

DANYLO HALYTSKY LVIV NATIONAL MEDICAL UNIVERSITY

Department of Biological Chemistry

APPROVED

The first vice-rector for scientific
and pedagogical work
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2022

**THE EDUCATIONAL PROGRAM IN THE DISCIPLINE
“BIOLOGICAL CHEMISTRY”**

**on training of specialists of the second (master's) level of higher education
in the field of knowledge 22 “Health care”
in the specialty 222 “Medicine”**

for students of II year of medical faculty

Discussed and approved
at the methodical meeting of the
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Head of the Department
Prof. L.I. Kobylinska

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specialized methodical commission in
physical and chemical disciplines
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INTRODUCTION

Program for learning of educational discipline

«Biological chemistry»

according to the Standard of higher education of the *second (master's) level*

field of knowledge 22 "Health Care"

specialty 222 "Medicine"

educational program of the *master of medicine*

Description of the educational discipline (annotation) Biological chemistry

Structure of educational discipline	Number of credits, hours, from which			Year of studies, semester	Kind of control	
	Totally	Auditorium				Individual students work
		Lectures (h)	Practical classes (h)			
Title of discipline: Biological chemistry Chapters 9	6.5 credits / 195 h.	18	80	97	II year (III, IV semester)	Exam
Due to semesters						
<i>Chapters 1 – 5</i>	3.0 credits / 90 h.	10	48	32	III semester	-
<i>Chapters 6 – 9</i>	3.5 credits / 105 h.	8	32	65	IV semester	Exam

The subject of educational discipline is:

the chemical composition of living organisms (human organism) and chemical transformations, to which their constituent molecules are exposed.

Interdisciplinary connections:

Biochemistry as educational discipline:

a) based on knowledge of medical students of biology, biophysics, medicinal chemistry (bioinorganic, physical and colloid chemistry), morphological disciplines and integrates these disciplines;

b) lays the groundwork for study of molecular biology, genetics, physiology, pathology, general and molecular pharmacology, toxicology and clinical disciplines propedeutics that provides the integration of the teaching of these disciplines and shaping abilities to apply knowledge of biological and bioorganic chemistry, especially biochemical processes that occur in healthy and sick individuals in further education and careers;

c) lays the groundwork for clinical diagnosis of the most common diseases, monitoring of the disease, monitoring the effectiveness of the use of drugs and measures to prevent the occurrence and development of pathological processes;

d) for further improvement of the skills to use the theoretical and practical knowledge of Pathobiochemistry, it is appropriate for the high scientific and methodological level of training to form a separate training course - "Clinical biochemistry", which is desirable to be taught for 5-6 year students, after learning the basic clinical disciplines, i.e. therapeutic and surgical cycles.

1. Aim and tasks of biological chemistry:

1.1. The aim of teaching the educational discipline “Biological Chemistry” is:

- interpretation of the results of biochemical tests and changes, biochemical and enzymatic indices used for diagnosis of human diseases;
- to analyze biochemical processes of metabolism and its regulation in ensuring the functioning of organs and systems of the human body.

The final goal is to learn practical skills in Biological chemistry.

1.2. The main tasks of studying the discipline “Biological chemistry” are:

mastering the skills to detect biochemical components in biological fluids and to analyze the results of biochemical investigations and changes in biochemical, in particular, enzymatic parameters used to diagnose the most common human diseases; apply acquired knowledge, skills, and abilities to perform a task of any level of complexity during professional activity or training.

1.3. Competence and results of training, the formation of which is facilitated by discipline (the relationship with the normative content of the training of higher education graduates, formulated in terms of results of study in the Standard of Higher Education).

According to the demands of the Standard the discipline provides the obtaining of the following **competencies** by the students:

General competencies (GC):

- GC 1. Ability to abstract thinking, to analyze and synthesize.
- GC 2. Ability to learn and master modern knowledge.
- GC 3. Ability to apply knowledge in practical situations.
- GC 4. Ability to acquire basic general knowledge, as well as basic knowledge of the profession.
- GC 5. Ability to adapt and act in a new situation.
- GC 6. Ability to make grounded decisions.
- GC 7. Ability to work in a team.
- GC 8. Ability to interpersonal interaction.
- GC 9. Ability to communicate in a foreign language.
- GC 10. Ability to use information and communication technologies.
- GC 11. Improve the ability to manage information from various sources.
- GC 12. Certainty and persistence on the tasks and duties taken.
- GC 15. Ability to preserve and multiply moral, cultural, scientific values and achievements of society based on the understanding of history and development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technics and technology, use different types and forms of activity for active recreation and leading a healthy lifestyle.

Professional (special, subject):

- PC1. Ability to collect medical information about the patient and analyze clinical data.
- PC2. Ability to determine the list of laboratory and instrumental studies necessary for patients and evaluate their results.
- PC 3. Ability to establish a preliminary and clinical diagnosis of the disease.
- PC 7. Ability to diagnose emergency conditions.
- PC 17. The ability to assess the impact of the environment, socio-economic and biological factors on the state of health of an individual, family, population.
- PC 21. Clearly and unambiguously convey one's own knowledge, conclusions and arguments on health care problems and related issues to specialists and non-specialists, in particular to people who are studying.
- PC 23. The ability to develop and implement scientific and applied projects in the field of health care.
- PC 24. Adherence to ethical principles when working with patients and laboratory animals.
- PC 25. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results.

Matrix of competencies

№	Competency	Knowledge	Skills	Communication	Autonomy and responsibility
1.	2	3	4	5	6
Integral competency					
Ability to solve typical and complex specialized tasks and practical problems in professional activity or in the process of learning, apply the acquired knowledge, skills, abilities and personal qualities, abilities, values for the task of any level of complexity during professional activity or training.					
General competency					
GC1	Ability to abstract thinking, to analyze and synthesize.	Find ways to analyze, synthesize and further modern learning	Be able to analyze information, make informed decisions	Be able to use knowledge in practice, when communicating	Be responsible for the timely acquisition of modern knowledge.
GC2	Ability to learn and master modern knowledge.	Know how to acquire basic knowledge, know how to apply this knowledge in professional activities.	Be able to use knowledge in a variety of practical situations.	Be able to define the purpose and the task of being persistent and conscientious in the performance of duties	To be responsible for timely acquisition of basic general and professional knowledge.
GC3	Ability to use knowledge in practical situations	Know the methods of applying knowledge in solving practical issues.	Be able to analyze information.	Be able to provide high-quality performance of work.	Be responsible for the timeliness of the decisions taken in these situations.
GC4	Knowledge and understanding of the subject area and understanding of professional activity.	Know and understand professional terms, patterns used during professional activity.	Be able to use professional knowledge in professional activity.	Establish vertical and horizontal connections depending on the practical situation.	Responsibility for contributing to professional knowledge and practice
GC5	Ability to adapt and act in a new situation.	-	Ability to solve new clinical tasks and problems.	Establish connections vertically and horizontally depending on the practical situation.	Responsibility for the timely and correct solution of new problems
GC6	Ability to make grounded decisions.	Specialized conceptual knowledge, including modern scientific achievements, is the basis for making professional decisions.	The ability to use knowledge to justify decisions.	Clear and unambiguous presentation of one's own knowledge, arguments, conclusions to justify decisions.	Be responsible for the validity of decisions in given situations
GC7	The ability to work in a team.	To know the sequence of the	The ability to perform tasks that	Ability establish	To be responsible for solving team

		stages of subject tasks, ways of solving team tasks.	are part of teamwork.	communication links to achieve goals.	tasks.
GC8	Ability to interpersonal interaction.	Specialized knowledge as a basis for establishing horizontal and vertical connections.	Ability to establish horizontal and vertical interpersonal interaction to solve professional problems.	Establish appropriate connections to achieve goals.	To be responsible for the formation of interpersonal interaction necessary for solving the tasks.
GC 9	The ability to communicate in a foreign language	To know professional terminology in a foreign language.	To be able to answer test questions in a foreign language.	To use foreign languages in professional activities.	To be responsible for contributing to professional knowledge
GC 10	Ability to use information and communication technologies.	Know basic information and communication technologies.	Be able to use information and communication technologies.	Establish appropriate connections to achieve goals.	Ability to continue learning with a high degree of autonomy
GC 11	Ability to search, process and analyze information from various sources.	Know the basics of finding, processing and analyzing scientific and professional sources.	Be able to integrate knowledge using the search, processing and analysis of information from different sources.	Establish communication links in the process of searching, processing and analyzing information from different sources.	Be responsible for contributing to professional knowledge
GC 12	Determination and persistence in relation to assigned tasks and assumed responsibilities.	Critical understanding of professional problems and interdisciplinary knowledge in order to determine tasks and persistence in their implementation.	Ability to determine ways to solve tasks and show persistence in their implementation.	Establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them.
GC 15	Ability to preserve and multiply moral, cultural, scientific values and achievements of society based on the understanding of history and development of the subject area, its place in the general system of knowledge about nature and society and in the	To know the scientific achievements of Ukrainian scientists in the development of biochemistry, to know the need to preserve moral, cultural, scientific values and achievements of society.	To be able to use different types of motor activity for a healthy lifestyle.	To establish appropriate connections for obtaining, preserving, popularizing moral, cultural and scientific values and achievements of society, forming an active lifestyle.	To be responsible for obtaining, preserving, popularizing moral, cultural and scientific values and achievements of society, formation of an active lifestyle

	development of society, technics and technology, use different types and forms of activity for active recreation and leading a healthy lifestyle.				
Special (professional, subject) competencies					
PC 1	Ability to collect medical information about the patient and analyze clinical data.	To know the basic biochemical parameters used in diagnostic and assessment of the state of patients.	Be able to analyze clinical and biochemical parameters of biological fluids.	Establish appropriate connections to achieve goals.	To be responsible for solving the assigned tasks
PC 2	Ability to determine the list of laboratory and instrumental studies necessary for patients and evaluate their results.	To know the necessary list of biochemical studies and be able to evaluate their results.	Be able to choose the necessary list of clinical and biochemical studies and evaluate their results.	Establish appropriate connections to achieve goals.	To be responsible for solving the tasks
PC 3	Ability to establish a preliminary and clinical diagnosis of the disease.	To know the correspondence between biochemical clinical parameters and the corresponding syndromes and diseases.	Be able to establish preliminary and clinical diagnoses of the disease on the basis of clinical and biochemical parameters.	Establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them.
PC 7	Ability to diagnose emergency conditions.	To know biochemical indicators that indicate emergency conditions.	Be able to diagnose emergency conditions using biochemical indicators.	Establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them
PC 17	The ability to assess the impact of the environment, socio-economic and biological factors on the state of health of an individual, family, population.	To know the biochemical parameters that indicate the influence of the environment, socio-economic and biological determinants on the state of health.	Be able to evaluate the influence of the environment, socio-economic and biological determinants on the state of health by biochemical indicators.	Establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them.
PC 21	Clearly and unambiguously convey one's own knowledge, conclusions and arguments on health care problems and related issues to specialists and non-	To know the methods of familiarization with knowledge, conclusions, arguments on health care issues.	To be able to clearly and unambiguously convey one's own knowledge, conclusions and arguments on health care issues and related issues.	To establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them

	specialists, in particular to people who are studying.				
PC 23	The ability to develop and implement scientific and applied projects in the field of health care.	To know the basic points of the development of scientific and research projects.	Be able to develop and implement scientific and applied projects in the field of health care.	Establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them.
PC 24	Adherence to ethical principles when working with patients and laboratory animals.	To know ethical principles when working with patients and laboratory animals.	Be able to follow ethical principles when working with patients and laboratory animals.	Establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them.
PC 25	Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results.	To know the principles of professional and academic integrity.	To be able to carry out professional activities, observing professional and academic integrity, to be responsible for the reliability of the obtained scientific results.	To establish appropriate connections to achieve goals.	To be responsible for the solution of the tasks and persistence in solving them.

Results of studying:

Integrative final program results of training (PRN), the formation of which is favored by the educational discipline:

- PRN1. To have thorough knowledge of the structure of professional activity. To be able to carry out professional activities that require updating and integration of knowledge. To be responsible for professional development, the ability for further professional training with a high level of autonomy.
- PRN2. Understanding and knowledge of fundamental and clinical biomedical sciences, at a level sufficient for solving professional tasks in the field of health care.
- PRN3. Specialized conceptual knowledge that includes scientific achievements in the field of health care and is the basis for conducting research, critical understanding of problems in the field of medicine and related interdisciplinary problems.
- PRN4. Highlight and identify leading clinical symptoms and syndromes (according to list 1); according to standard methods, using preliminary data of the patient's history, data of the patient's examination, knowledge about the person, his organs and systems, establish a preliminary clinical diagnosis of the disease (according to list 2).
- PRN5. Collect complaints, anamnesis of life and illness, assess the psychomotor and physical development of the patient, the state of organs and systems of the body, based on the results of laboratory and instrumental studies, evaluate information regarding the diagnosis (according to list 4), taking into account the age of the patient.
- PRN6. To establish the final clinical diagnosis by making a reasoned decision and analyzing the received subjective and objective data of clinical, additional examination, carrying out differential diagnosis, observing the relevant ethical and legal norms, under the control of the head physician in the conditions of the health care institution (according to the list 2).
- PRN7. To assign and analyze additional (mandatory and optional) examination methods (laboratory, functional and/or instrumental) (according to list 4) of patients with diseases of organs and body systems for differential diagnosis of diseases (according to list 2).
- PRN8. To determine the main clinical syndromes or causes the severity of the victim/injured's condition (according to list 3) by making a reasoned decision and assessing

the person's condition under any circumstances (in the conditions of a health care facility, outside its borders), including in the conditions of an emergency and hostilities, in field conditions, in conditions of lack of information and limited time.

- PRN21. To search for the necessary information in the professional literature and databases of other sources, analyze, evaluate and apply this information.
- PRN22. To apply modern digital technologies, specialized software, and statistical methods of data analysis to solve complex healthcare problems.
- PRN 23. Assess the impact of the environment on the state of human health in order to assess the state of morbidity of the population.
- PRN24. To organize the necessary level of individual safety (own and the persons he cares for) in case of typical dangerous situations in the individual field of activity.
- PRN25. It is clear and unambiguous to convey one's own knowledge, conclusions and arguments on health care problems and related issues to specialists and non-specialists.
- PRN27. Communicate freely in English language, both orally and in writing to discuss professional activities, research and projects.

As a result of studying the discipline

The student **must know:**

- The structure of bioorganic compounds and the functions they perform in the human body.
- The reactivity of the basic classes of biomolecules, which ensures their functional properties and metabolic transformations in the organism.
- General biochemical mechanisms of the occurrence of pathological processes in the human body.
- Features of diagnosis of the physiological state of the organism and the development of pathological processes on the basis of laboratory tests.
- Relationship of the structural features and transformations of bioorganic compounds as the basis of their pharmacological action as a medicinal product.
- Basic mechanisms of biochemical action and principles of the use of different classes of pharmacological agents.
- Biochemical and molecular basis of physiological functions of cells, organs and systems of the human body.
- Functioning of enzymatic processes occurring in membranes and organelles for the integration of metabolism in individual cells.
- Norms and changes in biochemical and enzymatic parameters used to diagnose the most common human diseases.
- Significance of biochemical processes of metabolism and its regulation in ensuring the functioning of organs, systems and the integral organism of a person.

The student should **be able to:**

- Analyze the correspondence between the structure of bioorganic compounds and physiological functions they perform in the organism.
- Interpret features of the physiological state of the organism and the development of pathological processes based on laboratory tests.
- Analyze the reactivity of carbohydrates, lipids, amino acids, ensuring their functional properties and metabolic transformations in the organism.
- Interpret the structural features and transformations of bioorganic compounds as the basis of their pharmacological action as medicines.
- Interpret biochemical mechanisms of pathological processes in the human body and the principles of their correction.
- Explain the basic biochemical mechanisms of action and principle of the use of different classes of drugs.
- Explain the biochemical and molecular basis of physiological functions of cells, organs and systems of the human body.

- Analyze the functioning of enzymatic processes in membranes and organelles for the integration of metabolism in individual cells.
- Classify the results of biochemical studies and changes of biochemical and enzymatic parameters that are used to diagnose the most common human diseases.
- Interpret the significance of the biochemical processes of metabolism and its regulation in ensuring the functioning of the organs, systems and integrated human body.

2. Information contents of the educational discipline “Biological chemistry”

6.5 IECTS credits, 195 hours are provided for the studying of the educational discipline «Biological chemistry»

The program of the educational discipline “Biological chemistry” is structured into 9 thematic modules:

Thematic module 1. Biochemistry as a science. Structure and features of enzymes. Medical enzymology.

Topic 1. Control of the initial level of knowledge. Subject and tasks of biochemistry. Purpose and methods of biochemical investigations; their justification, clinical and diagnostic value.

Topic 2. Investigation of the structure and physico-chemical properties of enzymes. Determination of the activity of enzymes, investigation of their mechanism of action and kinetics of enzymatic catalysis. Application of methods for detecting enzymes in biological objects.

Topic 3. Investigation of regulation of enzymatic processes and analysis of mechanisms of occurrence of enzymopathies. Medical enzymology.

Topic 4. Investigation of the role of cofactors and coenzyme vitamins. Role of water- and fat-soluble vitamins in metabolism of living organisms.

Thematic module 2. Basic principles of metabolism. Molecular basics of bioenergetics

Topic 5. Metabolism and energy. Investigation of the functioning of the tricarboxylic acid cycle.

Topic 6. Investigation of biological oxidation processes, oxidative phosphorylation and ATP synthesis. Investigation of the activity of inhibitors and uncouplers of oxidative phosphorylation and ATP synthesis.

Thematic module 3. Metabolism of carbohydrates in health and pathology, its regulation

Topic 7. Digestion of carbohydrates. Study of glycolysis – anaerobic oxidation of carbohydrates.

Topic 8. Investigation of aerobic oxidation of glucose and alternative pathways of turnover of monosaccharides.

Topic 9. Investigation of catabolism and biosynthesis of glycogen. Regulation of metabolism of glycogen, biosynthesis of glucose – gluconeogenesis.

Topic 10. Study of mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Diabetes.

Thematic module 4: Metabolism of lipids in health and pathology, its regulation

Topic 11. Digestion of lipids. Investigation of catabolism and biosynthesis of triacylglycerols and phospholipids. Intracellular lipolysis and molecular mechanisms of its regulation.

Topic 12. β -Oxidation and biosynthesis of fatty acids. Study of the metabolism of fatty acids and ketone bodies.

Topic 13. Biosynthesis and biotransformation of cholesterol. Pathology of lipid metabolism: steatorrhea, atherosclerosis, obesity. Transport forms of lipids - blood plasma lipoproteins.

Thematic module 5: Metabolism of amino acids in health and pathology, its regulation.

Topic 14. Investigation of digestion of proteins in gastro-intestinal tract. The study of amino acid transformations (transamination, deamination, decarboxylation).

Topic 15. Investigation of ammonia detoxification processes and urea biosynthesis. Biosynthesis of glutathione and creatine.

Topic 16. Specific pathways of amino acids metabolism, their inborn and acquired disorders. Aminoacidurias: reasons and consequences.

Thematic module 6. Metabolism of nitrogenous bases, nucleotides. General regularities of matrix syntheses in living organisms and their regulation.

Topic 17. Investigation of the metabolism of purine and pyrimidine nucleotides. Measurements of the end products of their metabolism. Hereditary disorders of their turnover.

Topic 18. Investigation of DNA replication and transcription of RNA. Analysis of mechanisms of mutations, DNA reparations. Acquisition of the principles of obtaining recombinant DNA, transgenic proteins.

Topic 19. Biosynthesis of protein in ribosomes. Investigation of initiation, elongation and termination processes in the synthesis of the polypeptide chain. The inhibitory effect of antibiotics. Mastering the principles of genetic engineering and cloning of genes, their application in modern medicine.

Thematic module 7. Biochemistry of intercellular communications. Biochemistry of the endocrine system.

Topic 20. Investigation of molecular and cellular mechanisms of action of proteins-peptide nature hormones on target cells. Mechanism of action of hormones – derivatives of amino acids and biogenic amines. Hormonal regulation of calcium homeostasis.

Topic 21. Investigation of molecular and cellular mechanisms of action of steroid and thyroid hormones on target cells.

Thematic module 8. Biochemistry of blood.

Topic 22. Investigation of intermediate products of biosynthesis of porphyrins and their accumulation in porphyrias. Structure and properties of hemoglobin and its derivatives. Pathological forms of hemoglobin.

Topic 23. Investigation of blood plasma proteins: acute phase inflammation proteins, plasma functional and plasma non-functional enzymes. Investigation of non-protein nitrogen-containing and nitrogen free components of blood.

Topic 24. Investigation of coagulation, anticoagulation and fibrinolytic blood systems.

Topic 25. Investigation of biochemical basics of the implementation of immune processes. Immunodeficiency states.

Thematic module 9. Biochemistry of tissues, organs and physiological processes

Topic 26. Study of the turnover of end products of catabolism of hem. Pathobiology of jaundice.

Topic 27. Investigation of processes of biotransformation of xenobiotics and endogenous metabolites. Microsomal oxidation, cytochrome P-450.

Topic 28. Study of water-salt and mineral metabolism.

Topic 29. Urinary function of the kidneys. Normal and pathological components of urine.

Topic 30. Investigation of the nervous system. Pathobiology of mental disorders.

Topic 31. Peculiarities of metabolism in muscular tissue. Biochemical disorders in miopathias and myocardial infarction.

Topic 32. Investigation of the biochemical components of the connective tissue.

3. Structure of educational discipline “Biological chemistry”

Topic	Lectures	Practical classes	Individual students' work	Individual work
Thematic module 1. Biochemistry as a science. Structure and features of enzymes. Medical enzymology.				
Topic 1. Control of the initial level of knowledge. Subject and tasks of biochemistry. Purpose and methods of	-	3	2	

biochemical investigations; their justification, clinical and diagnostic value.				
Topic 2. Investigation of the structure and physico-chemical properties of enzymes. Determination of the activity of enzymes, investigation of their mechanism of action and kinetics of enzymatic catalysis. Application of methods for detecting enzymes in biological objects.	2	3	2	
Topic 3. Investigation of regulation of enzymatic processes and analysis of mechanisms of occurrence of enzymopathies. Medical enzymology.	-	3	2	
Topic 4. Investigation of the role of cofactors and coenzyme vitamins. Role of water- and fat-soluble vitamins in metabolism of living organisms.	-	3	2	
Totally in the thematic module 1	2	12	8	
Thematic module 2. Basic principles of metabolism. Molecular basics of bioenergetics				
Topic 5. Metabolism and energy. Investigation of the functioning of the tricarboxylic acid cycle.	2	3	2	
Topic 6. Investigation of biological oxidation processes, oxidative phosphorylation and ATP synthesis. Investigation of the activity of inhibitors and oxidative phosphorylation uncouplers.	-	3	2	
Totally in the thematic module 1	2	6	4	
Thematic module 3. Metabolism of carbohydrates and its regulation				
Topic 7. Digestion of carbohydrates. Study of glycolysis – anaerobic oxidation of carbohydrates.	2	3	2	
Topic 8. Investigation of aerobic oxidation of glucose and alternative pathways of turnover of monosaccharides.	-	3	1	
Topic 9. Investigation of catabolism and biosynthesis of glycogen. Regulation of metabolism of glycogen, biosynthesis of glucose – gluconeogenesis.	-	3	1	
Topic 10. Study of mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Diabetes.	-	3	2	
Totally in the thematic module 3	2	12	6	
Thematic module 4: Metabolism of lipids in health and pathology, its regulation				
Topic 11. Digestion of lipids. Investigation of catabolism and biosynthesis of triacylglycerols and phospholipids. Intracellular lipolysis and molecular mechanisms of its regulation.	2	3	2	
Topic 12. β -Oxidation and biosynthesis of fatty acids. Study of the metabolism of fatty acids and ketone bodies.	-	3	2	
Topic 13. Biosynthesis and biotransformation of cholesterol. Pathology	-	3	2	

of lipid metabolism: steatorrhea, atherosclerosis, obesity. Transport forms of lipids - blood plasma lipoproteins.				
Totally in the thematic module 4	2	9	6	
Thematic module 5: Metabolism of amino acids in health and pathology, its regulation.				
Topic 14. Investigation of digestion of proteins in gastro-intestinal tract. The study of amino acid transformations (transamination, deamination, decarboxylation).	2	3	3	
Topic 15. Investigation of ammonia detoxification processes and urea biosynthesis. Biosynthesis of glutathione and creatine.	-	3	2	
Topic 16. Specific pathways of amino acids metabolism, their inborn and acquired disorders. Aminoacidurias: reasons and consequences.	-	3	2	
Totally in the thematic module 5	2	9	7	
Totally for the III semester	12	48	32	
Thematic module 6. Metabolism of nitrogenous bases, nucleotides. General regularities of matrix syntheses in living organisms and their regulation				
Topic 17. Investigation of the metabolism of purine and pyrimidine nucleotides. Measurements of the end products of their metabolism. Hereditary disorders of their turnover.	2	2	4	
Topic 18. Investigation of DNA replication and transcription of RNA. Analysis of mechanisms of mutations, DNA reparations. Acquisition of the principles of obtaining recombinant DNA, transgenic proteins.	-	2	4	
Topic 19. Biosynthesis of protein in ribosomes. Investigation of initiation, elongation and termination processes in the synthesis of the polypeptide chain. The inhibitory effect of antibiotics. Mastering the principles of genetic engineering and cloning of genes, their application in modern medicine.	-	2	4	
Totally in the thematic module 6	2	6	12	
Thematic module 7. Biochemistry of intercellular communications. Biochemistry of the endocrine system.				
Topic 20. Investigation of molecular and cellular mechanisms of action of peptide nature hormones on target cells. Mechanism of action of hormones – derivatives of amino acids and biogenic amines. Hormonal regulation of calcium homeostasis.	2	2	4	
Topic 21. Investigation of molecular and cellular mechanisms of action of steroid	-	2	4	

and thyroid hormones on target cells.				
Totally in the thematic module 7	2	4	8	
Thematic module 8. Biochemistry of blood.				
Topic 22. Investigation of intermediate products of biosynthesis of porphyrins and their accumulation in porphyrias. Structure and properties of hemoglobin and its derivatives. Pathological forms of hemoglobin.	2	2	4	
Topic 23. Investigation of blood plasma proteins: acute phase inflammation proteins, plasma functional and plasma non-functional enzymes. Investigation of non-protein nitrogen-containing and nitrogen free components of blood.		2	4	
Topic 24. Investigation of coagulation, anticoagulation and fibrinolytic blood systems.		2	4	
Topic 25. Investigation of biochemical basics of the implementation of immune processes. Immunodeficiency states.		2	4	
Totally in the thematic module 8	2	8	16	
Thematic module 9. Biochemistry of tissues, organs and physiological processes				
Topic 26. Study of the turnover of end products of catabolism of hem. Pathobiology of jaundice.	2	2	5	
Topic 27. Investigation of processes of biotransformation of xenobiotics and endogenous metabolites. Microsomal oxidation, cytochrome P-450.	-	2	4	
Topic 28. Study of water-salt and mineral metabolism.	-	2	4	
Topic 29. Urinary function of the kidneys. Normal and pathological components of urine.	-	2	4	
Topic 30. Investigation of the nervous system. Pathobiology of mental disorders.	-	2	4	
Topic 31. Peculiarities of metabolism in muscular tissue. Biochemical disorders in miopathias and myocardial infarction.	-	2	4	
Theme 32. Investigation of the biochemical components of the connective tissue.	-	2	4	
Totally in the thematic module 9	2	14	28	
<i>Totally for IV semester</i>	8	32	65	
<i>Totally h 195/6,5 credits IECTS</i>	18	80	97	
<i>Summary control</i>				<i>Exam</i>

4. Thematic plan of lectures for Biological chemistry

No	Theme	Number of hours
1	Biochemistry as a science. Enzymes: structure, properties, classification. Regulation of metabolic processes: regulatory enzymes. Coenzymes and	2

	cofactors	
2	Bioenergetics: general pathways of catabolism of carbohydrates, lipids, amino acids. Krebs cycle. Biological oxidation and oxidative phosphorylation. Electron transport chain in mitochondria.	2
3	Metabolism of carbohydrates. General characteristics of glycolysis, aerobic oxidation of glucose, glycogen metabolism, gluconeogenesis, PPP. Diabetes mellitus.	2
4	Metabolism of lipids. Characteristics of metabolism of triacylglycerols, fatty acids, glycerol, ketone bodies, cholesterol. Regulation and pathology of lipid metabolism.	2
5	Metabolism of amino acids. General pathways of amino acids turnover. Metabolism of ammonia: biosynthesis of urea and its disorders. Specific pathways of amino acids metabolism; hereditary enzymopathies associated with them.	2
6	Metabolism of nucleotides in norm and pathology. General characteristics of matrix syntheses and their regulation. Molecular mechanisms of mutations	2
7	Hormones. Structure and classification of hormones. Membrane-cytosolic and cytosolic mechanisms of action of hormones. Regulation of metabolism by the protein-peptide, steroid and thyroid hormones.	2
8	Biochemistry of blood. Hemoglobin, its structure, properties, types, derivatives, biological role. Pathobiochemistry of blood. General characteristics of coagulation and fibrinolytic blood systems	2
9	Biochemical functions of the liver. Catabolism of heme, biochemistry of jaundice; biotransformation of endogenous substances and xenobiotics in the liver.	2
	Totally	18

5. Thematic plan of practical classes in the discipline “Biological chemistry”

№	Topic	Number of hours
1.	Control of the initial level of knowledge. Subject and tasks of biochemistry. Purpose and methods of biochemical investigations; their justification, clinical and diagnostic value.	3
2.	Investigation of the structure and physico-chemical properties of enzymes. Determination of the activity of enzymes, investigation of their mechanism of action and kinetics of enzymatic catalysis. Application of methods for detecting enzymes in biological objects.	3
3.	Investigation of regulation of enzymatic processes and analysis of mechanisms of occurrence of enzymopathies. Medical enzymology.	3
4.	Investigation of the role of cofactors and coenzyme vitamins. Role of water- and fat-soluble vitamins in metabolism of living organisms.	3
5.	Metabolism and energy. Investigation of the functioning of the tricarboxylic acid cycle.	3
6.	Investigation of biological oxidation processes, oxidative phosphorylation and ATP synthesis. Investigation of the activity of inhibitors and uncouplers of oxidative phosphorylation and ATP synthesis.	3
7.	Digestion of carbohydrates. Study of glycolysis – anaerobic oxidation of carbohydrates.	3
8.	Investigation of aerobic oxidation of glucose and alternative pathways of turnover of monosaccharides.	3
9.	Investigation of catabolism and biosynthesis of glycogen. Regulation of	3

	metabolism of glycogen, biosynthesis of glucose – gluconeogenesis.	
10.	Study of mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Diabetes	3
11.	Digestion of lipids. Investigation of catabolism and biosynthesis of triacylglycerols and phospholipids. Intracellular lipolysis and molecular mechanisms of its regulation.	3
12.	β -Oxidation and biosynthesis of fatty acids. Study of the metabolism of fatty acids and ketone bodies.	3
13.	Biosynthesis and biotransformation of cholesterol. Pathology of lipid metabolism: steatorrhea, atherosclerosis, obesity. Transport forms of lipids - blood plasma lipoproteins.	3
14.	Investigation of digestion of proteins in gastro-intestinal tract. The study of amino acid transformations (transamination, deamination, decarboxylation).	3
15.	Investigation of ammonia detoxification processes and urea biosynthesis. Biosynthesis of glutathione and creatine.	3
16.	Specific pathways of amino acids metabolism, their inborn and acquired disorders. Aminoacidurias: reasons and consequences.	3
17.	Investigation of the metabolism of purine and pyrimidine nucleotides. Measurements of the end products of their metabolism. Hereditary disorders of their turnover.	2
18.	Investigation of DNA replication and transcription of RNA. Analysis of mechanisms of mutations, DNA reparations. Acquisition of the principles of obtaining recombinant DNA, transgenic proteins.	2
19.	Biosynthesis of protein in ribosomes. Investigation of initiation, elongation and termination processes in the synthesis of the polypeptide chain. The inhibitory effect of antibiotics. Mastering the principles of genetic engineering and cloning of genes, their application in modern medicine.	2
20.	Investigation of molecular and cellular mechanisms of action of proteins-peptide nature hormones on target cells. Mechanism of action of hormones – derivatives of amino acids and biogenic amines. Hormonal regulation of calcium homeostasis.	2
21.	Investigation of molecular and cellular mechanisms of action of steroid and thyroid hormones on target cells.	2
22.	Investigation of intermediate products of biosynthesis of porphyrins and their accumulation in porphyrias. Structure and properties of hemoglobin and its derivatives. Pathological forms of hemoglobin.	2
23.	Investigation of blood plasma proteins: acute phase inflammation proteins, plasma functional and plasma non-functional enzymes. Investigation of non-protein nitrogen-containing and nitrogen free components of blood.	2
24.	Investigation of coagulation, anticoagulation and fibrinolytic blood systems.	2
25.	Investigation of biochemical basics of the implementation of immune processes. Immunodeficiency states.	2
26.	Study of the turnover of end products of catabolism of heme. Pathobiology of jaundice	2
27.	Investigation of processes of biotransformation of xenobiotics and endogenous metabolites. Microsomal oxidation, cytochrome P-450.	2
28.	Study of water-salt and mineral metabolism	2
29.	Urinary function of the kidneys. Normal and pathological components of urine.	2
30.	Investigation of the nervous system. Pathobiology of mental disorders.	2
31.	Peculiarities of metabolism in muscular tissue. Biochemical disorders in miopathias and myocardial infarction.	2
32.	Investigation of the biochemical components of the connective tissue.	2
	Totally	80

6. Thematic plan of individual students' work in the discipline "Biological chemistry"

№	Topic	Number of hours	Kind of control
1	Modern biochemical methods of investigation. Contribution of scientists from the department of biochemistry of Danylo Halytsky Lviv National Medical University into the development of biological chemistry.	2	Current control on practical classes
2	Mechanism of catalytic action of chymotrypsin and acetylcholinesterase.	2	
3	Application of enzymes in the disorders of the digestive system, in purulent-necrotic processes as fibrinolytic drugs etc. Changes of physico-chemical properties of catalase under conditions of oxidative stress in different pathological conditions.	2	
4	Modern vitamin preparations and their preventive and therapeutic use in medical practice. Biologically active supplements.	2	
5	Role of the most important metabolites of amphibolic pathways (glucose-6-phosphate, pyruvate, α -ketoglutarate, acetyl-S-CoA, succinyl-S-CoA etc) in the integration of metabolism.	2	Current control on practical classes
6	Alteration of ATP synthesis under the effect of pathogenic factors of chemical, biological and physical origin on the organism Role of cytochromes and coenzyme Q in metabolic processes in the cell.	2	
7	Peculiarities of regulation of glucose turnover in health and disease. Molecular basis of Krebtri and Paster effects	2	
8	Causes and manifestations of inborn and inherited alterations of the pentose-phosphate pathway. Causes, manifestations and diagnostics of congenital disturbances of fructose and galactose metabolism.	1	
9.	Hereditary disorders of the exchange of glycoconjugates. Mucopolisaccharidosis.	1	
10.	Methods of diagnosis and principles of biochemical correction of diabetes mellitus. Biochemical bases of modern methods of diagnostics and treatment of diabetes mellitus.	2	
11.	Metabolism of sphingolipids in norm and in pathology; clinical significance, violation of the metabolism of sphingolipids. Biological functions of polyunsaturated fatty acids, their sources and use in clinical practice	3	Current control on practical classes
12.	Congenital and acquired lipid metabolism disorders. Primary and secondary deficiency of carnitine, their symptoms and treatment	2	
13.	Oxidative stress, its causes, manifestations and the possibility of correction.	2	
14.	Clinical diagnostic significance of determination of aminotransferases activity. Synthesis and breakdown of biogenic amines.	3	
15.	Urea cycle, hereditary defects of enzymes involved in urea synthesis. Specific pathways of metabolism of phenylalanine and tyrosine, their disorders	2	Current control on practical classes
16.	Metabolism of porphyrins in norm and pathology. Hereditary disorders of sulfur containing amino acids metabolism.	2	
17.	Phases of the cell cycle of eukaryotes. Biochemical mechanisms of control of cell entry to mitosis; cdc2 -kinase, cyclin.	2	
18.	Biochemical mechanism of development of apoptosis and necrosis	2	
19.	Regulation of gene expression in prokaryotes (repression and	2	

	induction). Structure of Lac-operon of <i>Escherichia coli</i>		control on practical classes
20.	Mutations: genomic, chromosomal, gene (point mutations), their significance in appearance of enzymopatias and human hereditary diseases.	2	
21.	Congenital and acquired disorders of mechanisms of DNA repair	2	
22.	Genetic engineering. Cloning The application of genetic engineering techniques in modern medicine.	2	
23.	Endocrine function of the pancreas in norm and in pathology.	2	
24.	Metabolism of arachidonic acid in a human body and the influence of its products on biochemical processes.	3	
25.	Biogenic amines with hormonal and neurotransmitter properties. Receptors of biogenic amines.	3	Current control on practical classes
26.	Acid-base equilibrium of blood. Regulation of pH in biological fluids, disorders of acid-base equilibrium.	4	
27.	Main types of hypoxias, mechanisms of their development, methods of diagnostics	4	
28.	Glycoproteins: their structure, biological role, changes in diseases.	4	
29.	AIDS and COVID-19, molecular mechanism of occurrence, pathochemical changes.	4	
30.	Changes in biochemical indicators in chronic hepatitis, cirrhosis, gallstone disease, dyskinesia and cholecystitis, their diagnostic evaluation. The connection of disorders of the excretory function of the liver with disorders of digestive processes in the intestine, diagnosis of these disorders.	5	Current control on practical classes
35	Reactions of microsomal oxidation and conjugation in the biotransformation of xenobiotics and endogenous toxins	4	
36	Human microelementoses.	4	
37	Biochemical mechanisms of urine production (filtration, reabsorption, secretion and excretion).	2	
38	Causes and mechanisms of renal stones formation, chemical composition of renal stones and preventive measures.	2	
39	Molecular mechanisms of muscular contraction: modern data on interaction of muscular filaments.	2	
40,	Biochemical changes of blood plasma enzymes in different periods of myocardial infarction and other heart diseases.	2	
41.	Heart damage and biochemical diagnosis in some diseases (thyrotoxicosis, hypothyroidism, hypercorticism, diabetes, parathyroid gland disease, radiation exposure, porphyria, gout, nutritional disorders, alcoholic heart damage).	4	
42.	Pathobiochemistry of connective tissue. Biochemical mechanisms of development of mucopolysaccharidoses and collagenoses, their biochemical diagnostics.	4	
	Totally ISW in Biological Chemistry	97	

7. **Individual tasks** - are creative, search character, promote the development of cognitive activity of students. Individual tasks students perform independently under the direction of a teacher. These are additional tasks that allow the student to deepen their knowledge of discipline, for example, preparing a speech at the conference and publication of abstracts on the topics of the department at the annual student conference, multimedia presentations on the specified topics.

8. **Methods of training:**

Forms of educational activity according to the curriculum are:

- lectures

- practical classes,
- individual students' work (ISW);
- work of students in a scientific group,
- participation in scientific conferences and olympiads.

Depending on the form of learning activities, different methods are used, including interactive, in particular:

- methods of organization and implementation of educational and cognitive activities (explanatory and illustrative, reproductive)
- methods of stimulation and motivation of educational-cognitive activity (problem presentation, part-search);
- methods of control and self-control of the effectiveness of educational and cognitive activities.

9. Control methods

The current control of educational activities is carried out at each lesson in accordance with the specific goals, as well as during the individual work of the teacher with the student for those topics that the student is working on his own.

Controls include:

1. Ordinary student survey - individual, frontal.
2. Student written answers to standard test assignments, including 20 tests. Each test task has one correct answer from the five proposed (format A). Tasks with several (3-5) correct answers out of 8 options (format B).
3. Writing tasks in three issues. The tasks are presented in the form of transformation chains of bioorganic compounds, a list of certain biochemical parameters, filling tables, compiling the scheme, writing the equations of chemical reactions, etc.
4. Solution of situational tasks in oral and written form.
5. Control of writing of independent work. Points for SIW are awarded with successful defense during an oral or written poll.
6. Control of implementation of practical (laboratory) work and registration of the protocol of practical training. The quality of performance is evaluated by the teacher during practical classes.

The final control is carried out in the form of a written examination upon completion of the study of the discipline and lasts 3 hours.

Students who complete all types of works provided for by the curriculum are admitted to the exam, when studying the discipline, they have scored at least the minimum points, as well as do not have absences in practical classes. The form of the exam is standardized and includes the control of theoretical and practical level of knowledge:

- written answers to 40 standard test questions, each of which has one correct answer from the five proposed (format A). The writing of test control is allocated 40 minutes (from the calculation of 1 test in 1 min);
- written standardized answers to 5 tasks in the form of conversion circuits of bioorganic compounds, a list of certain biochemical indicators, completed tables, compilation of schemes, writing of equations of chemical reactions on all topics of the module (1-4 questions); description of principles of methods and clinical and diagnostic value of determination of biochemical parameters (5 questions). Duration - 95 min.

In the case of lockdown and distant learning the exam is carried out online and includes:

- 40 multiple choice questions, each of which has one correct answer from the five proposed (format A).
- 40 multiple choice questions, each of which has 50% correct answers out of the eight proposed (format B). Duration of the exam is 90 min.

10. Current control is carried out during the training sessions and is aimed at verifying students' learning of the material.

Assessment of current training activities. When assessing the mastering of each subject in the current educational activity, the student is awarded a 4-point (traditional) scale based on the approved evaluation criteria for the discipline. It takes into account all types of works provided for by the curriculum. The student should get an assessment on each topic.

The assessment is "**excellent**" if a student participated actively in discussing the most complex issues in the class, gave at least 90% of the correct answers to standardized test assignments (19-20 out of 20), answered the written assignments without errors, performed the practical work and has formulated the protocol.

The assessment of "good" is received by a student who participated in the discussion of the most complex issues on the topic, gave at least 75% of the correct answers to standardized test tasks (17-18 out of 20), assumed some minor mistakes in the answers to written tasks, performed practical work and issued a protocol.

The assessment "**satisfactorily**" is received by a student who did not participate in the discussion of the most complex issues on the subject, gave at least 60% of the correct answers to standardized test tasks (15-16 out of 20), made significant mistakes in the answers to written tasks, performed a practical work and issued a protocol.

The evaluation is "**unsatisfactory**" for a student who did not participate in the discussion of the most complex issues on the topic, gave less than 60% of the correct answers to standardized test assignments (14 and less), made gross mistakes in the answers to written questions or did not respond at all, did not perform practical work and did not issue a protocol.

11. Form of the final control of the training success

The exam is a form of final control of the student's acquisition of theoretical and practical material from the discipline.

The form of the exam is standardized and includes the control of theoretical and practical level of knowledge:

- written answers to 40 standard test questions, each of which has one correct answer from the five proposed (format A). The writing of test control is allocated 40 minutes (from the calculation of 1 test in 1 min);
- written standardized answers to 5 tasks in the form of conversion circuits of bioorganic compounds, a list of certain biochemical indicators, completed tables, compilation of schemes, writing of equations of chemical reactions on all topics of the module (1-4 questions); description of principles of methods and clinical and diagnostic value of determination of biochemical parameters (5 questions). Duration - 95 min.

12. The scheme of calculation and distribution of students' points:

For the discipline "Biological Chemistry" the form of final control is the exam. The **maximum** number of points a student can score for the current educational activity for admission to the exam is **120 points**.

The **minimum** number of points that a student must score for the current training for admission to the exam is **72 points**.

The **calculation** of the number of points for the current activity is based on the student's assessment on the 4-point scale (national) during the study of discipline, by calculating the arithmetic mean (CA), rounded to two decimal places. The resulting value is converted to a score on a multi-scale scale in the following way:

$$x = \frac{CA \times 120}{5}$$

For convenience, the table is converted into a 200-point scale:

Calculation of average grade for the current activity into the multi-point scale:

4-score scale	200-score scale
5	120
4.95	119
4.91	118
4.87	117
4.83	116
4.79	115
4.75	114
4.7	113
4.66	112
4.62	111
4.58	110
4.54	109
4.5	108
4-score scale	200-score scale
4.45	107
4.41	106
4.37	105
4.33	104
4.29	103
4.25	102
4.2	101
4.16	100
4.12	99
4.08	98
4.04	97
3.99	96
3.95	95
4-score scale	200-score scale
3.91	94
3.87	93
3.83	92
3.79	91
3.74	90
3.7	89
3.66	88
3.62	87
3.58	86
3.54	85
3.49	84
3.45	83
3.41	82
4-score scale	200-score scale
3.37	81

3.33	80
3.29	79
3.25	78
3.2	77
3.16	76
3.12	75
3.08	74
3.04	73
3	72
Less than 3	Insufficiently

Individual students' work is assessed during the current control of the topic in the relevant class. Assimilation of those that are imposed only on individual work is controlled by the final control.

Evaluation of final control.

An assessment of the exam consists of evaluating the test tasks and evaluating the theoretical tasks (including practical skills).

Criteria for evaluating test tasks:

Less than 25 tests - "**unsatisfactory**";

25 - 30 tests - "**satisfactory**";

31 - 36 tests - "**good**";

37 - 40 tests - "**excellent**".

The correct answer for 1 test is 1 point.

The minimum number of points for 40 tests is 25 points.

The maximum number of points for 40 tests is 40 points.

Criteria for evaluating theoretical tasks:

Each of the five theoretical tasks is estimated at 5 to 8 points:

Less than 5 points - "unsatisfactory";

5 points - "satisfactory";

7 points - "good";

8 points - "excellent".

The minimum number of points for 5 theoretical tasks is 25 points.

The maximum number of points for 5 theoretical tasks is 40 points.

For theoretical questions the student receives:

The assessment "**excellent**", if without errors answered the written theoretical tasks (including practical skills), substantiated the obtained results, that is: comprehensively and deeply learned the educational and practical material; in full mastered theoretical knowledge and practical skills.

The evaluation is "**good**" if some minor mistakes were made in the answers to the written theoretical tasks (including practical skills).

The assessment is "**satisfactory**" if significant mistakes were made in the answers to written theoretical tasks (including practical skills)

The evaluation is "**unsatisfactory**" if gross mistakes were made in the answers to written questions or the student did not give answers to them at all.

For exam, a student receives:

The score "**excellent**" (**75-80 points**) is received by the student who gave correct answers to 37-40 standardized tests, answered the written theoretical tasks (including practical skills) without errors, substantiated the obtained results (38-40 points), ie: comprehensively and profoundly mastered the curriculum; in full mastered theoretical knowledge and practical skills.

A score of "**good**" (**62-74 points**) is obtained by a student who gave correct answers to 31 to 36 standardized tests, some insignificant mistakes were made in the answers to written theoretical tasks (including practical skills), and did not fully substantiate the obtained results of investigations (31 - 37 points).

A "**satisfactory**" score (**50-61 points**) is received by a student who gave correct answers to 25 to 31 standardized tests, made significant mistakes in the answers to written theoretical tasks (including practical skills) (25 - 30 points).

The assessment is "**unsatisfactory**" if the student gave the correct answers to less than 25 standardized tests, made gross mistakes in the answers to written questions or did not respond at all.

The maximum number of points a student can score for an exam is 80.

The minimum number of points during the examination - not less than 50.

An assessment from the discipline that is completed by the exam is defined as the sum of points for the current educational activity (not less than 72) and the marks for the exam (not less than 50).

Evaluation of exam carried out online due to the distant learning of subject.

<p>Distant exam</p>	<p>Exam is conducted using the Misa learning platform, according to the schedule.</p> <p>Duration of the exam – 2 academical hours (90 min).</p> <p>The procedure for the biochemistry exam includes the following stages:</p> <ol style="list-style-type: none"> 1. Compilation of test control, which contains 40 tasks with one correct answer. 2. Compilation of test control, which contains 40 tasks with several correct answers (4 correct answers out of 8). <p>Multiple-choice tests include material from various sections of the discipline "Biological Chemistry" as well as from practical work, which reflects the level of mastery of practical skills.</p>	<p>Criteria for evaluating test tasks:</p> <p>The correct answer for 1 test with one answer is 1 point.</p> <p>The maximum number of points for 40 tests is 40 points.</p> <p>Tests with many correct answers are scored:</p> <ul style="list-style-type: none"> - one correct answer 0.25 points; - two correct answers - 0.50 points; - three correct answers - 0.75 points; - four correct answers - 1 point; - incorrect answer(s) - 0 points. <p>The maximum number of points a student can score for an exam is 80.</p> <p>The minimum number of points during the examination - not less than 50.</p>
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Score points for students who have successfully completed the program are converted to the traditional 4-point scale by the absolute criteria listed in the table below:

Points in the discipline	Grade due to 4-score system
From 170 to 200 points	5
From 140 to 169 points	4
From 139 points to minimal quantity of points, which should be achieved by the student	3
Lower than minimal quantity of points, which should be achieved by the student	2

Scale of evaluation: national and IECTS

Sum of points for all kinds of educational activity	Mark due to national scale	
	For exam	For pass
200-170	Excellent	Accepted
169-140	Good	
139-114	Satisfactory	
>114	Unsatisfactory with the opportunity to take again	Not accepted with the opportunity to take again
>114	Unsatisfactory with the obligatory repeated studying of the discipline	Not accepted with the obligatory repeated studying of the

		discipline
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11. Methodical provision

1. Methodical instructions for practical classes
2. Methodical instructions for individual students work
3. Calendar thematic plans of lectures and practical classes.
4. Video-lectures represented on MISA
5. Examples of Krok-1 tests and MCQs with several correct answers represented on MISA.
6. List of theoretical questions for the exam in Biological chemistry represented on MISA.

14. Recommended literature

Main:

1. Gubsky Yu. Bioorganic and biological chemistry. Book 2. Biological chemistry. Second edition. Medicine 2021. 544p.
2. Harper's Illustrated Biochemistry 30th edition. V. W. Rodwell et al.; NY: McGraw-Hill Education, 2015. 817 p.
3. Satyanarayana U., Chakrapani U. Biochemistry. Fifth edition, N.Delhy: Elsevier, co-published with Book and Allied, 2017. 788 p.
4. Lippincott Illustrated Reviews: Biochemistry. 7th edition. D.R.Ferrier; Wolters Kluwer, 2017. 565 p.
5. Gubsky Yu. Biological Chemistry. Nova Knyha, Vinnytsia, 2017. 487 p.
6. Nelson D.L., Cox M.M. Lehninger Principles of Biochemistry. 8-th edition. W.H. Freeman and Company, New York, 2021. 1328 p.
7. Swanson T. A., Kim S. I., Glucksman M. J. Biochemistry, Molecular Biology, and Genetics 5th edition / Lippincott Williams & Wilkins, 2010. 380 p.
8. McKee T., McKee J.R.. Biochemistry. The molecular basis of life. Seventh edition. Oxford University Press, 2019. 448 p.
9. MCQs in biochemistry 2nd edition / A. Ya. Sklyarov et al.: Lviv: Danylo Halytsky Lviv National Medical University Press, 2020. 319 p.
10. MCQs in biochemistry / A. Ya. Sklyarov et al.: Lviv: Danylo Halytsky Lviv National Medical University Press, 2012. 308 p.

Optional:

1. Vasudevan D.M., Sreekumari S., Kannan Vaidyanathan. Textbook of Biochemistry for Medical Students.. Jaypee Brothers Medical Pub, Seventh edition 2013. 791 p.
2. Chatterjea M.N., Rana Shinde. Textbook of Medical Biochemistry. Eighth edition. Jaypee Brothers Medical Pub, 2012. 894 p.
3. Ronner P.. Netter's Essential Biochemistry. Elsevier, 2018. 482 p
4. Tymoczko J.L., Berg J.M., Stryer L. Biochemistry: A Short Course. W. H. Freeman; Third edition, 2015. 896 p.
5. Lieberman M.. Marks' Basic Medical Biochemistry: A Clinical Approach. LWW; 5th edition. 2017. P. 1008
6. Lorch M.. Biochemistry: A Very Short Introduction. Oxford University Press. 2021. 160 p.
7. Oraby S. Biochemistry for medical students and postgraduates. Twelfth Edition. – 2013. – Part 1, – 248 p.
8. Copeland R. A. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis. - Wiley-VCH, Inc. – 2000. – 412 p.
9. Toy E.C., Seifert W. E., Strobel H.W., Harms K.P. “Case Files in Biochemistry. 2nd edition” – 2008. – 488 p.
10. Moore J.T., Langley R.H. Biochemistry For Dummies. For Dummies; 3rd edition. 2022. 368 p.

11. Miesfeld R.L., McEvoy M.M .Biochemistry. W. W. Norton & Company; Second edition. 2021. 1392 p.
12. Pratt Ch., Cornely K. Essential Biochemistry. Wiley; 5th edition. 2021. 816 p
13. Combs G.F., McClung J.P. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press; 6th edition.2022. 774 p.

15. Information resources: <http://www.new.meduniv.lviv.ua>

Centre of testing – base of licenced test tasks Krock-1 <http://testcentr.org.ua/>