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Навчальний посібник з дисципліни «Методологія наукових досліджень» розрахований на студентів-магістрів закладів вищої освіти і має на меті допомогти студентам-філологам підготуватися до практичних занять з цієї дисципліни. Посібник складається із 10 розділів, фокус кожної із яких визначається відповідність до вимог навчального плану з цієї дисципліни.

Структура та зміст посібника орієнтовані на системну організацію навчального процесу та забезпечення комплексної підготовки студентів-філологів, будучи невід'ємною частиною навчально-методичних матеріалів з англійської мови для університетського рівня.

Для студентів-магістрів спеціальності 035 – «Філологія. Германські мови та літератури (переклад включно), перша – англійська)».

Anisenko O. V.

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The tutorial on the subject “Methodology of scientific research” is designed for master's students of higher educational institutions and aims to help the philological department students prepare for practical classes in this discipline. It consists of 10 units, each structured following the curriculum requirements for this discipline.

The structure and content of the tutorial are aimed at the systematic organization of the educational process and ensuring comprehensive training for philology students, serving as an integral part of the educational and methodological materials in English for university-level students.

For master's students of specialty 035 – “Philology. Germanic languages and literatures (including translation), Primary – English)”.

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CONTENT

PREFACE

Scientific and technological progress has increased the importance of training scientific personnel for society, as modern countries' most significant achievements are associated with scientific successes.

The profound changes in recent decades in Ukraine's economy, politics, ecology, and social life have resulted in a substantial rise in various problems at the individual, social group, and societal levels. The need to address these issues has intensified the development of research work as a profession aimed at ensuring the success of necessary systemic reforms, the country's economic growth, the establishment of the rule of law, and social protection for different population segments.

In the information age, where science has become a direct productive force and the scientific and technological revolution is expanding remarkably, addressing issues of methodology and logic in scientific research is considered one of the most pressing tasks. The continuous and ever-increasing stream of scientific studies, along with a noticeable rise in the number of individuals engaged in science, not only stimulates general interest in the problems of scientific cognition but also necessitates the analysis and development of research methods utilized in modern science.

Contemporary professional activity in any societal domain requires specialists to have the skills to solve fundamentally new tasks, conduct research in various forms, creatively apply scientific achievements, and enhance their qualifications.

In the 21st century, amid the growth of scientific information and the rapid, avalanche-like renewal of human knowledge, preparing highly qualified scientists with strong professional and theoretical training capable of independent creative research work becomes critically important.

In current socio-economic conditions, there is an increased interest in scientific research. However, the desire to engage in research activities often encounters insufficient mastery of methodological and methodical knowledge by researchers. This fact significantly reduces the quality of scientific research activities, preventing practitioners from fully realizing their potential creative capabilities.

A modern scientist, a specialist in various specific sciences, must know and understand the general characteristics of science as a form of activity and knowledge, as well as the nature and specifics of natural and humanitarian knowledge. Such understanding allows one to navigate the development of science at the current stage and comprehend its close connection with culture and social changes.

For contemporary researchers, it is crucial not only to be well-versed in the main principles characterizing scientific work but also to have a solid knowledge of the methodology and techniques of scientific creativity, as modern scientific practice shows that researchers often have the most questions in this area.

Thus, the comprehensive implementation of science and modern information technologies in the most critical spheres of societal life, the globalization of world development, the phenomenon of mass culture, and the formation of nonlinear and virtual models of consciousness – these and many other phenomena highlight the importance of philosophical-worldview and logical-methodological issues. Their professional and creative comprehension requires serious and focused preparation of future scientists.

The main objectives of the proposed textbook are to acquaint future highly qualified researchers with the specifics of conducting scientific work and help them master the sometimes complex system of organizing scientific activities, particularly in effectively planning and presenting obtained results, directing maximum efforts toward achieving outcomes.

Successfully mastering the methodology and techniques of conducting scientific research will contribute to developing rational creative thinking and the optimal organization of scientific creativity in practical activities.

The tutorial is prepared with an orientation toward the working curriculum of the discipline “Methodology of Scientific Research” for master's students of O. M. Beketov National University of Urban Economy in Kharkiv. It aims to help the philological department students prepare for practical classes in this discipline. The structure and content of the tutorial are aimed at the systematic organization of the educational process and ensuring comprehensive training for philology students, serving as an integral part of the educational and methodological materials in English for university-level students.

1 METHODOLOGICAL FOUNDATION OF SCIENTIFIC KNOWLEDGE

1.1 Definition of science. Science and other forms of mastery of reality

1.1.1 Definition of science

Science is a research activity that acquires new knowledge about nature, society, and thinking. Science is a crucial component of spiritual culture. The following interconnected features characterize it:

- a set of objective and substantiated knowledge about nature, humans, and society;
- an activity aimed at obtaining new, reliable knowledge;
- a set of social institutions that ensure the existence, functioning, and development of cognition and knowledge.

The term “science” is also used to refer to specific areas of scientific knowledge: mathematics, physics, biology, etc.

Science aims to acquire knowledge about the subjective and objective world.

The tasks of science are:

- collecting, describing, analyzing, generalizing, and explaining facts
- discovering the laws of motion of nature, society, thinking, and cognition
- systematizing the acquired knowledge
- explaining the essence of phenomena and processes
- predicting events, phenomena, and processes
- determining the directions and forms of practical use of the acquired knowledge

Functions of Science. The most important function of science is to be a productive force of society. The significance of science sharply increased during the Renaissance when practical activities reached a level where many problems could not be solved without scientific methods. In the 20th century, science became the leading driving force of production. New branches of production emerged, closely linked to the latest discoveries in radio electronics, biotechnology, information technologies, etc. Science has become a sphere of spiritual production, which develops and offers reliably substantiated programs and activity plans through theoretical research or engineering and design schemes.

The classification of sciences is the revelation of their interconnection based on certain principles and the expression of these connections in a logically substantiated arrangement or series. The classification of sciences reveals the interconnection between natural, technical, social sciences, and philosophy. Currently, sciences are categorized based on their sphere, subject, and method of cognition (fig. 1.1):

1. about nature – natural sciences
2. about society – humanities and social sciences
3. about thinking and cognition – logic, epistemology, gnoseology, etc.

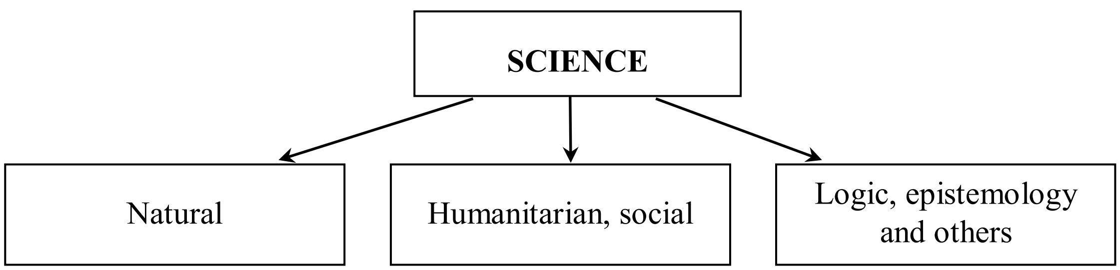


Figure 1.1 – Classification of science based on the field, subject, and method of cognition

Science, based on the method of cognition, is divided into:

- *empirical sciences,* which study knowledge obtained from material practice or direct contact with reality. The main methods of empirical sciences are observation, measurement, and experimentation. Science at the empirical level deals with collecting facts, their initial generalization, and classification. Empirical knowledge provides science with facts, recording stable relationships and regularities of the world.

- *theoretical knowledge,* which is the result of generalizing empirical data. At the theoretical level, the laws of science are formulated, which enable the explanation and prediction of empirical situations, i.e., the understanding of the essence of phenomena. Theoretical knowledge always relies on empirical reality.

Regarding practice, sciences are divided into *fundamental and applied.* The fundamental sciences aim to know the basic laws of nature, society, and thinking. In contrast, applied sciences focus on the practical realization of the results of fundamental sciences.

Science plays a huge role in the development of human society. It permeates all spheres of human activity, both material and spiritual. The science concept includes acquiring new knowledge and the result of that activity, i.e., the sum of scientific knowledge acquired up to the present, forming the overall scientific worldview.

The immediate goals of science are the description, explanation, and prediction of processes and phenomena of reality, which constitute its subject of study based on the laws it uncovers.

1.1.2 Science and other forms of mastery of reality

Science as knowledge production represents a very specific form of human activity. It differs significantly from activities in material production and other types of spiritual activity. While knowledge is only used in material production, acquiring knowledge is the main and immediate goal of science. This does not depend on the form in which this goal is embodied, whether in technological process schemes, theoretical descriptions, summaries of experimental data, etc. Unlike other types of activity, where the result is known in advance (i.e., it is determined before the activity begins), science leads to the increment of new knowledge. This is why science acts as a force that revolutionizes other forms of activity.

Science differs from aesthetic mastery of reality in pursuing the most generalized objective knowledge. While art develops the sensuous-figurative side and the creative abilities of humans, science primarily develops the intellectual side. However, science and art have a creative and cognitive attitude toward reality.

Key terms and definitions: science, definition of science, tasks of science, function, classification, empirical science, theoretical knowledge, fundamental science.

Questions for assessment:

1. Define "science."
2. What are the tasks of science?
3. Outline the functions of science.
4. What is the classification of sciences?
5. How are sciences divided in relation to practice? Discuss each type.
6. What does the concept of science include?
7. What are the immediate goals of science?

1.2 The concept of scientific knowledge

Knowledge results from cognition of reality verified through practice, representing its correct reflection in the human mind. The primary function of knowledge is to generalize disparate representations of the laws of nature, society, and thinking.

Cognition is the movement of human thought from ignorance to knowledge. The basis of cognition reflects objective reality in the human mind during practical (productive, social, and scientific) activity. Thus, human cognitive activity is determined by practice and aimed at the practical mastery of reality. This process is endless because the dialectics of cognition are expressed in the contradiction between the boundless complexity of objective reality and the limitations of our knowledge.

The main goal of cognition is to achieve true knowledge, which can be realized through laws and doctrines, theoretical propositions and conclusions, verified by practice and existing objectively, independent of us.

Knowledge can be relative or absolute. *Relative knowledge* reflects reality with some incompleteness in the match between the model and the object.

Absolute knowledge is the complete reproduction of generalized ideas about an object, ensuring an absolute match between the model and the object.

There are two types of cognition: sensory and rational.

Sensory cognition results from the direct connection between a person and the surrounding environment. It is expressed through elements of sensory knowledge, such as perception, sensations, representations, and imagination.

Perception is the reflection by the human brain of the properties of an object or phenomenon as a whole, perceived by the senses during a certain period. Perception provides the primary sensory image of an object or phenomenon.

Sensation is the reflection by the human brain of various properties of an object or phenomenon of the objective world perceived by the senses.

Imagination is the transformation of various representations in the human brain, combining them into a unified picture of images.

Representation is a secondary image of an object or phenomenon that is not currently affecting the human senses but did so earlier.

Rational cognition is an indirect and generalized reflection in the human brain of the essential properties, causal relationships, and regular connections between objects and phenomena. It complements and surpasses sensory cognition, contributing to understanding the essence of processes and revealing the regularities of their development. The form of rational cognition is abstract thinking and logical reasoning. The structural elements of rational cognition are concepts, judgments, and inferences.

A concept is a thought that reflects the necessary and essential attributes of an object or phenomenon. Concepts can be individual, general, abstract, concrete, or relative. *General concepts* are connected to a set of objects or phenomena, while *individual concepts* relate to only one object.

Judgment is a thought in which an affirmation or denial of something is made through connecting concepts. Judgments can be affirmative, negative, general, particular, conditional, or disjunctive.

Inference is a process of thinking that connects the sequence of two or more judgments, resulting in a new judgment. Inference is a conclusion that makes it possible to transition from thinking to practical actions. In direct inferences, one judgment leads to another.

The process of cognition moves from a scientific idea to a hypothesis, eventually turning into a law or theory.

A *scientific idea* is an intuitive explanation of a phenomenon without intermediate argumentation and awareness of the full range of connections based on which a conclusion is made. The idea helps to reveal previously unnoticed regularities of a phenomenon. It is based on the existing knowledge about it.

A *hypothesis* (from the Greek *hypothesis* – foundation, assumption) is an assumption about the cause that leads to a given consequence. A hypothesis always rests on an assumption whose validity cannot be confirmed at a certain level of science and technology. A hypothesis always goes beyond known facts and serves as a guiding force for conducting theoretical or experimental research. Any hypothesis undergoes careful testing, during which it is verified to ensure it does not contradict any other proven hypotheses and that the consequences it generates align with observed phenomena. The development of a hypothesis follows three main stages:

1. accumulation of factual material and expressing certain assumptions based on it.

2. expanding assumptions into a hypothesis.

3. testing and refining the hypothesis.

When a hypothesis aligns with observed facts, it becomes a law or theory.

A *law* is a necessary, essential, stable, and recurring relationship between phenomena in nature and society. A law reflects the general connections and relationships inherent to all phenomena of a certain type or class. The law is objective and exists independently of human consciousness.

The main task of science is to comprehend the laws that form the foundation for the transformation of nature and society.

A *theory* (from the Greek *theoria* – contemplation, study) is a form of scientific knowledge that provides a holistic view of reality's regularities and essential connections. A theory arises due to the generalization of cognitive activity and practice.

Any new theory is subject to the following requirements:

- a scientific theory must be adequate to the object or phenomenon being described
- it must conform to empirical data
- there must be connections between various propositions, ensuring a logical transition from one statement to another
- the theory must satisfy the requirement of completeness, describing a certain area of reality and explaining the interconnections between various system components
- the theory must possess constructiveness, simplicity, and heuristic potential

Heuristic potential refers to the ability to explain or predict phenomena. *Constructiveness* refers to the ease with which the core principles of the theory can be tested. *Simplicity* is achieved by reducing and consolidating information and introducing generalized laws.

The structure of a theory consists of facts and categories, axioms and postulates, principles, concepts and judgments, propositions, and laws. A theory always has an objective, practice-tested basis.

A *fact* is a knowledge about an object or phenomenon whose reliability has been proven.

A *category* is one of the most general and fundamental concepts reflecting the essential, universal properties and relations of phenomena in reality and cognition. Categories were formed due to the generalization of the historical development of knowledge and social practice. Well-known categories include matter, space, time, quantity, quality, contradiction, necessity, chance, essence, phenomenon, etc.

An *axiom* (from the Greek *axioma* – a position) is a proposition accepted without logical proof due to its immediate persuasiveness (an evident starting point). Axioms are self-evident and serve as the basis for deriving other assumptions according to predefined rules.

A *postulate* (from Latin *postulatum* – a requirement) is a statement (judgment) accepted within a scientific theory as true, even though it cannot be proven by its means, and thus plays the role of an axiom within the theory.

A *principle* (from Latin *principium* – beginning, foundation) is a basic starting position of a theory, teaching, science, or worldview. In scientific theory, a principle is an abstract definition of an idea arising from human experience's subjective reflection.

A *concept* is a thought in which objects (or properties) of a class (or phenomenon) are generalized and distinguished based on certain common and specific features.

A *judgment or statement* is a thought expressed in a declarative sentence that can be true or false.

A *proposition* is a formulated thought expressed as a scientific assertion.

Thus, the most advanced form of generalized scientific knowledge is a theory. Mastering a theory allows us to discover new laws and predict and forecast the future.

The process of cognition follows specific rules, which form the foundation of the doctrine – methodology.

The science methodology is the doctrine of the principles of constructing methods and forms of scientific knowledge.

Keywords and definitions: the study of the structure, logical organization, means, and methods of scientific activity.

Questions for assessment:

1. Define the concept of “knowledge.”
2. What underlies cognition? Why is the process of cognition infinite?
3. What is the main goal of cognition?
4. Two types of cognition are distinguished. Explain them in detail.
5. Define the concepts: perception, sensation, imagination, representation.
6. Define the concepts: judgment, inference, scientific idea.
7. What is a hypothesis?
8. What is a theory?

1.3 Scientific research: its essence and features

For beginning researchers, it is important to be well-versed in the basic principles characterizing scientific work and to have a general understanding of the methodology and methods of scientific creativity. As modern academic practice in higher education institutions shows, such researchers face many questions about these aspects during their initial steps toward mastering scientific work skills.

Every scientific research – from the creative concept to the final presentation of the scientific work – is carried out individually. However, common methodological approaches to its conduct can still be identified.

Modern scientific and theoretical thinking strives to penetrate the essence of the phenomena and processes under study. This is possible with a holistic approach to the object of study, considering this object's origin and development, i.e., applying a historical approach.

To study scientifically means to conduct exploratory research, looking into the future. Imagination, fantasy, and dreams are key factors in scientific research, based on the actual achievements of science and technology.

The development of an idea to the stage of solving a problem usually occurs as a planned scientific research process. Science also knows of accidental discoveries, but only planned research, well-equipped with modern tools, reliably allows us to uncover and deeply understand the objective regularities of nature. Subsequently, the initial concept's targeted and ideologically comprehensive refinement continues, introducing clarifications, changes, and additions and further developing the research plan.

Scientific research is purposeful cognition, the results of which appear as a system of concepts, laws, and theories.

The goal and immediate tasks of scientific-theoretical research are to find commonalities among a range of individual phenomena and uncover the laws according to which they arise, function, and develop, i.e., to penetrate their deep essence.

Main tools of scientific-theoretical research:

1. A set of scientific methods thoroughly substantiated and integrated into a unified system.

2. A set of concepts and strictly defined terms interconnected and forming the characteristic language of science.

The results of scientific research are embodied in scientific works (articles, monographs, textbooks, dissertations, etc.) and only after their comprehensive evaluation are used in practice, considered in the process of practical cognition, and later included in guiding documents in an abstracted, generalized form.

Keywords and definitions: the essence of scientific research, scientific-theoretical thinking, factor, phenomenon, process, study, scientific objectivism, object, means.

Questions for assessment:

1. List the most important factors of scientific research.
2. Which research structure reliably allows for uncovering and deeply understanding the objective regularities in nature?
3. List the distinguishing features of scientific research.
4. What is the object of scientific-theoretical research?
5. What are the goals and immediate tasks of scientific research?
6. Outline the main tools of scientific-theoretical research.
7. In what works are the results of scientific research embodied?

1.4 The Concept of method and methodology

In any form (scientific, practical, or other), human activity is determined by numerous factors. Therefore, its final outcome depends not only on who acts (the subject) or what is directed at (the object) but also on how the process is carried out and which methods, techniques, and means are applied. These are the problems of the method.

The method (from Greek – "way of cognition") in its broadest sense means "a path to something," a way of carrying out an activity in any form.

The concept of "methodology" has two main meanings:

1. A system of specific methods and techniques used in a particular field of activity (science, politics, art, etc.).

2. The study of this system – the general theory of method, a theory in action.

Methodology is the study of the rules of thinking in creating scientific theories.

Initially, methodology originated from the knowledge prescribed by geometry as a science, which contained normative guidelines for studying the real world.

Later, it developed into a set of rules for exploring the universe and transitioned into philosophy. Plato and Aristotle viewed methodology as a logical universal system, an instrument of true knowledge.

For a long time, methodological issues did not occupy a significant place due to the mechanistic or religious perspectives on the world. The principles of mechanics developed by Galileo and Descartes were taken as the model of knowledge for a long period. Empiricism remained the dominant approach to all problems for centuries.

Idealists such as Kant and Hegel gave a new impetus to methodology, attempting to examine the laws of thought itself – ascending from the concrete to the abstract, the contradictions of being and thinking, and more.

All previous achievements were reworked into the dialectical method of understanding reality, which is based on the connection between theory and practice, the recognizability of the real world, the determination of phenomena, and the interaction between the external and internal, objective and subjective.

Dialectical logic became a universal tool for all sciences, applicable to any problem of knowledge and practice.

Thus, methodology as a discipline lies between two poles: on the one hand, it is the technique of researching methods and techniques of scientific inquiry; on the other hand, it is the philosophy of science, a logical analysis of concepts that serve as the starting premises in scientific activity as a whole.

Modern methodology is based on the role and diversity of functions that science performs in understanding and regulating social and natural processes and phenomena, shaping public consciousness and worldview, and enhancing human activity. It is crucial for the rational use of science, industry, strategy, and tactics in economic and cultural development, social progress, and comprehensive human development.

The definition of methodology should be based on the following key characteristics:

- it determines how to obtain scientific knowledge, reflecting the ever-changing pedagogical reality.
- it directs and predetermines the primary path by which a certain research goal is achieved.
- it ensures that information about the studied process or phenomenon is collected comprehensibly.
- it facilitates introducing new knowledge into the body of scientific understanding.
- it refines, enriches, and systematizes scientific terms and concepts.
- it creates a system of scientific information based on objective facts and logical-analytical tools.

These defining features of methodology highlight its role as a conceptual framework for formulating research goals, content, and methods, ensuring the most objective, precise, and systematic knowledge of processes and phenomena.

Methodology disciplines the search for truth, allowing (if correctly applied) the conservation of effort and time, leading to the goal in the shortest possible way. The true method serves as a compass, guiding the subject of knowledge and action while preventing errors.

The methods used in scientific research play a crucial and sometimes defining role in constructing any scientific work. Research methods are classified into empirical and theoretical approaches.

Methodology is considered a study of the organization of activity. If scientific research is a cycle of activity, its structural units are directed actions. An action is a unit of activity characterized by having a specific goal. The structural components of an action are operations, which are linked to the objective conditions for achieving the goal. Depending on conditions, the same goal may be achieved through different actions, and the same action may be carried out using different operations. Likewise, the same operation can be part of different actions.

Based on this, methods are categorized as:

- operational methods
- action-based methods

This classification does not contradict the definition of the method given in encyclopedic sources:

1. a method as a way of achieving a goal or solving a specific task – an action-based method.

2. a method as a set of techniques or operations for practical or theoretical understanding of reality – an operational method.

Thus, research methods can be grouped as follows:

Theoretical Methods

- cognitive-action methods: Dialectics, scientifically tested theories, proof, systematic knowledge analysis, deductive (axiomatic), inductive-deductive, contradiction resolution, problem-setting, hypothesis formulation.

- operational methods: Analysis, synthesis, comparison, abstraction, concretization, generalization, formalization, induction, deduction, idealization, analogy, modeling, thought experiments, imagination.

Empirical Methods

- object tracking methods (observation, monitoring, experience generalization).
- object transformation methods (experimental work, experiments).
- object research over time (retrospective analysis, forecasting).
- operational methods (literature review, document analysis, observations, measurements, oral and written surveys, expert evaluations, testing).

Scientific methods are also classified based on the subject of study:

- natural sciences methods
- social and humanities research methods

They are also categorized by field:

- mathematical methods
- technical methods
- biological methods
- medical methods
- socio-economic methods
- legal methods

At the meta-theoretical level, methodologies include dialectical, metaphysical, and hermeneutic methods. Some scholars classify systems analysis as a meta-theoretical method, while others consider it a general logical.

Depending on their scope and level of generality, methods are classified as:

1. universal (philosophical) – applicable in all sciences and at all stages of knowledge;
2. general scientific – applicable in humanities, natural, and technical sciences;

3. specialized – used in specific related sciences;

4. highly specialized – developed for a particular discipline or field of knowledge.

Among the key epistemological features of a scientific method are:

- objectivity – based on reliable knowledge;
- universality – scientifically valid across different studies;
- reproducibility – ensuring consistent results in similar situations;
- purposefulness – guiding intellectual progress meaningfully;
- necessity – guaranteeing results as opposed to random discoveries;
- efficiency – ensuring the practical application of findings.

The concept of method should be distinguished from the concepts of technique, procedure, and methodology in scientific research.

- research technique refers to specialized techniques used to apply a particular method;
- research procedure refers to a specific sequence of actions and how the research is organized.

Methodology is a set of methods and techniques used for acquiring knowledge. For example, the methodology of criminological research refers to a system of methods, techniques, and tools for collecting, processing, analyzing, and evaluating information about crime, its causes and conditions, the personality of the offender, and other criminological phenomena.

Any scientific method is developed based on a specific theory, which serves as its necessary prerequisite.

The effectiveness and strength of a method depend on the depth, comprehensiveness, and fundamental nature of the theory that is "compressed into the method."

At the same time, the "method expands into a system," meaning it is used for further scientific development, deepening and expanding theoretical knowledge as a system and its practical application. In this way, theory and method are simultaneously identical and distinct. They are interrelated and, in their unity, reflect reality.

Although closely interconnected, theory and method are not rigidly separated from each other, nor are they exactly the same.

They transition and transform into each other: theory, reflecting reality, is transformed into a method through the formulation of derived principles, rules, and techniques, which, in turn, return to theory (and through it – to practice), as they are applied as regulatory guidelines in the process of understanding and changing the surrounding world according to its own laws.

Thus, the statement that a method is a theory directed at the practice of scientific research is inaccurate, as the method is also oriented toward practical, sensory-objective, and socially transformative activities. In other words, a method is the same theory brought into action and "sharpened," not only for deeper understanding but also for modifying reality through practice.

Developing theory and improving research methods form a single process with two inseparably linked aspects. Not only does theory condense into methods, but methods also expand into theory, significantly influencing its formation and the course of practical activities.

However, scientific theory and methods of cognition cannot be entirely equated. One cannot claim that every theory is simultaneously a method of cognition and action. A method is not directly and immediately identical to a theory, just as a theory is not inherently a method. Rather, the methodological guidelines, requirements, and regulations derived from theory constitute the method of cognition.

Key differences between theory and method:

1. theory results from previous activities, while method is the starting point and prerequisite for future actions;

2. the main functions of theory are explanation and prediction (aimed at finding truth, laws, causes, etc.), whereas the function of a method is to regulate and guide activities;

3. theory is a system of ideal images reflecting the essence and regularities of an object. in contrast, the method is a system of rules and prescriptions that serve as tools for further cognition and transformation of reality;

4. theory aims to solve the problem of what an object is, while method focuses on identifying ways and mechanisms for studying and transforming it.

Thus, theories, laws, categories, and other abstractions do not yet constitute a method. To fulfill a methodological function, they must be transformed from explanatory theory statements into a method's regulatory principles, requirements, and guidelines.

Every method is determined not only by previous and coexisting methods or by the theory it is based on.

Each method is primarily shaped by its object – what is being studied (individual objects or their classes).

As a way of investigation and activity, a method cannot remain unchanged in all aspects but must evolve along with the object to which it is applied. This means that the final result of cognition must be true, and the method leading to it must capture the specificity of the studied object.

A method is not imposed upon an object of cognition or action but adapts to its specifics. Research requires a thorough knowledge of facts and data related to its subject. It progresses through the study of material, its characteristics, connections, and relationships. The research method thoroughly masters factual and conceptual material analyzes various forms of its development and traces internal connections.

It has become evident that the system of methods and methodology cannot be confined solely to scientific cognition. It must extend beyond it and include the sphere of practice, recognizing the close interaction between the two.

The classification of scientific methods can be based on several criteria. Depending on their role in scientific cognition, methods can be formal or substantive, empirical or theoretical, fundamental or applied, and methods of research or presentation.

The nature of studied objects is a criterion for distinguishing natural science methods from social and humanities research methods. The key features of a scientific method, regardless of type, usually include objectivity, reproducibility, heuristic value, necessity, and specificity.

Modern science successfully employs a multi-level concept of methodological knowledge. Based on their generality and scope of application, scientific methods can be classified as follows:

1. Philosophical methods – The oldest are dialectical and metaphysical methods. Every philosophical concept has a methodological function and represents a specific way of thinking. Thus, philosophical methods are not limited to the two mentioned above. Other examples include analytical (from analytic philosophy), intuitive, phenomenological, and hermeneutic (interpretative) methods.

2. General scientific approaches and research methods serve as an intermediate methodology between philosophy and the specialized methodological principles of specific sciences. Examples include systematic, structural-functional, cybernetic, probabilistic, modeling, and formalization approaches.

3. Specialized scientific methods – These consist of research techniques and procedures used in particular scientific disciplines. Examples include methods specific to mechanics, physics, chemistry, biology, and the social sciences.

4. Formal and substantive methods – These involve representing substantive knowledge in symbolic form, differentiating between natural and artificial languages. The deepening of formalization is linked to the development of artificial languages designed for precise and unambiguous expression of knowledge, such as those used in mathematics, logic, and chemistry.

Using special symbolic notation helps eliminate ambiguity, ensuring each symbol has a strictly defined meaning in formal reasoning.

As a universal means of communication and knowledge exchange, language performs multiple functions, with logic and methodology aiming to enhance the accuracy and transformation of information. Artificial formalized languages are created for this purpose and are widely used in scientific research, programming, and algorithmizing processes using computers.

Methodology cannot be reduced to a single, even a highly significant method. Nor is it a mere sum of separate methods or their mechanical unity. Methodology is a complex, dynamic, integral, and hierarchical system of methods, techniques, and principles, varying in scope, applicability, heuristic potential, and structure.

Key terms and definitions: method, methodology, problem of method, history of methodological development, dialectical method of cognition, method as an action, method as an operation.

Questions for assessment:

1. What is the problem of method?
2. The term “methodology” has two primary meanings. Explain them in detail.
3. Describe the historical development of methodology.
4. What forms the basis of the modern understanding of methodology?

5. What criteria should the definition of methodology be based on?

6. List theoretical and empirical methods.

7. What is a methodology? Provide an example of a system of research methods used in practice.

8. What are the similarities and differences between theory and method?

9. What determines each method?

1.5 The essence of the theory and its role in scientific research

A scientific theory, emerging as a natural result of all preceding cognitive activity, incorporates elements and forms that researchers have already encountered during the empirical and initial stages of rational cognition. Empirical facts, hypotheses, and laws are essential components in building a theory, but they do not remain unchanged within it.

Since a theory represents the studied object in its unity and integrity, individual concepts, statements, and laws that characterize the object from different perspectives must be integrated into a system. This requires subjecting some generalizations and hypotheses to rational processing and introducing new assumptions, abstractions, and idealizations. Thus, the emergence of a theory is not merely a quantitative increase in knowledge but a fundamental qualitative leap, leading to a deeper understanding of the essence of studied objects and phenomena in reality.

A theory is the most advanced form of scientific knowledge – an evolving, integral system of verified, practice-based truths that reflect the fundamental, essential properties, relationships, and connections of objects and phenomena in the real world.

A. Einstein believed that any scientific theory must meet the following criteria:

- It should not contradict empirical data and facts but correspond to them.
- It must be testable based on available experimental material and meet practical requirements.

- It should possess “naturalness,” meaning “logical simplicity” in its assumptions (basic concepts and their interrelations).
- It must contain precise statements (between two theories with equally “simple” foundational principles, the one that more strongly limits possible a priori qualities of systems should be preferred).
- It should not be chosen arbitrarily among approximately equivalent and similarly structured theories, making it the most valuable.
- It should demonstrate the diversity of objects it integrates into a coherent system of abstractions.
- It must have a broad scope of applicability, ensuring that it will never be refuted within its domain of basic concepts.
- It should indicate the path toward developing a new, more general theory in which it remains a limiting case.

An idealized object (e.g., “a perfectly rigid body” or “an ideal gas”) plays a methodologically significant role in theory formation. Constructing such an object is necessary for developing any theory applied in specific forms across various fields of knowledge. This object is a theoretical model of a particular fragment of reality and a concrete research program that materializes in theory construction.

The key element of a theory is a law. Therefore, a theory can be considered a system of rules that comprehensively and concretely express the essence of the studied object.

Given the fundamental role of laws in theory structure, let us examine this element in more detail. Generally, a law expresses objective, essential, necessary, internal, recurrent, and stable connections (relations) between phenomena and processes in reality. A law always expresses a relationship that is:

- objective – inherent in the real world and human sensory-material activity, reflecting actual relations between things.

- essential and concretely universal – as a reflection of fundamental movement in the universe, any law applies to all processes of a given class or type and operates consistently wherever the relevant conditions exist.
- necessary – since it is intrinsically linked to the subject's essence, a law functions with "iron necessity" in the appropriate conditions.
- internal – as it reflects the deep interconnections and dependencies within a subject domain, uniting all its elements and relationships into a coherent system.
- recurrent and stable – because a law does not describe random, occasional connections but rather those that are regular, systematic, and consistently repeat within the real world.

The primary task of scientific research is to uncover the laws governing a given field and express them through corresponding concepts, ideas, principles, and theories. A researcher can accomplish this by relying on two fundamental premises:

1. the reality of the world in its entirety and development;
2. the lawful nature of this world, meaning it is “permeated” by a system of objective laws.

It is essential to recognize that human thought and the objective world are subject to the same laws, ensuring their results are mutually consistent. The alignment between the laws of the objective world and the laws of thought is achieved when scientists uncover and understand them.

The cognition of laws is a complex, deeply contradictory process of reflecting reality. However, the knowing subject cannot encompass the entire real world at once, entirely and comprehensively. Instead, they can only endlessly approximate this goal, creating various concepts and abstractions, formulating laws, and applying diverse scientific research methods and techniques.

Laws are first discovered in the form of assumptions and hypotheses. Further experimental data and new facts lead to the "refinement of these hypotheses," eliminating some and correcting others until a law is finally established. Since laws pertain to the realm of essence, their deepest understanding is not achieved at the level of direct perception but rather at the stage of theoretical research. At this stage, the accidental, which appears only in phenomena, is ultimately reduced to the actual internal movement. The result of this process is the discovery of a law – more precisely, a set of laws inherent in a given domain, which, in their interrelation, form the "core" of a particular scientific theory.

A. Einstein distinguished two main types of theories in physics: **constructive** and **fundamental**. According to him, most physical theories are constructive, meaning they aim to construct a picture of complex phenomena based on relatively simple assumptions (such as the kinetic theory of gases). In contrast, fundamental theories do not begin with hypothetical propositions but rather with empirically discovered properties of phenomena and principles, from which mathematically formulated criteria follow (such as the theory of relativity). Unlike constructive theories, fundamental theories employ an **analytical** rather than a **synthetic** method.

Einstein attributed constructive theories' completeness, flexibility, and clarity as their main advantages. On the other hand, he considered the logical perfection and reliability of fundamental theories' foundational principles their strengths. Regardless of the type of theory and the methods used to construct it, the most essential requirement for any scientific theory remains unchanged: a theory must correspond to the facts. Ultimately, only experience can deliver the final verdict on a theory.

The role of theory in scientific research is best understood through its functions. Below are the main functions of a scientific theory:

1. Synthetic function.

The theory integrates and synthesizes reliable knowledge into a unified, coherent system. A theory represents a kind of idea-synthesis, with its core being a scientific law that reflects the intrinsic, essential connection of phenomena and processes, determining their necessary development.

2. Explanatory function.

Based on established objective laws, a theory explains the phenomena within its subject area by identifying causal and other dependencies, various interconnections, essential characteristics and properties, origins, development processes, and inherent contradictions.

3. Worldview and methodological functions.

A theory serves as a crucial means of attaining new knowledge in all its forms across different areas of reality cognition. It forms the foundation for various research methods, techniques, and approaches. For example, the dialectics theory unfolds as a set of principles within the dialectical method of cognition. In contrast, general systems theory underpins systemic structural and structural-functional analysis methods.

4. Predictive function.

Theoretical models allow for predictions regarding the existence of previously unknown facts, objects, or their properties, as well as relationships between real-world phenomena. A famous example is Dmitri Mendeleev’s prediction of undiscovered chemical elements and their properties based on the periodic law.

Conclusions of chapter 1

1. The process of cognition follows specific rules that form the basis of methodology. *The methodology of science* is the study of the principles of knowledge construction, methods, and forms of scientific inquiry, which concerns the structure, logical organization, tools, and techniques of scientific activity.

2. The results of scientific research are embodied in scientific works (articles, monographs, textbooks, dissertations, etc.) and are only later, after thorough evaluation, applied in practice. These findings are considered in practical knowledge processes and, in a summarized form, are incorporated into guiding documents.

Key terms and definitions: essence, theory, scientific research, methodology, reproductive, productive, organization, science, function, knowledge.

Questions for assessment:

1. What is methodology?
2. What is science, and what are its defining characteristics?
3. List the functions of science.
4. What is knowledge? What are the types of knowledge?
5. What is the difference between sensory and rational cognition?
6. List the main structural elements of cognition.
7. What are the ethical foundations of methodology?

2 CHOICE OF DIRECTIONS OF SCIENTIFIC RESEARCH. STATEMENT OF SCIENTIFIC AND TECHNICAL PROBLEM AND STAGES OF SCIENTIFIC RESEARCH

2.1 Methods of choice and objectives of the direction of scientific research

In scientific research, a distinction is made between a scientific direction, problems, and topics.

A *scientific direction* is the research area of a scientific team dedicated to solving major fundamental theoretical and experimental tasks in a specific field of science. The structural units of a direction include complex problems, topics, and questions.

A *problem* is a complex scientific task that covers a significant area of research and must have long-term significance. A problem consists of multiple topics.

A *topic* is a scientific task that focuses on a specific area of scientific research. It is based on numerous research questions, understood as smaller scientific tasks. A particular research objective is formulated when developing a topic or question, such as a design, a new material, or a technology. Solving a problem involves a broader task, such as addressing scientific challenges or making a discovery.

The selection and formulation of a problem or topic is a complex and responsible task that includes several stages:

- formulating the problem
- developing the structure of the problem (identifying topics, subtopics, and questions)
- establishing the relevance of the problem, i.e., its value for science and technology

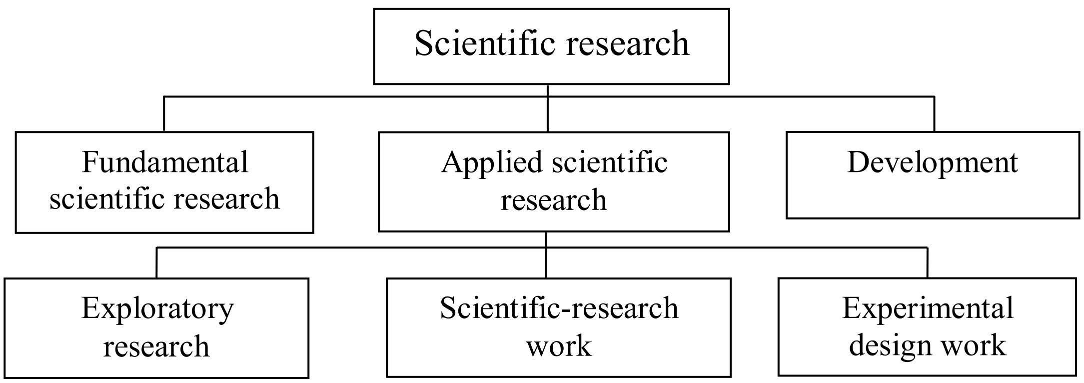
Selecting a research topic begins after justifying the problem and determining its structure. A topic must meet several criteria: relevance, novelty, economic efficiency, and significance.

The criterion for determining relevance is often economic efficiency. At the topic selection stage, the economic effect can only be estimated approximately. For theoretical research, economic considerations may give way to the significance requirement. An important characteristic of a topic is its feasibility and applicability, so when formulating a topic, a researcher must be well acquainted with production processes and industry needs at the current stage.

Scientific research aims to thoroughly and reliably study an object, process, or phenomenon, its structure, connections, and relationships based on established scientific principles and research methods, as well as to obtain and implement results beneficial to humans.

Each scientific research includes an object and a subject of study. *The object of scientific research* is a material, ideal, natural, or artificial system. *The subject of* *scientific research* refers to the system's structure, interaction patterns both within and outside it, development patterns, qualities, and various properties.

Fundamental scientific research aims to discover and study new natural phenomena and laws and develop new principles and research methods to expand scientific knowledge and assess their practical applicability. Such research is conducted at the boundary between the known and the unknown and involves the highest degree of uncertainty.



Applied scientific research aims to find ways to utilize the laws of nature, developing new and improving existing tools and methods of human activity. It is based on the knowledge obtained through fundamental research. Applied research is divided into exploratory, scientific research, and experimental design studies.

Exploratory research identifies factors affecting the object of study and explores ways to develop new technologies and equipment.

Scientific-research work results in the creation of new technologies, experimental setups, instruments, and prototypes.

Experimental design work focuses on selecting structural characteristics that form the logical basis of the designed machine, device, or construction.

Both fundamental and applied research contribute to accumulating new scientific and technical information and transforming it into a form suitable for implementation in industry and construction, ultimately leading to development.

Development aims to create new and improve existing technologies, materials, structures, and techniques, with the ultimate goal of preparing applied research results for practical implementation.

Key Terms and Definitions: scientific direction, problem, topic, problem formulation, problem structure, problem relevance, novelty.

Questions for assessment:

1. In scientific research, a distinction is made between scientific directions, problems, and topics. Describe each in detail.
2. The selection and formulation of a problem or topic is a complex and responsible task involving several stages. Explain each stage in detail.
3. What are the requirements for selecting a research topic?
4. What is the goal of scientific research?
5. Define “object of scientific research” and "subject of scientific research".
6. A complex problem consists of several interconnected problems with a common goal. List its components.
7. When achieving certain goals in practical activities becomes difficult, a problem arises. How should problems be defined based on their scale?

2.2 Formulation of a scientific and technical problem. stages of scientific research work

Selecting a research problem, direction, and topic, as well as formulating scientific questions, is crucial. The most relevant research directions are typically outlined in government directives and sectoral ministry documents.

When defining a scientific-technical problem in a specific field of knowledge or industry, a deep analysis of the tasks driven by societal needs and demands must be conducted. Major national economic problems are often presented in the form of targeted and comprehensive programs at the national or regional level.

Any scientific-technical problem begins with outlining the core concept of the economic problem. It is then necessary to analyze general issues within this scientific field and assess the current state of the specific problem under investigation. Researchers must study previous research and gain knowledge in related fields of science and technology.

At the initial stage of defining a research problem and topic, the problem is formulated based on contradictions within the research field, and expected results are outlined in general terms. After this, its structure is developed, key questions are identified, relevance is established, and main executors are determined.

To analyze scientific and technical information in the chosen field, a brief literature review on the problem must be conducted. This helps to:

- identify the problematic situation
- reveal contradictions between social needs and research objectives
- demonstrate the scientific significance and methodological value of the study in understanding causal and functional relationships between phenomena and processes

Such analysis enables researchers to formulate a working hypothesis, outline methods for solving the problem, define key research tasks, and determine major research stages. This phase should conclude with the formulation of the research goal, definition of the research object, assessment of scientific novelty, practical value of the results, and evaluation of their feasibility and effectiveness for implementation.

The goal of theoretical research is to study and justify the physical nature of an object or phenomenon, create an abstract mathematical model describing its behavior under certain conditions, and predict and analyze preliminary results.

When experimental research is required, its objectives are formulated, methodologies, instruments, and measurement tools are selected, and an experiment plan is developed. This plan outlines:

- scope of work
- research methods
- technical requirements
- labor intensity
- project timeline

Methodological guidelines for experimenting are formulated based on experimental research results.

After completing theoretical and experimental research, a general analysis of the results is conducted, comparing them with the initial hypothesis. If significant discrepancies are found, theoretical models are refined, and additional experiments may be conducted if necessary. Finally, practical and scientific conclusions are formulated.

The process of conducting scientific research consists of six stages:

1. Formulation of the research topic

A general introduction to the scientific problem is conducted at this stage, followed by a preliminary literature review. The research topic is then formulated, a plan is developed, a technical task is created, and the expected economic effect is determined.

2. Definition of research goals and objectives

This stage includes literature selection, compilation of bibliographic lists, patent research on the topic, annotation of sources, and analysis of processed information. The research goal and objectives are then defined.

3. Theoretical research

This involves studying the physical nature of the phenomenon, formulating hypotheses, selecting and justifying a physical model, followed by mathematical modeling and analysis of the obtained solutions.

4. Experimental research

After setting the goals and objectives for experimental research, the experiment is planned, methodologies are developed, and measurement tools are selected. The experimental phase concludes with experiments being conducted and the results processed.

5. Analysis and presentation of scientific research

This stage includes comparing experimental results with theoretical data and analyzing discrepancies. Theoretical models are refined if needed, and additional experiments are conducted, transforming hypotheses into theories. The scientific work is concluded by formulating conclusions and preparing a research report.

6. Implementation of research results and economic impact assessment

Theoretical research requires significant intellectual effort and may not always lead to immediate success. Experimental research is the most labor-intensive and resource-demanding, especially when repeat testing is required.

2.2.1 Stages and levels of scientific research

Based on methodological principles, a researcher determines:

- the object and subject of the study
- the sequence of their analysis
- the methods to be applied

Scientific research can be divided into two main stages and corresponding levels:

a) Empirical

b) Theoretical

The empirical stage consists of two steps (phases) of work:

- the first phase is obtaining facts, as it is clear that they must be acquired to analyze and understand facts.

- the second phase of empirical research involves the primary processing and evaluation of facts in their interrelationship, which includes:
  - understand and strictly describe the facts obtained in scientific terms
  - classifying facts based on different criteria and identifying their main dependencies

During this phase, the researcher performs the following tasks:

a) critically evaluates and checks each fact, removing random and insignificant impurities.

b) describes each fact in specific terms of the science within which the research is conducted.

c) selects typical, repetitive facts that express the main development trends.

d) classifies facts by the types of phenomena being studied, by their significance, and organizes them into a system.

e) reveals the most obvious connections between the selected facts, i.e., at the empirical level, and investigates the patterns that characterize the studied phenomena.

The theoretical stage and level of research are associated with a deep analysis of facts, penetrating the essence of the phenomena under study, and understanding and formulating laws in both qualitative and quantitative forms, i.e., explaining the phenomena.

At this stage, the researcher predicts possible events or changes in the studied phenomena, develops principles for action and provides recommendations on practical influences on these phenomena.

The theoretical stage includes a series of sequential phases of work, during which scientific knowledge is given specific forms, existing and developing within and through them.

The problem formulation serves as the link between the empirical and theoretical stages. This means:

- identifying the known and unknown; facts that are explained and those that require explanation; facts that align with the theory and those that contradict it.
- formulating the central question that expresses the essence of the problem and justifying its validity and importance for science.
- outlining specific tasks, the sequence of their solution, and the methods to be applied.

The main task of the researcher is to identify the causes of phenomena and the laws that govern them. Therefore, the primary form of a hypothesis is the assumption about the cause, conditions, or law underlying the emergence, existence, or development of the phenomena under study.

Proof is the next necessary stage and the form in which scientific knowledge exists and further develops.

Thus, scientific research in each cycle moves from empiricism to theory and from theory to practice, which verifies it.

Completing each cycle is simultaneously the beginning of a new one, leading to the further development and enrichment of theory.

Topic: Reflects the problem in its characteristic features. A well-formulated topic clarifies the problem, defines the scope of the research, and concretizes the core idea, creating the foundation for the success of the overall work.

Object: Refers to the set of relationships and connections that exist objectively in theory and practice and serve as the source of necessary information for the researcher.

Subject: More specific, including only those relationships and connections directly studied in the work. It sets the boundaries of the scientific search, and in each object, there can be several subjects of research.

The goal of the research is formulated briefly and precisely, expressing the main purpose the researcher aims to achieve. It is further specified and developed into research tasks.

The first task is typically associated with identifying, clarifying, deepening, and methodologically substantiating the essence, nature, and structure of the object of study.

The second task deals with analyzing the actual state of the research subject, its dynamics, and the internal contradictions of its development.

The third task involves the transformation, modeling, and experimental verification of the subject.

The fourth task focuses on identifying ways and means to improve the effectiveness of the studied phenomenon or process, i.e., practical aspects of the work and the problem of managing the research object.

2.2.2 Levels and content of scientific research

Scientific knowledge is a holistic, developing system that can be represented in various dimensions with different specific elements. These include:

- the object of knowledge
- the subject of knowledge
- the methods and tools of knowledge

Since scientific knowledge is a process, it assumes two primary levels of research:

- empirical
- theoretical

Both levels are interconnected and represent a unified process of scientific knowledge. However, empirical and theoretical knowledge within this unity are relatively independent levels with specific characteristics.

The empirical stage is concerned with obtaining and initially processing factual material. Empirical ***objects*** are objective properties, connections, and relationships of things discovered through practical human activities and included in the process of cognition and those identified through scientific experiments.

A defining feature of empirical objects is their sensory perceptibility. Studying empirical objects' properties, connections, and relationships is inseparable from observations, measurements, experiments, and comparisons. Cognitive operations with empirical objects always occur in a sensory-objective form.

The empirical level of research has a specific ***subject of knowledge.*** Empirical knowledge includes the basic research results expressed in scientific facts, statistical data, etc. While the empirical object determines the subject, they should not be equated. The empirical object exists independently of the subject of cognition, while the formation of the subject is a crucial function of the researcher.

The theoretical stage involves deep analysis of scientific facts, penetrating the essence of phenomena, and formulating scientific laws to explain the objects and processes of reality.

Building theoretical knowledge is a process of ascending from the concrete to the abstract, with the aim of returning to the concrete at a higher level based on the formulated scientific abstractions. The results of theoretical research are expressed in laws, theories, scientific hypotheses, and others.

The theoretical level of research is characterized by the predominance of rational processes – concepts, theories, laws, and other forms of "cognitive operations." Here, direct observation is not eliminated but becomes a subordinate aspect of the cognitive process. Theoretical knowledge reflects phenomena and processes from the perspective of their universal internal connections and regularities, understood through the rational processing of empirical knowledge. This processing uses a system of scientific abstractions – concepts, categories, laws, principles, and more.

Based on empirical data, the theoretical level involves the mental integration of the studied objects, understanding their essence, and the laws governing their existence, which comprise the core of theories. In other words, at the theoretical level of research, specific methods are used to solve cognitive tasks. First, the researcher seeks to understand the essence of the studied objects; second, at the theoretical level, the objective truth is comprehended in its full concreteness and completeness. Cognitive methods such as abstraction, idealization, synthesis, deduction, and ascending from the abstract to the concrete are widely used during this process.

Despite the differences between the ***empirical and theoretical levels of scientific research,*** they are closely ***interconnected,*** and the boundary between them is conditional. Empirical research uncovers new data through observations and experiments, stimulating theoretical knowledge and presenting new, more complex tasks. In turn, by developing and specifying new content based on empirical data, theoretical knowledge opens up new, broader horizons for empirical research, guiding it to search for new facts and contributing to improving its methods and tools.

The scientific resolution of problems at the empirical and theoretical levels serves as the foundation for addressing major issues in epistemology, methodology, and logic of science, including the resolution of problems related to the methods of scientific cognition at both the empirical and theoretical levels.

Key terms and definitions: scientific and technical problem, direction, topic, task analysis, concept, relevance, literature review, problem situation, phenomena.

Questions for assessment:

1. List the stages of developing a scientific and technical problem.
2. What allows for the formulation of a working hypothesis?
3. What is the goal of theoretical research?

4. What does a researcher determine based on methodological principles?

5. Provide definitions for the terms "fact of reality" and "scientific fact."

6. The empirical stage consists of two steps (phases) of work. Describe these stages in detail.

7. What does it mean to study?

2.3 Relevance and scientific novelty of the research

A scientific work should be relevant in both scientific and applied aspects.

One of the main criteria for evaluating a scientific study is the relevance of the research topic. Relevance means that the tasks require urgent solutions for practice or the corresponding branch of science.

Additionally, the relevance of the research topic highlights the relevance of the object and subject of research. Primarily, updating the topic implies its alignment with important scientific and practical tasks. The researcher needs to briefly outline the problems faced by the theory and practice of the scientific discipline in relation to the chosen research topic and specific conditions.

The following factors justify the scientific relevance:

- fundamental research tasks require the development of the topic to explain new facts.
- it is essential to clarify the development and resolution of scientific research problems in modern conditions.
- theoretical positions allow resolving existing contradictions in understanding the process or phenomenon.
- hypotheses and regularities proposed in the study allow the generalization of previously known and newly obtained empirical data.

One of the main requirements for a scientific work is its *scientific novelty.* The work must contain the resolution of a scientific problem or new developments that expand the existing boundaries of knowledge in the specific branch of science.

Scientific novelty can be related to old ideas, expressed through deepening, additional argumentation, and showing possible uses in new conditions or other areas of knowledge and practice, as well as new ideas proposed by the researcher.

To identify elements of scientific novelty, the following conditions must be met:

- a thorough study of the literature on the research subject, with an analysis of its historical development. A common mistake is to present something already known as new due to its omission from the researcher's field of view.
- considering all existing points of view. Critical analysis and comparison often lead to new or compromising solutions.
- introducing new factual and digital data into scientific circulation, such as those obtained through successful experiments, which already indicate originality.
- detailing an already known process or phenomenon.

New scientific results can be presented in three conceptual areas:

1. subject areas,
2. technology (i.e., means and methods of cognition),
3. results obtained.

New scientific results can be obtained in the following cases:

1. when a completely new, previously unstudied subject area is investigated.
2. when new technologies, means, or methods of cognition are applied to an already studied subject area. examples include applying a new research approach, using a theory from another area of knowledge, applying mathematical tools not previously used in studies, or using new instruments.
3. when a new subject area is researched using the latest technologies.

4. the scenario where new results are obtained by studying a well-known subject area using known technologies is impossible.

Key terms and definitions: relevance, scientific novelty, research, updating, scientific aspect, applied aspect, scientific result.

Questions for assessment:

1. What does relevance mean?
2. What does updating the topic involve?
3. What factors justify the topic's relevance in the scientific aspect?
4. What factors justify the topic's relevance in the applied aspect?
5. Why is scientific novelty one of the main requirements for a research topic?
6. What conditions are necessary for identifying elements of scientific novelty?
7. What elements of novelty can be presented in a scientific work?
8. Under what conditions can new scientific results be obtained?

2.4 Content of the hypothesis, its formulation and justification

The formulation of the hypothesis – clarifying specific tasks is carried out through a creative search for particular problems and questions of research, without which it is impossible to realize the concept and solve the main problem.

For this purpose, special literature is studied, existing viewpoints are analyzed; the questions that can be solved with the help of already existing scientific data are identified, and those whose solutions represent a breakthrough into the unknown, a new step in the development of science, and thus require fundamentally new approaches and knowledge, anticipating the main results of the research.

Hypotheses can be:

a) descriptive (assuming the existence of a certain phenomenon);

b) explanatory (revealing its causes);

c) descriptive-explanatory.

Certain requirements are placed on a hypothesis:

- it should not contain too many propositions.
- it should not include concepts and categories the researcher does not understand.
- when formulating a hypothesis, value judgments should be avoided, i.e., the hypothesis must correspond to facts, be verifiable, and apply to a wide range of phenomena.
- the formulation should be impeccably styled, simple, and maintain continuity.

When formulating a hypothesis, it is important to be aware of whether we are doing it correctly, relying on the formal characteristics of a good hypothesis:

a) adequacy of the answer to the question or consistency of the conclusions with the premises (sometimes researchers formulate a problem in a specific plan, but the hypothesis does not correspond to it and leads away from the problem);

b) plausibility, i.e., consistency with existing knowledge on the issue (if there is no consistency, the new research becomes isolated from the general scientific theory);

c) verifiability.

The next stage of research is highly individualized and does not tolerate rigidly regulated rules and prescriptions.

Nevertheless, some fundamental questions need to be considered: the research methodology, as it allows for the technical realization of various methods. In research, it is not enough to compile a list of methods; they must be constructed and organized into a system. There is no universal methodology; there are specific research methodologies.

Methodology is the set of techniques, research methods, the order of their application, and interpretation of the results obtained. It depends on the nature of the object under study, methodology, research goals, developed methods, and the general level of the researcher’s qualification.

To create a research program and methodology, the following conditions must be met:

- first, understanding in what external phenomena the studied phenomenon manifests itself, what indicators and criteria define its development;
- second, correlating the research methods with the various manifestations of the phenomenon under study. only by meeting these conditions can we hope for reliable scientific conclusions.

During the research, a program is created, which should reflect:

- what object or subject is being studied;
- what indicators are being measured;
- what research criteria are being applied;
- what research methods are being used;
- the order in which methods are applied.

Thus, methodology is a model of research that is developed over time. a specific set of methods is thought out for each research stage.

When choosing a methodology, many factors are considered, primarily the research's subject, goals, and tasks.

Despite its individuality, the methodology for solving a specific problem has a definite structure, and its main components are:

- the theoretical-methodological part, the concept on which the entire methodology is built;
- the phenomena, processes, signs, and parameters being studied;
- subordination and coordination links and dependencies between them;

- the set of methods applied, their subordination and coordination;
- the order of application of methods and methodological techniques;
- the sequence and technique for generalizing the research results;
- the researchers' composition, role, and place in implementing the research idea.

The skillful definition of the content of each structural element of the methodology and their interrelations is the art of research. A well-thought-out methodology organizes the research and ensures the acquisition of necessary factual material based on the analysis of which scientific conclusions are made.

Implementing the research methodology allows for preliminary theoretical and practical conclusions containing answers to the research questions. These conclusions must meet the following methodological requirements:

- they must be well-argued and summarize the main results of the research;
- they should logically follow from the accumulated material, being a logical consequence of its analysis and generalization.

The third stage is the implementation of the results into practice. The work is then literary formatted.

Literary formatting of research materials is a labor-intensive and responsible task, an integral part of scientific research.

The researcher must extract and formulate the main ideas, provisions, conclusions, and recommendations clearly, sufficiently, and accurately. Not everyone achieves this immediately, as formatting the work is closely related to revising certain positions, clarifying logic and arguments, and eliminating gaps in the justification of the conclusions. Much depends on the researcher’s overall development, literary abilities, and the skill to present their thoughts.

Formulation of the working hypothesis

When formulating a working hypothesis, thoroughly studying domestic and foreign literary sources and producing reports on similar studies is essential. All obtained information should be analyzed to determine what has already been achieved and developed, what remains to be improved, unresolved issues, and contradictions. As a result, methodological errors and miscalculations from previous researchers are identified, as well as the prospects for improving and enhancing the existing theory. The working hypothesis is formulated based on a summary of all the available materials related to the research object and its physical essence.

The main factors affecting the research object, established in the working hypothesis, are the causes, conditions, and driving forces that induce changes within it. At the initial stage of developing the working hypothesis, compiling the most comprehensive list of such factors, their boundary values, and the degree of their influence on the object is recommended. Based on this, an assumed explanation of the entire process of phenomenon development is made.

Then, in the adopted working hypothesis, the decisive and important cause-effect relationships and interactions should be identified, and the expected directions and course of the development of the object under study should be outlined. The working hypothesis must be logically simple and experimentally verifiable in all its details. Its formulations should be clear, concise, and contain strict, commonly accepted concepts and terms from the field of study.

If the main factors and links of the scientific problem being studied do not cause doubt, the development of the phenomenon or process can be conveniently represented using mathematical models expressed through a system of interrelated mathematical formulas. The choice of type and structure of these formulas is based on existing knowledge in the field of study, logical assumptions, and an analysis of the main influencing factors. This choice is often guided by the principles of analogy, using well-known relationships that may have been identified in the study of other problems within the same or adjacent scientific fields. Occasionally, this choice is made heuristically based on the researcher’s intuition.

The same phenomenon or process can be described using various mathematical models.

The mathematical model of the working hypothesis should be sufficiently simple and allow for changes in the structure of formulas, the nature of the included parameters (variable values), and boundary conditions in accordance with the experimental results. Sometimes, it is helpful to complement the mathematical model with tables, graphs, and diagrams with explanations.

A system of linear differential equations often represents the mathematical model of the working hypothesis.

Keywords and definitions: hypothesis, concept, relevance of the topic, deductive hypothesis, scientific novelty, element, methodology, component.

Questions for assessment:

1. What factors substantiate the topic's relevance in the scientific aspect?
2. How is a deductive hypothesis formulated?
3. What conditions are necessary for identifying elements of scientific novelty?
4. What elements of novelty can be presented in scientific work?
5. Under what conditions can new scientific results be obtained?
6. What is methodology? What does it depend on?
7. List the main components of the methodology.
8. What should a researcher strive for during the literary formatting of materials?

2.5 Content of the stages of the research process

The research process is a type of goal-oriented activity that differs from other types in that:

1. it contains a creative part, which can be described as a mental experiment with imagined objects;

2. it is aimed at determining the essential characteristics of phenomena and processes, which ultimately become important generalizations in the form of principles, patterns, and laws, the knowledge of which ensures human dominance in the corresponding field;

3. the researcher does not have algorithmic prescriptions, and success cannot be found in the literature or clarified with colleagues in the field of science;

4. the researcher faces the complexity of the scientific problem, experiencing an objective lack of information and an evident uncertainty about the direction of the search.

The structure of the research process is the source of the creative state of the researcher, in which the hypothesis and the methodology of scientific inquiry are developed.

What is the meaning of the term "structure" as a general scientific category? In the philosophical encyclopedia, "structure (from Latin 'structura' – building, arrangement, order) is a relatively stable unity of elements, their relations, and the integrity of an object, the invariant aspect of a system."

The structural components of the research process (which involves an experimental part) are optimally arranged as follows:

Stage I: General familiarization with the research problem and defining its boundaries

At this stage, the level of development and perspective of the problem are established. The researcher must clearly understand and justify the societal need for knowledge on this issue.

The main question of the first stage is the problem aspect of the topic, without which it is impossible to move on to the next research stage. If the first step is done correctly, it potentially contains the possible successes or inevitable failures. The quality of the problem aspect of the chosen topic will largely determine the study's final results.

Stage II: Formulating the research objectives

The research objectives are achieving new states at any link in the research process or a qualitatively new state - the result of overcoming the contradiction between the ideal and the real. In addition to formulating the general objective, intermediate objectives are also formed. These intermediate objectives can act as obstacles to removal and as a desired work hierarchy (general or individual).

The research objectives must be formulated concretely and find expression in describing the forecasted state in which the research object should be seen in accordance with the social demand. The objective is always a description of the projected result placed within the context of the more general system.

Stage III: Developing the research hypothesis

The research hypothesis becomes the prototype of the future theory if the subsequent work confirms it. Therefore, when developing a hypothesis, the researcher must consider the main functions of scientific theory.

Since the hypothesis is a theoretical construct, its truth must be proven experimentally or through organized, controlled experience. As a project, it should fulfill the following functions within the subject of study: descriptive, explanatory, and prognostic.

Stage IV: Defining the research tasks. confirmatory experiment

The internal mechanisms of the phenomenon under study, hypothetically described as essential characteristics, are related to the research objectives, i.e., the final projected results. This connection allows for the formulation of research tasks. Such theoretical work aims to create specific search tasks, optimizing varying conditions (external and internal), resulting in the hypothetical cause-effect relationship acquiring all the features of objective law.

Stage V: Transforming the experiment and its organization

A new stage in the scientific search begins after the formulation of the research tasks. A full list of essential conditions is required, both those that can be regulated and those that can at least be stabilized. This description clarifies the nature, content, and tools for transforming the object (process, phenomenon) into predefined qualities.

Stage VI: Organizing and conducting the experiment

The organization and conduct of the experiment begin with testing the experimental documentation: research methodologies, questionnaires, interview programs, tables, or matrices for data registration and accumulation. This check aims to refine the documentation and eliminate unnecessary data collection that could distract attention from the core issues.

The experimental process is the most labor-intensive and dynamic part of the research and cannot be stopped. The experiment does not allow unplanned pauses.

Stage VII: Generalization and synthesis of experimental data

The analytical stage of the research has been completed. At this stage, the synthesis of experimental data begins, reconstructing a holistic view of the object under study, but from the perspective of its essential relationships and based on its experimental transformation.

The accumulated factual material, partly organized during the experiment, is processed with logical and formal methods that acquire primary importance in the laboratory.

Conclusions for Chapter 2

1. The scientific solution to the problem of empirical and theoretical knowledge is the foundation for addressing important issues in epistemology, methodology, and

science logic, including solving problems of research methods at the empirical and theoretical levels.

2. A system of linear differential equations often represents the mathematical model of the working hypothesis.

The link between the empirical and theoretical stages of research is the formulation of the scientific problem.

Key terms and definitions: stage, research process, mental experiment, principle, creative state, structure, structural component.

Questions for assessment:

1. What is the meaning of the term "structure" as a general scientific category?
2. What does the first stage consist of?
3. What actions are performed at the second stage?
4. What is developed in the third stage?
5. What is done at the fourth stage?
6. Describe the structure of the fifth stage.
7. What actions are performed at the sixth stage?
8. What actions are performed at the seventh stage?

3 CLASSIFICATION OF SCIENTIFIC RESEARCH METHODS

3.1 Scientific methods of empirical research

There is no universally accepted classification of general scientific methods and techniques; they are categorized based on various criteria. The most effective approach, in our view, is one that distinguishes three levels in the structure of general scientific methods and techniques: logical, theoretical, and empirical.

Observation is a purposeful study of objects, primarily based on sensory data (sensations, perceptions, representations). Through observation, we gain knowledge about the object of study's external aspects and, as the ultimate goal, about its essential properties and relationships.

Observation is usually integrated as a component of an experiment. An important aspect of observation is interpreting its results – deciphering instrument readings, oscillograph curves, electrocardiogram data, etc.

The cognitive outcome of the observation is a description, which involves recording initial information about the studied object using natural and artificial language tools: schemes, graphs, diagrams, tables, drawings, etc. Observation is closely related to measurement, which determines the ratio of a given quantity to another homogeneous quantity taken as a unit of measurement. The result of measurement is expressed numerically.

The researcher is always guided by a certain idea, concept, or hypothesis during observation. They do not simply register any facts but consciously select those that confirm or refute their ideas.

Selecting the most representative group of facts in their interrelation is crucial. The interpretation of observation is also always carried out using specific theoretical principles.

The experiment is an active and purposeful intervention during the studied process, involving a corresponding change in the object or its reproduction under specially created and controlled conditions.

In an experiment, the object is artificially reproduced or placed in predetermined conditions that align with the research goals. During the experiment, the object of study is isolated from the influence of external, obfuscating factors and presented in its “pure” form. The specific conditions of the experiment are not only set but also controlled, modified, and repeatedly reproduced.

Key features of an experiment:

- a more active relationship with the object (compared to observation), including its modification and transformation;
- the ability to reproduce the studied object multiple times at the researcher’s discretion;
- the possibility of discovering properties of phenomena that are not observable under natural conditions;
- the ability to consider the phenomenon in its “pure” form by isolating it from complicating and masking circumstances or by altering and varying the experimental conditions;
- the ability to control the “behavior” of the object of study and verify the results.

Main stages of conducting an experiment:

- planning and design (purpose, type, tools, methods, etc.);
- control;
- interpretation of results.

An experiment serves two interconnected functions: testing hypotheses and theories, and forming new scientific concepts. Based on these functions, experiments are classified as research (exploratory), verification (control), reproducing, isolating, etc.

Experiments are also classified by the nature of the objects involved, such as physical, technical, chemical experiments, and so on.

One of the simplest types of scientific experiments is the qualitative experiment, which aims to establish the presence or absence of a phenomenon suggested by a hypothesis or theory. A more complex type is the quantitative experiment, which determines the quantitative specifics of a property of the studied phenomenon.

Comparison is a cognitive operation that forms the basis for judgments about the similarities or differences between objects. Through comparison, qualitative and quantitative characteristics of objects are identified.

To compare means to juxtapose one thing with another to uncover their relationship. The simplest and most important types of relationships revealed through comparison are identity and difference.

Key terms and definitions: scientific method, classification, empirical research, empirical method, observation, experiment, documentation.

Questions for assessment:

1. Describe the three levels of the structure of general scientific methods and techniques.
2. What is included in the empirical research methods?
3. What knowledge do we gain during observation?
4. What is the cognitive result of observation?
5. Describe the three levels of the structure of general scientific methods and techniques.
6. What is included in the empirical research method?
7. What knowledge do we gain during observation?
8. What is the cognitive result of observation?
9. What is an experiment?
10. Outline the main features and stages of conducting an experiment.

3.2 Scientific methods of theoretical research

Formalization is the representation of substantive knowledge in a symbolic form. Formalization is based on the distinction between natural and artificial languages. Expression of thought in a natural language can be considered the first step of formalization. Natural languages, as a means of communication, are characterized by ambiguity, complexity, flexibility, inaccuracy, imagery, and more. They are an open, continuously evolving system, constantly acquiring new meanings and interpretations.

Further deepening of formalization involves the construction of artificial (formalized) languages designed for more precise and strict expression of knowledge than natural languages, in order to eliminate the possibility of ambiguous interpretation, which is typical for natural languages (e.g., the languages of mathematics, logic, chemistry, etc.).

The symbolic languages of mathematics and other exact sciences aim not only at reducing notation (which could be done using shorthand), but also at making the formula language an instrument of knowledge. It plays the same role in theoretical knowledge as the microscope and telescope do in empirical knowledge.

The use of special symbolism eliminates the ambiguity of ordinary language words. In formalized reasoning, each symbol is strictly unambiguous.

Language serves many functions as a universal means of communication and exchanging thoughts and information. An important task of logic and methodology is to convey and transform existing information as accurately as possible, thereby addressing some of the shortcomings of natural language. This is why artificial formalized languages are created. These languages are primarily used in scientific knowledge and, in recent years, have become widespread in programming and algorithmizing various processes using computers.

The main advantage of artificial languages lies in their accuracy, unambiguity, and, most importantly, their ability to represent conventional substantive reasoning through computation.

The significance of formalization in scientific knowledge is as follows:

1. It allows for concept analysis, clarification, definition, and explication. Everyday representations (expressed in conversational language), although seemingly clearer and more obvious from the common sense perspective, prove unsuitable for scientific knowledge due to their uncertainty, ambiguity, and imprecision.

2. It plays a special role in analyzing proofs. Representing a proof as a sequence of formulas derived from initial ones using precisely specified transformation rules gives it the necessary rigor and precision.

3. It serves as the foundation for algorithmization processes and programming of computational devices, thus contributing to the computerization of scientific and technical knowledge and other forms of knowledge.

During formalization, reasoning about objects is transferred to operating with symbols (formulas). The relationships between signs replace statements about the properties and relationships of objects.

This way, a generalized symbolic model of a certain domain is created, enabling the discovery of the structure of various phenomena and processes while abstracting from their qualitative, substantive characteristics.

The main aspect of the formalization process is that operations can be performed on formulas of artificial languages, allowing the generation of new formulas and relationships.

Thus, operations with thoughts about objects are replaced by actions with signs and symbols. In this sense, formalization represents a logical method of clarifying the content of a thought by refining its logical form. However, it has nothing to do with absolutizing the logical form over content.

Formalization is, therefore, the generalization of forms of processes that differ in content, abstracting these forms from their content. It refines content by revealing its form and can be carried out with varying degrees of completeness.

The Axiomatic Method is one of the ways to build scientific theories, in which deductively:

- (a) a system of basic scientific terms is formulated (for example, in Euclidean geometry, this includes the concepts of a point, line, angle, plane, etc.);
- (b) from these terms, a set of axioms (postulates) is formed – statements that do not require proof and serve as the starting points from which all other propositions of the theory are derived according to specific rules (e.g., in Euclidean geometry: “Through two points, only one straight line can be drawn”; “The whole is greater than the part”);
- (c) a system of inference rules is formulated that allows for transforming the initial statements and moving from one proposition to another, as well as introducing new terms (concepts) into the theory;
- (d) postulates are transformed according to rules that allow deriving many provable propositions (theorems) from a limited set of axioms.

Thus, special rules of inference are formulated for deriving theorems from axioms (or generally, for deriving one formula from another).

All concepts of the theory (usually deductive), except for the initial ones, are introduced through definitions that express them through previously introduced concepts.

Therefore, a proof in the axiomatic method is a sequence of formulas, each of which is either an axiom or derived from previous formulas according to some rule of inference.

The axiomatic method is just one of the methods of constructing scientific knowledge. It has limited application because it requires a high level of development of the content theory being axiomatized.

Conclusions for Chapter 3:

1. Scientific methods of empirical research help identify and compare levels in the development of the studied phenomenon, the changes that have occurred, and determine developmental trends.

2. Scientific knowledge functions through a complex, dynamic, subordinated system of various methods at different levels, in different fields of action, and with different directions, all of which are implemented considering the specific conditions and subject of study.

Each individual method, including the dialectical one, is valid within its framework and sphere of application for solving specific tasks. However, it becomes invalid if it is absolutized, "exceeds its authority," undergoes "methodological canonization," and is universally applied outside its domain.

Key terms and definitions: scientific method, theoretical research, formalization, logic, methodology, artificial language, axiomatic method.

Questions for assessment:

1. What does the term “formalization” mean?
2. What is associated with the further deepening of formalization?
3. What is an important task of logic and methodology?
4. What is the advantage of artificial languages?
5. What is the significance of formalization in scientific knowledge?
6. What is the main aspect of the formalization process?
7. What is the advantage of the axiomatic method?
8. Define the concept of “hypothesis.”
9. Explain the essence of “deduction.”

4 SEARCH, COLLECTION, AND PROCESSING OF SCIENTIFIC-TECHNICAL INFORMATION

The successful conduct of any scientific research largely depends on the timely provision of operational and complete information about achievements in science and technology and the effective use of this information in scientific research, design, and production enterprises. It is impossible to accurately understand the best global and domestic examples of technology if the information about them is incomplete, unreliable, or delayed.

4.1 Documentary sources of information

The concept of *"document"*. We are surrounded by numerous documents that record social experience and can later be used in various fields of activity. A document is an external, material object relative to a person: a physical medium with information recorded in its structure, intended for storage and distribution within society.

The world of documents is infinitely diverse. Birch bark manuscripts, papyrus scrolls, clay tablets, handwritten texts, technical drawings, newspapers, photographs, books, films, and so on – all of these are documents. The general goal of any document is to preserve information of various forms, content, and purposes within the structure of a material medium and to provide the opportunity to use it as needed to solve scientific, production, identification, economic-financial, accounting, and other tasks.

The definition of a document encompasses an immense number of objects, including natural ones. A document is considered a material object containing information in a fixed form.

The term “literature” is often used as a synonym for a document, but this is incorrect. *Literature* refers to a collection of written works of public significance. The scope of this term is narrower than that of a document because it does not include sources of information that are recorded in other, non-written ways.

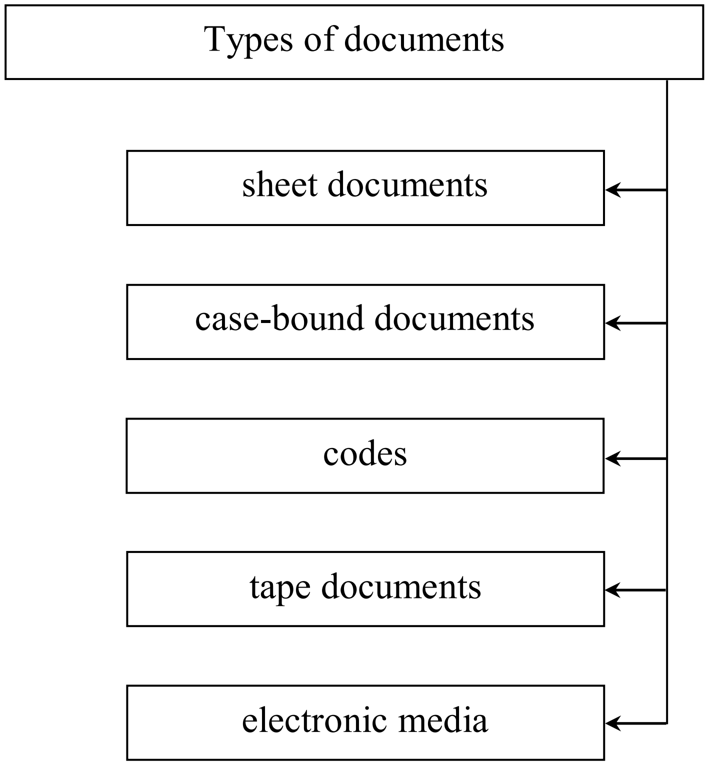


Figure 4.1 – Types of documents by structural form

Types of documents by structural form. The structural form of a document varies greatly (see fig. 4.1).

Types of documents based on the symbolic nature of information. Another characteristic that contributes to the classification of documents is the symbolic nature of information. It is defined as the form of symbols used to record and transmit the main content of the publication: alphabet letters, numbers, and punctuation marks (for written works), musical notation (for musical works), graphical, artistic, and cartographic images (fig. 4.2).

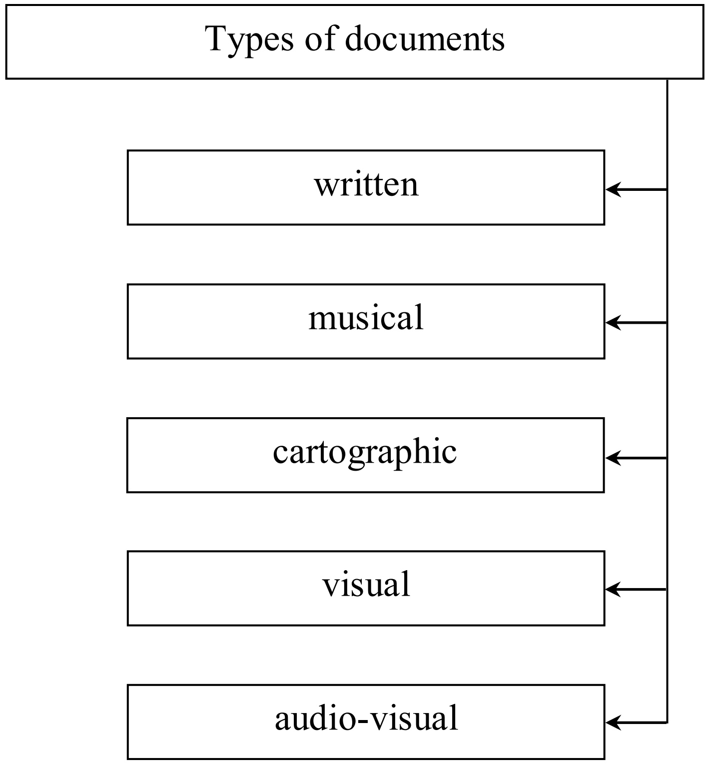


Figure 4.2 – Types of documents based on the symbolic nature of information

Types of documents based on their periodicity. From the perspective of publication frequency, all publications are divided into non-periodical, published once with no continuation, most often books; serial, and periodical – serial publications issued at regular intervals (fig. 4.3).

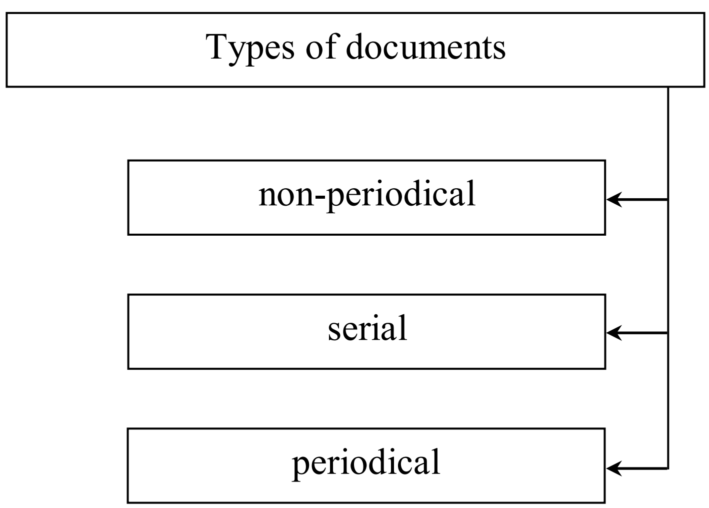


Figure 4.3 – Types of documents based on periodicity

Types of documents based on the nature of the text. Documents are classified by the nature of the text into individual, reflecting the author's perspective on the issue; standard, aiming for a standardized form of text; and stencil printing forms with blank fields (fig. 4.4).

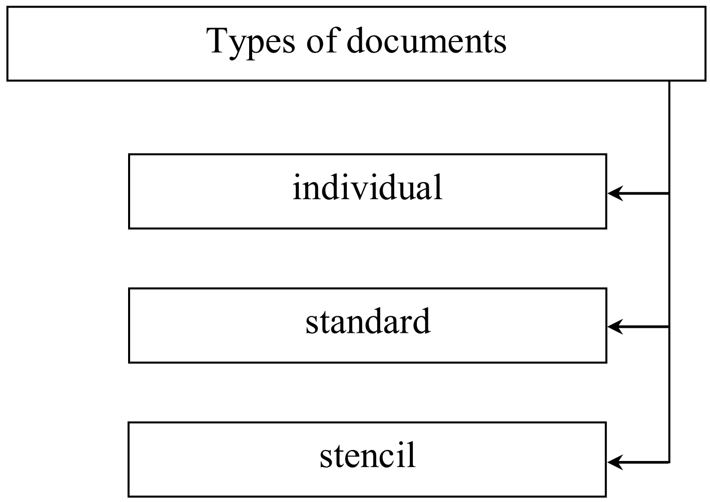


Figure 4.4 – Types of documents based on the nature of the text

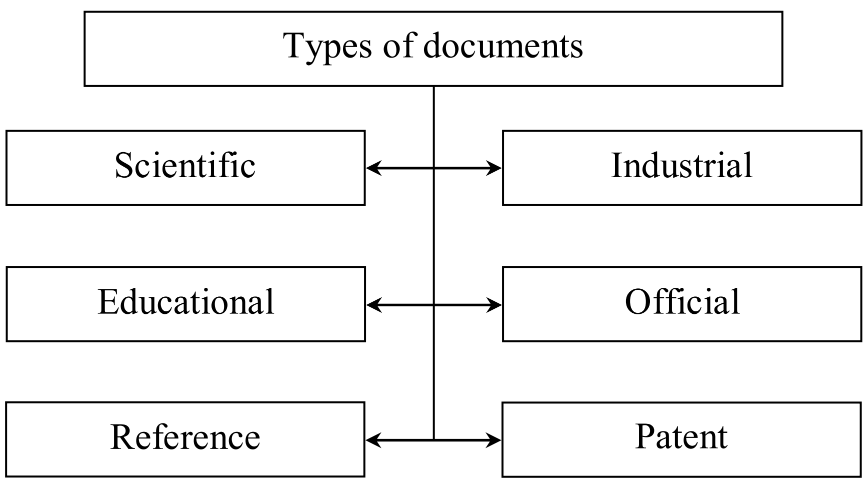


Figure 4.5 – Types of documents based on their intended purpose

Types of Documents by Their Purpose. Depending on their intended purpose and the field of activity, documents are classified into scientific, popular science, production, official, educational, reference, patent, literary-artistic, and others (see fig. 4.5).

Scientific Documents. Such documents contain the results of theoretical or experimental research, track the history of major discoveries, reveal the paths and nature of scientific research, and describe the methods and processes of conducting investigations.

A dissertation is a qualification scientific work in a specific field of science, which has internal unity and contains a set of scientific results and statements put forward by the author for public defense. These statements demonstrate the author's personal contribution to science and their qualities as a scholar.

Standardization is an activity to develop and establish mandatory and recommended requirements, norms, rules, and characteristics. Standardization aims to achieve an optimal order level in a particular area through the vast and repeated use of established provisions, norms, and requirements.

Each standard is reviewed every five years to determine whether it should be revised, canceled, or approved for use for the next five years. This measure ensures the continuous updating of standards.

The collection of standards is differentiated on various grounds. Based on the scope of the application, the following categories are distinguished:

- national standards (NS)
- industry standards
- enterprise standards
- standards of scientific-technical and engineering societies and other public organizations.

Key terms and definitions: document, constructive form, symbolic nature of information, intended purpose, dissertation, standardization.

Questions for assessment:

1. What is a document?
2. List types of documents based on their constructive form.

3. List types of documents based on the symbolic nature of information.
4. List types of documents based on their frequency.
5. List types of documents based on the nature of the text.
6. List types of documents based on their intended purpose.
7. What do scientific documents contain?
8. What is a dissertation?

4.2 Document analysis

Information analysis of a document involves a formal characterization of the text based on several parameters: information volume, information capacity, physical volume (dimensions), informativeness, etc.

The method of terminological analysis originated in linguistics but, over time, has been enriched by techniques from logic and is now successfully used in many scientific fields. Its application in each science has its own distinctive features.

Content analysis, or the method of quantitatively studying the content of a document, involves counting the frequency of occurrences of units in the text: letters, words, signs, combinations of signs, terms, etc. After being counted, the identified units are arranged in descending order of their frequency of use in the text, i.e., a thesaurus is formed. The count results allow one to see what is dispersed in the text and not immediately visible.

Psycholinguistic method of document study. This method studies the text from the perspective of its perception characteristics, influencing its appeal and accessibility to the reader. The author's intention is expressed in the text's main idea, as during its preparation, the author focuses on certain demands from the potential reader and aims to be understood. This targeted orientation of created messages affects how they are captured in texts, so the perception of the message is determined not only by requests but also by the methods of content transmission.

Expert assessment method. Expert assessments are applied in the analysis and resolution of poorly formalizable tasks, where the cause-and-effect relationships are not entirely clear, and the significance and quality of parameters of interest to the researcher cannot be directly measured. Expert assessments and expertise are indispensable in forecasting tasks, the solution of which usually relies on evaluative, approximate data.

Expertise is the central concept in expert assessments. Expertise is surveying experts, collecting, and initially analyzing expert information. There is *direct expertise,* where the relevant questions are directly posed to the experts, and indirect expertise, where answers to these questions are determined by processing other responses.

Bibliographic method of document study. Bibliographic and scientometric methods are focused on studying the quantitative collection of documents.

Source analysis. Source analysis can be referred to as "informational," as it includes the search for original sources of information combined with a preliminary study of their content.

Printed sources of information. These include periodicals, divided into newspapers, journals, and other special publications; books are harder to classify due to their thematic diversity.

Specialized information retrieval systems (SIRS). These are relatively new means of searching, collecting, systematizing, and analyzing primary sources of information. Their emergence and rapid development are primarily related to the swift progress of information and electronic technologies (invention of the computer, development of sophisticated operating systems, and new programming tools).

Electronic sources of information. These include television and radio broadcasting, the Internet, and other information distributed electronically on various computer media.

Keywords and definitions: analysis, document, informational analysis, terminological analysis, content analysis, expert evaluation, expertise.

Questions for assessment:

1. What does informational analysis of a document imply?
2. List the methods of document analysis.
3. What is the essence of the content analysis method?
4. What tool is the method of conceptual dictionary analysis?
5. What is the central concept in expert assessments?
6. To which methods do bibliographic and scientometric methods belong?
7. Specialized information retrieval systems. What are they?

4.3 Search and accumulation of scientific information

One of the simplest technological procedures is the collection of primary information sources. The researcher must gather most of the necessary sources near their workspace by a specific deadline to accomplish this task.

Systematization is the ordering and grouping of all collected material based on its content and the sequence in which it will be used in preparing a written work. Systematic analysis has two main objectives: a thorough check for the completeness of selected sources and a superficial verification of the accuracy of their bibliographic details.

Today, libraries remain the most comprehensive and accessible information repositories. Therefore, library catalogs are most frequently used to prepare written works.

A *catalog* is a systematically organized list of sources stored in an information repository and recorded according to established rules. Libraries typically use archival, alphabetical, thematic, chronological, bibliographic, subject, general systematic, and special catalogs.

- *General catalog* – a list of library sources systematized according to a fundamental principle different from alphabetical or other classifications discussed earlier. Often, this principle is based on the source's affiliation with a specific field of scientific knowledge or academic discipline.
- *Thematic catalog* – a list of library sources arranged by thematic order, where the thematic focus of a source's content serves as the main classification criterion.
- *Alphabetical catalog* – a list of library sources arranged in alphabetical order.
- Subject catalog – a list of library sources classified by subject, which is a more detailed categorization compared to the thematic catalog. In this case, information on unrelated subjects is arranged alphabetically.
- *Chronological catalog* – a list of library sources arranged in chronological order, reflecting the publication date of each edition, most commonly for periodicals. The publication year serves as the primary organizing criterion.
- *Archival catalog* – a list of archived library sources arranged alphabetically (or, less frequently, chronologically). To find a source in an archival catalog, one must know its title and author or its publication date.
- *Bibliographic catalog* – a list of library sources containing bibliographic (descriptive) information on the most significant and frequently used books and periodicals stored in the library.
- *Special catalog* – a list of library sources of a specific type. For example, a special catalog may list articles published in periodicals stored in the library or newly acquired materials.

The scientific reference system of a book plays an important role in searching, collecting, analyzing, and systematizing primary and auxiliary information sources.

Various supplementary materials included in a publication, which inform readers about its content, structure, composition, and functional purpose, are considered part of the scientific reference system of a book. The elements of this system are classified into search, explanatory, informational, and auxiliary components.

Information elements of the scientific reference system are used to help readers form a preliminary opinion about a source and its key features. These elements are typically found on the title page, its reverse side, and sometimes at the end of the source.

General Principles of Taking Notes. Taking notes while reading is one of the most effective methods for processing information from primary sources in preparing written work. When reading is accompanied by note-taking, the retention and comprehension of the material significantly improve.

Types of Notes. *Plan* (from Latin *planum* – plane) – serves as the framework of a written work, outlining the sequence of material presentation.

- *Excerpts* – small text fragments that contain the reading material's essence.
- *Theses* (from Greek *thesis* – statement) – a refined version of excerpts, presenting a concise summary of the studied material in affirmative or sometimes refuting statements.
- *Synopsis* (from Latin *conspectus* – overview, description) – a detailed note-taking method that includes quotes, a structured outline of the source, a brief analysis, and conclusions.
- *Summary* – a brief evaluation of the studied source, primarily based on its conclusions.
- *Annotation* – a short description of the main content of the source, providing a generalized understanding of it.

Compiling a Refined List of Primary Sources. After reviewing the collected notes, refining the initial list of primary sources often becomes necessary by removing irrelevant ones and adding previously omitted but relevant sources.

Scientific information search is a set of operations to find documents necessary for topic development. This search can be manual, mechanical, automated, or semi-automated.

Processing scientific and technical information requires creativity, concentration, and attention. Systematic and persistent efforts are crucial. Accurate note-taking is essential since recording processed material is a mandatory requirement.

Upon completing the analysis of scientific and technical information on a chosen topic, a researcher must define the goal of their research and outline the tasks necessary to achieve it. These are reflected in the topic of the scientific study.

Key terms and definitions: search, accumulation, scientific information, systematization, catalog, primary source, thesis, synopsis, summary, annotation, UDC (Universal Decimal Classification), excerpt.

Questions for assessment:

1. What is systematization?
2. List and describe the two main tasks of systematic analysis.
3. What types of catalogs exist? List and describe them.
4. What are the types of elements in the scientific reference system? Explain them in detail.
5. What is a thesis?
6. Explain the concepts of synopsis, summary, and annotation.
7. What is a scientific information search?
8. What is required for processing scientific and technical information?

4.4 Electronic forms of information resources

Informatics is the science that develops methodologies for creating the most efficient information systems. The foundation for designing and automating scientific research is based on informatics methods.

Any new scientific and technical information about original ideas, facts, scientific results, etc., is a crucial component of the *information support system.* The key issue in developing such systems is "addressability", which ensures timely information delivery to users who need it. Over time, *information support systems* have evolved into an independent system known as scientific communication, which is responsible for storing and disseminating scientific knowledge.

Databases. With the advancement of computing technology and data storage systems, it has become possible to accumulate and store large volumes of data in databases. These databases are classified into:

- *Factual databases* – contain factual information and serve as a final product for users.
- *Bibliographic databases* – contain secondary information, meaning details about publications.

The concept of a data bank is closely related to the database concept. *A data bank* is an information system designed for storing, managing, and using large volumes of interconnected and dynamic data. It consists of databases, a set of tools for database creation and usage, including database management software, programming languages, computing hardware, various procedures and methodologies.

Each type of information product requires a specific technology for its generation and is accompanied by application software packages (ASPs).

Information Networks. The development of computing technology and communication systems has made it possible to integrate data into a single information infrastructure, with information networks as its foundation. Through these networks, users gain broad access to data banks connected to the system.

Information consumers can be divided into four categories:

1. Consumers involved in designing and developing new technologies
2. Consumers responsible for managerial decisions in technology development
3. Consumers conducting scientific research
4. Consumers handling planning and administrative tasks

This classification allows for clearer formulation of requirements for specific information systems and improves the efficiency of information support.

Key terms and definitions: electronic form, information resource, informatics, information support, database, data bank.

Questions for assessment:

1. What does the science of informatics study?
2. What is one of the most important components of an information support system?
3. What function do databases perform?
4. What do factual and bibliographic databases contain?
5. What is a data bank?
6. What functions do information networks perform?
7. What are the four categories of information consumers?
8. How does classifying information consumers improve the efficiency of information networks?

4.5 Processing, recording, and storage of scientific information

When first familiarizing oneself with a scientific book, much useful information can be obtained from its publication details.

The *book annotation* provides a brief summary of the content and intended readership, highlights the scientific and practical significance of the publication, and reveals the main idea. The annotation allows one to learn about the main topic, objectives, methods used by the author, and the book's affiliation with a particular scientific school.

The *preface* to a scientific book may take various forms. It typically explains the reasons for writing the book, describes its content and structure, and outlines the extent to which certain issues are covered.

The *introductory article* evaluates the work, describes the scholar's worldview and system of scientific and social views, and lists their most significant works.

The introduction serves as the opening section of the main text and should be read particularly carefully when familiarizing oneself with a scientific book.

The ability to use speed-reading techniques significantly reduces the effort required when working with scientific literature. Being able to read quickly is one of the key conditions for assimilating a much larger volume of material.

When reading and summarizing, one should not focus solely on borrowing material. It is essential to reflect on the gathered information throughout the entire research process. The thoughts that arise while engaging with other works will serve as the foundation for acquiring new knowledge.

Only information directly related to the dissertation topic should be used in literature review, as it is the most valuable and relevant.

When working on a broad issue, it is important to break it down into parts and carefully consider each one. While studying a specific question or section, one should not lose sight of its connection to the problem.

Selection and Evaluation of Factual Material. Scientific work involves significant preliminary effort, including gathering primary and supplementary information, summarizing it, and presenting it in a form suitable for analysis and conclusions. Therefore, it is essential to learn how to select not just any facts but specifically scientific ones.

The concept of a “scientific fact” is much broader and more multifaceted than an everyday fact. *Scientific facts* possess specific characteristics – novelty, objectivity, accuracy, and reliability. The novelty of a scientific fact signifies a fundamentally new, previously unknown subject, phenomenon, or process. While it may not always constitute a scientific discovery, it represents new knowledge about something previously unknown.

The process of accumulating scientific facts on a chosen topic is always multi-dimensional. It involves an in-depth study of published materials, examination of archives and institutional records, consultations with experts, and analysis and synthesis of one’s own research results.

It is advisable to record valuable thoughts as soon as they arise. During the initial stages of organizing a scientific study, selecting the most appropriate system for storing primary documentation is crucial. This will facilitate the use of collected materials and save considerable time in the future.

Along with registering collected materials, one should simultaneously group, compare, and analyze numerical data. Classification plays a key role in this process, as no scientific structure or conclusion can be formulated without it. Classification allows researchers to navigate the subject matter efficiently, facilitates searches, and helps identify previously unnoticed connections and dependencies. Classification should be conducted throughout the entire research process, as it is one of the central and essential components of any scientific methodology.

The process of collecting, recording, storing, and classifying primary scientific information should ideally conclude with writing a comprehensive review text that summarizes and systematizes the gathered information.

Chapter 4 Conclusions

1. The system of standards is differentiated based on various criteria. According to the scale of application, the following types are distinguished:

- National standards (NS)
- Industry standards
- Enterprise standards
- Standards of scientific, technical, and engineering societies, as well as other professional organizations

2. Electronic sources of information include television and radio broadcasting, the Internet, and other electronically distributed information, including data stored on various digital media.

Key terms and definitions: scientific information, processing, recording, storage, document, method, expert evaluation, catalog, working record, UDC, principle.

Questions for assessment:

1. Define the concept of "document."
2. What types of documents are known to you?
3. List the methods of document analysis.
4. What does the expert evaluation method entail?
5. What is a catalog? What are its types?
6. Describe the principles of maintaining working records.
7. How is a refined list of primary sources compiled?
8. What are the principles of selecting and evaluating factual material?

5 THE EMPIRICAL LEVEL OF SCIENTIFIC RESEARCH

5.1 General characteristics of the empirical level of scientific research

Empirical knowledge should be considered as the starting point only within the framework of scientific knowledge. However, it is important to note that the origins of empirical research are, to some extent, prepared by other forms of knowledge. This means that empirical research should be linked not only to the sensory stage of cognition but also to its logical stage.

In empirical research, the researcher's preliminary data and methods serve one main goal – obtaining knowledge about the object. Consequently, every day and philosophical knowledge mobilized in empirical research plays an auxiliary role.

Empirical research consists of three stages, each producing empirical knowledge of different types.

- The initial stage provides basic empirical knowledge, consisting of primary data obtained through observation and experience.
- Preliminary logical and mathematical processing of basic empirical knowledge leads to the second stage of empirical research, where relationships between different data sets are identified, allowing for their grouping, systematization, and classification.
- The third stage involves generalizing data within each group to formulate empirical laws. At this point, empirical research concludes. Exceeding the limits of empirical laws would detach the study from its foundational empirical basis, disrupting the entire logic of empirical research.

Thus, the empirical level of scientific knowledge, as the first stage of scientific research, is divided into three stages:

1. Formation of basic empirical knowledge.
2. Grouping, systematization, and classification of basic knowledge.

3. Establishment of empirical laws (stable relationships between experimental data).

Starting from the collection of experimental data, empirical research includes linguistic expression and logical and mathematical processing of experimental data, leading to the discovery of patterns.

Given these aspects, we can characterize the sciences classified as empirical. These include sciences that do not have a single generally accepted theory, as well as those where facts are explained and interpreted by different theories. Such theoretical pluralism is characteristic of fields like medicine, where different theories of diseases and treatment concepts coexist. Empirical sciences are distinguished by a strong emphasis on experimentation and factual evidence, often fostering a more open academic atmosphere regarding the interpretation of facts.

Examples of empirical sciences lacking a single unified theory include psychology, geology, pedagogy, and sociology. Today, empirical sciences frequently emerge at the intersection of disciplines, as reflected in their names: biotechnology, biophysics, mechatronics, social psychology, etc. Success in these fields is often achieved by applying methods from one science to another.

Keywords and definitions: empirical level, scientific research, empirical knowledge, stage, mathematical processing, generalization, experimental data.

Questions for assessment:

1. How should empirical knowledge be considered?

2. What is the primary purpose of all preliminary data and methods in empirical research?

3. What are the results of the first stage of empirical research?

4. What type of knowledge is obtained in the second stage of empirical research?

5. What does the third stage of empirical research allow for?

6. What does empirical research include, starting from the collection of experimental data?

5.2 The First stage of empirical research

We have repeatedly used the term "experimental data." These data constitute basic empirical knowledge, reflecting objective phenomena and their properties. The only way to acquire this knowledge is through scientific experimentation. Experimental data include sensory perception of studied phenomena and awareness of this perception, expressed through corresponding concepts and terms. The simplest form of basic empirical knowledge appears in everyday language descriptions. These descriptions become more precise and concise when they transition into scientific language.

It is important to remember that scientific research involves using certain logical forms even in the first stage. The term "experience" is used in both everyday and philosophical knowledge. The unique nature of scientific experience becomes clear when we identify its key components:

1. Development and preparation of an experimental plan.
2. Conducting the experiment.
3. Preliminary verification of the accuracy of the experimental data.
4. Evaluation of how accurately the data reflects the studied phenomena.

The simplest form of scientific experimentation is observation, which involves a physical connection between the observer and the observed object.

At a more advanced stage of scientific knowledge, using instruments in ***observation*** became possible, making observations indirect. Automated instruments with recording devices greatly expanded indirect observations, enabling the study of the ocean floor, space, the surface of the Moon, and the atmospheres of Mars and Venus.

A more complex form of scientific experimentation is the ***experiment.*** In experiments, all the characteristics of observation become more intricate.

Preparing for an experiment requires more prior knowledge than preparing for an observation. Repeated observations are important in all forms of scientific experimentation. However, when studying rare phenomena, multiple observations may not be possible. In experiments, however, repetition is fundamentally important.

An experiment is characterized by the active influence of the experimenter on the object.

The simplest type of experiment involves isolating an object from its natural conditions and observing it under controlled circumstances.

A more complex experiment involves creating artificial conditions for the object's existence. For example, electrical discharges occurring during thunderstorms are studied in laboratory settings using induction coils. Many chemical reactions occurring in nature can be reproduced in a “pure” form in laboratory conditions.

A crucial process accompanying observation and experimentation is ***measurement.***

For measurement, the following are necessary:

1. a unit of measurement;
2. a measuring instrument;
3. measurement rules.

A specific unit is established for each measurable quantity, with fundamental units distinguished among them. In physics, for example, units of length, time, mass, charge, and energy are introduced. The fundamental units include length: centimeter, mass: gram, and time: second.

Measurement is a key pathway to discovering empirical laws.

Scientific descriptions of experimental data must have consistent meaning and significance for all researchers. This is achieved when experiments are described using precisely defined concepts, terms, and symbols. Any researcher who accurately replicates the experimental conditions should obtain the same numerical values for studied quantities (within acceptable margins of error) as those obtained by previous researchers.

Keywords and definitions: stage, empirical research, scientific experiment, component, observation method, experiment, experimental planning.

Questions for assessment:

1. What do "experimental data" reflect?
2. Describe the historical development of the observation method.
3. What constitutes the simplest type of experiment?
4. What does creating a more complex experiment involve?
5. What approach led to the development of the mathematical theory of experimental planning?
6. What are the necessary components for measurement? List them.
7. Why is it important to pay special attention to the first stage of empirical research?
8. Under what circumstances would you choose a profession or a related field?

5.3 The second stage of empirical research

The main goal of this stage of empirical research is to identify external relationships between phenomena. This is achieved through the following methods:

1. analysis
2. synthesis
3. systematization

Each scientific field has its own techniques for analyzing, synthesizing, and systematizing experimental results. For example, in chemistry, analysis is divided into qualitative and quantitative types. Qualitative analysis determines the components of complex chemical compounds, while quantitative analysis identifies characteristic features such as weight, volume, boiling point, and other constants. Based on how a given compound breaks down, and its characteristics, logical analysis and synthesis of experimental results are performed.

The analysis and synthesis of experimental data aim to reveal objective connections between phenomena, such as causal, functional, and structural relationships.

Systematization helps organize empirical foundational knowledge into structured, logically coherent descriptions. When measurements include numerical values, systematization enables the creation of tables and graphs.

Each classification reflects the specific features of empirical research developed in a particular scientific field. Accordingly, each science has its own methodology for analyzing and synthesizing experimental data and its own methods for systematizing and classifying these data.

In the second research stage, we encounter a crucial problem at both the empirical and theoretical levels – distinguishing between empirical and theoretical concepts. Most people unfamiliar with scientific research methods and procedures do not realize the fundamental difference between empirical and theoretical concepts. Therefore, special attention should be given to this distinction. These two concepts differ qualitatively, are not interchangeable, and originate from different sources. Theoretical concepts are derived or deduced from a particular theory, whereas empirical concepts emerge from foundational knowledge. The latter arise at the second stage of empirical research and express values directly observed in experiments.

Indexes and Indicators as Analytical Tools in Empirical Research

Induction is the primary tool for empirical generalization, which establishes empirical laws.

Keywords and definitions: stage, empirical research, qualitative analysis, quantitative analysis, systematization, theoretical concept, index.

Questions for assessment:

1. What is the main goal of the second stage of empirical research?
2. What does qualitative analysis determine?
3. What does quantitative analysis determine?
4. By what criteria can the social structure be analyzed?
5. What are the objectives of analysis and synthesis?
6. What is the purpose of systematization?

5.4 The third stage of empirical research

Various numerical data analysis methods are presented in the examples below. Earlier, we mentioned that induction is the primary means of empirical generalization, but in reality, generalization also involves deduction and other logical operations.

Attempts to develop rules for empirical generalization of scientific knowledge have led logicians to create the concept of scientific induction (distinct from logical induction), which essentially coincides with the concept of empirical generalization or inductive research.

An empirical law represents the highest form of empirical knowledge. It is broader and more complex than the knowledge obtained at the first and second stages. Through philosophical and common-sense understanding at the empirical level, it is possible to construct knowledge with general content. However, this content must be controlled and guided by experience. The scientific knowledge obtained through such generalization remains empirical, meaning it is derived from experience.

In logic, induction is defined as reasoning from the particular to the general. Alongside logical rules, various mathematical methods play a significant role in empirical generalization.

To uncover deeper-order essences, other research methods are necessary, ultimately requiring a qualitative leap that allows the transition from the empirical level to the theoretical level of scientific research.

Empirical Laws

What is a law? A law is a relationship, but not a random one – it is a stable, recurring connection between phenomena. Such a connection is reflected in our consciousness as a relationship between concepts. For example, Ohm's law establishes a relationship between the concepts of "electric current," "voltage," and "resistance."

When considering this logical aspect of a law, it is important to note what distinguishes empirical laws from theoretical ones. The difference lies like the concepts used to formulate each type of law.

Empirical laws are formulated using tangible, verifiable, and measurable concepts, whereas theoretical laws rely on logically defined concepts.

Keywords and definitions: stage, empirical research, scientific induction, empirical law, theoretical law, Maslow's hierarchy of needs, labor productivity.

Questions for assessment:

1. What led logicians to create the concept of "scientific induction"?
2. What is an empirical law?
3. What is a law?
4. How are empirical and theoretical laws formulated?
5. How do external stimuli affect labor productivity growth?
6. What terms describe human activity depending on the type of motivation?
7. List the motivating factors for job satisfaction.

5.5 Analysis of empirical data

Empirical data refers to information obtained through experience and practice. The spectrum of empirical data analysis tasks includes the following general groups:

1. *Data Description* – A concise summary of the available data using various aggregated (generalized) indicators and graphs. This category also includes determining the necessary sample size (the minimum number of research objects required to make justified conclusions).
2. *Study of Similarities/Differences* (Comparison of Two Samples) – This involves formulating statistical hypotheses:
   - Null Hypothesis – The hypothesis of no differences.
   - Alternative Hypothesis – The hypothesis that differences are significant (valid). Decision rules – statistical criteria – are used to determine which hypothesis to accept. The empirical value of the criterion is calculated based on observational data and compared with a critical value from statistical tables.
3. *Investigation of Dependencies* – After examining similarities and differences, the next step is to establish whether a dependency exists between indicators and to quantify it. Methods include:
   - Correlation Analysis – Determines whether there is a relationship between two or more variables (in the latter case, it is called multiple correlation).
   - Analysis of Variance (ANOVA) – Studies whether variables are dependent. It measures variance (spread of values) within and between groups to determine the strength of the relationship.
   - Regression Analysis – Unlike correlation and variance analysis, which determine whether a relationship exists, regression analysis identifies the explicit functional dependence between variables.

4. *Dimensionality Reduction* – Large-scale experimental studies often generate vast data. The goal is to identify and focus on the most significant variables while reducing data volume without losing essential information.

5. *Classification* – This broad category of data analysis tasks is based on statistical methods and includes grouping, systematization, taxonomy, diagnostics, forecasting, decision-making, and pattern recognition.

Chapter 5 Conclusions

1. Empirical sciences often emerge at the intersection of disciplines, such as bioengineering, biophysics, and social psychology, where the application of one discipline's methods in another yields success.

2. "Experimental data" forms the foundation of empirical knowledge, reflecting objective phenomena and their properties. The only way to acquire this knowledge is through scientific experimentation.

3. The primary goal of the second stage of empirical research is to identify external relationships between phenomena. This is achieved through analysis, synthesis, and systematization.

Key terms and definitions: analysis, empirical data, method, descriptive statistics, statistical criteria, null hypothesis, correlation analysis.

Questions for assessment:

1. What are the general groups of empirical data analysis tasks?
2. What are descriptive statistics used for?
3. In which cases is the null hypothesis chosen?
4. What is correlation analysis?
5. What is an analysis of variance (ANOVA)?
6. How does analysis of variance work?
7. What is regression analysis?
8. How is "dimensionality reduction" performed?

6 THE THEORETICAL LEVEL OF SCIENTIFIC RESEARCH

6.1 The concept of the theoretical level of scientific research. the first stage of theoretical research

Theory (from Latin *theoreo* – to contemplate) is a system of generalized knowledge that explains various aspects of reality. It is a mental reflection and reproduction of real reality, emerging due to the generalization of cognitive activity and practice.

The structure of a theory consists of principles, axioms, laws, judgments, statements, concepts, categories, and facts. A principle in a scientific theory is understood as the most abstract definition of an idea (the initial form of knowledge systematization).

An axiom (postulate) is a statement taken as an initial, self-evident truth within a given theory, from which all other propositions and conclusions of the theory are derived according to predefined rules.

A theory is the most advanced form of generalized scientific knowledge. It encompasses knowledge of fundamental laws and explains facts based on these laws. Moreover, it enables the discovery of new laws and the prediction of future developments.

Theoretical research significantly differs from empirical research. While empirical research focuses on studying physical or social reality, theoretical research addresses these indirectly. Instead, it is primarily concerned with concepts and their relationships, which requires a research methodology different from empirical studies.

A theory represents a logical framework where the smallest elements are concepts, while a larger "block" of the system is a law. Logically, a law represents a connection between concepts, expressed verbally (e.g., Newton's First Law) or in a formalized mathematical form (e.g., Newton's Second Law).

A theory's foundation are the statements from which it begins – these can be axioms (in mathematics) or principles (in natural sciences).

Theoretical knowledge differs from empirical knowledge in its greater generality, abstraction, and systematization. Due to these characteristics, theoretical knowledge cannot simply be derived from or reduced to empirical data. This raises the challenging question: how can theoretical knowledge correspond to the studied reality if it is not directly derived from empirical material?

The abstractness, generality, and systematization of theoretical knowledge make its structure deductive. This means that theoretical knowledge of lesser generality can be derived from more general theoretical knowledge. Consequently, at the foundation of theoretical knowledge must lie the most general knowledge (within a given field), forming its basis.

To construct a theory, it is first necessary to identify certain general concepts, principles, and hypotheses that, similar to axioms in geometry, serve as the starting foundation. This system of initial concepts, principles, and hypotheses forms what is known in the methodology of knowledge as the theoretical basis of scientific understanding.

Stages of Theoretical Research

1. The first stage of theoretical research involves developing a new or expanding an existing theoretical basis. This is the most complex process in theoretical knowledge.

2. The second stage consists of constructing scientific theories based on the established theoretical basis. This phase is well-developed and heavily relies on formal, logical-mathematical methods of theory construction.

3. The third stage involves the application of theory in practice. The key part of this process is deriving simpler laws from the theory that apply to specific groups of phenomena. In some cases, empirical laws may already exist for these phenomena. In such cases, the theoretical conclusions should align with the empirical laws.

As we can see, the first and third stages differ from the second in that they involve ideas that do not always align with common knowledge. It is crucial to consider and analyze these complexities carefully.

Keywords and definitions: theoretical level, scientific research, theory, axiom, theoretical research, empirical research, law.

Questions for assessment:

1. What is a "theory"? What does a theory represent? What forms the structure of a theory?
2. What is an "axiom," and what is its purpose?
3. What are the focuses of theoretical and empirical research?
4. How is a law represented from a logical perspective?
5. How do theoretical and empirical knowledge differ?
6. The abstractness, generality, and systematization of theoretical knowledge make its structure deductive. What does this mean?
7. What is necessary for building a theory?
8. What actions are included in the research's first, second, and third stages?

6.2 The second stage of theoretical research

At the second stage of theoretical research, a scientific theory is formed. To construct a theory, appropriate concepts are necessary. Their formulation relies on empirical data and laws on one hand and scientific principles and hypotheses on the other. The latter helps establish connections between theoretical concepts, allowing for the formulation of theoretical laws.

The highest level of abstraction belongs to the fundamental principles of a theory, from which other theoretical statements are derived deductively. The least abstract statements are those that can be measured. This means that the empirical interpretation of a theory can only be partial – only some elements of the theoretical system can be directly correlated with empirical data, and this interpretation is then distributed across other parts of the theory.

The partial correlation between theory and empirical data suggests that theory contains some “excess” or “supra-empirical” content.

The foundations of a theory consist of its basic concepts, principles, and hypotheses. For example, the theoretical premise of Einstein's Theory of Relativity was the principle of relativity (extended to electromagnetic phenomena) and the principle of the constancy of the speed of light.

The smallest building blocks of the language of science are concepts – for instance, in physics: mass, force, velocity, and acceleration. Concepts form the basis for laws, such as $F = ma$. At the foundation of the entire theoretical framework lies a principle, in this case, the principle of inertia. To study a theory or a scientific field means to study its language.

A widely used method in theory construction is the axiomatic method, which involves:

1. Formulating an initial system of axioms
2. Defining rules for deriving conclusions from them

This method assumes the existence of fundamental truths that do not require proof, from which all further conclusions follow.

Another method is the constructive (or genetic) method. Unlike the axiomatic method, which relies on formal logical deduction, the constructive method is based on ontological assumptions from which ideal objects are constructed.

This method is particularly evident in thought experiments – imaginary experiments using idealized models.

In addition to the axiomatic and constructive methods, theory construction also involves:

- analysis and synthesis
- deduction and induction

Scientific research methods can be divided into three categories:

1. methods applied only at the empirical level (e.g., observation, measurement, experiment);
2. methods applied at both empirical and theoretical levels (e.g., analysis, synthesis, deduction, induction);
3. methods applied only at the theoretical level (e.g., axiomatic method, idealization, formalization, historical and logical analysis).

Keywords and definitions: stage, theoretical research, abstraction, theory, mathematical formalism, axiomatic method, constructive method.

Questions for assessment:

1. What is formed at the second stage of theoretical research? What plays a key role in this process?
2. Which theoretical statements have the highest and lowest levels of abstraction?
3. What constitutes the foundation of a theory?
4. What enables the prediction of natural phenomena?
5. What does the axiomatic method assume?
6. How do the axiomatic and constructive methods differ?
7. What other methods, besides the axiomatic and genetic methods, are used in theory construction?
8. What are the three categories of scientific research methods?

6.3 The third stage of theoretical research

At this stage, a scientific theory is applied to explain phenomena, which leads to its verification and adjustment.

It is important to note that all possible conclusions from a theory fully express the infinite range of phenomena determined by fundamental laws. While reflecting fundamental laws, a theory does not directly encompass the phenomena themselves. The relationship between a theory and a phenomenon is akin to that between possibility and actuality. Therefore, limitations must be introduced regarding how phenomena are “derived” from a theory.

If a general equation represents the mathematical formulation of a theory, it must be simplified according to the specific characteristics of a given group of phenomena. The numerical values of variables describing particular phenomena are derived from this simplified formula, considering initial or boundary conditions. A theory that lacks a mathematical form does not adequately distinguish between a law and a phenomenon. Non-mathematical forms of theories exist in sciences where mathematical research methods are underdeveloped.

In mathematical theories, one of the main ways to verify a theory is by comparing its calculated values with experimental data. If they match, the theory is considered valid. However, this approach only provides partial verification, as a theory can yield infinite conclusions, making complete verification impossible. Another method of testing a theory is through prediction. This involves deriving information from the theory about facts that have not yet been observed. If the prediction proves correct, this also confirms the theory's validity.

One of the first triumphs of Newtonian mechanics was the successful prediction of Halley’s Comet’s return.

There have been many subsequent examples of celestial mechanics being confirmed through predictions. One famous example is the discovery of Neptune in

1846. While analyzing planetary motion, French astronomer Urbain Le Verrier noticed deviations in Uranus's orbit that did not align with calculations based on Newtonian mechanics. To preserve Newton's theory, Le Verrier hypothesized that an unknown planet was influencing Uranus's movement. He calculated the hypothetical planet's orbit and location. He then informed Berlin astronomer Johann Galle, who pointed a telescope at the designated area and discovered the previously unknown planet – Neptune. Thus, Le Verrier's hypothesis, predicting the existence of an unknown planet, confirmed Newtonian mechanics.

When discrepancies arise between experimental data and theoretical predictions, empiricists often demand a theory revision. However, experimental data should also be approached critically. The history of science shows that theoretical conclusions can sometimes be more accurate than empirical findings. The best approach is one that aims for mutual refinement of both empirical data and theoretical understanding.

Today, the process of verifying theories is influenced by technological advancements. There is now a close, bidirectional relationship between theory and technology throughout the process, from scientific discovery to industrial application. A notable example is the development of high-temperature synthesis as an independent scientific and technical field.

Thus, the theoretical level of scientific research contributes to scientific knowledge and progress. It involves discovering laws and regularities, justifying concepts and classifications, and developing principles and models that allow for the idealization of descriptions and explanations of empirical situations, i.e., understanding the essence of phenomena.

Conclusions of Chapter 6

1. Theory (from Latin *theoreo* – to contemplate) is a system of generalized knowledge explaining various aspects of reality. It is a mental representation and

reproduction of reality, emerging from the generalization of cognitive activities and practice.

2. Scientific research methods can be categorized into three groups:

- Methods used only at the empirical level (observation, measurement, experiment).
- Methods used at both empirical and theoretical levels (analysis, synthesis, deduction, induction).
- Methods used only at the theoretical level (axiomatic, idealization, formalization, historical, and logical research methods).

3. The theoretical level of scientific research involves discovering laws and regularities, justifying concepts and classifications, and developing principles and models that facilitate the idealization of descriptions and explanations of empirical situations, ultimately leading to a deeper understanding of phenomena.

Keywords and definitions: stage, theoretical research, theory, law, phenomenon, equation, mathematical formula, mathematical theory, level.

Questions for assessment:

1. What is the purpose of theory at the third stage?
2. Why does theory, while reflecting fundamental laws, not directly encompass phenomena?
3. How does theory relate to phenomena?
4. Why is it necessary to impose limitations on how phenomena are "derived" from a theory?
5. If a general equation represents a mathematical theory, how should it be simplified?
6. What is one of the main ways to verify a mathematical theory?
7. Under what circumstances is it necessary to verify a theory?
8. What does the theoretical level of scientific knowledge involve?

7 THE SCIENTIFIC PROBLEM, ITS FORMULATION AND DEFINITION

7.1 The essence of a scientific problem

A problem drives society to learn, develop knowledge, experiment, and observe. Science begins with problems rather than observations, although observations can give rise to problems.

The primary objective of a scientist is to solve a specific problem by developing a theory that addresses the issue – whether by explaining unexpected or previously unexplained observations. However, each new and interesting theory generates additional problems – problems of reconciling it with existing theories and conducting new, previously unimaginable observational tests. The fruitfulness of a theory is assessed primarily by the new problems it generates. The most significant contribution a theory can make to the advancement of scientific knowledge lies in the new problems it creates. For this reason, science and the growth of knowledge are understood as processes that always begin and end with problems – problems of increasing depth, marked by an ever-growing capacity to pose new questions.

A problem is a condition, question, or object that creates uncertainty or difficulty, prompting action and associated with either an excess or lack of expertise (specialist knowledge), information, resources, or regulatory structures (order, algorithms, or programs). It either compels or restricts action and, accordingly, remains unresolved or undesirable.

A problem is a rhetorical question posed by a researcher to nature, but one that they must answer themselves. A philosophical interpretation of a "problem" defines it as "an issue or set of issues that arise objectively during the development of knowledge, whose resolution holds significant practical or theoretical interest."

The essence of a problem for an individual is that it requires analysis, evaluation, and the formation of an idea or concept to seek an answer (i.e., solve the problem) through verification and confirmation by experience.

A problem typically refers to a question that lacks a definitive solution (a degree of uncertainty). The uncertainty of a problem distinguishes it from a task. The collection of possible questions interrelated through a common object of study is called a problem area.

If a problem is identified and formulated as an idea or concept, it means that the task of solving it can begin. A problem is essentially a task requiring resolution.

A scientific problem is the recognition and formulation of a concept regarding the unknown. Problem definition is the starting point of any research.

A scientific problem in epistemology refers to a theoretical or factual question that requires resolution. Scientists define a scientific problem as a question whose answer is not found in the accumulated knowledge of society. A problem is never confined to a single question; rather, it comprises an entire system. This system includes a central question (which constitutes the core of the problem and is often equated with the entire problem) and several auxiliary questions, whose answers are necessary to address the main issue.

Problem Definition and Formulation. A problem forms the foundation of all research work. Therefore, it must be clearly, precisely, and correctly formulated. It may be recognized in the form of a problematic situation, an unresolved question, a theoretical or practical challenge, etc.

A problem serves as a boundary between knowledge and ignorance. It arises when existing knowledge proves insufficient, while new knowledge has yet to develop into a structured form.

If a problem is identified and articulated as an idea or concept, it means that a solution-oriented task can be formulated.

The formulation of a research problem is essentially the crystallization of a scientific study's concept. A correctly defined problem is the key to success. To accurately identify a problem, one must understand what has already been explored in the chosen field, what has been weakly developed, and what has not been addressed at all – this is only possible through a thorough review of existing literature.

Every scientific investigation aims to overcome obstacles in the process of understanding new phenomena, explain previously unknown facts, or reveal the inadequacies of traditional explanations for known facts. These obstacles are most clearly manifested in so-called problematic situations, where existing scientific knowledge is insufficient to solve new cognitive tasks.

A problem always emerges when old knowledge proves inadequate, while new knowledge remains undeveloped. Thus, in science, a problem is a contradictory situation requiring resolution. Such situations typically arise from the discovery of new facts that do not fit within existing theoretical frameworks – that is, when no current theory can explain newly observed facts.

The proper definition and clear articulation of new problems often hold as much importance as their resolution. The choice of research problems largely determines the overall research strategy and the direction of scientific inquiry. It is commonly believed that formulating a scientific problem demonstrates the ability to distinguish the essential from the secondary, as well as to clarify what is already known and what remains unknown about the research subject.

The first stage in problem formulation involves identifying a lack of information necessary to describe or explain reality. The second stage, transitioning to common language, allows for interdisciplinary exploration, enabling the transfer of knowledge between different scientific fields. The third stage depends on the existing body of knowledge accumulated by a given scientific discipline.

A well-defined problem is described in precise, concrete terms that reflect the data being analyzed.

The first step is to determine whether a problem exists. Next, the problem must be precisely formulated and analyzed structurally. Subsequently, the problem's historical development (past and future), its external connections with other problems, and the question of its fundamental solvability are examined.

When Do Scientific Problems Arise?

A scientific problem arises within a problematic situation, when a contradiction between knowledge and ignorance is recognized – particularly between people’s knowledge of their needs and their lack of understanding of the means, methods, and mechanisms to satisfy those needs. Ultimately, this leads to a lack of knowledge about certain objective laws governing the world.

A problematic situation also arises as a contradiction between existing theories and new facts requiring a different theoretical interpretation. It may also emerge when logical inconsistencies within existing theories are identified. Contradictions indicate that established knowledge is overly general, incomplete, or one-sided.

Practical application is fundamental to the emergence of problematic situations.

In human interaction with objects of their activity, contradictions constantly arise and regenerate between the rapidly changing qualitative and quantitative needs of society and the means available to satisfy those needs. The necessity of uncovering the laws governing previously unknown spheres of activity forms the foundation of a problem.

Key terms and definitions: essence, scientific problem, new theory, problem area, scientific question, problematic situation.

Questions for assessment:

1. How is the fruitfulness of a new theory evaluated?
2. What is a problem, and what does it create?

3. When can a problem be addressed?
4. What should be included in the problem scope of a scientific work?
5. How does a scientific question differ from a scientific problem?
6. What is the procedure for problem definition and formulation?
7. Why is scientific research conducted?
8. What are the stages of problem emergence?
9. When does a problematic situation arise?

7.2 Problem statement and its solution

What problem should be chosen for solving?

It is important to understand the mechanism of how problems and tasks arise in science and to correctly define the actions that shape the problem and task statement.

For a problem to serve its purpose, it must be correctly formulated. For this, the specialist must be at the forefront of science and clearly understand what humanity already knows and what is truly unknown, what needs to be investigated. To properly formulate a scientific problem, a broad worldview is necessary. It's no coincidence that scientists argue that a properly stated problem is already half-solved.

A competent problem formulation involves the following groups of actions:

1. Problem formulation, which includes the central question of the problem, contradiction (fixing the contradiction that underlies the problem), and finalization (a probable description of the expected result).

2. Problem construction, involving stratification (breaking the problem into sub-questions, without which the main question cannot be answered), composition (grouping and determining the sequence for solving sub-questions), localization (limiting the study field according to research needs and the researcher's capabilities, distinguishing the known from the unknown in the selected area), and variation

(developing an approach to replace any problem question with another and finding alternatives for all problem elements).

3. Problem evaluation, which includes actions such as codification (identifying all conditions necessary for solving the problem, including methods, tools, techniques, etc.), inventory (checking available capabilities and prerequisites), cognition (determining the degree of problematicness, i.e., the balance between the known and unknown in the information required to solve the problem), analogy (finding analogous problems already solved), and qualification (classifying the problem within a specific type).

4. Justification, which involves the systematic realization of exposition (establishing value, content, and genetic links between this problem and other problems), actualization (presenting arguments for the reality of the problem, its formulation, and solution), compromisation (raising any number of objections against the problem), and demonstration (objective synthesis of results obtained during actualization and compromisation).

5. Designation, which consists of explication (clarification of concepts), recoding (translating the problem into another scientific or everyday language), and intimacy of concepts (subtle verbal differentiation – slight shifts in the expression of the problem and selecting concepts that most accurately capture its meaning).

Studying problems across various sciences reveals three levels of problem formulation:

- A common situation where, after defining the central question, little attention is paid to further elaboration of the problem. This is the lower intuitive form of problem formulation.
- Problem formulation according to the outlined rules but without full understanding of their meaning or necessity for adherence. It should be emphasized that all operations are not always fully realized by one specialist. However, each of

them is represented in some form in actual scientific problems. This forms the basis for procedural search.

- Conscious use of all procedures and operations within them.

Depending on how they arise, all false problems can be divided into two classes:

- Extrascientific false problems, whose causes lie outside of science. These arise due to worldview, methodological, ideological, and other misconceptions.
- Intrascientific problems, whose causes are rooted in the process of cognition, its achievements, and difficulties.

From a practical standpoint, the key task is developing criteria for distinguishing between real and false problems, as well as methodologies for their recognition. A dialectical approach allows the formulation of a series of criteria (existence, adequacy, necessity, prerequisites, continuity, solvability, verifiability, truth, etc.), which enable the reliable separation of true scientific problems from false ones. The absence of systemic thinking also leads to the appearance of false problems.

In contemporary times, it has become fundamentally important to study the general conditions that reduce errors in the work of specialists dealing with problem knowledge. Problem analysis allows for the correct and clear formulation of the problem for which the system is being created. In some cases, this leads to the negative conclusion that no problem exists and the system is unnecessary, which is still useful. In other cases, such research leads to the conclusion that the problem was initially formulated incorrectly, that it lies elsewhere, and consequently, the functions and structure of the envisioned system must be different.

The joint use of systems analysis and intuitive assessments of the relative importance of problems and evaluations of their effectiveness already yields tangible practical results, certainly better than traditional methods of calculating economic efficiency or cumbersome operations research methods.

Key terms and definitions: problem, problem choice, solution, level, scientific problem, false problem, problem analysis.

Questions for assessment:

1. What problem should be chosen for solving?
2. How should the problem be formulated for correct resolution?
3. What actions does a competent problem formulation involve?
4. What is the benefit of carrying out the above-mentioned actions?
5. Based on their origin, all false problems can be divided into two classes. Describe them.
6. What does problem analysis enable?

7.3 Hypothesis – theoretical stage of researching the problem

The formulation of a hypothesis follows the setting of the problem. The theoretical stage of cognition begins with the hypothesis.

A hypothesis (from Greek *hypothesis* - foundation, assumption) is a probabilistic assumption about the cause of certain phenomena, the validity of which cannot be verified and proven with the current state of production and science, but which explains these phenomena that would otherwise remain unexplained; it is one of the methods of cognitive activity.

It is known that when defining a concept through the nearest genus and species difference, one must point out the essential features that distinguish this species from other species within the same genus.

The nearest genus for the hypothesis as a result of cognitive activity is the concept of "assumption." What, then, is the specific distinction of this type of assumption – the hypothesis – from other types of assumption, such as guesses, fantasies, or postulations?

These essential characteristics are enough to distinguish the hypothesis from other types of assumptions and define its essence.

A hypothesis represents a system of concepts, judgments, and conclusions. Unlike them, its structure is complex and synthetic. No single concept, judgment, or conclusion by itself constitutes a hypothesis. The basis of a hypothesis is a collection of facts or substantiated statements on which the assumption is based.

The form of a hypothesis is a collection of conclusions that lead from the basis of the hypothesis to the main assumption.

An assumption (or hypothesis in a narrow sense) is a conclusion drawn from facts and statements that justify the hypothesis.

There are scientific and working hypotheses.

A scientific hypothesis is one that explains the regularities of the development of phenomena in nature, society and thought.

A working hypothesis is a temporary assumption or postulation used when constructing the hypothesis. Working hypotheses are typically proposed in the early stages of research. They do not aim to uncover the actual causes of the phenomena being studied but serve as conditional assumptions that allow for grouping and systematizing the results of observations and provide a consistent description of phenomena in line with these observations. Working hypotheses are successfully used, particularly in sociology.

A hypothesis represents the process of thought development. It is impossible to provide a general template for constructing a hypothesis for all situations. This is because the conditions for developing a hypothesis depend on the peculiarities of practical activity as well as the specificity of the problem being considered.

However, the general stages through which the thought process in a hypothesis passes can be defined.

Proposing a Hypothesis. To propose a hypothesis, one must have a collection of facts related to the observed phenomenon that justifies the likelihood of a certain assumption, explaining the unknown. Therefore, constructing a hypothesis primarily involves gathering facts that relate to the phenomenon being explained and do not coincide with existing explanations.

Based on the collected facts, a suggestion is made about what the studied phenomenon represents, i.e., the hypothesis is formulated in a narrow sense. The assumption in the hypothesis is a judgment (or a system of judgments). It is stated as a result of the logical processing of the collected facts. The facts on which the hypothesis is based can be logically interpreted in the form of analogy, induction, or deduction. Proposing the assumption constitutes the main content of the hypothesis. The assumption is the answer to the question about the essence, cause, and connections of the observed phenomenon. The assumption embodies the knowledge gained through the generalization of facts.

The assumption is the core of the hypothesis, around which all cognitive and practical activities revolve. The assumption in the hypothesis is, on one hand, the result of preceding knowledge, the main point reached through observation and generalization of facts; on the other hand, it is the starting point for further study of the phenomenon, indicating the path for knowledge and defining the direction in which the research should proceed. A hypothesis allows not only for the explanation of existing facts but also for the discovery of new facts that had not previously been considered.

Development of the Hypothesis. The development of the hypothesis involves deriving logical consequences from the hypothesis. Assuming the proposed proposition is true, a series of consequences is deduced, which must exist if the presumed cause exists.

Direct proof (or refutation) of the hypothesis proceeds through the confirmation or denial of the logical consequences deduced from newly discovered facts. The logical process of deriving consequences from the proposed assumption and justifying the truth or falsity of the hypothesis often occurs in the form of a conditional-categorical conclusion. From the assumed cause A, consequence B is deduced. Logically, this is expressed in the judgment: "If A exists, then B exists." Then, consequence B is tested in practice to see if it exists. If consequence B does not exist and cannot exist, then according to the rules of conditional-categorical reasoning, the absence of consequence leads to the conclusion that the presumed cause A also does not exist, i.e., the hypothesis is false. In addition to conditional-categorical conclusions, categorical syllogism, and other logical forms are also used.

Thus, the hypothesis is an essential form of the development of scientific knowledge, without which it is impossible to move to new knowledge. The hypothesis plays a crucial role in the development of science and serves as the initial stage in the formation of almost every scientific theory. All significant discoveries in science did not arise fully formed but went through a long and complex development process, starting from initial hypothetical propositions that acted as the guiding idea of the research and developing on this factual basis into a scientific theory.

Conclusions for Chapter 7:

1. Any scientific research is, by its nature, problem-oriented and consists of a chain of problems that are solved one after another, constantly emerging and resolving under new conditions and at new stages of cognitive development.

2. The hypothesis is a necessary form of the development of scientific knowledge, without which the transition to new knowledge is impossible. The hypothesis plays a key role in the development of science, serving as the initial stage in forming almost every scientific theory. All significant scientific discoveries did not appear fully formed but went through a lengthy and complex developmental process,

starting with initial hypothetical propositions that guided the research and evolving from these factual bases into scientific theories.

Keywords and definitions: hypothesis, stage, research, problem, stage of cognition, general hypothesis, specific hypothesis, scientific hypothesis, working hypothesis.

Questions for assessment:

1. Where does the theoretical stage of cognition begin?
2. What is a hypothesis?
3. What is the specificity of a hypothesis?
4. What constitutes the basis of a hypothesis?
5. What does a scientific hypothesis explain?
6. Define a working hypothesis.
7. Why is the assumption the core of a hypothesis?
8. What is the development of a hypothesis connected to?

8 THEORETICAL AND EXPERIMENTAL RESEARCH IN ENGINEERING

8.1 Methods and features of theoretical research

Analytical research methods are used to investigate physical models that describe functional relationships within or outside an object. They help establish mathematical dependencies between the model's parameters. These methods allow for a deep investigation of the object and the establishment of precise quantitative relationships between arguments and functions.

Analytical Methods with the Use of Experiments. Any physical process can be studied analytically or experimentally. Analytical dependencies are mathematical models of physical processes, which can be represented as equations, systems of equations, functions, etc.

However, mathematical models have serious disadvantages:

1. Establishing boundary conditions is necessary for conducting a reliable experiment. An error in their definition leads to alterations in the studied process.

2. It is often difficult or even impossible to find analytical expressions that reflect the studied process.

3. Simplification of the mathematical model (assumptions) distorts the physical essence of the process.

Experimental methods of research allow for a deeper and more detailed study of the process. However, the results of an experiment cannot be transferred to another process with similar physical properties. This is because the results of any experiment reflect the individual characteristics of the specific process under study. From an experiment, it is also impossible to determine which factors have the most significant influence on the process when various parameters are changed simultaneously. This means that each specific process must be studied independently in experimental research. Experimental methods allow for establishing partial dependencies between variables within strictly defined intervals of change.

Thus, analytical and experimental methods have their advantages and disadvantages, making the solution of practical tasks more difficult. Therefore, combining the strengths of both methods is promising and interesting.

Probabilistic-Statistical Research Methods. When using these methods, mathematical tools are applied. A probabilistic process is a process in which the characteristics or state of a system change over time under the influence of random factors.

System Analysis Methods. System analysis is a set of methods and techniques used to study complex objects or systems, which are composed of interacting elements. The essence of system analysis is identifying the relationships between system elements and determining their influence on the system's overall behavior.

System analysis typically consists of four stages:

1. Problem Statement. This step defines the goals, objectives, and criteria for studying the process. This is a very important stage. An incorrect or incomplete problem statement can nullify all subsequent work.

2. Defining the System's Boundaries and Structure. All objects and processes related to the goal are divided into two categories: the system itself and the external environment. Closed and open systems are distinguished. In a closed system, external environmental influence can be neglected. The system's structural parts are then identified, and the interactions between them and the external environment are determined.

3. Mathematical Model Construction. First, the parameters of the system's elements are determined, and then a suitable mathematical tool (linear programming, set theory, etc.) is used.

4. Theoretical Research. The primary goals of any theoretical research are:

   - Generalization of the results of all previous studies and finding common patterns by processing and interpreting these results and experimental data;
   - Studying an object that cannot be directly investigated;
   - Extending the results of previous studies to similar objects without repeating the entire study;
   - Increasing the reliability of the experimental research object.

Theoretical research begins with the development of a working hypothesis and modeling of the research object, and it ends with the formation of a theory. The development of the theory progresses from quantitative measurement of the object's parameters and qualitative explanation of the processes to their formalization in the form of methods, rules, or mathematical equations.

Any model is based on assumptions made to exclude insignificant factors that can be neglected without significantly distorting the task's conditions. The researcher must clearly understand the correspondence between the adopted model and the real object, as unjustified assumptions may lead to severe errors in research. However, considering too many factors influencing the object can result in complex analytical dependencies that are difficult to analyze.

In technical sciences, theoretical research typically aims at the mathematical formalization of the hypotheses and conclusions using various mathematical methods. A mathematical model is a system of mathematical relationships (functions, equations, formulas, systems of equations) describing certain aspects of the studied object.

Key terms and definitions: method, theoretical research, analytical method, mathematical model, physical process, experimental method.

Questions for assessment:

1. What are analytical methods used for?
2. In what form can a mathematical model of physical processes be represented?
3. What do experimental research methods allow?
4. What are the disadvantages of the experimental method?
5. What is the essence of the probabilistic-statistical method?
6. What do system analysis methods represent?
7. What marks the beginning and conclusion of theoretical research?
8. What is the basis for creating any model?

8.2 Structure and Models of Theoretical Research

Theoretical knowledge is the general principles formulated for a particular scientific field, which allow for the explanation of previously discovered facts and empirical patterns, as well as the prediction and anticipation of future events and facts.

Theoretical knowledge transforms results obtained during the empirical stage of cognition into deeper generalizations, revealing the essence of phenomena, the patterns of their occurrence, development, and changes in the studied object.

Theoretical research begins with a search. It is determined which concept, theory, or subject area can unite and consolidate all or most of the empirical results obtained. Often, some results do not fit into the overall framework and have to be discarded. However, sometimes it turns out that some necessary empirical results are missing, and the empirical part of the study should be continued.

Once the subject area is defined by the researcher, the process of building the logical structure of the theory, concept, etc., begins.

The process of constructing a logical structure consists of two stages.

The first stage is *induction* – ascending from the concrete to the abstract. The researcher must identify the central, system-forming element of the theory: the concept, a system of axioms or axiomatic requirements, or a unified methodological approach, etc.

At the induction stage, the researcher inventories all available results and anything that may be of interest. They begin grouping these by specific classification grounds into primary generalizations, then second-order generalizations, and so on. This inductive process – abstraction – ascends from the concrete to the abstract, until all results are summarized into the author's concept, a concise (5-7 lines) but comprehensive formulation reflecting the essence of the theoretical work and the accumulated results.

The next stage is the *deductive process,* or concretization – ascending from the abstract to the concrete.

At this stage, the formulation of the concept evolves into a set of factors, conditions, principles, models, mechanisms, theorems, etc. Sometimes, when the research problem is divided into several relatively independent aspects, the concept develops into several conceptual statements, which then develop further into a set of principles, etc. Principles can also develop into classes of models, types of tasks, and so on.

Only a properly and reasonably chosen methodology guarantees the reliability of the results obtained in research. Therefore, an important stage in research and development is the development of the research methodology. The methodology should include both theoretical and experimental research.

Usually, theoretical research is carried out using modeling methods, i.e., studying a phenomenon with the help of a model. A *model* is an artificial system that reflects the main properties of the studied object, i.e., the original.

In mathematical modeling, the physics of phenomena may vary, but the mathematical dependencies are the same. In physical modeling, the physics of phenomena in both the object and the model, as well as their mathematical dependencies, are the same.

Mathematical modeling is often used to study complex processes. When building a model, the studied object and its properties are usually simplified. However, it should be kept in mind that the closer the model is to the original, the closer the results of theoretical research will be to the actual results.

Models can be physical, mathematical, or natural.

Physical models allow for a visual representation of the processes occurring in nature and the investigation of the influence of individual parameters on their properties.

Mathematical models allow for the quantitative use of phenomena that are difficult to study with physical models.

Natural models are scaled versions of objects and allow for the most complete study of processes occurring under natural conditions.

A model should reflect the essential phenomena of the process and be optimal. Excessive detail complicates the model and makes theoretical research more cumbersome. However, an overly simplified model does not provide the required adequacy and accuracy. A phenomenon can only be fully studied and analyzed if its model is represented by descriptions of its physical essence and has a mathematical form.

Key terms and definitions: structure, model, theoretical research, theoretical knowledge, empirical knowledge, logical structure, physical model.

Questions for assessment:

1. Define the concept of "theoretical knowledge."
2. There are differences between empirical and theoretical knowledge. Provide an example.
3. How does theoretical research begin, and how does it continue?
4. When does the process of constructing the logical structure of a theory begin?
5. Why is the correctly chosen research methodology an important stage of R&D?
6. Describe the logical structure of theoretical research.
7. What is a "model"?
8. What types of models are there?
9. What do physical, mathematical, and natural models allow for?
10. What should a model reflect?

8.3 General information about experimental research

An experiment is a crucial component of scientific research, based on a scientifically designed experience with precisely controlled and measurable conditions. In scientific language and research work, the term *experiment* is usually used in a broad sense, encompassing a range of related concepts: purposeful observation, reproduction of the object of study, experience, organization of special conditions for its existence, and testing of predictions. This concept involves the scientific setup of experiments and the observation of the phenomenon under precisely controlled conditions, allowing for the tracking of its development and its reproduction whenever these conditions are repeated. The term "experiment" itself refers to actions aimed at creating conditions to reproduce a certain phenomenon as cleanly as possible, i.e., not complicated by other phenomena.

The main goal of the experiment is to identify the properties of the studied objects, test the validity of hypotheses, and, based on this, conduct a broad and deep investigation into the topic of scientific research. The design and organization of the experiment are determined by its purpose. Experiments conducted in various branches of science are sector-specific and have corresponding names: physical, chemical, technical, biological, social, psychological, and so on.

Experiments vary based on:

- research objectives (descriptive, transformative, exploratory, problem-solving, controlling);
- method of condition formation (natural and artificial);
- structure of studied objects and phenomena (simple, complex);
- organization of conduct (laboratory, natural, field, production, etc.);
- type of external influence on the research object (material, energetic, informational);

- interaction of experimental research tools with the object (standard and model-based);
- type of models studied in the experiment (material and conceptual);
- number of variable factors (single-factor and multi-factor);
- controlled quantities (passive and active);
- nature of the studied objects or phenomena (technological, sociometric, etc.).

Other criteria may also be used for classifying experiments.

Natural experiment assumes experiments conducted under the natural conditions of the research object's existence (most commonly used in technical, biological, social, educational, and psychological sciences).

Artificial experiment involves the creation of artificial conditions (widely used in technical and natural sciences).

Controlling experiment focuses on controlling the results of external influences on the research object, considering its state, the nature of the influence, and the expected effect.

Laboratory experiment is conducted in a controlled lab environment using special modeling devices, standard instruments, stands, equipment, etc. In laboratory experiments, the object is often not directly studied, but rather a sample (model) of it. This experiment allows for a precise and repeatable study of the effects of varying certain characteristics while controlling others, providing valuable scientific information with minimal time and resource expenditure. However, such experiments may not always fully replicate the real process, necessitating the need for natural experiments.

Natural experiment is carried out in natural conditions and on real objects. This type of experiment is often used during the field testing of systems. Depending on where the tests are conducted, natural experiments are classified into production, polygon, field, semi-natural, and so on. Natural experiments always require careful planning and a rational choice of research methods.

The difference in experimental tools used for modeling allows for the classification into conceptual and material experiments.

Model experiment differs from the classical approach in that it involves a model of the research object. The model is part of the experimental setup, replacing not only the object of study but often the conditions under which the object is studied.

Computational experiment refers to the methodology and technology of research based on applied mathematics and electronic computing machines as a technical base for using mathematical models. It is based on the creation of mathematical models of studied objects, which are constructed using a special mathematical structure capable of reflecting the properties of the object under different experimental conditions.

Mathematical structures serve as models of the studied object and reflect, in mathematical form, the dependencies, relationships, and laws that exist objectively in nature.

Each computational experiment is based on a mathematical model built using computational mathematics techniques. With the rapid development of electronic computing, modern computational mathematics, consisting of many fields, has also evolved. For example, discrete analysis, which recently emerged, enables obtaining any numerical result solely through arithmetic and logical operations. Here, the task of mathematics is reduced to presenting solutions (often approximate) in the form of a sequence of arithmetic operations, i.e., an algorithm for solving.

In conclusion, to conduct any type of experiment, the following steps are necessary:

- formulate the hypothesis to be tested.
- develop experimental work programs.

- determine methods and techniques for intervening with the research object.
- provide conditions for conducting the experimental procedure.
- develop methods and techniques for recording the course and results of the experiment.
- prepare the experimental tools (models, setups, instruments, etc.).
- provide necessary supporting personnel for the experiment.

Key terms and definitions: experiment, experimental research, scientific language, natural experiment, artificial experiment.

Questions for assessment:

1. What is at the core of an experiment?
2. In what meanings is the term "experiment" used in scientific language?
3. What is the main goal of an experiment?
4. On what criteria are experiments differentiated?
5. What do natural and artificial experiments imply?
6. In what conditions and on which objects are laboratory and natural experiments conducted?
7. What is the main scientific challenge of a natural experiment?
8. What phenomena and objects are studied in a complex experiment?
9. What other types of experiments exist?

8.4. Methodology and Planning of Experiments

The correct development of the experiment methodology is of particular importance. *Methodology* refers to the set of mental and physical operations arranged in a specific sequence to achieve the research goal. When developing the methodology for conducting an experiment, the following aspects must be considered:

- conducting preliminary targeted observations of the studied object or phenomenon to determine its initial data (selection of varying factors, hypotheses);
- creating optimal conditions in which experimentation is possible (selecting objects for experimental influence, eliminating random factors);
- systematic observation of the development of the phenomenon being studied and accurate descriptions of facts;
- determining the limits of measurements;
- conducting systematic registration of measurements and evaluations of facts using different methods and tools;
- creating cross-effects, recurring situations, changing conditions, and their nature;
- creating complicated situations to confirm or refute previously obtained data;
- transitioning from empirical study to logical generalizations, analysis, and theoretical processing of the obtained factual material.

A well-developed methodology for experimental research determines its value. Therefore, the development, selection, and definition of methodology must be carried out with particular care.

The researcher, when choosing the methodology of the experiment, should ensure its practical suitability.

The methodology elaborates in detail the process of conducting the experiment, composing the sequence of observations and measurement operations, and describing each operation separately, taking into account the selected tools for conducting the experiment. It also justifies the methods for controlling the quality of operations, ensuring the required accuracy and high reliability of the measurements with a minimal (previously established) number of measurements.

Equally important is the choice of methods for processing and analyzing experimental data. Data processing involves systematizing all the figures and classifying and analyzing them. The results of experiments should be presented in graphs, formulas, and tables, allowing for qualitative and quick comparisons and analyses of the obtained results. All variables should be evaluated in a unified system of physical measurement units.

Special attention in the methodology should be given to mathematical methods for processing and analyzing data, such as approximation of relationships between varying characteristics, establishing empirical dependencies, and determining various criteria. The range of sensitivity or insensitivity of the criteria should be stabilized.

When developing the experimental plan program, one should always aim to simplify it without losing reliability and accuracy. Recently, researchers have increasingly applied the mathematical theory of experiments, which allows for significantly reducing the volume of work and increasing the precision of the research. In this case, the methodology of the experiment includes stages such as developing the planned program, evaluating measurements and selecting tools for conducting the experiment, mathematical planning of the experiment with simultaneous execution, and processing and analyzing the obtained data.

Thus, the methodology of the experiment is a system of various methods or techniques for conducting the experiment in the most efficient and sequential manner.

Every experimenter must create a plan or program for conducting the experiment, which includes:

- setting the goal and tasks of the experiment;
- justifying the scope of the experiment and the number of trials;
- selecting varying factors;
- determining the sequence of changes in the factors;
- defining the order of the trials;

- choosing the step size for changing the factors, setting intervals between future experimental points;
- describing the conduct of the experiment;
- justifying the measurement tools;
- justifying the methods for processing and analyzing the experimental results.

In addition to the points mentioned above, the experimental plan includes: the research topic name, working hypothesis, methodology of the experiment, a list of necessary materials, instruments, and setups, a list of performers, a calendar plan, and an estimate.

Thus, conducting an experiment is the most crucial and labor-intensive stage.

Several stages of planning an experiment can be highlighted:

- collecting and analyzing the collected information;
- selecting input and output variables, and the areas for experimentation;
- choosing a mathematical model to represent the experimental data;
- planning the experiment and selecting the optimization criterion;
- analyzing the data and determining the method;
- conducting the experiment;
- checking the statistical assumptions for the obtained experimental data;
- processing the obtained results;
- interpreting and making recommendations for using the results.

During the collection and analysis of the gathered and processed information, all known data about the studied process or object are established and analyzed, such as which factors influence the state of the process or object, their interrelation, possible limits of variation, and so on.

The main requirements for selecting input factors are the ability to establish the desired value for the factor and maintain it throughout the experiment.

Often, the goal of research is process optimization, i.e., determining the input parameter values at which the output parameter reaches its maximum or minimum value.

Two main approaches are identified in solving this task: theoretical and empirical.

There is also an intermediate approach. In this approach, the outgoing model is theoretically presented, and the parameter values are calculated based on experimental data obtained while studying the object.

Key terms and definitions: methodology, planning, experiment, methodology process, mathematical theory of the experiment, program, journal, stage.

Questions for assessment:

1. What should be considered when developing the methodology?
2. What processes of conducting the experiment are detailed in the methodology?
3. What should be given special attention to the methodology?
4. Why have researchers increasingly applied the mathematical theory of experiments recently? What does this allow?
5. What does the experimental plan include?
6. List the stages of planning an experiment.
7. Factors can be qualitative or quantitative. Describe them.
8. What does the choice of research model depend on?

Conclusions of Chapter 8

1. To conduct any type of experiment, it is necessary to: formulate a hypothesis to be tested, create an experimental work program, determine methods and techniques of intervention in the object of study, provide conditions for the experiment, develop ways and methods for documenting the experiment's progress

and results, prepare experimental tools (models, setups, instruments, etc.), and ensure the necessary support staff.

2. An essential factor for the success of scientific research is metrological support, especially ensuring the unity of measurements and uniformity of measuring tools. In long-term experiments, it is recommended to periodically discuss them with a scientific team to adjust the course of the experiment in a timely manner.

Key terms and definitions: organization, workplace, experimenter, working space

Questions for assessment:

1. Define the term “experimenter's workplace.”
2. What is referred to as working space?
3. What constitutes a laboratory?
4. How is the workplace equipped in a stationary laboratory?
5. What should the equipment of a mobile laboratory be like?
6. What work does the experimenter perform in the laboratory?

9 TYPES OF ACADEMIC AND SCIENTIFIC RESEARCH WORKS

The spectrum of academic and scientific research works is quite broad. These include reports, theses, term papers, final qualification papers, and dissertations. They differ in volume, objectives, the presence or absence of empirical experiments, etc. At the same time, they share many similarities and require certain skills and critical thinking from the researcher. Below are some aspects of the similarities and differences of certain types of research works.

9.1 Report

A report is a type of independent work that contributes to the development of research skills broadens cognitive interests and fosters critical thinking. Preparing a report can be challenging for many. To avoid difficulties, it is necessary to follow some recommendations:

- define the purpose of the report;
- clearly formulate the topic, as the title serves several functions (suggests an idea, attracts attention, intrigues, introduces the problem, etc.);
- a poorly formulated topic is overly wordy, unmemorable, unclear, unattractive, cliché, and lacks novelty. The title should include a key concept that carries the main idea. Understanding a new concept begins with its definition and analysis of various interpretations and theories. This process guides the direction of the report and forms the basis for questions in the presentation plan.

When writing a report, it is necessary to:

- develop a plan (a strategic “bridge” to the goal);
- highlight the core idea for each point of the plan and formulate it as a thesis that needs to be substantiated and proven;
- collect facts and arguments to support each core idea (make clear notes on separate sheets and always cite sources);
- structure the material logically;
- consider the intellectual and psychosocial characteristics of the audience;
- pay attention to the emotional aspect of the material.

Types of reports by form and content:

- *theoretical* (usually presented at scientific conferences);
- *thematic* (presented at meetings, practical conferences, seminars);
- *summary* on completed practical work;

- *presentation report* aimed at presenting the results of term papers, theses, or dissertations.

The material should be presented logically, focusing on the goals, objectives, and hypotheses of the research. Arguments should be built with references to authoritative opinions, while also including personal judgments and conclusions.

The conclusion of the report includes summarizing findings, making recommendations, identifying future research tasks, expressing gratitude for attention, and acknowledging the research supervisor and others who assisted in the research process.

Keywords and definitions: report, report functions, theoretical report, thematic report, report-summary, presentation report, argumentation.

Questions for assessment:

1. What are the functions of a report?
2. What steps should be taken when writing a report?
3. What are the requirements for a report?
4. List the different types of reports by form and content.
5. What is essential when constructing arguments in a report?
6. Provide examples of introductory words and phrases that can be used in a report.
7. How should a report be concluded?

9.2 Abstract

A more complex type of research work than a term paper is an abstract.

An abstract (from the Latin *refero* – to report) is a brief written summary of the content of scientific work(s) or literature on a topic, where the author reveals the essence of the researched problem, presents various viewpoints, and offers their own perspective.

Stages of Working on an Abstract:

- formulating the topic (it should be relevant, original, and interesting);
- selecting and studying key sources (at least 8-10 sources are required);
- compiling a bibliography;
- processing and systematizing information;
- developing a plan for the abstract;
- writing the abstract (and preparing theses for public presentation if necessary).

Approximate Structure of an Abstract:

- *Title page:* institution name, the word "Abstract," topic title, author and supervisor details, city, and year.
- *Table of contents:* sequential list of sections with page numbers.
- *Introduction:* problem statement, justification of the topic choice, significance, objectives, and literature overview.
- *Main part:* divided into sections logically following one another, including graphs, tables, and diagrams.
- *Conclusion:* summary of findings and recommendations.
- *List of Reference.*

Keywords and definitions: abstract, term paper, stage, structure, requirement, evaluation criteria.

Questions for assessment:

1. Why is an abstract more complex than a term paper?
2. What is an abstract?
3. Outline the stages of working on an abstract.
4. Describe the approximate structure of an abstract.
5. State the criteria for evaluating an abstract.

9.3 Term Paper

A term paper is a deeper and more extensive study of a course topic compared to an abstract, report, or term paper. It must meet specific requirements.

Depending on its purpose, a term paper can be theoretical, practical, or experimental. The purpose usually determines the structure:

- *theoretical* term papers include a history of the issue, level of development in theory and practice, and comparative analysis of literature;
- *practical* term papers have two main sections: theoretical foundations and practical materials (calculations, methods, graphs, tables, illustrations, etc.);
- *experimental* term papers involve empirical research, analysis of results, and practical recommendations, including methods, stages, and data analysis.

Structure of a Term Paper:

Title page, table of contents, introduction, main part, conclusion, references, and appendices.

The paper should be 15-20 printed pages or 20-25 handwritten pages (excluding appendices).

Evaluation Criteria:

- relevance of the topic;
- content accuracy;
- depth of research;
- completeness of analysis;
- validity of empirical data;
- practical significance;
- proper formatting.

Keywords and definitions: term paper, purpose, practical, experimental, structure, volume, evaluation criteria.

Questions for assessment:

1. What is a term paper?
2. What types of term papers exist?
3. Describe the sections of a practical term paper.
4. What is required in an experimental term paper?
5. What are the components of a term paper's structure?
6. What is the required length of a term paper?
7. What are the evaluation criteria for a term paper?

9.4 Final Qualification Work

A final qualification work can have a practical, experimental, or, in some cases, theoretical nature, depending on the goal set by the author in the work.

A theoretical final qualification work consists of the following sections:

- *title page;*
- *table of contents;*
- *introduction,* which reveals the topic's relevance and significance and the work's key characteristics and formulates its goals and objectives;
- *main part,* where, based on an in-depth literature analysis, the content of the work is presented, including the history of the researched problem, its development in theory and practice, and justification from the perspective of the relevant scientific discipline;
- *conclusion,* containing conclusions and recommendations for further application of the theoretical research materials;
- *references;*
- *appendices.*

The structure of a *practical final qualification work* includes:

- *title page;*

- *table of contents;*
- *introduction, similar to the theoretical work, addresses* relevance, significance, goals, and objectives;
- *the main part is* divided into theoretical and practical sections. The theoretical section covers the theoretical foundations of the topic, analysis of various approaches, and the author's views. The practical section focuses on the design of tools, methods, programs, concepts, and models used in professional practice and their implementation and evaluation. This may include lessons, events, plans, and training sessions developed by the author and recommendations for their application;
- *conclusion,* where the author presents findings, results, and recommendations;
- *references;*
- *appendices.*

The final qualification work should be 30-50 pages long. In summary, the structure of any research work, whether an abstract, term paper, or final qualification work, is uniform, differing in the depth and scope of the research, methods used, and level of result analysis. All types of research work must follow specific rules and guidelines.

Chapter 9 Summary

1. A report develops research skills, cognitive interests, and critical thinking.

2. An abstract is a brief summary of scientific works or literature on a topic, presenting the essence of the problem, various viewpoints, and the author's perspective. Evaluation criteria include relevance, content accuracy, depth, proper use of sources, and correct formatting.

3. A term paper is a more in-depth study than a report or abstract, evaluated by relevance, content accuracy, depth, completeness, validity of empirical data, practical significance, and proper formatting.

4. A final qualification work can be practical, experimental, or theoretical, depending on the author’s goal.

Keywords and definitions: final qualification work, nature, section, theoretical plan, structure, dissertation research, research work.

Questions for assessment:

1. What types of final qualification works exist?
2. What determines the nature of a final qualification work?
3. What sections are included in a theoretical final qualification work?
4. What is the structure of a practical final qualification work?
5. How does an experimental final qualification work compare to a dissertation?
6. What rules and recommendations should be followed when conducting research work?

10 CONCEPT AND STRUCTURE OF A MASTER'S THESIS IN UKRAINE

10.1 Concept and features of a master's thesis

A Master's thesis is an independent scientific work with elements of scientific novelty designed to confirm the high level of a graduate, demonstrating their ability to solve complex practical and theoretical tasks. It is the final result of extensive scientific research conducted by a master's student, reflecting their acquired qualifications, research experience, problem-solving skills, proficiency in scientific and technical literature, and the ability to clearly express ideas and share knowledge with peers in the field.

A Master's thesis is prepared individually by the author and must contain new scientific results and statements for public defense. It should also propose directions for further research on the problem. As a scientific work, it must exhibit internal coherence and demonstrate the author's personal contribution to science.

A Master's thesis, as a scientific qualification work, has two key features:

1. *Formulation of a Hypothesis:* A hypothesis is a scientific assumption whose truth is not yet confirmed. It serves as a crucial method for scientific knowledge development. The master's student proposes how they intend to achieve the research objectives. The hypothesis may be refined, modified, or supplemented throughout the research process.

Including both positive and negative results in the thesis is essential, as this enhances its credibility and provides valuable insights for future researchers.

2. *Search for a Scientific Idea:* This creative process often involves generalizing existing results from published works or deeply analyzing specific cases of known general results. New theoretical findings are often preceded by extensive experimental studies, data collection, and analysis, leading to innovative solutions and technical advancements.

In modern science, new ideas or concepts rarely emerge from scratch; most new scientific results are outcomes of systematic development in specific directions.

Keywords and definitions: master's thesis, feature, hypothesis formulation, scientific idea, research.

Questions for assessment:

1. What is a Master's thesis?

2. How is a Master's thesis prepared, and what should it include?

3. What are the two key features of a Master's thesis as a scientific qualification work?

4. What is a hypothesis?

5. What is essential to consider when formulating a hypothesis and conducting research?

6. What advice can be given for finding a scientific idea?

10.2 Structure of a master's thesis in Ukraine

The structure of a Master's thesis in Ukraine follows the academic standards established by Ukrainian universities and consists of several key components.

The table of contents lists all thesis sections, including the introduction, chapters, subchapters, conclusion, references, appendices, and page numbers. It is included in the overall page count of the thesis.

The introduction explains the choice of the research topic, defines the aim and objectives, highlights the relevance and novelty of the research, and outlines the object and subject of the study. It also briefly presents the theoretical and practical significance of the research results and describes the structure and logic of the thesis.

Key Elements of the Introduction:

- *Relevance of the topic:* In Ukraine, the topic of a Master's thesis is not merely its title but the expected research outcome aimed at solving a specific academic or practical problem. Selecting a relevant topic is essential, as it determines the focus of the student's work and research efforts.
- *Research problem:* This refers to the gap between the current state of the studied system and its ideal state, considering the latest scientific advancements and practical applications. Identifying the problem involves analyzing the system's components and their interconnections and finding ways to address imbalances within the system through thorough research.

The main body is divided into chapters that include:

- *Literature review:* Analyzes existing research and theoretical foundations related to the topic.

- *Methodology:* Describes research methods and tools used to achieve the objectives.
- *Research findings:* Presents the results obtained during the research process.
- *Discussion:* Interprets the findings in relation to the research problem and existing literature.

The conclusion summarizes the main findings, evaluates whether the research objectives were achieved, and provides practical recommendations or directions for future research.

The list of References includes all sources used in the research, formatted according to Ukrainian academic standards (such as DSTU).

Appendices contain supplementary materials like data sets, tables, graphs, or other relevant documents supporting the research.

In Ukraine, a Master's thesis typically ranges from 60 to 100 pages, depending on the field of study and specific university requirements. It must reflect the student's ability to conduct independent research, analyze complex information, and contribute to the academic field.

Formulating a research problem is essentially the crystallization of the master's student's research idea. Therefore, its correct formulation is the key to the success of the entire work.

Steps for Formulating a Research Problem:

1. *Identify the research area:* Choose a broad subject area that aligns with your academic field and interests.
2. *Review existing literature:* Analyze current research to find gaps, unresolved issues, or areas needing further exploration.
3. *Narrow the focus:* Specify a particular aspect or question within the broader area you aim to investigate.

4. *Define the problem clearly:* State the problem precisely, explaining what needs to be solved or explored.

5. *Justify the problem:* Explain why this problem is significant, its relevance to the academic field, and its practical importance.

6. *Formulate research questions or hypotheses:* Develop questions that guide your study or hypotheses you will test through your research.

7. *Assess feasibility:* Ensure the problem can be addressed within your thesis's scope, time, and resources.

A well-formulated research problem sets a clear direction for the study and ensures coherence throughout the research process.

One of the important stages in clarifying the research problem is determining the degree of its development, analyzing various scientific viewpoints, identifying achievements, and uncovering “gaps” in the research of the chosen problem. This is done through the study of scientific literature. It is the first step a master's student should take, as it sets the algorithm for all subsequent actions and defines the purpose of undertaking the dissertation research.

In short, the parameters of the problem can be defined by answering the questions: “What?”, “Where?”, and “When?”. Only by answering these questions can the problem be formulated in a way that clearly defines the scope of the research tasks.

It is important to emphasize that the title of the problem should reflect its problematic perception, requiring extensive scientific investigation. Additionally, the title of the problem should correspond to the title of the dissertation itself.

Naturally, due to limited research experience, a master's student may lack the perspective, sense of relevance, and ability to express their thoughts correctly and concisely in academic terms. A research supervisor can help overcome these difficulties.

Other effective measures include:

- paying special attention to related fields of knowledge: sometimes, at the intersection of two scientific disciplines, one can find topics that seem overlooked by both fields but have research potential.
- referring to the catalog of already defended dissertations in a scientific library or at the department.
- reviewing scientific periodicals and specialized publications. the more literature you read in your scientific field, the easier it will be to navigate the research landscape.
- the methodological aspect of considering the problem is also significant. sometimes, changing the methodology or adopting a new perspective can become a research topic itself.

It is essential to note that all dissertations are written on relevant topics, as they address problems that have not been explored sufficiently. Students can effectively determine the study's relevance if they identify inconsistencies within the research subject.

After justifying the relevance of the dissertation topic, the next step is to define the research aim and objectives.

Keywords and definitions: structure, master's dissertation, content, introduction, dissertation topic, problem, scheme, problem perception, aim and objectives of the research.

Questions for assessment:

1. What does the content of a master's dissertation include?
2. What is justified in the introduction?
3. A dissertation topic is not just its title; what is it?
4. What is meant by a problem?
5. Outline a generalized scheme for solving the problem.

6. What does the “degree of development of the problem” mean?
7. Why should the title of the problem reflect its problematic perception?
8. List the requirements for defining a research topic.
9. When can you proceed to define the aim and objectives of the research?

10.3 Formulating the Aim and Objectives of the Research

The research aims to direct it towards its final result, which can be either theoretical-cognitive or practical-applied. The objectives pose the questions that need to be answered to achieve the aim of the research.

The aim and objectives form logically interconnected chains, where each link supports the others. The final aim of the research can be referred to as its general objective.

The identified problem should be reflected in the dissertation introduction's formulation of the research aim. The aim determines the research tactics, i.e., the sequence of specific research objectives through which the problem can be solved.

The solution to the problem constitutes the content of the dissertation. Initially, it is formulated as the main research hypothesis, a preliminary solution that needs to be tested and substantiated in the dissertation text.

Thus, the nature of the objective depends on the aim, and the aim depends on the clarity of the problem formulation. The aim implies solving the research problem, while the objectives determine various approaches to the overall research problem.

The object of scientific research is a specific element of reality with defined boundaries and relative autonomy of existence. The object generates the problematic situation and is chosen for study.

The subject of scientific research is a logical description of the object, defined by the researcher’s preference for a particular perspective, aspect, or specific manifestation of the observed reality segment.

The object and subject of research are related in general and specific ways. Only a part of the object, which serves as the subject of the study, is highlighted. The subject determines the dissertation topic, as stated on the title page.

Scientific results are new findings presented by the author for public defense, demonstrating their personal contribution to science. A scientific result is a fragment of the knowledge system and/or the effect of applying knowledge.

Scientific novelty indicates that the results obtained are presented for the first time, reflecting the study's originality. It confirms the author’s priority in the chosen dissertation topic.

Practical significance reflects the implementation of scientific novelty and justifies the necessity of the research, showing its potential for creating or improving something, thus achieving a certain effect.

Scientific Text of the Dissertation (Main Body)

This part of the dissertation presents scientifically substantiated and systematized research material corresponding to the set aims and objectives.

The number of chapters depends on the nature of the master's dissertation. There should be 3 or 4 chapters in the dissertation.

The first chapter usually includes a scientific review of various concepts, scientific approaches, and interrelations of system elements and methodological positions. The master's student briefly describes the stages of development of scientific views on the researched problem. During the scientific analysis of the literature, the student argues the merits of key scientific positions and factors influencing their development.

The first chapter is essentially the theoretical part of the dissertation and serves as a foundation for preparing the second (analytical) and third (practical) chapters.

In the second chapter, the student analyzes obtained experimental and computational data and other materials that justify the problem, support conclusions, and demonstrate the need to address the set objectives. This chapter also analyzes the state of the research field and argues the necessity of developing existing practices and methodologies for solving the identified tasks.

The third chapter presents developed methodological tools and algorithms that enable solving the set tasks and achieving the research aim. It justifies the implementation of models or methodological tools into practice.

The chapters should have an organic internal connection with the material presented logically. Each chapter may conclude with brief summaries synthesizing the main research results and providing specific data on significant findings.

Conclusion. The dissertation concludes with the final part summarizing the achievement of the research aim and completion of its objectives. It includes a summary of all information from the main body, scientific positions developed by the author, conclusions, and recommendations. The logic of the dissertation structure determines the order of presentation.

The conclusion also highlights key aspects of the practical application of the developed scientific and methodological positions and suggests directions for further research in the respective scientific field.

List of References. Following the conclusion is the list of references, which includes all literary sources used by the author during the research. Each source listed must be cited in the dissertation text. Encyclopedias, reference books, popular science books, and newspapers should not be included if they are not cited or used in the dissertation.

Chapter 10 Summary

1. In modern science, the emergence of entirely new ideas or concepts from scratch is rare. Most new scientific results are outcomes of the long-term development of scientific thought in a specific direction.

2. The content of a master's dissertation includes an introduction, titles of all chapters and sections, a conclusion, a list of references, and appendices.

3. The aim of the master's dissertation research directs it towards its final result, which can be either theoretical-cognitive or practical-applied. The aim and objectives form logically interconnected chains, where each link supports others and the final aim can be called the general objective.

Key terms and definitions: research aim and objectives, object of scientific research, subject of scientific research, scientific result, scientific novelty.

Questions for assessment:

1. What does the research aim direct? What types can it be?
2. What do the research objectives formulate?
3. What do the aims and objectives form together?
4. What determines the aim?
5. What do the aim and objectives imply?
6. Define the term "object of scientific research."
7. What is the subject of research?
8. What is a scientific result? What should it include?
9. What constitutes scientific novelty in a dissertation?
10. What is the practical significance of scientific research?
11. A dissertation should have 3 or 4 chapters. Name them.
12. The dissertation concludes with the final part. What results are presented in the conclusion?

11 PROBLEMS OF MAINTAINING ACADEMIC INTEGRITY IN THE LEARNING PROCESS

11.1 The Concept of Academic Integrity. Historical Aspect of the Approach to the Problem of Academic Dishonesty

11.1.1 Definition of Academic Integrity in the Context of Academic Culture.

11.1.2 Fundamental Values of Academic Integrity.

11.1.3 History of Academic Dishonesty and the Development of Punitive Measures for Unethical Behavior.

11.1.4 What is Considered Dishonest Behavior? The Problem of Students Identifying Their Own Actions as Dishonest.

11.1.5 Legislative Framework Regulating the Implementation of Academic Integrity Principles in Ukraine.

11.1.1 Definition of Academic Integrity in the Context of Academic Culture

The concept of academic integrity is implemented within the academic community and is closely linked to academic culture.

The term *academic community* refers to all individuals engaged in educational, pedagogical, and scientific activities (teachers, researchers, administrators, postgraduate students, doctoral candidates, and students). The term academic environment will also be used synonymously with the academic community.

Academic culture is a concept that characterizes the system of values, traditions, and moral-ethical norms of behavior functioning within a research institution or a higher education institution. In academic studies of this concept, two main approaches can be distinguished: social and intra-personal.

An example of the social approach is Hryhorii Khoruzhyi's characterization of academic culture as an integrated quality of the university community, manifested in collective activity methods and reflecting the level of development of an educational or research institution. The researcher emphasizes the historical conditionality of academic culture's specificity and the influence of the societal system on its formation. The social approach also forms the basis of the definition of academic honesty proposed by Tetiana Yaroshenko. She describes academic honesty as a "formed system of student behavioral stereotypes that express universal moral and ethical traditions in evaluating their knowledge. It reflects stable norms and relationships in such dichotomous connections as 'student-teacher,' 'student-student,' and 'student-university.'"[25].

Conversely, Olena Semenoh and her co-authors adopt an intra-personal understanding of academic culture, viewing it as an integrative phenomenon primarily realized within an individual's personality [25]. They highlight several key components of this phenomenon:

- Axiological (value-based),
- Motivational-ethical,
- Narrative-digital,
- Linguistic-communicative,
- Praxeological (activity-based),
- Behavioral-interactive.

The axiological and motivational-ethical components manifest in categories of professional duty, responsibility, academic honor, and respect.

The narrative-digital component relates to the ability to represent data through technical devices and virtual platforms.

The linguistic-communicative component is reflected in the appropriate and precise use of language in communicative situations related to scientific or educational tasks.

The praxeological and behavioral-interactive components are realized in academic literacy, encompassing knowledge, skills, and abilities based on critical thinking and communicative interaction techniques.

Academic culture inherently requires adherence to principles of integrity in teaching, research, and learning activities. The concept of academic integrity is clearly formulated and legally enshrined in modern Ukrainian legislation and in the regulatory documents of each higher education institution in Ukraine.

According to Article 42 of the Law of Ukraine "On Education", academic integrity is defined as follows:

"Academic integrity is a set of ethical principles and legally established rules that participants in the educational process must adhere to during learning, teaching, and scientific (creative) activities to ensure trust in learning outcomes and/or scientific (creative) achievements."[17]

In English discourse, the equivalent of "академічна доброчесність" is "academic integrity." Different research and educational institutions autonomously interpret and categorize this concept and often develop their own academic integrity codes.

However, the core meaning of academic integrity remains consistent across educational and scientific practices. For example, the website of the University of North Carolina defines it as:

"Academic integrity is the commitment to behave honestly and ethically in an academic environment and to demonstrate such behavior. At the university level, it involves respecting others when using their ideas. Simply put, it requires acknowledging others' contributions. Failure to do so is considered plagiarism."[19].

Thus, despite minor variations in the scope of the term "academic integrity," its meaning remains universally applicable in educational and scientific practices. Likewise, the fundamental values underpinning academic integrity remain universal.

11.1.2 Fundamental Values of Academic Integrity

The core moral and ethical values of both academic culture and academic integrity were outlined in the Bucharest Declaration of Ethical Values and Principles in Higher Education in Europe (2004):

"The key values of a conscientious academic community are honesty, trust, fairness, respect, responsibility, and accountability. These values are important in themselves and essential for ensuring the effectiveness and quality of teaching and research activities. [...] Intellectual freedom and social responsibility are fundamental values of research activities that must be respected and promoted. In the more open learning and knowledge production systems characteristic of the 21st century, these values should not conflict but reinforce each other."

A widely accepted declarative list of fundamental values of academic integrity was developed by the Office of Internal Relations at Oakton College, Des Plaines, Illinois, for the Center for Academic Integrity (now renamed the International Center for Academic Integrity). This list includes the following core values: honesty, trust, fairness, respect, responsibility, and courage.

Honesty is upheld in various aspects of learning, teaching, and research, as well as in providing different types of services under the directives of educational and research institutions.

Trust fosters and encourages the free exchange of ideas, contributing to scientific inquiry's fullest realization. It helps create a psychological climate that enables such open exchange.

Fairness in the relationships between students, faculty, and administration in educational institutions is reflected in establishing transparent and clear expectations, practices, and standards for academic activities within academic communities.

Respect is an essential component of interactions based on independent thoughts and perspectives on various processes and phenomena. Therefore, academic communities value **interactivity, cooperation, and collaboration** in learning and knowledge acquisition.

The personal responsibility of academic community members helps uphold commonly established standards and contributes to developing a shared policy for responding to violations.

Courage is necessary when defending integrity in the face of challenges. The ability of each academic community member to demonstrate determination, bravery, and commitment in combating violations of academic integrity standards is essential for the proper functioning of the entire system.

11.1.3 History of Academic Dishonesty and the Development of Punitive Measures for Unethical Behavior

Academic dishonesty has emerged in parallel with the formation of educational and scientific systems. Its history dates back to ancient times.

For example, in ancient China, cheating was common during examinations for candidates applying for civil service positions. Despite strict monitoring of both the candidates and examiners and the exams being held in sealed-off locations surrounded by high walls for three days, cheating still persisted. If a candidate died during the exam, their body was thrown over the wall. Examinees used various methods of deception, including crib notes, purchasing pre-written essays and answers, bribing exam staff, and engaging in unauthorized communication. Such offenses were severely punished – in 1858, five officials involved in an exam fraud scandal were executed.

Western education systems have also experienced periodic academic dishonesty scandals. In the 1860s, American society was shaken by a mass cheating scandal involving more than half of the students at Yale University.

Ukraine has not been immune to academic misconduct either. One notable example is the case of Ivan Puluj, a Ukrainian scientist whose discovery of X-rays was allegedly appropriated by Wilhelm Conrad Röntgen (this topic will be discussed in later sections).

Numerous academic fraud cases also marked the 20th century. For instance, Frank Spencer documented the case of Cyril Burt, a psychologist who studied intelligence in twins raised separately. His work was widely respected until, three years after he died in 1974, it was revealed that 33 of his reported cases were fabricated, and the research assistants he claimed had helped him never existed.

That same year, William Summerlin of the Sloan Kettering Institute falsified research on genetic inheritance in rats by drawing black spots on the test subjects with a marker. This scandal brought attention to academic research integrity's ethical and procedural aspects.

Another infamous case was Robert Fiddes, director of a research institute in Southern California in the 1990s. He conducted numerous clinical trials for pharmaceutical companies and was known for efficiently recruiting patients. However, an investigation revealed severe ethical violations:

- Patients who did not meet the criteria were included in studies.
- Some were pressured into participating.
- ECG and blood pressure readings were fabricated.
- Blood and urine samples were often taken from outsiders, some of whom were paid to provide them.

In 1997, Fiddes was found guilty of multiple legal violations and sentenced to 15 months in prison.

Academic dishonesty also became a national issue in the United States education reform. In 2002, President George W. Bush signed the "No Child Left Behind Act", which emphasized standardized testing. Poor student performance led to the dismissal of teachers and staff. As a result, in Atlanta (2008/2009), annual tests became a hotbed of mass cheating, involving over 170 teachers. Teachers even organized "cheating parties" in one school, gathering over pizza to correct students' answers before submitting them. Eventually, those involved faced various penalties – some were fired, while ten educators were imprisoned.

Even modern Ukraine has seen academic dishonesty scandals. In 2017, before the winter exam session, students at Vadym Hetman Kyiv National Economic University (KNEU) were caught buying crib notes on dormitory grounds. Photos of long queues for the notes went viral on social media and news outlets.

Academic dishonesty has a long history and a global scope, making it an important subject for study. To fully understand the phenomenon – its causes, consequences, and prevention methods – it is crucial to assess university students' awareness of academic integrity principles.

11.1.4 What is Considered Dishonest Behavior? The Problem of Students Identifying Their Own Actions as Dishonest

Cecilia Partner, in her review of academic dishonesty research [7], considers Charles Drake's 1941 work *Why Students Cheat* as the starting point. According to Drake, student dishonesty can be seen as a rebellious reaction to excessively difficult coursework, the competitive nature of education, and an expression of dissatisfaction and indifference. His study found that 30 out of 126 female college students had cheated at least once by exchanging answers during exams, though top-performing students did not engage in such behavior. Drake believed cheating in educational practices could not be eradicated if the teacher-student relationship remained adversarial.

According to Partner, another key milestone in the study of student dishonesty is William Bowers' 1964 study *Academic Dishonesty and Its Impact in College*, which revealed correlations between cheating tendencies, historical context, and students' chosen fields of study. Bowers surveyed 5,000 students across 99 institutions and found that 66% admitted to engaging in dishonest practices, considering it a norm for their generation. His research highlighted a stark contrast between the expected response to academic pressure – integrity – and students' actual reaction – cheating. Bowers also found that students in career-oriented fields were more prone to dishonesty than those in liberal arts disciplines.

In their 1981 article Why Students Cheat, David Barnett and John Dalton emphasized differences in how students and faculty perceive academic dishonesty. Only 45% of students considered using others’ sentences without citation a violation of academic integrity, compared to 73% of faculty. Similarly, 63% of students saw obtaining exam answers in advance as cheating, compared to 73% of faculty. Less than half of the students surveyed viewed collaborating on individual assignments as academic dishonesty.

A 20-year longitudinal study by Donald McCabe and colleagues found that 82% of students admitted to committing or witnessing academic dishonesty in some form. However, students’ assessment of dishonest acts often differed significantly from faculty perceptions. For example, only 38% of students considered working together on take-home exams a serious violation of academic integrity, compared to 85% of faculty who strictly condemned such behavior.

Studies on perceptions of academic dishonesty have also been conducted in Ukraine. For instance, Pavlo Artyomov and Inna Pak presented their findings in the 2017 article *Academic Dishonesty as an Element of Academic Culture Among Ukrainian Students: Empirical Research Results*. Their conclusions were based on surveys conducted by the Eastern Ukrainian Social Research Fund in collaboration with V.N. Karazin Kharkiv National University, involving 1,928 students and 374 faculty members across 25 Ukrainian universities. Additional research by the Sociological Association of Ukraine, supported by the International Renaissance Foundation, included 32 focus group interviews with students and faculty from different Ukrainian cities.

Survey results indicated that 82% of faculty believed students took exams honestly, while over a third admitted to cheating. Downloading online coursework was common practice by 60% of students and 75% of faculty. Among students, 50% recognized plagiarism as theft, 48% saw it as unfair to their peers, and 45% agreed that plagiarists become incompetent professionals. Notably, faculty respondents agreed with these statements at a significantly higher rate.

Thus, in international and Ukrainian higher education institutions, students' violations of academic integrity often stem from a lack of awareness regarding what constitutes dishonesty. This highlights the need for faculty-led educational initiatives to clarify the principles of academic integrity. Explaining the nature and forms of dishonesty and applicable sanctions is a key objective of the *Academic Integrity* course.

11.1.5 Legislative Framework Regulating the Implementation of Academic Integrity Principles in Ukraine

One of the key laws that lays the legal foundations for implementing the concept of academic integrity is the Law of Ukraine "On Education" (adopted on September 5, 2017, came into effect on September 28, 2017). It "regulates public relations arising in the process of exercising the constitutional right to education, the rights and obligations of individuals and legal entities participating in the realization of this right, as well as determines the competence of state bodies and local government bodies in the field of education" [17].

Article 42 of this law is dedicated to academic integrity.

"3. Compliance with academic integrity by education seekers includes:

- independent completion of educational tasks, current and final assessment of learning outcomes (for individuals with special educational needs, this requirement is applied considering their individual needs and abilities);

- referencing sources of information when using ideas, developments, claims, or information;
- compliance with copyright and related rights laws;
- providing truthful information about the results of one's own educational (scientific, creative) activity, used research methods, and sources of information" [17].

Article 42 of the Law "On Education" also provides responsibility for non-compliance with the law's provisions.

"6. For violations of academic integrity, education seekers may be subject to the following academic responsibilities:

- retaking assessments (tests, exams, credits, etc.);
- retaking the corresponding educational component of the educational program;
- expulsion from the educational institution (except for individuals obtaining general secondary education);
- deprivation of academic scholarship;
- deprivation of benefits for tuition fees provided by the educational institution" [17].

Aspects of dishonesty related to the problem of plagiarism in scientific texts are regulated by the Law of Ukraine "On Copyright and Related Rights" provisions dated December 23, 1993, No. 3792-XII.

In addition, the regulatory framework for the proper behavior of the academic community of each higher education institution consists of internal documents, collegially approved at the institution, including codes of honor (codes of academic integrity) or provisions on adherence to the principles of academic integrity of the respective institution.

Questions for assessment:

1. Analyze the concept of "academic culture."

2. Define the term "academic integrity."

3. How are the fundamental values of academic integrity implemented in the learning process?

4. Provide examples of academic integrity violations in the educational process in ancient times.

5. Give examples of academic integrity violations in the history of global science.

6. Analyze the statistical studies presented in the manual regarding students' assessment of academic dishonesty.

7. Compare the perspectives of students and their instructors on academic misconduct (based on survey materials mentioned in section 4).

8. What laws of Ukraine regulate the adherence to academic integrity in higher education institutions?

11.2 Types of Academic Dishonesty

11.2.1 The main types of academic dishonesty.

11.2.2 Data fabrication in scientific research.

11.2.3 Data falsification in scientific research.

11.2.1 The Main Types of Academic Dishonesty

The concept of academic dishonesty (or academic misconduct) contrasts the central idea of academic integrity in this course. It refers to the failure to adhere to the principles and rules established by law, which all participants in the educational and research process must follow.

The increasing scale of academic dishonesty in modern higher education is a global problem caused by three main factors:

1. The loss of higher education's intrinsic value and its treatment as a business project.

2. The massification of higher education leads to gradually lowering academic standards.

3. The bureaucratization of higher education.

There are multiple classifications of academic dishonesty in education. The Law of Ukraine "On Education " presents the universal classification."

Violations Listed in the Law of Ukraine "On Education" (Article 42, Part 4)

- Academic plagiarism
- Self-plagiarism
- Fabrication
- Falsification
- Cheating
- Deception
- Bribery
- Biased grading
- Providing or obstructing unauthorized assistance during assessment procedures
- Influencing educators (through requests, persuasion, directives, threats, coercion, etc.) to manipulate grading outcomes

Example of Severe Punishment for Academic Dishonesty

In Western education systems, unauthorized distribution of course materials is strictly punished. For instance, in 2007, students at the Indiana University School of Dentistry illegally accessed digital files intended for an exam (including X-rays and illustrations). They shared access credentials, downloaded the materials, and distributed them. Upon discovery:

- 9 students were expelled.
- 16 students were suspended for 3 to 24 months.
- 21 students received formal reprimands for knowing about the misconduct but failing to report it, as required by their signed student honor code.

Svitlana Revutska provides a more detailed classification of academic dishonesty, emphasizing the conditional division between dishonesty in scientific and educational activities**.** She refers to the fraud types outlined in the Letter of the Ministry of Education of Ukraine (23.10.2018 No. 1/9-650)**,** which offers academic integrity recommendations for higher education institutions.

Key forms of academic dishonesty

1. Plagiarism
2. Cheating during assessments
3. Purchasing and submitting academic or research work as one's own
4. Academic fraud, including:
   - Falsifying bibliographic references
   - Fabrication and falsification of research results
   - Pretending to have health issues to avoid assessments
   - Using unauthorized technical devices during assessments
   - Forging signatures on official documents
   - Having another person take exams or assessments
   - Submitting identical works under different names
   - Exchanging test answers during assessments
   - Using gestures or signals to convey answers during tests
   - Submitting work intended for individual completion as a group effort

5. Providing reviews or evaluations of academic work without conducting an actual assessment

6. Harming or sabotaging another person's academic or research work

7. Listing individuals as authors of publications or projects when they did not contribute

8. Giving or receiving rewards for academic or research advantages

9. Forcing students to make financial contributions or perform work under the threat of grade penalties

10. Conflicts of interest in academic or research activities

11. Nepotism, i.e., giving positions or privileges to relatives or acquaintances regardless of their qualifications and using family connections or official positions to gain advantages in academic, extracurricular, research, or administrative spheres.

11.2.2 Data fabrication in scientific research

According to Article 42 of the Law of Ukraine "On Education", fabrication is defined as: *"Inventing data or facts used in the educational process or scientific research."*

Svitlana Revutska further clarifies this concept as: *"Obtaining or publishing research results without conducting actual research (experiments, measurements, etc.)."*

Types of Data Fabrication

- Fabrication of statistical data when no research was conducted at all.
- Misrepresentation of partially conducted research where results were not properly recorded.
- Fabrication of entire studies or specific sections of a study.

Consequences of Data Fabrication

Fabrication is one of the most dangerous forms of academic dishonesty, as false data can:

- Become the foundation for ineffective or harmful practical developments.
- Mislead scientists, leading to further invalid research.
- Pose serious risks, especially in medicine and pharmaceuticals.

Notable Cases of Scientific Data Fabrication

📌 **Woo-Suk Hwang (South Korea)**

- A Seoul National University professor fabricated data in stem cell research.
- He also coerced women into donating their eggs for research.
- In 2009, he was convicted of fraud and bioethical violations.

📌 **Werner Bezwoda (South Africa)**

- In 1999, presented fraudulent breast cancer treatment results.
- External audit revealed that patient records were missing or falsified.
- No ethical approval or informed consent from patients.
- Fired after the scandal.

📌 **Jon Sudbø (Norway)**

- In 2005, published a study in *The Lancet* on anti-inflammatory drugs and oral cancer.
- Investigation found that all data were fabricated on his computer.
- Received a $10M grant for the fraudulent research.
- His doctoral dissertation was annulled, and he was banned from medical practice.

The Case of Yoshitaka Fujii

Yoshitaka Fujii co-authored over 200 articles studying the effects of anti-nausea and anti-vomiting drugs after surgical procedures. In 2000, a group of researchers working on a similar topic – Peter Kranke, Christian Apfel, and others – sent a letter to the journal Anesthesia and Analgesia editorial board, expressing concerns about the integrity of Fujii's research. Specifically, they pointed out that the reported incidence of headaches as a side effect of the drugs suspiciously coincided (or nearly coincided) across different randomized clinical trials discussed in 21 of Fujii's papers.

Fujii responded to these allegations without providing specific factual data or concrete evidence, asserting that he had conducted his research honestly. At the time, no verification was conducted, and his publications continued to be accepted for the next 12 years.

A renewed wave of scrutiny regarding Fujii's research integrity occurred in 2012 when British anesthesiologist John Carlisle published the results of an extensive statistical analysis of Fujii's research over the past 20 years. Based on numerous inconsistencies and statistical anomalies, Carlisle concluded that Fujii's research was highly questionable.

This time, despite Fujii's repeated claims of innocence and attempts to shift blame onto his "co-authors," the editorial boards of 23 journals that had published his work reached out to seven Japanese institutions where his clinical studies had been conducted, requesting a review of his research data.

Subsequently, the Japanese Society of Anesthesiologists launched its own investigation into 212 of Fujii's publications. The society reviewed laboratory records and interviewed his research collaborators. The findings were staggering: out of 212 papers, 172 were determined to be fraudulent, including 126 that were entirely based on fabricated data. In 37 cases, it was impossible to determine whether the data had been falsified. As a result, Fujii set a record for the highest number of retracted articles (183) due to falsified data.

Naturally, this marked the end of Yoshitaka Fujii's scientific and medical career. One of his co-authors, Hidenori Toyooka, was also implicated, as it was proven that he was aware of Fujii's data manipulation and may have even participated in it. Additionally, this large-scale fraud seriously affected other researchers, particularly those who used Fujii's data in their studies and cited articles that were later retracted. Some bizarre incidents, such as the *Egyptian Journal of Anaesthesia* retracting a 2018 article that referenced three of Fujii's previously retracted studies.

11.2.3 Data falsification in scientific research

According to Article 42 of Ukraine's Law "On Education," falsification is defined as "the deliberate alteration or modification of existing data related to the educational process or scientific research." [17].

Svitlana Revutska offers a similar definition, describing falsification as "the presentation of empirical data that differs from the actual results obtained to support one's theoretical claims."

In scientific research at various levels (including student research), falsification typically manifests in altering research results to fit a pre-established hypothesis or concealing certain results that contradict the hypothesis. Falsification can also include misrepresenting research materials and methods, such as using outdated or inadequate equipment, employing inappropriate software, or presenting data in an overly generalized manner to suggest specific methods or the presence of certain misleading findings.

In their article *Fraud in Clinical Trials*, Stephen George and Mark Baiz examined the prevalence of data fabrication and falsification in scientific research. They analyzed survey responses of two types:

1. Scientists were asked whether they witnessed others engaging in research fraud.

2. Scientists were asked whether they themselves had ever committed research fraud.

Naturally, the first type of survey reported significantly higher data fabrication and falsification rates than the second. However, neither method is considered reliable in determining the true extent of scientific fraud.

Even renowned scientists have faced suspicions of falsification, including Isaac Newton and Gregor Mendel. In his book *The Great Betrayal: Fraud in Science*, Horace Judson claimed that Sigmund Freud also engaged in falsification and fabrication, altering patient case histories to support the claims in his publications.

The Case of Louis Pasteur

An example of data falsification in scientific research can be found even in the biography of the renowned scientist – microbiologist and chemist Louis Pasteur. Gerald Geison, the author of *The Private Science of Louis Pasteur* (1995), reveals the true story behind Pasteur's invention of the anthrax vaccine.

In 1881, Pasteur announced that he had developed a vaccine against anthrax – a widespread disease in France at the time, which had caused massive losses of 20–30 million francs to French farmers in the 1870s. In May of that year, to prove the effectiveness of his vaccine, Pasteur and his assistants infected 50 sheep with anthrax, 25 of which had been previously vaccinated with his claimed preparation. When an invited delegation of government representatives, journalists, and farmers arrived to observe the results, it was found that only one vaccinated animal had died, while 23 unvaccinated sheep had perished. The study's outcome became a sensation, and the practice of vaccinating animals quickly spread worldwide.

However, Gerald Geison claims that Pasteur's first anthrax vaccination was not developed using his own method but by bacteriologist Charles Chamberland. Chamberland, a researcher in Pasteur's laboratory, used potassium dichromate to weaken anthrax spores, whereas Pasteur worked with chicken broth. At the time of the "demonstration" experiment, Pasteur's chicken broth-based vaccine was not yet ready, so he weakened the pathogen using Chamberland's potassium dichromate method. In Pasteur's defense, he eventually refined his own vaccine and began using it by mid-summer 1881.

The Case of Harry Snyder and Renée Peugeot

In 1994, dermatologist Harry Snyder led a clinical trial for the biotechnology company *BioCryst Pharmaceuticals* to test the effectiveness of BCX-34 (a purine nucleoside phosphorylase) in treating psoriasis and cutaneous T-cell lymphoma. His wife, Renée Peugeot, a registered nurse, coordinated the project. The couple had financial incentives to ensure the trial produced highly successful results.

According to the randomized, double-blind, placebo-controlled study's design, patients suffering from psoriasis and lymphoma were to receive the experimental drug on one affected area and a placebo on another.

In 1995, based on the study, the researchers reported that the drug was remarkably effective for both diseases, a finding beneficial to *BioCryst Pharmaceuticals* and the researchers themselves. However, the company's new medical director grew suspicious of the study's methodology. Subsequent investigations revealed that the results had been falsified – specifically, in the randomization of the drug and placebo assignments. In reality, the drug had no statistically significant effect on disease progression.

As a result, Snyder and Peugeot were criminally charged and sentenced to three and two and a half years in prison, respectively.

Like fabrication, data falsification is unacceptable in scientific research, including in student academic work at all levels. The penalties for violating academic integrity standards when writing a master's thesis can be severe, including expulsion, as data falsification turns research into a fake and strips it of any meaning.

Questions for assessment:

1. Name the reasons for increased academic dishonesty in higher education (according to Yu. Fedochenko).
2. List the types of academic integrity violations according to the Law of Ukraine "On Education" (Article 42, Part 4).

3. Enumerate the forms of academic dishonesty identified by V. Bakhrushyn and Ye. Nikolaiev.

4. Define data fabrication in scientific research.

5. Analyze the causes of the cases of data fabrication mentioned in the textbook.

6. Suggest ways to prevent the cases of data fabrication described.

7. Define data falsification. How does it differ from fabrication?

11.3 The Phenomenon of Plagiarism and Its Types

11.3.1 Definition of plagiarism, Academic plagiarism.

11.3.2 The history of plagiaristic activity and the formation of the concept of plagiarism.

11.3.3 Types of academic plagiarism. Plagiarism and citation errors.

11.3.4 Self-plagiarism.

11.3.5 Student cheating.

11.3.1 Definition of Plagiarism, Academic Plagiarism

The word "plagiarism" comes from the Latin word *plagiāre*, meaning "to steal." It was first used in ancient Rome to refer to the act of textual appropriation. The term later spread in the 17th century in Germany and France and eventually to other countries.

According to Article 50 of the Law of Ukraine "On Copyright and Related Rights," plagiarism is the public disclosure (publication), in whole or in part, of someone else's work under the name of a person who is not the author of this work.

Academic plagiarism (according to Part 4 of Article 42 of the Law of Ukraine "On Education") is the "public disclosure (in whole or in part) of scientific (creative) results obtained by other persons as the results of one's own research (creativity), and/or reproduction of published texts (disclosed works of art) of other authors without indicating authorship." [17].

There are several debatable points when classifying a scientific, educational text, or student work as plagiarism or original work. For example, it may not be necessary to cite information considered "common knowledge." Common knowledge refers to data found in encyclopedias, reference books, textbooks, etc. Information is also considered common knowledge if it appears in more than five sources. However, since the definition of "common knowledge" often varies, to resolve contradictions, we can refer to the letter from the Ministry of Education and Science sent to heads of higher education institutions on October 23, 2018, "Regarding recommendations on academic integrity for higher education institutions" (No. 1/9-650). In this letter, when determining whether certain knowledge is common, the following nuances are recommended:

- Who is the publication intended for? What is "common knowledge" for the author may not be so for the typical reader.
- Is the information about the original sources readily available? Sometimes, dozens of identical texts can be found in sources that are clearly not original or authoritative.
- Is there a possibility of alternative attribution of the author, for example, by stating their surname without specifying the source? (It should be noted that such attribution based on secondary sources may be incorrect.)

The letter also addresses the problem of correctly citing translated sources: should the translation of the original source be placed in quotation marks? Since translation inevitably introduces certain new meanings into the understanding of the original text, the letter suggests that a citation to it must be provided after a free translation of a fragment of the original. Putting the translation in quotation marks is unnecessary, but any distortions of the original content are considered a violation of academic ethics. Possible solutions include presenting the original fragment next to the translation or providing an interpretation of the most complex and ambiguous words in parentheses next to the translation.

For certain types of student work, compiling a text of a compilatory nature is allowed, provided each quote and reference to another's idea is correctly cited. However, for scientific works (such as master's theses and dissertations), the total compilation is unacceptable, as such works would fail to meet the requirements for scientific novelty, original research results, critical analysis of sources, etc.

Specific requirements also apply to the formatting of scientific-methodical works, such as textbooks, manuals, and methodological recommendations, as the standard bibliographic apparatus for scientific works complicates the perception of the text. However, even in such publications, direct quotes must be properly formatted. In any case, it is necessary to provide a comprehensive list of sources used in writing the text.

11.3.2 The History of Plagiaristic Activity and the Formation of the Concept of Plagiarism

The issue of the illegitimacy of "appropriating" someone else's words was raised by the ancient Greek grammarian and head of the Library of Alexandria, Aristophanes of Byzantium (circa 257–180 BCE). Once, while acting as a judge at a poetry competition, he justifiably accused most participants of stealing others' works – since he had read and recognized the copied originals. The winner of the competition was the poet who created original poetry.

Later, the 1st-century Roman poet Martial, upon discovering that another poet was reading his verses and passing them off as his own, exposed the dishonest colleague in his epigrams and first used the word *plagiator* – thief – against him.

However, it should be noted that plagiarism was widespread in ancient times. Notable figures such as Publius Vergilius Maro, Herodotus, and Plutarch were known for appropriating others' works and ideas.

During the Middle Ages, the appropriation of others' texts remained common. Copyists of religious texts could attribute authorship to the original work or fail to do so. This attitude towards authorship was more a reflection of the religious worldview of the time than a result of malicious intent, as the importance was placed on the Word of God being heard and spoken rather than on who recorded it.

The tradition of appropriating others' texts continued during the Renaissance. For example, Michel de Montaigne plagiarized excerpts from Plutarch and Seneca, and Brunetto Latini "borrowed" Procopius' *History of the Goths*. Moreover, plagiarism became a mainstream practice of the time. This is evident from the establishment in 1655 by Jean de Sacy of the "Academy of Orators," which cultivated the ability to paraphrase others' texts and present them as one's own – *plaginismus*. Jean de Sacy even wrote a guide titled *"Masks of Orators or the Way to Modify All Kinds of Compositions, Letters, Sermons, etc."* (1667), which essentially formulated the first rewriting principles.

It is known that William Shakespeare also borrowed literary ideas from others. His works were sometimes masterful compilations and adaptations of previous works. Benjamin Franklin also used others' ideas in his texts. However, attitudes toward authorship began to shift gradually during the Renaissance and afterward. By the 18th century, originality in authorship was beginning to be valued.

The first historical document recognizing copyright to some extent was the English Statute of Queen Anne of 1709, the "Act for the Encouragement of Learning by Vesting the Copies of Printed Books in the Authors or Purchasers of Such Copies." The statute granted the author rights to their work, but to publish and sell it, the rights had to be transferred to a publisher. It also established a copyright term of 14 years, which could be extended once.

In the 19th century, the foundations for properly citing others' works in scientific research were established. For example, historian Leopold von Ranke emphasized the strict adherence to citation practices in referencing others' thoughts. During this period, footnotes became widespread in scientific works.

At the same time, there were cases of plagiarism in groundbreaking discoveries. For example, the appropriation of Ukrainian scientist Ivan Puluj's research results by German physicist Wilhelm Conrad Roentgen is well-known. While Roentgen is credited with the discovery of X-rays, Puluj first invented the lamp that visualized X-rays. Roentgen worked with Puluj in the same laboratory and was aware of his colleague’s achievements, but he was the first to publish the discovery in 1895 as his own and later received the Nobel Prize for it in 1901. Contemporary scientists pointed out that Roentgen's explanation of X-rays was vague, and his images were blurry. In contrast, Puluj’s reports clearly outlined the phenomenon and proposed its use in medicine, producing much clearer images. This is a clear case of plagiarism of an entire scientific discovery.

Today, the fight against academic plagiarism is conducted at all levels, and often, plagiarists suffer reputational damage that can annihilate their careers. A notable case is that of German politician Annette Schavan.

In 2012, an anonymous blogger discovered plagiarism in Schavan’s PhD dissertation. The academic council of Heinrich Heine University Düsseldorf, where the dissertation was defended, conducted an expert review and confirmed the presence of uncredited citations. Schavan’s doctoral degree was revoked, and she was forced to resign. 2011, Germany established the VroniPlag Wiki page to search for plagiarism in doctoral dissertations. Thanks to this service, more than eight top-tier German politicians have lost their academic degrees (and some of their positions). Among them were former German Minister of Defense Karl-Theodor zu Guttenberg and Vice-President of the European Parliament Silvana Koch-Mehrin.

Plagiarism was also uncovered in the works of the Chief Rabbi of France, Gilles Bernheim, who used the works of several authors in his publications without proper citation. In the end, he had to resign.

Thus, we see that today, using foreign texts, ideas, and images in science and education without proper citation is clearly and unambiguously understood as unethical behavior. A set of principles, requirements, and rules for proper citation of foreign texts has been established, which are mandatory to apply (further details will be covered in the next topics).

11.3.3 Types of Academic Plagiarism. Plagiarism and Citation Errors

The following main types of academic plagiarism are distinguished:

- Directly borrowing textual fragments without formatting them as quotes with a source citation (in some cases, even using a single word without referencing the source is considered incorrect if the word is used in a unique sense attributed by the source);
- Using information (facts, ideas, formulas, numerical values, etc.) from a source without citing it;
- Paraphrasing a source text in a way that is too close to the original text, or providing a summary of ideas, interpretations, or conclusions from a specific source without citing the source;
- Presenting as one's own work (dissertations, monographs, textbooks, articles, theses, reports, assignments, term papers, diploma and master's theses, essays, abstracts, etc.) done by others, including works for which the original authors agreed to such use.

Academic plagiarism should be distinguished from citation errors. The most typical citation errors are:

- Absence of quotation marks when using textual fragments borrowed from other sources, even when there is a proper citation to the source.
- Incorrect citation of a different source;
- Improper citation formatting, which complicates source identification.

The most common citation errors in student works are improper formatting of quotes, errors in the bibliographic details of cited works, and in the authors' names. Also, in students' academic works (such as master's theses, articles, etc.), it is common to find compilations of foreign texts with too little original analysis of scientific concepts and research results, incorrect naming of authors, and author teams that the student is referencing. A widespread mistake is referencing not the original source of a particular scientific idea or concept but rather the works of researchers who retransmit that original source without acknowledging the author.

11.3.4 Self-Plagiarism

According to Part 4 of Article 42 of the Law of Ukraine "On Education," self-plagiarism is the "publication (partially or fully) of one's previously published scientific results as new scientific results" [17].

The Ministry of Education and Science's letter "On Recommendations for Academic Integrity for Higher Education Institutions" No. 1/9-650 provides the following list of typical self-plagiarism examples:

- Duplication of publications – publishing the same scientific work (completely or with insignificant changes) in several publications, as well as re-publishing (completely or with insignificant changes) previously published articles, monographs, and other scientific works as new scientific works;
- Duplication of scientific results – publishing the same scientific results in different articles, monographs, and other scientific works as new results being published for the first time;

- Submitting reports on scientific project results that were contained in previous works as obtained during the execution of the corresponding project;
- Aggregation or supplementation of data – combining old and new data without clear identification with corresponding references to previous publications;
- Disaggregation of data – publishing part of previously published data without citing the previous publication;
- Reanalysis of previously published data without citing the previous publication of those data and the previously performed analysis [6].

Self-plagiarism is a harmful practice because it distorts the scientometric indicators of individual authors and teams (unjustifiably inflating the number of publications). Secondly, it misleads and disorients readers of reproduced scientific texts, as the novelty and originality of scientific research are mandatory requirements.

In studying the issue of self-plagiarism, Christian Kollberg and Steven Koburov identified the following types:

- Textual, which is expressed in the repetition of entire fragments of text;
- Semantic, which occurs when identical ideas are rephrased;
- Flagrant, where there is no attempt to conceal the act, for example, submitting a previously published article for print without changes and with the same title;
- Selective, where only specific fragments of previously published works related to a narrow topic are disclosed;
- Unintentional, which happens without any special intention, for example, due to the closeness of the old publication's topic to the current material;
- Hidden, where an attempt is made to camouflage the act;
- Promotional repetitions, used when defending one's concept as a reaction to criticism;
- Repeated use due to memory issues

Recently, cases of self-plagiarism have also become the subject of criticism from the global scientific community. A notable example of such practice is the publication history of Reginald Smith, an honorary professor of mechanical engineering and materials science at Queen's University (Ontario, Canada). In 2005, his colleagues noticed that more than 20 of his publications, presented as original works, were reprints of previously published articles. Eventually, the Canadian Natural Sciences and Engineering Research Council, which had funded Smith's work, including his experiments aboard U.S. space shuttles, initiated an investigation into his publishing activities, revealing several self-plagiarism cases. Although Smith avoided punishment for self-plagiarism, three of his articles were withdrawn from the "Annals of the New York Academy of Sciences" and one from the "Journal of Materials Processing Technology". After this scandal, control over cases of self-plagiarism in scientific publications significantly increased.

A form of academic dishonesty closely resembling, but not identical to, self-plagiarism is known as "salami slicing" – dividing a cohesive study into parts and presenting each part as a separate, independent study. Some parts of the original work are duplicated or paraphrased in the resulting "salami" publications.

However, not all text similarities in the works of the same author are considered self-plagiarism. As clarified in the Ministry of Education and Science of Ukraine's letter dated 20.05.2020 No. 1/9-263 "On Avoiding Issues and Mistakes in Academic Integrity Practices," "textual overlaps that do not contain the author's scientific results and relate to the description of the state of the subject area and known research results of other authors, descriptions of established research methods, etc., are not considered self-plagiarism. Such textual overlaps with the author's previous results do not require citations or the formatting of these fragments as quotes. Furthermore, leading scientific journals and universities worldwide often view excessive references to one’s own publications as a violation of academic integrity aimed at artificially inflating the author’s scientometric indicators" [37].

11.3.5 Student Cheating

It is defined in Part 4, Article 42 of the Law of Ukraine "On Education" as "performing written tasks with the involvement of external sources of information, except those permitted for use, particularly during the evaluation of learning outcomes" [17]. Cheating is the most common type of academic dishonesty in today's student environment.

In the Ministry of Education and Science's letter "Regarding Recommendations on Academic Integrity for Higher Education Institutions" No. 1/9-650, the following types of cheating are outlined:

- Submitting or presenting identical works by different people as a result of their own educational activities;
- Writing others' versions of assignments during assessments;
- Using hidden signals (audio, gestures, etc.) during group assessments with identical tasks;
- Completing tasks unsupervised when help is not allowed or failing to indicate received assistance, consultations, or collaboration;
- Receiving unauthorized help for tasks that are supposed to be done independently

It's worth noting that the gradual digitization of modern life, including education, has contributed to a diversification of sources and technical means for cheating. This issue was discussed as early as the turn of the 20th and 21st centuries. For example, an incident at the University of Virginia in 2001 sparked a lively discussion on the moral and technical aspects of student integrity and internet use. The story involved an "Introduction to Physics" exam, which, for 160 years, students had taken without supervision, relying on trust and performing in a relaxed environment such as the park, sitting on benches under trees. This trust was based on students signing a code of honor upon entering the institution, promising not to cheat. After evaluating the work, a student complained to Professor Louis Bloomfield that her grade was too low compared to others who had cheated. This complaint led the professor to check exam papers over the past five semesters for textual similarities (note that 300–500 students took the course each semester). He spent 50 hours and was outraged to find many papers with significant similarities, including 60 works with over 1500 identical words.

However, the widespread use of the internet completely transformed the information search and storage process, thereby exacerbating the issue of academic integrity, even in top-tier universities, including those in the Ivy League. For example, in 2012, Harvard University was involved in a scandal due to widespread cheating in an exam for the "Fundamentals of Congress" course, where 125 students helped each other, i.e., cheated or allowed others to cheat. As a result, 60 students were expelled, and others faced various punishments.

Research conducted by Professor Donald McCabe and the Center for Academic Integrity from 2002 to 2014 showed that cheating on tests rose from 17% to 39%, and cheating on written assignments increased from 40% to 62%. Moreover, McCabe's research on more than 70,000 students across 24 U.S. institutions found that 64% of students admitted to cheating in various forms on tests, 58% acknowledged committing plagiarism, and 95% admitted to some form of academic dishonesty during their studies.

Questions for assessment:

1. Define plagiarism, specifically academic plagiarism.
2. Explain the concept of "common knowledge."
3. What are the differences in attitude toward compiling texts in students' academic and research works?

4. How has the attitude toward "borrowing" someone else's texts without citation evolved from ancient times to the present?

5. Provide examples of high-profile plagiarism cases in education and science in the 20th and 21st centuries.

6. List the types of academic plagiarism. Which of them are most common in students' academic activities?

7. Define self-plagiarism.

8. Why do some scholars consider "self-plagiarism" internally contradictory?

9. List the types of self-plagiarism.

10. Analyze the most famous cases of self-plagiarism in the history of science. What are the main motivations that lead scholars to self-plagiarism?

11. List the main types of cheating.

GLOSSARY

1. **Abstract** – A brief summary of a research study or article.
2. **Analysis** – Detailed examination of data to interpret results.
3. **Bibliography** – A list of sources in a research work.
4. **Bias** – A systematic error or deviation from the truth in research results.
5. **Case Study** – An in-depth study of a particular individual, group, or event.
6. **Causation** – The action of causing something, establishing that one variable causes a change in another.
7. **Citation** – A reference to a source of information used in research.
8. **Conclusion** – A judgment or decision reached by reasoning.
9. **Control Group** – A group in an experiment that does not receive the treatment used for comparison.
10. **Correlation** – A measure of the relationship between two variables.
11. **Data** – Information collected during research for analysis.
12. **Dissertation** – A substantial paper written for a doctoral degree.
13. **Empirical Research** – Research based on observed and measured phenomena.
14. **Ethics** – Moral principles governing research conduct.
15. **Experiment** – A procedure to test a hypothesis or demonstrate a known fact.
16. **Experimental Group** – The group receiving the treatment in an experiment.
17. **Findings** – The results or outcomes of a research study.
18. **Focus Group** – A group discussion aimed at gathering opinions or experiences.
19. **Framework** – A structure that guides research by outlining key concepts and relationships.

20. **Hypothesis** – A proposed explanation based on limited evidence as a starting point for investigation.

21. **Interview** – A structured conversation to collect information from participants.

22. **Literature Review** – A survey of research relevant to a specific topic.

23. **Method** – A systematic way to achieve an objective or solve a problem.

24. **Methodology** – Study of research methods, strategies, and principles.

25. **Observation** – The action of closely monitoring phenomena to gather data.

26. **Operational Definition** – A clear, precise definition of a variable in its measurement.

27. **Peer Review** – Evaluation of scientific work by others in the same field.

28. **Pilot Study** – A small-scale study conducted to test the feasibility of a research project.

29. **Plagiarism** – Using someone else's work or ideas without giving proper credit.

30. **Population** – The entire group from which data is collected in research.

31. **Proposal** – A plan or suggestion for a research project.

32. **Publication** – The process of making research available to the public.

33. **Qualitative Research** – Research that focuses on understanding concepts, thoughts, or experiences.

34. **Quantitative Research** – Research that focuses on numerical data and statistical analysis.

35. **Questionnaire** – A set of questions designed to collect data from respondents.

36. **Reliability** – The consistency of a research study or measuring test.

37. **Replication** – Repeating a study to verify its results.

38. **Research** – Systematic investigation to establish facts or principles.

39. **Research Design** – The overall strategy for conducting research.

40. **Sampling** – Selecting a group from a larger population for research.

41. **Sampling Error** – The error caused by observing a sample instead of the whole population.

42. **Scientific Method** – A systematic approach to research using observation, experimentation, and reasoning.

43. **Scientific Research** – Structured study to discover new information or verify existing knowledge.

44. **Survey** – A method of gathering information from a sample of people.

45. **Theoretical Research** – Research focused on developing new theories.

46. **Theory** – A system of ideas intended to explain facts or phenomena.

47. **Thesis** – A long piece of writing based on original research submitted for a degree.

48. **Triangulation** – Using multiple methods or data sources in research to enhance reliability.

49. **Validity** – The extent to which a test measures what it claims to measure.

50. **Variables** – Elements that can change or be changed in an experiment.

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