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For PhD graduate students of all specialities.

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Introduction

Philosophy of science is a branch of philosophy, that deals with both the philosophical problems of science in general and philosophical and methodological issues of particular sciences as its subject matter. This branch consists of such sections as the ontology of science, the epistemology of science, its methodology, practice, sociology, the logic of scientific research, psychology of scientific creativity, etc.

Thus, the philosophy of science and scientific knowledge contains all the main sections of traditional philosophy, and its main peculiarity as compared to all the rest of philosophy consists in that its object of study includes science with all its features and elements. The philosophy of science also considers the question of what science is, what the difference between the science and the so-called pseudoscience is, the criteria of scientific natural and humanitarian knowledge, the place and role of science in the system of human culture.

Since the time of L. Wittgenstein, the content basis of scientific theories, according to this paradigm, should consist in a strictly unambiguous interpretation (explication) of facts. However, during the twentieth century and the first years of the present millennium, another trend clearly developed: the creation of a transdisciplinary metatheory of the phenomenon of science, synthesizing in a single, if possible, logically consistent conception, its epistemological, ontological and civilizational-anthropological aspects. This process was initiated and supported with the technologies' turn onto the human himself (both in the individual and social sense of the word), with the transformation of knowledge into a source of an existential risk and the exhaustion of further extensive technological development (as a consequence of the depletion of natural resources by the bio- and anthroposphere). These changes have already shifted from the sphere of theoretical research to the sphere of didactic comprehension and translation. The need for this is especially felt in the field of genetic engineering, biomedical, political science and socioeconomic disciplines, where all these phenomena are most acute both regarding consequences and their perception by the public consciousness. Such presentation of the foundations of the philosophy of science for the novice economist-researchers in the synthesis of anthropological and epistemological approaches is the overriding task of the textbook.

1. Science as a cultural and civilizational phenomenon

1.1. The sociocultural nature and multidimensionality phenomenon of science. Basic definitions and terms

The term of science as well as many other terms, is not unambiguous. If we reject the everyday meaning of the word and focus on the science as a special field of human activity and culture, we can give the following definition: science is a field of research aimed at producing new knowledge about nature, society and thinking, which contains all the conditions and moments of this producing: scientists with their knowledge and skills, qualifications and experience, the distribution and cooperation of scientific work; scientific institutions, research equipment; methods of research work, conceptual and categorical apparatus, system of scientific information, as well as the whole set of available scientific knowledge, which serves as a prerequisite, means or result of scientific production. This definition represents science in a broad sense, it contains three components: 1) science as a system of knowledge; 2) science as a set of research activities (the latter are also often called science); 3) science as a system of social institutions and relations through which scientific activity is carried out.

Accordingly, narrower definitions of science may be given. For example, science as an activity that satisfies the following three conditions:

1) it is a search for understanding that means a feeling that a satisfactory explanation of any aspect of reality is found;

2) understanding is achieved through formulation of general laws and principles (laws that can be applied to a wider class of phenomena);

3) the laws and principles can be tested experimentally.

This definition emphasizes the research component of science, including scientific knowledge as a prerequisite, means and results of the research, omitting the system of social institutions and relations. Finally, if we take science simply as a system of knowledge, we may define it as a systematized, true, logically (explicitly) consistent, predictive knowledge, verified by experience.

It is now possible to give a clearer, from a logical point of view, definition of science itself and related philosophical categories (a fuller explication of their content and relationships will be provided throughout the course).

Thus, the phenomenon of science is complex and ambiguous in content, but we can distinguish three main aspects (three layers of content) of this category.

1. Science as a form of human activity supposes activity aimed at obtaining objective knowledge about the surrounding world, human society and knowledge. This form of activity is based on general methods of cognition, which are based in their own turn on a combination of experimental verification (correspondence with the data of sensory experience and consistency) and logical arguments (evidence). The result of research activities consists in explanation (identification of the most significant links that are regularly repeated between phenomena and processes) and understanding (identification of causes and drivers of phenomena and processes) that give people the possibility to act expediently in accordance with their interests and needs. Technology may be defined here as a set of rationalist ways of solving the problem (achieving the predetermined goal). Thus, science can be defined as a technology for producing new objective knowledge about reality.

2. Science as an objective knowledge. Science is a system of objective, impersonal, logically consistent knowledge, confirmed by the data of sensory experience and experiment, capable of predicting the course of phenomena and processes in the world around and within a person. Systematic scientific knowledge allows us to obtain new information from existing scientific knowledge, without each time resorting to in-depth study of empirical facts. The objectivity of scientific knowledge makes it possible to transfer effectively the latter from person to person and use it in practice in the process of activity.

3. Science as a social institution. In this sense, science is a collection of, first, all people professionally engaged in scientific activities, and, secondly, institutions and organizations that carry out and provide research, storage, and spread of scientific knowledge, as well as training of professional scientists.

Thus, science is a specific field of human activity aimed at producing new objective knowledge about nature, society and about man himself, which contains all the prerequisites, conditions, and elements of such production:

1) scientists who have qualifications and experience in accordance with the division of science into separate disciplines;

2) scientific institutions and equipment;

3) methods of scientific research;

4) conceptual and categorical apparatus and generalization of scientific data;

5) a system of preservation, reproduction and systematization of scientific information;

6) the whole set of current accumulated scientific knowledge, which acts simultaneously as a result, condition and prerequisite for scientific knowledge.

Attributes and characteristics of science

Science arises inside everyday knowledge as its result. The main difference of science from everyday knowledge consists in its ability to forecast long-term results of practical activities. To this end, science is forced to go beyond direct production and experience, to know objects that are not used in practice now, and may never be used in the future. Hence, the characteristic features of science are as follows.

1. Objects of scientific research. They can be seen as a specific weapon for new knowledge.

2. The language of science. Everyday language is suitable only for objects directly involved in everyday life. It is ambiguous, the specific meaning of what is said is revealed only in connection with a specific situation. Science needs a special conceptual and categorical apparatus which is suitable for unambiguous description of objects of scientific research, and which is not used and is not observed in practical life (atoms, genes, molecules, etc.).

3. A system of description and substantiation. The reliability of everyday knowledge is justified by the results of the direct use of this knowledge. Science needs special ways to test the validity of its assumptions.

4. Methodology of science. Specific techniques and means of identification and description of the object of scientific research and its essential properties and relationships.

5. Ethics of science. The ethics of a scientist's professional activity contains principles aimed at ensuring its main social function − obtaining new knowledge. These include the following:

- self-worth of knowledge;
- priority of new knowledge;

- lack of references to authority as evidence;
- honesty and accuracy in describing the results of scientific research.

These oversimplified definitions will be discussed in more detail in the following sections.

1.2. Science regarding the theory of civilization. Traditionalist and technological types of civilization development and their basic values

In the life of modern people, science and the technologies created on their basis play a special formative role. The future of civilization is ultimately determined by the trends of modern science and technology. This situation is peculiar only to a certain type of civilization − the so-called technological (Western) type, whose history lasts only 350 − 450 years.

The term "civilization" is quite ambiguous and polysemantic. Before proceeding to the analysis of the phenomenon itself, it is necessary to agree on the meaning of this term. In the most general form, the word "civilization" denotes the form of existence of beings endowed with reason; it is synonymous with culture defined as a set of material and spiritual formations, the process of formation of human society and its results. In an alternative interpretation, civilization refers to the purposeful activity of man on the material transformation of objective material reality, in which he lives according to their interests and needs, in contrast to culture, which is understood in this case as the formation of meaning, i.e. the formation and change of human attitude to reality and the manifestation of which are behavioral stereotypes and rituals.

At the heart of the development of the type of society that is commonly attributed to the man-made civilization, is an uninterrupted, expanded and in-depth process of transformation of nature by the technologies created by the development of science. The man-made civilization emerged relatively recently, it replaced (not everywhere and not at the same time) traditional society. It cannot be considered as a special stage in the development of civilization in general. Rather, it is one of the alternative ways of cultural evolution that has taken place in Europe and North America and is gradually spreading to the rest of the Ecumenical (human habitat), displacing local cultural types.

There is another concept − traditional (traditionalist) society. To clarify its content, it is advisable to compare the main characteristics of technological civilization and traditional society. A comparative analysis of the main features, and attributes of technological civilization and traditional society is given in Table 1.1.

Table 1.1

Comparative analysis of the basic features and attributes of the technogenic civilization and traditional society

Types of civilization	
1	2
Traditional society	**Industrial society**
Dynamics of social transformations	
Slow pace of social development (centuries and millennia)	Extremely fast pace of socio-economic and socio-political development (decades)
Perception of time	
Cyclical ("there is nothing new under the Sun, what has been will be again")	Axial (arrow of time is directed from past to future)
Susceptibility to foreign influence	
Closed society	Open society
Values and priorities	
Consistency, stability, security	Novelty, improving the quality of life, social and scientific and technological progress
Psychology	
The social status and psychological characteristics of an individual are determined by his belonging to a certain social community, corporation; happiness is the harmony of relations between the individual and society	Autonomous, capable of self-development based on free choice of personality; happiness is will
The relationship between the individual and society	
Dominance of collectivist interests over individual ones; the good of society is above all	The priority of individual interests over public, public good is achieved through the activities of its independent members

Table 1.1 (the end)

1	2
Nature and sources of power	
Power has a transcendental, divine origin and is inherited from ancestors[1]. Power is understood primarily as the ability to control the behavior of subjects (other people)	Power is determined by a system of communicative relations between people, possession of power is the result of a social contract, the source of power is knowledge. Power is understood primarily as the ability to control the properties and effects of objects (phenomena and processes)
Political organization	
A tendency to the authoritarian hierarchical scheme of the society organization	A tendency to a democratic scheme of the society organization
Social structure	
Society is a holistic organism where each of its members performs a social role inherited from ancestors	Society is a self-organized system formed on the basis of spontaneous connections between its members. Each individual can play different social roles depending on the time and circumstances
Economics and politics	
The economic mechanism is built on the basis of simple reproduction. Power is not directly associated with the accumulation of capital	The economic mechanism is based on expanded reproduction. Power and capital are associated with each other

Traditional society is, firstly, a stable, rigidly structured social formation, in which each individual performs social functions and has psychological characteristics "programmed" by his membership in a particular corporation, and the membership in the corporation as a rule is hereditary. Secondly, it adapted to a relatively narrow range of cultural and ecological environment and responds to its changes by the type of "challenge – response".

Technological civilization is a type of society with organization based on the formation of spontaneous links between autonomous individuals who have the right and opportunity (of course, not absolute) to choose freely their social role. The viability of man-made civilization is determined by its growing power and scale of purposeful activities to transform nature in accordance

[1] A curious manifestation of this feature of traditional society is the statement of one of the French bishops of the Bourbon Restoration period about the royal roots of the earthly family of Jesus Christ: "Our Lord was not only a son of God, but he also came from a beautiful family".

with their interests and needs. This activity is realized as a result of individual activity of independent individuals who cooperate their efforts in the common interest.

Expanding control over the socio-natural environment brings to life the need to develop new ways to influence the environment.

Technology may be defined as conscious and systematized ways of purposeful human activity that contains:

a) a set of knowledge about effective, rational, systematic ways to achieve the goals of transformation of nature and culture;

b) activities in the course of which the implementation of this knowledge is carried out to solve specific tasks;

c) technological processes, i.e. rational methods and means of transformation of substances, energy and information, methods of organization and management of production.

The main prerequisite for the progress of technology is the expansion of systematized objective knowledge about Nature, Society and Man, that is, in fact, science. Thus, while in traditional society knowledge was "woven" into the fabric of the production process, in the technological civilization there is an advanced development of science and technology in relation to society and economy. Science, at the same time, is a precondition, a driving force and result of the genesis and development of technogenic civilization.

Not surprisingly, until recently, the core of the ideology of this type of civilization presupposed two postulates:

- technological determinism − in the equation of social evolution, the development of science and technology are independent variables, and the development of society and economy are derived from them;
- technological imperative − everything that does not contradict the data of science and is technically possible will sooner or later be implemented in the practical activities of mankind.

1.3. Genesis and evolution of technogenic civilization

In the history of humankind we can distinguish several periods that have become key stages in creating the preconditions for the emergence and genesis of technological civilization.

Human as a biological species (Homo sapiens) in its modern form appeared about 30 − 40 thousand years ago. Beginning from this time social heredity began to play an autonomous and ever-increasing role in evolution.

Thus, anthropogenesis (the formation of human as a biological species) is the link between biological and social evolution.

Approximately 7 − 10 thousand years BC, the so-called Neolithic revolution, the transition of man from obtaining food and harvesting to animal husbandry and agriculture began. Since this time human became the only species on Earth that instead of adaption to the environment has chosen a survival strategy of transforming it according to their own needs and interests.

Much later (5th century BC), in Ancient Greece, the so-called Ancient Greek miracle began, which lasted 200 − 300 years and included rapid development of culture and society. In this time two important inventions were made in social technology:

1) a new way of regulating the life of society − political democracy;

2) a new way of cognizing the world − theoretical science.

Thus, the first cornerstones were laid for the later emergence of a principally new type of civilization based on the acquisition of objective knowledge grounded on experience, and the development of technologies based on them − rationalist ways of organizing transformed activities. The interdependence of these discoveries presupposed in particular that professional research was based on the inadmissibility of coercion in the implementation of the procedure of proving scientific theories, no non-scientific interference in the cognitive process, extremely low status of authority as an argument in scientific discussion.

One of the basic principles of Christianity that arose two thousand years ago was the idea of equality (albeit transcendent, otherworldly) of all people before God. In the 14th – 16th centuries (Renaissance) this idea was embodied in two fundamental worldview concepts:

- the intrinsic value of every human personality created in the image and likeness of God;
- the intrinsic value of scientific knowledge as a decipherment of the plan of the Divine creation, the comprehension of the language in which the books of Divine revelation are written.

Human realized its place in the universe as the creator and transformer of Nature. In fact, the emergence and expansion of technological civilization began in the 17th century. The history of this type of civilization includes several stages:

1. Pre-industrial society (17th – 18th centuries).
2. Industrial society (19th − mid 20th century).

3. Post-industrial society (1960 − 1990).

4. Risk society (since the end of the twentieth century).

Industrial society is characterized by a high level of industrial development, the orientation of the economy to the mass production of durable consumer goods. The transition to the phase of the post-industrial society is associated with the knowledge-intensive information technologies (computerization) and biotechnology, the central role of scientific knowledge as a source of innovation and political decision-making, the formation of a mechanism of self-sustaining technological progress. The stage of risk society in which technological (Western) civilization has entered, according to some sociologists and philosophers, in the late twentieth century, will be considered separately.

1.4. The modern phase of the evolution of technological civilization. Risk society

Attitudes towards the transformation and subordination of nature to man, the idea of scientific knowledge as the main tool of such transformation, have been the mental dominants of technological civilization throughout the period of its existence, i.e. the last 350 – 400 years.

Necessary conditions for the implementation of these attitudes, which can be called a stable strategy of Western civilization, were the principle of social autonomy of science, unconditional prohibition of outside (political, religious, ethical, etc.) interference in accepted norms and procedures to verify the validity and truth of scientific theories. As the famous American philosopher T. Kuhn wrote, one of the strongest ethical norms adopted in science is the ban on appeals to the heads of state and the masses on science. "Recognition of the existence of a single competent professional group (scientific community) and recognition of its role as a single arbitrator" is dictated by the specifics of scientific knowledge [13]. This had its rationale: an alternative solution leads to the coexistence of several incompatible standards of scientific success and calls into question whether scientific truth is not personal and objective.

The second principle of the ethics of science was the thesis of the ethical neutrality of scientific knowledge. Science was outside the system of evaluations associated with the concepts of good or evil.

This principle organically followed from the division of the system of values that depict the ideal image of the future and the interests that represent the conditions for the implementation of this method. Thus, scientific knowledge as a means must be separated from the goals themselves, scientific discourse (discussion of the validity and validity of knowledge) – from the axiological discourse (goals of human activity, on which its future depends).

Thus, the state and society in their own interests (preservation of long-term prospects of historical development) should not go beyond a certain limit in the pursuit of specific scientific results that meet their goals. However, non-interference in the internal laws of the process of scientific cognition remained, in principle, achievable, until the mental dominant was not a clear identification of the famous aphorism of F. Bacon that knowledge is power with another – knowledge is good. Society agreed that the danger was not in the scientific knowledge itself, but in its application for inhumane purposes, taking full responsibility for the cost of scientific progress. The development of science and technology was associated with the idea of progress and prosperity.

Now the situation has changed. Humans and humanity have ceased to perceive the progress of science and technology unequivocally positively.

The symptoms of the fact that the possibilities for the development of technological civilization on the basis of progressive increase in the scale and depth of technological transformation of the surrounding world are close to exhaustion, can be reduced to several global problems:

1. Improving weapons of mass destruction, which made it technically feasible for the self-destruction of humanity as a result of military conflict.

2. The global ecological crisis, which requires the creation of fundamentally new ways of interaction between society and nature in the process of economic activity of mankind.

3. Preservation of autonomy, dignity and identity of the human person in the conditions of creation of the information and genetic technologies capable to manipulate a biosocial basis of each person and mankind as a whole.

The fundamental difference between the risk society and the previous stages of development of technogenic civilization in the socio-economic sphere is the change in priority − the focus on the accumulation of social wealth is replaced by the focus on reducing social risk.

The category of social risk can be considered in comparison with either the category of reliability or the category of danger.

As a result, any variant of some repertoire of solutions, i.e. the whole area of alternatives, is risky − even if the risk is only that there will be no clear enough chances that in the future it may be favorable. Therefore, reliability as an alternative to risk is a meaningless concept like the concept of health in the distinction between sick/healthy − it is impossible to properly identify the achievement of reliability. Developing this idea of N. Luhmann, we can state further: reliability is a logical-mathematical abstraction, an unattainable limit to which a person strives when making decisions in conditions of incomplete objective information, while risk is an inevitable attribute of any human activity or deviation from active action − always specific, although loaded with an axiological component.

In contrast, in the risk/danger opposition the first member of this pair reflects some internal characteristics of the behavior of the appropriate actor ("compared to the decision", "considered as a consequence of the decision"), while the second (danger) has an external, objective source ("compared to the world around").

That is, the transition of technological civilization to the phase of the risk society means a change of mental dominants − the stimulus of human behavior. The danger posed by natural elements is supplanted in the mind by the risk arising from the activity. Fear has always accompanied man throughout the history of his existence. In the mentality of technological civilization, its main source is outside of human society, outside of culture. The struggle for existence has turned into a confrontation between a human endowed with reason and its irrational (though not malicious) nature. The image of nature, precisely because of its irrationality, was presented as a source of threat − the enemy, that you have to study, understand the reasons for its behavior and develop countermeasures that allow you not only to neutralize the threat but also, at least temporarily, use it itself for good.

In the society of risk the cause of fear spreading in the society goes from the man himself, from the things accepted in the conditions of incomplete objective, scientific knowledge about the processes and phenomena of decisions concerning their use. During the existence of technological civilization, human has achieved impressive success in the "creation of Nature". The dangers emanating from the natural elements were pushed out of the limits of humanized nature (culture). Almost all dangerous infectious diseases − plague, cholera, smallpox, etc., which have killed millions of people, have been eliminated or controlled. Life expectancy has increased several times. The problem of hunger has not been solved on a global scale, but the threat of starvation has been eliminated at least for the population of the industrialized countries of the world. But the threat to human existence has not disappeared, it has only changed its form − natural hazards are increasingly being replaced by the risk of unforeseen or unavoidable consequences of the development of science and technology.

The twentieth century was marked by the birth of the concept of dangerous knowledge or risky science. Dangerous knowledge can be considered as information obtained in the course of scientific research about man and his world, the negative consequences of which cannot be controlled effectively by society at this stage of its development. In other words, dangerous knowledge is a prerequisite for social risk. Manifestations of dangerous knowledge include those scientific concepts that are associated with the following types of social risk:

1. Increasing potential or actual probability of technological disasters caused by human factors − errors of service personnel or ignored consequences of the practical use of new technologies created by the development of basic science (classic examples are Chernobyl, Bhopal, etc.).

2. Creation of technologies of mass destruction (for example, biological and genetic-technological weapons), used for military purposes, and not controlled quite effectively by the current system of collective security.

3. The unauthorized legal use of the same technologies for intimidation (including bioterrorism and similar phenomena, the line between which and the so-called legitimate use during hostilities from the point of view of the authors is not very clear).

4. The growth of social instability due to the collision of the dominant mental attitudes in society with the newly discovered scientific theories and facts, especially in the case of a differential reaction to the latter by different social (ethnic, racial, religious, political) societies.

Thus, the following results of research and development can be recognized as dangerous knowledge:

- information obtained in the course of scientific research about man and the world around him, with the results of the technological use of this that society cannot currently predict and/or effectively control;

- scientific concepts that come into conflict with mental attitudes, ethical norms and their postulates of ideological and political doctrines and religious teachings that are basic for this type of civilization;
- technologies based on scientific developments, that open the fundamental possibility of targeted and large-scale human intervention in their own biological nature (reconstruction of the genome of Homo sapiens), as the nature and direction of evolution of modern human culture are linked by genetic heredity to previous biological evolution [21; 22].

What are the consequences of all these changes for the development of society?

1. Risks are identified only through science. The general dependence of society on the progress of science does not decrease, but increases. However, science itself is largely politicized, the objectivity of scientific concepts is under increasing pressure.

2. Social risks posed by technological civilization, erode the class structures of society, they are dangerous for all, regardless of wealth and social status.

3. The search for the risks themselves and the means to combat them is becoming a new area of business. Social communities and economic structures are being formed, the source of which depends on the presence of risk.

4. In a class society, according to the well-known postulate of Karl Marx, social being determines consciousness. In a society of risk, consciousness (awareness of the reality of risk) determines social being.

5. Politicization of those areas of science and social life that were previously out of politics (ecology, medicine, etc.) is observed [11;12].

1.5. Specificity and value of scientific rationality. Science in the system of spiritual culture

In order to understand further the nature and importance of science in modern society it is necessary to compare it with other forms of human cognitive activity, such as myth, religion, philosophy and art.

Science is not the only way of human cognitive activity. In addition to science, these methods include myth, art, and religion. All of them also reflect reality in their own way according to their own logic and specificity. The modern Western worldview is primarily based on science, which does not only give a picture of the outside world, but also claims to explain the process of cognition and its various ways. Other forms are considered unsuccessful and secondary in comparison with science, because they do not meet the cognitive criteria that science uses. However, another assumption can also be made, namely that they simply reflect other areas or levels of being to which scientific criteria cannot be applied. This view is shared, for example, by Paul Feyerabend, who believes that science is a myth of the twentieth century, that it has no advantage over other myths.

It is an indisputable fact that in modern society science, art, religion and myth have divided "spheres of influence": science studies the external material world and the natural picture of the universe, religion deals with the sphere of ideals and spiritual needs, art investigates the realm of creativity and human imagination, and finally some myth-like ideas have firmly taken their place of what natural hierarchy of ways of knowing reality. However, it is hardly worth of linking directly such a hierarchy with the modern distribution of spheres of influence. The basis for such hierarchy can only be the internal (not as obvious as it may seem) nature of science, myth, art and religion.

Science is rather a late invention of man, the earlier were myth and art, and myth should probably be given priority over art. The oldest form of human thinking was mythical thinking, art and religion originated from it, science appeared still later.

In scholar understanding myth is usually defined as a story that arises in the early stages of consciousness, fantastic images of which (gods, legendary heroes, events, etc.) were an attempt to generalize and explain various phenomena of nature and society. In this regard, we can mention the religious stage of development of human thinking in accordance with the ideas of A. Comte. However, considering mythical thinking to be only a primitive form of the nascent mind would be an unjustified simplification. Everything is much more complicated. The mythical is an integral part of human intellectual development of the outside world (including that at the present stage of development). In some cases, it is assimilated by analytical thinking, in others − as it is developed, it is pushed to the periphery of human activity. Myth is by no means just a fiction. There are many different interpretations of the nature of myth.

Modern researcher Kurt Hübner singles out nine main groups. These are the following groups of interpretations: 1) allegorical or euhemeric (named after the ancient Greek philosopher Euhemerus), according to which myth is an allegorical story about some real events or phenomena; 2) myth as a disease of language, according to which mythical stories are a direct consequence of the ambiguity of words and their misunderstanding; 3) myth as poetry (i.e. myth as a prototype of literature, theater, art culture in general); 4) ritual-sociological, based on the corresponding functions of the mythical in primitive societies; 5) psychological, according to which myth reflects the fundamental psychological archetypes inherent in all mankind (a striking example of such interpretations is the theory of sublimation and the oedipal complex of S. Freud); 6) transcendental (it consists in the fact that the mythical is an expression of transcendental, i.e. something that transcends the boundaries of ordinary experience); 7) structuralist, interested primarily in structural parallels between myth, language, customs and rituals of primitive society; 8) symbolic and romantic, according to which mythical images are symbols of some other (higher, divine, transcendent or mental) reality; 9) myth as a numinous experience (the experience of divine reality or the language of nature itself) [30]. Each of these interpretations reflects only part of the true nature of myth, but not all of it. Therefore, to understand this nature one should take into consideration all the above interpretations.

Without going into detailed consideration, it should be noted that the basis of mythical thinking and worldview is the identification of one object with another, as a result of which the former becomes the symbol of the latter and acquires an independent existence. The myth itself is sometimes widely interpreted as a symbol of something other that has acquired an independent existence. For example, the original totem, which was originally an image (symbol) of some natural powers, becomes in some time an independent element of life of primitive man and is endowed with its own properties. Modern analogues of the totem are a state flag, a coat of arms, etc. Such elements play their role of concepts in mythical thinking. This thinking: 1) precedes experience, acting as the highest truth, against which the rest of the knowledge is evaluated; 2) is impenetrable (indifferent) to the experiment, as well as isolated and closed to other systems; 3) is polysemantic (ambiguous), because it acquires an independent existence, which is determined by itself. Examples of identities underlying mythical thinking and worldview are the unity of the word and its meaning in the spell, the indistinguishability of dream and reality, the unity of the object of worship and its meaning.

1. The unity of word and meaning in a spell is manifested as the belief that the spoken word is equal in strength to the phenomenon itself and is able

to cause it. This kind of unity is able to create a corresponding mood in the mind of a person living within a mythical system, which will be identical to the reflection in the mind of the phenomenon itself or will lead to it. This can be illustrated by the fact that after performing the appropriate rituals, the original hunter comes to the appropriate state of mind, which allows him to succeed in hunting, war, and so on. Another example of this is prayer, which evokes a sense of belonging to the divine.

2. The indistinguishability of dream and reality (or fantasy and reality) is manifested in the fact that when a person living within the relevant culture dreams of a god or a dead ancestor, a person thinks that a god or ancestor really appeared before him. In the language of primitive peoples, there are often no words that could indicate such a distinction. The distinction between dream and reality is manifested, in particular, in Homer's "Iliad" and "Odyssey", and the ancient Greek word *Oneires* (dream) is related to *oneiren* (to foretell the truth). The ancient Greeks did not believe that all dreams foretell the truth. According to their mythology, the truth is only foretold by dreams that come out through the gates of the horn bone (it is possible that the word *keras* (horn) is related to *krainein* (bring the truth)), while dreams that come out through the ivory gate carry deception (*elephas* − ivory, *elephairesthai* − deception) [30]. In principle, here you can also see the corresponding state of mind: the dream in symbolic form reflects the inner meaning of the subconscious, which realizes the "foretold" situation in the dream. When something fails, people say they are out of shape, out of mood, and so on. The ancient Greeks associated this with the help or opposition of the gods, who directed the flight of an arrow or spear, or, conversely, took away power. That is, in this case there is an inseparable link between internal and external, which determines the events of objective reality. In this regard, K. G. Jung draws an analogy with complex numbers $Z = X + iY$, where the real part corresponds to objective and the imaginary part to subjective reality [2].

3. The unity of the object of worship and its meaning is embodied in the original totems and idols, in modern icons, church relics and temples, as well as in purely "secular" attributes, such as military flags, symbols of power, coats of arms and more. Just as for a primitive man a totem or idol is not just a piece of wood, but something larger, endowed with real power, so for a soldier a military flag is the embodiment of true fighting power and honor, capable of giving him strength and courage in battle. The explanation

mechanism is the same as in the previous cases. The conclusion that follows from the above examples is that the basis of such cases is the unity of the material and the ideal. It leads to the fact that the elements that lay its foundation are both true knowledge (which satisfies the relevant criteria) and the being (i.e., existence that flows from itself). They are not actually verified or falsified, their existence is independent, and at the same time it is a sign of something else. That is, it transcends itself, generating new meanings that did not exist in the beginning.

These examples do not exhaust the whole variety of elements of the myth; in principle, this diversity can be greatly expanded by the relevant elements that put the foundations of science, language and the modern worldview in general. That is, the myth reflects some fundamental properties of human thinking, without understanding of which it is impossible to understand what is thinking, cognition and reality that is being cognized. As already mentioned, the basis of primitive myths lies in the identification of the symbol and the object it denotes. Primitive myths are very closely related to rituals and ceremonies, which encode all the knowledge of primitive man about the world around him. They are not retold, they are played out − the words play only a supporting role, acting as additional marks of ritualized actions. Primitive man lives inside his myths, and they will be the whole reality for him. There is nothing outside of them for primitive man.

Some modern anthropologists connect the emergence of mythical thinking (as the first form of thinking in general) with the so-called pebble culture, which is characterized by the presence of a huge number of pebbles lined on one side, usually interpreted as primitive stone choppers, not yet made by the unskilled hand of primitive apes. However, it turns out that such stones are much more than the original ape-man could need, and, moreover, their use as tools is quite problematic. From here it is possible to conclude that these stones were never tools, but were marks, which primitive man left about certain events in his life. That is, these stones are actually proto-words of human language. Initially, these were purely individual labels, i.e. culture and language at the initial stage were a means of individual self-expression, rather than of social communication. Communication was already the next stage, the transition to which should be obviously associated with the animistic worldview, through which primitive man was able to survive and inhabit the entire planet.

While stones were just marks or elementary myths, the emergence of language is already associated with actual myths, which are expressed in the ritual game. Rituals − expressions, words, stones or other objects − are marks of elements. The same stones, the same marks can be used in different games and rituals, hence the polysemantics of elements of myth and words in natural languages. Conditional objects are polysemantic marks of objects of the surrounding world, the content of which is set by the ritual that is played out. Initially, the connection between one and another objects is purely associative, the idea of structural order and natural causality is almost absent, they have not yet been invented. Primitive man lives inside such systems, accumulating and transmitting with their help all the information he needs. From this we can deduce most of the above interpretations of the nature of myth and its truth.

As noted, primitive man does not know myths, but lives by them, participating in appropriate rituals. Verbal myths are the next stage at which the myth is alienated from itself, and the person gets an opportunity to go beyond the limits of the mythical representations and to look at them as if from the outside. Myth becomes a mythology, which later either grows into religion (if an element of faith is added), or provides ascending material for science and philosophy (if the place of faith is occupied by rational, unrelated to the tradition of reasoning). All further forms of cognitive (or other) human activity, which arose on the basis of myth, repeat certain features of myth in their structure. These are, first of all, primary identifications and associations, polysemantism, reliance on one or another ritualized (or otherwise legitimized) action, and so on. Each of these forms of human cognitive activity in its own way reflects reality, while science differs from other forms by additional rationalist postulates, such as causality, structural regularity and uniformity, and a methodology adapted to these postulates.

In parallel with the formation of the phenomenon of science the process of its theoretical interpretation, i.e. the genesis and evolution of the philosophy of science was going.

The term "philosophy of science" connects two socio-cultural phenomena − philosophy and science. Understanding their relationship passed through several historical periods, each of which was dominated by a certain paradigm (in this case, this term refers to a fundamental logically consistent concept) of the ontological nature of the phenomenon of science:

- The transcendentalist concept, according to which philosophy is the only source of absolute true knowledge, and science is deductively derived from its private and individual judgments, the truth of which follows from the established philosophy (metaphysical) principles. In other words, the slogan-brand of this concept was the thesis "Philosophy is the queen of sciences". In this aphorism, its evolutionary content (the development of philosophy is the cause of science) is completely replaced by the logic one (science is the result of a logical, deductive inference from abstract theoretical philosophical postulates).

- The positivist concept says that science provides knowledge based on experience, which alone can serve as a source of philosophical truths. Its slogan is "Science is true philosophy", and the latter is only a subject-specific scientific discipline, similar to physics, psychology, geography, etc.
- The anti-interactionist concept states that science, philosophy (and theology) form extraordinary conceptual fields in their subject, methods, nature and structure of knowledge, which cannot be reduced due to the incompatibility of the categorical-terminological apparatus used by each of them. They belong to different spheres of reality − what this reality is (scientific discourse, field of scientific competence, the world of being in the terminology of Immanuel Kant), and what this reality should be (public-axiological discourse, the sphere of competence of philosophy, the world of proper according to the definition of Kant). Sometimes, especially with regard to science and religion, this concept is denoted by the abbreviation *NOMA* (Non Overlapping Magisteria – non-overlapping areas of competence). The central thesis of this concept consists in the idea that science and philosophy are fundamentally different and largely incompatible.
- The dialectical (neo-Marxist) concept states that the interaction between philosophy and science presupposes both mutual negation and mutual judgment, i.e. it contains an indelible (dialectical) historically conditioned contradiction. In other words, just as philosophy forms the initial methodological and categorical basis of science and its understanding of itself, so the latter transforms the content of basic philosophical ideas.

As a scientific discipline, the philosophy of science mainly deals with ideas of positivist and anti-interactionist, with some influence, dialectical concepts.

As a separate philosophical field, the philosophy of science emerged quite late − only after the emergence of a developed system of natural sciences. The philosophy of science was preceded simply by scientific philosophy, that is, philosophy that sought to provide a worldview and methodological basis for the rest of the sciences. The ancient Greeks originally had one science − philosophy. Mathematics separated from it in the classical era, and a little later astronomy did. Such modern natural sciences as physics, biology or psychology first emerged as separate sections of philosophy. It is believed that Aristotle was the first to make such a division. However, despite such a fairly early time of emergence, some of these sciences became sciences (in the modern sense of the word) much later. Physics separated from philosophy in the seventeenth century with the advent of classical mechanics by I. Newton (Newton himself still called his science "natural philosophy", i.e. considered it a part of philosophy). Later, in the 18th century, chemistry, biology and other sciences became separate sciences. Their separation was somehow connected with Newtonian mechanics, which for a long time was a model to follow. Biology was the latest to stand out (closer to the end of the 19th century).

Of course, the emergence of the natural sciences did not come from nowhere. The philosophical foundations were laid by all the previous development of philosophy. In particular, ancient philosophy provided deductive logic and a number of metaphysical foundations, scholastic philosophy developed the concepts necessary for the further development of science. Methodological foundations were laid in the 17th century by the works of F. Bacon and R. Descartes. The former for the first time substantiated in detail the need for an empirical (that is, based on facts and experiments) approach. This made it possible to bring science closer to actual reality, to free it from excessive speculation and abstraction, to make it practically useful. Bacon is credited with the authorship of the phrase "knowledge is power". Bacon considered induction (generalization from the particular to the general) to be the main method of empirical knowledge of reality. R. Descartes laid the foundations of rationalist scientific knowledge. The main methodological prerequisite for such knowledge was clarity and obviousness. If some concept is not clear and obvious, then it should be analysed, that is broken down into components that would be. Later, within the framework of empiricism, the so-called sensualism was formed, i.e. a cognitive approach based on sensual data, as well as materialism, a worldview concept that postulates the existence of a completely objective carrier of all phenomena, processes and objects that precede everything subjective. As for the rationalist direction of scientific philosophy, its representatives tried to identify the general preconditions and possibilities of cognition (I. Kant), to build a universal metaphysical system of worldview (Schelling, Hegel), and so on. However, the actual sciences (primarily natural sciences) developed separately from these philosophical systems. In the nineteenth century, this gap between philosophy and science became quite apparent. There is a need for a new philosophy that would reflect and comprehend the rapid development of science at that time. Positivism became such a philosophy.

The founder of positivism was the French philosopher Auguste Comte, who in the first half of the 19th century declared that the era of metaphysics was over and the era of positive philosophy had begun. Positive philosophy or simply positivism is a philosophy based on the provisions of specific positive (i.e. natural) sciences. Philosophy must systematize and bring to unity the individual positive sciences. Positive philosophy became the first philosophy of science in the full sense of the word. The main provisions of Comte's positive philosophy were: 1) the law of three stages, 2) the law of the subordination of fantasy to observation and 3) the encyclopedic law, which is expressed in the classification of sciences. The law of three stages determines the stages through which humanity passes in its mental development. There are three such stages, namely the theological, metaphysical and positive stages. Hence, respectively, three kinds of philosophy.

The first variety, theological philosophy, is a necessary starting point for human thought. It tries to explain all the phenomena of reality with the help of supernatural powers, such as gods, spirits, angels, heroes.

The second kind, metaphysical philosophy, is a transitional stage from theological to positive philosophy. It explains the surrounding reality, referring no longer to supernatural powers, but to various fictional entities that seem to be hidden behind the phenomena of the outside world. Examples of such entities are Thales' water, Anaximander's apeiron, Plato's ideas, Descartes' and Spinoza's substances, Leibniz's monads, Kant's "thing as itself", Hegel's absolute spirit, and the matter in materialism. Kant argued that in experience you can find specific objects and phenomena, but not substances, ideas or matter. The latter are invented in order to create the appearance of an answer to the question of the beginning, to the question to which there is no answer in principle. Metaphysical philosophy is undoubtedly a step forward compared to theological, however, it remains no more than a degraded theology.

The third kind is positive philosophy. It leaves fruitless attempts to know the absolute principles and causes of the universe and goes through the accumulation and analysis of positive knowledge provided by individual sciences. Some sciences use laws to describe what is given in empirical experience. Laws are only repetitive connections and relations between the phenomena of experience. They remain on the surface without penetrating into the essence of the phenomenon. They answer the question "how", "in what way" but not "why".

Scientific knowledge is mainly empirical in nature, and the development of science is, first of all, the accumulation of knowledge. All theoretical positions of science must be subject to empirical data, i.e. imagination and fantasy must be subject to observation. This provision is the content of Comte's second law. This law enters into full force at the positive stage in the development of science and philosophy. It expresses the basic essence of this stage. Comte's third law is the law of classification of sciences according to the principles of movement from simple to complex, from abstract to concrete, from ancient to new. According to these principles, the following classification of sciences is given: mathematics, astronomy, physics, chemistry, physiology, sociology, ethics. Philosophy is not given a separate place, because it must deal with the rest of the sciences, its task consists in creation of a system of homogeneous science. The latter does not mean a complete reductionism of the laws of one science to the laws of another, but only the reduction of laws and principles inherent in different sciences to some minimal number of legal provisions and bringing the whole body of human knowledge into a single system of homogeneous science. That is, philosophy is a holistic system of general provisions of individual sciences. Comte is also the founder of the positive science of society, social physics, or sociology, built on the principles of his positive philosophy.

In England, positivism at that time was represented by the name of Herbert Spencer, whose main purpose was to reconcile knowable and unknowable elements of reality, as well as to build a system of synthetic (unified) philosophy. What cannot be known is everything that underlies the phenomena of the external world. This is, for the first, the concept of the First Cause, that precedes any other property. People can say nothing about whether material is divisible to infinity or not, and what is primary about another − determinism or indeterminism. The natural sciences eventually lead to the fact that all phenomena, all sensations are caused by some forces, but it is impossible to say what force is. It is not even known what consciousness is, whether it is finite or infinite in time. That is, any knowledge is relative, sooner or later it faces its limit, which cannot be overcome by rational means. Only completely different ways can help here − revelation, for example. In this place we again come to the complementarity of science and religion. H. Spencer recognized the theory of evolution and believed that all the variety of forms of nature is the result of evolutionary development. Most of the Spencer's eleven-volumed "Synthetic Philosophy" is devoted to the evolution of the universe, from the evolution of inanimate material to the evolution of living nature and evolution of human, society, and morality.

The second wave of positivist philosophy was the so-called empiriocriticism, a direction of thought that recognized in fact only empirical knowledge, considering theoretical knowledge only a convenient means of reproducing the empirical. True science, according to the proponents of empiriocriticism, is, first of all, empirical science, all non-empirical or irreducible to empirical components must be eliminated (expelled) from it. The science that at best satisfied this demand, according to Ernst Mach, the representative of this trend, is physics. The empirical is that which is subject to direct observation; the same that is not subject to such observation (as atoms in physics) is only a means of saving thought, that is, a sort of convenient mnemonic maps and schemes. The principle of economy of thought, formulated by Richard Avenarius, states that "the economy of communication and understanding is the essence of science". The philosophy of science has the task to purify science and its language from metaphysical elements (that is, those that are not subject to observation and verification).

In the twentieth century there is a third wave of positivism, the so-called new positivism or logical positivism. Its emergence is closely connected with the activities of the Vienna Philosophical Circle, whose representatives turned their attention to the language of science, to the analysis of which they actually reduced all scientific philosophy and philosophy of science. The founder of the Vienna Circle, M. Schlick, also paid considerable attention to the development and analysis of verification methods (verification). The scientific position must be subject to this procedure, and according to it all statements (scientific or everyday) can be divided into true, false and meaningless (i.e. those that cannot be said to be true or false because they cannot be verified). Neo-positivists devoted much effort to the analysis of scientific language and attempts to develop a universal system of scientific categories that would exclude any metaphysics from science. Their opponents in this matter were realists, pragmatists, and representatives of other schools.

In the end, the philosophy of science comes to the recognition of the historical and cultural conditionality of science and scientific categories. In the philosophy of postpositivists, logical analysis is replaced by historical analysis. Some postpositivists generally conclude that science is only one type of cognitive activity, perhaps not the best.

1.6. Social status of science. Scientism and anti-scientism as alternative civilization models

Science presupposes the objectivity of knowledge, its independence from the subject of cognition. This is the specificity that distinguishes it from myth (which does not particularly care about such distinction), religion (which is primarily a way of knowing the subjective, inner world), art (which is a sphere of free creativity, subject to more imagination than some objective criteria). This specificity can be interpreted in different ways: as an advantage or as a weakness. Some call for abandoning it, as well as for some weakening of other scientific criteria. But it can hardly be considered a science, rather not. Thus, in addition to science and pseudoscience, it is also possible to distinguish anti-science, i.e. an approach that openly and sharply opposes itself to the scientific approach and scientific values. Regarding the criteria for distinguishing between scientific and anti-scientific, Gerald Holton offers the following criteria. Scientific worldview supposes: high status of "objectivity"; the final desire for quantitative rather than qualitative results; intersubjective, suprapersonal, universal nature of results; anti-individualism; intellectual-theoretical, abstract nature of the results in contrast to the data of direct sensory experience; more instrumental than substantial understanding of the process of cognition (i.e. specific forms − notions, theories, concepts − are tools of cognitive development of reality, rather than a reflection of objective substantial forms); problematic guidelines for research (as opposed to guidelines for miracles, sacraments, practical interests, etc.); guidelines for evidence (possibility of verification or falsification); tendency to replication and repeatability of results ("Mind and routine"); specialization; skeptical attitude to authorities, intellectual independence and autonomy; rationalist rejection of any sacralization of one or another element; rejection of unfounded opinions, but openness to discussions, reasoned criticism and new experience; clearly expressed secular, anti-transcendent, anti-metaphysical character of the general active instruction; anti-romanticism, anti-sentimentalism; evolutionary as opposed to static and catastrophic (revolutionary) understanding of reality; as a rule, indifferent attitude to awareness of the meaning and basis of their activities, non-reflexivity; cosmopolitanism and globalism; activism, progressivism (i.e. belief in the existence of the relationship "scientific progress − material progress − progress in the field of human right").

Regarding the assessment of the social significance of science in social development and, in comparison with other means of cognition, there are two alternative models − scientism (that emphasizes the positive aspects of the development of science) and anti-scientism.

The anti-scientific perception of the cognitive role and social status of science can be summarized as follows: in the center is the ideal of subjectivity rather than objectivity; qualitative rather than quantitative analysis of results; personal rather than intersubjective nature of cognition; egocentrism; sensitive-concrete rather than abstract-theoretical form of knowledge; substantial rather than instrumental type of rationality; unique, single rather than generalized nature of the results; recognition of the right and opportunity to make "discoveries" for all comers rather than just for the intellectual elite and professional experts; focus on practical benefit, interest to the mysterious and amazing (in contrast to the problematic organization of scientific research); disinterest in checking for falsification; reliance on faith, conjecture, belief; significant role of authority. Thus, the anti-scientific could include, for example, Nazi theories about the peculiarities of the "Aryan race", "sons of ice", a special role in the history of a nation or state; the so-called "Michurin genetics" in the former USSR, and so on.

However, science does not always clearly meet all these criteria of scientificity, but on the contrary, what is not recognized by the scientific community as science, falls within the criteria of anti-scientific. The issue of distinguishing between science, pseudoscience and anti-science is quite complex and requires a lot of effort. Very often the problem cannot be limited to purely rational approaches, because the development of real science (as, in fact, any other form of activity) involves a number of other factors. The following sections will be devoted to the consideration of these rational and irrational issues.

If we reject one of the components in any of the above definitions of science, it will be no longer science, but pseudoscience, or at least pre-science. Yes, if knowledge is logically contradictory or simply does not correspond to reality or is not verified by experience, then it cannot be scientific, but only pseudo-scientific. If knowledge is not systematized, it should be attributed to pre-science. However, the problem of verification, explicit or implicit logical consistency, truth, etc., is not as clear as it may seem to first glance. All these problems belong to the field of epistemology, and, accordingly, the problem of science or pseudoscience acquires an epistemological nature. Traditionally, in Western culture, science means a rather limited range of theories, concepts, directions. These are traditional natural sciences, humanities, and formal-logical disciplines in the form and with the content that developed in Europe and the United States during the seventeenth and twentieth centuries. Everything else (astrology, palmistry, magic, various occult teachings, etc.) is usually considered pseudoscience or antiscience. Most of these pseudo-scientific teachings date back to antiquity and are much older than science in the modern sense of the word. One can, however, also mention such teachings as phrenology, physiognomy, graphology, which arose and developed together with science and within science, but were later recognized as pseudo-scientific. That is, there are many specific cases and features of the division into science and pseudoscience. Pseudoscience itself can be defined as a science-like formation, which, however, does not meet certain criteria of scientificity. Disputes are possible as to the criteria themselves, as well as to what extent one or another area of human activity meets them. All this will be discussed in the following sections.

Control questions

1. Find out the difference between the terms "pseudoscience" and "anti-science".

2. Where to (science, pseudoscience or anti-science) should astrology, palmistry, metaphysics, historical materialism, political economy, physics be attributed? Justify the answer.

3. Does science always meet all the criteria of scientificity? Why?

4. Do you think modern science and the humanities can be considered a kind of myth? Why?

5. Is there anything in common between science and myth, and if so, what exactly?

6. Analyze the features of the mythical. Try to find them in modern natural sciences and humanities or other modern forms of human activity.

7. Give arguments for and/or against the equality of science, mythology and other forms of human activity.

8. Give examples of elements of the mythical worldview in the lives of modern people.

9. Analyze the law of three stages of A. Comte, give arguments for or/and against it.

10. What should be considered as known and unknowable? Define the term "civilization".

11. What is the difference between traditional society and technological civilization?

12. Is technological civilization a necessary stage in the development of culture, or just one of the possible ways of evolution of civilization? Justify your answer.

13. What role does science play in the life of technological civilization?

14. Describe the main stages of formation of technological civilization.

15. Why are political democracy and the formation of science seen as interdependent social phenomena? Is the development of science possible under totalitarian regimes?

16. Why has the Christian perception of time become one of the prerequisites for the emergence of the concept of social and scientific and technological progress?

17. How has the social role of science changed with the transition of technological civilization to the stage of the risk society? Do these changes mean a reduction in the impact of science and technology on the development of society?

2. Genesis and evolution of science

Science in the strict sense as a cultural phenomenon and an element of survival strategy (the so-called stable evolutionary strategy of human being as a species) has a relatively short history. Its origin is attributed to the 17th century CE, the "birthplace" of classical science in the strict sense of the term is Western Europe, or rather, this name was given by the Transatlantic (Western) civilization.

But so far pre-scientific knowledge and early forms of science itself have undergone a long period of evolution. In its course, the prerequisites and necessary intellectual, economic conditions for the emergence and further development of science were formed.

2.1. Periodization of science development

The general scheme of the evolution of science is as follows:

1. Pre-science (from the birth of human society to the 4th century BCE).

2. Protoscience (4th century BCE – 16th century CE).

  2.1. Ancient protoscience (4th century BCE – 6th century CE).

  2.2. Protoscience of the Middle Ages and the Renaissance (6th – 16th centuries CE).

3. Science in the proper sense of the word (from the 17th century CE to the present day).

  3.1. Classical science (16th – 19th centuries CE).

  3.2. Non-classical science (1900 – 1970).

  3.3. Post-academic or post-non-classical science (in the mid 1970s).

2.2. Pre-science and science in the proper sense of the word. Two strategies for generation of knowledge

First of all, let us dwell on the evolutionary and anthropological preconditions of science. Every living organism has a certain species-specific feature – a special way of solving various problems of survival in the natural environment, the so-called stable evolutionary strategy. The difference between human and other living creatures' strategies consists in the fact that humans, unlike other creatures, do not adapt to the environment, but adapt it to themselves, more precisely, to the organization of their own biosocial substrate – physical and mental organization. Russian anthropologist A. A. Zubov, in the opinion of the authors, successfully calls this feature "adaptive inversion".

This became possible due to the fact that the stable adaptive strategy of Homo sapiens, which emerged during anthropogenesis, contains a superposition of three main modules that ensure its survival – biological, cultural and techno-rationalist. Each of them has its own system of generation, evaluation and dissemination of information important for survival. The supporting structure of the techno-rationalist module is the *Science – Technology – Machinery* complex.

The integrity of this complex is supported by science, which acts as a prerequisite and mechanism for the development of machinery and technology.

The first stages of the process of formation of science are called *pre-science.* Conditions which made possible the actual science as a civilizational phenomenon are being laid at this time.

This stage of the history of science is divided into two stages:

1. Formation of skills and abilities that are not stored and passed on to new generations by biological way (genetic heredity), but by socio-cultural transmission – through imitation of the master ("do as I do"). Language played only an auxiliary role here, the symbols for the corresponding concepts in the language were absent and accumulated very slowly. However, in this period a sign-symbolic system of calculations and calendar is formed.

2. Formation of knowledge within the framework of local cultures that correspond to the construction of cities and the emergence of primary states. To serve the functions of public administration (tax collection, unification and stabilization of relations within the state machine and between states, support of religious cults as the most important adaptation that supports social stability) writing arose. The first two social communities (scribes and priests) are distinguished, whose ability to perform their assigned social functions required schooling on the basis of language communication with the teacher. With the complication of the functions of the state, the corresponding social differentiation and stratification, schools of alchemists, dyers, sailors, physicians, architects, military engineers and agronomists emerged (in

ancient Assyria, the secret of date palm pollination and its practical implementation was the prerogative of priests). Positive (useful) knowledge acquired in schools is considered as corporate secret ("secrets" of the craft; special ways of encoding texts with words or signs are developed).

Thus, as a result of each stage there are two ways to generate new knowledge that has adaptive (essential for survival) significance for humans:

- based on imitation and memorization of random successful deviations in the implementation of ways to achieve a predetermined goal. This method was formed at the first stage of the formation of pre-science and is based on the inherent ability of human biological ancestors to mimesis (imitation of individuals who occupy a high social status in the group);
- based on rational thinking and verbal communication of information about ways to solve vital problems. This method is based on the inherent ability of man to convey information not about his own condition, but an external, objective situation with the help of conventional (contractual, not biological in nature) language of symbols.

2.3. A general overview of science development. The research program of the relationship between science and technology in history

The result of the first stage of the genesis of science is as follows [25, p. 55–60]:

1. Writing has been developed, account has been developed, and positive knowledge (in the form of a "diagnosis – prescription" connection) in the field of chemistry, astronomy, medicine, engineering, agronomy and geometry has been acquired.
2. Special terminology and symbols for different areas of knowledge have been developed.
3. Together with skills and abilities, text acquires a special role (symbolic transfer of information, first of all, positive).
4. The development of methods for obtaining and applying new knowledge has begun.
5. The truth of positive knowledge is established by achieving the desired result, as a consequence – positive knowledge and religious context acquire autonomous value and significance.

As a result, pre-science becomes a form of protoscience (4th century BCE, Ancient Greece – 17th century CE) and science itself (from the 18th century). Protoscience, in its turn, has three periods – ancient, medieval and modern (Modern times).

In the era of ancient science (Ancient Greece, Ancient Rome) there was a clear division of knowledge and skills into applied, practically useful, and theoretical, "pure" areas.

Applied, positive knowledge was considered a matter of "low" social strata and slaves, engaging in it was shameful for a free citizen (the famous inventor and engineer Archimedes of Syracuse hid his authorship, attributed it to slaves).

An elite, worthy occupation of a free man was theoretical knowledge: philosophy, rhetoric, pure (not applied) mathematics, natural philosophy (reflections on nature, astronomy, meteorologists, etc.). The first *research program of science* is created exactly here as a set of basic methodological goals, principles and rules for obtaining new knowledge of research (Aristotle):

1) scientific knowledge of any phenomenon or process is equivalent to identifying its structure or cause;

2) the initial stage of cognition – analytical, identification within the studied phenomenon of individual components and the relationship between them;

3) the truth of the analysis is confirmed on the synthetic stage, during which the result of the coordinated interaction of the elements detected by the analysis is established;

4) the truth of the study is achieved through the researcher's consistent criticism of his own research, continuous attempts to find internal contradictions and inconsistencies.

The most important achievement of theoretical ancient science is the logic of Aristotle, which became the main tool of rational cognition, which replaced intuition, sensory clarity, etc.; Euclidean geometry (near 330 – 277 BC); geocentric astronomy of Claudius Ptolemy (near 87 – 165 AD).

The main features of protoscience were formed in the Middle Ages. As a result of the triumph of Christianity, knowledge came to be regarded as a matter pleasing to God, provided that it did not go beyond the limits set by God. These boundaries were determined by the needs of the realization of the Divine plan and were set in the mentality of Western

European civilization by three slogans of Christian doctrine: the core of the Western mentality is man's desire for some ultimate ideal ("Per aspera ad astra" – Through thorns to the stars).

It is complemented by a second core structure that is sacralized and, at the same time, limits this ideal ("Ad imaginem suam ad imaginem Dei" – In the image and likeness of God) and the emphasis on God's election, the absolute priority of the uniqueness of the human person ("Unus ex nobis" – One of us, as God says about Adam). Thus the actualization of the desire to bring together the world of Being and the world of Proper acquires the character of movement to the Absolute, the ultimate goal ("Omega point", as Teilhard de Chardin called it). Anything that contradicted at least one of these imperatives was considered dangerous and rejected.

Areas of dangerous (forbidden to man) knowledge are outlined by medieval culture with an accuracy worthy of an expert – an analyst of the end of the 2nd millennium: first, the cosmic reality: it is forbidden to look into the sky, and in the mystery of Nature in general (arcana naturae). Secondly, religious reality (in an expanded interpretation – ideal reality, i.e. the content of human consciousness – ed.): it is forbidden to know the mysteries of God (arcana Dei), such as doom, the dogma of the Trinity, etc. Third, political reality: it is forbidden to know the secrets of power (arcana Imperii), i.e. the secrets of politics.

These are all different aspects of reality, each of which presupposes its own, well-defined hierarchy; different but interconnected, more precisely, mutually reinforcing by analogy.

The emphasis in cognition of the world came to the study of "things", objects of everyday practice, but on the basis of creating an ideal scheme of transformations of material objects, developing a sequence of operations that were to lead to a pragmatic goal. In other words, practical experience ("success") was implicitly viewed, along with Scripture, as a criterion of truth. Thus, cognition was woven into the cycle of transformation

→ ARTIFACT-I → KNOWLEDGE → ARTIFACT-II →

But the difference between empirical, sensory, spiritualistic, and spiritual experiences has not yet been realized; magic was considered equal to knowledge of natural objects and processes that, like them, bring only utilitarian benefits. That is why the methods of logical operations, analysis and synthesis, developed in magic, alchemy, numerology, were also used later in the development of the methodology of scientific knowledge. This is especially true of scholastic theology, philosophy, engaged in the study of acts of spiritual experience. The logical apparatus developed by them was later incorporated into epistemology with the necessary adjustments.

Thus, the notion of the dual nature of the origin of knowledge about the world is asserted implicitly – from the experience of everyday life, daily activity and from knowledge that has a higher status (Divine revelation).

Accordingly, the basic principle of classification of scientific knowledge has changed. In antiquity there was a division of knowledge into applied (low) and theoretical (pure) knowledge. In the Middle Ages, the dominance of theology led to the fact that in any field of knowledge they distinguished those objects of knowledge whose existence and essence is natural, that is, does not depend on the will of man, but is created by God, and artificial, created by human will.

As a result, within each science the presence of both applied (artificial) and theoretical (natural) arrays of knowledge, a complex intertwining of the divine and the earthly was assumed. There is a new type of educational institutions – universities, which by their etymology indicate the general, universal nature of scientific knowledge. They replaced the educational institutions that emerged in antiquity: academies, where they taught theoretical "pure" knowledge, and schools, where they prepared for "low" utilitarian activity.

At the stage of classical science itself, both sources of knowledge were "equalized in rights" and were reflected in the philosophical concepts of Rene Descartes' rationalism, declaring the source of knowledge – the human mind. And the empiricism of Francis Bacon, who took this role to sensory experience. The synthesis of both methods and concepts of cognition in one methodological scheme – the technology of generating new practically valuable (positive) knowledge and proclaiming it (knowledge) as the ultimate and main source of power served as the beginning of the phase of classical science.

Unlike protoscience, classical science separated from axiology (theory of values), became only a means to achieve goals, regardless of their ethical evaluation. The principle of ethical neutrality of scientific knowledge made it possible to purify scientific knowledge from subjective elements, which turned it into a publicly available element of the transformation of reality.

At the same time, science has become a system-forming element of the so-called technological civilization in which we live now.

The further evolution of science is connected with the completion of the concept of scientific knowledge (epistemology) and fundamental transformations of the methodology of scientific research. Since science is a rationalist form of cognition of reality, these transformations are combined with a common term – *types of scientific rationality*. This term combines a set of attributes of the regulatory framework for the organization and conduct of research, the relationship between subject and object, the nature of knowledge [3]. The basis of these evolutionary transformations are changes in views on the ratio between the object and subject of scientific knowledge and the criteria of validity and reliability of scientific knowledge (theories, hypotheses, etc.).

2.4. The history of formation of types of scientific rationality and methodology of scientific knowledge (based on the example of socio-economic disciplines)

It is necessary to consider these transformations directly based on the example of socio-economic scientific disciplines.

Just as in the methodology of scientific cognition in general, in the methodology of socio-economic cognition it is accepted to distinguish three stages, which correspond to separate types of scientific rationality.

1. **Classical scientific rationality** and methodology (18th – late 19th century) was based on *Laplace determinism* (the possibility of unambiguous and comprehensive description of the whole set of causal relationships of phenomena and processes of reality) and the Cartesian division of the object and subject of knowledge as two completely autonomous entities. The task of cognition was formulated as the creation of an objective picture of the world around us, which exists outside of human consciousness and independently of it. In natural science, this led to ignoring those insurmountable changes that caused the actual presence of the observer in the object and the interaction of the object with the observer and research tools. In socio-economic theory during this period, the target and value attitudes, political and ethical views of both individuals – business entities – and, directly, the researcher were ignored. According to the concept of the classic of economic theory, Adam Smith, human activity in a market environment is entirely determined by rationalist factors – the only universal law – leading, regardless of the will of the subject, to the growth of social wealth.

2. **Non-classical scientific rationality** and methodology (end of the 19th century – 1970s). It is realized that the object and the subject of cognition (scientific research) form a single system, the process of observation itself makes irreversible changes in both its components. This principle was originally formulated in quantum mechanics and the theory of relativity in physics, but proved to be very valuable in the field of competence of socioeconomic sciences. In the scientific analysis and comprehension the facts connected with features of individual behavior of the person, with achievement of the purposes set by it in the conditions of the limited resources providing their achievement were involved. Emphasis was placed on the real motives and incentives for the actions of the subjects; economic activity was seen as rational. The idea of a possible verification of economic theory was almost entirely based on the criteria of logical consistency. Logical-mathematical and statistical methods of analysis and interpretation of scientific facts obtained during observation and experiment have been widely used in socio-economic research.

3. **Postclassic or post-academic scientific rationality** (J. Ziman [45]) **and methodology** (since the 1970's) is based on the postulate of relativity and historical conditionality of any type of rationality. The principle of ethical neutrality of scientific knowledge, rigid division of spheres of competence of scientific (cognitive) and public (value) discourse (discussion) of reality has been revised and limited in its application. This was due to the transformation of man himself into an object of manipulation on the basis of scientific knowledge and changes in the status and functions of science in society. Any economic theory cannot be completely freed from the value-ethical and ideological-political components. The object and the subject of socio-economic cognition are included in the cycle of direct and reverse connections. The process of scientific research itself influences its behavior. The results of the study affect the subject of scientific knowledge and change the system of goals which is going to be achieved. Accordingly, the task of socio-economic methodology (as well as the methodology of scientific knowledge in general) is not to eliminate these components from scientific theories, but to identify them. An important place is occupied by the creation of a system of value priorities, which should guide the process of economic research, a system of guidelines for the creation of political and economic concepts, strategies for economic development.

Control questions

1. Identify the main stages of formation of science as a professional activity.

2. What is adaptive inversion?

3. Which consequences of pre-science as the first stage of the genesis of science are the most important in your opinion? Argue.

4. What social mechanisms have led to the stratification of basic and applied science?

5. What was the significance of the emergence of universities in the history of science?

6. Define and explain the origins of the two strategies for generating knowledge.

7. Formulate the most important prefaces and mechanisms of disciplinary-organized science.

8. Describe the main periods of development of philosophy of science in the context of the development of technogenic civilization.

9. Define the essence of the turn in the development of philosophical tradition and the emergence of logical positivism, made by Ludwig Wittgenstein.

10. Describe the features of the philosophy of science of the late 20th – early 21st century.

3. Science as a social institution. Sociology and culturology of science

3.1. Theoretical principles of determining the status of science in the system of social institutions of modern society

The development of science is determined not only by the internal rational aspects of scientific knowledge (this issue will be discussed in the following sections), but also by external factors that are not directly related to the knowledge itself. Socio-historical and cultural factors determine not only the speed or direction of development of science, but also its content and conceptual basis. Finally, this feature of the development of scientific knowledge was recognized only in the second half of the twentieth century, at the same time, science was thought of as something completely objective and rational. It was believed that scientific activity is completely devoid of any personal prejudices and subjective preferences, that it is independent (at least in its substantive form) of political, religious, cultural and other factors present in society. That is, science was considered something completely self-sufficient and autonomous.

As mentioned in the first section, science is not only knowledge in itself, but also the activities, people and social institutions that carry out these activities. That is, science is a social phenomenon by its definition.

This was well understood in the 19th century. Thus, one of the classics of sociology of the time, Emile Durkheim laid the foundations for the further development of the so-called sociology of knowledge. In his works he tried to build a sociological explanation of the genesis of the main categories and logical structures of human thinking. He noted that the ideas of force, contradiction, time and space are different in different human groups and can change over time. This indicates that he believed that the categories and laws of logic to some extent depend on historical, as well as, thus, on social factors. At the same time, he tried in every way to avoid relativism in the assessment of scientific knowledge, as it proceeded from the postulate of the unity of the physical world. E. Durkheim connected the existence of conceptual diversity with the living conditions of certain human groups. Thus, the notions of time in such groups are derived from the social rhythms of the collective life of the group. However, these rhythms are somehow connected with certain fundamental periodic processes of the physical world. The physical and social worlds together form one common area of natural phenomena. Thus, all socially conditioned categories will be to some extent "objective" [46, p. 41–42]. Objectivity becomes more and more decisive as the process of social evolution develops, during which science replaces religion as the basis of human thought. That is, as human societies develop, intellectual activity is increasingly freed from social constraints. Scientific thinking is the result of such liberalization, its products have relative immunity to direct social influences. Sociological analysis of science, according to S. Durkheim, is possible, but in a more limited form compared to other forms of human activity.

K. Marx also pointed out the social conditionality of scientific knowledge. His views on science follow from his general philosophical and economic approaches, according to which the history of mankind is the history of the constant transformation (humanization) of mankind of nature or the external objective world. In the course of such transformation, humanity creates knowledge about the outside world. Knowledge is always a response to the economic or other needs of different social groups, it is always limited by the ideological preconditions inherent in one or another mode of production. The emergence of capitalist society gave a strong impetus to the development and growth of scientific knowledge about nature. This was due to the economic interests of the bourgeoisie. Natural science was designed to create practical effective scientific knowledge that was used as a direct economic means. That is, since the nineteenth century, science has been closely linked to the capitalist economy and technological renewal required by capitalism. Initially, both capitalism and natural science were one of the forces designed to free mankind from the power of superstition and the errors of religious thinking. At the same time, science eventually becomes one of the means of exploitation for the bourgeoisie. In the field of industrial production, science contributes to the "dehumanization of human". It is impossible to speak of any objectivity or autonomy of scientific knowledge, because, as noted in the previous section, truth itself, according to Marxist philosophy, has an instrumental character (the criterion of truth is practice) [46, p. 42].

At the beginning of the twentieth century, the topic of the sociology of knowledge was developed by J. Stark, K. Mannheim, M. Weber, and others. Thus, Karl Mannheim in his sociological analysis combines the achievements of Marxist philosophy of knowledge with the ideas of neo-Kantianism with its clear distinction between the natural sciences and the humanities. This makes his analysis somewhat contradictory and inconsistent. On the one hand, he notes the quite objective and static nature of natural knowledge. The source of this nature is the immutability of the phenomena of the material world and the connections between them. Because of this, natural knowledge develops more or less linearly and consistently through the gradual accumulation of invariably accurate conclusions about a stable material world. A completely different matter is cultural products or social phenomena, for which unbiased analysis and impartial objectivity are impossible. Every researcher begins his analysis of cultural phenomena, starting from the structure of values inherent in his own culture. Natural knowledge is a special case that is beyond sociological analysis. Only such type of knowledge is desirable, which is free from all kind of influence of the subject's worldview.

Based on the identification of objectivity and intellectual consent, Mannheim also pays great attention to the problem of the relativity of knowledge. Consent is possible only if the results of one system of views are freely translated into another. If this is not the case, then we should wait for the emergence of a new broader system in which the previous ones will act as isolated cases. The old static epistemological concept, which was based on the idea of truth as a correspondence to the facts available for direct observation, is inadequate to most areas of thought. Mannheim sought to create a new relational epistemology that would analyze existing knowledge on a more acceptable basis, and draw parallels between the situation in epistemology and physics at a time when old methods of observing and measuring classical physics were insufficient for quantum physics and were rejected.

Further sociological analysis of scientific knowledge, based on the work of R. Merton, for about 30 years tried to avoid the substantive side of scientific knowledge, limiting himself mainly to the study of the impact of regulations on the development of science. Thus, Merton himself studied the distribution of rewards in science, economic, technical, military factors that contributed to the emergence and growth of modern science. He also for the first time outlined such a category as "scientific ethos" − that is, a set of ethical guidelines and values that authorize and support them. He, as well as M. Weber, argued that the Puritan complex of values in England stimulated modern science, as the Puritans attached special importance to such cultural values as usefulness, rationality, individualism, anti-traditionalism and earthly asceticism, which are parallel to similar values of science. At the same time, it should be noted that Merton never tried to record any direct connection between Puritan values and the intellectual achievements of scientific activity. However, it is the Puritan values that are most conducive to the development of science.

3.2. Organization and evolution of scientific ethos

The concept of scientific ethos as a system of regulations that make it possible for science to perform its social functions is key in the system of modern theoretical sociology of science. The evolution of the content of scientific ethos and the reflection and perception of this phenomenon by sociological theory is closely connected with the evolution of forms of scientific rationality (theme 2). In parallel with the transformation of scientific rationality, there was a transition from the so-called classical scientific ethos (Merton's ethos) to the modern one (Ziman's ethos).

3.2.1. Merton's ethos (ethos of classical science)

This idea is often denoted by the abbreviation CUDOS [46, p. 44]. From English (student slang), this acronym can be literally translated as "honor, prestige, respect". Strictly speaking, the methodologically correct meaning of the abbreviation corresponds to the phrase "institutional structure of remuneration". CUDOS consists of four imperatives:

• Communism or communalism: the subject that produces new knowledge is the scientific community as a whole, not an individual scientist, because each researcher uses the entire accumulated body of scientific knowledge. As a result, firstly, all researchers have equal rights to have sound and reliable knowledge and, secondly, new scientific results and theories are subject to immediate publication for public knowledge.

• Universalism: scientific knowledge is objectified and depersonified, scientific laws apply always and where there are necessary and sufficient conditions for their validity and reliability. Therefore, the evaluation of scientific data should be carried out solely on the basis of logical and empirical consistency; references to ethnic or racial affiliation, gender, reputation, as well as affiliation to a scientific school, political and other beliefs of the researcher (so-called argumentum ad hominen – "arguments to a person") are not acceptable and are not taken into account.

• Disinterestedness (impartiality, disinterest): the purpose of the scientist's professional activity is to search for objective truth, no considerations about the possible benefits or harms of the acquired knowledge should have an impact; scientific knowledge is ethically neutral, and the categories of good and evil cannot be applied to it. The responsibility for the consequences of the use of scientific knowledge lies within society (state, politicians, businessmen, public organizations), but not within the scientific community.

• Organized Skepticism: "De omnibus dubitandum est" − "everything can be doubted". Professional scientists are obliged to seek to identify errors in any scientific research, to question all published scientific results, both their own and those obtained by other scientists; because the methodology of scientific cognition is based on the ability to turn the detected erroneous knowledge into a source of truth.

Merton added later a few additional rules to these basic ones, such as originality, intellectual modesty, independence, emotional neutrality, and impartiality.

Among all these, universalism is one of the most important principles. The scientific community must be built according to universalist criteria, which are sociologically unproblematic or can be the basis for social stratification (division into strata, i.e. groups) of science. Only scientific merits and nothing more should be taken into account. The scientific community should approach *meritocracy,* a social system that is stratified on the principle of individual achievement.

It is important to emphasize that in Merton's interpretation the above principles are imperatives, i.e. prescriptions, ideal images of the scientist's behavior, rather than descriptors (objective descriptions) of the actual behavior of the "average" scientist. However, their very existence in the minds of the scientific community as a model of behavior ensures that the social institution of science fulfills its basic social functions − the generation of new "positive", i.e. "common" knowledge, understanding and explanation of reality. In everyday life, as pointed out by the author of the concept of scientific ethos, each researcher adheres to a system of mutually exclusive, but situationally necessary behavioral stereotypes. In particular, depending on the conditions, he must:

1) transfer their scientific results to colleagues as soon as possible, but should not rush with publications;

2) be receptive to new ideas, but should not be exposed to intellectual "fashion";

3) strive to acquire such knowledge that will be highly praised by colleagues, but should not work regardless of the assessments of other scientists;

4) defend new ideas, but should not support reckless conclusions;

5) make every effort to identify issues within its competence, but, at the same time, the scientist must remember that erudition sometimes inhibits creativity;

6) be extremely precise in wording and details, but not become a pedant, because it harms the content;

7) always remember that knowledge is universal, but the scientist must not forget that any scientific discovery honors the nation by whose representative it was obtained;

8) educate a new generation of scientists, but not give too much attention and time to the education of young people;

9) learn from a "great master" and imitate him, but not be like him.

Thus, the scientific ethos acts as a controller that ensures the existence of science within the social norm.

Further development of the sociology of knowledge is connected, on the one hand, with the study of the influence of socio-historical and culturological factors on the content of scientific knowledge, on the other − with specific empirical studies of certain sociological features of development and functioning of the scientific community. As for the first direction, it is represented by the works of postpositivists and was considered in the previous section. As for the second one, it can be divided into the study of the actual sociological features of scientific activity and the study of culturological features. Sociological features of scientific activity are connected, first of all, with the problems of internal scientific communication, evaluation of the obtained scientific results and recognition in the scientific community, as well as the interaction of the scientific community with the rest of society. As for communication, much has been done in terms of studying the impact of various forms of communication on the pace and direction of growth of the scientific product. These are such forms as scientific conferences, symposia, internships, systems of scientific periodicals, etc. As a concrete example, we can take the problem of the place and role of formal and informal transfer of knowledge from one member of the scientific community to another. An example is the introduction of TEA lasers in research. The first report and description of the principles of construction of such lasers appeared in the scientific literature in 1970. Many scientific groups have tried to create such lasers themselves. Some succeeded, others did not. The reason, as it turned out, was the presence or absence of direct contact with the group, which first began to manufacture such equipment. Contacts and consultations often had to be repeated many times for the laser made by the "young" group to work really. That is, information that can be transmitted through scientific publications in many cases is not sufficient. Because of this, direct formal and informal contacts between scientists are necessary.

There is also the problem of announcing and concealing scientific information. Of course, concealment of scientific information for one reason or another is condemned by the scientific community, but there are cases when such concealment is necessary or at least useful for the development of science. For example, when the first work on pulsars was published (with considerable delay) by a group of Cambridge astronomers in 1968, accusations were leveled from all sides of concealing information that could contribute to the progress of science. However, members of the Cambridge group referred to a number of justifying principles. First, they had every right to avoid disseminating information that could allow other scientists to intercept their discoveries. Second, secrecy was justified by the fact that it gave time to truly verify its results. Third, the group had the right to make sure that the results improved its reputation and facilitated the acquisition of additional research funds. Fourth, scientists had the right to protect the first achievement of a young scientist and the right of experimenters to interpret the results themselves. Fifth, in the case of pulsars, action had to be taken against misinterpreting this significant discovery in the general press. From this argument it is clear that the problem of transmitting or concealing information is not as simple as it may seem at first glance and may well be justified both in terms of morality and in terms of simple expediency.

The problem of evaluation and verification of the obtained experimental results is that in order to verify the scientific results obtained by a scientist or a group of scientists, theoretically another group should re-test the experiment. However, in reality this is almost never done. That is, repeated test experiments seem to be carried out, but they always differ in some details from the primary ones. This is due to the fact that each scientist or group of scientists has their own views on the problem under study, through the prism of which they approach the test. That is, denial or confirmation actually means nothing, because another experiment is being conducted.

Criteria that still affect the acceptance or rejection of the results obtained by someone are anything but objective. These can be any criteria related to the personal beliefs of certain authorities in this field, with the most common views on the problem, the economic balance of power in the scientific community and so on. In fact, as a deeper analysis shows, the scheme of scientific revolutions proposed by Kuhn does not work. Because, as can be seen from the history of science, the change of one paradigm to another is almost never preceded by a crisis. Moreover, in the examples given by Kuhn, the paradigms developed quite dynamically and promised many prospects. The change was almost always due to the situation in the scientific community, a lot of completely subjective factors not related to science itself. In fact, this feature has long been noticed by scientists themselves, many of whom more or less successfully used it in their work. An example is parapsychology that wasn't recognized science in the early twentieth century and no article on the subject was taken into consideration. Parapsychologists have pursued a well-thought-out policy in this direction. Many of them have made considerable efforts to obtain scientific diplomas, degrees, recognition in areas not related to parapsychology. And only after achieving such recognition in the scientific community, they returned to the promotion of their ideas.

The problem of the relationship between the scientific community and the rest of society is also serious. The problem is how society should treat the expert assessments made by scientists. On the one hand, scientists are indeed experts in their respective fields, to whom, if not to them, to give assessments. But, at the same time, as has been shown before, scientific criteria are quite conditional, based on certain metaphysical, cultural, or similar principles, which are neither objective nor generally accepted. Scientists as members of society cannot be independent in their assessments of society itself and its certain groups. An example is the fact that when considering socially significant projects, competing social groups are able to provide themselves with a favorable expert opinion of scientists. What criteria should be used in such cases? The modern scientific community is a clearly defined social group with its own socio-economic interests, which it tries to support in various ways. In order to support these interests, it contributes to the spread of ideas about the need and role of science, scientific approaches, specialists in solving certain socially significant problems. Undoubtedly, science and scientists are necessary for modern society, but where is the limit that defines the level of such a need in solving certain problems? It is not there. Decision-making is not determined by rational, but by completely irrational, cultural, historical, and other subjective factors.

In the worldview aspect, the very formulation of the problem of nature and organization of scientific ethos reflects the basic changes in the nature of the social institute of science, the appearance of a self-reflexive component in it (in a scientific worldview), i.e. the appeal of science to study its own cognitive and sociocultural essence.

This process has intensified and deepened with the transformation of human and human objects into the subject of scientific knowledge, technological management and manipulation. As one of the modern researchers writes: "The problem of the ethos of science is to a large extent the problem of such subjectivity, which is able to generate objectivity" [35, c. 23].

3.2.2. Modern (post-academic) science and Ziman's scientific ethos (PLACE)

In the second half of the twentieth century, profound changes took place in science, which marked its transition to the post-neoclassical phase (V. S. Stepin) or post-academic science (J. Ziman). In the methodology of scientific knowledge these changes were reflected in the concepts of growth of scientific knowledge, which were called the "modus-2" (H. Novotny) and "triple spiral" (G. Itskovich and L. Ledeysdorf) [11]. We will talk about them in section 8.3. In the sociology of science, the same changes were conceptualized by J. Ziman in his theory of post-academic science. Let's now focus on these works.

According to J. Ziman [45, p. 84] "what could be called post-academic science differs from the earlier stereotype of classical science, replacing the market competition of conceptual populations and scientific schools − their carriers with command-and-control. Research groups work by executing teams, as small firms that produce competitive goods for the market. Commercial entrepreneurship and personal mobility replace professional responsibility and career stability as principles for the organization of research activities". There is a transition from the classical disciplinary organized to post-academic science, the coherent transformation of technological civilization into the phase of information culture, and the market economy − in the knowledge economy. It is accompanied by the appearance in the semantic code of the scientific community of terms-brands, previously unknown and borrowed from outside − from the culture of civil society formed in the West in the last few centuries (management, contract, administration and control, responsibility, training, employment). J. Ziman rightly considers them a sign of progressive (let's add − permanent) "bureaucratization" and declares that the survival of basic science in the new social context is very "amazing".

The transformation of science into a post-academic form took place in parallel with the replacement of the ethos of classical science (Merton's ethos) by the so-called Ziman ethos (ethos of post-academic science), i.e. a radical change in the value priorities of the scientific community. *PLACE* became an acronym for this ethos. According to the ethos, there are such imperatives in modern science:

• proprietary (patentability): scientific knowledge is covered by the right of intellectual property, patent, instead of general possession of this scientific knowledge;

• local authoritarianism: the topics and goals of scientific research are determined authoritarianly, administratively rather than by the will of the researcher; the social autonomy of the scientific community and the individual scientist de facto no longer works;

• commissioned − the purpose of scientific research is not to obtain new knowledge in accordance with the internal needs of science, but to solve practical (social, economic and/or political) problems, i.e. "social order";

• expert work − the subject of scientific research is not the scientific community, but a small group of experts; the results of the research are evaluated in accordance with the ability to solve a practical problem with the help of research.

In the real scientific community, a certain parity is established between two ethos − Merton's ethos, characteristic of the community of scientists focused on traditional goals and values of pure science, and Ziman's ethos, i.e. the values and norms of the community focused on applied research.

This aspect is not about the selection of the most valid (relevant) theories and hypotheses, and the criteria for such selection, i.e. the principles and competitive procedures for verification of scientific knowledge. It is a question of "sociocultural motivation" of scientific and cognitive activity as such.

Hence the focus of philosophers of science is a set of social and cultural ideas about the goals of scientific knowledge, which fix together the social status of scientific and cognitive activities and determine the subjective and personal interest in it, i.e. motivate people to this activity, giving it sociocultural aspects in the eyes of society in general and each scientist in particular. In this sense, the scientific ethos is a program built into science that provides self-reproduction of this social institution and its basic forms. The replacement of Merton's ethos with Ziemann's is tantamount to a macro-cultural mutation that has determined the ideological and worldview foundations of technological civilization – its transition to the phase of risk society and information civilization. As it was noted earlier, the "trigger" for this transformation was the technological schemes of human-driven evolution.

Control questions

1. Define a social institution. What gives the right to consider science as a separate social institution?
2. Describe the different approaches to defining the social institution of science.
3. Identify the implications of developing ways to translate scientific knowledge from manuscripts to the modern computer.
4. Define the content of the category "scientific community".
5. Describe the differences and reasons for the transition from one historical type to another of scientific community in the era of disciplinary science (19th – 20th centuries) and interdisciplinary communities of science of the 20th century.
6. What is a scientific ethos?
7. Describe the ethos of classical science.
8. Describe the ethos of post-academic science.
9. Describe the development of types of scientific rationality and its relationship with the evolution of the social institute of science from classical science, through non-classical science to post-non-classical (post-academic) science.
10. Give and decipher the acronyms that denote Merton's scientific ethos and Ziman's one. Can we say that they are types or phases of development of the social institution of science?
11. What is a scientific school?
12. Training of scientific personnel. Identify the causes and consequences of the process of politicization and ideologization of science.

4. Socio-cultural determination of scientific and technological knowledge

4.1. Thematic analysis of science

Science is a part of human's culture and it is developing in the general cultural process. It is transmitted through influence of philosophical, metaphysical, outlook, aesthetic and other cultural aspects on the development of scientific knowledge. The development of science cannot be understood outside of this influence. For example, speculations of antique science were deep-rooted in all antique culture with its mass shows and orientation to the outside world.

The antique culture, according to O. Spengler, saw first of all a world of corporeal forms and nothing more outside of them. Eastern culture was different. Indian culture had been leaning all the time to the opinion about the illusion of all the existing world, that this world is an illusion which is subordinated to the law of karma. One should only wake up to get rid of the illusion. The Indian culture was in general subordinated to this goal. Consequently, its achievement takes place in the sphere of transformation of soul rather than the outside world. These are such achievements as yoga, meditative techniques, etc. The ancient Chinese saw the world to be a single giant organism in which everything is harmoniously adapted to each other. All problems arise from the violation of the original harmony.

Consequently, the task of science was to search for the ways of attaining both the internal and external harmony. From here, such achievements of Chinese science as geometry, gigong, feng shui, etc. are. The European science is closely linked to three cultural components. They are Greek rationality, Roman law and Judea-Christians religious ideas. From Christianity modern European science has inherited solid faith in reality of material world that was absent, for example, in Ancient India, where nobody would ever dream to explore the external illusory world. The Roman law also gave the awareness about the nature's law through the prism of Christianity, and the Greek rationality laid methodological basis of European science.

Science is based on the metaphysics, and not only in the sphere of its worldview base. There are a lot of cases in the history of science when some achievements directly resulted from the philosophy views of its authors. Albert Einstein in youth was under big influence of Mach's empirio-criticism which he reinterpreted in his own way, but this influence is undoubted, in particular, in the denial of the objective simultaneity which was a base for the whole theory of relativity. One of the founders of quantum mechanics and the authors of today' model of atom, N. Bor was under the great influence of S. Kierkegaard's philosophy from whom he borrowed the idea of dialectical jumps which was used in the so called Bor's model of atom. It is generally recognized that Malthus's ideas influenced the evolutionary theory of Ch. Darwin with its thesis about the fighting of the kinds for existence and natural selection. In his theory Darwin based his ideas in a lot of things on the breeders' achievements of his time. It means that the majority of phenomenons with which he had a deal belonged to the area of an artificial but not of natural selection. The breeders in their activity exceeded from the needs of market and from the market's competitive fight. Darwin just has transmitted these foundations onto the wild nature. In the role of breeder, who is guided by the need of biggest kind's fitness, discarding all unworthy perpetuation in time, in Darwin's conception is God. Exactly about that it was written nowhere but could be easily seen. Without this metaphor (or metaphysical base) all the Darwin's theory hangs out in the air.

It is possible to speak a lot about the influence of cultural factors on the development of scientific knowledge. Let's provide here one of the conceptions of this influence, in particular the idea of thematic analysis of science by J. Holton. His main concept is the notion of theme where three aspects are represented: 1) the thematic concept; 2) the methodological theme; 3) the thematic assertion. Thematic analysis shouldn't be confused with other similar constructions such as Jungian archetypes, metaphysical conceptions, paradigms or worldvisions. Themes have exceptionally individual character. Some examples of them are the themes of mathematical harmony of Kepler's world, Einstein's model of the scientific theory building, the principle of complementation by N. Bor, methods of the research organization by E. Fermi, etc. The theme is directly related with the culture of scientist, with his worldview and philosophy he shares but does not coincide with them.

The theme of J. Kepler (thematic concept) was the idea of mathematical harmony that he tried to find. The source of this topic was his pythagoreanism which consisted in his faith that God created the World in the form of a huge machine working in accordance with mathematical principles. Kepler tried to find out what these principles were. Success or failure of scientific activity is determined by the theme, how much it is suitable for working with it. Enrico Fermi supposed that nature does not admit excessiveness and it is arranged very economically. He put this principle in the base of his work. He only set those tasks that could be solved. For this purpose he created a strong, well organized team of scientists, who worked under his leadership. He carefully corrected spheres of their interests and used all political and economic possibilities which could contribute to his scientific work. The main Holton's idea consisted in the fact that unformal thinking in science depends on those basic (thematic) preconditions which inspire and direct the activity of a scientist. They can lead to erroneous conclusions but at the same time allow him to ignore unfavorable evidence in search of what may turn correct interpretation. Holton made no lowd conclusions, he only clarified some mechanisms of scientific research development in the general cultural process.

4.2. The main mechanisms of the united evolution of culture and scientific cognition

The process of connection of science with the rest of culture is not unilateral. Not only science is determined by the cultural situation in society, but on the contrary, it has a direct impact on the development of the rest of culture. This impact goes in several directions, namely: 1) science creates technical and economic preconditions for further development of culture (both in quantitative and qualitative terms); 2) science influences the worldview of culture (in the case of the modern situation we can even say that science puts the foundations of such a worldview); 3) science contributes to the emancipation of culture from other forms of cognitive activity, such as religion or mythology (although in return it tries itself to conquer culture); 4) it can give direct meaningful material for the development of artistic culture (to a lesser extent). The nature of relationship between science and the rest of culture changes with time. The second half of the 20th century opened a new stage of development of their relationship.

4.3. Convergent informational technologies (technologies of controlled evolution) and evolutional future of man

The second half of the 20th century is characterized by the emergence of qualitatively new approaches to knowledge systems. These approaches emphasize first of all the conventionality and pluralism of any possible knowledge preferring historical to epistemological and logical analysis. Their appearance is related with the expansion of the horizons of scientific knowledge which eventually led to the understanding of the unattainability of a single universal system of knowledge and understanding. In addition, the emergence and rapid development of information technology in the second half of the 20th century demonstrated once again the information (through existing knowledge) and pragmatic conditionality of the rules of legitimization of knowledge systems. Knowledge ceases to be seen as an objective reflection of reality, and is seen as a kind of language game or discourse. This understanding is accompanied by a growing distrust towards all kinds of meta-narratives such as the theory of cognition, methodology and ontology of natural sciences and humanities, hermeneutic interpretation of works of art, etc. All this is combined under the common name of metaphysics. The main task of the philosopher is to get rid of any metaphysics. This state was called the state of *postmodern,* i.e. one that follows directly after the classic epoch (modern).

Postmodernism (the philosophy of this state) is a wide enough range of different currents and directions of modern humanitarian thought, such as post-structuralism, deconstructivism, previously considered postpositivism, feminist studies, archeology of knowledge, schizoanalysis, etc. The common feature of majority of the cited directions is the attention to the historical analysis of the systems of knowledge and culture, recognizing general cultural and epistemic pluralism, as well as understanding of the reality under study in the form of text, represented by certain symbols. Friedrich Nietzsche is often called the predecessor of postmodernism. As for back as in the last century he defined the goal of his philosophy as "reavaluation of all values" and denied the universality of his time views. Among other things in Nietzsche's works there are remarks on the purely linguistic conditionality of our ideas, the comparison of the universum with a text or book, etc. [17].

It is not always possible to draw a clear line between postmodernism and previous classic philosophy. It is especially visible in the case of post-structualism and structuralism, the difference between them is reduced only to some shift of emphasis. Thus, while structuralism considers mainly linguistic, social, ritual and other structures, post-structuralism focuses on the conventionality of these structures and the primacy of the unstructured universum. Some researchers, who began as structuralists, became disillusioned with the search for universal structural patterns and turned to the analysis of the possibility of the structures themselves, as well as to how it is possible to go beyond structures.

So structuralists try to find universal structures inherent in all languages. Consciousness due to the fact that its activity takes place almost entirely within language, can be likened to text. Universal language structures in this case will be structures of the unconscious. At the same time, as already mentioned, Levi-Strauss, for example, denied the identity of this unconscious to the subconscious of the Freudians. However, J. Lacan reconsidered this view. The founder of structural linguistics Ferdinand de Saussure related the sense of a sign (word) to the corresponding object; the match may be arbitrary, but it is always there. Later, however, he recognized the possibility of a floating correspondence (for example, in poetic language). This idea was developed in the works of Lacan. His floating relevance becomes the norm instead of the exact one. Lacan develops the basic ideas of Freudianism within the structures of language and floating correspondence. The manifestation of the latter is the work of dreams, the images of which are correlated with the real like a word and the denoted object. The correspondence is floating − the same image (the same word) can correspond to different elements of reality at the same time. Blurring is caused by the action of condensation (identification with the same image or word of different meanings) and substitution (shift of mental energy from one phenomenon in the brain to another). Both the word and the image in dreams are symbols, the symbol appears only in the absence of the denoted thing. Absence creates conditions for polysemanticism and uncertainty of linguistic structures of the unconscious.

Poststructuralism is ideologically close to the so-called *deconstructivism* which tries to decompose (deconstruct) structures and go beyond their binary oppositions. Oppositions are identified with metaphysics and the goal of philosophy is defined by deconstructivists as liberation of any metaphysics. Oppositions define the boundaries between subject and object, truth and error, determinism and accidental, knowledge and reality. If they are removed, the difference between the opposing elements will disappear: knowledge will be a continuation of reality, the subject of an object, error be a supplement to truth and so on. Since thinking and knowledge are verbal, reality does not exist outside of language constructions. One of the most famous representatives of modern deconstructivism, Jacques Derrida, thinks that the basis of European culture lies in the opposition *voice − writing.* Voice is both speech and thought (in it, the greatest unity of the speaker and the listener is achieved, as well as of the speaker with what he says about; voice is the voice of being, the direct expression of reality). Writing is a "trace" voice [24, p. 53–58]. Writing should be distinguished from the system of writing, which is only an isolated case. Writing should be understood as any representation of reality, the voice of being. The opposition of the voice and writing forms the foundation of "logocentrism" and "monocentrism" (i.e. closeness of thought or voice and being) that underlie European culture, serving as the basis for all other centrisms (theocentrism, cosmocentrism, ethnocentrism) of European culture. The emergence of phonetic writing is also closely related to these centrisms, which is the essence of European metaphysics.

Deconstructivism, according to Derrida, began with Kant's distinction between phenomenon and thing in itself, developed later in Hegel's philosophy which is, in essence, a constant reflection on the voice of being and writing. Nietzsche did much for deconstructivism, as well as Zarathustra, who dances on the other side of existence, is free from metaphysics and its oppositions. Derrida sees the essence of his own method in showing that the opposition of voice and writing is vague and conditional, because writing itself is being along with voice, not just its reflection, while voice itself is the same trace of being as writing. Voice and writing are bizarrely intertwined, forming a compatible representation of being. Derrida admits that it is impossible to go completely beyond the oppositions of metaphysics because they are a property of language, within which our thought moves.

Deconstruction means discovering the mechanisms of metaphysics, that leads to cessation of pressure onto our thinking. Deconstructivism is also close to the *archeology of knowledge* by Michel Foucault, which was considered previously − in the presentation of the basic models of the evolution of science.

4.4. Psychology of scientific activity

The psychology of scientific activity contains the following main points:

1) the psychology of scientific research;

2) the problem of psychological motivation to engage in scientific activities;

3) other problems.

Regarding the psychology of scientific research, one of the central questions is the problem of the ratio of rational and irrational moments of solving specific scientific problems. It's possible that some persons believe that science is (at least on a conscious level) a purely rational activity, devoid of any emotional and intuitive experiences, that it consists in dry planning and calculation of results. It does not work however. And the scientists themselves point to it. Undoubtedly, in formal terms, science must fully satisfy all available norms of scientific rationality, objectivity and impartiality of the time. However, as can be seen from the preliminary examination, this is not the case. Scientists are the same people as everyone else, with all the flaws and weaknesses characteristic to ordinary people.

Therefore, the same factors influence the activity of scientists as the activity of all other people. A purely rational objective approach to reality is impossible in principle. The question is different – whether the implementation of operations that make up the daily bread of a scientist is a purely rational process. The affirmative answer can be given only in relation to the routine work of solving more or less trivial tasks that do not need a creative approach. Solving non-trivial problems is completely different and not only because of numerous trials and errors. In fact, the latter is also undoubtedly the case, but such activities are not effective and do not lead to bright results. A talented scientist differs from an average in the ability to solve non-trivial problems in a more efficient way. This way is intuition, the ability to directly feel the right decision. Most of the outstanding discoveries in science are due to its appearance. There are many examples.

These include D. I. Mendeleev's insight about his famous table of periodic elements (he had a dream about it), F. Kekule's insight about the structure of the benzene molecule and many others. That is the decision that comes as if on its own, from nowhere. However, in reality it only seems so. Intuitive insight is usually preceded by a long exhausting work, which consists in analysis, systematization, testing of options, etc. And it happens only after everything has been tested and there is no solution, the decision comes on its own. That is, the process of scientific creativity is closely related to the work of the subconscious, which eventually gives a "ready" solution. That how and why this happens remains unclear today. In order for this to happen the subconscious needs to be adjusted accordingly. This is actually the whole preparatory work of trial and error. After all such enlightenment never comes to people who are not intrigued by the relevant issues. A textbook example is the case when a young man in a state of intoxication thought that he had discovered some universal formula of the universe. But when he returned to normal state, he could not remember this formula. The person made several unsuccessful attempts and finally he managed to write something on a piece of paper. Going out from the state of gasoline vapors intoxication he read the inscription he had written: "Everywhere it stinks of gasoline". Some researchers are able to more or less control the process of intuition. To do this, you need to be able to distract from your ideas, without losing the general focus of consciousness on the subject. This happens in a state of half-sleep or just a short break. The problem is to keep the intuitive result, not to forget it.

Regarding the problem of motivating science, the following motives are usually mentioned: selfless love of Nature and Truth, beauty of laws, curiosity, desire to benefit, the need for self-realization or recognition (which can lead to vanity), the halo of success, fear of boredom and others. It is unlikely that motivation can be reduced to one of these motives. If you take curiosity, it itself can be satisfied much faster and easier by simply reading scientific journals. If we take the desire for recognition, it should be noted that in modern science recognition is often limited to a very small group of specialists in this field. That is, only a combination of several factors can motivate a person to really serious scientific activities.

Control questions

1. Analyze the development of the sociology of knowledge from its inception to the present. Is it possible to identify (if so, what) trends in this development?
2. Compare the views of Merton and Mannheim. What do they have in common? What's different?
3. Give arguments "for" and "against" the concealment of scientific information.
4. What are the cultural aspects of scientific activity?
5. What is a thematic analysis of science? How does it intersect with culturology and sociology of science?
6. What is the postmodern situation? What is it characterized by?
7. What is poststructuralism, deconstructivism, postpositivism, archeology of knowledge?
8. What are the three strategies identified by Foucault in the development of European thought?
9. Analyze the place and role of purely rationalist and intuitionistic aspects of scientific research. Give examples.

5. Logic and methodology of science

5.1. Scientific knowledge as a developing system. Psychophysical problem

As it was mentioned in the previous chapter, the definition of science contains three parts: 1) scientific knowledge; 2) activity connected with this knowledge; 3) social institutes connected with this activity.

The subject of logic and methodology of science is the analysis of specificity and organization of scientific knowledge and the development of tools in accordance with the needs of a certain scientific discipline and social demands. The starting point of this chapter of the philosophy of science is the so-called psychophysical problem. One can imagine the essence of this problem in the following way (according to Karl Popper): the subject's consciousness (I, Microcosm) is separated from the world of things (Universe, Macrocosm) by an insurmountable obstacle, which is our bodily form (fig. 5.1).

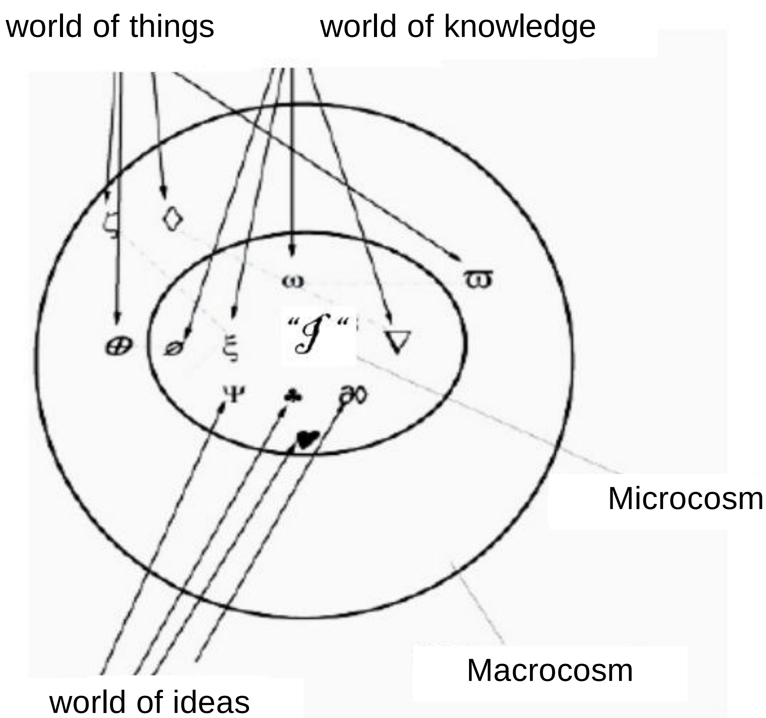

Fig. 5.1. **Demarcation and verification of scientific knowledge (psycho-physical problem)**

The elements of the world of things are marked on the picture with the following symbols: "ζ ", "ϖ ", "◊ ", "⊕ ". The only source of information (the world of knowledge, which is marked with the symbols "ξ", "ω", "∇", "∅") about the world of things that surrounds us, are the signals coming to our consciousness with the help of the sense organs. In this regard, the elements of the world of things and their ideal forms (in particular, knowledge) are not completely the same, there are differences between them. In addition, the elements not directly connected with the world of things and defined by the internal laws of the development of the consciousness (the world of ideas is marked with the symbols "ψ", "♣", "♥", "∂◊") are also present in the consciousness. Therefore, a human is an active creature (subject) that aims to rebuild the world (the object), the part of which he becomes.

Within this definition, the psychophysical problem tends to generate a system of questions, connected with the separation (demarcation) of the world of ideas, the world of knowledge and the world of things. The first questions among them are as follows:

1. Demarcation of the scientific knowledge: in what way and on the basis of what criteria one can differentiate scientific knowledge, i.e. ideal images arising within the objective reality (the world of things), and ideas (mental conditions) adequate (at least partly) to this reality that were generated exclusively by nature and internal regularities of the development of human consciousness and mental condition. The latter are not directly connected with the objective reality, but only occurred in the process of biological evolution and are caused by the features of the material medium of consciousness, the biological type Homo sapiens.

2. Verification (falsiability) of scientific knowledge: in what way and on the basis of what criteria can one differentiate scientific knowledge that is real or adequate to the objective reality from the false one or mistakes?

The theory of scientific knowledge (epistemology) answers these fundamental questions to create a theoretical basis for development of different methods of generation of new knowledge, that in turn serves for the creation of ways of rational transformation of the objective reality in accordance with the goal set in advance (technology). In other words, science serves the task of "lifting" the World of Life to the Due World (a metaphor by Immanuel Kant) as a result of purposeful human activity as the only known carrier of intelligence in the Universe.

In the theory of the classical epistemology the criteria of demarcation states that Knowledge K is scientific only in case if it can be represented as an applied calculation of predicates P, the language of which L is built on the multiplicity of actual atomic formulas, each being interpreted on a certain protocol offer and may be given as a theorem T.

In other words, scientific knowledge creates a system of non-contradictory assertions, which may be compared with the empirical (sensitive) experience directly or as a result of deductive conclusion and cannot be disproved by this experience. If such a comparison is impossible or any assertion on this concept is in the end disproved by experience, then such knowledge cannot be recognized scientific.

An assertion can only be considered protocol (that is having a sense) if it may be compared with empirical experience, and based on this comparison, may be recognized true or false. In epistemology, this principle was called the dogma of meaning (K. Popper) [46, p. 63].

This definition, as we will see, also gives the ways for solving the second task (searching for criteria, which make it possible to differentiate real scientific knowledge from mistakes). The first consequence coming from the criteria of demarcation and the dogma of meaning will be an induction problem: taking into consideration that protocol assertions depict the results of individual empirical experience, which means that they are individual according to the definition, then how can the truth and falsity of general scientific theories be outlined from them?

It is considered [33, p. 28] that modern science has a complex (systematic) criterion that contains seven attributes of merely scientific knowledge:

1. Objectivity, that is an orientation on the depiction of relations and regularities of different objects or fragments of reality, which exist independently of the researcher's consciousness ("The World of Things"). Even if these objects have an ideal form and are constructed by the researcher's and observer's consciousness, they (the objects) are simultaneously projected into the sphere of empirical experience and are viewed as elements of objective reality. This assertion is a fundamental principle of the concept of scientific realism.

2. Discoursiveness, which means that reality is represented in the form of speech or text built in accordance with some principles of organization of the system of conceptual apparatus. This parameter allows transferring of knowledge from one subject to another as to an informational message and, thus, provides a possibility for the communicative nature of scientific research.

3. Unambiguity of the objective **meaning** and subjective sense of its conceptual apparatus. The first component (meaning) ensures a non-variant depiction of objects while the second one provides the assessment of the results from the perspectives of interests and the system of values.

4. Empirical or analytical verification/ability, i.e. absence of apparent discords between the empirical experience and the conclusions acquired from the present knowledge through the deduction.

5. Systematic character or logical coherence, absence of logical discords among separate elements of knowledge. It ensures additional reliability and the ability of knowledge to improve and reproduce itself.

6. Evidential character or logical argumentation of the content of knowledge.

7. General significance, which means that knowledge ensures reception of the same results in case of coincidence of necessary and sufficient conditions always and everywhere independently of personal features of the subject.

5.2. Variety of formal types and levels of scientific knowledge organization

The systematic character of scientific knowledge leads to the complication of its structure and the variety of its forms.

Scientific knowledge is provided by several formal types [38, p. 178] and in this regard, every type of the organization of knowledge is characterized by different ratio of priorities of elementary parts of the complex scientificity criterion:

1. Sensitive knowledge, that is the observation and experiment data of the research object.

2. Empirical knowledge, that is a generalized description of observation and experiment data in the form of numerous facts and empirically observed (phenomenological) laws.

3. Theoretical knowledge, that is a logical and systematic description of properties, relations and laws of a certain multiplicity of ideal objects.

4. Metatheoretical knowledge, that is the general scientific principles (a general scientific picture of the world, elements of the disciplinary matrix, philosophical fundamentals of a certain science or discipline).

5. Interpretive ("centaur") knowledge, that is a multiplicity of proposals (resolutions) which bind the elements of various levels of scientific knowledge by identifying them; quite often it is a result of the synthesis of not only various theoretical concepts but also a combination of objective and descriptive, subjective and axiological elements meaning that it is a product of the integration of 3rd, 4th and 6th types of scientific knowledge.

6. Logical and mathematic knowledge, that is a language of mathematical theories, which are used in natural sciences for quantitative description and processing of massive sensitive data, formulation of facts, laws, principles, transformations, fundamental constants, systems of quantity measurements, etc.

7. Valuable knowledge, that is philosophical axiology and anthropology, which reflects and designs general values and meanings of humans and culture.

In addition, the elements of the demarcation criterion have a specificity of its concrete definition concerning various structural units of scientific knowledge, i.e. spheres of scientific knowledge. In the present time, scientific knowledge is a complicated system whose separate spheres differ by the objects and methods of the research, terminology, sphere of application, scientific criteria, structure, general principles, etc.

Therefore, modern science was divided into numerous separate sciences of the separate scientific disciplines.

Each of *the scientific disciplines* is a discrete unit of the scientific knowledge organization, which exists as a result of the unity of subject and content basics, scientists' interests and the unity of methods and means of getting scientific information of a certain sphere of scientific knowledge.

Thus, the problem of demarcation logically brings the epistemology theory to the issue of tenets and methodology of classification.

Scientific disciplines are classified based on one of two main principles – either according to the possibility to apply the scientific knowledge for practical goals, or according to the specificity of the research object.

According to the possibility of practical application, sciences are divided into:

- *fundamental sciences*, which do not set the goal to apply the acquired knowledge immediately;
- *applied sciences*, which aim to implement the research results into certain technological developments.

According to the subject of the research, scientists outline the following spheres of scientific knowledge:

- *mathematics*, which explores the most general and abstract terms – number, multiplicity, etc. As a rule, the objects of mathematics' research are formalized logical abstractions having nothing to do with any phenomena and processes of the material world;
- *natural sciences* having the subject of research that includes all natural (material) phenomena and processes which exist independently outside the human consciousness (physics, chemistry, biology, astronomy, etc.);
- *social-economic sciences*, which explore various aspects of human activity (economy, sociology, history, culturology, etc.);
- *liberal arts*, that have the subject that includes phenomena of the human, mostly spiritual culture (literature, arts, philology, etc.). The humanitarian sciences are often united with the social-economic ones, which according to the author's perspective, is not appropriate because of the specificity of the subject (which is entirely subjective and ideal) and methodology;
- *technological sciences*, that constitute (along with mathematics) a special sphere of science – a system of knowledge about the ways and tools, which are used by humans for the material impact on the environment and its transformation according to their own general demands and interests.

It should be noted that in the cultural tradition of the Western civilization only natural sciences are viewed as science in the proper meaning of this word. It was reflected in English where there is no expression "natural sciences" because the letter *s* (science) itself defines only natural studies, while there is a special term "arts" for liberal arts.

The organizational structure of knowledge in any scientific discipline is characterized by hierarchy. As an example, we provide the knowledge structure in the natural sciences:

1. Sensitive knowledge is the observation and experiment data over natural objects and experimental situations.

2. Empirical knowledge is a generalized description of observation and experiment data in the form of numerous facts and empirical laws.

3. Theoretical knowledge is a logical and systematic description of features, relations and laws of a certain multiplicity of ideal objects (material points, ideal gas, totally black body, totally isolated systems, etc.).

4. Metatheoretical knowledge is the general scientific principles (general scientific picture of the world, elements of the paradigm theory for a certain discipline, philosophical fundamentals of a certain science or discipline).

5. Interpretive knowledge is the multiplicity of proposals (resolutions), which bind the elements of various levels of scientific knowledge by identifying them.

6. Logical and mathematical knowledge is the language of mathematical theories that are being used in the natural sciences for the quantitative description and processing of massive sensitive data, formulation of facts, laws, principles, transformations, fundamental constants, systems of quantity measurements, etc.

Natural sciences create a single complex of disciplines differentiated into separate elements according to the process of the global evolution of the Universe that is accessible to our observation. All objects of the animate and inanimate nature create a certain hierarchy of holistic systems each with its specific phenomena and processes, which are difficult to describe using the terminology and regularities created by science for systems of other difficulty levels.

Evolution of substance goes through numerous organizational levels – physical (elementary particles, atoms, etc.), chemical (molecules, ions, free radicals), biological and social. Each of them arises as a result of the formation of connections and relations, which unite the objects of the former level into the elements of new holistic formations. The regularities characteristic of the elements of the system continue their action, however, to each level of the organization its own specific laws correspond.

According to this, natural science is divided into the following spheres:

- physics as a science about the most general features and forms of the substance movement;

- chemistry as a science about substance and its transformation;
- astronomy as a science about celestial bodies;
- geology and geography as a combination of sciences, which explore the surface, chemical composition, formation and evolution of the globe;
- biology as a science about life.

In summary, such natural science structure reflects the global process of natural evolution:

1. Prebiological evolution:

- cosmological evolution:

emergence of accessible material for observation of the Universe; creation of elementary particles; evolution of stars and galaxies;

creation of the atomic nuclei of the heavy elements as a result of thermonuclear synthesis;

formation of the planetary systems, the Milky Way in particular;

- chemical evolution:

creation of molecules of inorganic substances (H_2, O_2, H_2O, CO_2, CH_4, etc.);

emergence of the earth atmosphere, lithosphere and hydrosphere;

photochemical synthesis reactions of low molecular weight organic substances, HC≡N (cyanide), organophosphate compounds (ATP and others), carbohydrates, amino acids, nitrogenous bases, nucleotides; abiogenic cycle with carbon;

abiogenic synthesis of high molecular weight organic polymers with non-regular structure – proteins, nucleic acids, carbohydrates, etc.

2. Biological evolution (biogenesis):

emergence of molecular systems, which are capable of self-copying and metabolism;

emergence of primary cells;

photosynthesis and the biotic cycle of substance and energy;

emergence of eukaryotes (organisms with a structurally separated cell nucleus that contains the carrier of hereditary information − chromosomes) and multicellular organisms;

anthropogenesis (emergence of the human).

3. Sociocultural evolution (sociogenesis).

It is obvious that after the emergence of life the process of the further development of the material world separated into two directions – the development of inanimate and animate nature that was reflected in the provided scheme of the disciplinary organization of scientific knowledge (Fig. 5.2).

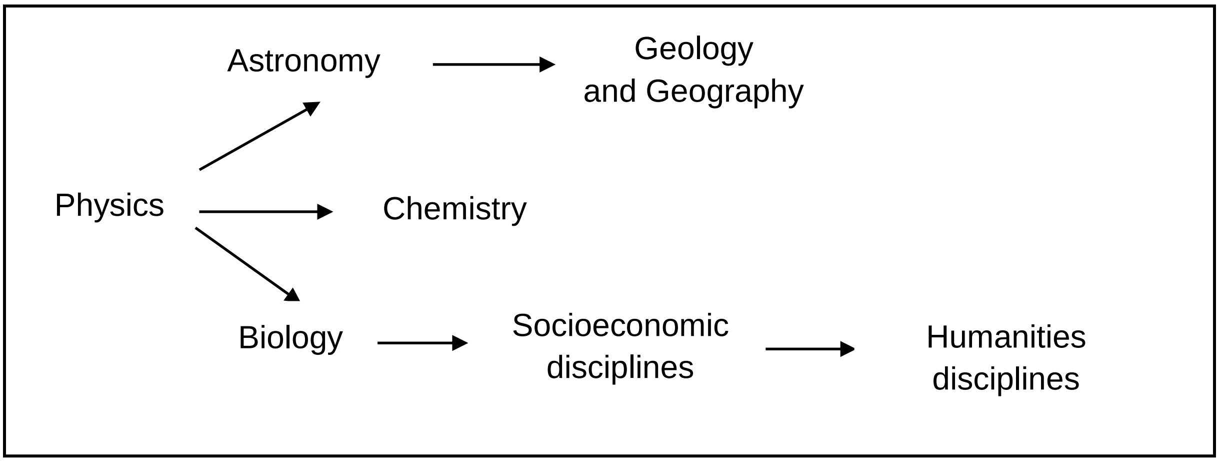

Fig. 5.2. **Disciplinary organization of scientific knowledge**

The specific objects of research determine specific methods and features of the structure of scientific knowledge in the relevant scientific disciplines. In general, the extreme members of the sequence of classification of scientific disciplines according to their subject − mathematics, which begins this sequence, and humanities, which complete it, are the most different.

Mathematical knowledge is organized according to a clear hierarchical scheme, and the boundaries of different levels, in contrast to the natural and, moreover, other scientific disciplines, are clearly defined:

1) mathematical problems and tasks;
2) meaningful mathematical theories;
3) formalized mathematical theories;
4) mathematical constructions that contain, in particular, certain philosophical foundations.

In the liberal arts, theoretical knowledge is represented by separate and general humanities theories that develop models of culture and human, the value and normative scale for assessing their evolution and behavior. As it can be seen in this regard, according to its form the theoretical knowledge is almost identical to interpretive and metatheoretical knowledge in science.

The hybrid subject of the technical sciences causes a special structure of these disciplines:

1. Ontological knowledge is the description of features and relations of artifacts in contrast to objectively existing facts – material objects created by a

reasonable subject with a predetermined purpose. Artifacts include both material objects (technical devices, mechanisms, building structures, chemicals and pharmaceuticals, artificially created living organisms − products of genetic engineering technologies, etc.) and technological processes.

2. Metrological knowledge is a description of measuring devices and technologies of the use of these devices, systems of units and standards, methods of processing the measurement results.

3. Model-design knowledge is the theoretical models of future artifacts, mathematical calculations of their functionality, reliability, safety and efficiency.

4. Empirical knowledge is a description of observational and experimental data on test specimens of artifacts and observed patterns of operation of prototypes and models.

5. Theoretical knowledge is a description of the properties, relations and laws of ideal objects − representatives of artifacts, the formulation of the laws of their functioning and change, methods of substantiation and verification of theoretical statements.

6. Everyday knowledge is a set of instructions and prescriptions for the use of artifacts and technological processes, a system of safety rules.

7. Metatheoretical knowledge is a basic knowledge of the social sciences and humanities and natural mathematical sciences, philosophical principles and foundations, ethical, economic and environmental regulations and restrictions, assessment of social and practical nature. Collectively, this type of knowledge determines the social and individual needs and ways to meet them, provided by specific scientific developments. Identification and development of norms, rules, methods and techniques that regulate purposeful activities for the formation and development of knowledge, is *the subject of logic and methodology of scientific knowledge.*

5.3. The structure of theoretical knowledge. Elementary components of the process of theoretical cognition

Thus, the competence of science methodology includes, first of all, the question of systematization of *forms* of organization of scientific knowledge, which usually include, in descending order, the following concepts: idea, problem, hypothesis, concept, theory, law, scientific fact and just fact.

An idea is a form of scientific knowledge that reflects the connections and patterns of reality and is aimed at its transformation, as well as combines true knowledge about reality and the subjective purpose of its transformation.

The idea in the scientific knowledge performs many functions the main of which are: 1) summarizing the experience of the previous development of knowledge; 2) synthesizing knowledge into a holistic system; 3) fulfilling the role of active heuristic principles of explanation of phenomena; 4) the direction of searching for new ways to solve the problems. The idea is at the same time a form of thinking comprehension of the phenomena of the objective reality. It includes awareness of the purpose and design of further development of knowledge and practical transformation of the world, fixing the need and possibility of such transformation. The idea, therefore, is a special form of scientific knowledge.

A problem (problem situation) is a form and means of scientific knowledge which is the unity of two meaningful elements: knowledge of ignorance and anticipation of the possibility of scientific discovery. A problem is a reflection of a problem situation, which objectively arises in the development of society as a contradiction between knowledge of people's needs in any effective practical and theoretical actions and ignorance of ways, means, tools for implementation of these actions.

Strictly speaking, a problem situation is clearly understood discrepancy between objective reality and its ideal description and explanation in scientific theory. A problem is a subjective form of expression of the need for the development of knowledge, which reflects the contradiction between knowledge and reality or the contradiction in cognition itself; it is both a means and a method of finding new knowledge. A problem statement is a transition from the sphere of what has already been studied to the sphere of what is yet to be studied.

A hypothesis is a form and means of scientific knowledge, with the help of which one of the possible solutions to a problem is formed, the truth of which has not yet been established and proven. The hypothesis is a form of development of scientific knowledge, a means of transition from the unknown to the known, from ignorance to knowledge, from incomplete, inaccurate knowledge to a more complete, accurate one. In methodology, the term "hypothesis" is used in two meanings: as a form of existence of knowledge that is characterized as problematic, probable, and as a method of formation and substantiation of explanatory proposals, which leads to the establishment of laws, principles, theories.

A concept is a form and means of scientific knowledge, which is a way of understanding, explaining, interpreting the basic idea of the theory, it is a scientifically substantiated and mostly proven expression of the main content of the theory, but, unlike the theory, it cannot be embodied in a coherent logical system of exact scientific concepts.

Control questions

1. Formulate a psychophysical problem. What are the key questions of the methodology of science that arise from it?
2. What is the problem of demarcation?
3. Is it possible to say that scientific knowledge differs from other forms of knowledge by the possibility of experimental verification? Why?
4. What are the procedures for verification and falsification of scientific knowledge? What is the difference?
5. What are protocol judgements?
6. What is the definition of trivial judgements? How do you understand the statement: "This judgement does not make scientific sense"?
7. Specify the attributes of scientific knowledge and its advantage in comparison with other forms of knowledge.
8. Specify general scientific methods at the empirical and theoretical levels of scientific knowledge.
9. Identify the basic attributes of scientific knowledge itself and explain their content.
10. Identify the basic formal types of scientific knowledge and give their characteristics in the fields of natural, socio-economic, technical and humanitarian disciplines.

6. Epistemology

In the previous section, attention was focused on the first problem of the logic of science − the problem of demarcation, i.e. the nature and specificity of the organization of scientific knowledge. This section will consider the mechanism of generation, determination of its (knowledge) reliability and validity (i.e. "truth" in the sense as this term is interpreted in epistemology) and integration of scientific knowledge − on the problem of verification and its derivatives.

6.1. The problem of truth and its criteria in epistemology. Ways of solutions

The concept of truth is a central problem of epistemology. The Slavic word *істина* – "truth" comes from the ancient Slavic *ість* which means true, real. That is, in etymologically, truth is being, that is, what is. Undoubtedly, we do not know everything what there it is, but only what is open to us and our cognition. Such non-unhiddenness is indicated by the etymology of the word "truth" in the ancient Greek language (*aleteya* – truth, non-unhiddenness). Unhidden (being) is intuitively accepted as given, without further questions, i.e. as something that is obvious. This is what R. Descartes exceeded from in his "Meditations on Method" and later became the basis of the phenomenological philosophy of the twentieth century. Thus, the founder of phenomenology E. Husserl points out that since we cannot go beyond our consciousness, no truth as a reflection of the outside world can be established. Because everything we consider external is only our feelings that can be neither obvious nor authentic.

Truth, according to Husserl, is obviousness, and the obviousness is that what rests only on itself and not on anything external to itself [6]. Feelings, facts, images cannot be obvious, because they are not self-sufficient. Only the so-called eidoi are obvious, i.e. unanalyzed entities, through which the phenomena of consciousness (i.e. feelings, images, facts) are built. Examples of eidos are formality, plurality, aspects of space and time, the position of logic and mathematics, and so on. That is, what is obvious, regardless of empirical reality, cannot be different. For example, the mathematical statement that 2 × 2 = 4 is obvious and eidetic, because it does not raise further questions, and also because of the impossibility to imagine that, for example, 2 × 2 = 5. The English poet Alexander Pope wrote of this: "Why, oh gods, in this world should be twice two four?" [2]. In principle, you can ask similar questions, but there will be no answers. The fact that 2 × 2 = 4 is the limit beyond which our intuition and the ability of the creative imagination cannot penetrate; that is, it is the limit of our ability to know, reason, justify. We can assume the existence of some other frame of reference in which 2 × 2 will no longer be equal to 4 (just as the axiom that parallel lines never intersect was once considered self-evident but was rejected by non-Euclidean geometries). But this will be a completely different system of ideas with their own positions and evidence.

Scientific knowledge is defined as knowledge that reflects reality. *Truth in this case can be defined as knowledge that corresponds to reality.* This is the so-called *classical* or *correspondent* conception of truth. It is one of the oldest and most common. For us, modern people, the representatives of mainly scientific culture, it seems the most natural and obvious, because what can be more obvious than the fact that truth is knowledge that corresponds to reality. However, in reality not everything is so simple: the type and method of correspondence are not always as obvious as it may seem to first glance. Truth always depends on the theoretical framework and is *contextual*. At the household level, this is illustrated by a phrase such as "St. Petersburg is in the United States", the truth of which depends on what kind of St. Petersburg we are talking about. Finally, the corresponding truth is always relative and partial. It gives only a kind of model of external reality. Absolute truth (i.e., the non-hiddenness of the being or reality itself) plays the role of an asymptote to which the relative truth is directed in its classical interpretation. Based on all this, as well as some other points, we can identify the main problems of the classical (correspondent) concept of truth.

The problem of the nature of reality being cognized [2]. *It is that we are not dealing with the outside world, but with our perception of this world*. In principle, we cannot go beyond our perception and say what is there. For the first time in a consistent form, this was formulated by I. Kant, who separated phenomena (that is, what we perceive) from things in themselves (that is, things as themselves, how they are on their own). Kant firmly believed in the existence of such things in themselves, but J. Fichte, and later the neo-Kantians denied the doctrine of things in themselves, focusing on the phenomenology of the subject of knowledge. That is, the problem of reality being cognized is what is behind our perceptions and theoretical constructions, and whether there is anything behind them at all (or, as stated in the philosophy of Advaita Vedanta, God is the only reality devoid of its constituent parts), while the rest is Maya, i.e. the illusion that is subject to the law of karma. Modern Western thinking does not reach such depths, because it is considered impossible to bring anything to the surface. What is perceived is recognized to be the border of reality, and the problem of reality, which is known, turns into a problem of theoretical reality, that is, what is behind scientific theories. An illustration of the latter can be, for example, the fact that a hydrogen atom has only one proton.

The problem of the nature of the correspondence between knowledge and reality *is that our language is not always just a copy of external reality: often the nature of compliance is greatly complicated by intermediate concepts, formulas, equations.* For example, why and how do Pauli matrices, wave function, value added, etc. correspond? Why and how do multidimensional spaces of linear algebra or irrational numbers correspond? What and how do ordinary real numbers correspond? Some of the questions are easy to answer, others may not be possible at all, because these objects play an instrumental rather than a reflective role.

The problem of the criterion of truth *is that substantiation of the truth of any knowledge requires a certain criterion, and since such a criterion is also some knowledge, it needs a second criterion, its own truth, this second criterion requires a third one, the third one requires the fourth criterion, etc., theoretically to infinity*. That is, the problem is the infinite regression of criteria. For example, the criterion for the truth that the university has two buildings may be a proposal to calculate yourself. The criterion that everything will be taken into account can be the relevant documents, for which the criterion will be the presence of certain seals. Then you can put the problem of the authenticity of seals, etc., to infinity. In fact, of course, everything is a little different − the endless regress is interrupted in some place, which is simply taken for granted. In some cases, self-evidence does take place, in others everything is simply taken for granted.

The problem of paradoxes is the already mentioned paradox of the deceiver, which arises when trying to determine the truth/falsity of a phrase like "I'm telling a lie". If we consider this phrase to be true, then it turns out that I am really telling a lie, and the phrase is false. If you consider it wrong, then it turns out that I'm telling the truth, and the phrase becomes true.

Another version of the same paradox is a phrase of the type "The village barber shaves all the men in the village, except those who shave themselves". The question is who shaves the barber himself. If he shaves himself, then, as follows from the expression, he should not shave himself, but if someone else does it for him, then this other must be himself. These and similar paradoxes occur due to the mixing of different language levels. In the first case, it is a mixture of the meaning of the phrase and its referent: they coincide, and the meaning of the phrase rotates on its own. In the second case, it is a mixing into one common class of those who shave and those who are shaved. In mathematics, the paradoxes of set theory are analogous to these paradoxes. To prevent all these paradoxes, it was proposed to build language in such a way that such phenomena be prohibited.

This is possible due to a so-called **semantic concept of truth**. It boils down to the following definition: "P" is true if and only if it is indeed P (or otherwise − the expression "white snow" is true if and only if the snow is really white) [46, p. 76]. That is, the statement is true if it really reflects the current state of affairs. The difference from the classical concept is the prohibition of turning the meaning of a statement into the statement itself. This difference follows from the above definition, which immediately draws a clear distinction between the object language (which includes P, which is on the left in quotation marks) and the meta-language (P on the right without quotation marks). The first part of the statement is connected with the second by means of a semantic connection (the word "true") and a criterion in truth ("if and only if"). The semantic concept is a purely logical move that prohibits statements that lead to paradoxes, and also immediately introduces a formal criterion of truth, which removes (formally) the problem of infinite regression of criteria. It also in practice reflects the impossibility of closed semantic constructions, replacing it with a hierarchy of "language + metalanguage".

The advantages of the semantic concept over the classical one are purely formal and belong to the sphere of logic of science rather than to the theory of cognition. For example, there is an object language O, in which statements are made about some objects. We speak about the truth of these statements in the M1 metalanguage, about the truth of the statements in M1 in another M2 metalanguage, about the statements in M2 in the M3 metalanguage, and so on, to infinity. That is, instead of the problem of infinite regression of truth criteria, we obtain an infinite hierarchy of languages and metalanguages. A very pertinent question arises which of these metalanguages can speak of the hierarchy itself. That is, as H. Putnam points out, the solution to the paradox becomes an even deeper paradox. It is also interesting to note the quantum mechanical analogy of this problem in the concept of the plurality of worlds of Everett, Graham, and Wheeler. If there is a plurality of worlds, then within which of them should an observer be in order to objectively examine this plurality? Two such concepts of truth try (each in its own way), first of all to solve the problem of the criterion of truth. It is a coherent and pragmatic concept.

The coherent concept of truth *reduces the problem of the truth of knowledge to the problem of its coherence, i.e. consistency and non-contradiction*. In general*, two variants of this concept are possible*. One of them retains the classical understanding of truth as the correspondence between knowledge and reality, considering consistency only as a criterion of conformity. Another considers coherence self-sufficient. In both cases, only a coherent and consistent knowledge can be true. The second interpretation of the coherent concept works well in logic and mathematics. The former can be applied in the empirical sciences if the composition of coherent and consistent knowledge is widened to include knowledge of empirical facts. Truth in this case is a system that connects all empirical facts. For example, there is statistical and so-called phenomenological thermodynamics. The former is a theoretical model of thermodynamic phenomena described by the latter. Both can be considered true if they are fully consistent with each other as well as with other systems of knowledge. It is often the case that a coherent system of knowledge that was considered true is eventually rejected. The conclusion that follows from this is that in order for a coherent system to be true and self-sufficient in its coherent truth, it must contain knowledge of absolutely all phenomena and events in the universe. Otherwise, it can claim only partial and temporary truth. As for the possibility of applying this system in mathematics, as noted earlier, according to one of the Gödel's theorems, if the formal mathematical system is consistent, it is incomplete, and vice versa. That is, the possibility of applying a coherent concept of truth, even in the first case, and only to formal systems, is limited.

The pragmatic concept of truth *replaces the conformity of knowledge to reality with the conformity of knowledge to the "final criterion"* [46, p. 78]. "Final criterion" means the purpose for which knowledge is intended. That is, in simple words − truth is the knowledge that leads to the achievement of the goal. If the goal is to match theoretical and empirical results, then we can say that the theory will be true if it allows you to make successful predictions. However, the question arises as to what to do when different incompatible theories meet the same goal. Should both of them be considered true in this case? The founder of pragmatism, Charles Pierce, answered this question as follows. The truth must be unique and objective. Such a single and objective truth is the stable belief to which competent researchers would inevitably lead a research process that would be conducted indefinitely. That is, again, the absolute truth is the knowledge of all phenomena and events in the universe. As for the systems that lead to the achievement of one group of results, they can only claim the role of temporary and partial truths. That is, here we can come to a problem similar to that which arises when considering a coherent concept of truth.

However, Peirce's follower, W. James, did not demand the unity of truth. According to his ideas, the world itself, that is, absolute, objective, independent of us and our views and efforts, the universe, simply does not exist. The world exists only with us, that is, in the unity of the objective and the subjective. And because our views and efforts are very diverse, the universe is also pluralistic. However, science does not share this view and tries to find more and more new truths that are still closer to the external reality, ruthlessly rejecting the old ones. A question arises as to what are all these temporal and relative truths for science, that they are unconditionally acknowledged today, and equally unconditionally rejected tomorrow. The answer to this question is given by such varieties of the pragmatist concept as *instrumentalism* and *conceptual pragmatism*, *which believe that scientific concepts and theories are only tools or instruments for successful resolution of cognitively stressful situations, or simply tools for cognitive development of reality* [2].

Absolute truth in instrumentalism becomes a universal instrument, and since such is impossible, there is no absolute truth (or at least it is unattainable). Any knowledge makes sense only within a particular context, determined by the conditions and challenges facing the researcher.

The difference between instrumentalism and conceptual pragmatism is that the former refers to the instruments of our cognition as both concepts and theories, while the latter refers only to theories and, accordingly, applies pragmatic criteria only to them. Conceptual pragmatism is a refinement and improvement of the approaches of instrumentalism, since most concepts are still closer to images than to tools. A tool provides for a rational (conscious) application, while the use of most concepts is not rational, but historically determined. Therefore, priority should be given to conceptual pragmatism as a more sophisticated and developed form.

As noted by B. Russell [15, p. 652], the Marxist conception of truth is close to instrumentalism, according to which truth is knowledge that corresponds to reality (classical approach), but not just in the form of passive reflection, but as a result of active interaction between object and subject, the criterion of which is practice. That is, man creates truth in the process of practical development of the external world. It is this selection of practice as the main criterion of truth that allows us to consider the Marxist concept as a kind of instrumentalist one. The peculiarity of the Marxist concept is the postulate of the priority of matter. Accordingly, it can be argued that truth in Marxist philosophy = instrumentalism (practice) + conformity (materialism).

Classical (correspondent), coherent and pragmatic concepts are the basic concepts of scientific truth. None of them exhausts the whole concept of truth completely. Taking this into consideration, two approaches are possible. The first is that truth is simply what is considered true. This is the so-called **conventional concept of truth** (from the word *convention* − agreement), according to which truth is the result of an agreement. In many cases, this is true. However, even if certain agreements are present in scientific knowledge, they are not completely arbitrary, and they cannot be considered the only sources of acceptance of certain theories or provisions. Conventionality is not always declared, after all. These or those provisions can be accepted by tacit agreement, because something seems most satisfactory or obvious to everyone (or at least to the majority). This brings the conventional concept closer to those religious conceptions of truth according to which truth is what I believe in. Yes, the phrase "I believe because it is absurd" has long been popular in Christian theology. That is, individual faith is above any argument. The already mentioned W. James believed that the objective meaning of faith is justified by its usefulness (i.e. pragmatic criterion), and also noted that "depending on our faith, God himself may become more alive and real". Similarly, in some esoteric concepts, it is believed that the gods, for example, are real and powerful, but created by humans themselves. That is, our thought forms are able to generate an equivalent reality, and we ourselves are also the product of thought forms.

In general, if we abstract from specific meaningful forms, we can say that faith is a necessary element of any knowledge. Any verification, obviousness, etc. sooner or later reaches its limit, that is, to elements that we can only simply accept or not accept. As M. Polanyi points out, *we must realize that the last basis of our beliefs is our own convictions.* The second approach is based on the fact that despite the presence of certain convention points, scientific truth is still something objective and greater than what these concepts can present. Scientific truth just is, and its criterion is the so-called epistemological criterion, which includes these concepts of truth in the role of individual aspects or criteria of their own adequacy. This second approach seems more acceptable than the first one, as well as the rest of the others, because it is the most complete and allows you to consider all *the others as individual cases.*

6.2. The practice of scientific research as a transition from empirical (scientific facts) to scientific theory. Natural sciences

The difference between the science of the Modern Age, i.e. science in the modern sense of the word, is that it turned its attention directly to the facts. The facts, as noted in the previous paragraph, are "loaded" with theory and do not exist in nature in its pure and finished form. That is, the facts must be "created", selected from a wide continual panorama of reality. It is necessary to choose not all, but the most essential and typical facts. They must then be properly described and interpreted. All this, as already mentioned, is impossible to do without theory. The question that arises in this regard is the question of the relationship and interaction of theory and facts. Modern science, unlike ancient or medieval science, has really learned to "create" facts. The methods of this "creation" were:

- *observation* – purposeful perception of the object of research, which allows the researcher to identify its most significant properties and connections;
- *experiment* – a method of research, which consists in the active influence on the studied phenomena and conditions of processes [3].

For the first time experimental methods in European science were tried in the thirteenth century by Roger Bacon, but at that time these ideas did not find a wide response. Therefore, the "official" founder of *empiricism* (*the approach according to which the only source of knowledge is sensory* *experience and all knowledge is substantiated by experience and through experience*) is the English philosopher of the 17th century Francis Bacon. However, he limited himself to the qualitative side of empirical methods, ignoring quantitative approaches. The result was Bacon's complete failure in the field of proper natural science. Apart from making no more or less significant discoveries in science, he also missed all the significant discoveries of his time. Being personally acquainted with Dr. W. Harvey, who discovered blood circulation, he did not even hear anything about this discovery. Harvey himself said of Bacon that "he wrote philosophy as Lord Chancellor" [46, p. 81], i.e. as a dilettante.

Other innovations were quantitative and quantitative-qualitative approaches instead of speculative-qualitative approaches of scholasticism or ancient philosophy. Quantitative approaches are thought to have been first used and propagated by the Pythagoreans. However, only in modern times, combined with experimental methods, these approaches really gave a qualitative leap in the development of human civilization. Science in the modern sense arises through a combination of empirical and quantitative approaches. This combination was first made by J. Kepler. He was a Pythagorean and believed that God created the universe on the principle of a celestial machine, which, like all machines, functions according to mathematical laws [3]. These approaches were later developed by Galileo.

Effective application of quantitative methods is possible only with the appropriate presentation of system parameters. That is, the parameters of the system must be clearly identified and outlined against the background of chaotic reality. It is also necessary to determine the possibilities of error and methods of neutralization of error. An effective quantitative-qualitative experiment is the result of many previous operations. The most important of these are abstraction and idealization. Abstraction (Latin *abstractio* – separation) *is the process of separating some properties and relationships from others, which are considered in this context as secondary insignificant*. In fact, abstraction is an essential element of research at the stage of defining concepts. Any scientific concept is not a direct reflection of something in the outside world. It is the result of comparing many similar objects and discarding everything uncharacteristic in favor of the invariant (immutable).

For example, in the course of economic research there is an abstraction from certain properties and relations. This is done not because they are not insignificant, but in order to simplify the situation and study the processes in a "pure" form. For example, studying the relationship between supply and demand of goods in the market economy, it is necessary at first to analyze the simplest, elementary relationship between quantity and price of goods that can be observed in the market. This ratio is expressed in inverse proportion − the lower the price, the more people buy the product (and vice versa). Obviously, this rejects a number of additional factors that affect demand and complicate the overall picture. Demand may depend on the income of the population, the ability to replace some goods with others, tax policy, the impact of monopolies on prices and so on. Demand can neither be analyzed without taking into account the peculiarities of supply, which, in turn, depends on production. All this complicates the picture even more at the level of microeconomics. When we move to the level of macroeconomics, we have to abstract from many of these and other points. For example, instead of analyzing supply and demand in individual markets, they analyze aggregate supply and demand, indicators of domestic product and national income, and so on. From this we can conclude that *abstraction* is one of the most important elements of economic research, in which the economic process or system as a whole is divided into constituent elements, parts or subsystems.

In general, in economic research there are two stages: *analytical* and *synthetic*. The first involves the division of the economic system into such subsystems as production, exchange, consumption, distribution with their subsequent division into even smaller (and therefore abstract) elements. Then, in order to reflect the economic process as a whole, move on to the second stage. It is on it that the reproduction of concrete holistic knowledge in a single system of abstract economic theories is achieved.

Idealization is a mental process of creating ideal objects by changing the properties of real objects in the process of boundary transition. Through idealization, such objects as the ideal gas, the material point, the rule of law, various economic models (classical, monetary, Keynesian models, etc.) emerge. The above-mentioned law of the ratio of supply and demand can also be considered as one of the examples of idealization, as this dependence in strict form is possible only in a completely abstract system, the subjects of which are deprived of any group or individual properties.

Abstraction and idealization are the primary theoretical operations that "load" already known facts with theory and make it possible to search for other facts. As for the search itself, as noted, its main tool is experiment. However, experiment is not always possible. There are cases, groups of cases or even entire areas of research or science, in which it is impossible to directly influence the studied phenomena, change the direction of the phenomenon, and so on. An example is economics, in which conducting experiments in the classical sense of the word is either completely impossible, or impractical or very limited. Examples include history, political science, or natural sciences such as cosmology and astronomy, individual sections of quantum physics or particle physics, and so on. In these fields, the usual experiment is replaced by the so-called mental experiment, computational experiment, various modeling methods, and so on. The basis of all these methods is *modeling* (French *modele* – sample, prototype), *that is reproduction of the characteristics of an object on another object, specially created for their study. This second object is called a model*.

Models are different: material, mathematical, conceptual, and so on. In a broad sense, the model can be understood as any representation (including abstraction or idealization). Conceptual ideas are a representation (often hypothetical) of some unknown phenomenon or group of phenomena with the help of already known provisions. Examples of such models are the planetary model of the atom, various models of the atomic nucleus, various historical theories that present certain events using their own conceptual schemes, economic models, and so on. Mathematical model is a special case of conceptual model, in which the role of theoretical concepts is played by certain computational (mathematical) methods. Material models are material objects, some properties of which coincide with the corresponding properties of the studied objects. For example, in order to finally find out the characteristics of the developed mechanism, its simplified model is made, the corresponding characteristics of which are the same as its own.

Models are widely used in experiments. In particular, the use of a conceptual model in an experiment means a so-called mental experiment, and the use of a mathematical model means a so-called computational one. Classic examples of a mental experiment are the mental experiments of A. Einstein with a falling elevator, or the mental experiment of Einstein, Podolsky and Rosen. Examples of computational experiments are any case of mathematical or computer modeling in the field of economics, sociology, biology, medicine and so on. Mental and computational experiments are widely used in economics, because the specifics of these sciences almost do not allow the use of other methods.

6.2.1. The hypothetical-deductive method of creating a scientific theory. The possibilities and limits of application of scientific theory

Going a bit back, we recall once again that all these methods on the one hand serve to build a theory, on the other hand, because they are factual, and the facts are always "loaded" with theory, are possible only with the help and through theory. Thus, we return to the question of the connection between facts and theory. Which came first, fact or theory? In light of what has been said, this question sounds almost rhetorical, almost like the question "what came first, the chicken or the egg?". There are different points of view on this issue. Thus, the mentioned founder of empiricism F. Bacon gave unambiguous priority to facts, considering theory only as a generalization of facts. He put forward the inductive method as opposed to the deductive one, which was widely used in scholasticism. As is known, there are two types of induction: induction through complete and induction through incomplete enumeration of the studied cases.

Regarding the latter, a classic example is given. A clerk, re-registering the population in a village, went around most of the houses and found that Williams lived in all these houses. He decided not to go to the rest of the houses, because in his opinion, some Williams lived probably there as well. However, it turned out that he was wrong − Jones lived in one of the houses. This anecdote demonstrates that induction due to incomplete enumeration does not give any reliable results, and therefore cannot be considered scientific. As for induction through complete enumeration, it does not give anything new, that is, it is useless.

The conclusion that follows is that simple induction itself is not a scientific method. In science, it can be used only in combination with other additional provisions or assumptions, for example, together with the postulate of causality. In the nineteenth century, John Stuart Mill tried to create an inductive logic that would not be inferior in its rigor to the deductive. He singled out six basic principles of such logic. This is the principle of single difference, exclusion, single similarity, single residue, accompanying changes and a combined method of similarity and difference. However, even all these principles do not provide the credibility inherent in deductive logic. That is, inductive methods in science, even if they exist, play a subordinate or secondary role, moreover, mainly in the humanities.

In modern natural science pure induction is not used. More acceptable is the so-called *hypothetical-deductive method*, *which consists in deriving deductive conclusions of hypotheses* [2]. According to this method, it is the hypothesis, i.e. the proto-theory rather than the meticulous collection of individual facts that is the basis for constructing the theory.

Hypotheses can be born from inductive generalizations or as ways of formulating a problem. Further, from these hypotheses the consequences which are subject to empirical check are deduced.

6.2.2. Scientific theory. Classification, components and logical structure

The basis of almost any scientific knowledge is scientific theory. *Theory is a system of generalized abstract knowledge, which differs from the existing concepts, laws, hypotheses* [2, p. 22]. In science, theory is the most adequate form of scientific knowledge, a system of reliable, deep and specific knowledge about reality, which has a coherent logical structure and gives a holistic, synthetic idea of the laws and essential characteristics of the object. Theory, in contrast to the hypothesis, is reliable knowledge, the truth of which is proven and verified in practice. It gives true knowledge and explanation of a certain area of objective reality, provides understanding of its general, necessary, essential, internal regular properties and connections. Theory differs from hypothesis by a positive certainty of its truth, reliable knowledge. Theory differs from other types of reliable knowledge by its exact logical organization and its objective content, and, accordingly, by its cognitive functions.

Theories are classified according to the same principles as the corresponding sciences. *Theories are humanitarian and natural, while natural, in turn, are divided into experimental (substantive) and logical-mathematical (formal)*. The latter do not necessarily have to be natural, there are just formal − mathematical and logical theories.

The main elements of *logical and mathematical theories* are ascending concepts, axioms, theorems, systems of proofs and computational tools. Ascending concepts include the concepts of number, set, measure, mathematical operations, various mathematical spaces, and so on. Axioms are the main connecting element of mathematical theory, and theorems are secondary positions formed on the basis of axioms and ascending concepts.

What is the essence of axioms? We can assume that they are self-evident positions. For the most part, at least in the historical context, it is so.

However, the case is not always limited to the obvious. Thus, the central axiom of Euclidean geometry about the non-intersection of two parallel lines seems almost the most obvious. But in Lobachevsky's geometry and Riemannian geometries this axiom is rejected. That is, the obvious, if any, is considered secondary or rejected altogether. Thus, axioms should be considered as a kind of definition, from which the construction of the theory begins. Logical and mathematical theories are not meaningful, they say nothing about the outside world. Accordingly, the criterion of scientificity cannot be the possibility of empirical verification, and the criterion of truth − compliance with external reality. The vast majority of mathematical theories were created without any regard for this reality. Empiricism is not popular in mathematics or philosophy of mathematics. There is even a widespread opinion among mathematicians that one of the main advantages of mathematical theory is the lack of practical use of it. Non-Euclidean geometries or group theory at the time of their origin fully satisfied this criterion. However, everything flows, everything changes. Those theories that once seemed absolutely unnecessary are used in certain substantive sciences. So, without non-Euclidean geometries and group theory, it is impossible to imagine modern physics.

If the obvious is conditional and doubtful, and the practical benefit is a sign of a bad tone, then there remains only one criterion of acceptability in mathematics, which is the absence of internal contradictions in mathematical theory. That is, a mathematical object exists, and a theory is considered true if they can be thought of without contradictions. However, this is also not always possible. When contradictions cannot be avoided, as, for example, in set theory, the theory cannot be considered plural. B. Russell believed that they arise because of the inversion of the plural on itself, just as in the well-known paradox of the deceiver, the meaning of the phrase "I am telling a lie" revolves around itself. If this is true, then "I" is really telling a lie, and it is not true. If this is not true, then it is true. Russell proposed to eliminate (exclude) such inversions, and then you can overcome all the existing paradoxes, and then derive all the mathematics from the laws of logic. Three volumes written in conjunction with A. Whitehead "Principia matematica" ("Fundamentals of Mathematics") were devoted to this program. However, this work ended in failure, because the conclusion required the introduction of a number of additional axioms, which are not among the laws of logic. This is how *logicism, a philosophical and methodological direction that tried to substantiate mathematics on the basis of logic itself, failed.* Another program of substantiation of mathematics also failed, the so-called *formalism, which connected this substantiation with the substantiation of internal coherence and consistency*. To do this, mathematical theory must first be fully formalized, i.e. written in axiomatic form using logical symbols. However, as it turned out later, a formal justification of the consistency is impossible even after that. In 1931, K. Gödel proved the theorem according to which, if a system, which includes arithmetic, is consistent, it is incomplete (i.e. its consistency cannot be proved within its own limits). Thus, there is only a third direction of substantiation of mathematics, the so-called *intuitionism, the ascending position of which is the belief that some objects of mathematics, as well as related operations are certainly clear and obvious in all respects, and actions with them will never lead to contradictions.*

A mathematical object exists if it is given intuitively or can be constructed using intuitive operations on intuitive objects. However, even intuitionism does not always work. In particular, it is difficult to determine the degree of intuitive clarity of such a mathematical construction as sets, as well as all related operations and provisions of set theory. In fact, the controversy over the nature of sets has revived medieval debates about the nature of universals, moving it to the plane of mathematics. Do sets (modern mathematical analogue of universals) have the status of real ones, or are they just the names of sets of single objects, which alone are real? Proponents of the first point of view are called realists, supporters of the second are nominalists. Elements of research (substantive) theories are ascending concepts, hypotheses, postulates, fundamental principles and individual laws. The ascending concepts of the research sciences, in contrast to the logical and mathematical ones, no longer reflect some abstractions, but something more tangible and concrete. It is assumed that behind them are real objects, their properties and relations of external reality, so the presence of consistency, even if it is, cannot be a sufficient criterion of acceptability. The concepts of research sciences are defined by semantic, ostensive and operational definitions.

Semantic definitions are *definitions in terms of content, through other concepts.* Since it is assumed that the concepts of the research sciences are some elements of external reality, the semantic definitions alone may not be sufficient − we need some connection with such reality, access to it [20].

Ostensive definitions are *definitions made by simple showing of the object being defined.* Ostensive definitions are the first definitions that man began to use. In fact, they are the identities that form the basis of mythical thinking. We can mention the pebble culture and the theory of the origin of language from the primary "mythical" identification of some objects with phenomena or events from the life of primitive man. This is based on primary ostensive definitions. However, in modern sciences, ostensive definitions are rare. The fact is that the objects with which modern science works are too abstract for such definitions. In fact, modern sciences use the ostensive basis of everyday language, building on the basis of its ostensive definitions their own semantic.

Operational definitions are aligned with the scientific term of the operations required for its introduction. Thus, the concept of length is introduced through the operation of measuring length, the concept of weight − through the operation of weighing, etc.

Definitions of more complex concepts are built semantically on the basis of existing operational definitions. However, there are two problems. The first one is that the same scientific concept can be operationally introduced in different ways. There are quite a number of ways to determine the values of length, energy, momentum, and so on. Does this mean that there are the same number of relevant definitions? The founder of operationalism, P. Bridgman, was a supporter of a positive answer. However, such scattering is incompatible with science itself, which recognizes the existence of only one, identical for all relevant cases and methods of measuring concept of length, energy, speed, and so on. The problem is not removed by a simple postulation, because there are cases when the equivalence of differently defined concepts is not obvious or absent (as in the case of the concept of energy, its physical and mental varieties). The second problem is the problem of so-called "pencil on paper" operations, i.e. defining concepts using formulas or diagrams. And since such a task can be considered a kind of semantic definitions, the question is whether it is legitimate to consider semantic definitions as a kind of operational. If you answer in the affirmative way, it will only exacerbate the first problem.

In addition to concepts, the constituent elements of scientific knowledge are laws and principles. According to the "Stanford Encyclopedia of

Philosophy" [48], the law is a connection that is characterized by the main features of an essential relationship: universality, necessity, repetition, stability. The general formalized form of this statement is stated as follows: (x) (Px ⊃ Qx), i.e. if an object x has the feature P then it has also the property Q.

Science also uses the concept of regularity – it is the result of an ordered multiple interaction of phenomena, processes and objects of reality. For the philosophy of science, the division of laws according to the degree of their generality is of fundamental importance. According to this criterion, laws are divided into partial (specific), general and universal. The task of any theory is to discover the laws that describe a certain class of phenomena. It is interesting to note that the words "internal essential and stable connection" (i.e., in other words, "essence") precede the words "ordered change", which express the external manifestation of the law in the material world. However, in reality, often the opposite happens. The phenomenon that is repeated, i.e. "ordered change", lays the foundation for ideas about the essence – "internal essential and stable connection". However, in European science, since its appearance, there is a tendency to deduction, i.e. the derivation of a separate from the general, orderly repetition − from the inner essence. The role of such a general ascending principle is usually principles, i.e. the most general laws. The "Stanford Encyclopedia of Philosophy" defines principle (Latin principum − basis, origin) as the beginning, the guiding idea, the basic rule of conduct. Laws are derived or at least confirmed experimentally. Does this apply to principles? Do they precede and depend on any experiment? H. Poincaré wrote in this regard: "Principles are agreements and hidden definitions. However, they were derived from experimental laws; the latter were, so to say, reduced to the rank of principles to which our mind attaches absolute importance" [39]. Principles together with postulates occupy the same place as axioms in logical and mathematical sciences. Postulates are the ascending principles of theory; in some cases they are both ascending principles. In others words, they are simply intermediate provisions, such as ad hoc hypotheses, aimed at saving or further developing existing theories. Not all principles are postulates (at least in explicit form).

A special place in scientific theories is occupied by hypotheses or assumptions. They are guidelines for scientific research, indicating the directions of theory. Hypotheses are like a primary theoretical grid that attacks reality. Without them, it is impossible to start research and build a theory.

I. Newton said: "Hypotheses non fingo" ("I do not put forward any hypotheses"); however, he was wrong. Certain assumptions (hypotheses) in his works were and could not but be. At least take the hypotheses about absolute space and time, the immutability of some force present in nature (where the laws of conservation of energy and momentum originate), and others. Pure empiricism is impossible. If someone goes to a quarry and starts counting the number of stones of one color or another, then, having no hypotheses, no matter how much he counts, he will not derive any theory. This can be confirmed by the scientific failures of the founder of European empiricism, F. Bacon, which will be discussed in more detail in the next paragraph. As for Newton's remark, it should be understood in the sense that he did not put forward hypotheses that could not be tested, and which were present in large numbers in the works of his contemporaries.

Experimental theory or hypothesis, in contrast to the logical-mathematical one, is not closed to itself, but speaks of something external. Therefore, the criterion for their acceptability is compliance with external reality, which is determined primarily by their compliance with the facts. The word "fact" as translated from Latin means "what is done, what happened". An objective fact is some phenomenon, event, fragment of reality. Scientific fact supposes regularly recurring events, phenomena, objects, etc., about which there are indisputable data. In fact, we receive from the world a set of stimuli that create for us a picture of reality, largely due to the socio-biological foundation on which our consciousness and culture developed.

Friedrich Schiller has the aphorism "Love and Hunger rule the world". If we add power to this, we really get three motives, the combinations of which exhaust all the variety of plots of fiction. Our worldview and outlook, ways of knowing the world from the beginning were limited (channeled) by the fact that mankind, as a biological species, is a set of individuals that reproduce sexually and receive basic information about the world through sight and hearing, organisms with heterotrophic type nutrition, herd lifestyle and a developed system of social hierarchy, the position of the individual in which is not determined solely by his genotypic characteristics. To a lesser extent, they are determined by the so-called social inheritance (cultural transmission) − those features that are passed on to us through education and training, parents, teachers, people around us. The influence of culture on the peculiarities of perception of the world and attitude to it has already been discussed in the first paragraphs of this section. Each particular researcher does not deal at all with atoms, genes or molecules, the rate of return, rent or similar objects. In fact, he observes certain colored spots in the microscope eyepiece, the oscillations of the recorder, the numbers that change on the calculator screen. Every scientific fact has an integral theoretical and sociocultural load. Thus, scientists first of all face the task of isolating certain elements from the holistic flow of impressions that come to their consciousness from the outside, − this is the task of identifying and creating scientific facts. Thus, the facts we are talking about are always "loaded with theory". In order to find the relevant fact (predict it), you need a hypothesis that would "load" its theory; the theory is tested through its conformity or inconsistency with the facts.

6.2.3. Verification and falsification of scientific hypotheses as a way to establish their reliability and validity

There exist two types of checking hypotheses: verification and falsification. Verification consists in empirical confirmation, and falsification consists in empirical refutation of a theory or other position.

Direct verification means direct comparison of a hypothesis or theory with the facts predicted by it. Indirect verification is comparison of a new hypothesis with existing fundamental scientific theories.

For example, the assumption that the increase in the number of dark butterflies is due to the direct effect of the environment on hereditary factors (genes) of color contradicts the fundamental laws of genetics and evolutionary theory, which are widely used by man in his practice. Therefore, such a hypothesis can be rejected, even if it cannot be refuted by direct experimental verification. Similarly, most "scientific" explanations of paranormal (telepathy, telekinesis, spiritualism, etc.) phenomena are based on postulates that contradict the fundamental laws of science, first of all, the law of conservation of mass and energy. Therefore, if and only if indisputable evidence is obtained that these phenomena really exist and cannot be explained without the involvement of "otherworldly" factors, i.e. on the basis of obvious, logically not contradictory system of already known laws of nature, such assumptions will be considered by science as acceptable.

Thus, the main difference between scientific knowledge and any other concept (philosophical, religious, ideological, etc.), contrary to popular belief about its absolute reliability, irrefutability, is that scientific theory in principle can always be refuted (falsified or forged) as a result of obtaining new facts.

A logically consistent philosophical doctrine (for example, about the primacy of creation or matter) cannot be experimentally refuted. However, the existence or non-existence of God is not a scientific problem, because it is impossible to imagine an experiment that would refute either of these two assumptions. Therefore, it makes no sense to look for a scientific justification for religious dogmas − the refuted scientific theory will be replaced by a new one, the idea of God will still be replaced by nothing. Religion and atheism are based on faith, not the results of scientific research.

As you can see, the process includes the development of a scientific hypothesis, testing its validity and integration into existing systematic scientific knowledge. New knowledge must not only agree with the facts and foretell the existence of new ones, but must not enter into obvious logical contradictions with already known scientific theories. In other words, new scientific knowledge must logically follow from a more general theory.

Therefore, ideally, scientific knowledge forms a hierarchical system of principles and laws that are logically derived from each other. Karl Popper was a supporter of the hypothetical-deductive method and falsification. He believed that falsification had a clear advantage over verification because, in contrast, it was final. Confirmation is always temporary, only in the existing context and in the existing sphere of known facts. The number of facts is constantly growing, respectively, there is always the possibility of refuting the already confirmed hypothesis. Therefore, a real scientist should try not to confirm, but to refute the hypothesis, and only if it fails, it temporarily receives the right to life (until someone else can refute it). However, as will be shown in one of the following sections, neither verification nor falsification can give definitive one hundred percent guarantees [2].

A type of falsification that is widely used can be considered the method of proof to the contrary. That is, an assumption is made that contradicts the original hypothesis, its falsity is proved, and this is considered a proof of this hypothesis. Such a method is widespread in mathematics, where it is really possible to model situations "either this or that". In the empirical sciences, the method of reductio ad absurdum, i.e. bringing to absurdity, to nonsense, is more often used.

6.2.4. Theoretical models and schemes for generating scientific hypotheses. Abduction and extrapolation

In the course of scientific research, usually not any, but only well-founded hypotheses are put forward. Hypotheses can be based either on the available theoretical basis, or on the basis of available empirical facts, their generalization. If a hypothesis is put forward on the basis of existing knowledge, then we talk about the extrapolation (transfer) of this knowledge to new, not yet studied areas.

The general scheme of extrapolation is shown in Fig. 6.1, and the general scheme of abduction is given in Fig. 6.2.

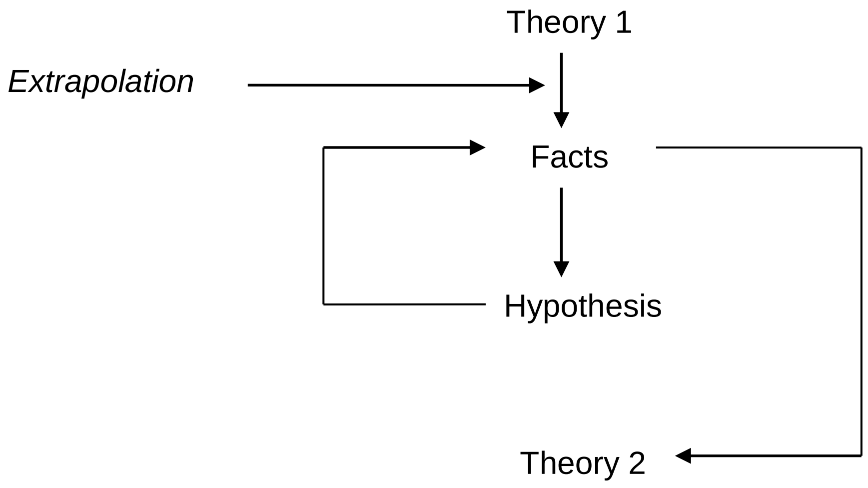

Fig. 6.1. **A general scheme of extrapolation**

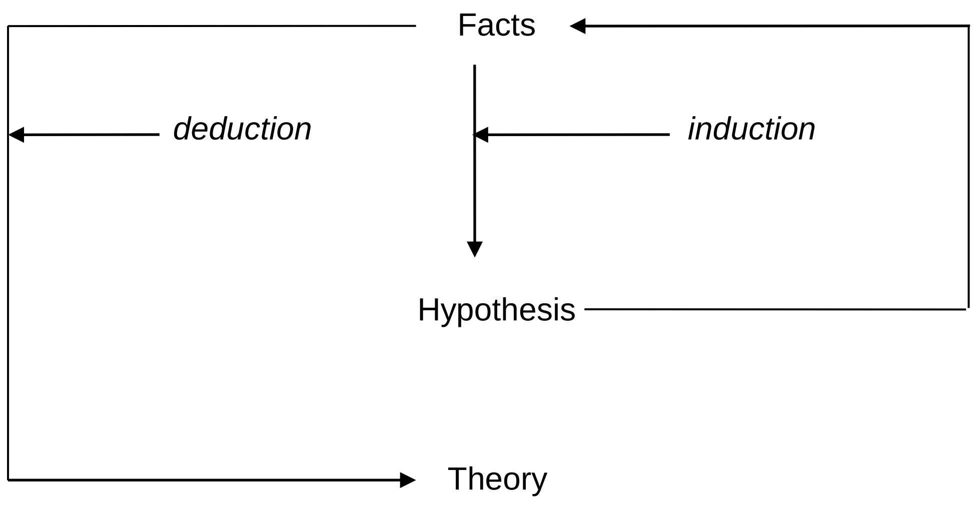

Fig. 6.2. **A general scheme of abduction**

If a hypothesis is, in one way or another, related to the facts themselves, then talk about the so-called abduction. Abduction is an analysis performed on the basis of information that describes relevant facts and leads to a hypothesis that explains these facts.

An example of abduction is the discovery of Mendel's laws of heredity. As the English mathematician R. Fischer showed, the notion that Gregor Mendel formulated the basic principles of genetics by simply inducing his own experimental data probably does not correspond to reality. It is a much more plausible assumption that even before the beginning of his research, as a result of analyzing the data of other researchers, he formulated the initial working hypothesis on the basis of deduction. The following experiments, apparently, are set for its final proof. Otherwise, it would be difficult to explain why, of all the variety of hereditary traits in Mendel's experiments, only those were used that most closely corresponded to the laws of heredity he later formulated.

According to many researchers, abduction is the most adequate method of scientific knowledge. Abduction moves in the direction of facts – hypothesis − facts and combines both induction (transition from facts to hypothesis) and deduction (transition from hypothesis to facts). Most of the scientific discoveries and theories in various fields of knowledge were made by the abductive method.

6.3. The practice of scientific research in the humanities. Hermeneutics and structuralism

Scientific theories do not occupy a leading place in all sciences. There are sciences (history, ethnography) in which a simple description of facts is dominant, and theories occupy an auxiliary, peripheral place. What then can claim the role of method in such sciences? One such contender is hermeneutics (exegesis), or the art of interpretation. The main provisions of hermeneutics were elaborated in Stoic and Peripatetic philosophy. However, in ancient Greece, hermeneutics had too narrow scope to be further developed. In the nineteenth century, the situation changed somewhat as it became clear that natural methods were unsuitable in the humanities.

In order to comprehend the meaning of a work of art, to evaluate it, to understand what taste means in art or life, what is genius, fashion, tragic and comic, logic, mathematical methods and empirical approaches are not enough. In order to understand a work of art, it is necessary to get used to it, to feel the thoughts and feelings that it is designed to convey. That is, one must learn to feel what their creator felt, or at least the one who "understands" them. This may require knowledge of the language in which the literary work is written, knowledge of the era and its customs, ideas and aspirations, knowledge of the aesthetic categories of the era and a lot of such things. And thus, to solve all these aesthetic problems in essence they turn to hermeneutics, developed in ancient times, the art of interpretation.

The field of application of hermeneutics is not limited to one art, it can also be extended to such humanities as history, psychoanalysis, linguistics, etc. Thus, according to F. Schleiermacher, "history is something like a great dark book written in the languages of the past collective work of the human spirit, the text of which must be understood" [5]. Later, this topic was developed by L. Ranke, W. Dilthey and others. Natural causality is not rejected, it only acquires a subordinate status. It is a mechanism by which something else is realized. What exactly is the issue that hermeneutics has to understand. History, spirit, thinking is the flow of life, which manifests itself in the form of the individual. In order to understand it, you need to keep in view both part and whole.

At the same time, if we try to start with one thing, we will fall into a logical circle. Because in order to truly understand a part, you need to know the whole; understanding the whole is impossible without understanding the part. With regard to history, this means, for example, that we cannot understand geopolitical tendencies without knowing individual historical tendencies or events, and we will not be able to understand these individual tendencies and events without understanding general geopolitical tendencies [9]. Or we cannot know a person's character without knowing his actions, and we cannot understand his actions without knowing his character. This is the so-called hermeneutic circle. In fact, we are always moving in this circle, and the obstacle to understanding is not insurmountable. It is overcome by the same implantation, the specific methods of which are given by hermeneutics. "Understanding is always self-movement in such a circle, due to which it is important to return from the whole to the parts and vice versa" [5]. It is achieved not at once, but is a repeated process of passing through the hermeneutic circle.

Moving in a hermeneutic circle, the researcher constantly draws into consideration the facts not previously taken into account, and as a result receives new knowledge, thanks to which he discovers new facts (Fig. 6.3).

In the twentieth century, the role of hermeneutics is primarily determined by the following areas: 1) understanding of other worldviews and cultures; 2) understanding of the conscious and unconscious; 3) understanding of natural, cultural, symbolic and other languages. It has been said enough about the first branch, we can only add that in the twentieth century a number of new sciences (for example, medieval studies) and areas of research that are almost entirely based on hermeneutics have emerged.

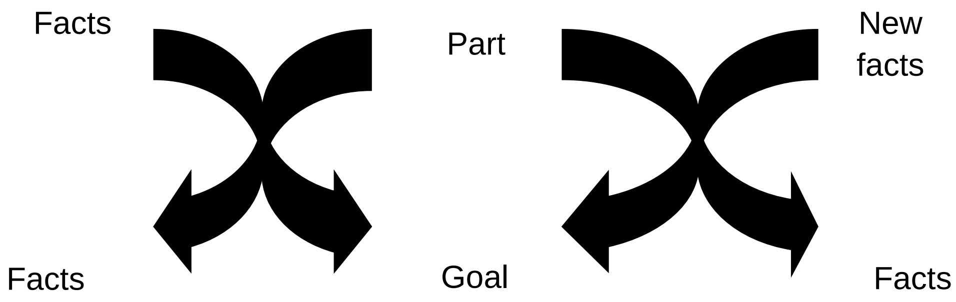

Fig. 6.3. **A general scheme of the hermeneutic circle**

Another interesting aspect of hermeneutics is the understanding of the subconscious, which is carried out with the help of psychoanalytic interpretations. The task of psychoanalytic practice is to find out exactly what experiences are hidden behind external mental manifestations, such as phobias, psychological complexes, dreams and fantasies. What is behind them, the instinct of pleasure, as Freud said, or the thirst for power, as Adler taught? And is it possible to answer this question at all? Often the same cases can be explained on the basis of both Freudian and Adler's conceptions, which indicates their fundamental non-falsification and metaphysicality. These concepts play the role of a framework within which interpretation is carried out. The whole (i.e. the general position that determines the nature of the subconscious in the relevant concept) is extremely abstract, which must be reconciled with the specific (specific mental states). Understanding of specific states is impossible without understanding the general principle, understanding of the general principle is impossible without knowing individual mental states.

Another example is legal hermeneutics, when a particular empirical case must be brought under the general legal law. Understanding the abstract law requires precedents, i.e. examples, for the classification of which an abstract law is required. Understanding is achieved during the movement of hermeneutic circles, this movement is a psychoanalytic or legal practice.

A similar situation is in the field of linguistics. Language consists of words that function according to structural rules. What determines the rules? What is behind them? Behind them is what the ancient Greeks called the "logos", which only later came to mean a doctrine or a set of rules. Initially, logos was understood as a kind of literal (unstructured language) reality. Everything we can know and think is within language. Logos is beyond this framework. The first Greek philosophers understood logos as a pure, holistic being, comprehended not logically but intuitively through holistic comprehension. For Thomas Aquinas logos was the word of God, which by its perfection is one and indivisible, while human words by their imperfection are multiple. One is determined by another, although the word of God is decisive.

In the modern interpretation, the place of logos is occupied by some universal rules ("natural grammar"), which are not only decisive for individual grammars, but also the laws by which the human unconscious functions. They can be deduced by means of hermeneutics, moving in the corresponding hermeneutic circle. Universal or natural grammar sets the rules for the functioning of language, thinking, the subconscious, the unconscious, and so on. According to some opinions, these rules are the most universal aspect of reality. They are engaged in a philosophical trend called structuralism.

The emergence of structuralism is usually associated with the name of the Swiss linguist F. de Saussure, who in his "Course of General Linguistics" published in 1916 showed the operation of the internal mechanisms of language as a sign system. Similar work was carried out by Chomsky, Trubetsky, Jacobson, and others. Their efforts laid the foundations of structural linguistics and phonology (the science of speech sounds), based on the so-called structural method, which consisted in the transition from concrete-semantic interpretations to abstract-theoretical structures. *Structure doesn't mean only the structure of an object, the combination of its parts and elements, accessible to observation, but also the set of hidden relations that are manifested by the "force of abstraction" in the course of movement from* *phenomenon to essence. Thus, there is an abstraction from concrete features of elements of this or that system*. These elements take into account only the "relational" properties, i.e. properties that depend on the position of the elements in the system and their relationship with other elements [2].

Later, the structural method was applied by K. Levi-Strauss in the study of the system of family and marriage relations, totems, rituals and myths of the primitive tribes of Brazil. Levi-Strauss tried to identify a priori (preceding experience) forms of functioning of thinking. He called them unconscious structures or structures of the unconscious (which in general should be distinguished from the subconscious of psychoanalysts). It is nothing but a hidden mechanism of sign systems. The words of human language or any other symbols with the help of which thinking is carried out can act as signs. Unconscious structures are an external form within which the process of thinking takes place. They are called unconscious because they are not realized in the process of daily work of consciousness. Thus, a person who speaks his native language quite normally and uses the necessary grammatical rules in his language may consciously not even guess about their existence. Moreover, primitive man living in their environment does not know about the unconscious mechanisms of myths.

The structural method allows us to move from superficial semantic connections and rules to hidden patterns, which Levi-Strauss considered to be universal structures of human intelligence that have a universal character. And since we cannot think of anything beyond our possible thought, cognition, according to Levi-Strauss, consists in the "selection of true aspects", that is, those which coincide with unconscious structures. Some other structuralists simply point out that unconscious structures are both structures of thought and structures of the external world. Examples of unconscious structures are the already mentioned grammatical structures, which, according to Levi-Strauss and some other anthropologists and linguists, are the most direct manifestation of the structures underlying consciousness. In this connection, the so-called "natural grammar" is often spoken of, the imperfect imprints of which are the grammars of existing natural and artificial languages.

However, it was not possible to reconstruct such a grammar. Now most researchers deny its existence. Another example of such structures is the rules of logic or mathematics, supplemented by the mechanisms of association and recognition. One of the main components of unconscious structures are the so-called binary (double) oppositions, such as: top − bottom, right − left, subject − object, material − ideal, truth − error, I − you, yes − no, good – bad, etc. Triple oppositions are also possible: right − in the middle − left, true − false − indefinite, I − you − he, earth − sky − sea; quadrangular: north − south − west − east, left − right − top − bottom, etc. At the heart of all of them are binary oppositions, the concentrated expression of which is yes − no or one − the other. Thinking and perception are impossible without such oppositions, which once found its mystical reflection in the philosophy of Neoplatonism, the founder of which Plotinus wrote that everything is based on the One, or God, who, overflowing by itself, generates the Other, or the World Mind, which, in turn, gives birth to the world soul, the Universe, etc. Currently, structural methods are used mainly in culturology, linguistics, anthropology.

6.4. Specifics of socio-economic cognition

Economy is a set of relations of production, distribution and exchange, material and spiritual goods in a limited amount of material, energy and intellectual resources of their production.

Relationships between people in the production process are formed depending on historical, social, political, cultural and other factors. In the concept of relations one should abstract from those material processes that serve as their basis, their functional essence is important.

The relations between people in the process of production and exchange are in this case more important than the properties of the substrate of which these goods consist. Abstracting from the real qualities inherent in the product, economists came to the concept of the *market*, the essence of which is a system of production relations, focused on obtaining the maximum possible profit.

But on the other hand, the transformation of a material object into a means of making a profit is associated with the interests and needs of people. Market does not only contain business individuals, but also multidimensional individuals, whose life does not only consist in the implementation of certain economic actions, but also in connection with other areas of human life. The behavior of economic entities is carried out in a certain socio-cultural and geopolitical space and is directed to the latter.

Economic life is studied by various economic sciences, which belong to humanities. The most important of these is general economic theory. It studies social relations in the field of production, distribution, exchange and consumption of goods, economic activity and relations arising in its process.

Philosophy of economics is a discipline that considers ontological, epistemological and methodological aspects of economics. Or in short, it is a philosophical doctrine of economic reality. It also considers economic approaches and specific economic tools. Based on philosophical categories and principles, it reveals the essential aspects of economic phenomena and processes. The philosophical approach to economic life involves the coverage of fundamental trends and patterns of relations between man and nature, as well as man with another person in the process of labor. In contrast to economic theory, which analyzes specific forms of economic relations and structural elements of economics, the philosophy of economics focuses on understanding the general, universal laws of economic life. Its focus is on fundamental issues of the nature of the economy, human behavior in the economic sphere, trends in the formation of material living conditions of man and society as a whole.

Thus, the relationship between socioeconomic sciences and philosophy has praxeological (activity) and epistemological (cognitive) aspects, which are the subject of philosophy of economics as an activity and philosophy of economics as a science.

First of all, the anthropological approach is key in the philosophy of economics. According to this approach, it is the person with his needs and interests, that is the determining factor in the determination of socio-economic activity. That is, man is the driving force of social life and the subject of economic activity. Economic human behavior is not uniform in nature and motivation. A person's economic expectations and orientations are largely determined by his or her affiliation with various social, demographic, or professional communities. The principle of philosophical anthropologism allows researchers to reveal the essence of the concept of socially oriented economy, to understand the mechanism of economic socialization, the formation of social types of personality, acting in the field of production, exchange, distribution and consumption. Experience shows that ignoring the value approach in economic policy in one way or another may bring severe socio-economic consequences. Most often such violations occur under a totalitarian regime. An example is collectivization in the USSR.

Thus, philosophical anthropologism cannot fail to take into account the concept of "value". The doctrine of values is called *axiology*. The central problem of axiology is the problem of good. What is good (in the economic sense in the first place)? In the English philosophy of the eighteenth and nineteenth centuries, the utilitarian view was widespread according to which the good is reduced to practical utility. However, along with practical "goods" the consumer goods, which means any things (material or ideal) used by man should also be distinguished. The philosophical approach is aimed at identifying people's attitudes to consumer goods and values. That is, it is about the ability of people to appreciate a variety of benefits and prefer certain of them. It should be noted that the nature of people's orientations determines the social activity of people, or vice versa − their passivity and consumption.

One of the central problems of axiology is the question of "to have or to be". With regard to the economy, this question grows into a question of property, the role of property relations in economic and social life and their impact on the individual. It has been established that the acquisition of property can cause not only a favorable but also a negative, degrading effect on the individual, which generates corruption, ignoring the laws and moral norms. The problem that arises in this case (communication) is the problem of preventing these negative phenomena. On the other hand, property is one of the main prerequisites for economic development and, as the historical experience of the twentieth century has shown, the lack of private property leads to stagnation. It is believed that the very desire for material well-being and personal gain is the driving force of development. However, the scientific literature describes in some detail the historical periods in which the key role belonged to somewhat different value systems [35].

Thus, in particular, as M. Weber showed, Protestant norms (self-restraint, thrift, earthly asceticism, hard work) provided their supporters with material advantages in the times of early capitalism. However, moral and religious values are not the only factor in socio-economic development. Well-known sociologists and philosophers have also substantiated the role of socio-cultural, political, institutional and many other factors in the development process. For example, in Eastern countries, religious, political, and solidarity values play a key role in the process of socio-economic development. Thus, Indian society proceeds from the priority of the basic values of Hindu culture, such as non-violence (ahimsa), austerity, self-improvement. Thus, the essence of civilization is seen not in the increase of material needs and boons, as is the case in the West and especially in the United States, but in the spiritual purification of oneself. Thus, the path of economic development is seen in maximum prosperity while minimizing consumption.

After a long period of Maoist "cultural revolution" and socialism, modern China also follows the path of reviving Taoist-Confucian traditions. The revival of Confucian values (order, justice, respect, personal and social harmony) is seen as a necessary condition for China's further economic development. A high level of economic prosperity was achieved in postwar Japan. The Japanese "economic miracle" became possible in large part by a rethinking of national cultural traditions. The Japanese rejected the Western way of stimulating entrepreneurial activity by encouraging and cultivating individualism. According to the traditional Japanese worldview, a person has no value outside of society. Shinto guidelines on the unity of human with nature and on mutual trust and care for each other found expression in the Japanese corporate ethics with its cult of firm interests and professional preferences. If we add to this the influence of Zen Buddhism with its guidelines on perseverance, consistency and patience, we get exactly the set of value orientations, which, according to researchers, has become one of the main factors of economic growth.

In Muslim countries, the value system is based on postulates enshrined in the Qur'an and Sharia law. It is believed that strict adherence to these postulates is primary in the pursuit of material well-being. Religious and ethical priorities, such as zakat (tax on the benefit of the poor), the ban on obtaining bank capital, the Sharia order of inheritance of property, are interpreted as "pillars" of the Islamic socio-economic system that restrict private property and promote income redistribution. In contrast to the Western consumer statement and the question "what do I want?" the question "what does God want?" is set. This, according to researchers, is the strength of Muslim civilization, which allows it to challenge the industrial West.

The dominant form of life in the West, as most researchers point out, is organized selfishness. Spirituality is pushed to the margins of life, spiritual values lose their role and devalue. Values and traditions that do not combine with benefit and efficiency lose their meaning. That is, as noted by modern representatives of social philosophy, modern Western society is the highest manifestation of economism. Calculation, the relationship of purchase and sale penetrate from the sphere of material production to other spheres of life. In the scientific community, intellectual property is increasingly saturated with this atmosphere. The products of scientific activity (as well as art) are increasingly designed for immediate economic results. That is, there is a total commercialization of society. The main role in this process belongs to the media. They are becoming one of the most important social institutions, influencing all spheres of human activity. In most industrialized countries, the media is a private institution, as well as a sector of the economy that employs tens or even hundreds of thousands of people. The media in modern society is occupied, among other things, with advertising, the philosophy of which is based on the thesis "man is a machine of desire", i.e. a purely consumer philosophy, which very often instills pseudo-values, false consumer standards [17; 19].

Nevertheless, the concept of the media, the socio-psychological foundations of advertising are an integral part of the philosophy of economics. The place and role of marketing for a market economy and the philosophy of economics should also be noted. The word "marketing" or "market action" means in the classical sense, first of all, entrepreneurial activity associated with the promotion of goods and services from producer to consumer. Modern specialists interpret it in a broader sense as a philosophy of business, which determines the strategy and tactics of the enterprise in a competitive environment.

Today, the idea of post-industrial society is quite widespread in Western social philosophy. Its appearance is associated with high information technology, which appeared in the second half of the twentieth century. Production becomes extremely complex, and it no longer requires competition, but clear planning and information (knowledge of know-how). Ownership becomes a legal fiction, and profit is provided through the development of creative abilities of the employees rather than through their exploitation. Traditional manufacturing companies are transformed into so-called adaptive corporations, the resource of which is non-economic motivation. A special social system is being created, in which education and intelligence play a key role. Commodity-money relations are being replaced by technological relations. However, they are not characterized by an increase in spirituality and culture, but only by an increase in formal communication contacts. That is, in fact, the persecution of material values is replaced by the persecution of information and intellectual property products. The flowering of technological civilization contributes to the development of a special symbolic type of consumption. The formation of a global technological civilization is also associated with the transformation of technology and technology into absolute value.

Thus, the philosophy of economics is based on the recognition of the key role of man in the development and functioning of the economy. This is how it differs from the philosophy of science (in its classical form), because it tries to consider scientific knowledge objectively, i.e. in isolation from other spheres of human life. That is, the philosophy of economics in general is not a philosophy of science. However, it should be noted that one of the components of the philosophy of economics is methodology, which, being scientific in nature, is one of the varieties of methodology of science in general. Thus, if the philosophy of economics is not a philosophy of science (but only partially intersects with it), then the methodology of economic cognition is fully related to the methodology (and hence the philosophy) of science.

Thus, the methodology of socio-economic cognition involves a synthesis of methodologies of natural and humanitarian knowledge. Two approaches are necessary and complementary:

1) the study of internal problems of economic activity, which focuses on the knowledge of the volitional attitudes of the subjects of economic relations, and, consequently, is based on the methodology of humanities;

2) the study of external relations between the subjects of economic activity, which is determined by the essence of the subject that carries out economic activity and is objective in nature. Thus, the methodology of natural sciences is adequate in this area.

Everyday socio-economic cognitive activity consists of clarifying the objective conditions for the formation of economic relations, serving the material needs of people's lives.

The result of socio-economic cognition is a system of objective knowledge about the totality of economic relations in the form of logically consistently explicit concepts, laws, theories and principles of management.

6.4.1. The object and subject of socio-economic cognition. Objectives of economic research

The object of economic knowledge is the system of economic and production relations, the principles of functioning of the economic environment, the laws and trends of their development. The subject of socio-economic cognition includes the individual, social groups, classes, the state, society as a whole.

Socio-economic research involves the achievement of the following goals or their complex:

1) search for economic resources (goods, services, specialists, finance);

2) creation of new economic resources (tangible and intangible innovations);

3) development of ways of concentration of economic resources for the subsequent use in innovative projects;

4) development of ways to form a favorable market situation with the help of optimal configurations of available resources or new organizational solutions;

5) formation of a legal system of responsibility and protection of the results of economic activity;

6) development of ways of survival of economic structures in extreme conditions (risk management);

7) conservation and transmission of accumulated knowledge and technologies from generation to generation.

6.4.2. Stages of formation of socio-economic theory

The development of any socio-economic concept goes through the following stages of formation:

1) accumulation of primary scientific facts about market relations, their internal structures and external manifestations;

2) the emergence of abstract economic theories;

3) the creation of a general economic theory as a holistic system of knowledge about the development of specific processes and phenomena of the economy.

Thus, the general scheme of socio-economic cognition can be presented as follows: *facts − hypothesis (model) − theory.* Based on the facts, a hypothesis is developed, and then a concept (conceptual model) of economic phenomena or processes (the concept of the tax system, pricing, the concept of agrarian reform, etc.). At this stage, as a rule, there are several alternative, competing concepts. The choice of a particular of them is carried out under the influence of factors of socio-cultural and socio-political environment.

Socio-economic knowledge by the nature of its subject from the beginning was more in line with the concepts of non-classical and post-academic science (rationality). Economic behavior of subjects and the content of economic theories simultaneously do not reflect only objective factors (in this case, the category of interests is used), but also subjective values. It is values that form the goal of economic activity ("Why?"), while interests determine the conditions and means of achieving it ("How exactly? How?").

In a broad sense, values are interpreted by modern scientific methodology as any features of the subject's consciousness and objects that have normative significance for the subject. Thus, values act as predispositions (prerequisites) of cognition.

Regarding socio-economic and humanitarian scientific knowledge, values are divided into two groups:

a) general worldview values that are "encoded" by the cultural and historical context of science development;

b) cognitive-methodological values that provide the actual generation of new objective knowledge (ways of forming, selection, testing hypotheses, their integration into the system of theoretical knowledge).

Thus, the subject of socio-economic as well as humanitarian knowledge is not only objects together with methodology, their idealization and description during the creation of scientific theory, but value objects of research, that is objects and essence of which are integral to each other. By their nature, the products of their theoretical idealization can be called *"ethical-epistemological hybrids"* [27, p. 46]. This leads to significant changes in the means of verification or falsification of the theory, which significantly affect its reliability. In order for socioeconomic theory to pass the test of empirical falsification, it must meet:

- the content of objective-empirical reality;
- subjective-value sense (i.e. the attitude of the subject to the same reality).

Economic theory, which has entered the minds of people, is able to transform their psychology, mentality (way of thinking and perception of reality), to change the usual scale of values and system of concepts, to form a new system of needs. As a result, the speed and depth of the transformations of the economy predicted by theory are multiplied many times over. In other cases, theory is faced with strong resistance from the socio-cultural environment, with political opposition from social groups and social movements that prevent or block its implementation.

A specific example is the agrarian reform of P. A. Stolypin. Representing its rationality and economic efficiency of the proposed solutions, it provoked fierce resistance and rejection of most of society, both among landowners and peasants, both on the right and on the left side of the political spectrum. In the end, after the death of its author, Russia's development went against the predictions of P. A. Stolypin and ended in a political catastrophe in February − October 1917.

Thus, socio-economic cognition by virtue of its prognostic function determines the objective conditions for the development of the economy and society, is a prerequisite for their implementation. In other words, socio-economic theory acts as a self-fulfilling forecast. This can be illustrated by the following scheme (Fig. 6.4).

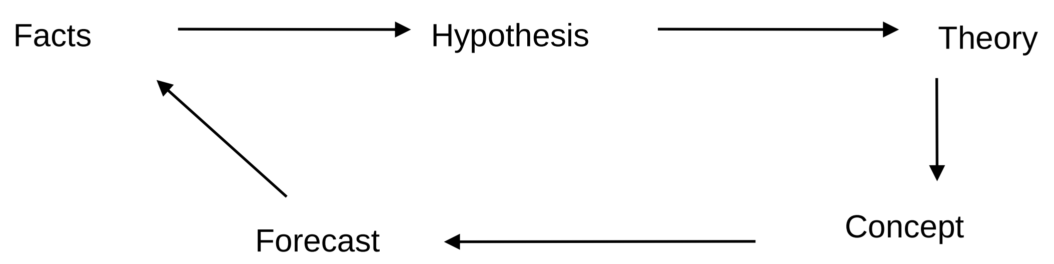

Fig. 6.4. **A general scheme of socio-economic theory as a self-fulfilling forecast**

It is the reverse effect of economic theory on the object of its study that makes a fundamental difference between natural and socio-economic forms of cognition.

6.4.3. Socio-economic knowledge as part of economic culture

The category of economic culture is usually used in one of two senses:

1) a set of professional knowledge, skills, norms of economic activity of values and symbols necessary to perform certain economic roles (entrepreneur, manager, consumer, etc.);

2) the system of values and incentives for economic activity of people.

Socio-economic knowledge performs the following social functions:

- regulatory − rationalized formation of norms and rules, according to which economic activity is carried out;
- innovative (prognostic) − development and evaluation of promising innovative projects;
- educational (translational) − the transfer of knowledge to new generations, ways of carrying out economic activities;
- selectional − selection from the available set of market values that correspond to trends in economic development.

6.4.4. Knowledge of management strategy

The epistemological situation in the risk society is changing. There is a new methodology of economic research, a number of principles that were absent in the socio-economic knowledge of the classical phase of science.

Social verifiability of scientific truth, the already mentioned parity of objective scientific knowledge and subjective "common sense" involved in the interpretation of reality are equal to each other. As a result, the principles of ethics that originated in medicine (the famous Hippocrate Code with all the following refinements and transformations) apply to all modern science and technology.

Teleology is scientific knowledge, which should initially serve to achieve the desired goal − to increase the chances of realization of the most desirable option for the future.

Manufacturability is a thematic and substantive structure of fundamental scientific theories, which in its foundations should contribute to the implementation of a specific technological scheme, the solution of a strategic technical problem.

Ethical orientation. In modern conditions, socio-economic knowledge provides a solution to three main problems:

1) cognitive − the acquisition of new knowledge;

2) economic − the development of new rationalist ways of transforming nature, society and man;

3) ethical − providing man and humanity with some guidelines that allow him to act in the name of creation rather than destruction.

Since the emergence of positivism in the philosophy of science, it has been considered an axiom that the first two of them are primary, while the third is derived from them. Harmonization in the research process of all three components is nowadays a fundamental basis for the preservation of high moral principles by the scientific community and individual scientists. Narrowly professional rationalism, which forced the researcher to treat the ethical aspects and results of his work as an annoying obstacle to the victory of new knowledge, can be a tragedy on a planetary scale.

Innovative orientation is the creation of new realities of life that meet the demands of society and individuals. Innovation already assumes in the future (predicted or spontaneous) bifurcation points that change the direction of socio-natural evolution and, consequently, strategic vectors, basic principles and goals of the knowledge management system.

Changes in methodology correlate with radical changes in socio-economic regulation and control, management and marketing. There is a transition from a science management system to a knowledge management system. The differences between them are fundamental − knowledge management implies internal control of scientific research. In other words, the value component becomes immanent to the content of scientific theory, and not just a criterion of socio-economic and political selection of research topics. The alienation of scientific knowledge (information) from its biosocial carrier (person) and its free circulation in information networks are replaced by the formation of a self-organizing socio-cultural context [9]. Such a context can be considered as a kind of collective memory, or rather − the collective mind of different levels of complexity. The latter determines the composition and content of a set of socially significant scientific concepts. Knowledge management becomes the most important function of state and political structures and, at the same time, the central principle of activity of market participants.

According to the results of sociological research in 2000 – 2002, at least 75 – 80 % of business firms in economically developed countries had a knowledge management system, in most cases (over 53 % of the companies taken into account) it was structured.

The integration of knowledge management systems in the management and marketing of individual firms allows the latter, in turn, to fit organically into the social structures of risk society, without conflicting with the currently dominant system of value priorities in society. The purely productive benefit is the coordination of innovation policy with the vectors of development of the mentality and worldview of modern humanity.

"Excess", i.e. not involved in existing or potentially possible technological schemes, knowledge is not a simple result of scientific and technological progress. By its very existence, this knowledge sets the direction of innovation, is a source of "permanent creative concern". Restoration and transformation of basic science in a risk society, in turn, stimulates the transformation of innovative economic activity into a system of self-renewal and self-programming. Thus, the organization of knowledge management contains two subsystems:

1) daily recognition, assessment and correction of risk situations, i.e. determining the implementation or impracticability of the conditions for the implementation of specific innovations, taking into account the consequences for the socio-ecological environment and human biosocial nature (tactical planning);

2) the choice of the optimal vector of the innovation process and its integration into the general course of the socio-biological evolution of mankind in order to increase the probability of actualization of the most desirable scenario of the future (strategic planning).

6.4.5. Modeling in socio-economic cognition

Modeling in socioeconomic research plays a particularly important role, because, as a rule, conducting experiments here is possible only on a very limited scale and only at the micro level. A feature of socio-economic models is the reflection of the behavior of economic entities depending on the type of economic activity and the functions they perform.

According to the specific purpose of socio-economic cognitive activity, as a rule, the following types of models are used (Table 6.1).

Table 6.1

Different types of socio-economic models

Type of model	The nature of the business entity
Investment model	Organization and implementation of investment projects, i.e. rational use of economic resources
Investment model	Organization and attraction of resources for the implementation of certain projects
Organizational model	Rationalization and optimization of the combination and integration of economic resources − human, financial, information, intellectual, etc. For example, production cycle schemes, tactical and strategic plans, payroll and planning systems, etc.
Activation model	Organization of control of research and development projects
Commercial model	Creation of new exchange channels that increase the rate of profit
Opportunity-game model	Ways to use confidential information to ensure the maximum possible economic effect
Consulting model	Development of forms and technologies of information support of different types of economic activity

Next, we will consider a specific example of the implementation of the methodology of socio-economic cognition − the study of consumer behavior, i.e. a series of interdependent actions carried out by individuals in a market environment. Each individual in the market space acts not only as a bearer of a certain economic function − the consumer − but as a multidimensional individual with its own cultural traditions, ethnic, psychological and other characteristics. For adequate modeling of their behavior, it is necessary to use an integrated approach, synthesis of methods of such areas of socio-economic and humanitarian knowledge as economic theory, marketing, psychology, culturology. This behavior is not always carried out only on a rational basis. A very important component of consumer behavior is the so-called symbolic consumption − not a material practical activity, where the product in addition to its own consumer value acts as a symbol, a sign of belonging to a certain social community.

On the other hand, the evolution of consumer behavior is largely defined as equivalent to specific indicators at the macro and micro levels. In turn, the transformation of behavioral modes affects market structure and macroeconomic indicators. For example, as the market formed in the post-

Soviet economic space, consumers initially stratified in terms of income into very rich and very poor. Accordingly, consumer behavior began to correspond to one of two behavioral modes − either the focus on extremely low prices, or very high ("prestigious"). In both cases, the quality of goods was not considered as a determining factor in demand. Accordingly, the market was dominated by boutiques and supermarkets on the one hand and inexpensive clothing markets on the other. As the "middle class" was formed, the criterion that determines consumer behavior was the optimal price/quality ratio. There are relatively inexpensive companies with fairly high quality products. At the third stage of market formation a brand − a trademark that has proven itself well − becomes a factor of demand.

6.5. Philosophy of engineering and technology

As can be seen from the first chapters, the philosophy of technology due to the specifics of its subject differs from the classical epistemological concepts based on the rigid demarcation of subject and object in the theory of knowledge, the worldview division of the existing world and the world proper to philosophical knowledge, and, as a consequence, the socio-political distinction between ethical and value (public) and professional research (descriptive) discourses.

In the technical and technological sciences, this is impossible, and in the organization of scientific knowledge from the very beginning there are elements of different nature − from ordinary to purely philosophical.

Probably, this feature of technical knowledge was intuitively felt by ancient culture, which was reflected in the division of two forms of knowledge: practically oriented (technical), which was considered the participation of "low" social strata and "high" theoretical knowledge, which was considered the participation of noble classes.

As a result of both these factors, as an independent discipline, the philosophy of technology emerged only in the last quarter of the 19th century (Ernst Kapp, "Elements of a Philosophy of Technology. On the Evolutionary History of Culture", 1877; Fred Bon, 1898). Kapp's views were shared by the French social philosopher Alfred Espinas. Both of them developed the concept of organ-projection, according to which technical devices (according to Kapp) and artifacts in general are nothing but projections on the objective reality of the organs of the human body, their continuation and mechanical imitation of their functions.

However, the Russian engineer-philosopher P. K. Engelmeyer should be considered its real founder. In 1898 he published an essay "Technical results of the 19th century", which, in 1912, was followed by his 4-volume "Philosophy of Technology", in which he consistently analyzed the general content of the subject and the main problems of philosophy of technology and the importance of technology in human life and human civilization, formulated the concept of "technicalism" (human creation of an artificial world as the basis of their own existence).

In general, the emergence of the philosophy of technology was due to a causal relationship with the evolution of the type of scientific rationality and the forerunner of its transition to the phase of post-neoclassical (post-academic science). In the *philosophy of technology two directions were formed*. The first − *technocratic* − is widespread among specialists in the field of natural and technical sciences, and it postulates an optimistic assessment of the prospects of modern technical development.

The second direction − *technocriticism* − dominates among the humanities and argues a critical attitude to the consequences of scientific and technological progress of modern civilization, expresses in some cases quite reasonable grounds to doubt the ability to solve emerging socio-humanitarian problems in this way.

In the modern sense, the subject of philosophy of technology is the understanding of the phenomenon of technology in general (1), its importance as a factor of social and cultural evolution (2), prospects for the evolution of sociocultural status of technology and its significance for the future as a cosmic phenomenon (3).

Attributes of technology and technical (engineering) activities are purposefulness and knowledge of the main means of achievement of the goal, designed in the form of a system of guidelines.

Like science, the content of engineering and technology categories is multidimensional. Their interpretation can be carried out in at least three aspects:

1) as a set of artifacts − artificially created by man (as opposed to spontaneously existing facts) in order to meet their own needs and interests of objects of reality and their coherently functioning technical systems;

2) as a technical activity for the creation of these devices, including all stages of this process (scientific study of objective capabilities, design and

construction, production and operation, development of individual elements of technical systems, systematic study of their system integration, design and operation);

3) as a systematized technical knowledge necessary for technical activities.

Obviously, the mutual causal relationship and interdependence of technology and science have gone through several stages of their formation (the driving force of this process was the rationalization of technical activities):

1) self-reproduction (teaching of new generations) of professional communities of craftsmen;

2) rationalization of technical activity as a result of penetration of elements of scientific knowledge into it;

3) general systematization and generalization of existing technical knowledge (the starting point was the creation of "Encyclopedia" in France of the 18th century, which combined knowledge accumulated that time from all branches of science and craft into a single system);

4) the emergence of a "symbiosis" of scientific methodology and techniques of creation and operation of technical devices and their systems, associated with the creation of scientific theories of technical devices, and, consequently, the emergence of a special field of research engineering [35].

The modern philosophy of technology can be divided into several areas, primarily sociological and anthropological. The basis for attribution to a particular direction is the basic principle according to which the origin of this phenomenon is considered.

Control questions

1. Does economics belong to the natural sciences or the humanities? Argue the answer.

2. What is the fundamental difference between natural and socio-economic form of cognition?

3. What is the result of socio-economic knowledge?

4. What are the stages of formation of the methodology of socio-economic cognition?

5. What is the object of socio-economic knowledge?

6. Who acts as a subject of socio-economic knowledge?

7. Formulate the main objectives of socio-economic knowledge.

8. What are the social functions of economic theory.

9. Name and describe the main stages of formation of the socio-economic concept.

10. What role does social and psychological context play in the implementation of the economic concept?

11. Why can economic theory play the role of a self-fulfilling forecast?

12. In what meanings is the category of economic culture used?

13. What determines the role of modeling in the construction of socio-economic theory?

14. Describe the main types of models used in socio-economic cognition. Determine the purpose of using them.

15. Give examples of specific use of the methodology of socio-economic cognition.

16. What are humanities and what are natural sciences? What is the difference between them?

17. Name the constituent elements of scientific knowledge, analyze their place and role in scientific knowledge.

18. What is scientific theory? What scientific theories do you know?

19. How are scientific concepts defined? What methods of definition are used in economics?

20. Analyze the place and role of hypotheses in science (in economics).

21. What is a fact? Are "naked" facts possible? Why?

22. What is an experiment? What types of experiment are used in economics?

23. What are the problems of induction? What are the possible ways to solve them?

24. What is a hypothetical-deductive method? What are its strengths and weaknesses compared to other methods?

25. What is an abduction? Give examples of abduction in economics.

26. What is modeling? Give examples of the use of models in economics.

27. What is verification and falsification? Does one of these methods have (if any) advantages over the other? Why?

28. What is hermeneutics? In what sciences are its methods used?

29. In which sciences does hermeneutics acquire ontological status?

30. What is structuralism? Are the methods of structuralism acceptable in economic sciences? Why?

31. What methods are used in modern economics?

7. Ontology of science

7.1. Dualistic interpretation of the category of science ontology

Ontology is the doctrine of being. Regarding the science it can be understood in different ways. This is, first, *the ontology of science itself as a type of activity, a system of knowledge and social institutions*. That is, here science itself is the object of one of the sections of knowledge. Secondly, *these are ontologies based on certain sciences*. As for ontology in the first sense, its subject is the existence of scientific knowledge and activity (we will not consider scientific social institutes here).

Knowledge is the property of consciousness, its content. The activity for the creation of knowledge is also the property of consciousness completely determined by it. That is, the existence of science is part of the existence of consciousness, one of its phenomena. Because of this, ontology should be considered in the framework of phenomenology, a direction of modern philosophy devoted to the phenomena of consciousness. One of the methodological foundations of phenomenology is that *we can never be beyond our consciousness*. No matter what we do, we always stay within those limits. That is, the problem of the external, the problem of objectivity disappears because the objective, also being within consciousness, is only a kind of the subjective. The founder of phenomenology, E. Husserl, defined phenomenology as an absolutely rational philosophy designed to restore the fallen rationality of Western thinking. If in such a case it is impossible to rely on empirical experience, then it remains only to look for what does not depend on such experience. These are the so-called *eide, or primordials, that is, elements that are in themselves self-obvious that are not reduced to anything else, do not depend on anything, are both material and ideal, objective and subjective and so on*. Examples of eide are the categories of number, form, color, part and whole, causality, transcendental self, and so on. That is, an eidos is what makes possible the phenomena of consciousness that embody the inner (and at the same time outer) universe. That is, in this sense, ontology is the doctrine of the existence of categories and their systems in science. Yes, if we take the category of being, then being can be defined as what is in itself, regardless of anything else. The only thing according to the Neoplatonists, which is somewhat vulgarized, can be defined as the whole universe in space and time as a whole. Everything that happens, all the phenomena of consciousness take place only in relation to this one, and not in themselves. It is erroneous to consider them separately from the whole.

For the first time in the history of European thought, this idea was put forward by Parmenides, who spoke of the world of eternal, perfect, unchanging, true being, and of the world of opinions that is changeable and untrue. Hence one step is towards conservation principles. That is, if there are any visible changes, it means that somewhere else there are opposite changes, designed to compensate for the first, because in fact in the world of the true, eternal, perfect being, nothing changes. The eidos of being gives rise to the eidos of invariance, which is complementary to variability. If something changes, then at the same time something in it must remain unchanged, invariant. It only remains to find out a specific form of this invariant (the form of the principle of conservation of energy, momentum, etc.). *In European science, the principles of preservation came from the medieval scholastic philosophy, according to which God created the world, and the world as a whole is unchanged, all changes are compensated by opposite changes.*

The ontology of science in this first sense can also be understood as a question of what science really is (the image and activity of depicting external to the researcher (psychophysical self) of the reality, model and modeling of such reality, something sui generis, etc.), it has ontological status. In the second sense, ontology is a complement consequence of science, that is, there is, for example, a formal scientific theory, which says something about external reality, but what exactly is not yet clear, that is, it still needs to be found.

There is an interpretation that complements theory, making it clear. This interpretation is ontology of this theory. The ontology of theory is also the sum of all the consequences and limit cases of theory. That is, ontology is a broad picture of reality that follows from this theory. For example, they talk about the Newtonian, Einsteinian, Friedmanian universes, the universe of Christianity or Buddhism. All these are relevant ontologies, i.e. broad panoramas based on relevant theories or teachings.

The key category of ontology in this sense is the scientific picture of the world. According to the generally accepted definition, the content of this category is a system of general scientific and theoretical principles and postulates about the fundamental laws of structure and development of objective reality, which evolves as science develops due to the specifics of the subject and methodology of certain areas of scientific knowledge. As mentioned above, the general scientific picture of the world is a set of private-scientific pictures of the world that are in the process of self-agreement.

Ontology in another sense should not be confused with metaphysics (the doctrine of what goes beyond physics, that is, beyond cognition in the ordinary sense). The ontology of science is always inextricably linked with science itself, follows from formal theory. Metaphysics is not based on any of the sciences, but is the science of all sciences. Positivists always tried to eliminate any metaphysics from science. However, this is completely impossible to do, because any science begins with explicit or implicit postulates and axioms that are not subject to the usual verification procedures adopted in science. They are the metaphysics that lays the foundations of science itself, acting in relation to it a kind of "science of science". Metaphysics as a separate science can be a science of such principles or a theory of cognition, as I. Kant substantiated in his "Critique of Pure Reason". Such metaphysics in many respects intersects or even coincides with ontology in the first sense of the word. The difference is mainly in the methods.

Despite all the variety of metaphysical and ontological concepts, there are two complementary principles, the interaction between which determines the general scientific picture of the world at any historical stage of its development.

According to the first – the "Copernican principle" – the attributes of reality and the laws of nature that reflect them are universal and therefore, purely statistically, there is a non-zero probability that, exept the Sun and Earth, there are other systems in the universe with identical conditions where biological life could arise. Giordano Bruno came to the latter conclusion for the first time, creatively generalizing the ideas of the heliocentric system of Copernicus and the pantheistic philosophical system of Nicolas of Cusa. This principle is basic for the methodology of scientific knowledge, its observance is an integral attribute of scientific knowledge.

The second, anthropic principle, formulated simultaneously by the American astrophysicists Robert Dick and Brandon Carter and the Soviet astronomer Gregory Idlis [28, p. 210–211], was based on the following observation.

The possibility of the emergence of human in the universe is due to a number of fundamental constants and parameters that characterize it – c (speed of light), e (electron charge), h (the Planck constant), H (the Hubble constant), γ (gravitational constant) and others, up to the average annual temperature on Earth, the features of the nervous system of primates. Deviation of each constant even by 0.01 of the size would make emergence of mind and its carrier, man, impossible, at least, in its present form. In other words, objective reality is arranged exactly as it is necessary for the emergence of human.

The anthropic principle is now formulated in various variants, the number of which reaches several tens. Yet most of them can be reduced to two – strong and weak anthropic principles.

The weak anthropic principle was best expressed by Stephen Hawking: "In a universe that is large or infinite, the conditions for the development of intelligent life will arise only in certain areas limited in time and space. Therefore, intelligent beings in these areas should not be surprised that in their universe conditions are just those that are necessary for their existence". In other words, the structure of the universe allows the emergence of biological life in it and the emergence of the being endowed with mind − human [21].

According to the so-called strong anthropic principle, reality must have properties that allow the development of intelligent life; not only universal constants are known in advance, but the development of a self-aware mind in the universe is inevitable.

7.2. The categories "causality" and "determinism" in the ontology of science

Usually, causality is defined as a necessary genetic connection of phenomena, in which one of them (cause) conditions another (consequence) [2]. Causal notions have become so familiar to us that we seldom think about what "conditioning" can really mean, what causality really is. In general, two approaches are possible here. One of them is *objective: it emphasizes the genetic, generative nature of causation. Another is subjective, formulated by D. Hume. It connects the idea of causality with the habit of observing two phenomena always together and in the appropriate sequence.* That is, there is no ontological basis, and we can talk about the ontology of causality only in the second sense, i.e. as a subjective category, dependent on a particular subject of knowledge, deprived of the status of natural necessity.

The first, objective or genetic approach, on the contrary, emphasizes the necessary nature of the process of generation of one phenomenon by another. How the generation occurs is not always clear, which allows for subjective interpretations of the generation itself; however, the process of generation is always present. Imagine that through a narrow door slit we see a cat passing by – first the head, then the tail. The tail is inextricably linked to the cat and its head, and always follows it. Approximately the same with the explanation of the nature of causation, which is a manifestation of the holistic nature of reality.

Causal relationships and explanations are sometimes contrasted with *teleological explanations, which assume that a phenomenon may be due not only to the cause but also to its purpose. That is, in order to understand something, you need to understand why it exists*. For example, a teleological explanation for a tiger's fangs and claws would be that it needs them to hunt and tear prey. Teleological explanations can also be considered a kind of causal ones, as Aristotle did, who distinguished four kinds of causes (material, formal, active and target). Modern natural science prefers current, formal and material reasons, teleological explanations can be used in biology, as well as in humanities (including psychology, economics, etc.). There are also internal and external types of causality. However, some, such as the modern philosopher of physics M. Bunge, believe that the internal states are not causes, but are simply antecedents of later states [3]. Finally, it should be noted that the category of causality is increasingly displaced from modern science, it is replaced by functional mathematical dependencies. The very reasons, the reflection of which are these dependencies, remain as if "behind the scenes". At the same time, the very use of functional dependencies in science becomes possible only due to the *principle of causality, which consists in the continuity of action between cause and effect and in the homogeneity of causes and effects (i.e. when the same causes give rise to the same consequences*).

The principle of causality is a postulate in the structure of scientific thinking that precedes any empirical generalization. As already mentioned, scientific induction is possible only in combination with the general inductive method with the principle of causality. There is an epistemic circle in this combination. It consists in the fact that the inductive method comes into force only in combination with the principle of causality, and the principle of causality cannot be justified other than through induction. This point testifies in favor of the postulatory nature of both causal relations and inductive generalizations. In general, as for the homogeneity of action between cause and effect, scientific thinking limits this homogeneity only to the sphere of action of forces and relations known to modern science, and continuity means continuity in space and time. Where it is not possible to trace at least potentially such continuity and homogeneity, the existence of causal relationships is denied by science. An example is the denial of the laws of karma by modern science. These laws, which by their nature are a special case of causal interactions, fall outside the scope of the conceptual apparatus of modern science and are therefore recognized as unfounded superstition.

However, it should be noted that the existing scientific paradigm can hardly be considered the ultimate truth. If we consider more closely at least the principle of causality, we can see that *each phenomenon is actually determined not by one but by a series of causes, which in turn generates a series of consequences*, as shown in Fig. 7.1.

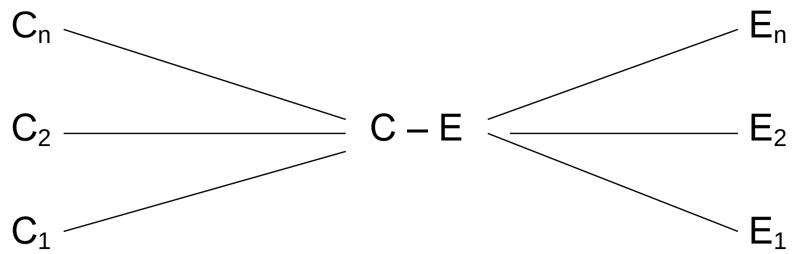

Fig. 7.1. **Causes and consequences**

That is, each phenomenon through chains of causation is associated with the rest of all other events in the universe, and if so, the series of causes and effects become infinite, and the selection of any finite sets of causes and effects is more or less conditional. As D. Bohm notes, every thing, every phenomenon make "their contribution to the universe as a whole, a contribution that cannot be reduced completely, absolutely and ideally to the actions of any set or sets of other interconnected things" [46, p. 122].

The causal mechanisms distinguished by modern science are one of such conditional sets that are sufficient and adequate in some cases and inadequate in others. Examples of this are many from different sciences. From the principle of causality (if we add the requirement of mandatory causality of each phenomenon) the principle of *determinism* or, more precisely, *causal determinism follows, which states the existence of a general, natural connection and causality of all phenomena*. In general, determinism does not have to be causal, it can also be structural, formal-logical, teleological and other types of determinism. Causation is simply the most common in philosophy. *The opposite point of view, which denies the existence of such a general natural connection and asserts the existence of spontaneity and free will, is called indeterminism.* In modern time, the ideas of determinism were grounded in classical Newtonian mechanics and brought to their logical conclusion in the so-called Laplace determinism, which formed the basis of the mechanistic worldview of the nineteenth century.

According to Laplace determinism, all processes in the world follow laws, which must eventually be reduced to the laws of classical mechanics. Because of this, knowing all the initial conditions at some point in time, we can calculate all the following and previous parameters of the system. Laplace, the founder of this kind of determinism, said that if there was a demon endowed with a sufficiently powerful intellect, which knew all the initial conditions at some point in time, he could calculate all the past and future in the universe. It is said that once, when Napoleon asked Laplace why there is no deity in his system, he replied: "Sir, I do not need this hypothesis". However, Laplace was a pragmatist and lived in a very troubled time, and probably because of this, as H. Yukawa writes, he also engaged in probability theory [2]. The latter can be used when knowledge of system parameters is incomplete or impossible. For example, when we toss a coin, the probability of one side falling out is 1/2. According to Laplace determinism, it is the result of our ignorance of all microscopic physical and physiological factors. If we knew them with the appropriate accuracy, we could predict the fall of one or another side with absolute probability. Probability in such an interpretation is subjective, i.e. it is a measure of our awareness, not an ontological property.

7.3. Substance, energy and information as components of the modern scientific picture of the developing world. Self-organizing systems

In modern science and modern philosophy of science, a different view of this problem has been established. According to it, probability is an objective ontological characteristic of certain states and systems. Putting it more precisely, in contrast to classical science, *objective reality has three* *rather than two basic attributes (forms): information is added to substance (matter in classical science) and energy, which thus acquires an objective meaning.*

Probability in mathematics *is simply a mathematical concept, defined as "a numerical characteristic of the degree of possibility of the occurrence of any relevant event in certain appropriate conditions that can be repeated an unlimited number of times"*. It is equal to the ratio of the number of cases of the relevant event to the total number of cases. This is the so-called classic operational method of determining probability. However, if you toss a coin a certain number of times, it turns out that the ratio of cases of falling of one or another side is actually slightly different from 1/2. It will be closer to this value, the greater the number of cases. 1/2 will only be when the number of cases is infinite, which makes this operational definition unusable. There is also another statistical operational definition of probability, where it is determined by the frequency of occurrence of an event, if the total number of cases is large enough.

The concept of probability is key in probability theory and statistical analysis, which are widely used in various fields of natural sciences and humanities. Probability reflects one of the general properties of large aggregates, but not individual objects. Therefore, for the general statistical distribution of results, it does not matter whether deterministic or indeterministic laws govern the behavior of individual objects. This allows the use of these methods in such dissimilar sciences as physics, biology, economics and more. As for the subjective aspects of the problem, it should be noted that there is an influence of subjective factors on objective phenomena and situations, and this influence is informative. It is usually called feedback. Feedback is not necessarily related to the influence of subjective factors, it can be quite objective material factors such as those used in cybernetics and electrical engineering, which are based on the operation of semiconductor and tube diodes, of any kind, fuses, etc. That is, when, for example, the voltage reaches a critical value, there is an automatic (based on the action of the voltage itself) disconnection or switching of the device. This is the so-called negative feedback – the simplest type of communication that operates on information principles.

Information (from the Latin *informatio* – explanation, exposition) is a set of some knowledge, one of the key concepts of cybernetics; the word "information" is related to the word "form".

Information is a fundamental component of the building material of the universe after matter or substance and is the same objective factor as they are.

The most adequate way to define the category of information as an attribute of objective reality is through surgery. Imagine two interdependent objects – S (source, transmitter) and R (receiver). Source S exists in several states, and each state Si of the source corresponds to the state Rj of the receiver with a certain probability P. In this case, the correspondence of Si-Rj cannot be unambiguously deduced from the properties of the medium connecting these two objects. Thus, knowing the state of the object S, it is possible with some probability to predict in what state the object R is. We can say that between these objects there is the transfer of information through the material environment that connects them (information channel). The rules of correspondence between Si-Rj states are information code (language). The amount of information (H) can be calculated by Shannon's formula:

$$H = -\Sigma P i \log_2 P_i. \quad (7.1)$$

It is due to the place of information in the modern scientific picture of the world that the calculation of all future and past states of the universe, based on the initial conditions at one point in time, is impossible, because it would contradict the second law of thermodynamics, according to which entropy of a closed system can only increase. In principle, it may decrease, but this is accompanied by the consumption of internal and external energy. The Laplace demon would need energy that in its order would be equal to all the energy of the universe. That is, it is impossible to calculate all the states of the deterministic universe, and if so, then determinism itself hangs in the air, turning into just a kind of hypothesis. The increase and maximum of entropy (chaoticity) means a uniform redistribution of matter throughout space and the disappearance of any structural features. That is, the law of increasing entropy means the thermal death of the universe.

This hypothesis was spread in the late nineteenth and early twentieth centuries, and was later rejected because, as it was recognized, our universe is not a closed system, and the second law of thermodynamics does not apply to it. In general, in our universe there are many phenomena that contradict the second law. These are all phenomena of evolution and self-organization in animate and inanimate nature.

Acceptance of the universe as an open nonequilibrium system opens a number of perspectives for the further development of science, in particular such its field as *synergetics or the science of nonequilibrium self-developing systems*. In general, cybernetics is also involved in the processes of self-organization and self-development. The difference between cybernetics and synergetics is that the former deals with stable and the latter with unstable (nonequilibrium) processes. Both are based on information processes. The non-equilibrium nature of the systems engaged in synergetics presupposes the possibility of not only negative (prohibitive) but also positive (such that it itself leads to some new results) feedback. It is the positive feedback that makes possible the processes of self-organization, evolution, and the emergence of new unpredictable properties that cannot be explained on the basis of classical probability theory. After all, it is really difficult to imagine that all the variety of forms of animate and inanimate nature arose spontaneously as a result of chaotic processes. It is like imagining that a sandstorm in the desert has created a modern aircraft with all the electronic and other technical equipment. That is, purely theoretically, this can be imagined, but the probability of this will be zero (according to the same second law of thermodynamics).

These contradictions are easily resolved within the synergetics. In it, in contrast to entropy, the concept of negentropy (measures of order) is introduced, which takes place in nonequilibrium systems. The expression of negentropy is information that does not obey the second law of thermodynamics. In an equilibrium system, all elements of this system seem to "sleep", being in equilibrium with each other. When (due to openness) the external action on the given system begins, and the balance is disturbed, these elements as if "wake up", becoming sensitive to external actions and influences. The system begins to behave as if each of its particles "knows" what the other is doing. As a result, correlations occur between the particles, and a coherent relationship is established. As a result, the structure of this system is formed and evolves in the direction of further complication and diversification. The system becomes unstable and can exist only due to the changing equilibrium with the environment. Variability leads to further evolution and structural complication. All general education systems fall under this general scheme: from systems of nonequilibrium thermodynamics to biocoenotic, social and other systems.

The development of consciousness, culture, economy, and civilization follows the laws of synergetics and is accompanied by an increase in negentropy, that is, structure and diversity. Thus, culture develops through increasing differentiation rather than unification, as depicted by some futurological predictions. The development and mutual enrichment (instead of merging) of national cultures, the differentiation of society according to lifestyle and preferences – all these are manifestations of self-organization, which takes place on synergetic principles. Socialist ideas have no basis, as they undermine and destroy the self-organizing foundations of human life. The inevitable consequence of introduction of these ideas is the regression and degradation of society, culture, civilization [40].

7.4. Scientific ontologies and scientific picture of the world

Each science establishes (explicitly or implicitly) its own ontology. Ontologies of different sciences can be with each other in a variety of relationships (complementarity, contradiction, neutrality, etc.). In general, since one of the founding principles of the Western scientific worldview is the postulate of a single objective reality, the scientific worldview shows a fairly clear line of orientation to create a common, common to all sciences (at least natural) ontology. For more than two centuries, such a general ontology was built on the basis of Newtonian mechanics, the so-called mechanism. It was believed that all processes in nature occur according to laws similar to the laws of classical mechanics. That is, the mechanistic ontology was fundamental to all the natural sciences. Attempts were made to bring humanities under this ontology as well. It was distinctly materialistic, based on the postulate of the material unity of the universe, Newton's hypothesis of absolute time and space, strict determinism, and so on.

Also, for a long time, classical mechanics was an ascending model for the construction of other areas of knowledge (it was believed that everything consists of atoms that move in absolute time and space according to mechanical laws). Later, the mechanism of this ontology was somewhat weakened, but on the whole the general principles remained the same for a long time. Various variants of materialism in both the natural sciences and the humanities can be considered derived from this ontology. The end of this ontology is associated with the emergence of two theories that rejected its principles in the early twentieth century. These are the theory of relativity (special and general) and quantum mechanics.

The first denied the absolute nature of time and space with all their attributes, the second rejects classical determinism. Regarding time and space, there are two main approaches to their interpretation. The first is the already mentioned concept of absolute time and space. *According to it, time and space do not exist in connection with matter, but in themselves, regardless of matter.* Of course, we cannot perceive absolute time and space, we perceive only relative, matter-related substitutes. As for the most absolute time and space, Newton defined them as "more sensitive to God" and I. Kant, who generally proceeded from a subjective understanding of the nature of empirical experience, defined them as aprioristic (preceding experience) forms of our perception. *The second, relative approach, denies the existence of absolute time and space, considering them only relative forms of existence of reality (matter with materialists).* The concept of relative time and space is as old as the absolutist concept. It was shared, in particular, by ancient Indian and ancient Chinese philosophies, and in modern Europe it was supported by Leibniz.

In general, Leibniz's philosophy, in particular his doctrine of monads, can be chosen as the basis for future general ontology. It is based on the concept of a monad, or short substance, endowed with the attribute of thinking. Monads "have no windows", i.e. are completely isolated from each other and interact through the so-called pre-established Harmony, which assumes that each monad reflects the entire infinite universe of the other monads. That is, the monads are synchronized, and any change in one of them means a synchronous non-causal change in the others. Each of the monads reflects the rest from its own perspective, the hierarchy of perspectives is space and time. So, actually space and time do not exist. In science, the concept of relativity of space and time is established together with the theory of relativity. As for Leibniz's theory of monads, it can be considered as purely phenomenological (which, in fact, E. Husserl did). And if so, it can serve as a unifying basis for the most diverse scientific and philosophical ontologies of our time. In particular, such as the hypothesis of the multiplicity of worlds of Wheeler, Everett and Graham, the concept and philosophy of bootstrap, the holistic philosophy of D. Bohm, etc.

Thus, *the hypothesis of the plurality of worlds assumes that the universe is being split at any moment into an infinite number of other* *universes. Due to this splitting, all the possibilities provided by the mathematical apparatus of quantum theory are realized (albeit in different universes).* Reality then is the infinity of such universes in the all-encompassing "superspace". Since these universes do not connect with each other, there are no contradictions [3]. This hypothesis is fully consistent with the theory of monads, significantly expanding it, as it assumes the existence of a totality of realities rather than one reality.

The second analogy is with the concept of bootstrap, which assumes that the whole world is a set of interconnected events, not individual entities. The selection of certain events or objects is conditional, because everything is intertwined like laces (*hence the name of the concept itself).* Changes in one place cause corresponding changes in another, the universe cannot be different from what it is. Finally, D. Bohm's holistic concept is based on some implications for quantum mechanics.

The ontology of quantum mechanics is based on such principles as the principle of corpuscular-wave dualism, the ratio of Heisenberg uncertainties, and the probabilistic nature of all processes, that is, on the basis which is quite different from mechanism. Indeterminism, derived from Heisenberg's relations, has long raised many doubts and objections. Among its opponents was, in particular, A. Einstein, who, to demonstrate the conventionality and incompleteness of quantum mechanics, proposed a kind of imaginary experiment, which formed the content of the so-called paradox of Einstein, Podolsky and Rosen. Suppose that as a result of the annihilation of a particle and an antiparticle, two photons are formed that fly in different directions at the speed of light. Each of them has its own spin orientation. The direction of the spin is related to the direction of polarization of the light beam, which allows for experimental observations. If before annihilation the total spin of the quantum system was zero, then after annihilation the sum of the spins will also be equal to zero. The spins of the photons are equal to each other and oppositely directed so that the sum continues to be zero. That is, determining the spin direction of one of the photons by polarization, we also determine the spin direction of the other. However, this contradicts the ratio of uncertainties, because, according to them, the exact values of the respective spin components do not exist before the measurement, as for the interaction between photons, it is impossible because they move away from each other at the speed of light. That is, it turns out that one photon "knows" what is happening to another [46, p. 130]. The explanation of this paradox put forward by D. Bohm is that *the integrity of the quantum system is preserved even after its apparent decay, which determines the existence of the paradox.* Bohm further expands his concept, based on the fact that the visible multiple universe is based on the indecomposable integrity of the subquantum level. The limit of multiplicity is limited by the Planck constant, which is the limit of divisibility of action, and since reality in quantum mechanics is reduced to action, the stable structures of the multiple world are no more than abstractions derived from indefinite and unknown universality.

Phenomena described by science are only a fragment of reality, its detailed or *explicit* order. At the core, in depth, lies a condensed or *implicit* order in which there is no (explicit) space and time, and certain aspects of being are inextricably linked with the whole. *Consciousness and matter are only abstractions of the explicit level, which is generated by the development of the implicit order*. All our means of representation and perception are conditional. Rational – one of the manifestations of a broader irrational order. The latter is also reflected in the so-called principle of complementarity, which was introduced by N. Bohr first only to interpret the corpuscular-wave dualism of the properties of quantum objects, and later extended to the general philosophical principle.

In a narrow sense, the principle of complementarity states that the corpuscular and wave properties are complementary to each other because their observation requires different complementary experimental setups. In a broad sense, this principle says that any statement, any truth has complementary statements or truths that are not compatible with them, but equal to them in depth and significance. Bohr considered the principle of complementarity universal, suitable for any field of knowledge. Material and ideal, mental and physical, right and wrong, determinism and indeterminism and other binary oppositions complement each other, but do not completely contradict each other. The latter has in fact become the cornerstone of postmodern philosophy, which will be discussed in the following chapters.

As for scientific ontologies, we should also mention the problem of the general basis, i.e. the position or concept on which it is based. Such a common basis is the postulate of material (intersubjective, ideal or other) unity of the world. The expression of this unity can be the parameters of matter itself or the acting force, namely mass, energy, force. The concept of mass has long been synonymous with matter, and since everything is based on the material unity of the world, the law of conservation of mass is an expression of this unity. And not only in the natural sciences, but also, for example, in economics (preservation of goods, capital, added value). However, in operational terms, mass is reduced to force (as noted by G. Spencer). There are no universal principles of conservation of force, and therefore the concept of energy is necessary, i.e. some potency of action. In addition, in modern physics, mass actually becomes the equivalent of energy in the formula $E = mc^2$. Thus, the principle of conservation of energy is a universal principle, a postulate that reflects the unity of external reality. This principle also has a clear psychological basis.

In the human subconscious there is an idea of pervasive power, an idea of preserving which is the archetype of the unconscious [22]. Manifestations of this archetype are the idea of *prana (life force in Indian mythology)*, the flow of qi in Taoist concepts, and so on. In European psychoanalysis, their analogue is the concept of mental energy of libido, endowed with all the attributes of physical energy. However, whether libido can be equated with physical energy, science is silent. The reason for this is the fragmentation of scientific knowledge, its distribution between different specific areas.

In the humanities, one can also single out the problem of a general basis. For example, if we take the historical or economic sciences, it is a question of what is still primary – the material and economic level of society, which determines the social consciousness, or, conversely, the consciousness that can change the material and economic level. Marxists were supporters of the first point of view. Among modern supporters of the second view are representatives of the so-called psychohistory, a new interdisciplinary direction that studies the impact of accepted methods of raising children in society (which determine the nature of individual history of the individual) on historical events in society. It can also be assumed that neither approach in isolation from each other can give a definitive answer to all questions. As for the problem of the general basis, this problem does not belong to those that can be solved once and for all. There will always be something that will raise new questions. That is, if we remember the positivists, science is able to answer the question "how" but not the question "what".

Control questions

1. What is the difference between ontology and metaphysics?

2. Analyze the ontological aspects of phenomenology. Do they coincide with the ontological aspects of the natural sciences, humanities, and formal sciences?

3. What is causality and determinism? How are they related? Is one possible without the other? Why and how?

4. Give arguments in favor of the objective and/or subjective nature of causality and determinism.

5. What is information? What is its nature? How does information affect natural and social processes?

6. What is synergetics? What is culture (economics, politics, science) in terms of synergetics?

7. What is the reason for the use of statistical methods in science?

8. Analyze the concepts of holism, bootstrap, multiple universe for the possibility of building on their basis a universal scientific ontology for modern science.

9. What is the principle of complementarity? Where and how can it be used?

10. Analyze the ontological aspects of economics. Do they intersect with the ontological aspects of other sciences?

8. Evolutionary epistemology (dynamics and patterns of growth of scientific knowledge)

Scientific knowledge, first of all, consists of scientific theories. The truth, according to the most common in science, classical concept of truth, is a theory that corresponds to facts. The methods of verification of compliance with facts are the already mentioned verification (checking for confirmation) and falsification (checking for refutation). Thus, the very study of these phenomena raises the problem of how science develops, one scientific theory replaces another, how the growth of scientific knowledge occurs, and so on.

Concepts of historical development of science are quite numerous. According to their authors, all of them can be combined under the name of evolutionary epistemology, although only one of them, namely that created by a number of philosophers, primarily Karl Popper, is usually called this way.

8.1. Features and paradoxes of the process of scientific cognition

M. Schlick, the founder of the Vienna Philosophical Circle, dealt with the problems of verification of scientific knowledge in the epistemological context. In the course of his research, he showed the conditionality and unreliability of any indirect verification. Thies, imagine that we need to verify the position of P1. Direct verification is not possible, but position P1 together with another (additional) position D1 gives position P2, which, in turn, together with the additional position D2 gives P3, etc. Eventually we come to some position Pn, which together with an additional position Dn gives position F, which can already be verified directly. But it is obvious that such verification cannot guarantee the truth of the ascending position P1.

The conducted indirect verification only confirms (or does not confirm) the acceptability (or inadmissibility) of the whole set of provisions from P1 and D1 to Pn, Dn, F. Verification of P1 through verification of F is possible only if all intermediate provisions are true. The method of falsification proposed by K. Popper does not solve this problem either, because falsification (like, in fact, verification) of the last component of the chain indicates only that one or more intermediate components are falsified, but does not indicate which ones. There are many examples of the limitations of such indirect verification/falsification from the history of science. All of them indicate, among other things, that actual empirical arguments play a rather limited role in the choice of a particular theory. Often the final choice becomes possible only after others related to this theory go far ahead. In this case, the choice is simply dictated by the need to reconcile different theories with each other. As follows from the above analysis of indirect verification, a theory or hypothesis is tested for truth (falsity) not in itself, but only together with a set of all other theories or hypotheses associated with it.

This feature is reflected in the so-called *Duhem − Quine thesis* (abbreviated D-thesis), which was first formulated in the early twentieth century by the French physicist Duhem, and according to which it is possible to empirically test only a group of hypotheses rather than one hypothesis. If experiment contradicts theory, it means that at least one of its components must be changed, although it is unknown which one. That is, the researcher can preserve any of the existing hypotheses by changing other complementary provisions [3]. Not all researchers agree with the validity of the D-thesis. They point out that such a reassessment is not always possible, if at all possible.

Thus, according to A. Grunbaum, the D-thesis is simply erroneous, because a separate test of each individual hypothesis still occurs within a broader theory. D-thesis, according to Grunbaum, is valid only in the trivial semantic sense, i.e. when the preservation of the hypothesis is achieved by redefining its components. However, this is where the trap is. As shown earlier, facts are not independent of theory. Therefore, semantic redefinition can be considered the same heuristic operation as any other. That is, justice or injustice of the D-thesis also depends on the general philosophical approach, rather than on specific facts. From the two alternative theories, choose the one that best corresponds to the facts. And because, as noted in previous sections, facts are impossible without theory, that is, "loaded" with theory, such a choice is often a very serious problem.

Thus, Newton's mechanics is now recognized as true, and Aristotle's physics as false, because the former agrees with more facts than the latter. However, in reality, as shown, for example, by P. Feyerabend, these two theories are simply incompatible with each other. The "impetus" of Aristotelian physics, for example, does not coincide with the "momentum" of Newtonian, although it is numerically equal to it.

The incompatibility of these or other theories results in the fact that each of them may correspond to the facts in its own field, and in choosing one of them we cannot be guided by a simple correspondence or inconsistency of facts. This is reflected in the so-called *Kuhn-Feyerabend thesis*, which can be formulated in the form of the following provisions:

1. The facts on the basis of which theory is built, are formulated in its language.

2. Competing theories have different incompatible languages.

3. From the previous two statements we can conclude that there are no facts on the basis of which it would be possible to make a rational choice in favour of one of the competing theories [29].

Kuhn-Feyerabend's thesis agrees well with the instrumentalist conception of truth, according to which concepts and theories are, first of all, tools for the cognitive development of reality (among other things, tools for describing facts).

In connection with this thesis, we can also mention the theory of conceptual-linguistic frameworks, which emerged in analytical philosophy in the 30s of the twentieth century, according to which any area of knowledge, culture or other human activity is represented by its own more or less closed conceptual-linguistic framework. Meaningfulness, significance, truthfulness and the possibility of verification (verification or falsification) are inextricably linked to the relevant frameworks and have no meaning outside of them. The relations established within the frameworks are, first of all, logical relations. If each area of knowledge really corresponds to its framework, then each area is a separate truth, which is determined from this area itself. The criteria of truth that operate within the framework are coherent − that is, what is true is what is consistent with the internal rules and the content of the framework. As for the facts, they also simply become elements of one or another framework. A more universal truth, common to several frameworks at once, is determined by the ratio of the respective domains to each other. The latter raises the problem of *reductionism*, that is the possibility of bringing different theories or areas of knowledge together.

This problem is relevant because it is assumed that some theories and areas are not just frameworks in themselves, but reflect different areas and aspects of the same reality. As for the frames themselves, as noted by K. Popper, they are not closed, and any of their contact immediately leads to interpenetration and the formation of new frames based on them.

Practical reductionism, as the practice of real science shows, is unattainable not only within all or the natural sciences in general, but even within the same science. As for the sciences in general, today there is only a theoretical possibility of reducing the laws of chemistry to the laws of atomic and nuclear physics, and there are no even theoretical ways to reduce the laws of biology to the laws of chemistry, psychology to biology, humanities to psychology. The absence of reduction is by no means connected either with the lack of relevant knowledge or with the conditionality of this knowledge. Everything is explained by the idea of *emergence,* which implies that the properties of the whole cannot be reduced to the properties of its parts, and because of this it is impossible to explain or reduce the features of one level of being through the features of another.

8.2. Models of evolution (growth) of scientific knowledge

Post-positivist concepts of science are concepts that emerged in the second half of the twentieth century in place of the old positivist approaches, which by that time had almost exhausted themselves. The inevitability of conditional and conventional elements in epistemology and science, the limitations of purely rationalist approaches, and so on, became apparent.

The central problem of postpositive philosophy of science is its evolution, i.e. the development of science over time. The growth of scientific knowledge over time seems indisputable, but the simplified-linear representations of the positivism era have been replaced by more refined and nonlinear models by T. Kuhn, S. Toulmin, P. Feyerabend, H. Novotny, and others.

8.2.1. Karl Popper's evolutionary-epistemological model of growth of scientific knowledge

The transitional (between positivism and postpositivism) concept of growth (evolution) of scientific knowledge is the evolutionary-epistemological concept of Karl Popper. Its author relied on the similarity of the processes of biological evolution and scientific cognition: in both cases between the two systems (environment − biological species and the object of knowledge − the subject of knowledge), despite the impossibility of direct exchange of information, there is a certain correspondence. The scheme of biological evolution and growth of scientific knowledge in Karl Popper's interpretation is constructed as a periodically repeated cycle of generation, selection, replication of theoretical explanatory constructs [46, p. 137]:

$$TT_{i-1} \rightarrow EE_i \rightarrow PP_i \rightarrow HH_i \rightarrow \underset{\substack{\uparrow \\ \text{Falsification}}}{FF_i} \rightarrow TT_i \rightarrow EE_{i+1} \rightarrow PP_{i+1} \rightarrow, \qquad (8.1)$$

where EE_i is experimentally obtained data;

PP_i is problem situations, i.e. discrepancies between available data and their theoretical explanations (TT_{i-1});

HH_i is proposed explanatory models;

FF_i is falsifiers, i.e. the consequences that are deductive, allowing a test for compliance with experimental data;

TT_i is hypotheses that have passed the test for falsification and received the status of a reliable theory;

EE_{i+1}, and PP_{i+1} are new data and new problem situations identified as a result of the development of TT_i.

Thus, verification in the generally accepted interpretation is a selection of abstract theoretical concepts, in which the selection criterion is the procedure for finding and formulating provisions − forgeries that allow the test of the adequacy of empirical experience and the procedure for updating this test (verification) has consistently taken this form [27]:

$$T \rightarrow A \wedge A \rightarrow -T, \text{ (I)} \qquad (8.2)$$

$$T \wedge H \wedge Z \rightarrow A \wedge A \rightarrow -T, \text{ (II)} \qquad (8.3)$$

$$T \wedge H \wedge Z \wedge E_0 \rightarrow A \wedge A_V E_T = -E_0 \rightarrow -T_V - E \text{ (III)}, \qquad (8.4)$$

where T is the abstract theory;

H is "translation" of theoretical positions into an experimentally verified form;

Z is similarity criteria;

E_0 – ethical and social assessment of the initial situation, based on the dominant system of ethical priorities;

A is counterfeiter;
E_T is ethical burden of falsified theory;
I is classical scientific rationality;
II is non-classical scientific rationality;
III is non-classical scientific rationality.

In Popper's model, the adaptation of new knowledge to new data is carried out as new falsifiers of the scientific hypothesis or theory are discovered, and each detected inaccuracy of the scientific concept becomes a generator of new scientific knowledge. However, the strict logic of this scheme implies that a single rebuttal is sufficient to conclude that the theory does not pass the selective test for falsification of research data.

There are two possible ways out of this situation:

1. A strong solution involves a complete rejection of the falsification of the scientific and theoretical construct and the search for an alternative explanation.

2. A weak solution is to locally rearrange the argument system of the theoretical construct so as to explain the reasons for the negative test for verification/falsification of this particular conclusion from the theory (for example, the discovery of a new planet in the solar system, explaining the reasons for the apparent deviation of laws of classical mechanics and the law of gravity).

Thus, one of the key problems of the evolutionary-epistemological model is to find the conditions for a reasonable choice between the first and second result in the case of a negative test for falsification and analysis of their consequences for the development of theoretical scientific knowledge. Several such conceptual models have been devoted to this.

8.2.2. The research program model by Imre Lakatos

The idea of emergence is the basis of the so-called *emergent* (non-reductive) *materialism*, which makes it possible, in particular, to give a materialist concept of consciousness. Kuhn-Feyerabend's thesis does not necessarily indicate the complete incompatibility of alternative theories. It only speaks of the conventionality of the choice of one of the alternative theories, which may be quite compatible with each other.

Facts, due to their theoretical "burden", cannot be the only argument for such a choice. Hypotheses are neither pure experimental, they always contain something that goes beyond pure experiment. This something (additional non-experimental ontology) determines the program of further research, during which the previously mentioned separate test of a separate hypothesis is carried out. That is, a hypothesis (as well as, in fact, a theory) contain a program of further research.

In the theory of confirmation (the concept of a research program), Lakatos believes that it is not individual theories that are subject to confirmation, but large aggregates of them, the so-called *research programs.* If such a program progresses, that is, if the theoretical growth leads to the growth of the empirical (the theory allows us to predict more experimental results), then it confirms itself. If this does not happen, i.e. if the empirical growth overtakes the theoretical (the theory is constantly adapted to empirical data), the program regresses and is eventually replaced by a competing program [3]. Lakatos also highlights the core and related elements in the program. In the course of theoretical growth, according to the D-thesis, one element is constantly replaced by another. However, such changes apply only to related elements, the core remains unchanged. Changing the core means abandoning this program and replacing it with another, alternative one.

In other words, the choice between modifying an existing research program and replacing it with another program is determined by whether the number of unexplained falsifier facts increases faster than the number of new facts predicted and confirmed by theory. The destruction of the theoretical core of the research program, which includes invariant abstract general methodological principles, occurs only after the destruction of the peripheral protective belt, consisting of private conclusions that reconcile the core of the program with specific facts. The protective belt in the process of transformation of a human from the objects including the human as their element, into a subject of scientific research, the further, the more acquires applied and value measurement. V. S. Stepin called this property of modern science the "human dimension" of scientific theory [46, p. 140]. As a result, the hard line between scientific (descriptive) and value discourses, on which the phenomenon of classical science was based, is subject to destruction and erosion.

In scientific concepts belonging to the so-called interpretive (human-sized) scientific knowledge, the explanatory model has not one, but two systems of initial postulates and principles that are only partially compatible with each other − natural science and socio-humanitarian. The connection between them is carried out through applied − project outputs of theoretical concepts. Accordingly, the "disciplinary matrix" of such research program (examples are considered bioethics, social economics, modern political science theories, etc.) has two central cores and overlaps the belt of applied design, which is theoretically possible to empirically verify (falsify). The "hybrid nature" of the generator of new knowledge is reflected in the "hybridity" of the structure of the theory itself − the appearance in its composition of what we previously referred to as "ethical and epistemological hybrid constructs" [11].

8.2.3. The model of network organization of theoretical knowledge by Lawrence (Larry) Laudan

The given scheme, in addition to the concept of I. Lakatos, combines some elements of the concepts of the paradigm of T. Kuhn [13] and the network organization of theoretical science by L. Laudan.

According to the latter, the organization of scientific knowledge contains three conceptual levels − factual (facts and scientific theories), methodological (methods of scientific knowledge) and axiological (values and standards of scientific knowledge), between which there is a network of direct and feedback links that impact the process of verification of theories and hypotheses by the scientific community. Only the axiological level in classical science was considered both sensitive to external influences and invariant with respect to the remaining two. As can be seen when considering the problem of scientific ethos, this statement is denied by modern data and theoretical ideas of the sociology of science.

According to Laudan, all three conceptual levels are capable of transformation, and the latter do not lead to a hierarchical metaconceptual level, which determines the changes in all remaining components of knowledge, but are interdependent, creating a systemic integrity. According to him, the network model is very different from the hierarchical model, as it shows that a complex process of mutual consideration and mutual justification permeates all three levels of science. The rationale flows both up and down the hierarchy, linking goals, methods and actual assertion. So he doubts if it makes sense to further treat any of these levels as more privileged or more fundamental than the others [32, p. 139].

8.2.4. The disciplinary and paradigmatic model of organization and the evolution of science by T. Kuhn

Thus, later epistemological analysis is replaced by historical analysis, i.e. the identification and demonstration of the historically determined nature of any knowledge. Such an analysis is the main content of post-positivist concepts. Lakatos's theory describes, first of all, the mechanisms of confirmation and development of theories and groups of theories. However, it does not take into account the socio-historical aspects of the development of science. These aspects are taken into account in post-positivist concepts.

The beginning of "postpositivism" was laid by T. Kuhn with his famous book "The Structure of Scientific Revolutions". This book, which soon became a bestseller, did not contain any fundamentally new ideas. In fact, it dealt with what had long been circulating in the minds of many scientists. The advantage of this book was that for the first time it developed a consistent and empirically based on many specific examples concept of the historical conditionality of scientific knowledge, which served as a model for further research in this area. In fact, soon after the publication of "The Structure of Scientific Revolutions", Kuhn's conception became conditional and limited. However, even this has not diminished the importance and popularity of this work to this day.

The key concept of Kuhn's work is the concept of paradigm (later named the disciplinary matrix), which is defined as a fundamental scientific theory, a generally recognized scientific achievement, which had long served as a model of setting and solving a research problem for a research scientist [13].

Further the terms "paradigm" and "disciplinary matrix" will be used as equivalent, although the latter is methodologically more rigorous and unambiguous, and the former (paradigm) is more metaphorical and allows for ambiguous interpretations. The disciplinary matrix includes extremely heterogeneous elements: symbolic generalizations, metaphysical and value priorities and predispositions (initial settings), "generally accepted patterns" of solving specific problems (explanatory models or, as T. Kuhn wrote, ways to solve "puzzles" (the author used this term to indicate a range of tasks, the solution of which was considered the task of the scientific discipline within the existing disciplinary matrix and using the methods allowed by it).

Thus, the paradigm:

1) determines the range of research tasks that are considered to be the subject of science;

2) determines the boundaries of the search for possible ways and means of solving these problems;

3) determines the ideal to which the scientist aspires when solving a specific research problem;

4) programs the direction of future development of science.

For example, Newton's mechanics outlined the main trends in the development of physics in the 17th – 19th centuries − the union of phenomena and processes of Nature, based on the laws of mechanical movement of material bodies and the particles that make them up. The ideals of classical physical theory of the time were reflected in a beautiful metaphor known in the history of science as the Demon of Laplace (after its author): if there was a creature (demon) that would know the coordinates and impulses of all material particles in the universe, it, based on knowledge of the laws of mechanics, could completely reconstruct the past and accurately predict the future.

The discovery of new facts, even if they cannot be explained within the existing paradigm, does not lead to its demise as long as the rate of accumulation of such facts is significantly lower than the number of facts predicted by scientific theory and revealed later. In this case, there are no conditions that could lead to abandoning the paradigm and replacing it with another. As long as the growth of scientific knowledge occurs while maintaining the scientific paradigm, there is an evolutionary and progressive development of science, which T. Kuhn called normal science.

But periodically in the development of any scientific discipline, a point in time comes when new facts that cannot be explained within the existing theory accumulate much faster. So, to explain them, hypotheses are used that are logically incompatible with this paradigm and are contrary to its basic tenets. There is a kind of "crisis situation". Signs of such a crisis are:

1) the need for theoretical understanding of new empirical material;

2) the accumulation of logical contradictions within scientific theory;

3) a radical revision of basic ideas about nature.

Solving the crisis in science goes through a *scientific revolution, i.e. change of the scientific paradigm.* Quite often, the starting point of a scientific revolution is a separate scientific discovery (quantum nature of radiation, constancy of the speed of light, elucidation of the molecular structure of DNA, etc.), which caused a sequence of events that lead to radical changes in the scientific world. According to the scope and scale of the changes caused by it, scientific revolutions can be:

- local (affecting only a separate scientific discipline), complex (affecting several interrelated areas of science);
- global (radically changing the foundations of the scientific worldview).

Examples of global scientific revolutions are:

1) the creation of a heliocentric model of the solar system by Nicolaus Copernicus (1473 − 1543), which was the beginning of the formation of modern science;

2) the emergence of classical mechanics in the works of I. Newton (1643 − 1727);

3) creation of the theory of evolution of inanimate and animate nature (18th – 19th centuries) as a result of works by I. Kant, P. Laplace, A. Maxwell, A. Mayer and C. Darwin;

4) the creation of the theory of relativity and quantum mechanics (late 19th − early 20th centuries).

5) the development of computer technology and genetic engineering in the opinion of many experts has led to the beginning of the 5th global scientific revolution − information.

Global scientific revolutions cause not only a radical expansion of our knowledge of the world. Their inevitable consequence is radical changes in the means of technological transformation of the world, spiritual and material culture, mentality, philosophy, socio-political organization and so on.

Thus, the paradigm acts as a set of theoretical, philosophical, methodological models for the further development of science. These or those variants of paradigms are present in all developed natural sciences. As Kuhn noted, "paradigms acquire their status because the use of them leads to success faster than the use of competing solutions" [13]. They are firmly embedded in the minds of future scientists in the learning process, leaving a deep imprint on all their thinking.

"Normal science" means research that is firmly based on one or more past scientific achievements − achievements that for some time have been recognized by the scientific community as a basis for further practical activities. In general, paradigms fully become paradigms only after the advent of normal science. The achievements that give rise to them and "normal science" are reflected in the textbooks, which prepare personnel for the further development of "normal science". At various times, the role of such textbooks was played by Aristotle's "Physics", Ptolemy's "Almagest", Newton's "Principles and Optics", Franklin's "Electricity", Lavoisier's "Chemistry", etc., which for a long time served as models in the relevant fields of knowledge. Alternative schools are replaced by the prevailing paradigm, due to which scientists who are its supporters become a professional group, and "the subject of their interest becomes a scientific discipline" [13].

A scientific discipline is, first of all, a normal science. What does a scientist do within the framework of normal science if the paradigm establishes the conceptual and methodological framework of his activity, beyond which he cannot go? His work is to solve three classes of problems, such as "establishing significant facts, comparing facts and theory, developing theory"; that is, his activity is reduced to the deepening of the existing paradigm. Such activity is completely determined by the existing paradigm and in fact is a solution to puzzles. Accordingly, all the results of this activity are predetermined, and qualitative jumps are impossible. Puzzles are reduced to establishing a correspondence between paradigm-determined theories and empirical facts. Facts that cannot be reconciled with the existing paradigm are postponed until better times, until finally someone can reconcile them, or when they are accumulated too many, lead to persistent anomalies, i.e. violations of expectations inspired by the paradigm. Anomalies are also possible only against the background of paradigms − when "the anomaly turns out to be something bigger than another puzzle of normal science, the transition to a state of crisis begins" [13].

A crisis situation can arise not only due to anomalies, but also as a result of the collision of two or more competing paradigms. Thus, modern thermodynamics was born as a result of the collision of two competing theories prevailing in the 19th century; quantum mechanics is one of the many difficulties in interpreting the peculiarities of black body radiation and the photo effect*. The crisis leads to the emergence of qualitatively new alternative theories that are designed to eliminate the anomaly. If the new* *theory is suitable to take the place of the previous one, i.e. reaches the level of the paradigm, then there is a "scientific revolution", i.e. a change in the dominant paradigm.* Examples of such revolutions are the emergence of the heliocentric theory of Copernicus, Newton's physics, quantum mechanics, the theory of relativity, and so on.

It should be noted that revolutions do not necessarily mean a complete change and rejection of the old paradigm. In some cases, such as the creation of quantum mechanics or probability theory, the new paradigm simply becomes a more general theory, incorporating the old theory as a limit case.

Revolutions mean a change in worldview, the emergence of new rules and methodological models for new generations of scientists. New textbooks appear in which the development of science is presented in the light of a new paradigm, and all the former path traversed by science before, is overlooked. Kuhn considers such a conclusion necessary for the further development of science, citing the words of the English philosopher A. Whitehead: "Science, which cannot forget its founders, will perish" [20].

8.2.5. Michel Foucault's model of epistemes

Considering the concept of episteme as a basic structure of social and humanitarian knowledge, we somewhat violate both the logical and evolutionary sequence of presentation. Although phenomenologically the category of episteme and paradigm look similar. Indeed, they go back to one conceptual "archetype" − the idea of the influence of prerequisite knowledge on the content of scientific theory. In the understanding of Foucault [19] an episteme is a set of hidden, historically conditioned cultural and cognitive predispositions (prerequisites) that determine the form of imaginary processes through which the content and limits of scientific knowledge, in particular are formed. In other words, an episteme is a socio-cultural code, the rules of correspondence between phenomena, concepts and signs denoting them (language, speech).

While Kuhn's organization of a paradigm is determined by the relationship between the objects of scientific knowledge (things) and the system of basic norms of cognitive activity, in epistemology the role of things is replaced by socio-humanitarian phenomena, which inevitably contain inseparable unity of subjective and objective, value and descriptive resources, the meaning of this concept is much broader than scientific methodology in the field of spiritual culture and philosophy.

Foucault proceeds from Nietzsche's concept of the will to power. He, like Nietzsche, argues that objective knowledge does not exist, knowledge is only a means of controlling an object or other subject. Thus, in the Middle Ages there were detailed instructions on the methods of torture. They were knowledge of the exercise of control over the person himself and over his individual organs. Power is the interaction of forces and determines the strategies of power − knowledge complexes. The task of archeology is to identify and understand strategies. The general archeology of European culture over the last few centuries is presented in the work "Words and Things" and is as follows. From the Middle Ages to the 17th century cognition strategy was aimed at finding visible and hidden similarities. All the science of that time (theology, astronomy, linguistics) was based on similarities, analogies and signs. At the heart of this science was the belief that God created the world in some image and likeness (man, the microcosm created by God in his own image and likeness, is a reflection of the macrocosm) and scattered everywhere the signs or manifestations of these similarities to be found and deciphered. Thus, anatomy likened the human body to space and placed certain celestial objects in accordance with its organs. Linguistics sought similarities between the sound and meaning of the word [17; 19].

The era of similarities and analogies ends at the beginning of the 17th century, when the time of taxonomies and classifications began. The sign of this transition can be the novel "Don Quixote" by M. Cervantes, whose hero, forgetting what century it was and wearing knight's armor, is everywhere looking for similarities and everywhere getting into trouble, because the world no longer believes in similarities [2]. In this world, everything is already laid out on its shelves and classified. Since then, that is, since the seventeenth century, new methods and approaches have emerged, as well as sciences based on these methods, such as general grammar, natural history, taxonomic biology, anatomy, and English economic theory.

However, their time is also passing, no one is interested in taxonomies, everyone is interested in what is behind them, that is, the hidden deep foundations of things. An expression of this reorientation is de Sade's novel "Justine". Justine, an honest and virtuous girl, is constantly in trouble, falling victim to some villains. The obvious difference between Justine's character and her fate is striking. Behind all her misfortunes the dark intentions of bad people are hidden, knowledge of which allows us to understand the fate of Justina. Similarly, in science, hidden patterns allow us to understand the causes of taxonomic features.

The last episteme is a system and organization (19th – 20th centuries), characterized by a strict systematization of the conceptual apparatus and a set of symbols by which the description of reality, and this system of symbols (language) finally becomes autonomous from reality and, therefore, the subject of knowledge. At this time there are such sciences as physiology, psychoanalysis, the doctrine of the structure of matter and so on.

Thus, if the essence of the paradigm belongs to the internal organization of the actual scientific discipline, i.e. the objects of study and methods used, the episteme is a set of external constraints imposed on the development of scientific knowledge by the general cultural and ideological context.

8.2.6. The model of conceptual populations by Stephen Toulmin

Kuhn's theory, despite all its obvious advantages, has a number of significant shortcomings. First, the scientific revolutions cited by Kuhn as an example took time from several decades to several centuries, and, accordingly, it is better to speak of the evolution of scientific ideas rather than of revolutions. Second, the final definitions of paradigm and normal science are presented one after the other, which leads to a logical circle and reduces the logical value of Kuhn's argument. Thirdly, it is not entirely clear to what the concept of paradigm should be attributed: to the scientific worldview as a whole or to very specific individual samples of a science. In principle, it is possible to refer to both, but in this case a rather complex hierarchy of paradigms is formed, which complicates the discourse on scientific revolutions, forcing us to abandon the Kuhn concept in favor of other concepts, including evolutionary ones.

The evolutionary concept of the development of science is presented by A. Toulmin. He replaces the concept of paradigm with the concept of a population of scientific ideas, which includes such factors as general worldview elements, technical capabilities, existing achievements, and so on. Population frameworks do not necessarily coincide with the framework of a particular science, more often they simply intersect in some places. Thus, the population of atomic ideas forms its own domain, crossing the boundaries of physics and chemistry.

The evolution of science is the evolution of populations of scientific ideas. The driving forces of this evolution are the struggle between populations of scientific ideas, conceptual variability and intellectual selection [42]. Conceptual variability is determined by internal factors of evolution, such as theoretical validity, consistency with other theories, the results of verification or falsification. In addition to internal, there are also external factors, such as the social characteristics of the scientific community and the available technical capabilities. External factors serve as a limitation of internal (intellectual) factors.

Intellectual selection is carried out by a community of specialists in accordance with the above internal and external factors. One of the key moments of development is the emergence of scientific specification and the associated professional embodiment of science. After that, the scientific community becomes almost a direction associated with the population, the death of which means the cessation of its activities. This gives rise to additional factors that complicate evolution and create the illusion of revolution. A separate scientific community hinders the spread of ideas that threaten its own population.

As a result, populations change each other not immediately and not only due to objective factors alone, but after a more or less long struggle, which may become visible in the revolution. It is impossible to avoid the influence of social factors on science, it can only be partially balanced by maintaining a historical understanding of "intellectual ecology" [42].

If modern science is not the only one of its kind, but only one of the possible results, which is also determined by social factors of development, then a question arises about the possibility of alternatives among other options for cognitive development of the world. If such alternatives are possible, then a question arises of their equivalence or non-equivalence to existing science. There are various possible answers to this question. Some of them are those that proceed from the aprioristic belief in the unity of truths; they rely mostly on the modern natural sciences and believe that such absolute truth is most fully and adequately represented in science. It is also assumed that the adequacy of the scientific reflection of reality is constantly growing.

Alternative (mostly anti-scientific) approaches, in principle, can also to some extent reflect reality, but the degree of their adequacy is no comparison with purely scientific. The justification of such a point of view is not always consistent with post-positivist approaches, as well as with the fact that, for example, a wide range of phenomena of the human psyche, physiology, relationship of man with man or environment, which are not explained in modern scientific ideas, may have a fairly complete and detailed interpretation in the philosophical systems of Taoism, yoga, Buddhism, etc. It is difficult to refrain from reminiscences associated with Kuhn's concept of science development. The question can be reformulated more specifically − whether or not science has any advantages over other ways of cognitive development of the world.

8.2.7. The model of epistemological anarchism by Paul Feyerabend

The main argument in favor of a positive answer to this question is the practical achievements of scientific approaches, i.e. a pragmatic criterion. However, there is another point of view, the so-called conceptual or epistemological anarchism, according to which all methods of cognitive development of reality are in principle equal.

One of the most prominent representatives of this view, P. Feyerabend, argues that science is much closer to myth than the philosophy of science suggests. It is one of the forms of thinking developed by humans, and not necessarily the best one. It blinds only those, who have already made a decision in favor of some ideology or do not think about the advantages and limitations of science [29].

In his argument, Feyerabend proceeds from the previously mentioned thesis of Kuhn − Feyerabend on the disproportion of alternative theories. Each theory has its own language, which provides its own interpretation of already known facts. New theories are introduced using ad hoc hypotheses; the factors influencing the adoption of these theories have nothing to do with the theories themselves. For example, in the case of Galileo, among the factors that contributed to the spread and popularity of his ideas were the brilliant technique of persuasion, the vernacular Italian, not Latin, and the fact that he addressed people, "who strongly protested against old ideas and related canons of teaching". It should also be noted that Galileo's scientific arguments did not stand up to any criticism, either from the standpoint of science at the time or from the standpoint of modern science. That is, in fact, all factors were purely irrational. "Copernicanism and other essential elements of the new science" – Feyerabend writes, – "survived only because at the time of their emergence mind kept silence" [29].

Kuhn's theory of scientific revolutions does not work at least because the alternative paradigms are so disproportionate that there can be no question of any scientific revolutions. In addition, the presence of disproportionate theories leads to the fact that "normal science" as such does not exist either. Based on all this, Feyerabend concludes that "science is a purely anarchist enterprise, and theoretical anarchism is more humane and progressive than its alternatives based on law and order". Science is a myth of the twentieth century − one of the other myths. The dominant position of science in modern society is associated with public policy, rather than the predominance of the scientific worldview over other worldviews. This policy is manifested in the field of education, as well as public funding. The totalitarian policy of the state deprives citizens of the opportunity to choose their own worldview. In a completely free society, everyone should have the right to choose their own worldview (religious, scientific, mythological) and form of education that would suit him. The state should not interfere in this area.

8.3. Sociological models of the evolution of science (theoretical sociology of science)

During the last decade of the 20th century in epistemology there was a kind of sociological turn. The most influential developments of the problems of mechanisms of evolution of scientific theories are no longer based on the analysis of internal cognitive mechanisms of generation, development and "death" of scientific theories, where the main role is played by communicative interactions between members of the scientific community. The latter (scientific society) is considered as a collective subject of scientific knowledge in general and the evolution of theoretical science in particular.

In contrast to these concepts, created in the 1990s and 2010s, the main role is given to extrascientific communicative interactions: the relationship of science with other social institutions, sociocultural context and sociocultural determination of scientific knowledge (see [24]).

8.3.1. The problem-transdisciplinary model (Mode-1 and Mode-2) of the evolution of scientific knowledge by Helga Novotny and Michael Gibbons. General characteristics of the statics of modern (post-academic) science

The first of the sociological and epistemological concepts of the evolution of science of this period is the study of two alternative ways of new scientific knowledge of Helga Novotny and her colleagues [38, p. 8–17].

It is possible to understand the essence of conceptual changes in the interpretation of the evolution of science made by this group of researchers if we return to the concept of Thomas Kuhn [13].

The disciplinary-paradigmatic model assumes: a two-phase nature of the process of growth of scientific knowledge ("normal science" is scientific revolution), with both phases cyclically changing each other.

Both normal science and the transition to a scientific revolution are reshaped by the content and logical structure of the paradigm itself, the internal transformations and collisions of the scientific discipline. It is the paradigm that determines both the subject and the research methods, the ideal form of the explanatory model obtained as a result.

The "natural" course of scientific and technological development involves a rigid disciplinary organization with clear boundaries between discrete paradigms, around each of which a corresponding discipline is formed with an adequate instrumental and methodological basis.

If we follow some researchers [29], a disciplinary matrix in the understanding of T. Kuhn, characteristic of the so-called classical science and corresponding to "Mode-1" has the following distinctive features of its metaphysical predispositions (initial principles) and priorities:

1. The idea of the universe (scientific picture of the world) is that nature is unique, unrepeatable, identical to itself.

2. The predominant value is the elimination of all subjective, arbitrary, accidental.

3. Rules, laws, theories are stable and obvious.

4. Action based on samples in the solution of "puzzles".

Paradigmatic-disciplinary mode ("Mode" can also mean a method) for the production of scientific knowledge (Mode-1 in the terminology of H. Novotny and her co-authors):

- *first, concentrates on the study of a specific subject;*
- *second, the research itself, its topic and tasks are initiated and determined by the content and structure of the relevant scientific paradigm (disciplinary matrix).*

Here Thomas Kuhn put an end to his concept.

According to the problem-transdisciplinary model ("Mode-2") in modern science, research:

- *first, focuses on solving a socially significant problem;*
- *second, it is initiated by the social context – the presence of an appropriate social order.*

The first feature is actualized in the new structure of scientific theory, in which the disciplinary-paradigmatic organization of theory is replaced by interpretive, or "centaur" knowledge (at least as a historical perspective), combining an objective description of reality ("The World of Being") with the subjective assessment of the same reality ("The World of Proper") [22].

The second feature of Mode-2 has equally significant consequences, the most important of which are included by the authors of the model as the following [34; 46]:

- *ideologizing* (management of priority research tasks) – direct and, most often, decisive participation of political and business structures in the initiation of research projects;
- *commercialization* of research, i.e. the acquisition of scientific concepts of the attributes of a marketable product;
- *politicization* (reporting) of science − a noticeable control by non-scientific social structures and institutions of all aspects of the flow and, moreover, the results of all stages of scientific research (topics, concepts, methodologies) − already directly and openly (de jure) rather than indirectly and implicitly.

Finally, the very organization of research is changed. Its mainstay is not scientific schools and stable research teams, but teams formed on the principle of multidisciplinarity, which arise to work on specific problems that exist and cooperate for short periods of time, and after achieving this goal break up or reshape to solve the next socially demanded scientific problem.

The disciplinary matrix in "Mode-2" is characterized by metaphysical predispositions, fundamentally different from the ideas about the scientific paradigm of T. Kuhn and "Mode-1" [31, p. 51]:

1. The idea of the universe as a unity of connected, multiple worlds and worlds that are undergoing formation.

2. Correlation of internal scientific values with the goals and values of the universe is also necessary for the status of natural sciences and humanities.

3. Laws are changeable, irreversible, the principles of "communication without generalization", which go beyond disciplinary knowledge, operate.

4. Action on the model of general laws and principles underlying the processes of self-organization in open systems of different nature: physical, chemical, biological, social, etc.

The authors themselves apparently considered "Mode-1" and "Mode-2" as successive evolutionary phases, rather than alternative mechanisms for generating scientific theoretical concepts.

But then the transition from "Mode-1" to "Mode-2" means a significant departure from the principles of social autonomy of science, revision of the criteria of validity and reliability, a radical revision of methodology and scientist's normative base (scientific ethos, which will be discussed below), which is reflected in the semantic code and provides communication of members of the scientific community, makes possible to diagnose the tendency to integrate science into political and business institutions and structures as their functional element.

In terms of evolutionary epistemology, the change in the social landscape in which the selection of research teams, schools, areas, is reduced to their ability to fulfill some socio-political order. An advantage not only in the field of applied development, but also in theoretical science is a research group that is able to move as quickly as possible from the objective content of the theoretical construct to its subjective meaning, to enter the sphere of sociopolitical correctness and/or social utility. It is usefulness (not validity and reliability) that becomes the main criterion for evaluating scientific and theoretical concepts.

8.3.2. The nonlinear coevolutionary model of innovative development (a triple spiral) by G. Itzkovich and L. Leydesdorff. The general characteristics of developmental dynamics of modern (post-academic) science

Formally, this model belongs to the sphere of socio-economic innovations, but according to its methodology and "metaphysics" (in T. Kuhn's interpretation and in relation to the scientific paradigm) it is certainly a development of Karl Popper's evolutionary-epistemological concept. Like the previous model, it is most adequate to the field of socio-economic science.

The triple spiral is based on Popper's analogy of the evolutionary process and scientific cognition, and in its most general and abstract form – on a set of mechanisms of evolution in all spheres of reality, including cultural, socioeconomic, and cognitive. However, only as a result of the work of the Franco-Romanian mathematician B. Nicolescu [37] the idea of a triple spiral was integrated into socio-humanitarian knowledge and constituted as the ideological core of modern theory and practical policy.

The triple spiral model assumes that they are self-organizing and capable of what is commonly called the progressive evolutionary development of the system, necessarily contain a structure of three autonomous but interdependent elements that coevolve and overlap.

It is in these hybrid zones, where there is interpenetration and autonomous social institutions with the formation of hybrid structures that new adaptive information promoting the growth of stability and plasticity is generated. The ideological continuity with the dialectical theory of Hegel-Marx development is obvious.

However, in contrast to the Hegel scheme, the concept of the triple spiral states that the binary connections of these elements oscillate around equilibrium points and only as a result of the superposition of three separate connected but autonomous objects into a single connection, where each part is associated, from any other cycle of direct and feedback, a different dynamic structure is generated. In this case, in the phase space of the parameters of systemic complexity − adaptability there is an evolutionary curve (triple spiral), which in application to scientific knowledge and society is called scientific and technological development.

The triple spiral that was originally intended as a generalized model of innovation, on the one hand describes an effective mechanism for generating scientific knowledge, on the other provides an evolutionary transition to problem-transdisciplinarity of research, which does not entail the erosion of existing social institutions [9; 37].

It ensures both the organizational integrity of the system Science – Politics (State and Law) − Economics and functional differentiation and autonomy of its constituent social institutions. The model is adapted to the Western socio-cultural context, where:

1) the function of production of new knowledge (scientific research) and reproduction of the scientific community (education) are combined in one structure − the university;

2) production is represented by independent subjects of economic activity (firms), in whose relations horizontal (network) rather than hierarchical communications dominate;

3) the functions of state power are to form the legal field and favorable conditions for society (socially oriented market).

The hybrid character of the generator of new knowledge is reflected in the hybridity of the structure of the theory itself − the appearance of what we previously referred to as ethical-epistemological hybrid constructs in its composition.

8.4. The post-academic phase of science evolution and the mechanism of social determination of the process of scientific cognition

During the previous three or four centuries of the existence of technogenic civilization, its rational-humanistic ideology could put in parentheses the equations of social and global evolution, the substantial basis of human existence − human nature as, so to speak, the world constant. This operation, the results of which were reduced to the assertion of the extinction of the biological evolution of Homo sapiens in the modern era, the replacement of anthropogenesis by sociocultural genesis, made logically consistent the concept of human rights and its consistent transformation of its naturalistic version ("natural rights") into a purely conventional doctrine. The scientific and technological development of the twentieth century radically transformed our ideas about the evolution of the universe and human nature, radically changed the structure of science itself, its social status and, ultimately, brought us to the threshold of a "posthuman future" [10].

The main event here was the emergence of a new class of technological schemes that do not currently have a common name – convergent technologies, technologies of controlled evolution, NBIC (nano-, bio-, info-, cognitive) technologies, High Hume. However, the essence of these technologies remains the same – their subject is the purposeful improvement of human biosocial nature (Human enhancement) or self-organized systems that include human as an element. The mentality of the technogenic civilization, ascending to the individualism of the Western European (more precisely, the Transatlantic) variant, is characterized by a deep value system.

In its rationalist form, it is tantamount to recognizing the degree of liberation of the status and social role of the individual from the power of the biological constitution of man as a measure of social progress. A classic example of this kind is the famous saying of Charles Fourier. According to him, "women's freedom", going beyond the "natural" (determined by genetically determined sexual dimorphism) division of social roles is a basic principle of social and political progress [27]. Since the middle of the last century, this attitude has become the dominance of the will of spiritual and somatic (bodily) self-expression and self-determination of the individual as an absolute value, which is supported and provided by the development of science and technology. The ideological brand of this premise of further evolution is the aphorism "My body is my matter", the meaning and influence of which goes far beyond the actual feminist movement, where it actually originated [9].

The emergence of the concepts of transhumanism by J. Huxley (1957) and the bioethics of R. Van Potter (1970) was a symptom of a profound reconstruction of the evolutionary landscape in which the process of socioanthropogenesis takes place. As one researcher recently wrote, "We don't have to know much about human nature to have ethical concerns about changing it (human nature) through biotechnology. The concept of human nature must relate to something in the real world, if we want to have a moral basis for this, but we do not have to be able to say exactly what it means to be a human" [12]. Any explanation of human nature in both humanities and natural planes are logically inevitably reinterpreted as an anthropic theoretical understanding of the ontological basis of the evolutionary process in general and the evolution of intelligent life in particular.

The concept of transhumanism affirms the necessity and desirability of man going beyond his own biologically determined psychosomatic bodily organization, bringing it in line with the requirements of the technological socio-ecological environment. Bioethics, in its turn, is a philosophical alternative to transhumanism and, at the same time, a social practice designed to regulate this process in accordance with the system of humanistic universal values and norms.

In the binary connection of coevolutionary elements of culture, bioethics-transhumanism, bioethics was quickly constituted as a typical example of a new − post-academic organization of scientific research and its product − scientific theory.

The features of the new organization of scientific theory can be transferred to one extremely capacious category − transdisciplinarity. In bioethics (like in other scientific concepts related to the so-called interpretive scientific knowledge), the explanatory model has not one, but two systems of only partially compatible with each other initial postulates and principles − natural science and socio-humanitarian. The connection between them is carried out through applied project outputs of theoretical concepts. Accordingly, the "disciplinary matrix" of bioethics has two central cores and a belt of overlapping design and application developments, which can theoretically be possible empirically verified (falsified). Hence the sociologization of science in modern risk society:

1) ideologization (management of priority research tasks) − direct and, most often, decisive participation of political and business structures in the initiation of research projects;

2) commercialization of research, i.e. the acquisition of scientific concepts of the attributes of a marketable product;

3) politicization (reporting) of science − a noticeable control by extra-scientific social structures and institutions of all aspects of the course and, moreover, the results of all stages of research (topics, concepts, methodologies) − already directly and openly (de jure) rather than indirectly and implicitly (de facto);

4) stratification of a single process of scientific knowledge into two autonomous flows − risky (dangerous) science (transformation of the world according to the ideal image of the desired future) and warning of science (detection and calculation of risks posed by scientific and technological development, i.e. risky science) [8; 9].

The significance of the latter factor is all the greater because it acts as an agent that catalyzes and directs the flow of the three previous ones, which in fact look extremely alien to the classical concept of science of the eighteenth and nineteenth centuries.

The conceptual model of post-academic science functioning as an antinomy of dangerous and cautious knowledge implies that the factor that initiates the transformation of the sociocultural component of adaptive strategy in the direction of origin and connection of risky Science − Precautionary Science was the achievement of evolutionary risk of the scientific and technological development of existential level.

Control questions

1. What is truth? What concepts of truth exist?

2. What concepts of truth are most acceptable in the economic sciences? Why? Justify.

3. What is the classical concept of truth? What problems does it cause?

4. What is the semantic, pragmatic, coherent, phenomenological concept of truth? What problems arise when they are applied?

5. What is the thesis of Duhem − Quine? Is it suitable for economics?

6. What is the thesis of Kuhn − Feyerabend? When and how does it work?

7. What is reductionism and emergence? Give examples. What is a paradigm and a normal science?

8. When and how do scientific revolutions occur?

9. Name the strengths and weaknesses of Kuhn's concept of scientific revolutions.

10. What caused the evolution of science in the concept of Toulmin? Name the internal and external factors of such evolution.

11. Can science be considered a "myth of the twentieth century"? Why? Justify.

12. Analyze the place and role of science in a free society. Give arguments for and against Feyerabend's concept.

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ФІЛОСОФІЯ НАУКИ

Навчальний посібник
для здобувачів вищої освіти усіх спеціальностей третього (освітньо-наукового) рівня

(англ. мовою)

Самостійне електронне текстове мережеве видання

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Відповідальний редактор *О. С. Вяткіна*

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Рекомендовано для здобувачів вищої освіти усіх спеціальностей третього (освітньо-наукового) рівня.

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