НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ
КОРАБЛЕБУДУВАННЯ
ІМЕНІ АДМІРАЛА МАКАРОВА

О. В. ПАТЛАЙЧУК, О. О. ГОНЧАРОВА

THE COURSE OF LECTURES ON THE PHILOSOPHY OF SCIENCE FOR GRADUATE STUDENTS

Навчальний посібник з філософії науки для підготовки аспірантів та здобувачів наукового ступеню PhD (доктор філософії)

Н серія авчальні посібники

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ISBN 978-966-321-415-3

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
Національний університет кораблебудування
імені адмірала Макарова

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Рекомендовано Вченою радою НУК

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2021

УДК 001.1:101(075.8)
П 20

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Рекомендовано Вченою радою НУК як навчальний посібник
(*протокол № 6 від 30.05.2019 р.*)

Патлайчук О. В.

П 20 The course of lectures on the philosophy of science for graduate students : навчальний посібник з філософії науки для підготовки аспірантів та здобувачів наукового ступеню PhD (доктор філософії) / О. В. Патлайчук, О. О. Гончарова. – Миколаїв : НУК, 2021. – 200 с.

ISBN

Тексти лекцій складені для підготовки аспірантів та здобувачів наукового ступеню PhD (доктор філософії) відповідно до програми дисципліни "Філософія науки".

Призначено для аспірантів та здобувачів наукового ступеню PhD (доктор філософії), а також всіх, хто цікавиться проблемами філософії науки.

УДК 001.1:101(075.8)

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INTRODUCTION

The decisive role of science in the transformations of the modern age implies a philosophical understanding of this phenomenon.

Philosophy of science is a separate section of philosophy, containing all the main sections of traditional philosophy. Its subject is the philosophical problems of science in general, as well as the philosophical and methodological issues of individual sciences, and the object of research is science with all its features and elements. The proposed educational publication highlights the fundamental problems of philosophy and methodology of science, such as the complexity and depth of the concept of "science", the diversity of its characteristics in the philosophical and scientific discourse, the opposite of the assessments of the nature of science, the directions of its historical development, the principles of scientific knowledge, its methodological and methodological problems. It is the presentation of the foundations of the philosophy of science was the task of the manual.

The course of lectures covers 7 topics distributed in four modules. Within the content module "Science as a social-cultural phenomenon" the main questions of the philosophical aspect of understanding the essence of science, its historical origin, the problem of development of the philosophical foundations of scientific research are analyzed. The material of the content module "Historical types of scientific rationality" characterizes scientific rationality as a philosophical problem, the concept of scientific tradition and scientific revolution, the problem of innovative development of science in modern society. The content module "Modern philosophical problems of social cognition" reveals epistemological models of modern scientific discourse, its specifics. The content module "Modern Philosophical Problems of Engineering and Technical Sciences" shows the analysis of the interaction of the philosophy of technology and the methodology of technical sciences, the identification of features of non-classical scientific and technical disciplines, examines the methodology of technical sciences and the actual problems of the philosophy of technology.

This tutorial is intended for graduate students and PhD candidates, as well as for anyone interested in the problems of the philosophy of science.

LECTURE 1.
PHILOSOPHICAL ASPECTS OF THE COMPREHENSION OF SCIENCE

1. The philosophy of science as a discipline and as one of the approaches of the philosophy: its main tasks and the subject of studying.
2. What is philosophy?
3. What is science?
4. Philosophy and Science: the complex of relationships between these two spheres of human cognitive activity

1. The philosophy of science as a discipline and as one of the approaches of the philosophy: its main tasks and the subject of studying

The philosophy of science is the division of philosophy, which studies the concept, boundaries and methodology of science. There are also more special sections of the philosophy of science, such as the philosophy of mathematics, the philosophy of physics, the philosophy of chemistry, the philosophy of biology, the philosophy of medicine.

Philosophy of science is represented by many original concepts that offer one or another model for the development of science and epistemology. It focuses on identifying the role and importance of science, the characteristics of cognitive, theoretical activity.

Philosophy of science as a philosophical discipline arose in response to the need to comprehend the sociocultural functions of science in the context of scientific and technological revolution. This is a young discipline, which manifested itself only in the second half of the XX century. While the trend, called "the philosophy of science," arose a century earlier.

The tasks of philosophy of science are:

1. Philosophical understanding of the phenomenon of science;
2. The inclusion of scientific achievements in the present socio-cultural context of the era;
3. Synthesis of philosophical and part-scientific knowledge.

The subject of the philosophy of science is general laws and tendencies in the development of science which is a system of knowledge, cognitive activity and social institution. Only the philosophy of science has such an apparatus (cognitive, logical, methodological) that allows us to determine the place and significance of science in human culture.

2. What is philosophy?

Quite literally, the term "philosophy" means, "love of wisdom." In a broad sense, philosophy is an activity people undertake when they seek to understand fundamental truths about themselves, the world in which they live, and their relationships to the world and to each other. As an academic discipline philosophy is much the same. Those who study philosophy are perpetually engaged in asking, answering, and arguing for their answers to the most basic questions. To make such a pursuit more systematic academic philosophy is traditionally divided into major areas of study.

Philosophy takes on the knowledge of the most general principles of the reality, the beginnings of the whole things in the world. It provides an opportunity to go beyond the limits of empirical experience, but it also emphasizes the fact that human cognition has its own limits.

Three Questions of Philosophy by Immanuel Kant

1.) what can I know?
2.) what should I do?
3.) what can I hope for?

The philosophical way of thinking is critically reflexive. Philosophy carries out the specific role of the world-view "sieve": as a rule, the most progressive thinkers question the outdated views, dogma, schemes of world-view, but besides, they try to keep everything invaluable, rational, true, in the deviant theories, to preserve all, that is valuable in them, in centuries.

Functions of philosophy:

1. world-view;
2. epistemological;
3. methodological;
4. informational and communicative;
5. value-orientation;
6. critical;
7. integration;
8. ideological;
9. educational;
10. prognostic;
11. projective.

The contradiction in the role of the philosopher lies in the paradox: on the one hand, he or she thinks in the context of that culture and that time in which he or she is living at the moment, but on the other hand he or she criticizes the old customs and traditions, because there is a need to divide what is generally accepted (public opinion), and what is "truly true" (knowledge). The philosopher puts the obvious (at first sight) aspects in doubt in order to "catch up" the true roots of these aspects.

3. What is science?

Definition. Science is the basic form of a systematic, constantly evolving and relying on the practice of cognition of the objective substantial connections of reality, which makes it possible to foresee events and acts as the basis for the expedient activity of people.

Science can be viewed from 3 main sides:

1.) as a system of knowledge and the form of social consciousness;

2.) as a specific type of social division of labor, as a scientific activity, as a social institution;

3.) as a sphere of practical application in real life.

Extreme points of view on the definition of science:

1.) science is an ordered system of knowledge;

2.) science is a specific method of cognition, science is the method by which doubt is cast out and stable ideas are achieved;

3.) science is an embodied mathematics = absolutization of mathematics.

2 polar points of view on the importance of science for the mankind:

1. Scientism (from the Latin "scienta" "knowledge", "science"): science can do everything and is an absolute blessing for humanity. The methods of mastering reality that have not received scientific status, in particular, all kinds of arts, as well as personal, emotional and evaluative ways of cognition are subjective by their nature, therefore they are not able to bring anything that is ever useful for understanding the world.

2. Anti-scientism: science is accused of all the troubles of mankind, considered as an absolute evil. One-sidedness of this approach is due to the inability to distinguish scientific knowledge from imperfect, erroneous or even criminal use of its results. The achievements of scientific and technological progress are axiologically (valuably) neutral, and therefore people are responsible for the consequences of the practical use of various results of knowledge, because they possess the spiritual freedom, they personally make a free choice of possible moral and immoral alternatives.

Science has a complex of its special fundamental aspects which allow us to distinguish science from all the others spheres of human cognitive activity.

Fundamental aspects of Science:

1. ontological aspects – the ideas about the picture of the world, the types of material systems, the nature of their determinations, the forms of the motion of matter, the general laws of the functioning and development of material objects adopted in one or another science;

2. epistemological aspects – provisions on the nature of the scientific process of cognition, the relationship of the rational and sensory levels of cognition, the status of theoretical concepts;

3. logical aspects – the accepted rules of abstraction, the formation of output and derived concepts and statements, rules of inference;

4. methodological aspects – provisions of the methods of discovering and obtaining real knowledge, ways of proving and substantiating the individual components of theory and theories;

5. value or axiological aspects – accepted statements about the practical and theoretical significance of science as a whole phenomenon or as a number of individual sciences, the aims of science, scientific progress, its links with social progress, the ethical aspects of science.

Key features of science that distinguish it from all other forms of knowledge:

1.) The desire to know the objective world.

Alternative point of views.

G. Rickert: "Cognition is not a reflection, but a transformation, and always is a simplification of reality." With this simplification, the main role is played by the teleological question: "For what? For what purpose?"

Neopositivism and the question of the scientific language. **R. Carnap**: "To accept the world of things means only accepting a certain form of language. The adoption of a material language leads to the acceptance and confirmation of certain assumptions and to belief in them. But the thesis about the reality of the world of things cannot be among these assumptions, because it cannot be formulated in a material language and, apparently, in no other theoretical language. A sentence claiming to affirm the reality of a system of objects is a pseudo-affirmation that is devoid of cognitive content. Adoption of any language framework should not be seen as implying any metaphysical doctrine concerning the reality of the objects under consideration. "

2.) Revealing the essential, most important aspects of all phenomena of nature, society, thinking – "production" and discovery of objective laws, according to which material phenomena operate.

B.M. Kedrov: "While the relevant laws are not discovered, we can only describe phenomena, collect and systematize facts, accumulate empirical material. But this is not science, in any case, not a real, developed, formed science: it cannot explain anything and cannot predict anything. " The legitimacy in science is a more or less exact coincidence of the conclusions of science and the essential, necessary links of reality. This is not just a formal logic, but a reflection of objective reality.

3.) Creation of a single logically harmonious system of knowledge about different sides of the surrounding world = *science is a knowledge which is brought into the system*. Moreover, this systemic character is a characteristic of the object itself = in its structure science only reflects the patterns that are observed in a real object. Such systematization is an adequate reflection, reproduction of the structure of the object in the structure of scientific knowledge about it. + Thanks to systematization, science acquires the form that is the most appropriate to its public tasks – the preservation and consolidation of knowledge, their transfer from one person to another, their using in practice.

4.) The possibility of prediction: on the basis of the allocated regularities and the systemic nature of the construction of science, the ability to predict the consequences of human activity, the tool for decision-making becomes possible.

G.V. Plekhanov: "*The future can be predicted by the one who understood the past.*" + the principle of the Cartesian method of the "fishing net", which allows to fill all the "white spots" in the unknown objects. This is a general pattern that extends to the logical series of objects and phenomena that we will be able to observe in the future (the principle of function).

5.) The active search character of science: since science is a reflection of the objective world, and the latter is in a state of constant change and development, it, naturally, must also constantly move forward, find new solutions and results. This does not abolish the old gains of science, but complements them, contributes to the creation of more detailed and integral theories. Any science exists not in a static state, but in a dynamic state, in the process of constant development and improvement of knowledge (the analogy is like the Sagrada Familia of Antonio Gaudi. "There is no reason to regret that I cannot finish the temple, I will grow old, but others will come after me." The spirit of work must remain, but its life depends on the generations to which it is transferred and with whose life it is connected ").

6.) Science tells people how to do what they want to do.

The division of science into "pure" – which operate with theories, explore methodology and are necessary for new discoveries – and "applied" – which are applicable in specific areas of knowledge – is very conditional.

B. Russell: "Pure sciences influence our way of thinking deeply, applied sciences influence our way of life ... These two branches of science are different in many respects and require different thinking abilities for their development".

This distinction is conditional, because "pure" sciences are simply more remote from the direct application of their results in practice, since they are engaged in the search and discovery of new regularities (theoretical physics, theoretical chemistry, etc.). Applied sciences are more closely associated with production, since they have the development of technic as their goal and finding the most rational and the most economically profitable ways of introducing the discoveries of "theoretical" science as their main aim = *all the achievements of applied science are based on theoretical science.*

Specificity of scientific knowledge. It is…

1. clearly expressed, shows the purposefulness of the cognitive process: from the very beginning the scientist has an idea of what exactly he or she is going to study and for what purpose he or she is going to study something.
2. planned: is carried out according to a certain plan;
3. systematic, with high level of organization;
4. armed with certain methods and tools of cognition.

All these features of scientific knowledge are inherent in other types of human cognition, but only in scientific knowledge they do exist all and in the most concentrated form.

Therefore, scientific cognition is the special kind of cognition which is the most purposeful, systematically organized and armed with special methods cognition of the human. The social role of science is very important and multifaceted: it is connected both with the progress of the productive forces of society, and with the spiritual culture of mankind, with the sphere of education and upbringing of future generations. In other words, the achievements of science depend not only on the level of production of material goods, but also on the development of the human and the main humanistic principles.

4. Philosophy and Science: the complex of relationships between two spheres of human cognitive activity

3 types of historical relationship between philosophy and science:

1.) the first set of knowledge of ancient people, which was called "philosophy" and appealed to the most diverse subjects;

2.) the specialization of knowledge, the formation of specific sciences. At the same time, the formation of philosophy as a special branch of knowledge took place;

3.) the formation of theoretical sections of a number of sciences, their gradual integration, synthesis.

According to Aristotle, philosophy is the doctrine of the first principle, the root causes, the most common principles of being. In the past philosophy had to construct a general picture of nature (natural philosophy) and society (the philosophy of history) blindly. Therefore, along with ingenious conjectures, the annoying misunderstandings were also conducted. *That is why the universal theoretical picture of the world should be built not by philosophy instead of science, but with philosophy and with science.*

The concepts of the relationship between philosophy and science:

1. The transcendentalist concept. It recognizes the cognitive priority of philosophy as the most fundamental kind of knowledge in comparison with specific sciences, the self-sufficiency of philosophy with respect to private-scientific knowledge and the dependence of particular sciences on philosophy. The main representatives: Aristotle, Thomas Aquinas, Benedict Spinoza, Georg Hegel, Friedrich Schelling. "*Philosophy is the science of all sciences*!" *There are some principals of understanding philosophy and science according to this concept:*

• Philosophy seeks to achieve an objectively true and demonstrative nature of its general provisions ("first principles", "axioms", rational knowledge). Private science, unlike philosophy, does not study the world as a whole one, but its separate fragments, so their truths are not based on a general nature of the world.

[Philosophy offers a method of superabsorption and abstract thinking, operates abstract concepts and models that are harmful for an everyday understanding of these generalizations, for binding them to the common, visible reality. And particular sciences "try on" these methods of generalized thinking for the visible, discrete reality, and with the help of these ideal concepts, reality can be organized much better and in more rational way].

• Because the world ("cosmos") is integral one, and the whole one always determines its parts, therefore the truths of philosophy are "higher" than the truths of particular sciences.

• The source of philosophical truths is thinking that is self-knowledge (Logos), whereas the source of particular sciences is empirical experience and its further logical processing through thinking.

2. The positivist concept: shows the priority of private scientific knowledge in comparison with traditional philosophy. *"Science is philosophy to oneself!" "Physics, be afraid of metaphysics!"* The main representatives: Auguste Comte, Herbert Spencer, John Stuart Mill.

The historical mission of philosophy towards science is ended: the child has matured; the pupil has surpassed his teacher. For concrete scientific theories, the only basis and criterion of their truth should be only the level of their correspondence to the data of the experiment, the result of systematic observation, measurements, experiment or statistical data.

A significant disadvantage of this approach is: under the same empirical data, completely different scientific theories can be brought – and all of them will be approached, including mutually exclusive ones. Also, the methods of empirical cognition do not give "pure" knowledge, it is still subjected to subjective distortion.

3. The antiinteractionist concept: shows the dualism in the relationship between philosophy and science, absolute cultural equality and self-sufficiency of each of them, the lack of internal communication and mutual influence between them. Philosophy appeals to the phenomenon of values. The close connection of philosophy and science only harms philosophy, because it leads to a substitution of the inner experience of the values that can only be comprehended and cannot be expressed by an external visual experience of knowledge. None of the value systems can become true for a person until it is directly experienced in his or her own unique experience. The main representatives: the philosophers which studied the philosophy of life (Henri Bergson, Friedrich Nietzsche), existentialism (Martin Heidegger, Sшren Kierkegaard, Jean-Paul Sartre, Albert Camus), the philosophy of culture (Wilhelm Dilthey, Georg Simmel).

4. The dialectical concept: shows that philosophy and science are qualitatively different, but internally interrelated types of knowledge, which actively use the cognitive resources of each other. From the point of view of the knowledge of reality as a whole one, both philosophy and particular sciences are equally one-sided parts of the whole knowledge. Objective reality as a whole one is indifferent to the methods of human cognition, it is the unity of the general, the particular and the individual aspects. The general aspects exist only through the singular and the particular aspects, and the singular and the particular aspects exist only as a single and a special manifestation of some general aspect. Therefore, an adequate cognition of reality as a whole one still represents the highest theoretical and practical task of mankind, requires a complementary relationship between the results of philosophical and particular scientific knowledge. Between the empirical and theoretical levels of knowledge, there is an indirect connection which leads through an empirical interpretation of the theory.

With the help of its categorical apparatus, philosophy reflects the real unity of all kinds of human activity in a specific form, realizes the theoretical synthesis of the whole existing culture. In depicting this unity, philosophy is the self-consciousness of the age, its spiritual "quintessence."

What philosophy can offer to science?

1.) the function of prevision, the formation of hypotheses about general principles, development tendencies + *primary hypotheses about the nature of specific phenomena*, which have not yet been worked out with socio-scientific methods. On this basis we can observe "sketches" of certain natural or social realities, which are worked out by science then. Philosophy allows you to think in fundamentally concessive, logical, theoretically possible way. Thus, philosophy contributes to the correct formulation of scientific problems;

2.) *the solution of characteristic problems*, contradictions which arise at the border of various industries, levels, sections of science in their "docking". General science and the theoretical and cognitive basis of science are fulfilled in philosophy;

3.) *science does not substantiate itself in a value relation*. Science is not self-sufficient: it needs a value justification; it cannot serve as a universal spiritual guide of human history. Critically analyzing the different systems of philosophical views, we should not immediately "sweep off " the one that seems false to us from the first sight. It is necessary to be able to see and to share the most valuable ideas, views, approaches in it.

Therefor, **the scientific-philosophical worldview** is such a system of understanding the world and the place of a human in it which relies on science, corrects and develops together with science, and produces an active influence on the development of science itself.

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LECTURE 2.
SCIENCE IN THE HISTORY OF PHILOSOPHY

1. The roots of science in ancient times: Ancient China, Ancient India, Ancient Greece
2. The principles of cognitive activity in Middle Ages, in Renaissance, in the Modern Times and in German classical philosophy
3. The XIX and XX centuries in the development of science
4. Modernity in the development of science

1. The roots of science in ancient times: Ancient China, Ancient India, Ancient Greece

Mythology: we need to influence the nature of things through the rituals. We change the world and adapt it to ourselves with the help of magic.

Science: we also have a motive to "crush" the world for ourselves, to adjust it to our needs, but the tool is completely different to learn the nature of things, the laws by which things act.

Ancient China, India, Greece: science is in its nascent state and is in the hands of philosophers. Natural philosophy is the first stage of philosophical search, which is aimed at elucidating the question of what substance the world consists of.

1.1. Ancient China:

The first principle of being is the will of the sky. Sky is called "Tien". The sky is the common progenitor and legislator of the hierarchy. Therefore, it is important to maintain common rules.

Confucianism. Confucius (551 – 479 years BC). Prominent books: "Shi Jin", "Lun Yu", "Li Ji".

Li is "rule", "ceremony". "Where there is no lie, there is no difference between the ruler and the subjects, the upper and the lower, the old and the young. Li is the established order of things ".

Taoism. Lao Tzu (579-499 BC) The prominent book is called "Tao de ching" ("Path of charity"). Tao is an outgrowth, the Great Single, boundary reality. Tao is eternal and has no name, it is unbodied and doesn't have forms, it is inexhaustible and infinite in motion, it is an ancestor of all things.

Mohism Mo-tzu (468 – 376 years BC.). The prominent book is called "Mo Tsi". Mohism provides reflections on the categories of being, space and time, causation, etc. Cognition is the process of disclosure of causality, the identification of common features and differences in phenomena, division of things by their nature.

3 rules of verification of knowledge: 1.) the "basis" is the experience and judgments of ancient sages; 2.) the "source" is the facts that have been heard and seen by commoners; 3.) the "applicability" is a practical benefit. Mohism opposed Confucianism. Mohism developed natural sciences, engineering, mathematical problems.

Feature of the process of cognition in Ancient China: the Chinese philosophers did not operate the concept of "contradiction" (without which it is impossible dialectics), but they used the concept of "opposition". Two energies yang and yin male and female – start the world. All subjects are the result of a combination of yang and yin energies, and their qualities depend on the proportions and the location of the yang and the yin in the subject. The numerological methodology was used: the basis is numbers 2, 3 and 5: Number 2 symbolizes the energies yang and yin; number 3 symbolizes heaven, earth and human; number 5 symbolizes five elemental elements. In Ancient China 2 directions of knowledge of reality were actual – numerological and proto-logical ones.

1.2. Ancient India

There were numerous philosophical doctrines and understanding of the world and corresponding philosophical schools. *There were two main direction of philosophical thought in Ancient India:* the schools of **astika** (**darshan = orthodox schools**) recognized the authority of Vedas, the schools of **nastika** – didn't recognize the authority of Vedas.

Astika	Nastika
1., 2. Vedanta + Mimansa are the closest schools to Vedas. The purpose of human life is to overcome a number of reincarnations and to merge with atman and brahman. Brahman is the only thing that exists and non-exists at the same time; it is not involved in the world of natural transitional forms. Brahman defines the order of things, acts as a force that stands above the human. ? deprivation of personality + path of purely individual salvation. Atman is a real and eternal set of material elements and souls that obey the law of karma. ***But!!*** **Vedanta** presents the recognition of the only monistic god - Brahman. **Mimansa** presents the denial of the idea of the supreme god and creator	1. **Buddhism** is the world religion, moral and ethical doctrine with significant philosophical impregnations. Life is a suffering; it is caused by desires of people. The degree of regulation of them is the eight-step path of moral perfection: 1.) the right understanding, 2.) the right aspiration, 3.) the right thought, 4.). the right speech, 5.) the right action, 6.) the right life, 7.) the right efforts, 8.) the right concentration. In this way, nirvana is reached – it is the state rest, which stops samsara - the infinity of births. Buddhism denies the substantive model of the world, considers being as a process, as a continuous formation. All things consist of material and psychic elements - dharmas, which are

Astika	Nastika
= the world does not have its root causes. 1. **Vaishesika** - recognizes 9 substances: 1.) earth, 2.) water, 3.) light, 4.) air, 5.) ether, 6.) time, 7.) space, 8.) soul; 9.) mind. 1 to 4 consist of atoms. The atoms differ in quantitative and qualitative terms. As a result of their combination and unification, which is guided by the world soul, things arise and disappear. Atoms (*unlike the doctrine of the ancient Greeks!*) form the moral image of the world, implement the moral law - the so-called dharma. 4. **Sankhya**: the basis of the world is a matter (pracrity); Atman is the principle of individuality and spirituality. Dualism is recognized in a non-manifested pracrity, which has non-defined elements - the Huns. At the same time there is purusha - pure spirit. 5. **Nyaya**: the main attention was paid to the theory of cognition, logic, it deduced the doctrine of syllogism. The world consists of eternal small particles of "anu": water, earth, air and fire. 6. **Yoga** is a set of rules for regulating of the physical and mental processes of a human, through which supposedly comes an insight and reveals the truth.	constantly in the state of being and non-being and ripples between these states. On this basis, Buddhism denies the existence of soul as a separate entity. 2. **Jainism** - arose simultaneously with Buddhism, has common reasons for it. Believes that samsara can be interrupted by ascetic life. 3. **Charvak-lokayat** - the only materialistic school of Ancient India. The basis of the world is recognized in 5 elements: water, fire, earth, air, sometimes - ether. Each of them consists of its atoms, which are indestructible and immutable. (that is, the world soul does not control them!) Denies the Vedic doctrine of karma and samsara, the existence of God and soul. A departure from the established traditions of ancient Indian philosophy.

The forms of cognition

Argjanavada = agnosticism	**Pravanavada** = there is a certain toolkit in the cognition
Cognition of the world is impossible: the elaboration of schemes that can be refuted by any statement (analogy with Sophists)	The doctrine of the ways for achieving knowledge. 1. Sankhya: 3 prayanas: perception (pratyaksha), logical inference (anuman), testimony of authority (sabda) 2. Nyaya: perception (pratyaksha), logical inference (anuman), testimony of authority (sabda) + comparison (upamana) 3. Mimansa: perception (pratyaksha), logical inference (anuman), testimony of authority (sabda) + prediction.

The principles of cognition

Realistic	Unrealistic
All schools except **Buddhism.** The external world is known in its true reality. The external world is causal, and it can be fixed by sensory organs. It is possible to know the world and intelligence, reason, but it is the secondary knowledge, and it is more appropriate to people. Especially viewed in **Nyaya** and **Vaishesika** (atomists).	**Buddhism.** The real nature of things is not the subject of causal relationships, and therefore it is outside the world of phenomena, it is in the area of eternal, immutable entities.

1.3. Ancient Greece

Ancient Greek natural philosophy poses the question, from what, from which substance the world arose. According to ancient Greek sages, this substance is…

Thales – water.

Anaximenes – air.

Anaximander – apeiron – infinite.

Heraclitus – fire.

Pythagoras the basis of all things is the number.

Democritus – at the heart of all things are atoms, between which there is emptiness.

Philosophers-Eleatic (Eleanian Philosophical School):

Parmenides: being is something you can think about. Nothing from what we see, feel, does not really exist, there is only an invisible world, because there are no contradictions in it.

Xenophanes, Zeno – isolated the notion of being. Being is immutable. Sensual experience is illusory. The aphoria of Zeno ("aporiyas" – "complications", "hopeless position") – logical paradoxes, in which we can see the rudiments of dialectics. Thinking is the ability to comprehend unity, but through the senses the multiplicity is comprehended, but it is only the plurality of heterogeneous signs of the whole.

3 postulates of the Eleatic:

1.) being exists, and non-being does not exist;

2.) being is one and indivisible;

3.) being is cognized, and non-being cannot be cognized.

The key sign of being is measure! The thing that is perfect is bound to be limited in size, may be large, but not infinite.

At this stage in the development of philosophical thought, ingenious scientific conjectures are observed, for example, the doctrine of atoms. In the course there is the dialectical method – the construction of a conclusion from the principle "from the *general to the private". However, science has not yet separated from philosophy and is only its peculiar branch. There is also no developed epistemology – the science of knowledge.*

2. The principles of cognitive activity in Middle Ages, Renaissance, in the Modern Times and in German classical philosophy

2.1. Middle Ages. Patristic and scholasticism as the main philosophical schools.

Patristic: The Holy Scripture can answer all questions, including the questions according to the surrounding world and the principles of its cognition + the authoritative opinion of the Holy Fathers who are guided by the Holy Spirit, and He, in turn, explains to them all (or almost all) difficult questions.

Scholasticism: makes theological knowledge as systemic and dogmatic one. ***The main principle of dogma:*** 1. The authority of the church and the authority of the Holy Scripture is correct; 2.if it is quoted, interpreted and supplemented by the second "researcher", the second "researcher" is automatically right, because he referred to authority of the Holy Scripture; 3. if a third "researcher" begins to quote and supplement the second "researcher", he is also automatically right – and even more – because his thought is reinforced by two authorities. *Thus, the probability of a system error in cognition is great, it can be fixed and so becomes a dogma.*

Undisputed authority for the scholastics was originally Aristotle and his doctrine of form and matter, which was then re-traced in the spirit of the Christian religion (Thomas Aquinas, for example). However, the doctrine of Aristotle reached Europe in the translation of the Arab sages (that is, it was not already in the original).

Scholasticism produced a huge number of works and treatises. It was also marked by the emergence of the first universities. The principle of university autonomy is the first precedent of the independence of science from the views of the church. In the European university there was formed the faculty of art in the system of which the discipline of philosophy was present. The faculty of arts was often in disgrace, different vanguard points of view were formed (Thomas Aquinas, Erasmus of Rotterdam "Praise of human stupidity").

The main key points in the system of cognition in the Middle Ages:

- Traveling teachers.
- Knowledge is elitist.
- The workshop system, including the universities.
- Discussion about realism and nominalism. (Realism: shows primary general concepts about things. Nominalism: shows the primary things as objects, focuses on experience).

The appearance of realism and nominalism in the philosophical discussion means another step towards the formation of science and its separation from philosophy. On this stage of the formation of science we can see the disengagement of the subject and the object of cognition. And still dialectic acts as a general method of cognition.

2.2. Renaissance. *The main key points of cognition in this historical period:*

- Science as another facet of human self-improvement.
- Partly serves the art or is perceived as a specific kind of art.
- But still science is not completely separated from philosophy.

2.3. The Modern Times. *The main key points of cognition in this historical period:*

- The doctrine of substance (Substance is something self-sufficient and self-determining, from which the world comes. Substance is always the *self-determined* one.). Substance must be studied with empirical orientation to empirical experience ≥ the emergence of scientific methods of *observation and experiment.*
- The appearance of the method of induction.

Francis Bacon: brought the revolutionary changes in the methods of cognition. In nature, there are causal relationships, and from them, if we also use the systematic observations, general conclusions can be drawn. But the built-in stereotypes of cognition, which exist in the human psyche (the so-called idols or ghosts), are not very conducive to the induction method. These are stereotypes that make it difficult to see the world objectively, to see it as it is.

Rene Descartes: provided the doctrine of a single method in scientific cognition. It is a method by which one can fill almost all "white spots" in our knowledge of the world. The scientific method is a specific function that describes all the points on the graph that fit into it (there are points that are the discoveries we have already made and those points about which we do not know anything yet and yet have not encountered in our experience). But the starting point of this chart is point 0 "I think, therefore I exist." This is the only truth in which a person can be sure in any occasion, under any circumstances.

- The method of scientific experiment ≥ the first scientific laws.
- Classical mechanics (based on the law of universal gravitation of Newton). Gradual division of science into various spheres.
- The emergence of scientific methodology.
- The main emphasis is made on the study of the object the substance, the surrounding world.
- The spreading of education in the masses of people; knowledge is still elitist but it is no more the privilege of priests.
- Absolutizing of the role of science for human and society. Science is needed in order to subjugate nature so that human gets maximum benefit from it. Knowledge must be as specific as possible, it must be also mathematical, measurable.

2.4. German classical philosophy. *The main key points of cognition in this historical period:*

- Is interested in the subject of knowledge – in a common person ≥ we can observe the increased interest in history as a science, because it focuses on a person and large masses. + A great interest in literature and art. They are considered more advanced than mathematical, exact science.

• The emergence of Hegel's dialectic as a universal method of cognition, the unfolding of being and human thought.

In connection with the development of science and the acquisition of human power over nature questions of human morality raise. Disproportion between intellect and morality. Philosophy thinks about how moral science can be incorporated into scientific knowledge. There is an understanding that no science or theory can give absolute knowledge.

3. The XIX and XX centuries in the development of science

Marxism: scientific knowledge is "extracted" from human practice.

3.1. Positivism. The development of science is the main orientation in the prospect of the Western civilization. The main question is: what kind of knowledge is considered as the true one, and which one is false? Positive knowledge is such knowledge, which can always be found in correspondence with the sensory experience. If we claim that there is something that cannot be explained from our sensory experience than it should be removed from the scientific circle of discussion.

The observation and sensory experience are the main criterion of scientific knowledge. If philosophy is a science, it must rely on positive knowledge. The non-positive knowledge is called metaphysics. Language is the reason for the emergence of metaphysics. The language analysis is an important factor in getting rid of metaphysics.

Auguste Comte is the founder of positivism and sociology. Philosophy should refuse the question "why?"but should answer the question "how?" He based on classical mechanics. Shifts in classical physics showed that the principles of classical physics are not universal.

Periodization of society development (according to Auguste Comte):

1. Theological level – the main root of the thought is religion, the main pusher of society's life is faith in God:

2. Metaphysical level – at the beginning of the Renaissance (17th-18th centuries);

3. Positive level – the orientation on scientific knowledge, sensory experience, logical reasoning.

Herbert Spencer Biology is an example of science. The whole world and any object in it is an organism. The idea of the development of reality: the development of being is a result of differentiation, the division of individual elements into quality, properties, which form a new, more organized object.

Positivism gave birth to **psychology** which soon became one of the most important disciplines in the scientific discussion.

Positivism also gave birth to empiriocriticism and machism. **Machism and empiriocriticism** were at the root of a specific type of philosophizing.

Empiriocriticism: provides critiques of sensory scientific experience. Within the limits of human experience, there is no clear boundary or fundamental difference between the physical and the mental: in one case, the complexes of feelings relate to the world which is outside of us (and act, for example, as atoms studied in physics), and in the other case complexes of feelings relate to our body (and act as a feeling that is in interest of physiologists).

Richard Avenarius (1843 – 1896): tried to escape from the ghosts of "subjectivism," by creating the concept of "neutral elements of experience," which are devoid of extremes as subjectivity and objectivity. "We came to the conclusion that every being in its own content should be conceived as a feeling, but in its form it should be conceived as a movement."

Machism: proceeds from the thesis of the relativity of our knowledge.

Ernst Mach (1838 – 1916): all the laws of classical science are not laws of the objective external world, but are the laws of our psyche. He provided the special discipline – the psychology of sciences. Also he restored the concept of agnosticism.

3.2. Neo-positivism. The founders are **Moritz Schlick** (1882–1936) + **Ludwig Wittgenstein** (1889– 1951) + **Bertrand Russell** (1872–1970).

The only sensible data object that science deals with is the language by which the behavior of astrophysical and quantum phenomena are described. Science produces its own language – the artificial language. Each icon of the language must correspond to reality (condition). The subject of philosophy is the analysis of the language by which we describe reality. We need to describe this language in order we want to study it like the special phenomena. We need to create an artificial language number 2 to describe the artificial language number 1, artificial language number 3, to describe the artificial language number 2, and so to infinity. The human world is formed under the influence of an already existing language. Neo-positivism is also called the linguistic philosophy and the logical positivism (identical but shaded by different aspects). The theory can be true in case if its provisions do not contradict each other.

3.3. Postpositivism. The main figures are **Carl Popper** (1902 – 1994), **Thomas Kuhn** (1922–1996) and **Imre Lakatos** (1922–1974). **Postpositivism** appears in 40–50s of the 20th century. The founder is **Paul Feyerabend** (1924 – 1994). Science is influenced by non-scientific factors. Scientific knowledge cannot claim absolute truth, as other forms of knowledge (religion, moral and ethical knowledge, everyday knowledge) are also true.

Carl Popper: the prominent book is "Logic and growth of scientific knowledge". Popper tries to eliminate the disadvantages of the inductive method. Proposes to supplement the principle of verification of the theory (verification in practice) by the principle of falsification (creating any theory, the scientist should outline a range of facts that could refute this theory). e" Value of knowledge and ignorance in science.

Thomas Kuhn: the prominent book is "The Structure of Scientific Revolutions". He provided the term "scientific paradigm" which is a set of research methods, a way of analyzing of the reality, it is inherent in a certain stage of the development of science. But one should not accept the cumulative effect (new knowledge is accustomed to the old ones). It is impossible to compare paradigms: new knowledge and new paradigm has essentially different properties than the old one.

Imre Lakatos is the author of the theory and methodology of research programs. The theory of Lakatos is aimed at studying the driving factors of the development of science, it continues and at the same time challenges the methodological concept of Popper, polemicises with the theory of Thomas Kuhn.

Lakatos described science as a competitive struggle of "research programs". The research program consists of a "rigid core" which is a priori accepted in the system of fundamental assumptions and cannot be disproved inside the program; also the research program has a "safety belt" of auxiliary hypotheses ad hoc, which mutate and adapt to counterexamples of the program. The evolution of a specific program is due to the modification and refinement of the "safety belt", the destruction of the "hard core" theoretically means the abolition of the program and the replacement of it by others, which have won the competition of justifying by the reality.

The main criterion of the scientific nature of the program by Lakatos is the increase of the actual knowledge due to predictive power of this research program. While the program gives an increase in knowledge, the work of the scientist within its framework is "rational". When the program loses predictive power and begins to work only on the "belt" of auxiliary hypotheses, it is better to abandon its further development. However, it is pointed out that in some cases the research program is experiencing its internal crisis and then gives scientific results again. Thus, the "fidelity" of the scientist to the chosen program, even during the crisis, is recognized as "rational" by Lakatos.

The common and the different in the theories of Carl Popper, Thomas Kuhn and Imre Lakatos:

The common: We tried to show the process of development of scientific knowledge. **The difference:** ***Popper:*** scientific knowledge develops at the expense of internal human potential. ***Kun and Lakatos***: scientific knowledge is influenced beyond non-scientific factors (religion, art, morality). In the history of the development of science there were periods in which there were common principles of scientific research, postulates, there were different types of scientific rationality. These are called scientific programs.

3.4. Phenomenologia. At the same time there was the special approach that denied the role of the language in the development of science. At the beginning of the 20th century, the issue of psychology was relevant to science. All natural sciences are based on observation, that is, they depend on the psyche. e" The point of view according to which psychology is the head of all sciences. This problem was solved in such a way as to find certain steady, intersubjective connections in the human psyche. In the psyche there are phenomena – the deepest constants of the psyche, which correspond to intersubjectivity, deprived of layers, which allow a person to know the truth. In order to grasp the phenomena, phenomenological reduction is necessary. The 1st step is to remove the word we call this subject. Language prevents to know the truth. The 2nd step is to abstract from the sensory impressions of this subject. The 3rd step is to abstract from the subject at all. The phenomenon is a certain impression of the subject, without thought. This approach votes for spontaneous flow of consciousness. The phenomenon is the foundation of being. Consciousness is inherent to intentional being (the direction of consciousness on something is the intention). Due to the intention there is an object. The object is the result of consciousness, internal human activity e" so we can speak about intentional object.

3.5. Philosophical hermeneutics: the term arises from the name of God Hermes (Mercury), the messenger of the gods. Hermeneutics means the "art of interpretation". Hermeneutics occurs in the early 20^{th} century in the works of Wilhelm Dilthey as a philosophical discipline. In this discipline arises the phenomenon of manticus – the art of prediction, divination. Hermeneutics solves the problem of translating texts of Sacred books (Veda, Bible). Translation is an interpretation to some extent. In the interpretation of Scripture, the main tool is the presence of the Spirit of God in translation.

But before Wilhelm Dilthey there was **Friedrich Schleiermahrer** (1768 –1834) who raised the question of the general theory of the interpretation of the text.There are several levels of interpretation of text:

1. grammatical level of interpretation – the objective interpretation;
2. psychological interpretation – the awareness of the motives of the author of the text, which are not written in the text themselves. "The interpreter must know the text better than the author himself." The interpreter must be congenial (the same genius as the author). The problem of the hermeneutic circle that arose as a result of the analysis of the interpretation process reveals contradictions between the part of the text and the whole of this text. In the classical theory of hermeneutics, there was a belief that the interpreter can adequately understand the author's opinion.

At the end of the 19th century, **Wilhelm Dilthey** (1833 – 1911) formulates the principles of philosophical hermeneutics. Before Wilhelm Dilthey there believed that interpretation, understanding is peripheral in human abilities. **W. Dilthey:** human nature is the ability to interpret reality; extends the idea of a text which is not just a written language, but any phenomenon of reality (biological, physical, chemical). The phenomenon of understanding is the process of interpretation, in the opposite side of which it is knowledge. Understanding is the intuitive process, while knowledge is the rational-logical process, although these processes are interrelated.

2 types of sciences according to Wilhelm Dilthey:

1. science of nature is the explaining science, answer the question "Why?", "What is the reason?", formulates laws, use appropriate methods of research: generalizing (concurrent) methods (analysis, synthesis, induction, deduction);

2. science of the spirit (about a human, society, human psychology), the main drawback is the methods of natural sciences which are unjustifiably transferred into the science of the spirit. The core of the methods of sciences of spirit (individualizing methods) is understanding. Every phenomenon of the human spirit is unique and individual one, therefore generalization is unacceptable here. *Empathy is the ability to identify yourself with the subject.*

20^{th} century in hermeneutics is marked by the appearance of **Hans Georg Gadamer** (1900-2002) and **Paul Ricker** (1913, 2005). The prominent book by H. Gadamer is "Truth and Method". There was formulated the problem of the interpreter and the author of the text: in fact, the interpreter uses the author's text for not to find out what the author wanted to say, but to express his own ideas through the author's text. *The absolute truth cannot be found. The paradigm is postmodern.*

4. Modernity in the development of science

Transhumanism (from Latin "trans" "through", "for" and "homo" "person") is a philosophical concept and an international movement that supports the use of science and technology to improve the mental and physical capabilities of a human in order to eliminate those aspects of human existence that transhumanists consider undesirable – suffering, disease, aging and death. Human accentuates attention, studies and transforms himself. Gradual approximation of the subject and object of knowledge. In principle, there is a process which is analogous to the primary syncretism of the subject and object – as in mythology, from which everything began, but at a new level. Thus, we can see the dialectic in action and the law of denying negation – the unity of the scientific subject and object in the course of the historical process and the departure from magic is divided into separate subject and object of cognition in order to re-unite again.

The question arises: *perhaps the way out of the oncoming crisis of scientific cognition, its fixation on human needs and interests lies in a similar dialectical process – the next division of the subject and object of cognition, but already – at a new level and a spiral of the development of science. But what kind of turn it will be and how exactly the subject and object of cognition will be again separated from each other – all these questions are a matter of our scientists. Or rather – the matter of each of you ...*

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LECTURE 3.
THE PHILOSOPHICAL BASES
OF THE SCIENTIFIC RESEARCH

1. Science as the systematic cognitive activity
2. The main features of the concept "method", its basic characteristics and its main species
3. The main features of the concept "methodology", its basic characteristics and its main species
4. The main principles of interaction between scientific disciplines as the multimethodological level in science
5. The special role of philosophy in the process of determination of the methodology in science

1. Science as the systematic cognitive activity

A characteristical feature of modern science is the growth of the role of methodology in solving problems of the development of specialized knowledge. The unity of the general scientific and philosophical levels lies in the heart of the methodology of science as the core of the philosophy of cognition.

Science should be considered not only as a collection of theoretical knowledge of the reality, but also as a special type of spiritual production – **the production of systematic knowledge**. Scientific knowledge is a form of knowledge, the main function of which is the creation and theoretical systematization of objective knowledge of reality.

Scientific knowledge as a relatively independent, purposeful cognitive activity is a complex multicomponent process that encompasses:

1.) **cognitive activity** of specially trained groups of people who have attained a certain level of knowledge, skills, understanding, developed relevant philosophical and methodological settings for their professional activities;

2.) **objects of cognition** which may not coincide directly with the objects of production activity, as well as practices in general. The object of cognition is a certain phenomenon of reality;

3.) **subjects of cognition**, which are determined by the objects of cognition and are manifested in certain logical forms. The subject of cognition is the phenomenon of reality in conjunction with the angle of view under which it is considered by the scientist.

However, scientific knowledge encompasses not only methods and means of cognition, but also the logical forms of cognition and linguistic tools. However, concepts, theories, scientific hypotheses, etc., are not only the result but also the forms of scientific cognition, aimed to achieve true (reliable), systematic knowledge which is capable to explain phenomena, to predict their possible changes and to be able to be applied practically. **Thus, scientific knowledge solves well-defined tasks which are determined by the goals of cognition and, which, in turn, are determined by the practical needs of society and by the needs of the development of science itself.**

Such forms of cognition as concepts, judgments, inferences, do not reflect all the specifics in scientific knowledge. For this purpose the forms and tools of cognition such as fact, problem, hypothesis, concept, theory, idea, etc. were formed and acquired relative independence in the methodological arsenal of science.

Subject activity involves both theoretical actions, intellectual activity aimed at setting the task, solving the problem, etc. ***However, theoretical knowledge is not limited on the operation with abstractions, concepts, categories, principles, etc.*** Theoretical activity of scientists, if it is successful and effective one, should be based on practice, experiment, observation, because they provide empirical data to researcher.

2. The main features of the concept "method", its basic characteristics and its main species

The term "method" comes from Greek "Metodos", which means "way of research", "theory", "doctrine". The method is a tool of achieving any goal, solving a specific task; a set of techniques or operations for practical or theoretical mastering of reality.

In modern science quite a successful multi-level concept of methodological knowledge is functioned. In this regard, the methods of scientific knowledge can be divided into several main groups according to the degree of universality and the field of activity:

1. Philosophical methods, among which **dialectical and metaphysical methods** are the most general and historically first ones. They also include **analytical, intuitive, phenomenological, hermeneutic methods**, and other ones.

2. General scientific methods (approaches) of research, which have received wide development and foundation in the science of the twentieth century. They act as a kind of intermediate methodology between philosophy and the fundamental theoretical and methodological provisions of special sciences. General scientific methods often include such theoretical constructions as information, model, isomorphism, structure, function, system, element, optimality, etc.

3. Regional methods of scientific research – cognitive tools that are used within each of the three major sets of sciences – natural sciences, technical disciplines, social and humanitarian sciences. They have a complex hierarchy.

4. Specialized methods of research from separate sciences.

Accordingly, the term "methods" ("technique") specifies the specific principles, forms and means of using the methods by which a deeper knowledge is carried out. In comparison with the methodology the method solves tactical problems – it develops certain algorithms of research activity in specific conditions, with a specific object, using a certain system of tools, etc. It contains a description of a set of methods, systems of methods and means that are used to study phenomena. **The method answers the question: "How, in what way we should organize and conduct our research?"** Its main function is the organization of the research itself.

Therefore, the methods should have the following characteristics: correctness, reasonableness, cost effectiveness, optimality, control over research manipulation and compliance with the conditions and rules for conducting scientific research, documentation, tables, etc.

In the science of the twentieth century such scientific methods have widespread:

- systemic method;
- structural-functional method;
- cybernetic method;
- probabilistic method;
- the method of modeling, etc.

The main generalized methods of scientific cognition

1. methods of empirical research;
2. methods of theoretical research;
3. methods that can be applied both at the theoretical and empirical levels of scientific research;
4. Sometimes there is distinguished a metatheoretical level of research – "the theory of theory".

1. Empirical research is based on direct experience, while **the theoretical level of scientific research** involves the generalization of experience, social practice, the allocation of the most essential properties of a large number of individual real objects and the construction of a special, theoretical world, in which we can observe objects that are largely idealized. **The difference between the empirical and theoretical levels of scientific cognition can be defined in such way: in the empirical level of cognition we can observe phenomena and relationships between them, in the theoretical level of cognition we study the essence of phenomena in its pure manifestation** (therefore, the theoretical level of cognition is a higher degree of logical generalization of the set of phenomena and the allocation of the most essential properties of them). Objects of study can be the same in both cases, but the vision of these objects is fundamentally different in nature and depth. The theory is far from the last degree different from the empirical level of cognition by the fact that it considers relevant objects in a rationalized context. **The theoretical level of cognition creates a special theoretical world.**

The empirical and theoretical levels of scientific cognition are organically interconnected: on the one hand, without the preliminary accumulation of empirical material there is impossible to construct the theoretical explanation; on the other hand, the theory appears as the prerequisite for the certain knowledge and determines the direction of the search for new empirical data.

The main methods of the empirical level of scientific knowledge are **observation and experiment.**

1.1. Observation is a systematic purposeful perception of subjects and phenomena of reality by scientists in order to obtain certain knowledge about them.

Observation as a method of cognition must meet the following requirements:

• it must be thought in advance – must be conducted for a certain, clearly defined task;

• it must be planned – is carried out according to the plan that is drawn up in accordance with the task of observation;

• it must be purposeful – there are observed only certain aspects of the phenomenon that are of interest in the search;

• it must be active – the observer actively searches for the interested objects, features of the phenomenon;

• it must be systematic – the observation is carried out continuously or according to a certain system.

But at the same time the observer should not interfere in the vital process of the object that he or she observes!!! It does not aim at any change in the researched object. The main thing is adequate perception of the object as it is in itself, regardless of the person who examines it. Therefore, observation gives the opportunity to get initial information about the object of research in the form of a set of empirical allegations.

Observations are often combined with research methods such as **comparison and measurement**. During the use of these methods the object of the research is compared with the standard in which a certain physical unit is implemented, and thus a quantitative estimate (height, volume, temperature, etc.) of the object of research is formed.

1.2. Comparison is one of the most common methods of cognition, the process of establishing similarities or differences between objects and phenomena of reality, as well as finding common, inherent features in two or more objects.

Comparison must meet the following requirements:

• it is possible to compare only those phenomena between which there is a certain objective community;

• comparison should be carried out on the most significant, most important features (within the specific cognitive task).

Using the method of comparison, you can get information about an object in two ways:

1. direct comparison result – primary information;

2. the result of the processing of primary data – secondary information.

The most widespread and the most important way of such processing is inference by analogy. Objects or phenomena can be compared directly or indirectly by comparison with any other object – a benchmark. In the first case, qualitative results are obtained – more or less, higher and lower. Comparison of the same objects with the standard provides an opportunity to obtain quantitative characteristics. Such comparisons are called **measurements**.

1.3. Measurement is a procedure of determining the numerical value of a particular value using a unit of measurement. The value of the measurement is that it gives accurate, quantified information about the object. While measuring the following basic elements are required: object of measurement, standards, measuring instruments, measurement methods.

However, the method of observation is not always accompanied by comparisons and measurements. **But the description of observations is always required!** In the description of the object its detected characteristics and the results of its observation are recorded.

1.4. In contrast to the observation, the experiment involves the active intervention of the researcher in the course of the processes of the researched phenomena.

Experiment (from the Latin – "experimentum" "attempt", "experiment") is a method of active empirical research, which consists in the intervention of the scientist in the course of the known phenomena and processes by creating conditions that allow to identify certain connections of phenomena and repeatedly reproduce them. **The key features of experiment:**

• the object is trying to be researched in "pure form", which eliminates all external, undesirable effects;

• the phenomenon can be reproduced as many times as necessary (observing each phenomenon of reality is unique, and it can be observed only once);

• unlike an observer, a researcher-experimenter can systematically change the conditions of the process and separately investigate its dependence on each of them.

Experiment is a method of scientific research that requires more specialized and complex equipment than the method of observation. This is especially true of a laboratory experiment.

Types of Experiments:

• laboratory experiment – a scientific laboratory is needed in which the investigated processes are reproduced and they are analogous to those ones that occur in real life

• manufacturing experiment – the production is the necessary base for this experiment, and not only the material components but also the organizational forms of the production are needed;

• field experiment – takes place in natural conditions of the environment where the object exists;

• imaginative experiment – the researcher performs certain operations with the object not in reality, but only in his or her mind, in his or her imagination, trying to predict the results;

• experiment in social sciences – can be occurred in special social conditions and for certain social aims which involve determined masses of people.

2. Theoretical methods of research

First of all, the theoretical research actively uses general methods of cognition, such as analysis and synthesis, induction and deduction, abstraction and concretization, generalization and limitation, analogy. All of them are peculiar to the thinking of any person, at all the levels of knowledge of the world from the simplest, everyday knowledge.

That is the way science uses and improves all that is available in pre-scientific means of rationalization.

2.1. Analysis is the method of thinking, when we decompose the object which is under investigation into component parts and blocks; **synthesis** is when the previously selected parts are connected.

2.2. Abstraction is the process of mental production of properties of interest of scientist.

2.3. Specification (from the Latin "concretus" – "thick", "solid") is a method of researching objects in all their versatility, in qualitative versatility of real existence, in contrast to the abstract research of objects. In this case, the state of objects is researched in connection with certain conditions of their existence and historical development.

2.4. Generalization is a basic element of human logic and reasoning. The generalization takes one or more properties which are common to 2 or more objects, as the basis for the existence of a plurality of their elements. This is the basis of deductive reasoning. It is necessary to use the verification process to determine the accuracy of generalization in each individual situation.

2.5. Limitation is a logical operation, which lies in adding a new feature to the content of the concept.

2.6. Idealization is an imaginary procedure, the result of which is the common concept: a point, a straight line in geometry, a material point in mechanics, an absolute black body in physics, and others.

2.7. Induction is the movement of thought from individual to general; **deduction** is the direction of the process of cognition from general to individual.

2.8. Analogy is the method of thinking when we see the similarity of objects on certain properties and relations and put forward assumptions about similarities of these objects in other aspects.

At the same time, there is a number of theoretical research tools that are inherent in scientific analysis.

Formalization is the generalization of forms of objects and processes which are different in the content, and then abstraction of these forms from their content in order to use the very formal aspect of the research. This method is usually used when we try to avoid a simple description in the characteristic of objects of research, which requires as much accuracy as possible. Mathematics remains the source of this method and an example of the effectiveness of formalization in science.

Axiomatic method is used when we take the initial fundamental principles of the theory without proof, and then they are postulated as axioms, and the other provisions are derived from them according to certain rules.

Hypothetic-deductive method orientates the researcher on the development of the theory in the form of a system of deductively coupled hypotheses.

The historical method is focused on the research of processes and events such as they took place in reality (in the history of nature or society), when the scientist does not change anything absolutely: does not violate the sequences of individual stages or moments, does not ignore anything and does not put some aspects of the object on the first plan. This method is aimed at the maximum possible reflection of the historical development of the process in all its specificity and uniqueness. *(A vivid example of the application of the historical method in scientific cognition is the novel by Strugatsky's brothers "It's hard to be a god")*. The principle of historicism has developed in the bosom of historical cognition as a methodological paradigm (in connection with the development of historical disciplines itself), but then it has spread into other branches of science.

Logical method organically complements the historical method; guides the scientist to the distinction of the main, most essential aspects in the object of research, and hence to the deviation from the purely historical form of reproduction of the phenomena of reality in scientific theory.

The method of modeling detects certain properties of the object with the help of a specially created analogue of it – a model. Depending on the nature of the models, two main types of modeling are distinguished – physical (material) and logical (ideal) modeling, that is why this method can be used both on the theoretical and empirical levels of scientific research. In the first case models are cognitive images, circuits, formulas, equations, fragments of the theory, even individual concepts.

Modeling is a scientific method of indirect study of objects of cognition, the direct study of which is impossible, difficult, ineffective or inappropriate for certain reasons. This method is provided by the study of their models like objective, sign or thinking systems that respectively reproduce, simulate or reflect certain characteristics (properties, signs, principles of internal organization or functioning) of the originals.

Application of modeling requires the implementation of a number of objective laws and laws of the development of phenomena and processes, violation of which eliminates the ability of the model to replace the original, to be its certain prototype. In philosophy modeling regarded as one of the methods of scientific research, but it must also be made on the basis of general scientific methods.

In the mathematical model of the real system (process) it is necessary to understand the totality of relations (formulas, equations, inequalities, logical conditions, operations, etc.) that determine the characteristics of the system depending on its parameters, external conditions, initial conditions and time. In general, by definition *V.M. Glushkov*, mathematical model is a set of symbolic mathematical objects and relations between them. According to *M. M. Amosov*, mathematical model is a system that reflects another system.

Classification of mathematical models:

• Static models characterize the specific state of the object at a given time point.

• Deterministic (hard) models suggest that the relationship between inputs and outputs of the system can be described by known deterministic functions and input values are precisely defined.

• Stochastic (statistical) models are built, if the parameters of the researched object exposed to uncontrollable random factors or if it is characterized by the uncertainty of their own behavior.

• Linear models are characterized by a linear relationship between input and output variables.

In modern scientific cognition, the tendency of building **cybernetic models** of objects of various classes is very widespread. *K. B. Baturov* wrote that "the cybernetic stage in the study of complex systems, marked by significant transformations of the" language of science ", is characterized by the possibility of expressing the main features of these systems in terms of information theory and management. It makes their mathematical analysis accessible".

While characterizing the process of cybernetic modeling, pay attention to the following circumstances. The model, being analogous to the investigated phenomenon, can never reach the degree of complexity of the latter one. While constructing the model, we resort to the known simplifications, the purpose of which has the aim not to reflect the entire object, but to describe as much as possible, its certain "cut". The task is to highlight important properties for research by introducing a number of simplifications. While creating cybernetic models, informational and management properties are distinguished. All other aspects of this object are out of the question.

The system modeling has an interdisciplinary character and performs an important integration function that continues to differentiate in the scientific cognition of our era. In addition to computerization, modeling also has the property of multimodality in our time, because it is necessary to form a system of modeling in the study of super-complex objects, which include elements that relate to different forms of motion of matter.

Idealization is a special method of logical modeling, which consists of the thoughtful construction of concepts about objects that do not exist and cannot exist in reality, but have some pre-images in the real world with some degree of approximation. Properties of these idealized objects ("point", "straight line", "absolute zero", "absolute black body", etc.) reflect the corresponding properties of rational objects in hyperbolized and absolutised form. The value of the method lies in the fact that it gives an opportunity to construct theoretical models that are more easily subjected to formalization of different kinds; the scientific explanation of the phenomena of a certain sphere of reality becomes simpler and more obvious at the same time.

3. The main features of the concept "methodology", its basic characteristics and its main species

The concept of "**methodology**" in philosophy has two meanings:

1. a system of methods, measures and operations which are used in science and other fields of activity;
2. the doctrine of the system, the theory of the method.

Methodology is a meta-scientific research, aimed not at the object, but on the cognition of the object, on the methods and means by which it is obtained. The main purpose of the methodology is to carry out critical functions in relation to the science. This tradition is laid down by the German philosopher Immanuel Kant. In his opinion, the methodology has the task not only to describe the cognitive process, but also to determine the possibility of gaining the new knowledge. Kant formulated questions that have a methodological significance and in modern conditions: "How the theoretical sciences are possible?"; "How the general and the necessary knowledge are possible?"; "What are the conditions for the implementation of continuity in cognition?" Therefore, the methodology cannot be descriptive or normative (proposed), its task is to analyze the current state of scientific knowledge and to predict its further development from the standpoint of the past experience of scientific knowledge and its history. One should not lose the sight of the fact that any such prediction has a very probable and heuristic nature.

The methodology of science is a theory of scientific knowledge that explores cognitive processes. It includes not only a set of applied methods, but also relates other elements of the cognitive process (goals, concepts, tasks, hypotheses, etc.), the principles of organization of research activities – consistency, systematic, purposefulness, manageability, comparison of the results of cognition with his goals – to them.

The determining task of the methodology of science is the formation of ideas about the general foundations, ways, patterns, principles and methods of organization, implementation and development of scientific knowledge. The methodology of science produces general schemes of scientific description and explanation of the scientific phenomenon.

The development of methodological innovations in science and the analysis of promising directions for the development of modern methodology shows that solving complex research tasks involves the use of new methods and strategies for scientific research.

Evolution of the levels of scientific methodology:

1. Methodology = the level of specialized scientific methodology + philosophical level.

2. Methodology = the level of specialized scientific methodology ≥ regional level methodology ≥ methods of general scientific level ≥ philosophical level.

In the modern philosophy, the problems of method and methodology are discussed in the philosophy of science, the systematic approach, synergetics, phenomenology, structuralism and other branches of philosophy. Issues of social methodology are also considered in hermeneutics (Hans Gadamer, Henry Rickert, etc.). The modern methodology avoids extreme evaluations of methodological programs or the absolutism towards any of them that took place in the past. Many researchers justify methodological pluralism. In modern science there is a multilevel concept of methodological theory. In the arsenal of modern methodology, there is also the principle of social conditionality of cognition, sociocultural determinism (ie, science is considered as a subsystem of culture, the subjective parameters of the cognitive process are taken into account), reductionism ("push back"), evolutionism, synergetics, etc.

The methodology studies not only methods, but also the forms of scientific knowledge – it is no less important for its task.

The main forms of scientific knowledge include:

• problem;
• scientific fact;
• hypothesis;
• idea;
• conception;
• theory;
• law

Scientific problem is the statement of the existing contradiction in the knowledge about reality, the contradiction between known and unknown. Sometimes the essence of the scientific problem is also formulated like "knowledge about unknown". The statement of a scientific problem is an important impetus to scientific research in order to solve it.

Scientific fact is an elementary form of scientific knowledge that contains probable information about a certain fragment of reality; reflection in the mind of the researcher of the fact of reality. From the accumulation of facts, science inevitably passes to higher, more perfect forms of knowledge – ideas, concepts, theories, laws. However, this transition is not carried out directly, but through a kind of intermediate link – a scientific hypothesis.

Scientific hypothesis is the scientifically grounded (corresponds to the level of scientific development of its time) assumption about the logical connection and the causal predetermination of certain phenomena. Hypothetical knowledge is not accurate, but probable. The hypothesis must be checked, and the result may be either its confirmation, or its refutation and followed exclusion from the scientific arsenal.

Scientific idea – this form of comprehension of phenomena of the world contains not only the reflection of certain objects, but also the awareness of the purpose of their subsequent cognition and practical transformation, as well as projections of possible ways of these processes. Ideas are the principles of the synthesis of knowledge in some integral system, and the heuristic principles of enriching knowledge and its use to explain previously unknown phenomena, and the base for finding new ways to solve scientific problems, and options for replenishing the arsenal of purely methodological tools. Ideas (which arise on the basis of generalization and comprehension of many facts, as well as verification of the corresponding hypotheses) become decisive steps in the creation of new scientific conceptions.

Conception is a system of views on a certain phenomenon, a way of understanding, the interpretation of this phenomenon; it is also the general idea of the researcher in the cognition and transformation of the corresponding plane of reality, the leading constructive principle of the relevant activity. The difference in conceptual vision can be characterized not only by different scientific fields and scientific schools, but also by different researchers in the womb of the same school.

The development of the conception in the spirit of its improvement, deepening and comprehensive substantiation can be a way of creating of a scientific theory on its basis. **Scientific theory** is the highest and the most advanced form of scientific knowledge, which contains an organically homogeneous idea of the laws and essential causal relationships between the phenomena of a certain field of reality. It has a particular importance among all of the forms of scientific knowledge. The common aspect for all theories is the use of idealized objects, which, in fact, form a special fabric of theoretical knowledge.

All the theories consist of a certain set of logically interconnected thoughts called **provisions**. A separate provision of the theory, in which the independent and important thought is embodied, can also be regarded as a peculiar, subordinate form of scientific knowledge.

Scientific theory is related to the discovery of scientific laws. The content of the law is objective, since it expresses the necessary, substantial, persistent, repetitive relationship between certain phenomena of reality. It is necessary to distinguish the form of scientific law as a certain reflection of its objective content, the result its formulation in the language for a certain age, a certain level of approach to reality from the content of the law (which belongs to the very reality). **The scientific form of the law**, in contrast with its ontological content, has a logical-gnoselogical and methodological status, and therefore can be considered as a special form of scientific knowledge itself.

There are specific forms of scientific knowledge, which are used in certain branches of knowledge. For example – the axiom, the theorem, the formula, the equation, the scheme, etc. – are used mainly in mathematics, physics, techniques but then specific forms of scientific knowledge have passed into scientific fields in which they were not inherent primarily. For example – the transition of forms of axioms, theorems, formulas, equations, schemes into economics, statistics, sociology, even linguistics.

4. The main principles of interaction between scientific disciplines as the multimethodological level in science

The most effective and most widespread integration strategy in modern science is the collaboration between disciplines – **interdisciplinarity**. It is carried out in various forms, from temporary joint research and to the emergence of new disciplines. Such areas of science as social psychology, biophysics, biochemistry, bioethics, economic geography, etc., are examples of scientific synthesis and scientific cooperation, despite the fact that they have a different basis, a different problem field and different ways of interdisciplinary interaction.

The main integration tool in science is the transfer of methods from one discipline to another. However, in most cases there is a so-called leading discipline, which becomes the basis for further synthesis. All the integrations, interdisciplinary processes can be classified according to goals, methods and results.

Multidisciplinarity is the widespread scientific and cognitive method that involves the coexistence of several disciplines. This is a collaboration between disciplines, which does not involve their further integration or change of methodological basis of a separate discipline. The multidisciplinary community consists of academics from different fields who become equal partners in the study of a particular problem. The main task of such a synthesis is to distinguish between the functions and fields of research clearly and, as a result, to obtain more substantive knowledge, due to the fact that everyone works in his or her disciplinary "ranges", thereby helping to obtain professionally verified conclusions.

Interdisciplinarity, in contrast to multidisciplinarity, has an integral character. Interdisciplinarity is an approach that combines methodologies with the interaction of two or more disciplines, creating new opportunities for studying problems that are often overgrown into new disciplines. Therefore, interdisciplinarity has double significance: on the one hand, it creates the basis for interdisciplinary cooperation, on the other hand, it points to the non-disciplinary space, the problems which have not become the subject of research of any scientific direction at the present time.

Transdisciplinarity is an approach that is widely used in modern science and does not have a clear and unambiguous definition. For the first time, it was used by the Swiss psychologist and philosopher

Jean Piaget in 1970. Transdisciplinarity eliminates the boundaries between disciplines in order to create a new vision of the problem and to expand the research field. This method forms the basis for the birth of a new discipline with its mechanisms, norms, values, outlining the methodological basis for the application of integrated scientific approaches to such complex problems that go beyond the limits of academic disciplines (natural environment, energy, health, culture). That is why transdisciplinarity is usually considered as the integration of not science, but knowledge.

Paradisciplinarity is similar to transdisciplinary. Sometimes paradisciplinarity is considered "parasitic" on a certain discipline. Such an approach combines discipline through dialogue and exchange, through the opposition of their methods, theories, and means to open and / or expand interrelationships between individual areas of scientific knowledge.

Another method of integration is **cross-disciplinarity** – a scientific approach, which involves the use of methods of other disciplines in the study and explanation of the problems of a separate discipline. Cross-disciplinarity studies the subject by using methods borrowed from disciplines that are not directly related to the primary discipline. Cross-disciplinarity ties and overcomes the boundaries of disciplines, but neither their methods nor goals change.

Hyperdisciplinarity is an approach that focuses on the study of the most common properties, laws of development and operation of both human and the world. An example of hyperdiscipline can be physics, because it provides a fundamental and the most general explanation of those natural processes that occur in the world, while being the basis for the unification of other natural sciences. ***Philosophy can be also considered as a hyperdiscipline.***

Metadisciplinarity is the synthesis of scientific, technological, social knowledge with the human factor. This method calls for cognitive science to understand and explain such a phenomenon as the relationship between computer science and the theory of culture. It is close to the socio-humanitarian knowledge, where the scientist is not a distant observer, as in natural sciences. **Metadisciplinarity** combines theory and practice; science becomes not only the subject of knowledge, but also the object.

There are a number of other models of interaction between different sciences that characterize the integration trends in modern science: intras-, infra-, oligo-, extra-, and so on. All these methods have no unambiguous definition that would be recognized by the entire scientific community and a shared vision of how effective they are and how they can (or at all can) influence the creation of new science.

5. The special role of philosophy in the process of determination of the methodology in science

In the analysis of the specifics of the methodology of modern science, a special place is the question of the significance of philosophy and its methodological function. At all times, philosophical knowledge had a fairly significant influence on any branch of science, even purely special one, not only with its problematic and conceptual apparatus, and not only with decisive attention to the principles of the world outlook, but also with the main methods of cognition and transformation of reality. However, this latter aspect the methodological aspect cannot be considered as a self-sufficient and isolated one from the other aspects of the development of philosophy. In fact, in any historical period, the methodological function is inherent in philosophical cognition as an integral integrity, as an inextricable alloy of all its essential components and properties. A considerable role is played not only by the methods of philosophy, the cornerstone principles and laws, but also by such properties of philosophical cognition as the highest level of generalization and abstraction from the qualitative nature of any concrete phenomena in the world or their analysis in the aspect of the subject-object relations.

Evolution of the role of philosophy in the development of scientific methodology:

1. Philosophy is the science of all sciences: the beginnings of scientific methods and approaches of the most diverse branches of knowledge + the identification of universal methods of scientific knowledge;

2. Metaphysics is the philosophical methods of cognition and the static picture of the world as a basis, the basis for further empirical research; the doctrine of substances that are not susceptible to purely scientific comprehension, from which then scientific constructions and approaches to the knowledge of reality are constructed;

3. Positivism: the separation of various scientific fields, "philosophy is no longer needed"

4. XX century: the development of quantum physics, the emergence of relativity theory, basic science comes from the purely "terrestrial" position and begins to appeal to the concepts of the universe, above-ground structure; classical mechanics ceases to be a universal science, the boundaries for scientific knowledge are expanding – philosophy goes into the arena once again! In new quality. It not only summarizes the previous achievements of various sciences and fields of knowledge, contributes to their generalization, but serves as a justification, explanation of a new scientific knowledge at the same time and weaves it into a coherent picture of the world, making it meaningful and traced the inner goal and further sense. That is to say that philosophy brings the logos to the scientific world picture – the total sense in which the achievements of each individual scientific fields are not only desirable, but necessary. Through a variety of scientific approaches by philosophical comprehension of reality you can see the integrity of life, comprehend its versatility.

You can compare being with a large jug. There are various elements in it – a dance, a pen, a wall, a crown. You can look at these items separately. But if we look at them separately, then we will never be able to grasp the general idea of a jug. Separately, each of its elements is important, but it is senseless to argue, which is still more important – the jug will not exist without any of them. Similarly, without any of the branches of knowledge, we will not get a coherent picture of the world. But to see it, we have yet to get out of the plane coordinates of each separate science and look at the world more broadly, to rise to high level of abstraction, which in this case is a reflection of very specific things. Philosophy gives such an abstract, generalized, but at the same time, no less real vision of the world. It brings us to a general understanding of what we are exploring and why and where do we go further in our scientific quest.

Conclusion. *Philosophy is often compared with the image of the owl of the goddess of wisdom Athena (in Ancient Rome – Minerva),* ***" Minerva Owl flies in twilight" (G. Hegel).*** *This aphorism means that generalizing wisdom appears when the rich "day" of achievements has passed, when the results were obtained, when it is necessary to summarize the general conclusion. The flight of Minerva's owl means that philosophy crowns all the achievements of various sciences, fundamental discoveries, stunning inventions, and gives an opportunity to see in which direction we need to move further the next day. Because it is precisely in the "twilight of knowledge," when it seems that nothing more is visible, and at this time the generalizing wisdom can guide us by its insightful eyes.*

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LECTURE 4.
SCIENTIFIC REVOLUTIONS AND THE CHANGE OF TYPES OF SCIENTIFIC RATIONALITY

1. The main factors, patterns and principles of the growth of scientific knowledge
2. The phenomenon of scientific revolutions
3. The construction of the new research strategies as a consequence of the scientific revolution
4. Different types of scientific rationality
5. Global scientific revolutions: from classical to post-non-classical science
6. Historical types of scientific rationality

1. The main factors, patterns and principles of the growth of scientific knowledge

The general laws of the development of science are based on the main factors and tendencies of the evolution of science as a special social and cognitive system.

The general factors of the development of science are:

1. the evolutionary-revolutionary character of the development of science;
2. the continuous growth of scientific information;
3. the objective, socio-cultural, social, practical and worldview conditionality of science and scientific knowledge;

4. the complexity of the internal structure of science and scientific knowledge;

5. the strengthening of the internal interaction of all subsystems of science such as knowledge, cognitive activity, social institution, subsystem of culture, innovative activity, a special form of life and a way to realize the creative and personal potential of a human;

6. the differentiation and integration of scientific knowledge;

7. the growth of the role and importance of scientific communications in obtaining, evaluating and applying of scientific knowledge;

8. the continuous growth of disciplinary diversity of science;

9. the interaction and balance of management and self-government of science as a prerequisite for its effective development;

10. the growth of the role of the state and private business in regulation of scientific activity and definition of its priority directions;

11. the strengthening of international cooperation in the field of science as a factor of its effective development in the modern conditions;

12. the increasing of importance of information and computer technologies in the dissemination, mastering and practical use of scientific knowledge;

13.the strengthening of interconnections between science and education and increasing of their diversity.

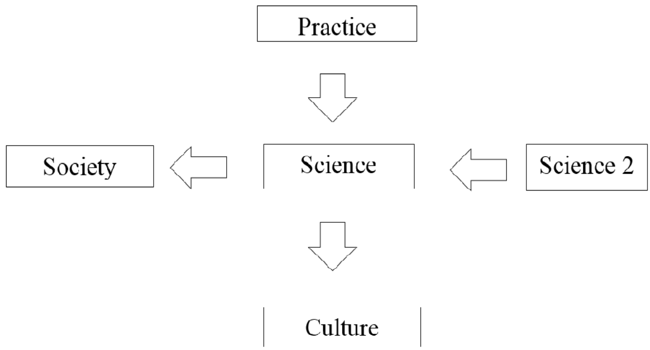
The basic concepts of development of scientific knowledge are philosophical theories about the main causes and driving forces of dynamics and development of scientific knowledge, changes in its content, directions, priorities, and rates of development.

There are three main directions in the allocation of the factors and determinants that have a decisive influence on the dynamics and development of scientific knowledge:

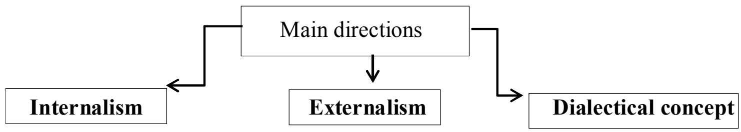
1. internalism;

2. externalism;

3. dialectical concept.



Pic.1 "The main determinants of the development of science"



Pic. 2. "Basic concepts of the development of scientific knowledge"

1. Internalism: the main determinants of the dynamics of scientific knowledge, changes in its content, rates and directions of development of science are intra-scientific factors (accumulated reserves of scientific knowledge and its problems, new areas of objects, methods of scientific knowledge, the aspiration of more perfect and deep scientific truth).

There are three main types of internalism:

1.1 empiricism (Aristotle, F. Bacon, I. Newton, A. Comte, J. C. Mill, etc.);

1.2 theoricism (Plato, R. Descartes, R. Leibniz, I. Kant, etc.);

1.3 hypothetical-deductivism (R. Galilei, J. Herschel, S. W. Wellwell, R. Carnap, C. Popper, etc.).

2. Externalism: the main causes of the development of scientific knowledge, qualitative change in its content, issues, directions and rates of change are various socio-cultural factors (needs of the development of production and material practice, social and cultural opportunities and needs of society, the prevailing philosophical and ideological concepts, the personal potential of scientists, social psychology of science and organization of scientific research, etc.).

There are the following types of externalism:

2.1. economical externalism (J. Bernal, B. Hessen, etc.);

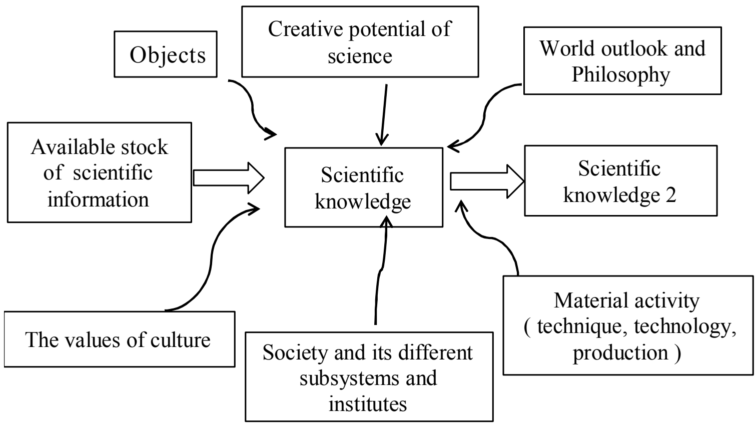
2.2. social externalism (A. Bogdanov, D. Lukach, etc.);

2.3 socio-psychological externalism (T. Kuhn, M. Polyana, etc.);

2.4 philosophical externalism (R. Hegel, E. Husserl, etc.);

2.5 cultural externalism (O. Spengler, R. Gachev, M. Foucault, etc.).

3. Dialectical concept: an integral cause that determines the change and development of scientific knowledge is the dialectical interaction of intra-scientific and socio-cultural factors, which always has a specific character regarding the importance of different intrinsic and socio-cultural factors. Their combination can be very different for specific states of science and cannot be determined a priori (A. Einstein, M. Born, M. Plank, I. T. Frolov, P. P. Gaidenko, V. S. Steopin, etc.).



Pic. 3 "The main determinants of the development of scientific knowledge"

The patterns of the development of scientific knowledge are the main conditions, determinants and trends of the evolution of science as a system of scientific knowledge.

The general patterns of the development of scientific knowledge are:

1. the determination of the increasing volume of previously accumulated scientific knowledge;
2. the continuous character of the evolution of the systems of scientific knowledge.
3. the increasing of the informational capacity of scientific theories which changes one another;
4. the motion from the knowledge of simple objects and systems to the knowledge of more and more complex objects and systems;
5. the increasing of the degree of accuracy, evidence of the knowledge and the ability to check the received knowledge;
6. the increasing of the methodological and methodical arsenal of science;
7. the strengthening of the interactions in objective, practical, socio-cultural and ideological determination;
8. the growth of theoretical and methodological pluralism of scientific constructions; the increasing of the role of cognitive communication between scientists in the process of creating, evaluating and verifying different units of scientific knowledge;
9. the growth of differentiation of scientific knowledge and scientific disciplines;
10. the strengthening of integration links between different areas of scientific knowledge;
11. the interpenetration of scientific methods and concepts from different branches of science;
12. the growth of the number of interdisciplinary, problem and complex studies;
13. the increasing of the value of creative and personal potential of scientists in the process of creation and approval of scientific theories;

14. the growth of cognitive responsibility of scientists for the scientific decisions;

15. the strengthening of innovative orientation of scientific concepts, standardization of scientific knowledge as an informational product in the process of its inclusion in the global informational network.

2. The phenomenon of scientific revolutions

In the dynamics of scientific knowledge, a special role is played by the stages of the development of science which are associated with the restructuring of research strategies. **These stages were called scientific revolutions.**

What is the scientific revolution?

The foundations of science ensure the growth of knowledge as long as the common features of the system organization of the studied objects are taken into account in the world picture, and the methods of mastering of these objects correspond to the established ideals and norms of research. As science develops, it may encounter fundamentally new types of objects that require a different vision of reality in comparison with the previous objects which presuppose the prevailing picture of the world. New objects may require a change in the scheme of the methods of cognitive activity, represented by a system of ideals and norms of research.

In this situation, the growth of scientific knowledge implies the restructuring of the foundations of science. The latter one can be carried out in two varieties:

a) as a revolution which is associated with the transformation of a special picture of the world without significant changes in the ideals and norms of research;

b) as a revolution, during which, along with the picture of the world, the ideals and norms of science change radically.

In the history of natural science one can find patterns of both situations of intensive growth of knowledge:

An example of the first one is the transition from the mechanical to the electrodynamical picture of the world, carried out in the physics of the last quarter of the 19th century in connection with the construction of the classical theory of the electromagnetic field. This transition, although accompanied by a rather radical reorganization of the vision of physical reality, did not significantly change the cognitive attitudes of classical physics

An example of the second situation is the history of quantum-relativistic physics, characterized by the restructuring of the classical ideals of explanation, description, justification and organization of cognition.

A new picture of the reality under investigation and new norms of cognitive activity, affirmed in some science, can then have a revolutionizing effect on other sciences.

In this regard, there are two ways of restructuring of the bases of research:

1) due to the interdisciplinary development of knowledge;

2) through interdisciplinary connections, "grafting" the paradigmatic attitudes of one science to another one.

Both of these paths in the real history of science seem to overlap, so in most cases it is more correct to talk about the dominance of one of them in each of the sciences at some stage of its historical development.

The reorganization of the foundations of a scientific discipline as a result of its internal development usually begins with the accumulation of facts that do not find an explanation within the framework of the earlier established picture of the world. Such facts express the characteristics of new types of objects that are drawn by the science into the orbit of research in the process of solving special empirical and theoretical problems. The detection of these objects can lead to the improvement of means and methods of research (for example, the emergence of new instruments, equipment, observation techniques, new mathematical tools, etc.). In the system of new facts there can be not only anomalies that do not receive their theoretical explanation, but also the facts that lead to paradoxes in attempts to assimilate them theoretically.

The revision of the picture of the world and the ideals of cognition always begins with a critical understanding of their nature. If previously they were perceived as an expression of the very essence of the reality which is under study and the procedures of scientific knowledge, now their relative, transitory character is realized.

Such awareness presupposes posing questions about the relation of the picture of the world to the reality and the understanding of the historicity of the ideals of cognition. ***The formulation of such questions means that the researcher enters the sphere of philosophical problems from the sphere of scientific problems. Philosophical analysis is a necessary moment of criticism of the old foundations of scientific research.*** In addition to this critical function, philosophy performs a constructive function, helping to develop new research grounds. Neither the picture of the world, nor the ideals of explanation, justification and organization of knowledge can be obtained in a purely inductive way from a new empirical material. This material is organized and explained in accordance with certain ways of its vision, and these ways are set by the picture of the world and the ideals of cognition. The new empirical material can only detect a discrepancy between the old vision of the new reality and the new one, but does not indicate how this new vision should be reconstructed. Philosophical and methodological tools are actively used in the restructuring of the foundations of science and in the situation where the factors of the interdisciplinary interaction play a dominant role.

It is not necessary for paradoxes to be fixed in order to transform the picture of reality and to transform the norms of research of a certain science. The transformation of its bases is carried out by transferring paradigmatic attitudes and principles from other disciplines, which forces researchers to reevaluate the facts that have not yet been explained. Usually, as the paradigmatic principles are "grafted" into other sciences, components of the foundations of the leading science act. The core of its picture of reality forms the foundation of a general scientific picture of the world in a certain historical epoch, and the ideals and norms adopted in it acquire a general scientific status.Paradigmatic principles, which were modified and developed with the reference to the specifics of the objects of a certain discipline, can then have a reverse effect on the sciences from which they were originally borrowed.

3. The construction of the new research strategies as a consequence of the scientific revolution

Rebuilding of the bases of research means changing of the main strategy of scientific research. However, any new strategy is not approved immediately, but in a long struggle with the old attitudes and traditional visions of reality.

The process of affirming of the new foundations in science is defined by predicting new facts, by the generation of specific theoretical models, but also by the causes of socio-cultural nature.

The new cognitive attitudes and the knowledge which is generated by them enter into the culture of the corresponding historical epoch and are consistent with the values and worldview structures of it. From this point of view the reorganization of the foundations of science in the period of the scientific revolution represents a choice of a special directions of the growth of knowledge that provide both an expansion of the range of research of objects and a certain correlation of the dynamics of knowledge with the values and ideological attitudes of the corresponding historical epoch.

During the scientific revolution there are several possible ways of increasing knowledge, which, however, are not realized totally in the real history of science. Two aspects of the non-linearity of the growth of knowledge can be distinguished:

1. The first of them is connected with the competition of research programs within a single branch of science. The victory of one and the degeneration of another directs the development of this branch of science along a certain channel, but at the same time closes some other ways of its possible development.

This style of thinking, with its intention to build definitively true ideas about the essence of the physical world, was one of the manifestations of the "classical" type of rationality realized in philosophy, science and other phenomena of consciousness of this historical epoch. This type of rationality suggests that thinking observes the object from the outside, comprehending its true nature in this way.

The modern style of physical thinking (within the framework of which an unrealized but possible line of the development of classical electrodynamics was realized) appears as a manifestation of another, nonclassical type of rationality that is characterized by a special relationship between thinking and object. According to this type of thinking, thinking reproduces the object as woven into human activity and builds images of the object, correlates them with the notions of historically developed means of its development. The type of scientific thinking that develops in the culture of a certain historical epoch is always correlated with the nature of the communication and activity of people of this epoch, which is conditioned by the context of its culture.

2. The second aspect of the nonlinear growth of scientific knowledge is related to the interaction of scientific disciplines, conditioned by the features of objects which are under the study, and by the socio-cultural environment within which science develops.

The development of science (as, indeed, any other development process) is realized as the transformation of possibility into reality, and not all possibilities are realized in its history. When predicting such processes, a tree of possibilities is always built, and various variants and directions of development are taken into account. Representations about rigidly determined development of science arise only when we retrospectively consider them, when we analyze their history, already knowing the final result, and restore the logic of the motion of ideas which have led to this result. But there were also possible directions that could be realized in other turns of the historical development of civilization, but they turned out to be "closed" in the real history of science.

4. Different types of scientific rationality

General rationality is a set of requirements that must satisfy any rational knowledge: objectivity, conceptuality, discourse, certainty, reasonableness, consistency, openness of critical analysis.

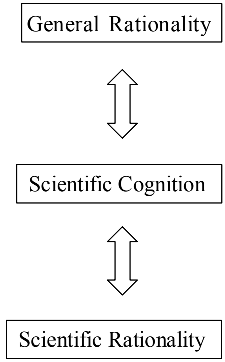
Scientific rationality is a set of requirements that must satisfy all the scientific knowledge: object objectivity, unambiguous certainty, provability (logical or empirical), verifiability (empirical or analytic), openness to criticism, the possibility of improvement.

Logical-mathematical rationality is a set of requirements that must be met by logical and mathematical knowledge: ideal objectivity, constructive unambiguousness, formal evidence, analytical verifiability, openness to criticism and refutation, the possibility of improvement.

Natural-scientific rationality is a set of requirements that must satisfy natural science: empirical objectivity, supervisory-experimental definiteness, partial logical evidence, experienced verifiability (confirmation and falsification), openness to criticism, the possibility of classification.

Socio-humanitarian rationality is a set of requirements that must satisfy social and humanitarian knowledge: social and value object, reflexivity, consistency, cultural validity, adaptive utility, openness to criticism, the possibility of change.

Technological rationality is a set of requirements which must be met by technical and technological knowledge: "real" objectivity, constructive system, empirical verifiability, system reliability, practical efficiency, social utility, accuracy, openness to criticism, the possibility of optimization or refusal of the former models. Interdisciplinary and integrated scientific researches and the obtained models and solutions correspond to the requirements of technical and technological rationality in general.



Pic. "The types of scientific rationality"

5. Global scientific revolutions: from classical to post-non-classical science

In the development of science, it is possible to single out such periods when all components of its foundations were transformed. The change of scientific world pictures was accompanied by a radical change in the normative structures of research, as well as by the change in the philosophical foundations of science. These periods can rightfully be considered as global revolutions, which can lead to a change in the type of scientific rationality.

In the history of natural science, you can find 4 such revolutions:

The first revolution broke out in the 17th century, which marked the emergence of classical natural science. Its emergence was inextricably linked with the formation of a special system of ideals and norms of research, in which, on the one hand, the attitudes of classical science were expressed, and on the other hand, their specification was carried out by taking into account the leading role of mechanics in the system of scientific knowledge of this era.

The ideals, norms and ontological principles of the natural sciences of the 17th and 18th centuries were based on a specific system of philosophical foundations in which the ideas of mechanism played a dominant role. As an epistemological component of this system, the notion of cognition came forward as observation and experimentation with objects of nature. There was given the status of sovereignty to the human cognition. Ideally, it was interpreted as being distanced from things, observing and exploring them from the outside. It was considered as not determined by any prerequisites, except the properties and characteristics of the objects which were under study.

Radical changes in this integral and relatively stable system of the foundations of natural science took place at the end of the 18th and the first half of the 19th century. ***They can be regarded as the second global scientific revolution*** that determined the transition to a new state of natural science a disciplined and organized science. At this time, the mechanical picture of the world loses the status of the general scientific one. In biology, chemistry and other fields of knowledge, there are being formed the specific images of reality which were not reducible to the mechanical image of reality. Corresponding to the peculiarities of the disciplinary organization of science, its philosophical grounds were modified. They became heterogeneous, included a rather wide range of meanings of those basic categorical schemes according to which objects were mastered (from the preservation of the certain limits of the mechanistic tradition to the inclusion of the phenomenon of "thing", "state", "process" and other ideas of the development). In the epistemology the central role is played by the problem of the correlation of various methods of science, the synthesis of knowledge and the classification of sciences. Putting it on the forefront is associated with the loss of the former integrity of the scientific picture of the world, as well as the emergence of specific regulatory structures in various fields of scientific research. The search of the ways of the unity of science, the problem of differentiation and integration of knowledge turn into one of the fundamental philosophical problems, preserving its sharpness throughout the subsequent development of science.

The first and second global revolutions in natural science proceeded as the formation and development of classical science and its style of thinking.

The third global scientific revolution was associated with the transformation of this style and the emergence of a new, non-classical natural science. In the process of revolutionary transformation, the ideals and norms of a new, non-classical science were formed. They were characterized by a rejection of rectilinear ontology and an understanding of the relative truth of the theories and the picture of nature that were worked out at one or another stage of the development of natural science. In contrast to the ideal of the only true theory, which "photographs" the objects under investigation, it is possible that several concrete theoretical descriptions of the same reality differ from each other, since in each of them the moment of objective-true knowledge can be contained.

Correlations between the ontological postulates of science and the characteristics of the method through which the object is mastered are interpreted. In this regard, we accept such types of explanations and descriptions that explicitly refer to the means and operations of cognitive activity.

A new system of cognitive ideals and norms ensured a significant expansion of the field of the objects which are under the study, opening the way for mastering complex self-regulating systems. Unlike small systems, such objects are characterized by a level organization, the presence of relatively autonomous and variable subsystems, the mass stochastic interaction of their elements, the existence of a control level and feedbacks that ensure the integrity of the system.

There is an understanding of the fact that the answers of the nature to our questions are determined not only by the design of nature itself, but also by the way in which our questions are posed, and this way depends on the historical development of the means and methods of cognitive activity. On this basis, a new understanding of the categories of truth, objectivity, fact, theory, explanation, etc., has emerged.

Categorical grid introduced a new image of the object, which appeared as a complex system. Promotions about the relationship between the part and the whole with respect to such systems include the ideas of the irreducibility of the states of the whole to the sum of the states of its parts.

The transition from classical to nonclassical natural science was prepared by changing the structures of spiritual production in European culture in the second half of the 19th century and the beginning of the 20th century, by the crisis of the world outlook of classical rationalism, by the formation of spiritual culture of a new understanding of rationality in the various spheres, when the consciousness which comprehends the reality constantly encounters situations of its immersion in the very reality, feels its dependence on social circumstances, which largely determines the cognition, its value and target orientation.

In the modern era, from the last third of 20th century, we are witnessing new radical changes in the foundations of science. ***These changes can be described as the fourth global scientific revolution***, during which a new post-non-classical science have been born.

Along with disciplinary research, interdisciplinary and problem-oriented forms of research are increasingly on the forefront. If classical science was oriented toward comprehending an increasingly tapered, isolated fragment of reality that acted as the subject of a particular scientific discipline, then the specifics of modern science at the end of the 20th century are determined by complex research programs in which specialists from various fields of knowledge take part.

The implementation of complex programs generates a special situation in the unification of theoretical and experimental research, applied and fundamental knowledge, intensification of direct and inverse connections between them. As a result, there is intensified the processes of interaction between the principles and representations of reality pictures that are being formed in various sciences.

Scientific cognition begins to be considered in the context of the social conditions of its being and its social consequences, as a special part of society's life, determined at each stage of its development by the general state of culture of a given historical epoch, its value orientations and ideological attitudes. The historical variability of not only ontological postulates, but also the ideals and norms of cognition is comprehended. Accordingly, the content of the categories "theory", "method", "fact", "rationale", "explanation", etc., is developed and enriched.

6. Historical types of scientific rationality

There are usually distinguished 3 types of scientific rationality, each of which marks the transition to the next scientific revolution:

– ***classical rationality*** (corresponding to classical science in its two states – pre-disciplined and disciplined one);

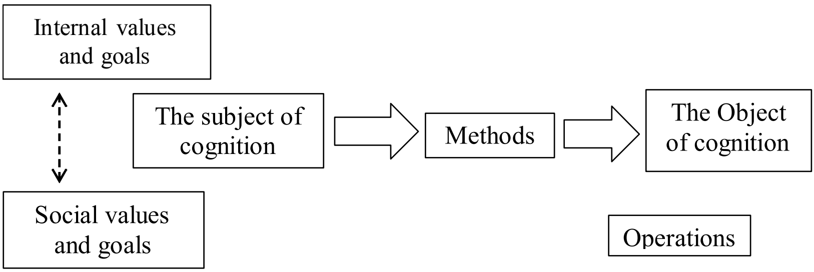
– ***non-classical rationality*** (corresponding to non-classical science);

– ***post-non-classical rationality.***

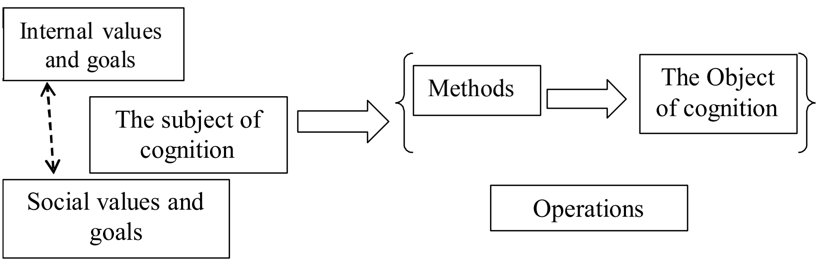
Between them, as stages of the development of science, there is kind of "overlaps", and the emergence of each new type of rationality did not discard the preceding, but only limited its scope, determining its applicability only to certain types of problems and tasks. Each stage is characterized by a special state of scientific activity aimed at the constant growth of objective-true knowledge.

The classical type of scientific rationality pays attention to the object, tends to eliminate, in the theoretical explanation and description, everything that relates to the subject, the means and operations of its activity. Such elimination is considered as a necessary condition for obtaining an objectively true knowledge of the world. The goals and values of science, defining research strategies and ways of fragmentation of the world, at this stage, as well as on all others, are determined by culture's prevailing attitudes and values. But classical science does not comprehend these determinations.

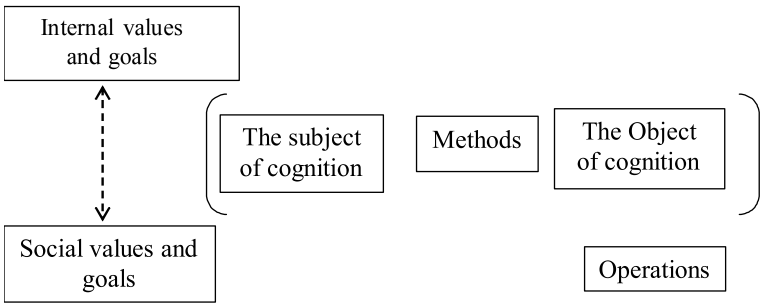
This type of scientific activity can be schematically represented in the following form:



The non-classical type of scientific rationality takes the relationship between knowledge about the object and the nature of the means and operations of activity into account. The explication of these links is considered as conditions for an objectively true description and explanation of the world. But the connections between intrascientific and social values and goals are still not the subject of scientific reflection, although they implicitly determine the nature of knowledge (determine what exactly and how we allocate and comprehend in the world). This type of scientific activity can be schematically represented in the following form:



The post-non-classical type of rationality expands the field of reflection over activity. It takes into account the correlation of the received knowledge about the object not only with the features of the means and operations of activity but also with value-oriented structures. Moreover, the connection of intrascientific goals with extrascientific ones, social values and goals is explicated. This type of scientific knowledge can be represented by the following scheme:



Conclusion: Each new type of scientific rationality is characterized by special scientific grounds, which make it possible to identify in the world and study the corresponding types of system objects (simple, complex, self-developing systems). At the same time, the emergence of a new type of rationality and a new image of science should not be interpreted as simplistic in the sense that each new stage leads to the complete disappearance of the representations and methodological guidelines of the preceding stage. On the contrary, there is continuity between them. Non-classical science did not destroy classical rationality at all, but only limited the scope of its action.

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LECTURE 5.
THE CONCEPT OF THE POST-NON-CLASICAL TYPE OF SCIENTIFIC RATIONALITY

1. The prerequisites of the development of post-non-classical type of scientific rationality
2. Imperative of education: sustainable development of mankind through the formation of the post-non-classical type of world perception
3. The main characteristics of post-non-classical science
4. The integration of synergetics in modern science: extrapolation of its principles of nonlinearity and self-organization

1. The prerequisites of the development of post-non-classical type of scientific rationality

Formation of post-non-classical type of world perception is based on the elimination of linear uniqueness, the creation of a noosphere synthesis of the whole body of knowledge, the development of a holistic worldview. The fourth scientific revolution of the last third of the 20th century is associated with the appearance of the special objects of research, which led to radical changes in the foundations of science. Post-non-classical science is born, the objects of study of which are historically developing systems. The rationality of the post-non-classical type is formed. Its main characteristics are:

First, if in the non-classical science the ideal of historical reconstruction was used primarily in the humanitarian sciences (history, archeology, linguistics, etc.), as well as in a number of natural disciplines such as geology and biology, then in post-non-classical science the historical reconstruction as a special type of theoretical knowledge was used in cosmology, astrophysics and even in particle physics, which led to a change in the world picture.

Secondly, a new direction in scientific disciplines which was called synergetics arose. It became the leading methodological concept in the understanding and explanation of historically developing systems.

Thirdly, the subject of cognition in such a situation is not an external observer, whose existence is indifferent to the object: it modifies the field of possible states of the system each time by its action, so the subject of cognition becomes a major participant in ongoing events.

Fourthly, for the first time, post-non-classical science turned to the study of such historically developing systems, the direct component of which is a human. These are the objects of ecology, including the biosphere (global ecology), biomedical and biotechnological (genetic engineering) facilities, etc. It is impossible to research such objects without using computer programs and carrying out a special mathematical experiment.

Fifthly, in the research of such complex systems involving the human with his transformative production activity, the ideal of value-neutral research is unacceptable. Objectively true explanation and description of such systems involve the inclusion of values of social, ethical and other nature.

Sixthly, post-non classical science involves the formation of a new rationality nonlinear rationality, the formation of nonlinear thinking, sizigious rationality. The basis of the methodological transformation of traditional science into modern post-non-classical science is the transition from the methodology of reductionism, which involves the decomposition of systems on elements, reduction to the elements and their further research, to the holism. Holistic approaches to the research of systems are formed on the basis of the idea of integrity as a total one, unity of manifold, identity.

An especially important moment in the fourth scientific revolution was the appearance of cosmology as a scientific discipline in the last 10–5 years of the XX century., the subject of study of which was the universe as a whole. The theory of evolution of the universe led to the appearance and a special "reincarnation"of elements of ancient rationality in the post-non-classical type of science. This fact can be shown in such aspects:

1. Appeal to pure speculation in elaboration of the theory of the development of the universe;

2. For the first time since the time of Greek philosophy and protoscience in cosmology, the question was posed: "Why is the Universe structured in this way, and not otherwise?"

3. In modern physics and cosmology, more and more often they began to talk about the anthropic principle, according to which our world is arranged in such a way that it allows the appearance of a human in principle.

4. Mankind should perceive the cosmos not as something which is out of place and hostile, but as the "home" of its being. In other words, there is a correlation of the type of rationality, corresponding to modern physics and cosmology and to the ancient type of rationality.

5. The experience of the soul is only a mental examination. Such a "work" of the soul is theorizing, to which modern scientists are actively addressing.

6. The similarity to the ancient type of rationality is also due to the fact that the boundary between the theory of elementary particles and the theory of the universe begins to blur.

So, in the post-non-classical science, the paradigm of wholeness is affirmed, according to which the universe, the biosphere, the noosphere, society, the human, etc. represent single integrity.

The manifestation of this integrity is that a researcher is not outside the studied object, but is inside of it, **he or she is only a part that knows the whole**.

As a consequence of this approach, there is a convergence of natural and social sciences, in which the ideas and principles of modern natural science are increasingly being introduced into the humanitarian sciences, and the reverse process also takes place.

2. Imperative of education: sustainable development of mankind through the formation of the post-non-classical type of world perception

Sustainable Development (SR) is a non-alternative global strategy for a responsible and wise combination of contemporary and future interests, the implementation of which is a responsibility of every nation and every state.

The Concept "The Education for Sustainable Development" (ESD), introduced by the Johannesburg Summit (2002), reflects the need for rethinking and reforming all social practices, including education, in order to "empower people of all ages to take responsibility for creating a sustainable future."

Principles of the ESD are formulated in the statement "About The Education for Sustainable Development":

• ESD is cross-sectoral, it covers economic, environmental, technical and social aspects and requires a participatory and holistic approach;

• ESD should encourage critical thinking of students at all levels of education as a prerequisite for specific activities;

• The ESD problems should be reflected in all educational programs of all levels of education, including professional education and advanced training;

• ESD is continuous, it covers formal and informal education;

• The main aim of the ESD is to increase the capacity of citizens to promote positive environmental change, it suggests the personal responsibility and the involvement of everyone.

The methodological basis of the ESD should be post-non-classical science, the object of study of which is synergistic systems that co-evolve together with a human.

This science is distinguished by the transdisciplinary, overcoming the opposition between a human and a nature, non-linearity and generationality. The basis of making managerial decisions should be the criterion of environmental and economic efficiency.

A compulsory element of the ESD are the disciplines that form the philosophical vision of SD's issues, including history and philosophy of science, and enable the ecologization of the philosophical and scientific world outlook and social practice.

The necessary element is the economic theory the philosophy of economic science with an extended subject space, in which the problems of wealth are considered in three dimensions: economic, institutional and environmental. Particular attention should be paid to the specific didactic methods of implementing ESD. Thus, this approach is disclosed in the work of K. Henderson and D. Tilbury and contributes to the increase of the efficiency of the ESD.

According to this approach, the content of education should be reinforced and extended by:

1) the corporate culture of universities (collegial decision making, support for creative students and teachers, cooperation with the community and nongovernment organizations, norms, traditions and events that support the values of the institution);

2) ecological management of "green studios" that are open to eco-innovations;

3) educational methods that form students' problem-solving skills on the basis of SD, in particular group and joint training, active learning in the course of project implementation, learning in real contexts.

3. The main characteristics of post-non-classical science

The comparison table "Philosophical foundations of classical, non-classical and post-non-classical science"

Classical science	Non-classical science	Post-non-classical science
Pure objectivity of scientific knowledge	**The subjectivity-objectivity** of scientific knowledge	**Consensuality** (general significance) of scientific knowledge
Absolute certainty (uniqueness) of scientific concepts, judgments, theories	**Relative certainty** of the values of scientific concepts, judgments, theories	**Principal insufficiency** o the meaning of any scientific concepts, judgments, theories
Unambiguous determinism (laws, relations)	**Probabilistic determinism**	**Indeterminism (**cooperative, resonant relations between objects and their states)
Transcendental individual subject of scientific knowledge	**Transcendental social subject** of scientific knowledge	**Empirical (individual or collective) subject** of scientific knowledge
Absolute truth as an opportunity and purpose of scientific knowledge	**Relative truth** as an opportunity and purpose of scientific knowledge	**The substantiated and practically useful hypothesis** as the real purpose of scientific knowledge
Universality (general character) of scientific laws and theories	**Particularism** (limited scope) of any scientific laws and theories.	**The idealized nature** of any scientific laws and theories
Ontological primacy is a **necessity**	Ontological primacy is a **probability**	Ontological primacy is a **randomness**
Priority type of scientific laws is **dynamic**	Priority type of scientific laws is **statistical and probabilistic**	There is **no objective priority type of laws**, all scientific laws are idealizations and schematizations of reality

Classical science	Non-classical science	Post-non-classical science
Elementarism (the whole one is an additive sum of elements)	**System** (an integer of the sum of parts)	**Holism** (the integral one is expedient interaction of the parts)
The initial beginning of scientific knowledge is a **sensory experience**	The initial beginning of scientific knowledge is **thinking**	The initial beginning of scientific knowledge is **common sense**
Monotheoretism (only one true theory about the same object is possible)	**Complementarity** (additionality) (several real theories about the same object)	**Pluralism** (the possible existence of an unlimited number of theoretical representations and descriptions of the same thing)
Proof of scientific laws and theories	**Confirmation** of scientific laws and theories	**Affirmation** of scientific concepts (based on cognitive creativity and cognitive will of a scientist)
The subject of scientific knowledge is an **object (as "thing in itself")**	Direct subject of scientific knowledge is **an abstract object**	The subject of scientific knowledge is **the constructed thinking of reality**
A scientific theory is a **deductive-ordered text**	A scientific theory is a **partly logically structured text**	A scientific theory is a **narrative (a story)**
The basic linguistic characteristic of scientific knowledge is **text**	The basic linguistic characteristic of scientific knowledge is **context**	The basic linguistic characteristics of scientific knowledge are **intertext and hypertext**
The elementary unit of a scientific theory is **notion**	The elementary unit of a scientific theoryis **term**	The elementary unit of a scientific theory is **sign, symbol**

Classical science	Non-classical science	Post-non-classical science
It is possible that there is a **universal scientific method**	**Methodological pluralism**	Scientific cognition is a **special linguistic way** of expression and creativity
Scientific cognition is **value neutral**	Scientific cognition is **partly due to value.**	Scientific cognition is **the result of a scientist's cognitive creativity.**
Logical homogeneity of scientific text	**Partial logical homogeneity** of scientific text	**Logical and linguistic heterogeneity** of scientific texts
Cognitive dogmatism (the objective truth about the object of cognition exists and it is the one)	**Intelligent skepticism** (perhaps there exists not the one truth)	**Irony and self-irony to any claims to the absolute objective truth**
Internationalism (scientific knowledge develops primarily in accordance with its internal laws)	**Moderate internationalism** (the unity of the inside-scientific and socio-cultural factors in the development of scientific knowledge)	**Cognitive externalism** (science is an alloy of knowledge, will, and creativity of scientists, experiencing the influence of various social factors)
Scientism (science is the main force of social progress)	**Socioculturalism** (science is one of the factors of social progress)	**Humanism** (science must serve the human and be under his control)

The characteristic features of post-non-classical science:

In the field of ontology:

• globalization and complication of research objects; actual is the study of global processes of information, ecology, economics, politics, science, etc. The subject of research is super-complicated and evolving objects (physical, biological, technological, computer, social, etc.);

• the socialization of the object of research, the growing interconnection of science and technology with social processes;

• the actualization of humanitarian and ethical problems in scientific knowledge.

In the field of epistemology:

•the strengthening of the influence of the subject in scientific research: the increasing role of the human factor, the moral position of scientists in solving biological, medical, environmental, energy, demographic and other problems;

• the change in the understanding of scientific truth: the awareness of its sociocultural nature and consensual nature;

•the awareness of the fundamentally interactive, communicative nature of the process of scientific cognition;

•the orientation on the practical result in scientific research and projects, the achievement of their effectiveness and economic feasibility.

In the field of methodology:

•the emergence of the new methods of cognition: computer, system, information, synergetic ones, etc;

•the emergence of comprehensive cognitive programs in the natural and social sciences, which are based on the principle of methodological freedom and diversity;

•the emergence of a poststructuralist cognition matrix, which is based on awareness and understanding of the contextual nature of existence, consideration, and solution of any scientific problems.

The main characteristics of the modern post-non-classical science

1. Wide dissemination of ideas and methods of synergetics – the theory of self-organization and development of systems of any nature.

In this regard, there is an increasingly strengthened view of the world which appears not only as a self-developing entity but also as an unstable, nonequilibrium, chaosogenic, uncertain one. These fundamental characteristics of the universe come to the fore today, but this fact, of course, does not exclude the "presence" of the opposite characteristics in the Universe.

2. The strengthening of the paradigm of integrity, i.e., the awareness of the need for a global all-round view of the world.

Today it becomes obvious that the acceptance of the dialectic of integrity, the inclusion of a human in the system is one of the greatest scientific achievements of modern natural science and civilization in general.

The integrity paradigm is manifested:

a) in the integrity of society, the biosphere, the noosphere, the universe, etc. One of the manifestations of integrity is that a human is not outside the studied object, but is inside of it. He (or she) is always only a part that knows the whole;

b) in the formation of a new – "organismic" – vision (understanding of nature). The latter one is increasingly seen not as a conglomerate of isolated objects and not even as a mechanical system, but as an integral living organism, the changes of which can occur within certain boundaries. Violation of these boundaries leads to a change in the system, to its transition to a qualitatively different state, which can cause irreversible destruction of the integrity of the system. The central place is occupied by the principle of organic integrity, applied to the whole nature, and to its various subsystems. Organism, species, biocenosis, biogeocenosis are the basic forms of organization of life, levels (stages) of its organization;

c) in the output of the private sciences beyond the limits set by the classical culture of the West.

For the beginning of the XXI century the natural sciences have been uniting, and the convergence of natural and human sciences, science and art have been intensified. The concept of open rationality, developing in post-non-classical science, was expressed, in particular, in the fact that the European science of the late XX – early XXI century began to focus on oriental thinking. Without this, the modern concept of nature is probably unthinkable.

3. Strengthening and increasing use of the idea (principle) of co-evolution, i.e. conjugate, interdependent change of systems or parts within the whole.

A characteristic feature of post-non-classical science is the aspiration to build a general scientific picture of the world on the basis of the principles of universal (global) evolutionism, which unite the ideas of the systemic and evolutionary approaches into single integrity. The concept of universal evolutionism is based on a certain set of knowledge obtained within the framework of specific scientific disciplines (biology, geology, etc.) and at the same time, it includes a number of philosophical and philosophical attitudes. Evolutionism is understood as a principle that provides extrapolation of evolutionary ideas into all spheres of reality and consideration of inanimate, living and social matter as a single universal evolutionary process.

4. The introduction of the time into all sciences, the ever wider dissemination of the idea of development ("historicization", "dialectization" of science).

In recent years, I. Prigogine developed the idea of the "constructive role of time", its "entry" into all areas and spheres of special scientific knowledge. One of his main ideas is "building a bridge between being and becoming," a "new synthesis" of these two important "dimensions" of reality, two interrelated aspects of reality, with the decisive role of time (becoming).

5. Changing the nature of the object of research and strengthening the role of interdisciplinary comprehensive approaches in its study.

If the object of classical science were simple systems and the object of nonclassical science were complex systems, then at the present time the attention of scientists is increasingly attracted by historically developing systems that, over time, form all new levels of organization. Moreover, the emergence of each new level has an impact on the previously formed ones, changing the links and composition of their elements.

The object of modern science is complex, unique, historically evolving systems that are characterized by openness and self-development, the so-called "human-sized" systems.

6. The combination of the objective world and the world of a human, overcoming the rupture of the object and the subject.

7. The wider application of philosophy and its methods in all sciences.

8. The increasing mathematization of scientific theories and the increasing level of their abstraction and complexity.

9. Methodological pluralism, awareness of the limitations, the one-sidedness of any methodology – including rationalistic one (including dialectical-materialistic one). This situation is clearly expressed by Paul Feyerabend: "Everything is allowed."

4. The integration of synergetics in modern science: extrapolation of its principles of nonlinearity and self-organization

Synergetics becomes the central principle of cognition in modern science. It is grounded on the idea of self-organized objects, which effectively interact with the environment. Environment and such objects form the integral system, each element of which is connected with others with certain links so that any part of the system can theoretically influence the other one. And this influence can appear in non-linear consequences. Properties of a system are not simply the sum of the properties of its elements, but something new inherent only to the system as a whole.

The concept of synergetics is grounded on the following notions: system, element, structure, function.

System is the unification of a certain variety into a single and clearly divided integrity, which elements with respect to the integrity and other parts occupy the corresponding places. System is a collection of elements and connections between them. Integrity of a system means that all its components, joining together, form unique integrity which has new properties of the whole. The subsystem is the largest part of the system, which has a certain autonomy, but at the same time it is subordinated and controlled by the system.

Structure is a relatively stable system of connections of elements that form the whole thing. Sometimes a structure is defined as a set of stable links of an object, ensuring its integrity and identity to itself, i.e. preservation of basic properties under various external and internal changes.

Function is the role, the appointment of a separate element in the system, as well as the appointment of the system as a whole.

Element is such an integral component of the object, which can be indifferent to the specifics of this object. This definition means a minimal, indivisible component of the system.

An important characteristic of a system organization is **hierarchy, subordination** – the sequential inclusion of systems of lower levels into systems of increasingly higher levels.

Links on the "horizontal" are the relationship of coordination between single-order elements. They are correlative: none part of the system can change without other parts being changed.

Links on the "vertical" are connections of subordination, i.e. subordination of elements. They express the complex internal structure of the system, where some parts of their importance can be inferior to others and obey them. A vertical structure includes levels of organization of the system, as well as their hierarchy.

According to modern concepts, the theory of systems is closely related to the concept of "organization". The first attempt to determine what is an organization, led to the idea of expediency, and the idea of expediency, in turn, contains the idea of the goal.

The organism, the organization have each its "goal" and are arranged in accordance with it. At the present time, the definition formulated by ***J. Cleare*** is generally accepted: "***A system is a set of elements that are in relationships or connections with each other and form integrity or organic unity***".

The "general theory of systems "and" systemic approach "are not synonyms. The general theory of systems is a science that formulates regularities and principles which are common to the most diverse fields of knowledge. The systemic approach is a methodology based on the study of objects as systems.

The theory of systems begins with the classification of systems.

Often, three types of systems are distinguished: **discrete (corpuscular)**, **rigid** and **centralized**. The first two types are extreme ones, or ultimate ones.

1. Systems related to the "discrete" type consist mainly of similar elements that are not directly related to each other, but are united only by a common relation to the environment.

2. A rigid type of system can be considered as the opposite of a discrete one. Often these systems are more organized than the simple sum of their parts and they have completely new properties. The destruction of one particular body destroys the entire system.

3. The centralized type of systems contains one main link, which is organizationally, but not necessarily geometrically, located at the center of the system and connects all other links or even controls them.

In addition, there are distinguished **simple, complex and supercomplex systems**, which differs in number, heterogeneity, and by the method of organization of their elements. There are also distinguished **open and closed systems** by the criterion of presence or absence of informational exchange with the external environment.

The systemic approach introduced new content into the concept of evolutionism, creating the possibility of considering systems as self-organizing ones, which have an open character. As Academician N. N. Moiseev noted, everything that is happening in the world can be represented as a selection and there are two types of mechanisms that regulate it: 1) adaptive mechanisms, under the influence of which the system does not acquire fundamentally new properties; 2) bifurcation mechanisms, under the influence of which systems gain the radical rearrangement.

N. N. Moiseev proposed the principle of saving entropy, giving "advantages" to complex systems in comparison to simple ones. Evolution can be represented as a transition from one type of self-organizing system to another, which is more complex.

The idea of the principle of universal evolutionism is based on **three major conceptual directions** in the science of the end of the XX century:

1) the theory of the nonstationary universe;

2) synergetics;

3) the theory of biological evolution and the concept of the biosphere and noosphere which are developed on its basis.

At our times the most complex types of systems are considered within the framework of a special kind of systemic approach – synergetics. Synergetics is the science that studies systems consisting of many subsystems of the most diverse nature; the science of self-organization of simple systems and the transformation of the chaos into the order.

In the post-non-classical picture of the world, chaos did not come as a source of destruction, but as a state derived from the primary instability of interactions, which can cause spontaneous structureogenesis. According to the latest theoretical developments, chaos appears not simply as a formless mass, but as a supercomplex sequence, the logic of which is of considerable interest. Scientists define chaos as an irregular movement with non-recurring, unstable trajectories, where a random distribution is typical for the correlation of spatial and temporal parameters.

The discovery of dynamic chaos is, in fact, the discovery of new types of motion, as fundamental in nature as the discovery of elementary particles by physics. The science of chaos is the science of processes, but not about states, about becoming, but not about being.

Synergetics proved to be a very productive scientific concept, the subject of which was the processes of self-organization spontaneous structurogenesis. It includes the new priorities of the modern picture of the world:

1. the concept of an unstable disequilibrium world,
2. the phenomenon of uncertainty and multi-alternative development,
3. the idea of the emergence of order from chaos.

The fundamental idea of synergetics is that the disequilibrium is conceived by the source of the emergence of a new organization, that is, of order. The main work of the major representatives of this science I. Prigogine and I. Stengers is called "Order out of Chaos."

The peculiar organizational openness of the world presupposes various scenario-structural links of material interactions. The strategy of mastering of self-organizing synergetic systems is related to such concepts as bifurcation, fluctuation, chaos, dissipation, strange attractors, nonlinearity, uncertainty, etc. They are used to explain the behavior of all types of systems: preorganizmic, organic, social, activity, ethnic, spiritual, etc. Synergetics studies the coherent, coordinated state of self-organization processes in complex systems of various nature.

In order to make possible the use of synergetics, the system which is under the study must be open and non-linear, consist of many elements and subsystems (electrons, atoms, molecules, cells, neurons, organs, complex organisms, social groups, etc.), interaction between which can be influenced only by small fluctuations and insignificant random changes, and to be in a state of instability, i.e. in a nonequilibrium state.

Fluctuations in the general case mean perturbations and are divided into two large classes: **created by the external environment and reproduced by the system itself.**

Such a point, after which various scenarios of development are possible, is called the **bifurcation point.**

Attractors are attracting sets, which form themselves as centers, to which elements gravitate.

The system "looks" for its optimal way of organizing. In this situation, a strong influence destroys the system, leads to its simplification, whereas a set of weak effects can bring the system to one of the stable attractors the lines of development. The ystemic approach has become an important stage in the development of science. And the appearance of synergetics allowed us to include elements which traditionally had been considered as systemic, chaotic ones. The new understanding of the notions "chaos" and "possibility" has been introduced. **Chaos is not the negation of the system, but its most complex kind**. By the category "**posibility**" the future state of the object is reflected, it is aimed at correlating the prerequisites and trends of the evolving phenomenon and suggests options for subsequent changes. The set of possibilities is the existential field of uncertainty. The situation is often estimated as uncertain because of the many competing opportunities. Uncertainty accompanies the selection procedure and qualifies the "pre-election" state of the system. **Moreover, the choice is understood not only as the conscious and purposeful action of, but also as the choice of the system.**

The use of synergetics in the study of social processes is limited in some aspects:

1. Only mass processes can be satisfactorily understood, from the point of view of synergetics. The behavior of the individual, the motives of its activity, preferences can hardly be explained with its help since it deals with macrosocial processes and general tendencies in the development of society. It gives a picture of macroscopic, socioeconomic events, which summarizes the personal decisions and acts of choosing by individuals.

2. Synergetics does not take into account the role of the conscious factor of the spiritual sphere since it does not consider the possibility of a person to counteract directly and consciously the macro-tendencies of self-organization that are inherent in social communities.

3. When moving to higher levels of the organization, the number of factors that participate in the determination of the social event increases, while synergetics is applicable to the study of such processes, which are determined by a small number of facts.

Conclusion: *the appearance of the post-non-classical type of scientific rationality in the last third of the 20th century is a great stage in the comprehension of the world by a human. This world consists not only of the external objects but also of the inherent subjects and the researcher is one of them. These subjects influence the objects but the objects and the special environment in which they function influence the subjects, too. In this case, we can speak about the open synergetic systems of subjects which interact with the local environment and in some cases are even determined by it. So if we go further and try to predict the development of scientific rationality for the next stages than maybe we can come to the conclusion that in the future the subject and the object of the research will be like the whole integrity.*

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LECTURE 6.
EPISTEMOLOGICAL MODELS IN THE MODERN SCIENTIFIC DISCUSSION

1. The distinction between classical and non-classical epistemology
2. Different types of vision of the problems of epistemology in different periods of human history.
3. A revolution in the traditional theory of cognition by L. Wittgenstein, M. Heidegger, J. Dewey.
4. Features of the theory of cognition in the natural, mathematical and humanitarian sciences.
4. The development of evolutionary epistemology.
5. Consequences of the linguistic turn in philosophy for the theory of cognition. Postmodernism and change in relation to the problem of knowledge.

The main categories

Epistemology is a philosophical and methodological discipline that examines knowledge, its structure, functioning, and development. *Gnoseology* is a philosophical discipline which is engaged in research, criticism, and theories of knowledge. *Gnoseology* studies the relations in the model "subject-object". *Epistemology* studies the relations in the model "object-knowledge".

1. The distinction between classical and non-classical epistemology

There are distinguished classical and non-classical epistemology:

Features of classical epistemology:

1. Criticism. Epistemology can be seen as a criticism of the notion of knowledge that is offered within the framework of ordinary common sense, scientific concepts or other philosophical systems; it begins with a consideration of the problem of the relationship between illusion and reality, as well as with the distinction between opinion and knowledge.

2. Fundamentalism and normativism. The requirement of validity also extends to the ideal of knowledge; accordingly, it is necessary to discover a certain foundation, the basis for all human knowledge that can avoid any doubt and ensure the distinction between knowledge and non-knowledge. From this point of view, the key concept can be considered as the concept of norm and conformity to this norm, with the obligatory distinction between actual existence and reality.

3. Subject-centrism. The basis for the whole system of knowledge is the fact of the existence of the cognizing subject; this fact is self-confident (according to R. Descartes) and is undeniable, while everything else can be successfully questioned (thereby the criticism in epistemology is strengthened). Knowledge about the things that are outside the consciousness is mediated (whereas knowledge of what is present in the mind is considered to be direct) e" *The key epistemological problem: how it is possible to know the outer world and consciousness of other subjects.*

4. Science-centrism. Since epistemology in its classical form was formed in connection with the creation of science of Modern

Times and acted as a means of legitimizing of it, most of the concepts within this discipline considered scientific knowledge as the highest form of knowledge, recognizing the reality of certain objects or phenomena based on the position of science on this issue.

Features of non-classical epistemology:

At the end of the 20th century, the so-called non-classical epistemology began to form. Non-classical epistemology is characterized by the following features:

1. Post-criticism. For any criticism a certain support point is needed; it should not be questioned at a given time and under the conditions of a given moment so that the attitude for distrust is replaced by its opposite one, by setting the trust to the results of activity. In essence, the post- criticism is based on the idea that knowledge cannot start from nothing.

2. The rejection of fundamentalism. Since cognitive norms undergo various modifications during the development of human knowledge, researchers come to the conclusion that it is not possible to formulate rigid regulatory requirements and prescriptions.

3. The refusal of subject-centrism. The cognizing subject is initially included in the real world and in the system of relationships with people, and, consequently, the causes, the process and the result of the generation and formation of individual consciousness are in the focus of attention.

4. The rejection of science-centrism. Although science is the most important way of knowing reality, it is, however, not the only one and cannot ultimately replace all other forms of cognition. Alternative forms and types of cognition are also worth to be studied. It is important that scientific knowledge does not exclude other forms of cognition, but also interacts with them; although science may not follow, for example, common sense, it, however, must be considered with it.

2. Different types of vision of the problems of epistemology in different periods of human history

Ancient Greek Philosophy and the problem of epistemology. One of the first thinkers who had raised the epistemological problem was **Parmenides**, he introduced the difference between truth and opinion. Truth is the knowledge of being, therefore its main criteria are consistency, immutability, and timelessness. **Socrates** developed one of the first methods of cognition – ***mayaevtic*** – which was based on the idea of the pre-existence of truth, and the truth was hidden from the concrete subject by his opinion. **Plato** treated true knowledge as a memory, which was possible due to the former involvement of the soul in the world of ideas. **Aristotle** laid the foundation of rationalism by developing such a method of cognition as an analysis.

Medieval Philosophy. European Medieval philosophy views knowledge as a grace emanating from God. God reveals Himself in the creation and in the revelation, therefore epistemology becomes hermeneutics the art of interpreting the Bible. **Origen** has developed the doctrine of the three levels of understanding. **The Scholastics** developed the concept of the deductive way of the obtaining of the knowledge.

The New European philosophy. In the New European philosophy, the so-called epistemological turn took place e" the questions of knowledge became the central theme of philosophy. The traditions of rationalism (Descartes, Leibniz) and empiricism (Bacon, Locke, Hume) compete here, the first of which continues the scholastic tradition of deductive cognition, and the second one asserts the thesis that all knowledge comes from experience.

German classical philosophy. **Kant** raises the question of the prerequisites for knowledge, that is, the sphere of the transcendental, and denies the possibility of an adequate cognition of the world. **In the Hegelian understanding** of the question, logic completely, without an irrational remnant, covers the whole field of the problems of cognition, leaves no images of contemplation or images of imagination beyond its borders. It includes their consideration as external products of the active power of thinking, for they are also the thinking, but the thinking which isn't objectified in words, judgments, and conclusions, but in sensually things which are opposite to individual consciousness (deeds, events, etc). Logic is wholly and uninterruptedly merged here with the theory of knowledge because all other cognitive abilities are considered as types of thinking, as thinking, which has not yet reached an adequate form of expression, has not yet matured before it.

Neo-Kantianism. At the end of the 19^{th} century, the term "gnoseology" came into use as a designation for a special science, a special field of research.

Marxism. Developing the point of view of Hegel, Marxism considers logic as the identical theory of knowledge. From this point of view, logic is nothing more than a theory that elucidates the general patterns of the development of cognition and transformation of the material world by a social person.

Modern philosophy. In modern philosophy, epistemology is divided into two currents:

• the first one is based on irrational methods of cognition, in particular on intuition and understanding. In the context of the crisis of classical rationalism, special attention is paid to the search for a scientific criterion that is seen in the consensus of scientific communities (the concept of intersubjectivity), and also in exposing of logocentrism through deconstruction.

• the second one is based on the abstract structure of knowledge and on the social preconditions for the creation and functioning of knowledge. The main direction of epistemology, which studies the structure of knowledge is jastificationism. It proceeds from the existence of the definition of knowledge as a true and justified belief and functions as a scientific discipline with its sub-divisions (coherence, deflationism, fallibilism). The greatest influence on epistemology in this field was rendered by sociology, methods of case studies.

3. A revolution in the traditional theory of cognition by L. Wittgenstein, M. Heidegger, J. Dewey.

The world in which we live changes rapidly. The rate of change is such that scientists are sounding the alarm about the possibilities of psychological adaptation of the modern human to these processes. The turning points of historical development, when certain processes received powerful impulses for acceleration or a new direction of motion were identified by researchers as revolutions, turns, waves, explosions, etc. Powerful shifts are made both in the very socio-cultural reality (industrial revolution, technical revolution, massification, globalization) and in the ways (perspectives) of its comprehension in social, humanitarian and philosophical knowledge. Thus, it is necessary to ascertain the different nature of the considered cultural turns: some of them have an ontological status, another an epistemological status. The analysis made it possible to identify three types of turns.

The turns that have epistemological status. It can be a concept of linguistic, ontological, spatial turns, which describe changes in intentions, new perspectives and ways of considering of reality.

The researchers associate **the ontological turn** with the names of the German philosophers N. Hartmann and M. Heidegger and regard it as a kind of reaction to the long-standing dominance of the epistemological paradigm in European philosophy. Despite the name, the ontological turn has a pronounced epistemological status. If the visual turn primarily fixes the changed conditions for the existence of mankind (the dominance of new media), then the ontological turn reflected precisely the formation of a new view of the world.

The linguistic turn was also the result of a change in the research paradigm and its development from the linguistic philosophy of

L. Wittgenstein, E. Husserl's phenomenology to the theoretical constructions of structuralism. The main idea was the appeal to language as the only reality on the basis of which a person can be known. Being began to be seen through the prism and structure of the language.

The whole world of culture was understood as a text written in different languages, which must be studied in order to read and understand the text.

The epistemological turn-is a historical and philosophical concept for the designation and development of epistemology in the early and mid-20th century the epistemological turn is associated with the emergence of analytical philosophy, the revival of ideas of Kant's transcendental aesthetics and the theory of the sensory experience of British empiricists-classics. Instead of the philosophy of nature which is inherent in the idealistic types of the philosophy of science in the 19th century, a realistically oriented science is grounded on the sensory experience, its reflection in the form of concepts, and the problem of the existence of the external world. In this connection, the epistemological turn was historically conditioned by empiricist philosophy.

4. Features of the theory of cognition in the natural, mathematical and humanitarian sciences

The structure of knowledge in natural sciences

The structure of knowledge in the developed natural sciences has a level organization and consists of four basic types of knowledge: sensual, empirical, theoretical, metatheoretical ones. *Sensual knowledge* is data of observation and experiment on objects of nature and experimental processes. *Empirical knowledge* is a summary description of observations and experiments on empirical and mathematical language in the form of facts and empirical laws. *Theoretical knowledge* is a theoretical-logical systematic description of the properties, relations, and laws of a certain set of ideal objects. *Metatheoretical knowledge* is general scientific principles (private and (or) general scientific picture of the world, fundamental knowledge of paradigmatic theories), philosophical foundations of this branch of science and (or) of this discipline. *Interpretative knowledge* is a set of definitions that connect the elements of neighboring levels of knowledge through their identification. *Mathematical knowledge* is the language of mathematical theories, used for processing sensual data, formulation of facts, laws, principles, constants, description of theoretical structures and their transformations.

The structure of knowledge in mathematical sciences

The structure of knowledge in mathematics characterizes the internal structure of mathematical knowledge; it has a level organization and consists of four basic levels: mathematical problems and tasks, meaningful mathematical theories, formalized mathematical theories, meta-mathematical constructions, including certain philosophical foundations.

The structure of knowledge in technical sciences

Technical sciences is a set of technical, technological, engineering, building, medical and other disciplines. The structure of scientific knowledge in these sciences has a network with a horizontal and vertical organization. This network consists of seven main units: ontological; metrological; model-projective; empirical; theoretical; everyday, metatheoretical knowledge. The knowledge in technical sciences is divided into such types. *Ontological knowledge* is the properties and relations of the artifact ("things"): machines, mechanisms, building structures, construction engineering, technological process, architectural structures, food products, new drugs, etc. *Metrological knowledge* is the description of measuring equipment, devices, standards, systems of units and methods of measurement, methods of processing the results of measurements, etc. *Model-projective knowledge* is theoretical models of future artifacts, their description, mathematical calculations on functionality, reliability, safety, and efficiency, etc. *Empirical knowledge* is the description of observations and experiments on prototype samples of artifacts, their systematization and graphic design, the formulation of facts and laws of behavior and functioning of samples, etc. *Theoretical knowledge* is the introduction of ideal objects as the theoretical representatives of artifacts, the formulation of the laws of their functioning and change, the methods of substantiation and verification of theoretical allegations, etc. *Everyday knowledge* is a set of instructions about the use of machines, mechanisms, technologies, compliance with safety rules, etc. *Metatheoretical knowledge* is fundamental knowledge in natural sciences and social sciences, humanitarian sciences, mathematical theories, philosophical principles and grounds, ethical, economic and environmental regulations and restrictions, social and practical assessments, etc.

The structure of knowledge in social sciences

The structure of knowledge in social sciences is a characteristic of the internal structure of scientific knowledge in social sciences; it has a level organization and consists of four basic types of knowledge: sensual, empirical, theoretical, value ones, including philosophical foundations. The knowledge in social sciences is divided into such types. *Sensual knowledge* is observation and perception of social systems and interactions, practical activity, social relations, history of society. *Empirical knowledge* is a summary description of the data of social observations and perceptions with the help of the empirical language of the social sciences, their primary logical systematization and quantitative description (social facts and laws). *Theoretical knowledge* is private and general social theories, which are aimed at the theoretical representation of social facts and empirical laws of society, their logical justification and assessment from the standpoint of a certain value scale. *Value knowledge* is metatheoretical constructions, which represent the formulation, philosophical reflection, justification of the goals and principles of organization and evolution of society. *Interpretative knowledge* is a set of interpretive statements that identify the concepts of different levels of social science. *Logical-mathematical knowledge* is logical procedures and mathematical language, used for accurate description and substantiation of social knowledge.

The structure of knowledge in humanitarian sciences

The structure of knowledge in humanitarian sciences is the characteristic of the internal structure of scientific knowledge in the humanitarian sciences; it tends to a level organization and consists of the following types of knowledge: sensual, empirical, theoretical, value, interpretative, semiotics ones. We'll describe all of them. *Sensual knowledge* is a set of observations and perceptions of the life of culture and the human, strategies of their behavior and adaptation to changing conditions. *Empirical knowledge* is a generalized description of sensual humanitarian information, its rational and logical representation, and systematization. *Theoretical knowledge* is private and general humanitarian theories, developed models of the culture and the human, the value and normative scale of assessment of their evolution and behavior. *Value knowledge* is philosophical axiology and anthropology, reflexive and constructive common values and meanings of the human and the culture. *Interpretative knowledge* has many interpretative proposals, connect and identify the concept of adjacent levels of knowledge. *Semiotics* is general knowledge of signs, language, their capabilities, and applications.

The regularities of the development of natural science

The regularities of the development of natural knowledge are the main factors and tendencies of the evolution of knowledge in natural sciences. They consist of:

1. The constant increase of objective (object) sphere of natural science; increase in the volume of scientific observations and their accuracy.

2. The growth of the experimental base of natural science and its role as the basis and criterion of the objective truth of knowledge.

3. The increase in the weight and relative independence of the theoretical level of knowledge in relation to empirical knowledge.

4. The strengthening of the mathematization in natural science.

5. The growth of the systematic organization of all natural science knowledge with the release of the leading role of paradigm theory and the scientific picture of the world in ensuring its integrity.

6. The strengthening of the relationship and interaction of the natural sciences with the technical, social and human sciences.

7. The growth of the innovative orientation of the natural sciences to the solution of fundamental economic, practical and social problems.

8. The general regularities of the development of scientific knowledge.

The regularities of the development of mathematical knowledge

The regularities of the development of mathematical knowledge are the main determinants and trends of the evolution of mathematical knowledge. Among them there can be distinguished:

1. The strengthening of the abstract mathematical knowledge.

2. The significant use of logic and methods in constructing and substantiating of mathematical theories.

3. The growth of the variety of methods of input and construction of mathematical objects and theories.

4. Ensuring the internal integrity of mathematical knowledge.

5. Finding unified bases of mathematical sciences.

6. Formalization of meaningful mathematical theories and reasoning.

7. Constructivization, algorithmization, and computerization of mathematical knowledge.

8. The strengthening of the relationship between the mathematical knowledge and all the other sciences (natural sciences, technical and social sciences, humanitarian sciences).

9. The growth of the orientation of modern mathematics to solve fundamental and practical social problems.

10. The general regularities of the development of scientific knowledge.

The regularities of the development of technical knowledge

The regularities of the development of technical knowledge are the main determinants and trends of the evolution of knowledge in technical and technological sciences. They are:

1. The cumulative-intermittent character of changes.
2. The close relationship with natural, social and military sciences.
3. The direct connection with practice and material interests and needs of society.
4. Depending on the level and nature of support from the state and private business.
5. The compliance of technical and technological projects with environmental and humanitarian requirements.
6. Improving the level of mathematization and computerization of models.
7. Strengthening of the interdisciplinary complex nature of technical and technological knowledge.
8. From the modeling of individual technical systems and technological processes to the creation of models of complex systems of technosystems and modeling the evolution of the technosphere in general.
9. The general regularities of the development of scientific knowledge.

The regularities of development of social and humanitarian knowledge

The regularities of the development of social and humanitarian knowledge are the main determinants and trends in the evolution of knowledge in social sciences and humanities.

1. Significant worldview-value determination.
2. Direct dependence on the historically changing and controversial socio-cultural context.
3. Pluralism and dialogue.
4. The reflexive and emotional-expressive character of discourse.
5. Use of all linguistic and semiotic tools in the presentation, justification, and evaluation of concepts.
6. Maintaining a high level of criticality of discourse.
7. Improvement of hermeneutic art.
8. The high degree of intensity of cognitive communications among members of the professional scientific community.
9. The close nature of communication with the broad reader of social and humanitarian scientific texts.
10. General regularities of development of scientific knowledge.

4. The development of evolutionary epistemology

Evolutionary epistemology is a direction in Western philosophical and epistemological thought, the main task of which is to identify the genesis and stages of the development of cognition, its forms and mechanisms in the evolutionary key, and, in particular, the construction of the theory of evolution of a single science on this basis. Evolutionary epistemology is a new, rapidly progressing trend in contemporary epistemology and methodology, which is due to the emergence of Darwinism and the subsequent advances in evolutionary biology, human genetics, cognitive psychology, information theory, computer science. Evolutionary epistemology seeks to create a generalized theory of the development of science, laying the foundation of the principle of historicism and trying to mediate the extremes of rationalism and irrationalism, empiricism and rationalism, cognitive and social aspects, natural science and socio-humanitarian science, etc. Evolutionary epistemology builds its models of the development of scientific knowledge on the basis of the general theory of organic evolution and, above all, on the similarity of the mechanisms of development, operating in the living nature and knowledge.

Proceeding from the fact that an evolutionary approach can be extended to epistemological problems, representatives of evolutionary epistemology reconstruct the development of scientific theories, ideas, the growth of scientific and theoretical knowledge, involving evolutionary models for these purposes.

Evolutionary epistemology is based on the theses:

1. Specifically, human ability to know, as well as the ability to make knowledge, is the result of natural selection. They are closely related to the evolution of language;

2. The evolution of scientific knowledge is the evolution in the direction of building the best theories. By analogy with Darwinism, theories become better adapted through natural selection.

3. The condition of the development of the theory is the possession of language.

The fundamental assumption of evolutionary epistemology is that people, like other living creatures, are the product of evolutionary processes and their mental abilities, their knowledge is guided by the mechanisms of biological evolution.

By virtue of this, the study of evolution turns out to be relevant to the understanding of the phenomena of knowledge and cognition.

Of greatest interest is those concepts of evolutionary epistemology, which reconstruct the development of scientific theories, consider the growth of scientific and theoretical knowledge and involve evolutionary models for solving these problems. Among the authors of these concepts are K. Popper, S. Toulmin, I. Lakatos and others.

Many philosophers of science admit the **lawfulness of an analogy between organic evolution and the growth of scientific knowledge.** They believe that the mechanisms of scientific growth are similar to natural selection. Such a point of view, in particular, was adhered by **S. Toulmin**, who developed an evolutionary model of natural science.

Other researchers also tried to use the evolutionary paradigm as a model for explaining the growth of scientific ideas (D. Campbell, K. Popper, etc.). From their point of view, ideas, hypotheses, and scientific theories, as well as living organisms, must prove their superiority, but in their case, it is **the superiority in the intellectual struggle for existence.**

The concept of the "third world" is used by Popper in describing the mechanism of the development of science in evolutionary epistemology, where the combination of the Popperian principle of "critical argumentation" and the Darwinian model of evolution is the base model.

In the early 1960's S. Toulmin (1922 – 2009) formulated an evolutionary research program on the basis of the idea of functioning "standards of rationality and understanding".

S. Toulmin came to the conclusion that the concepts and understanding depend on a particular historical situation and environment residence.

This line of evolutionary epistemology, based on an analogy with the Darwinian model of biological evolution, is developed by **Stephen Toulmin**.

The growth of knowledge is the process of eliminating errors or "Darwinian selection", i.e. ideals of natural selection. There are some analogues between these conceptions and we'll describe them:

1. The cognitive process is the mechanism of adaptation developed in the course of biological evolution.

2. The theory is a population of concepts.

3. Survival of theories is the conservation and mutation processes.

4. Mutations are restrained by factors of **criticism and self-criticism**, which play the role of **natural and artificial selection** by analogy.

5. The idea of an intellectual initiative that controls the historical development of knowledge: **major changes in science occur not**

as a result of the jumps, but through the accumulation of small changes.

6. The evolution of scientific ideas is the result of the interaction of intellectual, social, economic and other factors.

7. The decisive role belongs to the intellectual factors, hence the scientific elite, on which the emergence of new productive populations of concepts depends. The role of leaders and authorities in science is emphasized.

8. The content of science is the transfer of intellectual knowledge to a new generation.

Thus, the evolutionary model of the development of science, according to S. Toulmin, is the interaction of "innovation and selection."

The most important ideas of S. Toulmin are:

First, the intellectual content of scientific discipline is prone to changes and the preservation of apparent continuity.

Secondly, in the intellectual discipline, there are continuously emerging test ideas, but only some of them gain a solid place in the system of disciplinary knowledge in the process of critical selection.

Thirdly, additional conditions are required for changes: a sufficient number of people capable of supporting the flow of intellectual innovations; the existence of "competition forums" in which trial intellectual innovations can exist for a long time to reveal their advantages and disadvantages.

Fourthly, the intellectual ecology of any historical and cultural situation is that disciplinary selection recognizes those of the competing innovations that meet the requirements of the local "intellectual environment" in the best way. These requirements cover both the issues that need to be addressed directly and other well-established concepts that must co-exist.

In the 1980s **two different research programs of evolutionary epistemology** were formed.

The first program: is an attempt to investigate cognitive mechanisms of animals and humans by spreading the biological theory of evolution to such structures of living systems that act as carriers of cognitive processes – the nervous system, sensory organs.

At this level evolutionary epistemology acts as a biological theory of cognitive processes (**Lorentz** and the others.), it is based on the results which are obtained by ethology, neurobiology, evolutionary biology, physiology, etc.

Conclusion: over the course of millions of years, the nervous system and organs of perception of living organisms have been transformed in such a way as to ensure the most adequate reflection of reality. Only those organisms whose means of cognition allow them to act adequately in the conditions of their environment, survive and give the offspring.

The second program: proceeds from the possibility of explaining culture in terms of biological evolution, i.e. using models of evolutionary biology.

At this level evolutionary epistemology acts as a meta-theory which explains the development of ideas, scientific theories, the growth of scientific and theoretical knowledge (the work of **Popper, Toulmin, Lakatos** and others).

The second program is aimed at studying the evolution of ideas, scientific theories and culture through evolutionary models, that is, through the evolutionary explanation of the content of knowledge itself. Here we are talking about the dynamics of scientific knowledge. This direction is also called the evolutionary theory of science.

There is the evolutionary theory of cognition and the evolutionary theory of science. The first one examines the formation of the cognitive apparatus. The second one deals with the products of knowledge: hypotheses, theories, concepts. The first one relies on the natural-scientific concept of evolution; the second one relies on its metaphorical significance.

Representatives of both of these programs share the belief that an evolutionary approach can be extended to the theoretic-cognitive perspective, including the problems of scientific cognition.

As a result, the main question of epistemology is "What is knowledge and how does it arise?" becomes the subject of evolutionary theory.

5. Consequences of the linguistic turn in philosophy for the theory of cognition. Postmodernism and change in relation to the problem of knowledge

Postmodernism is a concept used in the 60-70s of the XX century in the theory of literature and architecture, and then (especially after the appearance of the work of J. F Lyotard "The Postmodern condition", 1979) entered into the philosophical lexicon. This concept denotes a new way of thinking and activity, manifested in the XX century in all areas of human culture.

J. F. Lyotard defined postmodernism as "**distrust for metanarratives**", such as "the dialectic of the Spirit, the hermeneutics of meaning, the emancipation of a rational subject or worker, the growth of wealth."

Postmodernism recognizes the game equality of the set of coexisting world pictures, **it proclaims "the decline of metanarratives**."(Metanarrative is a narrative about the world, which legitimizes a certain way of thinking, knowledge, social institutions).

Leading representatives of postmodernism are R. Bart, J. Bataille, M. Blanchot, J. Baudrillard, F. Guattari, J. Deleuze, J. Derrida, F. Jamieson, P. Klossowski, J. Kristeva, J. Lyotard, M. Foucault, I. Hassan, and the others. Postmodernism does not represent a philosophical school or direction. Often philosophers, called "postmodernists", are skeptical about this name.

The stages of postmodernism are structuralism and poststructuralism. **Structuralism** arose at the beginning of the

20th century in the humanitarian sciences (linguistics, literary criticism, psychology, etc.) as a methodological orientation that put forward the identification of the structure of objects as a task of scientific research. Structuralism had a linguistic orientation and relied on the concept of linguistics, primarily on the theory of the sign by F. de Saussure. According to this theory, the sign is as an integer, including the signifier and the signified thing.

The structuralists considered all phenomena accessible to sensory perception as "epiphenomena," that is, as external manifestations, as "manifestations" of internal, deep and therefore "implicit" structures, which they considered to be the task of their analysis. The wide dissemination of structural methods in various fields of knowledge gave rise to attempts to elevate structuralism to the rank of a philosophical system.

Poststructuralism, formed in the 1970s and 1980s, came to replace structuralism and was its self-criticism, the continuation, and development of its tendencies. Poststructuralism is also oriented toward the semiotic interpretation of reality ("the world as a text"), but brings to the fore the "underside" of the structure, "chaosmosis".

The basic ideas of poststructuralism are the following ones:

1. The whole world is represented by text, and the traditional subject, object, and means of cognition are its parts.

2. The reality which lies outside the linguistics is unknown or inappropriate, and the mention of it is a tribute to the doubling of the world (according to the scheme: subject   object, material   ideal, phenomenon essence).

The cause of this situation is the irremovable mediation of any activity, by the text. Since the degree of this mediation seems almost infinite, the research focuses on the analysis of the mediation by the text. The deliberately artificial and contradictory character of the texts gives the notions of reality a shaky and elusive appearance so that the possibility of comprehending reality is questionable and actually rejected, not feasible. Any human experience is organized by selected narrative genres: realism, fantasy, detective, scientific knowledge, mysticism, etc. Typical formulas of postmodernism are pluralism, particularity, difference, coexistence, competition, discourse, dialogue, etc.

The main belief of postmodernism is that reality is structured not homogeneously, but heterogeneously, not harmoniously, but dramatically, not uniformly, but diversely.

The fundamental philosophy of postmodernism is post-metaphysical thinking, meaning the rejection of universal philosophical systems, the rejection of logocentrism, that is, the desire to ascribe to all the logos (order and meaning). The vision of reality is referred to so-called postmodern sensitivity = a sense of peace as chaos.

If classical philosophy is mainly concerned with the problem of cognition = the relationship between thinking and the material world, then practically all modern Western philosophy is experiencing a kind of "turn to language", putting the problem of language at the center of attention, and therefore the issues of cognition and meaning acquire are purely linguistic in their nature. As a result, criticism of metaphysics takes the form of criticism of its discourse, or discursive practices, as it is claimed by M. Foucault and J. Derrida.

In neopositivism, the key role in the realization of the linguistic turn was played by L. Wittgenstein, who came to the conclusion that it is a language that shapes our image of the world. Developing his thought, he concludes that the boundaries of language mean the boundaries of our world.

This approach radically changes the relationship between language, thinking, and reality. Earlier, the language played a secondary, instrumental role in these relations: it served as a way of expressing thinking that reflected real reality. Now it comes to the fore: the structure of the utterance determines the structure of possible facts. The same is true of thinking: the language either equalizes with it or plays a decisive role. Therefore, philosophy should focus on language.

The linguistic turn is connected with a new interpretation of the symbol, which comes from H.-G. Gadamer and has this form:

1. Understanding is not a separate type of human activity, but a way of its being.
2. Any understanding is essentially an interpretation.
3. The object of interpretation is a symbol, therefore any object of human activity has a symbolic nature.

The main features of the linguistic turn are:

1. the refusal from epistemological and psychological problems,
2. the criticism of the concept of the subject,
3. the reference to the study of the sense and the meaning,
4. the replacement of the concept of truth by the concept of meaning,
5. the desire to view language as the ultimate ontological basis of thinking and activity, relativism and historicism.

Philosophy is a secondary (metalinguistic) activity associated with the analysis of language, which can be either the language of science or a natural, ordinary language.

In the diverse specification of different types of languages, there are:

• **assertory language** the language of the statement, with the help of which the main statements of the theory are formulated;

• **model language** a language that serves to build models and other elements of a model-representative subsystem;

• **the procedural language** serves to describe measuring, experimental procedures, as well as rules for the transformation of linguistic expressions, the processes of setting and solving problems. A feature of procedural languages is the unambiguousness of the prescriptions;

• **axiological language**, which makes it possible to describe various value elements of the theory;

•**erotetic language**, which is responsible for the formulation of questions, problems, tasks or tasks;

• **heuristic language** that describes a research search, contributes to the problem.

We can note the following stages of the "linguistic turn":

The first stage of the linguistic turn takes place in the 1920s and is connected with the attempt to reform the language or improve it by eliminating confusion with the aim of solving philosophical problems; it represents a variety of attempts to clarify and reform the language in accordance with the laws of logic, which is treated as a unified structure of reality.

The second wave of the linguistic turn occurs in the 1940s and the 1950s when language improvement projects are being replaced by the study and description of different types of language in its routine functioning. Structuralism, hermeneutics, linguistic philosophy emphasizes the contexts and premises of statements, on objectified structures of the language outside of the connection with the subject. The idea of a single perfect language is replaced by the concepts of difference, polysemy, and historicity of the foundations of language, a description of its political and social functions.

In the anti-centrist direction, the central role in the implementation of the linguistic turn belongs to M. Heidegger, who in the article "Being and Time" (1927) concludes: "**The world is only where there is language."**

In his reflections, language acquires a fundamental dimension of human existence. He develops the idea that being, the life of a person unfolds and proceeds in the language. M. Heidegger proclaims: "**Language is the house of being**." M. Heidegger in 1947 in the "Letter on Humanism" comes to the conclusion that "language is the house of being." Thanks to the language, a person is revealed to the world. In the speech process, the initiative does not belong to a person, but to a language: with the help of a mouth of a person the language speaks itself.

In 1953 M.Merlo-Ponty expressed the idea that the theory of the sign of F. de Saussure allows overcoming the fundamental opposition for the philosophy of the New Times called "Subject-object", and this leads to a radical renewal of philosophical reflection.

In the 70-90s, studies of linguistic practices are conducted in the mainstream of various philosophical currents: the "agonist of the language" by J.F.Liotard, the concept of the genealogy of "power-knowledge" in M. Foucault, the critics of ideologies and the analysis of communicative practices in J. Habermas, "The struggle of interpretations" in P. Ricker, "deconstruction of texts" by J. Derrida, the narrative aspect of epistemological and moral crises in A. Makintyra, etc.). In the USSR, at the same time, V. Nalimov creates a probabilistic model of the language and a version of probabilistic metaphysics.

Conclusion: *The epistemological models in the modern scientific discussion have changed radically from the ancient time to nowadays. In the past, the most popular way to understand the external world was to divide the subject and to object of cognition, the picture of the world was certain and unambiguous. In the 20th century while we have the idea that the subject of cognition have an influence on the object of cognition and that's why the certain picture of the world is no longer appropriate. It is replaced by the concept of narrative (the main principle of modern), in which the external world appears as the text which is interpreted by the reader – the researcher. That's why the concept of scientific truth is also revised. But in the concept of postmodern we face the opinion that even the narrative is also destroyed. The reality loses its logos – the crossing sense and the whole world appears as the mosaic of fragments. All these evolutional changes of the picture of scientific rationality bring us the idea that the future discoveries in different branches of science depend on the abstract picture of the reality in general which is offered by philosophy.*

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LECTURE 7.
PHILOSOPHY OF TECHNOLOGY AND METHODOLOGY OF TECHNICAL SCIENCES

1. Understanding the philosophy of technology
2. The history of technical development: linear and evolutionary models of technical development
3. The formation of rational generalization in technology
4. Theoretical schemes and abstract objects of technical theory
5. The evolutionary and revolutionary development of technical theory
6. Modern social assessment of technology and technical activities
7. Evaluation of modern scientific and technical progress: constructive solutions

1. Understanding the philosophy of technology

Philosophy of technology is a philosophical discipline, the subject and task of which is a philosophical reflection of technology, the discovery of its nature and patterns of development. One of the central problems of the philosophy of technology is the determination of the specificity of technical knowledge. What is the nature of technical knowledge? What objects are exploring technology? What goals does it have for itself? The solution of such issues involves addressing to the problem of the correlation of different forms of human knowledge, and, first of all, scientific and technical knowledge.

The term "philosophy of technology" was introduced by the German philosopher **Ernst Kapp** (1808 –1896).

Since the 1960's philosophical studies of technology have received the status of the independent philosophical discipline. In the 1970s, a program of this direction was formulated, and it envisaged a comprehensive study of technology as one of the most important factors in the development of human society. At this time, the influence of technology in the world is truly comprehensive. The determining influence of technology is felt by such social spheres and institutes as economics, ecology, science, politics, etc. In the XX century, the social status of technology has fundamentally changed, turning out into a factor that determined the future of mankind.

Otto Spengler: "Today, technology should not be interpreted in terms of the instrument. It doesn't matter how things are done, but it really matters what can be done with them..."

The scientific and technological revolution has put humanity in the face of global problems. It would be a tragedy for world civilization to continue the further spontaneous, ill-conceived development of technology. Therefore, it is so important to create a new branch of knowledge, drawn to the study of the phenomenon of technology. It is necessary to bring into use the critical philosophical analysis of the current situation, evaluation of the results of technical activities, possible prospects for its development.

According to the well-known American philosopher **H. Skolimowski**, "...the philosophy of technology is the philosophy of our culture. This is the philosophy of a human civilization, which has seen itself in a dead end and is threatened by specialization, fragmentation, and atomization, and it realizes that it has chosen a false language for its communication with nature. "

What is technology? What can it give to a human and what does it deprive a human of? These are the main issues of modern philosophy of technology. Today their analysis is carried out under the influence of at least two philosophical traditions: philosophy and methodology of science (in particular, the analysis of technical knowledge) and philosophical anthropology (moral, ethical and culturological problems of technology, humanistic and value aspects of technology).

Sources and evolution of the definition "technology"

In a broad sense, the technology usually refers to the world of artifacts, that is, the artificial world, "the second nature" in the terminology of Karl Marx. The notion of "technology" also relates to the activities which deal with artifacts and it relates not only to the production of artifacts but can also lead to the formation of specific (technical and technological) knowledge about them.

In the narrow sense, with the technology, the world of means-artifacts (primarily machines and mechanisms) that facilitate, improve the life of a human and society. Activity which is coordinated with this world is called engineering, design, construction. Now while designing and constructing a machine, the engineer means not only mechanical or electric machines.

Technical knowledge can be considered as a combination of theoretical and experiential knowledge. However, technical knowledge is embodied not only through technical activities in various kinds of technical devices but also in articles, books, textbooks, etc., because without a well-established mechanism of production, accumulation, and transfer of knowledge, any technical development in our modern society would be impossible.

The clarity of the formulated tasks with sufficiently substantiated considerations regarding experimental data distinguishes the technical knowledge from other branches of knowledge; its main feature lies in the direction on production and design.

Prospects of the philosophy of technology

Today we can speak only about the period of formation of the philosophy of technology as a special field of philosophical research. Until recent times it was believed that technology does not deserve special consideration in the theoretical and philosophical terms.

Therefore, the theoretical concept of technology has not yet been developed in detail. The system of basic concepts, models of argumentation, has not yet been developed as it has historically developed in other branches of philosophy, such as the philosophy of history, social philosophy, philosophy of science etc. For the philosophy of technology the creation of such a branch of a detailed theoretical system of relations is the future perspective. This task is faced by modern scientists and philosophers who create a new philosophical discipline.

The development of the philosophy of technology is determined by the achievements of the technology itself, the expansion of technical capabilities of mankind.

The philosophy of technology is a young philosophical discipline, aimed at researching technical knowledge, analyzing and evaluating the results of technical activities, as well as forecasting possible social perspectives for technical development.

2. The history of technical development: linear and evolutionary models of technical development

The problem of the correlation of science and technology

In the modern literature on the philosophy of technology, the following basic approaches to solving the problem of changing the correlation of science and technology can be singled out:

1. technology is regarded as applied science;

2. the processes of development of science and technology are viewed as autonomous but coordinated processes;

3. science has developed with focusing on the development of technical apparatus and instruments;

4. at all times the technology of science has overtaken the technology of everyday life;

5. until the end of the 19th century, there was no regular application of scientific knowledge in technical practice, but scientific knowledge is a basic characteristic of modern technical sciences.

Linear model

The linear model considers technology as a simple application of science or even as an applied science. However, this point of view has been seriously criticized in recent years as too simplistic. Such a model of the relationship between science and technology, when science recognizes the function of the production of knowledge, and technology is only its application, is misleading since it asserts that science and technology represent different functions performed by the same community.

Sometimes it is believed that the main difference between science and technology is only in the breadth of horizons and in the degree of commonality of problems: technical problems are narrower and more specific ones. However, in reality, science and technology constitute different communities, each of which is differently aware of its goals and value system.

Such a simplified linear model of technology as applied science, i.e., a model postulating a linear, consistent trajectory from scientific knowledge to technical discovery and innovation – has been recognized as inadequate by most specialists today.

Evolutionary model

The processes of development of science and technology are often regarded as autonomous, independent of each other, but coordinated at the same time. Then the question of their relationship is solved in such a way:

a) there exists a belief that science uses technology instrumentally at some stages of its development to obtain its own results, and vice versa technology uses scientific results as a tool to achieve its goals;

b) the other opinion expresses that the technology sets the conditions for the choice of scientific options, and science, in turn, sets the conditions for the choice of technical options. The latter is called an evolutionary model.

The first point of view emphasizes that the idea of technology just as applied science should be discarded since the role of science in technical innovation has a relative, rather than an absolute value. According to this point of view, technological progress is guided primarily by empirical knowledge obtained in the process of the immanent development of technology itself, and not by theoretical knowledge brought into it from outside by scientific research.

But no less one-sided is the opposite position, which emphasizes only the empirical nature of technical knowledge. It is quite obvious that modern technology is inconceivable without deep theoretical studies, which are conducted today not only in natural but also in special technical sciences.

In the evolutionary model of the relationship between science and technology, three interrelated, but independent spheres are distinguished: science, technology, and production (or, more broadly, practical use). In each of these spheres, the internal innovation process occurs according to the evolutionary scheme.

Thus, in this case, the philosophers of science are trying to transfer models of the dynamics of science to the explanation of the development of technology. However, such a procedure still requires special justification and meaningful analysis of the development of technical knowledge and activity, but not a search for supporting examples for the a priori model obtained on completely different material. Of course, it does not mean that many of the results obtained in the modern philosophy of science cannot be used to explain and understand the mechanisms of the development of technology, especially the question of the relationship between science and technology.

According to the third point of view, science is developed by focusing on the development of technical apparatus and tools and represents a series of attempts to explore the way these instruments function.

The fourth point of view disputes the previous one, arguing that the technology of science, that is, measurement and experiment, is ahead of the technology of everyday life at all times.

The most realistic and historically grounded point of view is the one that claims that until the end of the XIX century there was no regular application of scientific knowledge in technical practice, but this is typical for the technical sciences today. During the 19 century, the relations of science and technology are partially overturned in connection with the "scienification" of technology. This transition to scientific technology was not, however, a unidirectional transformation of technology by science, but their interrelated modification. In other words, the "scientification of technology" was accompanied by the "technology of science".

During a long period technology was not associated with science broadly; people could do and make devices, not understanding why they work in such a way. At the same time, until the nineteenth century, natural science solved its own tasks, although often it was based on technology. Engineers, proclaiming the orientation on science, guided it insignificantly in their immediate practical activities. After many centuries of such "autonomy" science and technology joined in the XVII century, at the beginning of the scientific revolution. However, only by the XIX century, this unity has brought its first fruits, and only in the twentieth century, science has become the main source of new types of technology.

In the first (pre-scientific) period, three types of technical knowledge are consistently formed: practical methodological, technological and constructive technical knowledge.

In the second period the emergence of technical sciences (from the second half of the eighteenth century to the 1970s) has taken place: firstly, the formation of scientific and technical knowledge based on the use of knowledge of natural sciences in engineering practice, secondly, the emergence of the first technical sciences. This process occurs, of course, today, in the new areas of practice and science, however, the first samples of this method of forming scientific and technical knowledge refer specifically to this period.

The third period the classical period (until the middle of the XIX century) is characterized by the construction of a number of fundamental technical theories.

Finally, the fourth stage (present time) is characterized by the implementation of complex studies, the integration of technical sciences not only with natural sciences, but also with social sciences, and at the same time the process of further differentiation and "budding out" of the technical sciences from natural and social ones.

The identification of the role of technology in the development of society and the role of social factors in the development of technology is one of the most important tasks of the philosophy of technology, as well as of social philosophy in general.

Technological determinism (technicalism) is an approach that absolutizes the role of technology in the development of society.

Supporters of this approach consider technical progress to be the main or even the only factor in the development of all spheres of public life. At the same time, the very development of technology is presented as an autonomous process, driven only by internal causes and being independent of external social factors – economic, political, ideological ones. Technological determinism arose in the twentieth century as an alternative to the Marxist explanation of history.

3. The formation of rational generalization in technology

The first stage of rational generalization in the artisan technology was connected with the need for training within each separate type of craft technology. All kinds of handbooks and teaching aids have not yet been strictly scientific, but have already transcended the mythological picture of the world. Society was aware of the need to create a system of regular training for the craft.

Further development of the rationalization of technical activity could only proceed along the path of scientific generalization. Engineers focused on the scientific picture of the world, but in real technical practice, the world of "approximation" dominated. Samples of exact calculation were demonstrated by scientists, developing more and more advanced scientific instruments, which only fell into the sphere of industrial practice later. At this time the mutual relations of science and technology were determined in many respects by accidental factors for example, by personal contacts of scientists and practitioners, etc. Until the nineteenth century, science and technology developed as if along independent trajectories, being, in fact, separate social organisms each with its own special value systems.

The second stage of a rational generalization of technology consisted in the generalization of all the existing areas of craftsmanship.

The next stage of rational generalization of technology finds its expression in the emergence of technical sciences (technical theories). Such theoretical generalization of certain areas of technical knowledge in various fields of technology occurs primarily for the purpose of scientific education of engineers in the orientation toward a natural scientific picture of the world.

At first scientific technology meant only an application to the technology of natural science. In the XIX century "technical knowledge was wrenched from age-old craft traditions and grafted to science," wrote the American philosopher and historian **E. Leighton**. The technical community, which in the 1800s was a handicraft and differed a little from the medieval one, is becoming a "crooked mirror" of the scientific community. On the front lines of technological progress, artisans were replaced by new figures a new generation of learned practitioners. Oral traditions, passing from master to pupil, replaced the new technology by teaching in the college, professional organization and technical literature created on the model of the scientific one. So, technology has become scientific but not in the sense that now it obeys all the requirements of the natural sciences without resentment, but in the fact that it develops special technical sciences.

The technical sciences, which were formed primarily as applications of various fields of natural science to certain classes of engineering problems, formed a special class of scientific disciplines in the middle of the twentieth century and these scientific disciplines differed from the natural sciences both in terms of object and internal structure, but also possessing a disciplinary organization.

Finally, the highest stage of rational generalization in engineering today is system engineering as an attempt at a comprehensive theoretical generalization of all branches of modern technology and technical sciences in the orientation not only of the natural sciences but also of the humanities of engineers, that is, with orientation to the system picture of the world.

System engineering is a special activity to create complex technical systems and in this sense is primarily a modern kind of engineering and technical activity, but at the same time includes a special scientific activity, since it is not only a sphere of application of scientific knowledge. It also produces new knowledge. Thus, in system engineering, scientific knowledge passes a full cycle of functioning from its receipt to use in engineering practice.

The last two stages of scientific generalization of technology are of special interest for philosophical analysis since at these stages the truly global influence of technology on the development of modern society can be traced.

The process of scientification of technology would be unthinkable without the scientific training of engineers and the formation of a disciplinary organization of scientific technical knowledge on the model of disciplinary science. However, by the middle of the 20th century, the differentiation in the field of scientific and technical disciplines and engineering activities had gone so far that further development of them became impossible without interdisciplinary technical studies and system integration of the engineering activities themselves. Naturally, these system integrative trends are reflected in the field of engineering education.

A lot of various scientific and technical disciplines and corresponding fields of engineering practice are being formed. There were narrow specialists who knew "everything about nothing" and did not know what was happening in the adjacent laboratory. There were also the so-called "universalists", who, on the contrary, knew "nothing about everything." The status of these universalists in the system of the disciplinary organization of science and in the structure of specialized engineering activity is still not clearly defined, now it is impossible not only to solve specific scientific and engineering problems but also to detect the further development of science and technology as a whole. The engineering tasks become complex, and in their solution, it is necessary to take into account a variety of aspects that previously seemed to be of secondary importance, for example, **environmental and social aspects**.

When the interdisciplinary, systemic problems in technology arise, the importance of the philosophy of technology increases substantially, since they cannot be solved within the framework of any one established scientific paradigm. Thus, the traditional disciplinary organization of science and technology that has arisen in the twentieth century must be supplemented by interdisciplinary research of a completely new level. And as the future development of science and technology is laid in the process of training and educating professionals, it becomes necessary to form a new style of engineering scientific thinking precisely in the process of engineering education.

In addition, in the field of engineering and technical sciences, a layer of exploratory, actually fundamental research, i.e., a technical theory is being formed. It leads to specialization within certain areas of technical science and engineering. A very important and necessary division of labor also generates a whole series of problems of cooperation and docking of different types of engineering tasks.

Naturally, this trend finds its expression in the field of engineering education. This leads to the fact that the design setting penetrates the sphere of science, and the cognitive one enters the field of engineering. Just as the philosophy of science does in relation to scientific knowledge and scientific theory, the philosophy of technology begins to perform a reflexive function in relation to technical knowledge and technical theory.

Unfortunately, the thought of the need to turn to the history of technology and science not only for studying cultural patterns and knowledge of the past, but also for searching for new technological solutions, still very slow penetrates into the engineering consciousness. This applies, for example, to ancient medical technologies, where the centuries-old verification by tradition is supplemented with rigorous scientific analysis today. The history of technology understood not only as of the history of individual technical instruments, but also as the history of technical solutions, projects and technical theories (both successful and unrealized, which seemed deadlocked at their time) can become the real basis not only of the present but also of the foreseeable future. To know and to foresee is not a historical task, but a philosophical task. **Therefore, the philosophy and history of science and technology should take one of the important places in modern engineering education.**

In this case, the philosophy of technology has similar tasks in relation to technology, as the philosophy of science in relation to science.

Its role naturally increases with the transition from simple systems to complex ones, as well as from specialized types of technical activity to system and theoretical studies and design types. The processes that take place at these stages of the development of the scientific technical activity require the greatest degree of philosophical reflection.

In the complex cooperation of various types and spheres of modern engineering activity, **three main areas that require different training of relevant specialists can be identified:**

Firstly, these are the engineers of the production company, who are called to perform the functions of a technologist, production manager, and maintenance engineer. Such engineers should be prepared to take into account their preferential practical orientation.

Secondly, there are engineers, researchers, developers who must combine the functions of the inventor and the designer, closely related to research work in the field of technical science. They become the main link in the process of connecting science with production. They need a thorough scientific and technical training.

Thirdly, they are engineers of system engineering or, as they are often called, "wide-profile system operators" whose task is the organization and management of complex engineering activities, complex research, and system design. The training of such an engineer as an organizer and "universalist" requires the widest systematic and methodological direction and interdisciplinarity. For such engineers, interdisciplinary and general humanities education is particularly important, and in such an education the philosophy of science and technology could play a leading role.

Thus, it is the last two stages of rational generalization in technology that are of greatest interest for philosophical methodological analysis, namely, the methodology of technical sciences, engineering design, and system design. In this sphere, the interests of the philosophy of technology and the philosophy of science are particularly closely intertwined. **The philosophy of science provides the knowledge**

of the means of methodological analysis, which is developed on the basis of the natural-scientific, primarily physical cognition, to the philosophy of technology; the philosophy of technology gives a new material – technical sciences – for such analysis and further development of the methodological tools themselves.

Fundamental and applied research in engineering

Applied research is a study which results are addressed to producers and customers and which are directed by the needs or desires of these customers, and **fundamental research** is addressed to other members of the scientific community.

Modern engineering requires not only short-term studies aimed at solving specific problems, but also a broad, long-term program of fundamental research in laboratories and institutes which are specifically designed for the development of technical sciences. At the same time, modern fundamental research (especially in the technical sciences) is more closely related to applications than it was before.

For the modern stage of development of science and technology, the use of fundamental research methods for solving applied problems is the main characteristic. The fact that research is fundamental does not yet mean that its results are non-utilitarian. The work aimed at applied goals can be very fundamental. The criteria for their separation are mainly the time factor and the degree of generality. It is quite legitimate today to talk about fundamental industrial research.

In scientific and technical disciplines it is necessary to distinguish clearly the studies which are included in direct engineering activities (regardless of the organizational forms in which they occur), and theoretical studies = technical theory.

In order to identify the features of the technical theory, it is compared primarily with the natural sciences.

H. Skolimowski has written: "Technical theory creates reality, while scientific theory only explores and explains it." **G. Boehme** noted that "technical theory is designed to achieve a certain optimization."

M. Bunge stressed that in technical science theory is not only the top of the research cycle and a reference point for further research but also the basis of the system of rules that prescribe the course of the optimal technical action.

The greatest difference between physical and technical theories is the nature of idealization: a physicist can concentrate his attention on the simplest cases (for example, eliminate friction, fluid resistance, etc.), but all these cases are very essential for a technical theory and must be adopted by it in Attention. Thus, the technical theory deals with a more complex reality since it cannot eliminate the complex interaction of physical factors which take place in the machine. The technical theory is less abstract and idealized; it is more closely related to the real world of engineering.

The special cognitive status of technical theories is expressed in the fact that technical theories deal with artificial devices, or artifacts, while scientific theories refer to natural objects. However, the opposition of natural objects and artifacts still does not give a real basis for the distinction being made. Almost all the phenomena studied by modern experimental science have been created in laboratories and in this regard represent artifacts.

According to E. Layton, technical theory creates a special social layer of intermediaries – the so-called "scientists-engineers" or "engineers-scientists. Its serious reformulation and development is necessary because it is necessary to form the pass from one community (scientists) to another (engineers).

Thus, in the modern philosophy of technology, researchers were able to identify fundamental theoretical research in the technical sciences and conduct a primary classification of types of technical theory. The division of research in the technical sciences into fundamental and applied sciences makes it possible to single out and consider technical theory as a subject of special philosophical and methodological analysis and to proceed to the study of its internal structure.

The structure of the technical theory. To explain the specifics of technical sciences, it is very important to show the similarities and differences of physical and technical theories. The first technical theories were modeled on the physical ones. In the structure of the developed natural-scientific theory, along with the conceptual and mathematical apparatus, theoretical schemes that form a kind of "inner skeleton" of the theory play an important role.

4. Theoretical schemes and abstract objects of technical theory

Theoretical schemes are a collection of abstract objects oriented, on the one hand, to the application of the corresponding mathematical apparatus, and on the other hand, to a mental experiment, that is, to the design of possible experimental situations. They are special idealized representations (theoretical models), **which are often (especially in the technical sciences) expressed graphically.**

Theoretical schemes express a special vision of the world under a certain angle of view, which is given in concrete theory.

These schemes, on the one hand, reflect the properties and sides of real objects of interest to the theory, and on the other hand, are its operational means for an idealized representation of these objects, which can be practically realized in an experiment by eliminating side effects in a technical way.

Thus, the abstract objects that form part of the theoretical schemes of mathematized theories are the result of idealization and schematization of experimental objects or, more broadly, of any objects of object-oriented (including engineering) activity.

The peculiarity of engineering sciences is that engineering activity, as a rule, replaces the experiment. It is in engineering activity that the adequacy of the theoretical conclusions of the technical theory is checked and new empirical material is scooped up. This does not mean that experiments are not conducted in the technical sciences, they are simply not the ultimate practical basis for theoretical conclusions. Great importance in this respect is acquired by engineering practice.

Abstract objects of the technical theory have a number of features:

1. They are "homogeneous" in the sense that they are assembled from some fixed set of blocks according to certain "assembly" rules.
2. Any mechanisms can be represented as consisting of hierarchically organized chains, links, pairs, and elements. This ensures, on the one hand, the correspondence of abstract objects to the constructive elements of real technical systems, and on the other, creates the possibility of their deductive transformation at the theoretical level.

Since all the mechanisms are assembled from the same set of typical elements, it remains only to specify certain procedures for their assembly and disassembly from ideal chains, links, and pairs of elements. These idealized blocks correspond to the standardized constructive elements of real technical systems. In the theoretical schemes of engineering science, the image of the engineering system being designed and projected is given.

The specificity of the technical theory is that it is oriented toward the design of technical systems. Scientific knowledge and laws obtained by natural science theory require a long "refinement" for their application to the solution of practical engineering problems, which is one of the functions of the technical theory.

Theoretical knowledge in the technical sciences must necessarily be brought to the level of practical engineering recommendations. To fulfill this task, the rules of correspondence, the transition from one model level to another, serve in the technical theory, and the problem of interpretation and empirical justification in technical science is formulated as an implementation problem.

Therefore, in the technical theory, the development of special operations of transferring theoretical results to the field of engineering practice, establishing a clear correspondence between the sphere of abstract objects of the technical theory and the constructive elements of real technical systems plays an important role, which corresponds to the actual theoretical and empirical levels of knowledge.

The main stages of the formation of technical theory: empirical and theoretical level

The first technical theories were formed as the application of physical theories to specific areas of engineering practice, usually in two phases:

- In the first phase, a new applied research direction is formed and new private theoretical schemes are formed,
- In the second phase, generalized theoretical schemes and mathematic theory are developed.

At the same time:

– the basic natural theoretical scheme is translated from the basic natural science (for the technical science it is a flow scheme);

– the structural theoretical scheme appears from the adjacent technical science(or it is being developed anew);

– the functional scheme appears from the mathematical theory.

Then, these schemes are adapted to new empirical material and their modification due to the constructive introduction of new abstract objects.

In the first phase, the schemes of experimental situations borrowed from the basic natural science theory are processed into structural diagrams of specific technical devices, the improvement, and modification of their design. The object of research and design is considered in this case only as a kind of object of research of the basic natural-scientific theory.

The development of a generalized theoretical scheme is the final phase of the construction of a technical theory. More often this scheme is translated from adjacent areas or from the basic natural science theory. However, if there is no corresponding section in the basic natural-scientific theory, then it is built anew, which is a special task.

The technical theory introduces homogeneous abstract objects consisting of typical and hierarchically organized ideal elements and connections between them (the rules of assembly and disassembly of these elements), which are necessarily put in line with the constructive elements of real technical systems, ie, a procedure for the analysis and synthesis of theoretical schemes. If a specific field of engineering activity has already taken shape by that time, then it is possible to reconstruct it into a theoretical model (bringing the constructive elements to the ideal elements of abstract objects). At this stage, there are made attempts to project a generalized theoretical scheme into a class of hypothetical technical systems, which leads to the need to create a mathematized theory.

Specifying operations for the equivalent transformation of functional schemes (deductive inference) and allows for the above projection, i.e., the synthesis of technical systems that have not yet been created. This leads to the creation of a block of practical methodological knowledge on the empirical level of a technical theory – recommendations for still unimplemented engineering activities. Approbation of the technical theory is made in the engineering practice, and the proof of its vitality and constructiveness is the creation on its basis of new technical systems.

5. The evolutionary and revolutionary development of technical theory

The development of the technical theory is carried out in two main ways evolutionary and revolutionary way.

In the first case, new research directions and areas of research are allocated in the framework of the same fundamental theoretical scheme.

In the second case, there is a change of one fundamental theoretical scheme to another in the transition to a new family of scientific and technical disciplines.

The fundamental theoretical scheme performs an important methodological function in technical science – a methodological reference point for still unfulfilled engineering activities. It sets the principle of seeing the newly created technical systems and allows choosing the most suitable theoretical tools from adjacent technical, mathematical or natural disciplines for solving this engineering problem. The engineer always focuses on such a theoretical scheme, whether he realizes it or not. He correlates the image of the system being studied and projected by him with this scheme, although he does not always realize that this scheme is quite rigidly directing his search.

Empirical and theoretical in technical theory

The empirical level of the technical theory form constructively technical and technological knowledge, which is the result of generalization of practical experience in the design, manufacture, debugging, etc. of technical systems. These are heuristic methods and technologies developed in engineering practice but considered as an empirical basis of technical theory.

Structurally, technical knowledge is mainly oriented to the description of the structure (or design) of technical systems, which are a combination of elements that have a certain form, properties, and method of connection. They also include knowledge of the technical processes and parameters of the functioning of these systems.

Technological knowledge captures the methods of creating technical systems and the principles of their use.

Empirical knowledge of engineering science is displayed at its theoretical level in the form of multi-layered theoretical schemes, abstract objects of various levels. However, the empirical level of the technical theory contains not only constructively technical and technological knowledge, which, in fact, is focused on generalizing of the experience of engineering work, but also special practical methodological knowledge that represents practical recommendations for the application of scientific knowledge obtained in technical theory, in practice engineering design.

The theoretical level of scientific technical knowledge includes three basic levels of theoretical schemes: functional, flow and structural one.

The functional scheme fixes a general idea of a technical system, regardless of the way it is implemented and is the result of the idealization of a technical system based on the principles of a certain technical theory.

Functional schemes coincide for a whole class of technical systems. The blocks of this scheme fix only those properties of the elements of the technical system, for the sake of which they are included in it for the performance of the common goal. Each element in the system performs a certain function.

In the classical technical science, functional schemes are always tied to a certain type of physical process, i.e., to a certain mode of operation of a technical device, and can always be identified with any mathematical scheme or equation. However, they may not be closed to a specific mathematical apparatus. In this case, they are expressed in the form of a simple decomposition of interrelated functions aimed at fulfilling the common goal prescribed for this technical system. With the help of such a functional scheme, an algorithm is constructed for the functioning of the system and its configuration (internal structure) is selected.

The flow scheme, or the scheme of functioning, describes the natural processes taking place in the technical system and linking its elements into an organic whole. Blocks of such schemes reflect various actions performed on the natural process by the elements of the technical system in the course of its functioning. Such schemes are built on the basis of natural-science (for example, physical) representations.

The structural diagram of the technical system captures those nodal points to which the flows (processes of functioning) are closed.

The structural scheme fixes the constructive arrangement of the elements and connections (i.e., the structure) of the given technical system and already presupposes a certain way of its realization. Such schemes, however, are the result of some idealization, reflect the structure of the technical system, but are neither its scrupulous description for the purpose of reproduction, nor its technical design, according to which such a system can be built. This is still a theoretical outline of the structure of a future technical system that can help to develop its project, ie, a starting point for subsequent engineering activities produced by a technical theory, or an initial theoretical description, a theoretical scheme of an already existing technical system for the purpose of theoretical calculation and search opportunities for improvement. In addition, often these schemes are built on the basis of representations of more specialized scientific and technical disciplines and solve the problems arising in them by theoretical means.

Structural schemes in the classical technical sciences reflect the design of the technical system and its technical characteristics in technical theory.

Thus, in the technical theory, on the material of the same technical system, several operational spaces are constructed, and different theoretical schemes correspond to them. In each such "space" different abstract objects and means of operating with them are used, special problems are solved. At the same time, their clear adequacy to each other and the structure of a real technical system makes it possible to "transport" the solutions received from one level to another, as well as in the field of engineering. The mechanisms of interaction of these operational spaces can be disclosed as a result of methodological analysis of the functioning of the technical theory.

6. Modern social assessment of technology and technical activities

Nowadays the development of technology is increasingly showing the dual nature of its achievements. On the one hand, it is impossible to imagine the development of mankind without technology, and on the other hand, technology is a powerful force that can cause the most negative, even tragic, consequences. The ill-fated development of technology leads to the fact that the success of technical progress is turning into complex social problems. Replacing the human's workforce in production, thereby leading to increased productivity labor, technology exacerbates the problems of employment and unemployment; residential comfort leads to undesirable disunity of people today.

At the beginning of the XXI century, mankind faced the need to solve problems of the world order: pollution of the environment with industrial waste; irreversible exhaustion of natural resources; disturbance of balance in demographic processes; the danger of a radioactive catastrophe, etc. All this makes us think about the goals and prospects of technical development, about measures from its possible restriction.

Increased technological expansion caused a broad polemic in the West world. The 1960s became milestones in the growing crisis of the era. This time has come to replace the overwhelming enthusiasm of technology, the rejection of the successes of the scientific and technological revolution, and it was marked by a change in the relations in the system "society – technology – nature", the growth of social concern, mass appearances of young people, the movement of "green" in the protection of the environment.

Throughout the history of mankind, scientific and technological progress continues. There are conflicting approaches to assessing the consequences of this process. The twentieth century was dominated by **technical optimism** an approach that absolutized the positive effects of technological progress ("technology decides everything").

Supporters of technical optimism believe that even environmental problems generated by technological progress can be resolved with the help of the same technology and new technologies.

In the second half of the 20th century, **technical pessimism** was widespread, an approach that absolutized the negative consequences of scientific-technical progress ("all evil is from technology").

Technical optimism and pessimism absolutize one or other side of scientific-technical progress. Dialectical thinking requires a deeper, more comprehensive evaluation of this phenomenon, recognition of the inconsistency of scientific and technical progress. It would be erroneous to try to stop progress. But it is necessary to learn to predict its consequences in order to minimize the negative consequences. In developed countries, laws are adopted and state bodies that control the use of new technologies are formed. A comprehensive environmental and social and humanitarian expertise of new technologies is being carried out. Possible positive and negative consequences are projected. The right of citizens to participate in decision-making related to the introduction of potentially dangerous technologies is recognized. The largest projects should be openly discussed with the involvement of specialists from various fields of knowledge, representatives of public organizations and authorities. These measures are aimed at the transition from spontaneous development to a conscious scientific and technological policy.

The problem of assessing the social, environmental and other consequences of technology

The goals of modern engineering and its consequences

The engineer must listen not only to the voice of scientists and technicians and not only to the voice of his own conscience but also to public opinion, especially if the results of his work can affect the health and lifestyle of people, affect cultural monuments, disrupt the balance of the natural environment.

When the influence of engineering activity becomes global, its decisions cease to be a narrowly professional matter, become the subject of general discussion, and sometimes of condemnation. And although scientific and technical development remains to be the work of specialists, the decision on such projects is the prerogative of society. No references to economic, technical and even state expediency can justify social, moral, psychological, environmental damage, which may be a consequence of the implementation of some projects. Their open discussion, explanation of merits and demerits, constructive and objective criticism in the wide press, social expertise, promotion of alternative projects and plans become the most important attribute of modern life, an inevitable condition, and consequence of its democratization.

The initial goal of engineering activity is to serve a person. However, modern technology is often used to harm people and even humanity as a whole. This applies not only to the use of technology for the purposeful destruction of people but also to the daily operation of engineering technical devices. If the engineer and the designer did not envisage that, along with precise economic and clear technical requirements for operation, the requirements of safe, noiseless, convenient, environmentally friendly engineering devices should be met, then from the means of serving people, technology can become hostile to human and even be subjected to its very existence on Earth. This feature of the current situation highlights the problem of ethics and social responsibility of the engineer and designer to society and individuals.

Of course, such decisions hampered technical and economic progress came into conflict with the requirements of the emerging market economic system. However, today mankind is in a fundamentally new situation when inattention to the problems of the consequences of the introduction of new technology can lead to irreversible negative results for the entire civilization and terrestrial biosphere. In addition, we are at the stage of scientific and technical development, when such consequences are possible and necessary, at least in part, to anticipate and minimize of new technology at the early stages of its development. In the face of a very real environmental catastrophe, which can be the result of the technological activity of mankind, it is necessary to rethink the very idea of scientific and technical and socioeconomic progress.

7. Evaluation of modern scientific and technical progress: constructive solutions

Such consequences of the development of nuclear energy, as the consequences of the Chernobyl disaster, cannot always be predicted. But it is necessary, at least to try to do this with respect to new projects, to conduct relevant studies, to listen to the views of oppositionists before the final decision is taken, and to create legal mechanisms regulating all these issues.

Evaluation of technology is an interdisciplinary task and requires, undoubtedly, the training of specialists of a broad profile, possessing not only scientific technical and natural science but also social and humanitarian knowledge. However, this does not mean that the responsibility of a single rank-and-file engineer decreases on the contrary, a collective activity must be combined with individual responsibility. And such responsibility means the need to develop the self-awareness of all engineers in terms of understanding the need for social, environmental, etc., technology assessment.

As a conclusion: *Even at the beginning of the XX century, the Russian engineer and technologist* ***P. K. Engelmeyer*** *wrote: "Engineers often rightly complain that other spheres do not want* *to recognize the importance that should rightfully belong to the engineer ... But are the engineers ready for this work themselves? .. For the lack of general mental development, engineers do not know anything and do not want to know about the cultural significance of their profession and consider the reasoning about these things for a waste of time ... Hence it is a challenge to engineers: It is important to increase intellectual development and to penetrate the importance of their profession on the basis of historical and sociological data in the modern state. "*

These words have not lost relevance today.

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(*англійською мовою*)

Комп’ютерне складання та верстання *В. В. Москаленко*
Коректор *М. О. Паненко*

Формат 60×84/16. Ум. друк. арк. 12,0. Тираж 100 прим. Вид. № 19. Зам. № 00.

Видавець і виготівник Національний університет кораблебудування
імені адмірала Макарова
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Свідоцтво суб’єкта видавничої справи ДК № 6402 від 19.09.2018 р.