According to Popper, science and philosophical doctrines must constantly prove their right to exist by participating in competition and undergoing critical scrutiny for courage, clarity and efficiency.

Credit for critical rethinking and further development of Popper's ideas is owed to his follower **Imre Lakatos** (1922-1974), who remained faithful to the **historicist** movement in philosophy of science. He believed that any methodological concept must be also historiographical and that its evaluation may be given in terms of that rational reconstruction of history of science which it offers. At the same time, Lakatos distinguishes the real history of knowledge with its social and psychological context from its logical reconstruction used in the analysis of scientific knowledge, calling it "internal history".

He agrees with his teacher that philosophical study of science should focus primarily on the identification of its rational justifications, which determine, in his opinion, the professional activity of the scientist. He presented arguments for this idea in his book **Falsification and the Methodology of Scientific Research Programmes**. Lakatos believes that only those sciences are real that allow for their examination in terms of certain logical requirements. These may include both empirical and theoretical sciences, but they must comply with a whole set of **logical rules and laws**, which serve as the main ways for growth of scientific knowledge.

At the same time, highlighting the relationship between the problem of scientific rationality with methodology, he acknowledges the uncertainty of rational justifications with regard to Popper's model of science. Moreover, according to Lakatos, attempts to solve the problem of justification of knowledge lead to an infinite regression of justifications: the justifications of any knowledge must have its own justification, etc.

In his work **History of Science and its Rational Reconstructions**, Lakatos distinguishes four types of methodological doctrines (which are also criteria for rationality). He recognises the first three methodologies -- inductivism, conventionalism, and falsificationism – to be ineffective in terms of adequacy of rational reconstruction of science. The search for justifications that would make it possible, from a single perspective, to study and explain the knowledge acquisition activities of scientists, the logic of scientific research and the historical progress of science, leads the philosopher to the fourth doctrine – **the concept of scientific research programmes** (SRP), which can help avoid the problems of justification of specific theories.

In Lakatos' interpretation, the critical rationalism of Popper loses its negative and destructive nature and becomes constructive, because it creates alternative concepts for the investigation of the problem in question from as many perspectives as possible. The acknowledgment of SRPs as the starting point for a scientific research allows the researcher to demonstrate the autonomy and the actual investigative role of "theoretical science", which, according to Lakatos, Popper's concept of scientific research in unable to do. He believes that his concept of scientific research makes it possible to explain a certain continuity in the development of scientific knowledge, as well as its relative independence from the empirical level. The continuous nature of the development of science within the framework of the SRP concept brings the latter closer to Thomas Kuhn's "normal science". However, unlike him, Lakatos' concept explains the growth of scientific knowledge by the **objective logic of this process, and not by the psychology of the scientific community**.

In his works **Proofs and Refutations** and **Falsifications and the Methodology of Scientific Research Programmes,** Lakatos regards the development of science as competition between programmes. He uses "progressive or degenerative" shifts in problems as an objective criterion for comparing research programmes. In the first case, the shift is accompanied by an increase in the empirical basis of the programme, and in the second case, by its narrowing. In addition, a research programme is progressive, if its theoretical growth takes place before the empirical growth. In other words, it progresses when it successfully predicts new facts, and regresses when it gives only belated explanations to new facts that have already been predicted by a competing programme. When the heuristic possibilities of the program are exhausted or become inferior to the competing programme, it is removed from scientific discourse.

The idea of scientific research programmes focuses philosophy on the understanding of the profound changes in the nature of modern science. Although it should be noted that, in Lakatos' concept of science, the actual structure of scientific research is replaced with the methodological concept organised according to the rules of the scientific game. He does not give a decisive answer with respect to the rules of this game with reality.

The Austrian-born American philosopher **Paul Feyerabend** (1924-1994) was the most radical among postpositivists. He developed the concept of **"epistemological anarchism"** consistently defending scientific, philosophical and methodological pluralism. Feyerabend described himself as an "epistemological anarchist" as he had questioned the fundamentals of science (but not science itself). In his main work **Against Method: Outline of an Anarchist Theory of Knowledge**, Feyerabend put forward three theses: proliferation (increase in the number of ideas and theories), counterinduction (research from the general to the particular) and the emphasis on the language of observation.

He posits that the growth of knowledge is a result of **proliferation** (from Latin *proles* – offspring, *ferre* – bear), i.e. "reproduction" of theories that are incommensurable, i.e. have a different empirical basis, use different methods, standards and norms, and are not deductively linked with each other. The creation of such alternative theories contributes to their mutual criticism, thereby accelerating the development of science -- it is the so-called **period of conflicting alternatives**. Thus, Feyerabend rejects the idea of the progressive development of science. He believes that the discoveries in science do not occur on the basis of induction and deduction, but rather on the basis of counterinduction. Significant discoveries in science, according to Feyerabend, although based on previously acquired knowledge, are the result of the harsh opposition to the conclusions that have been previously made. New discoveries carry some negative, destructive, but vital charge. And finally, an adequate methodology should be extremely attentive to the language of observations and should develop within itself methods for solving these problems

According to Feyerabend, the replacement of one theory with another is a non-cumulative process in science. Theories replacing each other do not have a continuum relationship; on the contrary, the new theory is new exactly because it distances itself as much as possible from the old theory. He sees the meaning and value of the new theory, that has replaced the old one, in its problem-solving ability. If this theory solves problems that are different from those that it was originally intended to solve, then certainly such theory is recognised as progressive. It is clear from this proposition that the progress of science is conceived as movement towards solving more complex and more profound problems in substance and that the growth of knowledge in this context is understood as gradual replacement of one problem with another or a succession of alternating theories that determine the "shift of the problem".

He reveals difficulties in the thesis of the invariance of the meaning of terms, which is an expression of a rigid separation of the empirical and theoretical levels of knowledge in neopositivism. By criticizing this thesis, Feyerabend gives Popper's idea of a theory loading of perception a universal character. This was manifested in the attempt to provide justification for the methodological role of theoretical knowledge, which, as he puts it, constitutes the substance of "theoretical realism". He emphasises the role of the deterministic basis for the perception of experience and for any phenomenon in general: there is no and cannot be any other meaning for terms other than that defined by the basic provisions of this particular theory. Since each theory has its own set of initial postulates, the meanings of their terms are not only noninvariant, but also incomparable. Moreover, due to the autonomy of theories, each requires its own language of observation. Noncritical borrowing of "foreign" terminology and language can damage the activities of a scientist. Common sense as a means of knowledge should be discarded. In place of the criticised theses Feyerabend proposes his own principles opposing them. Proceeding from these principles, Feyerabend appears as an anticumulativist and an advocate of the thesis of incommensurability of theories.

Following the postpositivist tradition of science, **Thomas Kuhn** (1922-1996) does not accept the understanding of the process of scientific development as a cumulative process (from Latin *comulatio* -- increase), which is effected by continuously adding new knowledge. He believes that the development of science necessarily results in substantial transformation, or "scientific revolutions", when a considerable part of the previously recognised and valid knowledge, as well as the mode of activity of the scientific community undergo a revision.

The fundamental part of Kuhn's philosophical legacy is his famous book **The Structure of Scientific Revolutions**, which was first published in 1962 and had a bombshell effect on Western philosophy. In this work, he shared Lakatos' critical attitude to neopositivist and Popperian conceptions of scientific development. At the centre of his attention is **the explanation of the mechanism of transformation and change of leading ideas in science and the direction of scientific knowledge**.

To describe this process, Kuhn uses, in his work The Structure of Scientific Revolutions, the concept of **paradigm** or "disciplinary matrix" to refer to a set of fundamental theories and methods of research, which defines, for a certain period of time, the model for posing problems and offering their solutions and which is recognised by the entire scientific community.

Kuhn posits that the activities of a scientist within the framework of normal science are predictable to the effect that he is studying subjects through the conceptual framework which has been provided to him by professional education. This is why normal science does not predict new kinds of phenomena that do not fit into its conceptual framework. Therefore, the problems of normal science are, in principle, not aimed at major discoveries, be it either discovery of new facts or creation of a new theory. Within its framework, the scientist is so rigidly preprogrammed, that not only he does not seek to discover or create something completely new, but also not even inclined to accept new discoveries.

The problems of normal science do not go beyond the boundaries defined by the paradigm and Kuhn describes is as "puzzle-solving", because there are samples, rules for their solution and the scientist can only test his personal ingenuity in their solution. This explains the appeal of normal science for the scientist, who is left with nothing more that checking and updating the known facts and with collecting new facts, that have been in principle predicted or produced by theory.

Kuhn demonstrated that scientific tradition is a necessary condition for rapid accumulation of knowledge. For example, the value of normal science is that it promotes accuracy, reliability and breadth of methods. Thus, in studying new phenomena within the framework of normal science, scientists rely on the paradigm adopted by the scientific community. It defines the use by scientists of standard methods of analysis or explanation of the phenomena, helps them in understanding and comparing scientific results, forms the activities of the scientific community, and creates conditions for the organisation of the knowledge production "industry" in modern science.

Due to the fact that scientists work in accordance with the accepted rules, they easily notice any discrepancies in the solutions obtained as a result of research with the expectations that follow from the accepted theory. Sometimes the problem of normal science, which must be solved with the help of known rules and procedures, cannot in principle be subjected to this decision. In other cases, these known rules and procedures of normal science are unable to function in accordance with expectations. According to Kuhn, the development of science is a process of alternating periods of "normal science" (a period of total dominance of a certain paradigm) and scientific revolutions in the course of which the old paradigm breaks up and, as a result of the competition between alternative concepts, a new one is established.

Kuhn's views are shared by the Hungarian-born British postpositivist **Michael Polanyi** (1891-1976). He believes that the task of the philosophy of science is the study of the human factor. Polanyi rejects neopositivists' contrasting of the object and the subject of knowledge and insists that it is not an inherently human trait to look for abstract insights into the essence of things in themselves, but that we rather tend to link the reality and the human world. This is because any attempt to remove the human perspective from the view of the world leads not to objectivity, but to absurdity. Scientific progress is based on **personal knowledge**, i.e. the scientist's insight into the essence of the task of the scientific research. And the condition of the successful functioning of the scientific team is the acquisition by its members of general intellectual skills, which form the basis of their joint work.

According to Polanyi, the meaning of scientific research is in the study of objective rationality and the internal structure of reality. Scientific hypotheses cannot be derived directly from observation, and scientific concepts cannot be directly derived from experiments, because it is impossible to build the logic of a scientific discovery as a formal system. His concept is aimed at rejecting both purely empirical and formal logical approaches and is based on **the epistemology of "tacit knowledge"**. In his work **The Tacit Dimension**, he put forward a number of fundamental ideas, in particular, about the incommensurability of various fundamental conceptual systems, e.g. the variability of standards of scientific rationality, understanding of the anomalies of scientific development. The offered solutions of these problems determined, to a great extent, the further evolution of postpositivism.

Polanyi's **theory of personal knowledge** is associated with the concept of tacit knowledge. He posits that knowledge is obtained by certain individuals, that learning process cannot be formalised and that the quality of knowledge depends on the ingenuity of the scientist. Although Polanyi does not pay sufficient attention to the social aspects of knowledge, the thesis of the personal nature of the process of knowledge leads him, however, like Karl Popper, to the conclusion of the relativity of all knowledge.

According to Polanyi , the key factor determining the acceptance by a scientist of a particular scientific theory is not the extent of its critical justification, nor is it its conscious correlation with accepted scientific standards, but only the degree of his personal "involvement" in this theory and his trust in it. For him, the category of **faith** is central in the interpretation of learning and knowledge. He regards an individual's involvement in science as an act of personal commitment, akin to commitment to a religious faith.

Impressed with the ideas of Michel Foucault and Jacques Derrida, the American scientist **Richard Rorty** participated in the discussions of postmodernists, "deconstructivists", and hermeneuticists. In his book **Philosophy and the Mirror of Nature** was a massive attack on the idea of "philosophy as epistemology".

Rorty's philosophy is not a search for truth, but **conversation and communication**. He noted in his book that to see the self-sufficient goal of philosophy in keeping a conversation and to see the meaning of wisdom in its ability to keep it means to see **human beings as generators of new descriptions, rather than people who are supposed to produce exact descriptions**. The refocusing from knowledge of truth to conversation and communication could create a basis for changing the image of philosophy and implementing in life a new philosophical ideology which is **built not on "objectivity," but on "irony" and "solidarity"**. According to Rorty, the goal of the deconstructivist project is to undermine the reader's confidence in consciousness as something that should be interpreted in "philosophical" terms, in "knowledge" which should be based on "foundations" and "theory", and to philosophy as it appears after Kant.

Rorty does not advocate for cutting off any particular activities from philosophy. We do not need to change anything in the building of philosophy and can leave it as it is. The only thing that is required is to destroy the idea that this building has a foundation. That there are some "data" that substantiate philosophical knowledge, certain criteria for distinguishing between true and false.

He warns that the realisation that the building has no natural foundations and that philosophy is a "language game" should not lead to nihilistic conclusions and desperation. Philosophy can be a viable and prosperous cultural field if, without making epistemological claims, it works simply as a **"literary genre"** or **"literary criticism"** which is not constrained by rigid academic canons and uses a metaphorical poetic language. In this case, logic and epistemology will be replaced with an "engaging conversation" and a theoretical consensus about what is considered true will be replaced with a "solidarity" of incommensurable and irreducible beliefs.

The postmodern is defined as the period of the post-war (after the 2nd World War) development, beginning from the 1950s and the 1960s. The term "postmodern" applies not only to social, economic and political trends and realities, which is emphasised by the concepts of the postindustrial and information society, but also to the axiological space, culture, and personality and its being. The term "postmodern" and the notion of postmodernism became relevant during the period when poststructuralist ideas were formed and formalised into a comprehensive concept. The justification of the substantial characteristics of postmodernism, as is commonly believed, was presented by Jean-François Lyotard, who borrowed this concept from the philosophical and cultural language used in the United States. The philosopher included this term in the title of his work *The Postmodern Condition* (1979). Lyotard analyses the conditions of acquiring knowledge in the most developed societies of the West from the perspective of the philosophy of language. The situation that had developed here by the end of the 20th century is characterised as "postmodern" (from French *postmodernes*), or the postmodern condition. By postmodernity (the postmodern), Lyotard means the condition of culture after the changes which affected the rules of the game in science, literature, and art since the beginning of the 19th century.

We should distinguish the concepts of the postmodern (postmodernity) and postmodernism. If the postmodern can be understood as a certain stage of the development of culture in general, and industry, information, and social space in particular, then by postmodernism we should understand the style or type of critical thinking and state of mind, the key feature of which is the reflection on the modern European culture and the realities and trends of postmodernity (the postindustrial society). Therefore, postmodernism as a world view is manifested in art, literature, philosophy, as well as in the way of life. Postmodernism is a product of both the modern European culture and becomes both a reaction to the modern and the brainchild of the postmodern absorbing and simultaneously criticising these two eras and their values.

- Self-Checking
- Logical positivism and the principle of verification.
- Evolutionary epistemology and the principle of falsification.
- Polanyi's concept of tacit knowledge.
- Rorty's postmodernist discourse.
- Jean-François Lyotard and the contradictions of contemporary science.

CHAPTER 7
The Structure and Levels of Scientific Knowledge

7.1 Scientific Knowledge as a Complex Evolving System

People acquire knowledge in the course of everyday practical activities. We distinguish extrascientific, nonscientific and scientific knowledge. Scientific knowledge is reliable, valid and logically consistent knowledge. The most important criterion of the scientific nature of knowledge is the growth of the objectively true substance of knowledge, which expresses the degree of adequacy (relevancy) to reality. This is accomplished by specific means and methods of acquisition of knowledge.

In the process of scientific knowledge, we can distinguish different levels, qualitatively unique stages of knowledge differing in terms of fullness, depth and comprehensive coverage of the object, by the method for achieving the substantive content of such knowledge, by the form of their expression. These include empirical and theoretical knowledge or cognition.

The empirical and theoretical levels of cognition are closely interrelated. An empirical study, through discovery of new knowledge by observation and experimentation, gives impetus to theoretical knowledge and sets before it new, more complex tasks. On the other hand, theoretical knowledge, by developing and empirically specifying its own substantive content, opens up new, wider horizons for empirical knowledge, directs and guides it in the search for new facts, contributes to the improvement of methods and tools, and so on.

The boundary between these levels is conventional and flexible. At certain points of the development of science, the empirical transforms into the theoretical and vice versa. In the course of development of knowledge from the empirical level to the theoretical level, certain successive steps can be distinguished, i.e. forms of scientific knowledge, which fix the depth and degree of completeness of reflection of the objects being studied and simultaneously identify the ways of their further examination.

A scientific research or inquiry begins with a **statement of the problem**. The concept of problem is usually associated with the unknown and it is, therefore, possible, to offer an initial definition of the problem: what has not been learned by man and what needs to be studied and learned. Problems stem from the needs of practical human activity, as a certain desire for new knowledge. Science must be sophisticated enough to have the necessary and sufficient basis for setting a specific problem. Formulation of the problems necessarily includes some preliminary, albeit imperfect, knowledge of ways for its solution

Formulation of the problem requires **facts**. By fact is meant the phenomenon itself (the thing, the process of objective reality), as well as knowledge which has its own distinctive characteristics. In this case, we are talking about facts in the second sense of the term. Factual knowledge is attained empirically. In addition, solution of a problem requires knowledge the objective truth (accuracy, reliability) of which has been established. This reliable knowledge constitutes the fact on which the inquiry is based. Accuracy of knowledge is a prerequisite for its transformation into a fact, this is why facts, as "stubborn things", should be acknowledged regardless of whether we like it or not, whether it is convenient to the inquirer or not. All other attributes of fact are derived from its accuracy and reliability. Accumulation of facts is an important part of scientific research, but by itself does not solve problems. Solution of problems requires a system of knowledge describing and explaining the phenomena or processes that are of interest to us.

The pillar, the guiding programme of a scientific inquiry is **the idea**. Its purpose is in the formulation of a generalised theoretical principle explaining the essence of phenomena without intermediate arguments, without the awareness of the totality of all links and relationships that serve as a basis for a conclusion. Principles, on the one hand, reflect the general and essential parameters of the system being studied, and on the other hand, apply its forms and methods to the inquiry and, to a certain extent, inhibit the outcomes of the inquiry. For example, the principle of causality is universal, therefore, a theory that rejects this principle cannot be a genuine scientific theory. It is in this context that the principle of causality acts as an inhibitor for the theoretical system

A scientific idea finds its specific materialisation in a **hypothesis**. This form of knowledge is problematic and unreliable. It requires verification, validation and justification. The hypothesis organically merges two aspects: the formulation of a certain assumption and its subsequent logical and practical verification and proof. Unlike a simple assumption, a hypothesis has a number of features. These include: conformity to the facts on which and for the verification of which it was created; verifiability; applicability to a possibly wide range of phenomena; and relative simplicity. Hypotheses may emerge on the basis of concepts that represent a particular way of understanding, interpretation of certain events or a system of views on various phenomena.

A tested and proven hypothesis transforms into the category of reliable truths and becomes a scientific **theory**. This is the most advanced form of scientific knowledge which provides a coherent reflection of the regular and substantive relationships of a certain area of reality. Some examples of this form of knowledge are evolutionary theory, cell theory of the structure of living organisms, electromagnetic theory, etc.

In the most general sense, a scientific theory is a system of knowledge that allows us to explain the origin, emergence and functioning and to predict the development of objects and phenomena of reality, and these objects and phenomena can be material or ideal.

Components of a scientific theory as a coherent system are:

- the initial empirical basis, the subject of the inquiry;
- the language (natural or artificial, or symbolic) used for the study of this empiria;
- the means for the transition from the empiria, from the given concrete and sensual reality, to the general, the essential, the consistent, explicable and logical;
- a set of rules, principles, in other words, the logic of inference from the laws or axioms of certain theoretical, but mainly practical, consequences, conclusions, recommended tools, that address the same reality for the purpose of its transformation and change.

The main element of a theory is **an idealised object**, an abstract model of the essential properties and relations of the objects of inquiry. The variety of types of idealised objects have their corresponding variety of types of theories:

- descriptive mathematised, deductive and inductive;
- fundamental and applied;
- formal and substantive;
- "open" and "closed";
- explaining and describing (phenomenological);
- physical, chemical, mental, etc.

A theory has a number of functions. It synthesises reliable knowledge into a coherent system. It explains the causal relationships and connections of phenomena and objects and, on this basis, forecasts the prospects for their development. A theory is the basis for formation of diverse tools, methods and techniques of research. But the main function of a theory is its practical implementation, is to be a guide to action. To be implemented, a theory must materialise. People should learn and master it as a programme of action. The materialisation of a theory in practice should not be a one-time act (to eventually fade out), but a process, in which, instead of the already implemented theoretical propositions, new, more substantive and more developed ones emerge.

A number of theories, that collectively describe to man the known natural and social world, are synthesised into a single scientific picture of the world. These are the main forms of scientific knowledge. There are many other forms: axioms, postulates, presuppositions, paradoxes, etc. Forms of scientific knowledge are closely interrelated. The scientific method is a perfect example of the unity of all forms of knowledge about the world.

7.2 The Concept of Truth in the Philosophy of Science

Successful application of acquired knowledge in practice is possible only if such knowledge is valid, i.e. true. Therefore, the question of **truth** is one of the most important questions in the theory of knowledge. What is truth?

By truth we traditionally understand **the reality adequately reflected in human thought**, and the process of such reflection. In other words, truth is the concordance (identity, equivalence) of our knowledge about an object to the object itself. The longstanding usage treats truth as something that can be searched, can be possessed, etc. In fact, truth (or falsity) is the ability of a statement to have (or not to have) a certain object as its denotation (denotatum), as what is posed in accordance with this statement.

Contemporary epistemology accepts three theories of truth: **the correspondence theory, the coherence theory, and the communicative-pragmatic theory**. Each of them has deep roots in the history of philosophy. The current situation is distinctive in that only today the conditions for their amicable coexistence have formed. This is largely due to the linguistic turn, which has made it possible to apply the principles of linguistic complementarity and linguistic relativity.

The **correspondence** theory (or theory of correspondence) states: knowledge about an object is true when it corresponds to the object itself. The **coherence theory** (or theory of consistency) defines true knowledge as knowledge included in a consistent system of knowledge and coherent (or consistent) with the other elements of this system. The **communicative-pragmatic** theory holds that true is any knowledge that allows us to explain what is happening, to predict the future and to effectively use the forecasts in our actions.

The arguments against the correspondence theory are that any correspondence which is not based on real similarity is only conventional; and how can we treat as comparable such diverse phenomena as, for example, thought and thing or thought and action.

The arguments against the coherence theory are that an intercoherent system of knowledge can, at the level of individual elements, be poorly correlated with the corresponding fragments of reality; this happens when the logic of the intercoherence of knowledge suppresses the logic of its adequacy.

The arguments against the pragmatic theory of truth are that truth is identified with useful delusions that can at any time cease to be useful (as opposed to truth).

The pragmatists have rejected the notion of truth claiming that the pair "truth and falsity" must be replaced with another pair "belief and doubt". Belief (or faith) is a human ability to evaluate direct (sensory images) and indirect (statements, information) knowledge as true without any evidence. Man trusts his feelings more than the results of reasoning. He trusts the stories of others to an even lesser degree. However, due to his limited experience, man has to use a lot of knowledge, including knowledge of the second and third kind. Often these three kinds of knowledge contradict each other, and knowledge of the third type, which is obtained from various sources, can also be contradictory. Man is forced to interpret certain sources of knowledge as superior to other sources, i.e. assigning them the status of authority.

Religious faith is a special case. Despite all the diversity of religious traditions both inside and outside Christianity, different models of faith are similar in the sense that they are all based on trust, i.e. "belief in something," as opposed to "believing that".

Religious faith has a certain "intellectual dimension" as it is based on the recognition of a certain truth about the nature of reality. Knowledge which is based on faith is distinguished from other types of knowledge by its acceptance of transcendence and involvement of will in the process of acceptance of truth.

The problem of reliability depends on common sense rather than theoretical constructions. One of the eternal disputes in the history of philosophy is the dispute about the possibility of proving the existence of the external world. Over time the debate between realists and their opponents, who at various times have been called skeptics, agnostics and solipsists, has calmed down only to flare up with renewed vigor at some later point.

Types of faith differ among themselves in what source of knowledge is considered a true authority:

- life experience and common sense suggest that the supreme authority is only the direct knowledge received through the sense organs and everything else should be treated with doubt;
- the same life experience tells us that we should trust socially approved sources of information whose authority is backed up by tradition and public opinion;
- there is also the authority of reason which relies on the system of commonly accepted proofs; it has been formulated by Western intellectual tradition, although there are references to it in some other cultures as well;
- religious knowledge as the most authoritative source of knowledge was suggested as a result of the direct mystical experience obtained as revelation, i.e. extrasensory insight.

Contemporary materialism approaches the problem of truth in terms of reflection of the objective reality in human consciousness. Truth is the adequate reflection of the object in the mind of the subject, which recreates the object such as it exists independently of the consciousness of the subject. The materialist theory of knowledge makes the traditional concept of truth more specific (concrete) through dialectical relationship of the concepts of "objective truth", "subjective truth", "absolute truth", "relative truth", and "concrete truth".

Objective truth is the substance of human knowledge of reality which is independent of the subject, or man, or society.

In the process of acquiring knowledge the subjectivity of truth should be taken into account, because true knowledge is always a knowledge of a specific subject, i.e. an individual, social group, or all mankind. Truth as a process is objective in substance, but it is subjective in form. Truth cannot be understood as a ready-made knowledge, immutable and given once and for all. Truth is an infinite process of approximation to the object, which itself is developing or evolving. In this regard, any knowledge fixed at a particular historical level of development of knowledge deals only with relative truth.

Relative truth is knowledge that is in principle accurate, but its reflection of reality is incomplete and it does not produce its full and exhaustive image.

Absolute truth is a complete, accurate, and comprehensive reflection of the object in the consciousness of the subject; or, broadly speaking, it is the absolute knowledge about the world. In this sense, the absolute truth is the limit, which scientific knowledge is trying, but never manages, to reach. Strictly speaking, absolute truth is the complete and accurate knowledge of certain aspects of reality, and, in this sense, it is an element of the achieved knowledge.

It should be noted that there is no, and cannot be, a separate absolute truth and a separate relative truth. There is one truth, which is objective in its meaning and sense, which serves as the dialectical unity of the absolute and the relative, i.e. it is the truth which is absolute, but only within certain limits. The absolute and the relative are two necessary aspects of the objective truth.

From the analysis of absolute and relative truth follows the doctrine of the concreteness of truth. Concrete truth is a truth which accurately reflects the essence of certain phenomena and of the specific conditions under which these phenomena develop. If the concept of "objective truth" emphasises its main characteristic as an accurate reflection of reality, and the concept of "relative and absolute truth" emphasises the process of knowledge itself, the concept of "concrete truth" shows the possibility of practical use of the acquired knowledge.

7. 3 Methods of Knowledge Acquisition

The term "method" means a set of tools, procedures and operations for practical or theoretical exploration of reality. It is a system of principles, techniques, rules, and requirements that must be followed in the process of obtaining knowledge. A method is determined by the subject matter of research. But its "medium" is a concrete person. Distinctive features of the scientific method are: objectivity, reproducibility, heuristics, necessity, and concreteness. The main function of a method is the internal organisation and regulation of cognitive and other forms of activity. The variety of types of human activity determines the variety of methods that can be classified based on various criteria.

Methods of scientific knowledge acquisition are traditionally divided into three groups, which are based on the level of similarity between the methods of each group:

- general (or universal) methods, i.e. pertaining to all philosophy in general. These methods characterize human thought in general and are applicable in all spheres of human cognitive activities;
- general scientific methods, i.e. methods that characterise the process of acquisition of knowledge in all sciences. General scientific methods also include the system method, the structural methods, the method of probabilities, and the formalisation method. Generally speaking, classification of methods is closely related to the notion of levels of scientific knowledge.

A good example of formalisation are the widely used in science mathematical descriptions of various objects and phenomena which are based on respective content theories. Notably, the mathematical symbols used not only help consolidate the already existing knowledge about the objects and phenomena under study, but also act as a tool in the process of their further investigation.

Specific scientific methods, i.e. methods applicable only within particular sciences or research into a particular phenomenon. The distinctive feature of these methods is that represent particular cases of application of general scientific research techniques to investigation of a concrete area of the objective world.

Depending on the methods used, the natural sciences can be nominally classified into two main groups:

- the descriptive applicable sciences which are mainly concerned with collection of facts and examination of the relations between them; and
- the explaining theoretical sciences which generalise relations into principles, laws, trends and general patterns.

The whole corpus of general scientific methods can be classified into methods used at the empirical and theoretical level of research, i.e. empirical methods, and theoretical methods of research (or knowledge acquisition).

The empirical level of knowledge acquisition is a process of thought – i.e. linguistic – processing of sense data, and information in general, obtained through the senses. Such processing can take place as **analysis, classification, generalisation of data obtained through observation**. Here concepts are formed that generalise the observed objects and phenomena. Thus, an empirical basis for different theories is formed.

The theoretical level of knowledge acquisition is characterised by the fact that it includes the thought process as another source of knowledge: there is a construction of theories explaining the observed phenomena and discovering the laws of the realm of reality which constitutes the subject-matter studied by a certain theory. The scientific methods used both at the empirical and theoretical levels of knowledge acquisition are such methods as **analysis and synthesis, analogy and models.**

As regards general scientific methods and techniques, there is no generally accepted classification and classifications are made on the basis of different criteria. For example, there is a classification which distinguishes three levels in the structure of general scientific methods ("in the descending order of priority"): the general-logical, theoretical, and empirical. Traditionally, we distinguish general scientific and specific scientific methodological approaches, depending on the degree of similarity and the scope of application. Some of the general scientific methods are described below.

Observation – the method of study of objects and phenomena of objective reality in the form in which they exist and occur in nature under natural conditions and are accessible to immediate human perception. Observation is related to experiment, which is not identical to it.

Induction (from Latin *inductio* – I lead) is a method of knowledge acquisition which is based on a formal-logical inference that leads to a general conclusion based on specific premises. Induction, when used in scientific knowledge, can be in the form of the following methods:

- the method of single agreement (in all cases of observation of a phenomenon only one common factor is detected, all others are different, hence this single similar factor is the cause of this phenomenon);
- the method of single difference (if the circumstances of the occurrence of a certain phenomenon and the circumstances under which it does not occur are similar in almost all respects and differ only in one factor which is present only in the first case, it can be concluded that this factor is the cause of this phenomenon);
- the joint method of agreement and difference (a combination of the two methods described above);
- the method of contaminant variations (if certain variations in one phenomenon are always followed by certain variations in another phenomenon, it can be concluded that there is a causal relationship between these phenomena);
- the method of residue (if a complex phenomenon has a multi-factor cause and some of these factors are known to be the cause of a part of this phenomenon, it can be concluded that the other part of the phenomenon is caused by the other factors constituting part of the common cause of this phenomenon).

Deduction (from Latin *deductio* – inference) means specific conclusions made on the basis of knowledge of any general propositions. In other words, this is the flow of our thought from the general to the particular, the individual.

For the purposes of acquisition of scientific knowledge the following are widely used: **analogy, comparison, measurement, analysis and synthesis.**

Analysis is a thought technique which involves breaking down the object under investigation into components, constituent parts, aspects, development trends and functioning ways in order to study them relatively separately from each other. Some of such parts may be certain materials element of the object or its properties, features or characteristics. Analysis plays an important role in the study of the objects of the material world, but it is only an initial stage in the process of knowledge acquisition. The method of analysis is applies to study constituent parts of an object. While it is a necessary thought technique, analysis is only one of the aspects of the process of knowledge acquisition. Tools of analysis are manipulation of abstractions in consciousness, i.e. thinking.

To investigate an object as a whole, we cannot limit ourselves by the study of its components only. In the process of knowledge acquisition, it is necessary to reveal objectively existing relations between them, to consider them together, as a whole, in unity. To carry out this second stage in the process of knowledge acquisition is – i.e. to move from studying individual constituent parts of an object to studying it as a single connected whole – is possible only if the method of analysis is supplemented by another method, the method of synthesis. In the process of synthesis, the components (parts, aspects, properties, features, etc.) of the object under study, which have extracted and separated as a result of the analysis, are combined together. On this basis, further study of the entire object as a whole takes place. Analysis basically identifies the specific properties which distinguish the constituent parts from each other.

Synthesis identifies the place and role of each element in the system of the whole, establishes the relationships between elements, or makes it possible to understand the common which connects separate parts into the whole. Analysis and synthesis are in unity. In essence, they constitute two sides of the single analytic-synthetic method of knowledge acquisition. Analysis and synthesis originate in practical activities. Constantly breaking down in his practical activities various objects into their component parts, man gradually learned to break down objects mentally as well. Practical activities not only involved the breaking down of objects, but also the combination of parts into a single whole. Thought process was based on this as well. Analysis and synthesis are the basic methods of thinking, which have their objective basis both in practice and in the logic of things: the processes of connection and separation, creation and destruction form the basis of all processes in the world. At the empirical level of knowledge acquisition, direct analysis and synthesis are used, in order to get a first, general idea of the object of investigation. They summarise the information about the observed objects and phenomena.

At the theoretical level of knowledge acquisition, reverse analysis and synthesis are used, which are carried out by multiple returns from synthesis to re-analysis. They reveal the most profound, essential aspects, connections, patterns and regularities inherent in the objects and phenomena under investigation. These two interrelated methods of research receive are adapted specifically for each branch of science. They can transform from a general technique into a special method and there are specific methods of mathematical, chemical and social analysis. The analytical method has been further developed by some philosophical schools and movements as well, the same can be said about synthesis.

Analogy is a plausible probable conclusion about the similarities of certain properties of two objects based on the established similarities of their other properties. Analogy is in the nature of the very understanding of facts which connects the threads of the unknown with the known. Anything new can be comprehended and understood only through the images and concepts of the old and the known. The first airplanes were created by analogy with how birds, kites and gliders fly in the air. Despite the fact that analogies allow only probable conclusions to be made, they play a huge role in knowledge acquisition as they lead to the formation of hypotheses, i.e. scientific conjectures and assumptions, which, in the course of additional research and proof, can transform into scientific theories. An analogy with what is known helps to understand what is unknown. An analogy with what is relatively simple helps to understand what is more complex. The most developed area where analogy is often used as a method is the so-called similitude theory, which is widely used in modelling.

Modelling is based on similarity, analogy, common properties of different objects and on relative independence of form. This is a method of research when an object which is of interest for a researcher is substituted with another object which is similar to the first object. The first object is called the original and the second object is called the model. Afterwards, the knowledge acquired during the study of the model is applied to the original based on analogy and the theory of similitude. Modelling is applied when the study of the original is impossible or inconvenient or if it involves great costs and risks. A typical example of modelling is the study of properties of new airplane models using their scaled-down models in a wind tunnel. Modelling may be physical, mathematical, logical and symbolic depending on the chosen type of the mode.

A model is a means and a way of rendering the properties and relationships of the object taken as the original. A model is a system, objectified in reality or imagined, that replaces the object of inquiry. Modelling is always and inevitably associated with certain simplification of the object being modelled. But it still plays a huge role being a prerequisite for a new theory.

Modelling, as a wide-spread approach in scientific research today, is based on inference by analogy. In a broad sense, modelling, due to its complex nature, may be classified as a research method or technique.

Experiment offers active, purpose-oriented, and strictly controlled impact of the researcher on the object being studied for identification and examination of certain aspects, properties, relationships, etc.

Advantages of the experiment:

- more active (compared to observation) approach to the object, including its presentation and transformation;
- multiple reproducibility of the object being studied as required by the researcher;
- the possibility of detecting such properties in a phenomenon that are not observed under natural conditions;
- the possibility of examination of a phenomenon in a "pure form" by isolating it from complicating circumstances; and
- the possibility of controlling the "behaviour" of the object being studied and verifying the results.

Carrying out an experiment requires its planning, construction, control, and interpretation of its results. Experiment pursues two interrelated goals: experimental testing of hypotheses and formation of new scientific hypotheses. Experiments may have the following functions: research, testing (controlling), reproducing, isolating. Depending on the kind of objects, there are physical, chemical, biological and social experiments.

Observations and experiments study primarily natural objects. But sometimes this may be impossible and objects are studies indirectly with the help of models.

Thought experiments are widely used in today's science. A thought experiment is a system of thought procedures applicable to idealised objects. A thought experiment is a theoretical mode of experimental situations. A researcher here uses not real objects and the conditions for their existence, but their conceptual images.

Specific scientific methods or methods of specific sciences may include:

- in physics – spectroscopy, electron diffraction, X-ray diffraction analysis;
- in chemistry – activation analysis, chemical spectral analysis;

- in biology – the hybridologic method, biometrics.

It should be noted that methodology cannot be reduced to just one, even a very important method, and even more so to the only scientific method. Each method, as a rule, is applied not in isolation, in itself, but in combination with other methods.

The universal foundation, the "core" of the system of methodological knowledge is **philosophy** – the universal method. Its principles, laws and categories determine the general direction and strategy of research, "penetrate" all other levels of methodology where they are adapted to satisfy the specific needs of each method.

7. 4 Dialectics, System Approach and System Analysis

In the mid-twentieth century, cybernetics and a group of associated scientific and technology disciplines played an important role in understanding the modus operandi of the control system (large, complex systems). From this time, intensive development work in the field of system approach and the general theory of systems began to be conducted.

System (from Greek *systema* – organised whole, body) is a group of interrelated and interconnected elements forming a unified whole. This term plays an important role in contemporary philosophy, science, technology and practical activities. The notion of system has a long history. The thesis that the whole is greater than the sum of its parts was formulated as early as in Antiquity. The Stoics' interpreted system as the world order. As philosophy was developing, starting in Antiquity from Plato and Aristotle, great attention was also paid to the exploration of specific properties of the system of knowledge. The systemic nature of knowledge was emphasised by Comte; this notion was further developed by Schelling and Hegel. In the 17th and 19th centuries, various specialised sciences studied certain types of system (geometric, mechanical systems, etc.).

The notion of system is organically related to the notions of wholeness, integrity, element, subsystem, links, relationships, structure, etc. A system is characterised not only by the presence of links and relationships between its elements (a certain structure), but also by its inseparable unity with the environment, in the relations with which the system manifests its integrity. Any system may be viewed as an element of a higher-level system, while its elements can act as a lower-level system.

Hierarchy and multiplicity of levels characterise the structure and morphology of a system and its behavior and functioning: its individual levels determine certain aspects of its behaviour, and coherent functioning is the result of the interaction of all its parts and levels.

Most systems typically have processes of transfer of **information and management**. The most complex systems, whose behaviour is aimed at achieving a certain goal, and self-organising systems are capable of changing their structure in the course of their functioning. And many complex systems (living, social, etc.) are characterised by the presence of different-level, often incoherent goals, by cooperation or competition between these goals, etc. In the most general sense, systems are divided into material and abstract (ideal). Materials systems include systems of inorganic nature (physical, chemical, geological, etc.), living systems; a separate class of material systems forms social systems. Abstract systems are a product of human thinking, and they can also be divided into a number of types. Other criteria for system classifications are also used.

Methodology expressing philosophical aspects, system approach became the basis for studying the substance and general properties of system knowledge, its epistemological foundations and terminology, the history of system ideas and system-centric ways of thinking, analysis of system regularities in various areas of objective reality. In the real process of scientific knowledge, the specific scientific and philosophical types of system knowledge complement each other, forming a coherent system from this knowledge. In the history of knowledge, the identification of systemic properties of holistic phenomena was associated with the study of the relationship between the part and the whole, composition and structure patterns, internal connections and interactions of elements, and properties of integration, hierarchy, and subordination. However, it was an isolated knowledge about individual system forms that did not go beyond the consideration of the "subject as a system". The assertion in science of systematics as one of the universal principles of methodology began with the appearance of ideas about the systemic structure of the world. The system approach as one of the universal principles of methodology began to take root in science with the emergence of the ideas about the systemic structure of the world.

The methodology of dialectical materialism covers both procedural and object-based (static) aspects of reality relying on a wide range of scientific methods. The method of knowledge acquisition is mainly focused on the study of stable forms, structural dependencies and relationships (part and whole, stable unity, subordination and hierarchy, etc.). However, in the practice of scientific research, it acts in a dialectical connection with the **principle of development** and naturally complements the acquired knowledge about the processes of change, formation and development.

The method of knowledge acquisition is one of the methodological foundations of the synthesis and integration of contemporary scientific knowledge. Specialisation of scientific knowledge results in a serious need for a systematic synthesis of knowledge, overcoming the disciplinary narrowness generated by the subject or methodological specialisation of knowledge.

On the other hand, multiplication of knowledge of different level and scale about the subject requires such a **system synthesis** which expands the understanding of the object of knowledge in the studies of deeper bases of being and more systematic study of external interactions. The knowledge acquisition method serves as a methodological method for the identification of the system specifics of the theoretical-cognitive tools used in the natural sciences and engineering, as well as the development of heuristic techniques of knowledge acquisition and practical activities. The system synthesis of different types of fundamental knowledge used for long-term planning, forecasting results of practical activities, modelling of development scenarios and their consequences, etc. is also of great importance.

The use of system analysis methods for solving the aforesaid problems is required, above all, because, when making decisions, we have to make choices in the conditions of uncertainty which is caused by factors that cannot be rigorously assessed in quantitative terms. The procedures and methods of system analysis are aimed at offering alternatives and comparing such alternatives based on effectiveness criteria.

The intensive expansion of the scope of application of system analysis is closely connected with the extension of the goal-oriented programme management method when a programme is designed specially to solve an important problem, an organisation (institution or network of institutions) is formed and the necessary material resources are allocated.

System analysis is often thought to be based the general theory of systems and the system approach. However, system analysis borrows from them only the most general initial ideas and propositions and its methodological status is very distinct: on the one hand, system analysis uses detailed methods and procedures derived from modern science and created specifically for it, which puts it in line with other applied areas of modern methodology; on the other hand, within the framework of system analysis, it is not strictly applied, but is based on intuition, qualitative judgments, estimates and methods, while, however, the need for their use in each case is specifically justified. In system analysis, the elements of science and practice are closely intertwined.

The most important principles of system analysis boil down to the following: the decision-making process must begin with the identification and clear formulation of the objectives. It is necessary to consider the entire problem as a whole, as a single system and to identify all consequences and interrelations of each individual decision; it is also necessary to identify and analyse possible alternative ways of achieving the objectives; the objectives of individual units should not conflict with the objectives of the whole program.

The central procedure in system analysis is the construction of a **generalised model** (or models) that reflects all factors and relationships of the real situation that can manifest themselves in the process of implementing a chosen solution. The obtained model is examined in order to find out the proximity of the result of applying one or the other of the alternative actions to the desired result in terms of the cost of the resources for each of the options, the degree of sensitivity of the model and various undesirable external influences. System analysis is based on a number of applied mathematical disciplines and methods widely used in modern management. The technical basis of system analysis are **modern computers and information systems**.

The breadth of principles and basic concepts of the system approach puts them in close connection with other methodological approaches of modern science. The cognitive attitudes of the system approach have a lot in common with **structuralism and structural-functional analysis**, with which it is associated not only by their use with the terms of structure and function, but also by the emphasis on the examination of various object relationships. At the same time, the principles of the system approach have a wider and more flexible content, they have been subjected to too rigid conceptualiation and absolutisation as has has been the case with some other of these approaches.

- Self-checking
- Distinctive features of the empirical level of knowledge acquisition.
- Specifics of theoretical knowledge acquisition.
- Scientific knowledge as a complex and evolving system.
- Contemporary concepts of truth.
- Methods of theoretical knowledge acquisition.

CHAPTER 8
Science as a Vocation. Ideals and Norms of Science

8. 1 Science as a Vocation, Its Ideals and Norms.

Today, science is a profession, whose representatives are engaged in the study of objective and diverse things and phenomena of the surrounding world. Science itself has both a practical and a purely theoretical aspect. First, science develops the practice of exploring and transforming the surrounding world. Second, science develops methods of scientific research and their cultural and historical conditioning. The methodological tools and skills of working with them allow us to specify the ideals and norms of scientific research in relation to the specific nature of the subject area of a particular science. Third, science helps gain clarity in understanding practical and technical goals in line with the expectations gained from people's scientific experience. At the same time, scientists are engaged in science not only for the sake of achievement of practical goals, but also "for its own sake", because they understand that without science there can be no intellectual progress of society.

The structure of ideals and norms of research and description; verifiability and validity of knowledge; the construction and organisation of knowledge; and scientific progress constitute an essential part of the process of rationalisation of society. This process of deepening and expanding knowledge about the life conditions of man means "disenchantment" of the world.

Rationalisation of society leads to strengthening of the technicist type of thinking and a loss of spirituality. Restoration of society's spirituality is possible with the development of the mentoring and guiding function of university education. The spiritual and moral role of universities should resist the limited-professional understanding of education that is characteristic of the technocratic approach when the discourse of the vocation of the scientist and the social role of science is usually seen as falling within the scope of philosophy. Here an important role in the life of a scientist is played by his or her vocation, mission, inspiration, dedication and commitment to excellence. This can make the profession of scientist attractive to the younger generation. According to Max Weber, the origins of this vocation can be understood by referring to the specifics of scientific culture and the purpose of science. Leo Tolstoy believed that the results of scientific research are worthy of attention, because they form man's attitudes toward life.

We can distinguish three components as the basis of the scientific activities of a scientist: ideals and norms of research, a scientific view of the world and philosophical foundations of science.

Ideals and norms are a body of conceptual, value-based, methodological, and other attitudes which are characteristic to science at each particular historical stage of its development. The forms in which the ideals and norms of science are embodied pertain to the spheres of activity and the justification of knowledge; explanation and description; and coonstruction and organisation of knowledge. Scientific knowledge per se is governed by certain norms that reflect the ideas about the purposes of scientific activity and the ways of achieving them. Among the ideals and norms, we can identify the following: knowledge acquisition attitudes; social norms that express the value of science in the life of society. These aspects of ideals and norms of science correspond to the aspects of its functioning both as a specific area of knowledge acquisition, and as a social institution. Together, they form an original structure of the method of research activity which ensures a thorough examination of the objects of the external world.

- Self-checking
- Science as a vocation and a distinct activity.
- Social norms of scientific research.
- The notion of the style of thinking.
- The structure of ideals and norms of research.
- The regulative role of ideals and norms of science.

CHAPTER 9
Philosophical Foundations of Science and a Scientific View of the World

9.1 Philosophical Ideas as the Foundation for the Ontological Premises of Science, Epistemological Norms of Scientific Inquiry and Axiological Attitudes (Ideals and Norms)

Philosophical foundations of science are a body of philosophical ideas providing justification for the philosophical view of the world, ideals and norms of science that incorporate scientific knowledge into the culture of a particular historic era.

In the fundamental fields of research of developed science, scientists, as a rule, deal with objects that have not yet been applied either in material production or in everyday life. From ordinary common sense perspective, these objects may seem unusual and incomprehensible. The knowledge about them and the methods of obtaining such knowledge may significantly differ from the norms and perceptions of the world from ordinary knowledge of a respective historical era.

This is why scientific views of the world as well as ideals and normative structures of science during their formation and development require a certain adjustment to the postulates of the prevailing worldview of the respective era, to its cultural concepts. Such adjustment is expected to provide the philosophical foundations of science. They include ideological postulates, philosophical ideas and principles that determine the search heuristics, that is the creative development of the methodology of scientific research. These components usually influence the evolution of the scientific view of the world and norms of science. They are then used to justify the obtained ontological postulates of science, epistemological norms of scientific search and axiological attitudes (ideals and norms).

Philosophical heuristics and philosophical justification do not always coincide. Sometimes, when constructing new ideas, a scientist relies on certain philosophical ideas. Then the ideas developed by him receive a different philosophical interpretation, whereby they gain recognition and are incorporated into the intellectual culture. Philosophical grounds are heterogeneous, because they allow variations of philosophical ideas and conceptual meanings applied in research activities. Philosophical foundations of science are not identical with the general corpus of philosophical knowledge. Of all the multitude of philosophical problems and the different versions of their interpretations that emerge in the culture of each historical period, science usually uses only certain philosophical ideas as justification structures.

The construction of philosophical grounds of science requires that the scientist has both philosophical and specialised scientific knowledge and expertise. He must understand the specifics of the subject of his field of science, its traditions, procedures, etc. Drawing on this knowledge, the scientist must select and subsequently adapt the ideas developed through philosophical analysis to the needs of his field of scientific knowledge. He must specify the original philosophical ideas, clarify them, form new conceptual and terminological meanings. The whole range of research should be carried out jointly by philosophers and representatives of specific sciences. Currently, this complex field of scientific activity is an important aspect of the history and philosophy of science. This discipline shows that in the development of its problems an important role was played by outstanding scientists who combined philosophical and specialised scientific research in their work.

The heterogeneity of philosophical foundations does not exclude their interconnection and complementarity. Thus, the ontological basis of science can be made up of concepts of different schools of philosophy which can serve as a matrix of understanding and knowledge of the studied subjects and phenomena of the world. These include the concept of "form", "content", "possibility", "reality", "causality", "necessity", "chance", "space", "time", etc. In addition, this foundation also includes such epistemological concepts as truth, knowledge, explanation, proof, theory, practice, etc.

The philosophical foundations of classical science made specifically focused on the ontological component of the subject of research. At this stage in the development of science, truth was viewed as a complete adequate description of the object itself and the study of the object excluded impact on the results by the subject's and the applied research methodology. Such study of the object without regard for the subject and the nature of the research methodology was characteristic of the philosophical foundations of science of the 17^{th} and 18^{th} centuries, when the philosophical ideas of mechanistic materialism dominated it. In the classical science of the 19^{th} century, when the disciplinary structure of science was formed and the philosophical foundations became diverse, the mechanicism in the field of biology and social sciences was superseded by the ideas of organicism and evolutionism.

For this reason, in the non-classical science of the late 19th century - the first half of the 20^{th} century, the emphasis was shifted to epistemological problems. This emphasis manifested itself in the fact that the new meanings of ontological categories were influenced by the researcher and by the nature of means and operations of research. In modern post-non-classical science, its philosophical foundations are viewed from the perspective of the sociocultural conditioning of knowledge acquisition, taking into account the worldview assumptions and the social and ethical regulations of research. These factors have a significant influence on the definition of the meanings of the categories of being and knowledge acquisition. As such, development of philosophical foundations is a necessary prerequisite for mastering by science of fundamentally new types of objects and phenomena.

9.2 Main Types of the Scientific View of the World: the General Scientific, Natural Scientific, Social and Local (Special) Views of the World. The Common Cultural Meaning of the Scientific View of the World.

The scientific view of the world which acts as a certain model of the world constitutes an important foundation of scientific knowledge. The world is the object of research in many sciences and each science forms its own perspective and understanding of the world. On the one hand, science uses the term "world" to refer to the world as a whole, and on the other hand, it reflects a certain part of the world. In the first sense, it can be described as "the universe", "nature", and in the second sense this term can be used in such phrases as "physical world", "astronomical world", "biological world", etc. At the same time, their substance should be distinguished from the meaning that is attached to the concept of "general scientific view of the world", which synthesises in itself those views of nature and society that are used in specific sciences. Taking into account that natural science forms, in a certain sense, the basis of modern scientific knowledge, the natural scientific view of the world can also be regarded as the basis of a general scientific view of the world. But, the latter cannot be reduced to the first, because it includes the view of society as well, which is also created by the technology, social and human sciences. The general scientific view of the world gives a general idea of the fundamental foundations of being and the evolution and development of nature and society. This view reflects the essential difference as well as the internal relationships between nature and society.

As such, any view of the world includes an idea of the following:

- fundamental objects from which all other phenomena studied by a respective science are formed;
- typology and classification of the studies objects;
- general patterns and regularities in the interactions of objects.

All these ideas may be expressed as principles revealing the substance of the picture of the studies reality and acting as the foundation for respective scientific theories. For instance, the mechanistic view of the world of the second half of the 17th century relied on such principles as:

- the world is made up of indivisible particles;
- the interaction between particles takes place as instant transmission of forces along a straight line; and
- particles and the bodies made up from them in absolute space with the passage of absolute time.

The history of philosophy shows that the scientific view of the world was preceded by the mythological, religious, spontaneous-empirical, and natural-philosophical views of the world. The deepening and widening of the scope of knowledge of the reality being studies result in changes of the scientific views of the world. For example, in the second half of the 19th century, there was a transition from a mechanical to an electrodynamic view of the world, and in the first half of the 20th century, from the electrodynamic to the quantum-relativistic view of the world, the construction of which is not yet complete.

These changing views are accompanied by changes in principle of physics. Similar changes of the views of the world were taking place in other sciences as well based on the principle of continuity. The old view of the world was not fully rejected, but, to a certain degree, maintained its significance within the scope of its application. For example, the electromagnetic view of the world in physics did not reject the mechanistic view, but clarified the scope of its application. Similarly, the quantum relativistic view of the world did not discard the electromagnetic picture, but determined the limits of its applicability. Just as the general scientific view of the world is connected with the views of the world of individual sciences, so is philosophy which forms its theoretical basis and which is also in interrelation with concrete, specific sciences. However, the relationship between philosophy and specific sciences has not always been the same. In the past, until the beginning of the 19th century, philosophy was seen as a "science of sciences" which dominated other sciences and imposed its own rules and ideas on them. The superiority of philosophy over sciences for some of the positivist scientists in the mid-19th century was faced with opposition, which was expressed in the well-known maxim, "Physics, beware of metaphysics!" Specific sciences, from the point of view of the positivists, can solve all their important issues independently, without the help of philosophy.

Today, however, the point of view according to which philosophy and specific sciences are in a common series of unified scientific knowledge is gaining increasing recognition. Therefore, none of them has and should not have any special priority. Both philosophy and specific sciences solve their own different knowledge acquisition tasks. Although they study the same objective world, but explore and discover its different aspects. If specific sciences study the relationships and laws operating in individual areas of reality, philosophy seeks to identify the most general relationships and laws of nature, society and thinking. In this regard, philosophy and specific scientific knowledge are interrelated and complement one another. Philosophy provides specific sciences with a general theory and a common method for finding solutions. Philosophy itself in its generalisations relies on the achievements of research in specific sciences. On this basis, they have the opportunity to create both a holistic picture of the world, and a scientific understanding of it in particular aspects and details.

- Self-checking
- Philosophical foundations of science.
- Philosophical ideas as conditions for scientific research heuristics.
- Philosophical justification as a condition for the incorporation of scientific knowledge into culture.
- Main types of the scientific view of the world.
- The common cultural meaning of the scientific view of the world.

CHAPTER 9
Scientific Traditions and Scientific Revolutions

9.1 The Interaction Between Traditions and the Emergence of New Knowledge

The progressive development of science is influenced by the dialectical relationship between traditions and innovation, the interaction of socio-cultural experience and its creative continuation in relation to new historical conditions. When studying this process, it is necessary to understand, above all, the very concept of tradition. Tradition (from Latin *Traditio* - transmission, transfer) is a common form of establishment, fixation and preservation of certain elements of experience. It is an effective way of transferring the experience of generations which ensures the historical-genetic continuity in the development of culture. Tradition determines the present and future of human culture through its past cultural heritage. Reliance on the accumulated cultural heritage gives rise to new traditions that did not exist before.

Traditions are heterogenous in nature. They may be made up of elements both in explicitly expressed forms of being (text, verbalization) and in forms of implicit knowledge (value systems contained in ongoing scientific research). Together, they constitute the "scientific mentality", the paradigm of the respective era.

Innovations in science also emerge when problem solving models are transferred from one area of knowledge into another as metaphors. Ecology, for example, which emerged as a biological discipline, gave rise to many metaphorical interpretations, such as: cultural ecology, population ecology, technical ecology, city ecology, etc.

Researchers' ability to work with different traditions and to combine them is one of the conditions for innovation and scientific progress. Innovations are manifested in many different ways.

These include the discovery of previously unknown objects, the formulation and solution of new problems, the development of new experimental methods of investigation, etc. They serve as a basis for the creation of new theories and scientific disciplines which often lead to ground-breaking discoveries and scientific revolutions. The latter lead to a radical revision not only of a special, but also of a general view of the world which integrates most important results of the natural, technology, social and human sciences.

9.2 The Phenomenon of Scientific Revolutions

Scientific revolutions transform a special view of the world both with and without significant changes in the ideals and norms of research. This is well illustrated in Kuhn's famous work *The Structure of Scientific Revolutions*. He believes that science develops through periodic radical transformation and change of the dominant ideas -- through periodically occurring scientific revolutions. According to Kuhn, each of these revolutions means the need for the scientific community to abandon one scientific theory in favour of another which is incompatible with the former. Kuhn believes that it is impossible to characterise all scientific activity after Popper in terms applicable only to revolutionary periods.

The first revolution of the 17th century lead to the formation of classical natural science. Its emergence was closely connected with the formation of a distinct system of ideals and norms of research. This, on the one hand, resulted in the emergence of the attitudes of classical science, and on the other hand, they started to be specified from the perspective of superiority of mechanics in the system of scientific knowledge of that era

Starting from the 17th century, all classical natural science is dominated by the idea according to which the objectivity and focusing on a specific subject-matter of scientific knowledge is achieved only when everything that pertains to the researcher and the procedures of his cognitive activity is excluded from the description and explanation. These procedures were accepted as constant and given once and for all. The ideal was seen as the construction of an absolutely true picture of nature. The main attention was paid to the search for obvious experienced-based ontological principles on the basis of which theories explaining and predicting facts can be constructed.

In the 17-18th centuries, these ontological principles in combination with the ideals and standards of research were supplemented with a number of specifying provisions that expressed the approach according to which nature is seen as a mechanism. Explanations boiled down to the search for mechanical causes and substances which were supposed to serve as foundations of objects. These foundations suggested the inclusion of the idea of reducing the knowledge of nature to the fundamental principles and concepts of mechanics. Based on these approaches, a mechanical picture of nature was built and developed. It acted as a knowledge of both the physical picture of the world and the universal scientific picture of the world.

The ideals, norms and ontological principles of the natural sciences of these centuries were based on the philosophical ideas of mechanistic materialism. Thus, the cognitive component of this materialism was the idea of knowledge as observation and experimentation with objects of nature revealing the secrets of their being to the learning knowing mind. The mind was seen as a sovereign subject of cognition, independent of the characteristics of the object, i.e. an external observer. Properties of the studied objects were considered through the prism of ontological concepts of "thing", "process", "part", "whole", "causality", "space" and "time", etc.

Major changes in the existing system of the foundations of natural science took place at the end of the 18th and first half of the 19th centuries. They can be understood as the second global scientific revolution of natural science, which determined its transition to a discipline-based organisation of science.

As a result, the mechanical view of the world loses its universal scientific status as biology, chemistry and other fields of knowledge begin to form their own views of the world.

Some areas of natural science see a differentiation of disciplinary ideals and norms of research. For example, ideas of development (evolution) begin to take ground in biology and geology which results in the emergence of the ideals of evolutionary explanation. New ideals of explanation change the specifics of the discipline-based organisation of science and, accordingly, its philosophical foundations. For instance, the idea of development (evolution) gives a broader range of meanings to ontological categories. In theory of knowledge, the problems of interrelation of various methods of science, synthesis of knowledge and classification of sciences become important. The questions of the unity of science and the problem of differentiation and integration of knowledge are seen as fundamental and retain their significance throughout the subsequent development of science.

The third global scientific revolution which covers the period from the late 19^{th} to the middle of the 20th centuries is associated with the transformation of the classical style of thinking and the emergence of a new, nonclassical natural science. During this period, revolutionary changes in different fields of knowledge were taking place:

- in physics (the discovery of the divisibility of the atom, the formation of the theory of relativity and quantum theory), in cosmology (the concept of a non-static Universe);
- in chemistry (quantum chemistry), in biology (the development of genetics).

Such general scientific disciplines as cybernetics and the general theory of systems that have played a large role in the development of the modern scientific view of the world are being formed.

In the course of all these revolutionary changes, the ideals and norms of a new, non-classical science were formed. They come from the rejection of a straightforward interpretation of being and the understanding of the relative truth of theories and the picture of nature formed at certain stages in the development of natural science. The ideal of the only true theory of depiction of the objects under study is replaced with the understanding of the admissibility of the truth of several of their competing theoretical descriptions. Attempts are also being made to establish a relationship between the ontological approaches of science and the characteristics of the method of examination of objects. This means that when studying them, the types of explanations and descriptions that are influenced by the means and operations of research activity are applied. For example, the justification of theories in quantum-relativistic physics presupposed an explanation of the introduction of a system of concepts (the principle of observability) and the identification of the relationships between the new and preceding theories (the principle of correspondence).

The emerging new system of the ideals and norms knowledge acquisition significantly expands the field of studied objects, including complex self-regulating systems. The latter are characterised by a level-based organisation, the presence of relatively autonomous and variable subsystems, the mass-scale stochastic interaction of their elements, and the existence of a controlling level and feedbacks that ensure the integrity of the system.

The inclusion of holistic systems in the process of scientific research led to radical changes in the scientific views of reality of the main areas of natural science. This restructuring caused the integration of scientific views and the development of a universal scientific view of the world based on the perception of nature as a complex dynamic system. The complexity and dynamism of systems were determined by a number of circumstances:

- the discovery of the specifics of the laws of the micro-, macro- and mega-worlds in physics and cosmology;
- thorough examination of the mechanisms of heredity in close connection with the study of superorganismic levels of organisation of life; and
- the discovery by cybernetics of general laws of control and reverse causality.

This created the prerequisites for the development of an integral picture of nature, in which hierarchical organisation and dynamic unity of the world were manifested. The views of the world developed by individual sciences, although they still retained their independence, but each of them had a role in the formation of a developing universal view of the world.

These fundamental shifts in the perceptions of the world and the methods of its exploration were accompanied by the formation of new philosophical foundations of science. The ideas that of the historic nature of changing scientific knowledge and relative truth of ontological settings was combined with new ideas about the proactive approaches of the researcher. There was an understanding that knowledge about nature is determined not only by the structure of nature itself, but also by the ways of posing questions and the historical development of the means and methods of research. This determined a new understanding of the substance of the concepts of truth, experience, theory, explanation, etc.

The foundations of natural science of the era of the first scientific revolution were formed within the framework of the rationalistic worldview of early bourgeois revolutions, the emergence of a new understanding of man's attitude to nature, new ideas about the goals and tasks of knowledge, the truth of knowledge, etc.

The formation of the foundations of the disciplins of natural science in the period from the late 18th century to the first half of the 19th centuries was taking place in response to the strengthening of the productive role of science, the transformation of scientific knowledge into a special product that has a commodity price and, accordingly, brings profit when consumed. This entails the formation of a system of applied and engineering and technology sciences as an intermediate link between fundamental knowledge and material production. The specialisation of various fields of science begins, which leads to the formation of specialised scientific communities

The transition from classical to nonclassical natural science in the second half of the 19th -- beginning of the 20th centuries is associated with the change in the structures of the nonmaterial production of European culture, the degradation of the worldview of classical rationalism. In different areas of spiritual culture a new understanding of rationality is formed, when the consciousness becomes increasingly aware of its dependence on social circumstances which determine the norms of knowledge acquisition, its axiological and purpose-related meanings.

The fourth global scientific revolution of the last third of the 20th century lead to fundamental changes in the foundations of science and gave birth to a new post-non-classical science. This revolution caused the intensive application of scientific knowledge in all spheres of social life. It has changed the nature of scientific activity, the means of storing and gaining knowledge. By this we mean the computerisation of science, the emergence of complex and expensive instrument packages and systems operated and maintained by research teams. This brings interdisciplinary and problem-oriented forms of scientific activity to the forefront. The specifics of modern science are beginning to define complex research programs that can be implemented by scientists of various fields of science. The choice and organisation of programs depends on a number of factors:

- from the determination of priority areas, their funding, training of qualified personnel, etc.
- the process of determining research priorities depends on both language acquisition goals and economic and socio-political goals.

The implementation of such programs leads to a combination of theoretical and experimental research, fundamental and applied knowledge, intensifies the direct links and communication and feedback between them. Such integration results in the development of the processes of interaction of the principles and concepts of various scientific views of the world. As such, thanks to this, the rigid boundaries between the views of the world and the different sciences themselves are gradually disappearing. They become interdependent and appear as parts of a holistic, universal scientific view of the world. Its development is influenced not only by the results of fundamental sciences, but also by the achievements of interdisciplinary applied research.

Its development is influenced not only by the results of fundamental sciences, but also by the achievements of interdisciplinary applied research. In this regard, it should be noted that the ideas of synergetics arose and developed in the course of numerous applied research projects. These studies discovered the effects of phase transitions and the formation of dissipative structures, such as structures in liquids, chemical waves, laser beams, etc. Open, unique and self-developing objects of interdisciplinary research are gradually beginning to determine the nature of the subject areas of the main fundamental sciences forming the image of modern post-non-classical science. At the heart of this image are the synthesis of the ideas of evolution and historicism, i.e. global evolutionism. These idea lead to a wide use of such methods of describing and predicting states of systems as construction of scenarios of possible lines of system development at points of bifurcation. Along with the ideal of theory construction as an axiomatic-deductive system, theoretical descriptions based on the use of the approximation method, computer pro grams, etc., are becoming increasingly popular. The ideal of historica reconstruction, which was previously used in the social sciences, is increasingly being used in natural science.

Also, among the dynamically developing systems of modern science, a large place is occupied by natural complexes in man himself is incorporated as an element. Such systems include medical and biological objects, objects of ecology, biosphere, biotechnology, complex information complexes, artificial intelligence systems, etc. When studying them, the researcher is faced with the questions of strategy and possible directions of transformation, humanistic values of such systems. These systems cannot be freely subjected to experiments, because some of their interaction strategies, which can cause catastrophic consequences, are prohibited.

Such systems not only allow, but also presuppose the inclusion of axiological factors in research. Their exploration raises the need to explain the relationship of fundamental intrascientific values with extrascientific values of the general social order. This means that modern software-oriented research must undergo a social scrutiny, not go beyond the ethical boundaries for interfering with objects. In other words, the internal ethics of science, aimed at finding the truth and acquiring new knowledge, must be correlated with universal humanistic principles and values. The emergence of new methodological attitudes and ideas about "human-sized" subjects causes significant changes in the philosophical foundations of science.

These changes are caused by the fact that scientific knowledge of objects begins to be considered in the context of the social conditions of their being, as a distinct part of the life of society. These objects are determined at each stage of their development by the general state of culture of the historical era, its value orientations and worldview attitudes. As such, it is necessary to understand the historical variability not only of ontological postulates, but also of the ideals and norms of research themselves. There is also the development and enrichment of the substance of the concepts of theory, method, fact, explanation, justification, etc. The ontological basis of the philosophical foundations of science begins to include new interpretations of the concepts of space and time, possibilities and reality, causes and effects, etc.

9.3 Historical Types of Scientific Rationality

Three major stages of the historical development of science caused by global scientific revolutions are characterised by respective historical types of scientific rationality:

- the first type of classical rationality corresponds to classical science in its pre-disciplinary and disciplined organised states;
- non-classical rationality corresponds to non-classical science; -
- post-non-classical rationality corresponds to non-classical science.

There is a close relationship between these stages of development of science which is why new types of rationality do not reject the previous types, but only outline the limits of their applicability to certain types of problems and tasks.

Each stage of the development of science has a distinct character of scientific activity aimed at the steady growth of objectively true knowledge. This growth of science can be represented as a pattern of relations of the system 'subject-means-object' which has a different level of understanding of scientific activity itself.

The classical type of scientific rationality focuses attention on the object, disregarding in its explanation and description everything that relates to the subject, the means and actions of the subject. This type of rationality forgets that the goals and values of science are in fact determined by the worldview attitudes and value orientations that dominate the culture.

Each new type of scientific rationality is characterised by its own scientific foundations, which make it possible to single out and study simple, complex, or self-developing systems. The emergence of a new type of rationality and a new image of science does not lead to a complete disappearance of the perceptions, ideas and methodological guidelines of the previous type of rationality. Moreover, there is a continuity between them and, depending on the nature of the research tasks, one can turn to the norms of knowledge acquisition of the respective types of rationality.

As such, we can say that as modern science develops, axiological moments and humanistic guidelines will become the starting point in determining the strategies for scientific search.

- Self-checking
- The interaction between traditions and the emergence of new knowledge.
- Concepts of scientific revolution.
- The substance and structure of scientific revolutions.
- Scientific revolutions and paradigms.
- The relationships between revolutions and traditions in the dynamics of science.

CHAPTER 10

History and Philosophy of the Natural, Technology, Social, and Human Sciences

10.1 The Role of Classical Philosophy in Formation of Natural and Technology Sciences

The subject of natural sciences are various forms of matter in the natural world: their materials (substrata) forming a hierarchy of successive levels in the organization of the matter, their interrelations, internal structure and genesis. The natural sciences are mechanics, physics, chemistry, geology, and biology. Their goal is to study the essence of the natural phenomena, the laws of their existence and to foresee therefrom or create new objects and their application in practice.

Philosophy played an important role in the development of natural science providing for its methodological (epistemological) and ontological justification. Philosophy is similar to natural science in terms of its inclination towards theorisation of knowledge and logical deduction.

Philosophy, being a science of the most general laws of the nature, society and knowledge, serves as the methodology for all natural sciences.

Philosophy and natural science are objectively interrelated through the physical unity of the particular and of the general in the matter, i.e. general and particular laws of the nature.

The interrelationship of philosophy and natural science lies in the very subjects they study: the method of the natural sciences is the specific laws of the nature while the subject of philosophy is the universal laws of nature, society and knowledge.

Philosophy influences natural science simply because any human theoretical and practical activity is purposeful. Therefore, philosophical ideas affect not only ontological outcomes of natural scientific inquiry, but also the specific theories and empirical work. The subjects of research are selected in accordance with the purpose of the inquiry, which means that philosophy is already present at the initial experimental stage of scientific research.

As you have read above, the theoretical natural science began to form in the 17th century due to the rapid development of industry. This was when philosophy and natural science started to demarcate. Therefore, the philosophical questions of natural science began to change with time.

Philosophical problems for natural science arise mainly in interdisciplinary research as their development and solution becomes essential for integration of scientific knowledge.

Philosophical problems of natural science study and reveal the most common properties, laws of structural organisation, changes and development of various types of objects. The laws discovered by natural scientists can be codified not only qualitatively, but also quantitatively as mathematical equations. The philosophy pays much attention to the study of logic, methodology, psychology, and history of science. Philosophy deals with analysis and synthesis, differentiation, integration, and changes in the dynamics and prospects of scientific knowledge.

Philosophy of natural science is an intermediate between philosophy and fundamental science. However, it does not boil down to any of them, since it has its own ontology and social meaning.

Classical technology science emerged through application of natural science to the solution of particular engineering problems. Gradually it became independent scientific and technology discipline having a number of features that distinguish it from other scientific disciplines. Initially, it was developed by engineers who tried to combine the requirements of science and technology. That combination boosted considerably theoretical training of future engineers, on the one hand, and strengthened scientific research component in technology sciences on the other. All these led to the formation of the discipline of technology science similarly to the natural science.

By the middle of 20th century, differentiation of technology scientific disciplines and engineering resulted in emergence of interdisciplinary technology studies and systematic integration of engineering. Thus, a whole class of new types of non-classical scientific and technology disciplines emerges with new forms of research that prompts specialists from the most diverse fields of science, technology, and practice to unite their efforts to solve complex issues that have clear practical character. Project is now an integral part of scientific research changing its norms and value. Project approach influences such disciplines within the systemic school of thought as cybernetics, systems engineering, and systems analysis.

Technology sciences today are a specific class of science. Their specificity is in their connection with technology, when experiment is replaced by engineering to validate technology theories and collect new empirical data.

Technology sciences are similar to applied natural science, but are not identical to it. This may be explained by the fact that they emerged through application of natural science. Technology sciences use the achievements of natural science and develop them. Technology sciences were influenced not only by natural science, but also by mathematics.

Both technology and natural sciences shall be considered on equal footing as disciplines. Any technology science produces objective knowledge that, although serves technological purpose, shall not be reduced to it. The emergence and development of technical sciences was caused by the willingness of professionals to formulate the knowledge accumulated through engineering. Engineers, in their turn, appropriated the outcomes of scientific research, their methods, and social institutions so that they could be able to produce and accumulate new technical knowledge.

As technology is present in almost all spheres of life of modern society, many social sciences - primarily sociology and psychology - increasingly draw from special technical analysis. There is also the history of technology as a special humanitarian discipline. However, historic technology studies are often on some individual sectors or stage and do not raise the questions about the trends and prospects for the modern technology.

These are the subjects of philosophy of technology. Firstly, it studies the phenomenon of technology in general, secondly, it raises the questions going far beyond immanent technological development, such as social implications of technology, and, thirdly, it does so within broader historic context. Thus, if technology is the subject of the philosophy of technology, the question it raises is "What is technology"? Every sane person will point to the devices and tools we use in everyday life at home or at work. Specialists will give specific examples of such devices in their typology. However, all these are only outcomes of technical activity of humans, the material results of technical efforts. All these is only possible because of the vast technical knowledge and the industries based on this knowledge. Technical knowledge is embodied in various technical devices and is codified in articles, books, textbooks since no technical development of our modern society would be possible without established mechanisms of production, accumulation and transfer of this knowledge.

Being a part of the technical civilization does not mean to purchase some devices no matter how advanced they are. It is about particular education, training, and transfer of technical knowledge. Modern-day China is a perfect example of that. As soon as China rejected the previous model of "importing" from the West and started to restructure its entire economic, educational and technological life, technological and economic growth came immediately.

Technology refers to the sphere of material culture it is everything we have our homes and in social life, the means of communication, defense and attack, all tools we use.

However, it is well known that material culture is interconnected with spiritual culture. For example, archeologists reconstruct the beliefs and life of ancient peoples trying to decode the remnants of material culture. In this sense, philosophy of technology is, in large part, archeology of technical knowledge when it studies the past (this is especially true in relation to the Antiquity and the Middle Ages, where the written tradition in technology was not sufficiently developed) or the methodology of technical knowledge when it is focused on the present and the future.

As such, technology should be understood as: firstly, a set of technical objects ranging from simple tools to the most complex systems; secondly as a complex of various types of technological activities to produce those devices ranging from scientific and technical research and design to manufacturing and operation, from development of individual elements of technical systems to the systematic research and design; and finally, as a body of technical knowledge ranging from specialized knowhow to theoretical and systematic technical knowledge. Today, technology means not only application but also production of scientific technical knowledge. Moreover, applying scientific knowledge in engineering is not as simple as it was thought to be and it is not only about application of the existing knowledge, but also about production of new knowledge.

Thus, modern technology and, above all, technical knowledge are inextricably linked with development of science. Today, this is a commonly shared opinion. However, the relationship between science and technology has been changing throughout history.

The 21st century is characterized by comprehensive role of technology in social life. Technology is increasingly popular in various spheres of management. Technology determines social development. Thus, it is sometimes said that technology is being transformed into a **social force**. At the same time, technology is important ontologically and its role as immediate productive force is strengthened. Modern philosophy of technology considers the development of technical knowledge as a socio-cultural phenomenon. It studies how technical knowledge has been historically evolving and how this process is influenced by socio-cultural factors. The philosophy of technology does not set "teaching" as its task. It does not offer any specific rules or procedures, it explains, describes, but does not prescribe. Philosophy of technology in our time has overcome previously inherent illusions that it would have been able to offer a universal method or system of methods to ensure success for all applications at all times. It revealed the historic nature of specific methods and, more importantly, methodological bases of technological rationality.

Contemporary philosophy of technology has shown that technical rationality is historic as is the predominant technological consciousness both depend on the type of objects being studied and changing cultural conditions under which technology makes its specific contribution.

10.2 The Role of Non-classical Philosophy in the Formation of Social and Human Sciences

The emergence of social and human sciences completes the formation of science as a system of disciplines which is designed to cover all main domains of being: nature, society and the human spirit. Science acquires the features of universality, specialisation and interdisciplinary connections. Its petentration into more and more new subject areas and the expansion of technological and socially-regulative application of scientific knowledge constantly changes the institutional status of science.

The process of the formation of social and human sciences also has its own distinct features. In the late 16th - early 17th centuries, they were influenced by the ideal of science, in terms of knowledge acquisition, which at that time was a deductively constructed mathematical system. Then, until the end of the 19th century, they remained under the influence of classical mechanics. The prevalence of mathematics and mechanics was caused by their maturity and successful development. The consequence of this was the desire of social and human sciences to study their subject areas on the basis of the laws of mechanics and the application of mathematical methods. The prevalence of the principles and methods of the natural sciences could also be explained by the development of various forms of positivis and structural and functional analysis.

The specific nature of the subject and method of social and human sciences lies in the fact that they represent a form of human self-awareness. These sciences are a kind of self-reflection in which man is split into the subject and the object. This is due to the fact that the essence of man is dualistic. The anthropological turn in the history of philosophy was expressed in man's awareness of the fact of this duality. Socrates described this in the maxim "I know that I do know nothing". Therefore, the history of self-knowledge of man is full of collisions. It became obvious that knowing yourself was much more difficult than knowing the world. According to Socrates, in order to know yourself you need to know the whole world.

The process of self-knowledge raises a number of philosophical questions and answers which must be taken into account by specific sciences. Here are some of them:

- in which relationships with himself can and cannot man-as-subject engage under any circumstances?
- is he capable of fully open to himself? And what prevents him from doing so?
- is it possible in this type of knowledge to establish a correspondence between the subject and the objective?
- what are we actually faced with when exploring the objectivations of the human spirit?
- what the criteria of truth in the social and human studies?

These questions can be addressed not only to philosophy, but also to science itself. Science is not only a means of knowing the surrounding world, but also one of the types of objectivation of the human spirit. However, all these questions cannot be solved by the social sciences themselves. Within the framework of these sciences, the solution of such philosophical questions serves as a criterion for demarcation of scientific schools. But a lot depends on their solution for these sciences themselves. These issues have great heuristic value. Depending on how they are solved, research trends and directions are formed.

The methods used in human sciences also require a serious philosophical consideration. When applying these methods, the researcher is faced with difficulties of both epistemological and ethical nature. These difficulties caused by the fact that humanitarian knowledge is the cognition of singularities, unique manifestations of the human spirit. This requires more adequate research methods. We can see that social and human sciences are filled with questions that can only be solved by philosophical methods. This means that they are always open for choice of a position. To formulate the problems of these sciences, scientists must be aware of different movements and schools of non-classical philosophy. For example, by the end of the 19th and the beginning of the 20th centuries, it became obvious that social and human sciences should have a certain philosophical foundation, in particular, to be familiar with the Baden school of neo-Kantianism, philosophy of life and hermeneutics

The founders of the Baden (Heidelberg) School of Neo-Kantianism, Wilhelm Windelband, Heinrich Rickert and others made a great contribution to the development of their own methodological foundation for the social and human sciences.

For example, Wilhelm Windelband held that the basis for their division should be the "formal characteristic of their theoretical goals", because some sciences search for general laws, while others look for individual facts.

Windelband defines the first way of thinking as **"nomothetic"**(the tendency to generalise in the form of the law). The way of thinking which is opposite to the "nomothetic" way of thinking he defines as the **"idiographic"** (the tendency to specify the individual). The same object can simultaneously be the object of both nomothetic and idiographic research. He holds that the reason for this possibility is that the distinction between the uniform (general) and the individual is, to a certain extent, relative. For example, the science of organic nature as a taxonomy or a systematic science is a nomothetic science, but as a history of development it is an ideographic science. It is this difference between the nomothetic and idiographic way of thinking, according to Windelband, that determines the difference between natural science and history.

In the case of natural science, the nomothetic type of thinking tends to go from establishing the particular to understanding the general relationship and aims to seek more general principles in the reality that has always existed.

He believed that the idiographic historical method had long been neglected. According to Windelband, disregard of everything except the general and genetic is a bias of Greek thought, which perpetuated from the Eleatics to Plato, who found not only the real being but also real knowledge only in the general. Of the Modern Age philosophers, he considers Schopenhauer to be a follower of this approach, who refused to see history as a true science on the grounds that it deals only with the particular and individual and never reaches the general. He believes that this view of the idiographic method is an age-old misconception. In contrast to it, Windelband emphasises, every human interest and any evaluation, everything of value to a person is related to the single and the individual. If this is true in relation to the individual human life, then it is all the more applicable to the whole historical process; it has value only if it is single. Therefore, he concludes, in all the data of historical and individual experience, a residuum of incomprehensible brute fact remains, an inexpressible and indefinable phenomenon. Thus the ultimate and most profound nature of personality resists analysis in terms of general categories. From the perspective of our consciousness, the incomprehensible character of the personality emerges as the sense of indeterminacy of our nature – in other words, individual freedom".

This reasoning was further systematically developed in the works of Heinrich Rickert, In his book *The Limits of Concept Formation in Natural Science*, he argues that the world of values creates the realm of the transcendental (other-worldly) meaning. He believes that the relationship of values to reality determines the highest task of philosophy. Just like Windelband, Rickert reduces the difference between sciences to the differences in their methods and believes that there are two fundamental methods.

The purpose of any scientific concept can be either the knowledge of general, identical, recurring features of the phenomenon under study, or, in contrast, the knowledge of its particular, individual, single and unique features. In the former case, we are dealing with natural science, and with history in the latter case. Natural science concepts are focused on the general and historical concepts are focused on the individual. Rickert defines the method of natural sciences as the "generalising" (summarising) method, and the method of history as the "individualising" method.

In both cases, scientific concepts are interpreted as "simplifying" reality and formed through selection based on the teleological principle that guides the researcher separating the essential from the nonessential. While with respect to the logical doctrine of the two types of concepts, Rickert formally recognised the equality of "natural scientific" and "historical" forms of knowledge, with respect to the ontological concept, he acted as a proponent of nominalism, according to which the general does not actually exist in the being and only the particular and individual is real. He used this nominalist concept to limit the competence of the natural sciences and to "denigrate" them in comparison with historical sciences.

Ideas about the specifics of social and human sciences were developed in the "Philosophy of Life" of Dilthey, Simmel, Spengler, and others. This philosophical movement of the last third of the 20th century emerged as a reaction to the crisis of mechanistic natural science. They believed that life is a primary reality, a holistic organic process. In their opinion, works of art, poetry, music, non-rational methods of exploring the world, such as intuition, understanding, etc. are the most adequate way of life expression. They demonstrated an understanding of life beyond its biological meanings, its sociocultural and humanitarian substance. They succeeded in revealing the characteristics of society and man, his communications and spiritual life as objects of knowledge.

For example, the German cultural historian and philosopher Wilhelm Dilthey proceeded from the thesis of the Neo-Kantians that natural science knowledge opposes cultural and historical knowledge. He argued that there really are sciences of nature and the science of the spirit. Dilthey aimed to raise the entire corpus of humanitarian knowledge to the level of natural sciences in the sense that he tried to identify the terminology and some general principles and approaches of such knowledge. In this case, they would have acquired a more rigorous appearance, a scientific form. Thus, it was a question of developing the theoretical foundations of the "sciences of the spirit", although the transfer of science categories to the realm of the spirit was rejected.

In his work *The Critique of Historical Reason*, sought to overcome the speculative philosophical systems of Kant and, particularly, Hegel, as well as the intellectualism of the Renaissance.

He posited that the human sciences are based on life itself which is expressed in the teleological (i.e. the innate divine purpose) relationship of its experiences, understanding and interpretation of the expressions.

We can conclude from this that the subject of knowledge is one with his object, and this object remains the same at all stages of objectivation. If the reality or the present constantly exist, then the content of the experience changes continuously. Another important characteristic of life, according to Dilthey, is its "coherence". In the historical world, there is no natural scientific causality, because it requires that well-defined consequences always follow. And history knows only the relationship of impact and suffering, action and reaction

A significant contribution in the development of problems of formation and specifics of social and human sciences was also made by hermeneutics. This philosophical school paid great attention to the study of the prerequisites, possibilities, distinctive properties of the process of understanding and comprehending the meaning ("the essence of the matter") of the phenomena of non-material culture. Text was regarded as a distinct reality and a "unit" of methodological and semantic analysis of social and humanitarian knowledge. This allowed us to better understand the textual certainty of intersubjectivity as an object-oriented universe of the human sciences. From this perspective, interpretation began to be regarded as assignment of meanings and sense to statements, texts, phenomena and events, i.e. as a universal scientific method and basic operation of social and humanitarian knowledge

In other words, the works of Friedrich Schleiermacher, Martin Heidegger and, most importantly, Hans-Georg Gadamer allowed philosophers to approach the problems of scientific modelling of human behaviour and activities, game-based techniques for organising actions, the construction of a typology of communication links and relationships, and social and cultural reality in general.

For example, the German philosopher, theologian and philologist Friedrich Schleiermacher put forward the principle according to which that the researcher should seek to at first understand what is said just as well as and then even better than its author. This principle does not imply penetration of the learner into the objective meaning of the text, but strengthening of the "fullness of feelings" of the interpreter.

By seeing interpretation of hermeneutics as an art, he reminds us that, in the past, the initial and comprehensive was the situation of understanding, and a failure to understand was an exception to the rule. In other words, hermeneutics was required only where a person encountered a problem that interfered with the continuity (field, space) of the understandable. Unlike this approach, Schleiermacher treats a failure to understand as a fundamental phenomenon. In his opinion, hermeneutics should be an art of understanding speech from the very beginning, and not only from the moment when "understandability" disappears.

According to Schleiermacher, while "grammatical interpretation" considers language in terms of language totality, "technical ("psychological") interpretation considers language expression as a manifestation of the internal attitude to it. It is "psychological interpretation" that he considers the most important problem and task of hermeneutics, as his understanding of hermeneutics as an "art" conditioned by the creative nature of language is related to it.

It is no coincidence that, having formulated many rules (canons) of interpretation, he did not provide the rules for the application of these rules. Within the framework of psychological interpretation, according to Schleiermacher, "divination", "guessing" is of great importance. This is a special position of the interpreter which corresponds to the stylistic productivity of the author (in the event of poetic creativity, i.e. expansion and creativity in the field of language). He believes that since understanding cannot rely here on a certain ready-made "technique", it must take the form of congenial creativity or "art."

Since the problem of existence, or being, takes a leading roles in research, this allows man to better understand his essence, interpersonal communication and socio-cultural changes in society.

Since man is the central problem of the human and social sciences, it is not surprising that hermeneutics and existentialism pay great attention to the problems of being of an individual, his desire to be himself. Also interesting is the problem of the "existing individual" who enters into genuine communication for the preservation of his own self. This is explained by the fact that social philosophy is aimed at finding a way to discover man's self on the basis of "subjective reflection". This search is aimed at understanding man as a unique and distinct creature, at finding one's place in the world. The understanding of man presupposed a certain solution of questions of faith and knowledge, reliability and doubt, the entrenchment of faith as a "form of life" in pre-conceptual structures.

The Danish thinker, "the father of existentialism" by Seren Kierkegaard sees the problem of being for social and human sciences research as human existence, a lonely relationship of the "Single One" to God.

Kierkegaard introduced the concept of existence as a means of understanding the inner being of man in the world. He believed that objective external existence reflects an "inauthentic existence". The discovery of existence forces man to make an existential choice. This choice means that he moves from the contemplative-sensory perception of being to its comprehension through the reflection about the distinctness, the uniqueness of "himself," that is "genuine existence". Such existence can be achieved by man through a series of stages. These are: an aestheti, which is determined by the person's orientation toward pleasure; ethical - his orientation towards duty; and religious - orientation to higher suffering, when he identifies himself with God.

In his work *Fear and Trembling*, Kierkegaard the meaning of the "existing individual" by contrasting the concepts of "subjective thinker" and "objective thinker". On the basis of abstract thinking, the "objective thinker" considers the problem of existence in the realm of the possible, and not the real. Abstraction suggests that "everything is, and nothing becomes". This prevents him from noticing the formation of the being of the "existing individual". Therefore, he highlights the process of objective reflection, putting his own existence aside. As opposed to the "objective thinker", the "subjective thinker" treats his own existence as priority and shows special interest towards it. He considers thinking as a means of filling his life with unique content and meaning and allows himself to become self-actualised.

Exploration of being as an immanent element of the universe was suggested by the founder of existentialism as a philosophical trend Martin Heidegger. He believed that being can be defined as that what exists which becomes the subjective, the field of thoughts and actions of man. Therefore, man's main task is to become subjective. To realise this task, people should devote their whole lives to settle and finish their affairs before life finishes themselves. Becoming subjective involves certain stages:

- man has to distinguish his own being from events;
- ask the question of What/Who I am;
- make himself a point of reference and the managing authority.

Hans-Georg Gadamer, one of the founders of hermeneutics, in his views is a follower of Heidegger and proposes that hermeneutics should be considered not as a theory of the methods and mechanisms of understanding, but as the **theory of being, as ontology**. For him, understanding is the way of existence of man, who is the learning, acting and evaluating individual, it is the universal method for man's exploration of the world in the "experience of life", "experience of history", and "experience of art".

The main idea of hermeneutics is "to exist is to be understood" (W. Dilthey). Normally, the subject-matter of a study is a text. In his works **Truth and Method** and **Dialogue and Dialectics,** Gadamer further develops this Dilthey's thesis. He explores the nature, limits and conditions of understanding. The principle idea of his concept can be briefly summarised as follows. **Man lives in a world which is depicted in language and is linguistically shaped**. In such a world language is an independent substance, therefore, understanding in the human existence is ontological.

Considering the understanding and interpretation as integral parts of a single process, he emphasises its "horizontality", openness, and non-closure. Understanding includes and constitutes the application of a text to be understood to the interpreter's situation. Both understanding and interpretation are by nature pluralistic and historical. They are based on the dialogue between "I" and "Thou". This dialogue is not limited to the communication between two persons -- the author and the interpreter, it is "built-in" into the relationship between the interpreter and the text. The interpreter approaches the historical and literary text with questions. Working with the text, he not only tries to "understand" it, but also to endow it with "new interpretations". He should be able to address questions to the historical and literary text, not to its author. For Gadamer, the philosophical significance of hermeneutic experience --"**hermeneutic circle**" (the circle of understanding) – is that it is where we comprehend the truth which is beyond scientific knowledge.

From the perspective of hermeneutics, the world of human communication is the only attainable and valuable world for us. For it is inside this world where the world of culture, values and meanings is created. Gadamer, therefore, considers understanding as a prerequisite for understanding social existence and comprehending cultural meanings and phenomena. The process of understanding, as well as the process of cognition, is infinite.

Over time, Gadamer becomes increasingly opposed to the interpretation of hermeneutics as a method -- a text interpretation technique. This version of hermeneutics has nothing to do with meaning. He also stands against the understanding of hermeneutics as a method of comprehending the spiritual, (nonmaterial, metaphysical) reality and against the understanding of texts as recognition of meaning, because in such interpretation, too, a hermeneutic text is no longer a text per se in the proper hermeneutical sense of the word; it turns into the object of study similar to the object of natural science knowledge.

According to Gadamer, the purpose of understanding is not in a proper interpretation of the text, not in the reconstruction of ideas and opinions of the interpreted, but in the **activation of their own thought processes** through the formation of a dialogue 'question-answer' system. Text interpretation becomes a productive, creative part of hermeneutic experience. Emphasising the importance of ontological interpretation of the problem of understanding, Gadamer defines understanding as a state which opens up the possibility of achieving the fullness of being.

According to Gadamer, understanding is not an act of though analysis, but a reason to reflect on the text in the course of which the interpreter's self-assertion takes place. In the process of Meeting the Other (with the capital 'O', because of its ontological meaning), "Thou-experience" is formed. This understanding is the basis of human activity and even life in general precisely because the true and real formation of meaning is born through dialogue. The birth of meaning serves as the initiator of understanding. Meaning is "woven" into the structure of life itself, even into the thickness and density of life.

As such, the establishment in philosophy of the term "hermeneutic experience", which expresses a fundamental openness to the world and the process of derivation of meanings built on it, allowed philosophers to formulate the requirements **of methodological pluralism,** which acquires a certain cognitive value in the structure of social knowledge.

The term **"postmodernism"** (post - after) is used to refer to both the specificity of culture in the second half of the 20th century and to the philosophical thought which is represented by the following philosophers: **Jacques Lacan, Jacques Derrida, Gilles Deleuze, Michel Foucault** and others. Postmodernists offer a new type of philosophising – philosophising without a subject. It can be said that postmodernism is a reaction to the change of the role of culture in society: to the shifts taking place in art, religion and morality in post-industrial societies. Postmodernism insists on humanisation and anthropologisation of scientific knowledge. This is manifested in the fact that it is trying to find a new way for solving the questions of truth and justification. Communication, interaction and dialogue serve as such justification.

Under the influence of the ideas of Michel Foucault and Jacques Derrida, the American scientist Richard Rorty gets involved in the discussions of postmodernists, "deconstructivists", and hermeneutics. The result of his reflections was the book **Philosophy and the Mirror of Nature**, which is a massive attack on the idea of "philosophy as epistemology."

10.3 Typology of the Social Organisation of Society from the Perspective of Development of Technologies and Production as Comprehension of the Achievements of the Fundamental Sciences

There is an undeniable continuity between the concepts of industrial and postindustrial society and, for example, the latest concepts of the information society, - it is precisely in the loyalty to the methods and techniques of technicalism and scientism. Again (in the "new" versions as well) the cult of reason and science is proclaimed.

An example of this is the concept proposed by the Japanese author Yoneji Masuda which is presented in his book entitled which clearly reveals the continuity which we mentioned above: *The Information Society as Post-Industrial Society* and which was first published in 1986. It would be fundamentally wrong to underestimate the practical impact of such concepts as they serve as a kind of "**philosophy of action**" in the implementation of large-scale scientific and technological innovations and social transformations associated with them. Yoneji Masuda was among those who developed a plan-forecast of the information society, which, or at least its scientific, technical and organisational aspects, was successfully implemented in Japan and other industrialised capitalist countries. Usually, these kinds of concepts contain entire sections, ideas and conclusions which are of considerable theoretical and practical interest. For instance, in Yoneji Masuda's (as well as in the authors of other concepts of the information society - Daniel Bell, Alvin Toffler, Manuel Castells in their latest works, John Neisbitt and others) work, priority is given to analysis of the distinctive properties of science and technology at the "information" stage of the development of society (the integration of computers and telecommunications), as well as to clarifying the specifics of information as the primary basis for the latest scientific and technical activities. The advantages and specifics of information Masuda sees in the fact that it does not disappear when consumed, not transmitted in full when exchanged (remaining in the information system and with the user) is "indivisible", meaning that it makes sense only with a sufficiently complete set of information and that its quality is enhanced with the addition of new information.

Indeed, society whose scientific and technological, productive-practical, and theoretical activity is based on expediently accumulated and reasonably used information acquires, in principle, at its disposal resources of enormous importance, available for multiple and multilateral use, further "renewal" and improvement and rapid creation of new information systems. Information is, firstly, knowledge of a relatively new type, suitable for further use, and secondly, knowledge the production, storage and use of which does become an increasingly important activity for society and generates technical and organisational structures compatible with it.

The increasing role of information and information systems is a historical fact underlying the concepts of the information society. Another fact is the rapid, truly revolutionary impact of the "information mind" on production, management, and all aspects of human life.

Masuda also discusses a number of other real questions: about the formation of a "new environment" of human lives, meaning "computopolis" - a city with such "information systems" as cable multi-channel television; about the transport rail system of passenger two-seat vehicles; about automated delivery of goods; about new computer systems of public health services and training; about automatic monitoring of environmental pollution; about centers of scientific and management information, professional orientation, etc. It should be noted that these are not utopian dreams, but projects that are currently at the stage of experiment, implementation or design.

From the scientific, technical, organizational and managerial perspective, studies of the latest concepts of the information society are of great positive interest. As regards the social and philosophical prerequisites and conclusions of these concepts, their common features are technicalism and scientism, the cult of "information reason", whose progress is again expected to directly and crucially transform social relations, including property and power relations.

The reaction to scientistic and technicistic utopias is the intensification of the anti-technicistic, anti-scientistic wave. However, throughout the 20th century, it reached a fairly high level. Debunking the illusions of technicistic and scientistic optimism caused the emergence of **"dystopias"**.

The 20th century produced a a great number of dystopias. Many well-known writers worked in this genre Herbert Wells, Andre Frank, Upton Sinclair, Jack London (*The Iron Heel*), Kurt Vonnegut (*Player Piano*), Ray Bradbury (*Fahrenheit451*), the Strugatsky brothers, and others. The works of Evgeny Zamyatin *We* and the British writers Aldous Huxley *Brave New World* and George Orwell *1984* are considered contemporary classics. They present sharply critical images of a "mechanised" future which is identified with a totalitarian state where science and technology are brought to perfection and where freedom and individuality are suppressed.

The authors of dystopias, together with technicists and scientisists, essentially proceed from the idea of the absolute power of science and technology, although they do not accept their technisistic and scientisistic optimism, replacing it with anti-technisistic pessimism. The ideological and theoretical foundations of technisistic and scientisistic and anti-technisistic concepts, utopias and dystopias, are therefore very similar. And only emotional evaluations are replaced with their opposites. Non-Marxist philosophy and sociology of the 20th century most often ended up with using these extremes, which diverge, but then converge again, in the world of social and political discussions, the world of culture. And yet, the role of dystopias as a specific type of social criticism, as a humanistic warning, addressed to man and to mankind, should not be discounted: look what can happen if there is not control over the development of science and technology, if human needs, spiritual and moral goals and values are not given the priority.

10.4 The Problem of Computer Modelling of the Main Functions of the Human Brain

Our time is the time of universal computerisation and the number of people working in the information industry in comparison with the production industry is steadily growing all over the world. Automation and computerisation of the information sphere, in general, lags behind the automation of the production sphere. Now it is not enough for is that a computer quickly and accurately solves the most complex computational problems, today we need the help of the computer in rapid interpretation, semantic analysis of a huge amount of information. These tasks could be solved by the so-called "artificial intelligence". The question of creating artificial intelligence appeared almost at the same time as the beginning of the computer revolution. The term "artificial intelligence" was introduced by John McCarthy in 1956. The term "artificial intelligence" itself has two main meanings: first, artificial intelligence means the **theory of creating software and hardware capable of performing intellectual activity comparable to human intellectual activity**; and second, **software and hardware, as well as the activities performed with their help**.

But on the way to its creation we are faced with many questions: the fundamental possibility of creating artificial intelligence based on computer systems; whether the artificial intelligence of a computer, if it can be created, is similar to the human form of perception and comprehension of the real worl, or whether it will be an intellect of a completely different quality; the ability to represent knowledge in computer systems and many other questiosn. Many oproblems have not been solved, and some of the most urgent among these problems could be solved with the help of philosophy.

One of the most important questions of current philosophical discussions is the question of **what is information, what is its nature**? To determine the specifics of the nature of information processes, it is necessary to briefly consider the natural basis of all information, and such natural basis of information is the objective property of reflection which is inherent in matter.

The premise of the inseparable relationship between information and reflection has become one of the most important in the study of information and information processes. Information in living nature, unlike inanimate nature, plays an active role because it participates in the control of all life processes.

Consciousness is not so much a product of the development of nature as it is a product of human social life, of social labour of previous generations. It is an essential part of human activity through which human nature is created and can not be accepted outside this nature. And in machines, on the contrary, reflection is not conscious, since it is realised without the formation of ideal images and concepts, but occurs in the form of electrical pulses, signals, etc. Since the machine does not think, it is not the form of reflection that takes place in the process of human comprehension of the surrounding world. The patterns of the reflection process in the machine are determined, first of all, by the laws of reflection of reality in the human mind, since the machine is created by man in order to more accurately reflect reality, it is not the machine itself that reflects reality, bit man reflects it with the help of the machine. Therefore, the reflection of reality by the machine is an integral element of the reflection of reality by man. The emergence of cybernetic devices leads to the emergence of not a new form of reflection, but a new link mediating the reflection of nature by man.

The similarity of thinking to the ability to reflect serves as an objective basis for modeling the processes of thinking. Thinking is related to the creation, transmission and transformation of information, and these processes can occur not only in the brain, but in other systems, for example, a computer. Cybernetics, establishing the relationship between reflection, sensation and even thinking, takes a certain step forward in solving the problem posed. This relationship between thinking and other properties of matter follows from two fundamental principles of the materialist **dialectic of the principle of the material unity of the world and the principle of development (evolution)**. However, one can neither absolutise nor deny this kinship. Thinking is a human quality and differs from its cybernetic form.

Despite the qualitative difference between the machine and the brain, there are general patterns in their functions (in the field of communication, operations and control), which are studied by cybernetics. But this analogy between the activities of the automatic and nervous system, even in terms of processing information, is relatively arbitrary, and it should not be absolutised. It should be noted in this regard that metaphysical tendencies were characteristic for some studies on cybernetics, especially those implemented during the initial period of its development, mechanical and, although on the surface they appeared to be completely opposite. The professional community failed to take into account the qualitative differences between inanimate matter and the thinking brain, and every line between the knowing subject and the object of the material world was erased. Since modern computers are multipurpose machines and are capable of performing a number of logical functions, it was asserted that there is no reason not to recognise this activity as intellectual. It was considered possible to create an artificial intelligence or machine that would be "smarter" than its creator. Other questions related to the possibility of such a machine were raised. Can the machine completely, in all respects replace humans? Are there any limits to the development of cybernetic devices?

Considering the possibility of creating, by artificial means based on modeling, a thinking being, it is necessary to discuss two aspects of this problem. First, cybernetics does not model all functions of the brain, but only those that are associated with the receipt, processing and delivery of information, i.e. functions that are amenable to logical processing. Yet other, infinitely diverse functions of the human brain remain outside the scope of cybernetics. Second, from the perspective of modeling theory, it makes no sense at all to talk about complete identity of the model and the original.

The complete identification of the human and "machine" brain takes place when the subject of thinking is replaced with any material system which is capable of reflecting. But the only subject of thinking is man armed with all the means that he has at the given level of his development. These funds include cybernetic machines, in which the results of human labour are materialised. And, like any instrument of production, cybernetics continues and enhances the capabilities of the human brain. Man will transfer to the machine only some of the functions that he performs in the process of thinking. Thinking itself as a spiritual production, the creation of scientific concepts, theories, ideas in which the laws of the objective world are reflected, will remain with man.

The main difficulty of artificial intelligence lies in the fact that there is still no **definitive and universally accepted definition and understanding of natural intelligence**. Therefore, most researchers of artificial intelligence, as well as specialists in information epistemology, are forced to resort to ad-hoc solutions. In practice, artificial intelligence means a set of software and hardware, the use of which should lead to the same results which are reached by human ntellectual activity when solving this class of problems.

Another popular partial solution defines artificial intelligence as a complete or approximate imitation of human intellectual activity, because human intellect still remains the greatest philosophical mystery. Even at a specific scientific-psychological, psychiatric and logical level, it has been studied only phenomenologically, and none of the definitions of artificial intelligence can be considered quite acceptable, let alone definitive. Therefore, when solving practical problems, often the listed tasks are used and the assertion is accepted that the given system is an artificial intelligence system if it is able to solve the given problems.

As a matter of fact, the central problem of artificial intelligence is as follows. If we have clear, formally explicated knowledge of the solution to a particular class of problems, then, **clear algorithms or heuristic rules** can be obtained from regularisation of such knowledge. Using them, we can design programs, the implementation of which with modern hardware can provide a solution to these problems. However, man quite often solves problems without knowing how he does it. In other words, people do not actually have complete and exhaustive self-knowledge. This applies not only to the purely intellectual sphere of abstract, logical thinking, but also to the emotional and physiological sphere. We see, we use visual images, we hear, we operate with sound images, etc. not knowing exactly how the images arise and what are the exact patterns of their functioning in our consciousness. We often set tasks, make guesses, make unexpected, including fundamentally new, creative solutions, not knowing how we do it, not knowing exactly how to represent the algorithm of such activity. From this it follows that we cannot always regulate the processes, procedures and operations underlying it, and therefore we cannot entrust the computer with the performance of certain imitative or duplicative actions. Here, as if the famous "Ada Lovelace's thesis" turns the tables, according to which machines will never be able to do something which has not been instructed to it by man and which it does not know how to do. In fact, man himself is capable of doing much more than he knows how to do. These arguments serve as the basis for computer agnosticism. It is also supported by certain philosophical considerations, based on the limited cognisability of the world in general and the subjective and spiritual world of man in particular.

Both computer agnosticism and computer euphoria have philosophical roots. And this is why we should talk about clarifying the conceptual, and not the technical side of the matter. From the philosophical point of view, it is in investigating whether thinking is the exclusive prerogative of man, more precisely, the human brain, or whether such activity is not uniquely and permanently associated with it and can be carried out by non-human, including technical, hardware systems. If we accept the first alternative, we should further answer the question of whether the human brain has any specific unique mechanisms not reproducible by any other systems, and, on top of that, unknowable, so that adequate knowledge cannot be obtained with respect to the purely human nature of thinking, and, therefore, their regularisation is impossible. If a negative answer supported by evidence can be obtained to this question, this also does not mean recognising direct practical possibility of creation of artificial intelligence, since it may, for example, prove that its creation is limited by the technical impossibility of certain intellectual procedures. But still such an answer would give a substantive basis if not for euphoria, then, at least, for a limited computer optimism.

The debate between computer pessimists and optimists implies two opposite philosophical hypotheses. The first is based on the absolute uniqueness of "human corporeality", the uniqueness of human individuality. Therefore, creation of artificial intelligence, like human intelligence, is declared impossible. The second hypothesis, on the contrary, accepts the thesis about the fundamental identity of elementary operations of human and machine thinking. Cognitive processes, sensory images, attitudes and values can be more or less adequately realised and modeled on discrete electronic computer systems. The basis of the second hypothesis is a well-developed theory of computational function aimed toward constructive-hardware realisability.

Since the emergence of the question about creation of artificial intelligence, scientists have made many efforts focused on the comparison of the intellectual system and the human mind. This comparison is done along different lines, some of which have been mentioned above: the mechanisms and results of the computer system and human thinkin and their effectiveness in solving various types of problems are compared.

The question of the similarity and difference between the artificial intellectual system and the human mind is often associated with the issue of the prospects of artificial intelligence as a scientific domain. At the same time, some researchers believe that the strategic line should be an increasing approximation of the capabilities of the computer system to the capabilities of the human mind; others, on the contrary, defend the view that the goal of artificial intelligence is not to simulate human thinking, but to invent ways of processing information that would be fundamentally different from human and would be applied in places where human thinking is not effective or where its use is impractical.

At the same time, there already exist huge data bases and powerful expert systems containing thousands of rules and capable of solving some tasks better than the programmers who have written programmes for them or that experts from the appropriate profile. Currently, there are intelligent computer systems that read newspaper texts in any voice, even in real time and perform translations of at least technical literature. These and other facts underlie the computer euphoria that argues that the difficulties in creating an artificial intelligence that surpasses the power and creativity of human intellect are of a temporary nature and are related only to technical problems that will be fundamentally eliminated in the foreseeable future.

10.5 Expert Systems and New Technologies of Scientific Research

The problem of knowledge representation in computer systems is one of the main problems in the field of artificial intelligence. The solution of this problem will allow specialists, who are not trained in programming, to work with the computer directly in the language of "business prose" in an interactive mode and to form the necessary solutions with its help. Thus, the solution of the problem of representation of knowledge in computer systems will significantly enhance the intellectual creative activity of man with the help of computers.

We should discuss the history of the development of this problem in more detail. The spread of computers opened the possibility of **electronic representation of knowledge**. At the first stage, this included the data itself and the programmes that processed them. The interaction of professionals from different fields of expertise, in whose interests the computer was used, was carried out through applied mathematicians and programmers. Subsequently, the data was separated from the programmes -- databases and data banks emerged, which, in turn, allowed the creation of information and reference systems and information retrieval systems of various types. There was a dialogue mode for interaction between a person with a computer, which, within certain limits, made it possible for specialists not trained in programming to work with computers.

In turn, the creation of databanks and databases, as well as the most complex programmes became in many respects possible because the language and principles of programming were radically changed. Almost all the evolution described here was based on a difficult but steady process of convergence of computer languages with the human language.

Certain achievements in this area made it possible to speak about even computer intellectualisation. First and foremost, the problem of convergence of languages was solved for creating large information retrieval systems, where the user communicated with computers in a limited natural language or in the language of "business prose".

The problem of the semantic analysis of texts that emerged here immediately posed the question of constructing a semantic (meaning-based) model of a certain subject domain. However, since computers are now capable of processing only formalised data, such models could have only be built if the knowledge in this field was successfully formalised. In this regard, the theory of artificial intelligence proposed formalisms for representation of knowledge in semantic networks, frames, and production systems. The formalisms of artificial intelligence made it possible, on the one hand, to build knowledge bases as an abstract superstructure over a database, and on the other hand, to create models of knowledge from many fields of descriptive and poorly formalised sciences (geology, medicine, biology, social sciences, etc.).

However, we should not ignore the fact that creating artificial intellect which is similar to human intellect through total formalisation of the entire surrounding world is an unsuccessful attempt: where absolute formalisation begins, true creative human intellect ends. Adapting this premise to computer systems, it can be argued that complete formalisation is the enemy of artificial intelligence.

Today, computers are consciously used as a means of representing knowledge. However, computers themselves do contain **not knowledge, but information**, i.e. representation or model of knowledge. Based on this model, the user recreates the knowledge he needs. The content of computer memory is not equivalent to human knowledge, which is a much more complex phenomenon, but can serve as a convenient communication model for this knowledge. This principle of modeling professional knowledge is the basis of expert systems.

Since expert systems directly assist in the implementation of human intellectual activity, the development of expert systems is often referred to as achievements in the field of artificial intelligence. However, many experts consider expert systems to be an effective alternative to artificial intelligence, although many modern achievements in the field of artificial intelligence have been used in their creation.

While artificial intelligence aims to create intellectual models of reality that ensure rational and reasonable behavior, the main thing in the development of expert systems is the model of professional knowledge about a certain aspect of reality inherent in man -- an expert or several experts.

Developments in the field of artificial intelligence are aimed at replacing intellectual functions of humans with computer functions. In contrast, expert systems not only do not presuppose the expulsion of man from any intellectual spheres of activity, but, on the contrary, they are guided by the fact that, as a rule, professional knowledge of an expert describes the poorly structured reality better than any artificial model, and that the role of expert systems is in making the knowledge of one or several experts available to any specialist in the respective field, regardless of the space and time constraints. At the same time, as a condition for the effective use of the provided consultations, the user of the expert system is expected to have professional creative knowledge of the subject. Ideally, the user himself becomes an expert in the process of interaction with the expert system, the knowledge of which is taken into account in this system. While artificial intelligence traditionally gives man the passive role of someone shifting the gravity of difficult decisions to computers, expert systems are guided by the creativity of the user who is able to take responsible decisions independently, taking into account the professional knowledge that is provided to him through expert systems.

Although the creation of "genuine" artificial intelligence can hardly be considered an event of the foreseeable future, today computers (and not only artificial intelligence systems) already have a sufficient degree of autonomy and uncountability to man in creating problems associated with confidence in the results of information processing activities (i.e. processing of information in a broad sense which involves the acquisition, storage, transformation, and transmission of information).

Ma y of these problems are of a technical or practical nature. However, there are also metaphysical issues, certain solution of which can explicitly or implicitly affect on the choice of a strategy for practical control measures over computer processing of information.

The problems of control over the computer and evaluation of the results of information processing by a computer (or using a computer) are caused by the impossibility for man to follow the course and sequence of performed operations. Reaching a certain amount of data and a certain speed of processing, we must rely on the dubious assumption that the computer will not behave differently in the event of larger numbers and greater speeds compared to those with which we are directly familiar.

As far as humans are concerned, they are not able to test many even relatively short sequences of operations performed by conventional computers. This is even more true for complex programmes in which many parallel computations are performed simultaneously.

If it is not possible to directly control the operation of the machine and exhaustively verify the results of machine operations, it makes sense to aim at ensuring maximum achievable control and maximum achievable reliability of methods for verifying results of computer calculations. The means for achieving this goal are different for different types of systems.

- Self-checking
- Physics as the foundation of natural science.
- Biology and formation of contemporary evolutionary view of the world.
- The specifics of the technology sciences.
- Formation of Social and Human Scientific Disciplines.
- Social and Human Sciences in Kazakhstan.

CHAPTER 11
Philosophical Problems of Development of Contemporary Global Civilisation

11.1 Principal Global Challenges faced by Contemporary Civilization

In the 21st century, the term "global civilization" (from French *global*, universal; from Latin *globus [terrae]*, the globe) has emerged. The terms "civilization" usually has several meanings. The most common is that designating as civilized a modern, developed, mainly Western type of society. At the same time, a civilized society is contrasted with those who failed to reach the level of economic, social and political wellbeing that is perceived as normative today. Civilization, in this sense, is synonymous with the highest level of social and cultural development among all those currently existing.

Global problems are not new. They existed before, in one way or another, and manifested themselves as local and regional conflicts. Civilization has a number of features: integrity and internationalism of social life; unified system of socio-economic, political, cultural ties and relations; sociocultural unification all these serve as the basis for the planetary system of social division of labor, political institutions, and information. In other words, global civilization, in terms of its form, is the integral system of the planetary scale, but with diverse content.

In the modern era, civilization has acquired a planetary character. There are several reasons for this: sharp increase in inequality in terms of socioeconomic, scientific and technological development and internationalization of social life and the consequent global social integration. In terms of importance and urgency, challenges may be assessed quantitatively and qualitatively. Quantitative criteria are territorial, spatial. Thus, any problem can be called "global" if it affects the whole planet or a region in its entirety. Local problems are particular; they affect a state or a group of states. They may be considered "potentially global" depending on a number of factors. To be deemed "global" in terms of qualitative criteria, a problem shall:

- affect vital interests of whole humanity and each human being on the planet;

- be an acute factor influencing further development on global scale, on mire existence of the contemporary civilization;
- require global universal efforts of all or overwhelming majority of nations to be resolved;
- if unresolved, may have irreparable consequences in future.

Global problems of social development never fixed in time and space: they are constantly changing in terms of their character and intensity. Therefore, their significance in a particular historical era varies considerably. When resolved, some problems may lose "global" relevance and transform into local ones, or even disappear altogether. Global problems are never isolated; they are complex interconnected and interdependent. This means that to solve one particular problem the impact of the others shall be always taken into account.

Some new problems constantly emerge in every part of the world; some may even become universal. For example, for the recent decades, the world has witnessed the depletion of the ozone layer, the greenhouse effect and global warming, the syndrome of acquired immunodeficiency (AIDS) and other problems affecting the entire population of the planet.

Since global problems are closely interrelated and have common origin, it is important to classify and conceptualize them in a certain way to understand their causes and the conditions under which they can be solved by the international community of states. Literature enumerates the following task of global significance:

- prevention of the nuclear world war,
- maintenance of peace as the condition for development of all;
- overcoming economic inequality and income gap between the developed and developing countries by eliminating of hunger, poverty and illiteracy on the globe;
- curtailing of population growth (known as "demographic explosion") in the developing countries and "depopulation" in the developed industrialized countries;
- prevention of catastrophic environmental pollution including that of the atmosphere and the oceans;
- supplying further progressive development of humanity with the necessary natural resources (both renewable and non-renewable) including food, raw materials, and fuel;
- prevention of immediate and prospective negative consequences of the scientific and technological revolution.

Since the 1970s, all these issues have been subjects on the agenda of the Club of Rome - a global think tank of the world famous scientists, cultural figures, businessmen, and statesmen that deals with a variety of international issues, including the world economic system, climate change, and environmental degradation. For a number of years, **Aurelio Peccei,** a prominent Italian entrepreneur and economist (1908-1984) headed the Club of Rome.

In his book "The Human Quality", Peccei assesses the ecological situation in the world at the beginning of the 1970s as critical. Peccei emphasizes that a humans, whose material power has peaked, are turning the planet from their kingdom into the ecological hell. Humans' insatiable appetite for consumption eliminates completely any considerations about the consequences of their growing aspirations and needs. The diverse artificial world, created by humans, increasingly presses on the nature.

Peccei concludes that the limited planet necessarily implies the limits of human expansion in relation to the nature. His position was contrary to the almost universally prevailing idea of unrestrained growth of production and consumption as being a good thing the humanity should aspire for that symbolized a new style of thinking about a person's relationship to the nature.

In the 1980's the Club of Rome proposed a new concept of "organic growth and continuous development" that replaced its "Limits to Growth". In the context of the new model for development, the Club of Rome (Mihajlo Mesarovic) identified the following tasks as global:

- decrease of the population growth on the Earth;
- reduction of consumption of non-renewable resources;
- reduction of environmental pollution and other natural degradation;
- reduction of inequality;
- elimination of hunger and poverty.

In his "Eight Deadly Sins of Civilized Humanity", the Nobel laureate, ethologist and philosopher Konrad Lorenz considers thoroughly the following global problems and calls for their immediate solution:

1) Overpopulation that forces a person avoid excessive social interaction and triggers aggression due to overcrowding;

2) Devastation and degradation of the natural living space, destruction of environment; humans do not reverence the beauty and majesty of nature any longer;
3) Accelerated development of technology with disastrous effects on people, making them blind to all genuine values of the world of nature and art, when human communication is almost completely eliminated;
4) Effeminacy when almost all powerful feelings and affects are suppressed or eliminated;
5) Genetic degradation, growth of deformities, physical and mental pathology in human offspring;
6) Breakdown of traditions in the context of the hypertrophied significance of ideological dogmas;
7) Further indoctrination of humanity when increasing number of people belong to the same cultural group;
8) Proliferation of nuclear weapons.

The nature of the today's global problems change significantly our understanding of evolutionary processes. Evolution transforms people, but people influence the course of evolution as well changing its character. Responsibility for human evolution lies, largely, with the human themselves, and people have no option but take it.

Thus, philosophy of global problems represents a wide range of analysis of the challenges faced by the modern world and the ways to address them. This branch of philosophy proceeds from and concludes on the interests, aspirations and opportunities of humanity.

Evidence of these is the raising awareness about environmental problems and increasing popularity of the eco movement; the green parties and massive social protests being a perfect example of this trend. What is characteristic about the green movement is that it is now conducting its activities in accordance with three most important principles:

- concept of unlimitedness shall be replaced by the concept of finiteness of the natural resources;

- pace of the natural and social development should be comparable;

- people should seek not artificial, but the natural sense of their existence.

- Self-checking:
- Modern global civilization and its features, how it influences the development of the world order;
- Civilizational concept of social history: its main schools;
- Concept of information culture of McLuhan;
- Theory of post-industrial society of D. Bell.

RECOMMENDED READING

Main Reading:

1. M.Sh. Khasanov, V.F. Petrova, B.A. Dzhambayeva: Ғылым тарихы мен философиясы. – Almaty, 2015. – 142 pages.
2. S.K. Myrzaly: Ғылымның тарихы мен философиясы. – Almaty, 2014.
3. G.Zh. Nurysheva: Philosophy. - Almaty, 2013.
4. M.Sh. Khasanov, V.F. Petrova:: History and Philosophy of Science. – Almaty, 2013. – 150 pages.
5. Zh.A. Altayev: Ғылым тарихы мен философиясы. Толықтырылып, өңделген. – Almaty, 2011. – 468 pages.

Additional Reading:

1. E.V. Ushakov: Philosophy and Methodology of Science. - Moscow, 2017. - 392 pages
2. John D. Baldwin. Ending the Science Wars. -Routledge, 2016. – 84 pages
3. G.A. Sardanashvili: The Crisis of Scientific Knowledge. A physicist's Perspective. - Moscow, 2015. - 251 pages
4. History and Philosophy of Science. Edited by Y.V. Kryanev, L.E. Motorina: - Moscow, 2011. - 416 pages
5. V.S. Stepin: History and Philosophy of Science. – Moscow, 2011. – 423 pages
6. P.P. Gaidenko: Scientific Rationality and Philosophical Mind. – Moscow, 2010. – 528 pages
7. S.B. Kulikov: Prospects of Development of the Progressivist Image of Science. Saarbrücken. 2011, 140 pages
8. V.P. Kohanovsky et al, The Foundations of the Philosophy of Science. - Moscow, 2010. – 603 pages
9. S.A. Lebedev, V.V. Ilyin, et al: Introduction to Philosophy and History of Science. - Moscow, 2009. – 344 pages
10. Ilyin V.V., Philosophy of Science. – Moscow, 2009. – 224 pages

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