

DANYLO HALYTSKY LVIV NATIONAL MEDICAL UNIVERSITY
Department of Biological Chemistry

APPROVED

The first vice-rector for scientific
and pedagogical work
Assoc. prof. I.I Solonynko

“ ” 2022

**THE WORKING 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 226 “Pharmacy, industrial pharmacy”**

Discussed and approved
at the methodical meeting of the
department of Biological Chemistry
Protocol № 15
from 07.06.2022.
Head of the Department
Prof. L.I. Kobylinska

Approved by the
specialized methodical commission in
physical and chemical disciplines
Protocol № 3 from 21.07.2022.
Head of the specialized methodical
commission
Prof. S.B. Bilous

THE PROGRAM IS ELABORATED BY:

Dr. Denysenko N. V. – assistant professor of the Department of Biological Chemistry at Danylo halytsky Lviv National Medical University

REVIEWERS :

Prof. Lesyk R. B. – Head of the Department of Pharmaceutical, Organic and Bioorganic Chemistry at Danylo halytsky Lviv National Medical University

Prof. Drapak I. V. – Head of the Department of General, Bioinorganic, Physical and Colloidal Chemistry at Danylo halytsky Lviv National Medical University

INTRODUCTION

Program of study of academic discipline "Biological chemistry"

According to the Standard of higher education of the second (master's) level
fields of knowledge 22 "Health care"
specialty 226 "Pharmacy"
Master of Pharmacy educational program

Description of the educational discipline (annotation)

The study discipline "Biological Chemistry" is studied by students of the third year of the Faculty of Pharmacy for two semesters. Each semester includes 3 credits and 2 sections. The total number of hours is 180 (90 auditorial hours and 90 hours of independent student work). The discipline program is structured into sections, which include blocks of 8 sections.

The volume of the student's academic load is described in ECTS credits - credits that are credited to students upon successful mastering of the corresponding section (credit).

The structure of the academic discipline	Number of credits, hours, of them				Year of study / semester	Type of control
	Total	Auditory		SIW		
		Lectures	Practice			
Biological chemistry <i>2 sections</i>	6,0 credits ECTS / 180 hours	20	70	90	3rd year (V-VI semester)	Credit, exam
By semesters						
Section 1	3,0 credits ECTS / 90 hours	10	32	48	V semester	
Section 2	3,0 credits ECTS / 90 hours	10	38	42	VI semester	Exam

The subject of study of the educational discipline: the chemical composition of living organisms (the human body) and the chemical transformations to which the molecules that make up their composition are subjected, the correction of pathological conditions associated with the violation of metabolic processes with pharmaceutical drugs.

Interdisciplinary connections. Biological chemistry as an educational discipline:

- is based on students' knowledge of medical biology, biophysics, medical chemistry (bioinorganic, physical and colloidal chemistry), morphological disciplines and is integrated with these disciplines;
- makes the basis to study molecular biology, genetics, physiology, pathology, general and molecular pharmacology, toxicology and propaedeutics of clinical disciplines, which involves the integration of teaching with these disciplines and the formation of skills to apply knowledge of biological and bioorganic chemistry, primarily biochemical processes that take place in the body of a healthy and sick person, in the process of further education and professional life;
- makes the basis for clinical diagnosis of the most common diseases, monitoring the course of the disease, control over the effectiveness of treatment and actions aimed to prevent the occurrence and development of pathological processes;
- further improvement of the ability to use theoretical and practical skills in pathobiochemistry at a higher scientific and methodical level should be carried out in a separate educational course - "Clinical Biochemistry", which should preferably be taught in 5-6 years of study.

1. The purpose and tasks of the educational discipline.

1.1. The purpose of teaching the educational discipline "Biological Chemistry" is to train specialist pharmacists who possess a significant amount of theoretical and practical knowledge regarding the biochemical foundations of the body's functioning and the nature of metabolic processes occurring in the human body in normal and pathological conditions. The ultimate goal is to acquire practical skills.

1.2. The main tasks of studying the discipline "Biological Chemistry" are:

- formation of knowledge about the structure of compounds that are part of living organisms and the relationship with their biochemical functions;
- forming a modern idea of the principles of structural organization of the main classes of biomacromolecules - proteins, nucleic acids, etc.;
- formation of knowledge of patterns of release, accumulation and consumption of energy in biological systems;
- formation of knowledge about the main metabolic pathways in the body, their relationship and molecular mechanisms of regulation;
- formation of knowledge of molecular bases of genetic information transfer, protein biosynthesis and mechanisms of their regulation;
- familiarization with modern methods of biochemical diagnosis of the body's metabolic state;
- creation of a base of ideas about the necessary therapy of pathological conditions with pharmaceutical drugs;
- formation of skills of scientific analysis and generalization of observed phenomena and facts;
- providing a theoretical basis for the study of other medical and biological disciplines: pharmacology, pharmacotherapy with pharmacokinetics, clinical pharmacology and certain pharmaceutical disciplines.

1.3. Competences and learning outcomes, the formation of which contributes to the discipline (relationship with the normative content of the training of higher education applicants, formulated in terms of learning outcomes in the Standard).

According to the requirements of the discipline standard, students acquire the following *competencies*:

- *general*:

Ability to act socially responsibly and civically; ability to apply knowledge in practical situations; ability to think abstractly, analyze and synthesize, learn and be modernly educated; knowledge and understanding of the subject area and understanding of professional activity; ability to communicate in the state language both orally and in writing; ability to communicate in a foreign language (mainly English) at a level that ensures effective professional activity; skills in using information and communication technologies; ability to conduct research at an appropriate level.

- *special (professional, subject)*:

Ability to provide pre-medical assistance to the sick and injured people in extreme situations and emergencies; ability to ensure the rational use of prescription and OTC drugs and other products of the pharmacy assortment in accordance with the physicochemical, pharmacological characteristics, biochemical, pathophysiological features of a specific disease and pharmacotherapeutic schemes of its treatment; ability to monitor the effectiveness and safety of the use of medicinal products by the population according to the data on their clinical and pharmaceutical characteristics, as well as taking into account subjective signs and objective clinical, laboratory and instrumental criteria for the examination of the patient; ability to identify medicinal products, xenobiotics, toxins and their metabolites in biological fluids and body tissues, to conduct chemical and toxicological studies for the purpose of diagnosing acute poisoning, drug and alcohol intoxication; ability to demonstrate and apply in practical activities communicative skills, fundamental principles of pharmaceutical ethics and deontology, based on moral obligations and values, ethical standards of professional behavior and responsibility in accordance with the Code of Ethics of Pharmaceutical Workers of Ukraine and WHO guidelines; ability to develop methods of quality control of medicinal products, including active pharmaceutical ingredients, medicinal plant raw materials and auxiliary substances using physical, chemical, physico-chemical, biological, microbiological, technological and organoleptic control methods.

Detailing of competencies in accordance with the NQF descriptors in the form of the "Competence Matrix".

Matrix of competences

№	Competence	Knowledge	Skill	Communication	Autonomy and responsibility
1.	2	3	4	5	6
Загальні компетентності					
GC1	The ability to act socially responsibly and civically	To know your social and public rights and responsibilities	To form one's civic consciousness, to be able to act in accordance with it	The ability to convey one's public and social position	Be responsible for your civic position and activities
GC2	The ability to apply knowledge in practical situations	To know the methods of applying knowledge in solving practical issues	To be able to use knowledge in various practical situations	To establish connections vertically and horizontally depending on the practical situation	To be responsible for the correctness of the decisions made in these situations
GC4	The ability to think abstractly, analyze and synthesize, learn and be modernly trained	To know methods of analysis, synthesis, possess abstract thinking and modern scientific knowledge	To be able to synthesize, analyze information, think abstractly and make informed decisions	To establish appropriate connections to achieve goals	To be responsible for the timely acquisition of modern knowledge
GC6	The knowledge and understanding of the subject area and understanding of professional activity	To know the methods of acquiring basic knowledge in the subject area, to know the methods of applying this knowledge in professional activities	To be able to use the acquired subject knowledge in practice, when communicating	To establish connections vertically and horizontally depending on the practical situation	To be responsible for the timely acquisition of basic general and professional knowledge
GC8	The ability to communicate in the state language both orally and in writing, the ability to communicate in a foreign language (mainly English) at a level that ensures effective professional activity.	To know the state language and a foreign language (mainly English) to ensure effective professional activity	To be able to communicate in the national and foreign languages (English) for professional activities	To establish communication ties in the field of professional activity	To be responsible for the adequate use of the state and foreign (English) languages in professional activities
GC9	The skills in using information and communication technologies	To know the methods of information management and communication technologies	To be able to use communication technologies and analyze information	To establish appropriate connections to achieve goals	To be responsible for timely acquisition of knowledge and operation of information and communication

GC12	The ability to conduct research at an appropriate level	To know the methods of modern research	To be able to ensure the translation of modern research at the appropriate level	To establish relationships to ensure quality performance of work	To be responsible for the high-quality performance of work and conducting research at the modern level
Special (professional, subject) competences					
SC3	The ability to provide pre-medical assistance to the sick and injured in extreme situations and emergencies	To have specialized knowledge regarding the provision of pre-medical care to the sick and injured in extreme situations and in emergency situations	To be able to use the acquired theoretical knowledge to provide pre-medical assistance to the sick and injured in extreme situations and emergency situations	To establish contacts and properly communicate with victims and witnesses in extreme situations and emergencies	To be responsible for your actions when providing pre-medical care to the sick and injured in extreme situations and in emergency situations
SC4	The ability to ensure the rational use of prescription and OTC drugs and other products of the pharmacy assortment in accordance with the physicochemical, pharmacological characteristics, biochemical, pathophysiological features of a specific disease and pharmacotherapeutic schemes of its treatment	To know the principles of ensuring the rational use of prescription and OTC drugs in accordance with the physicochemical, biochemical, pathophysiological features of a specific disease and pharmacotherapeutic schemes of its treatment	To be able to apply theoretical knowledge based on biochemical and pathophysiological features of a specific disease for ensuring the rational use of prescription and OTC drugs	To communicate competently with patients and colleagues to ensure rational use of prescription and OTC medications	To be responsible for the correct provision of rational use of prescription and OTC drugs in accordance with the physico-chemical, biochemical, pathophysiological features of a particular disease and pharmacotherapeutic schemes of its treatment
SC5	The ability to monitor the effectiveness and safety of the use of medicinal products by the population according to the data on their clinical and pharmaceutical characteristics, as well as taking into account subjective signs and objective clinical, laboratory and instrumental criteria for the examination of the patient	To know the main biochemical and molecular basis of the functions of cells, organs and systems of the human body for the establishment of clinical and pharmaceutical characteristics in order to monitor the effectiveness and safety of the use of medicinal products by the population	To be able to apply the acquired theoretical knowledge to monitor the effectiveness and safety of the use of medicinal products by the population according to the data on their clinical and pharmaceutical characteristics, as well as taking into account subjective signs and objective clinical, laboratory and instrumental criteria for the examination of the patient	To carry out competently consultative work among the population and colleagues in order to monitor the effectiveness and safety of the use of medicinal products by the population according to data on their clinical and pharmaceutical characteristics	To be responsible for the quality of the performance of professional duties regarding the monitoring of the effectiveness and safety of the use of medicinal products by the population according to the data on their clinical and pharmaceutical characteristics

SC6	The ability to identify medicinal products, xenobiotics, toxins and their metabolites in biological fluids and tissues of the body, to conduct chemical and toxicological studies for the purpose of diagnosing acute poisoning, drug and alcohol intoxication	To know the principles of biochemical methods for determining medicines, xenobiotics, toxins and their metabolites in biological fluids and body tissues	To be able to interpret received research results for the determination of drugs, xenobiotics, toxins and their metabolites in biological fluids and body tissues	To use competently professional terms in the scientific community and use them in documentation	To be responsible for the correct interpretation obtained research results for the determination of drugs, xenobiotics, toxins and their metabolites in biological fluids and body tissues
SC13	The ability to demonstrate and apply in practical activities communication skills, fundamental principles of pharmaceutical ethics and deontology, based on moral obligations and values, ethical standards of professional behavior and responsibility in accordance with the Code of Ethics of Pharmaceutical Workers of Ukraine and WHO guidelines	To know the methods of communication technologies in practical activities	To be able to use communication technologies and communication skills	To apply competently communication skills, fundamental principles of pharmaceutical ethics and deontology, based on moral obligations and values, ethical norms of professional behavior and responsibility in accordance with the Code of Ethics of Pharmaceutical Workers of Ukraine and WHO guidelines in practical activities	Be responsible for the correct application of communication skills, fundamental principles of pharmaceutical ethics and deontology based on moral obligations and values, ethical norms of professional behavior in practical activities
SC20	The ability to develop methods of quality control of medicinal products, including active pharmaceutical ingredients, medicinal plant raw materials and auxiliary substances using physical, chemical, physico-chemical, biological, microbiological, pharmacotechnological and pharmaco-organoleptic control methods	To know the main biochemical and physicochemical methods for development methods of quality control of medicinal products, including active pharmaceutical ingredients, medicinal plant raw materials and auxiliary substances	To be able to apply various research methods for development methods of quality control of medicinal products, including active pharmaceutical ingredients, medicinal plant raw materials and auxiliary substances	To use competently professional terms in the scientific community and communicate with colleagues when conducting physico-chemical, biological and biochemical research methods for the development of methods of quality control of medicinal products	To be responsible for accuracy and professionalism and correct interpretation of the results of biochemical studies in the development of methods of quality control of medicinal products

Learning outcomes:

Integrative final program learning outcomes, the formation of which is facilitated by the educational discipline "Biological chemistry":

PRL1. To conduct professional activities in social interaction based on humanistic and ethical principles; to identify future professional activity as socially significant for human health.

PRL2. To apply knowledge of general and professional disciplines in professional activities.

PRL4. To demonstrate the ability to independently search, analyze and synthesize information from various sources and use these results to solve typical and complex specialized tasks of professional activity.

PRL7. To perform professional activities using creative methods and approaches.

PRL8. To carry out professional communication in the state language, use oral communication skills in a foreign language, analyzing specialized texts and translating foreign language information sources.

PRL9. To carry out professional activities using information technologies, information databases, navigation systems, Internet resources, software tools and other information and communication technologies.

PRL10. To adhere to the norms of communication in professional interaction with colleagues, management, consumers, work effectively in a team.

PRL12. To analyze information obtained because of scientific research, generalize, arrange and use it in professional activities.

PRL15. To provide pre-medical assistance to patients in emergency situations and victims in extreme situations.

PRL16. To determine the influence of factors affecting the processes of absorption, distribution, deposition, metabolism, and excretion of the medicinal product and are determined by the condition, features of the human body and the physico-chemical properties of medicinal products.

PRL17. To use the data of clinical, laboratory and instrumental studies to monitor the effectiveness and safety of the use of medicinal products.

PRL18. To choose biological objects of analysis, determine xenobiotics and their metabolites in biological environments, and evaluate the results obtained considering their distribution in the body.

PRL25. To contribute to the preservation of health, in particular the prevention of diseases, the rational prescription and use of medicinal products. To faithfully fulfill one's professional duties, to comply with the legislation on the promotion and advertising of medicinal products. To possess psychological communication skills to achieve trust and mutual understanding with colleagues, doctors, patients, consumers.

Learning outcomes for the discipline:

As a result of studying the academic discipline "Biological Chemistry", the student should **know:**

- The structure of bioorganic compounds and the functions they perform in the human body.
- The reactivity of the main classes of biomolecules, which ensures their functional properties and metabolic transformations in the body.
- Biochemical mechanisms of pathological processes in the human body.
- Peculiarities of diagnosing the physiological state of the body and the development of pathological processes based on biochemical studies.
- The relationship between the peculiarities of the structure and transformations in the body of bioorganic compounds as the basis of their pharmacological action as medicines.
- Basic mechanisms of biochemical action and principles of directed application of various classes of pharmacological agents.
- Biochemical and molecular bases 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 indicators used to diagnose the most common human diseases.
- The importance of biochemical processes of metabolism and its regulation in ensuring the functioning of organs, systems and the entire human body.

be able to:

- Analyze the correspondence of the structure of bioorganic compounds to the physiological functions they perform in the human body.
- Interpret the peculiarities of the physiological state of the body and the development of pathological processes on the basis of laboratory studies.
- Analyze the reactivity of carbohydrates, lipids, amino acids, which ensures their functional properties and metabolic transformations in the body.
- Interpret the peculiarities of the structure and transformations of bioorganic compounds in the body as the basis of their pharmacological action as medicines.
- Interpret the biochemical mechanisms of pathological processes in the human body and the principles of their correction.
- Explain the basic mechanisms of biochemical action and the principles of targeted use of various classes of pharmacological agents.
- Explain the biochemical and molecular basis of the physiological functions of cells, organs and systems of the human body.
- Analyze the results of biochemical studies and changes in biochemical and enzymatic parameters used to diagnose the most common human diseases
- Classify the results of biochemical studies and changes in biochemical and enzymatic indicators used for the diagnosis of the most common human diseases.
- Interpret the meaning of biochemical processes of metabolism and its regulation in ensuring the functioning of organs, systems and the entire human body.

2. Information volume of the educational discipline

6 ECTS credits of 180 hours are assigned to the study of the academic discipline.

The discipline "Biological Chemistry" is structured into 2 content modules:

Content module 1. General patterns of metabolism. Metabolism of carbohydrates, lipids and its regulation.

Topic 1. Introduction to biochemistry. Methods of biochemical research. Amino acid composition, structure, physicochemical properties, classification and functions of simple and complex proteins.

Topic 2. Enzymes: structure, physical and chemical properties, classification and mechanism of action of enzyme proteins. Methods of detecting enzymes in biological objects.

Topic 3. Kinetics of enzymatic reactions. Regulation and determination of enzyme activity.

Topic 4. Regulation of enzymatic processes and analysis of mechanisms of occurrence of enzymopathies. Use of enzymes as pharmaceuticals.

Topic 5. Study of the functional role of water-soluble vitamins (coenzymes) in metabolism and implementation of cellular functions. Water-soluble vitamins as pharmaceuticals. The role of cofactors and coenzyme vitamins in the manifestation of catalytic activity of enzymes.

Topic 6. Study of the functional role of fat-soluble vitamins in metabolism and implementation of cellular functions. Fat-soluble vitamins as pharmaceuticals. Antivitamins. Vitamin-like substances and food supplements.

Topic 7. Processes of biological oxidation. General patterns of metabolism of substances and energy. Functioning of the cycle of tricarboxylic acids.

Topic 8. Molecular bases of bioenergetics. Enzymes of biological oxidation; molecular organization of the chain of biological oxidation. Oxidative phosphorylation, its regulation. Inhibitors and uncouplers of respiration and oxidative phosphorylation of the mitochondrial respiratory chain.

Topic 9. Study of glycolysis - anaerobic oxidation of carbohydrates.

Topic 10. Research of aerobic oxidation of glucose and alternative ways of monosaccharide metabolism.

Topic 11. Glycogen catabolism and biosynthesis. Regulation of glycogen metabolism. Biosynthesis of glucose - gluconeogenesis.

Topic 12. Mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Violation of carbohydrate metabolism.

Topic 13. Catabolism and biosynthesis of triacylglycerols. Intracellular lipolysis and molecular mechanisms of its regulation.

Topic 14. Metabolism of complex lipids and ketone bodies.

Topic 15. β -Oxidation and biosynthesis of fatty acids. Study of fatty acid metabolism.

Topic 16. Biosynthesis and biotransformation of cholesterol. Regulation and pathologies of lipid metabolism.

Content module 2. Biochemical bases of proliferation, intercellular communications and physiological functions of organs and tissues.

Topic 17. General pathways of transformation of amino acids in the body (transamination, deamination, decarboxylation). Biosynthesis of glutathione and creatine.

Topic 18. Research of ammonia detoxification processes and urea biosynthesis. Specific pathways of amino acid metabolism.

Topic 19. Research of specialized pathways of metabolism of cyclic amino acids. Disorders and pathology of these metabolic pathways.

Topic 20. Study of the biochemical composition and biosynthesis of purine and pyrimidine nucleotides. Biochemical functions of nucleotides and nucleic acids.

Topic 21. Catabolism of purine and pyrimidine nucleotides. Determination of the final products of their exchange. Hereditary disorders of nucleotide exchange.

Topic 22. DNA replication and RNA transcription. Analysis of the mechanisms of mutations and DNA repair. Principles of obtaining recombinant DNA and transgenic proteins. Mutations.

Topic 23. Protein biosynthesis in ribosomes. Processes of initiation, elongation and termination in the synthesis of a polypeptide chain. Inhibitory effect of antibiotics. Principles of genetic engineering and gene cloning, their application in modern medicine.

Topic 24. Study of molecular and cellular mechanisms of action of hormones of protein-peptide nature, derivatives of amino acids and biogenic amines on target cells. Hormonal regulation of calcium homeostasis.

Topic 25. Study of molecular and cellular mechanisms of action of steroid and thyroid hormones on target cells.

Topic 26. Chromoproteins (hemoglobin and its derivatives). The structure of hemoglobin and its biological role. Biosynthesis of porphyrins, mechanisms of porphyria formation.

Topic 27. Research of biochemical functions of blood. Blood plasma proteins, non-protein nitrogen-containing and nitrogen-free blood components. Blood acid-base status and its regulation.

Topic 28. Research of coagulation, anticoagulation and fibrinolytic system of blood. Biochemical regularities of implementation of immune processes.

Topic 29. The role of the liver in the metabolism of carbohydrates, lipids, and proteins. Exchange of end products of heme catabolism. Pathobiochemistry of jaundice.

Topic 30. Study of detoxification function of the liver. Processes of biotransformation of xenobiotics and endogenous toxins. Microsomal oxidation, cytochrome P-450. Basics of pharmaceutical biochemistry.

Topic 31. Research on the metabolism of water and mineral salts.

Topic 32. Study of the urinary function of the kidneys. Biochemical composition of human urine in normal and pathological conditions. Drugs used to correct kidney dysfunction.

Topic 33. Biochemistry of muscle tissue. Pharmaceuticals used for the correction of disorders of muscle tissue.

Topic 34. Biochemistry of nervous tissue. Pharmaceuticals used for the correction of disorders of nervous tissue.

Topic 35. Biochemistry of connective tissue. Pharmaceuticals used to correct disorders in the connective tissue.

3. The structure of the academic discipline

№	Topic	Lectures (hours)	Practice (hours)	SIW (hours)	Individual work
Content module 1. General patterns of metabolism. Metabolism of carbohydrates, lipids and its regulation.					
1	Introduction to biochemistry. Methods of biochemical research. Amino acid composition, structure, physicochemical properties, classification and functions of simple and complex proteins.		2	3	Work with studying literature, lecture notes, performing
2	Enzymes: structure, physical and chemical	2	2	3	

	properties, classification and mechanism of action of enzyme proteins. Methods of detecting enzymes in biological objects.				test tasks, filling in tables, working on the Internet, watching materials on computer
3	Kinetics of enzymatic reactions. Regulation and determination of enzyme activity.		2	3	
4	Regulation of enzymatic processes and analysis of mechanisms of occurrence of enzymopathies. Use of enzymes as pharmaceuticals.		2	3	
5	Study of the functional role of water-soluble vitamins (coenzymes) in metabolism and implementation of cellular functions. Water-soluble vitamins as pharmaceuticals. The role of cofactors and coenzyme vitamins in the manifestation of catalytic activity of enzymes.	2	2	3	
6	Study of the functional role of fat-soluble vitamins in metabolism and implementation of cellular functions. Fat-soluble vitamins as pharmaceuticals. Antivitamins. Vitamin-like substances and food supplements.		2	3	
7	Processes of biological oxidation. General patterns of metabolism of substances and energy. Functioning of the cycle of tricarboxylic acids.	2	2	3	
8	Molecular bases of bioenergetics. Enzymes of biological oxidation; molecular organization of the chain of biological oxidation. Oxidative phosphorylation, its regulation. Inhibitors and uncouplers of respiration and oxidative phosphorylation of the mitochondrial respiratory chain.		2	3	
9	Study of glycolysis - anaerobic oxidation of carbohydrates.	2	2	3	The same
10	Research of aerobic oxidation of glucose and alternative ways of monosaccharide metabolism.		2	3	
11	Glycogen catabolism and biosynthesis. Regulation of glycogen metabolism. Biosynthesis of glucose - gluconeogenesis.		2	3	
12	Mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Violation of carbohydrate metabolism.		2	3	
13	Catabolism and biosynthesis of triacylglycerols. Intracellular lipolysis and molecular mechanisms of its regulation.	2	2	3	The same
14	Metabolism of complex lipids and ketone bodies.		2	3	
15	β -Oxidation and biosynthesis of fatty acids. Study of fatty acid metabolism.		2	3	
16	Biosynthesis and biotransformation of cholesterol. Regulation and pathologies of lipid metabolism.		2	3	
	Content module 2. Biochemical bases of proliferation, intercellular communications and physiological functions of organs and tissues.				
17	General pathways of transformation of amino	2	2	3	

	acids in the body (transamination, deamination, decarboxylation). Biosynthesis of glutathione and creatine.				The same
18	Research of ammonia detoxification processes and urea biosynthesis. Specific pathways of amino acid metabolism.		2	2	
19	Research of specialized pathways of metabolism of cyclic amino acids. Disorders and pathology of these metabolic pathways.		2	2	
20	Study of the biochemical composition and biosynthesis of purine and pyrimidine nucleotides. Biochemical functions of nucleotides and nucleic acids.	2	2	2	The same
21	Catabolism of purine and pyrimidine nucleotides. Determination of the final products of their exchange. Hereditary disorders of nucleotide exchange.		2	2	
22	DNA replication and RNA transcription. Analysis of the mechanisms of mutations and DNA repair. Principles of obtaining recombinant DNA and transgenic proteins. Mutations.		2	3	
23	Protein biosynthesis in ribosomes. Processes of initiation, elongation and termination in the synthesis of a polypeptide chain. Inhibitory effect of antibiotics. Principles of genetic engineering and gene cloning, their application in modern medicine.		2	3	The same
24	Study of molecular and cellular mechanisms of action of hormones of protein-peptide nature, derivatives of amino acids and biogenic amines on target cells. Hormonal regulation of calcium homeostasis.	2	2	3	
25	Study of molecular and cellular mechanisms of action of steroid and thyroid hormones on target cells.		2	2	
26	Chromoproteins (hemoglobin and its derivatives). The structure of hemoglobin and its biological role. Biosynthesis of porphyrins, mechanisms of porphyria formation.	2	2	2	The same
27	Research of biochemical functions of blood. Blood plasma proteins, non-protein nitrogen-containing and nitrogen-free blood components. Blood acid-base status and its regulation.		2	2	
28	Research of coagulation, anticoagulation and fibrinolytic system of blood. Biochemical regularities of implementation of immune processes.		2	2	
29	The role of the liver in the metabolism of carbohydrates, lipids, and proteins. Exchange of end products of heme catabolism. Pathobiochemistry of jaundice.	2	2	2	
30	Study of detoxification function of the liver. Processes of biotransformation of xenobiotics and endogenous toxins. Microsomal oxidation, cytochrome P-450. Basics of pharmaceutical		2	2	

	biochemistry.				
31	Research on the metabolism of water and mineral salts.		2	2	
32	Study of the urinary function of the kidneys. Biochemical composition of human urine in normal and pathological conditions. Drugs used to correct kidney dysfunction.		2	2	
33	Biochemistry of muscle tissue. Pharmaceuticals used for the correction of disorders of muscle tissue.		2	2	The same
34	Biochemistry of nervous tissue. Pharmaceuticals used for the correction of disorders of nervous tissue.		2	2	
35	Biochemistry of connective tissue. Pharmaceuticals used to correct disorders in the connective tissue.		2	2	
	Total, hours – 180 Credits ECTS - 6	20	70	90	
	Final control				Exam

4. Thematic plan of lectures

№	Topic	Hours
1	The history of the development of biochemistry. Methods of biochemical research. Enzymes: mechanism of action and regulation of enzyme activity, kinetics of enzymatic reactions. The role of cofactors and coenzyme vitamins in the manifestation of catalytic activity of enzymes. Enzymopathies. Use of enzymes as pharmaceuticals.	2
2	Vitamins. Water-soluble and fat-soluble vitamins. Vitamins as pharmaceuticals. Vitamin-like substances. Antivitamins. Food supplements.	2
3	General patterns of metabolism of substances and energy. Tricarboxylic acid cycle. Molecular basis of bioenergetics. Biological oxidation. Oxidative phosphorylation and its regulation. The influence of pharmaceuticals on the processes of biological oxidation.	2
4	Carbohydrates. Metabolism of monosaccharides: aerobic and anaerobic oxidation. Gluconeogenesis. Alternative pathways of monosaccharide metabolism. Metabolism of polysaccharides. Regulation and pathologies of carbohydrate metabolism. Correction of carbohydrate metabolism disorders with pharmaceuticals.	2
5	Lipids. Metabolism of simple lipids. Metabolism of complex lipids and its regulation. Transport of lipids in the blood. Correction of lipid metabolism disorders with pharmaceuticals.	2
6	General pathways of amino acid metabolism in the body (transamination, decarboxylation, deamination). Study of the processes of ammonia detoxification and urea biosynthesis. Specific metabolic pathways of cyclic and sulfur-containing amino acids and their disorders. Metabolism of arginine.	2
7	Peculiarities of nucleotide metabolism in normal and pathological conditions. General characteristics of matrix syntheses and their regulation. Molecular mechanisms of mutations.	2
8	Modern classification and molecular mechanisms of hormone action. Regulation of metabolism by hormones of protein-peptide, thyroid and steroid nature. Hormone-like substances. Hormones as pharmaceuticals.	2
9	Biochemistry of blood. Regulation and maintenance of homeostasis of the human body. Biological role and metabolism of hemoglobin (heme synthesis). Regulation of the acid-base state. Blood plasma proteins. General characteristics of coagulation, fibrinolytic and immune systems of blood.	2
10	Biochemical functions of the liver (catabolism of heme and its disorders). Biochemistry of jaundice. Biotransformation of endogenous substances and	2

	xenobiotics in the liver. Metabolism of drugs in the liver.	
	Total	20

5. Thematic plan of practice

№	Topic	Hours
1	Introduction to biochemistry. Methods of biochemical research. Amino acid composition, structure, physicochemical properties, classification and functions of simple and complex proteins.	2
2	Enzymes: structure, physical and chemical properties, classification and mechanism of action of enzyme proteins. Methods of detecting enzymes in biological objects.	2
3	Kinetics of enzymatic reactions. Regulation and determination of enzyme activity.	2
4	Regulation of enzymatic processes and analysis of mechanisms of occurrence of enzymopathies. Use of enzymes as pharmaceuticals.	2
5	Study of the functional role of water-soluble vitamins (coenzymes) in metabolism and implementation of cellular functions. Water-soluble vitamins as pharmaceuticals. The role of cofactors and coenzyme vitamins in the manifestation of catalytic activity of enzymes.	2
6	Study of the functional role of fat-soluble vitamins in metabolism and implementation of cellular functions. Fat-soluble vitamins as pharmaceuticals. Antivitamins. Vitamin-like substances and food supplements.	2
7	Processes of biological oxidation. General patterns of metabolism of substances and energy. Functioning of the tricarboxylic acids cycle.	2
8	Molecular bases of bioenergetics. Enzymes of biological oxidation; molecular organization of the chain of biological oxidation. Oxidative phosphorylation, its regulation. Inhibitors and uncouplers of respiration and oxidative phosphorylation of the mitochondrial respiratory chain.	2
9	Study of glycolysis - anaerobic oxidation of carbohydrates.	2
10	Research of aerobic oxidation of glucose and alternative ways of monosaccharide metabolism.	2
11	Glycogen catabolism and biosynthesis. Regulation of glycogen metabolism. Biosynthesis of glucose - gluconeogenesis.	2
12	Mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Violation of carbohydrate metabolism.	2
13	Catabolism and biosynthesis of triacylglycerols. Intracellular lipolysis and molecular mechanisms of its regulation.	2
14	Metabolism of complex lipids and ketone bodies.	2
15	β -Oxidation and biosynthesis of fatty acids. Study of fatty acid metabolism.	2
16	Biosynthesis and biotransformation of cholesterol. Regulation and pathologies of lipid metabolism.	2
17	General pathways of transformation of amino acids in the body (transamination, deamination, decarboxylation). Biosynthesis of glutathione and creatine.	2
18	Research of ammonia detoxification processes and urea biosynthesis. Specific pathways of amino acid metabolism.	2
19	Research of specialized pathways of metabolism of cyclic amino acids. Disorders and pathology of these metabolic pathways.	2
20	Study of the biochemical composition and biosynthesis of purine and pyrimidine nucleotides. Biochemical functions of nucleotides and nucleic acids.	2
21	Catabolism of purine and pyrimidine nucleotides. Determination of the final products of their exchange. Hereditary disorders of nucleotide exchange.	2
22	DNA replication and RNA transcription. Analysis of the mechanisms of mutations and DNA repair. Principles of obtaining recombinant DNA and transgenic proteins. Mutations.	2
23	Protein biosynthesis in ribosomes. Processes of initiation, elongation and termination in the synthesis of a polypeptide chain. Inhibitory effect of antibiotics. Principles of genetic engineering and gene cloning, their application in modern medicine.	2

24	Study of molecular and cellular mechanisms of action of hormones of protein-peptide nature, derivatives of amino acids and biogenic amines on target cells. Hormonal regulation of calcium homeostasis.	2
25	Study of molecular and cellular mechanisms of action of steroid and thyroid hormones on target cells.	2
26	Chromoproteins (hemoglobin and its derivatives). The structure of hemoglobin and its biological role. Biosynthesis of porphyrins, mechanisms of porphyria formation.	2
27	Research of biochemical functions of blood. Blood plasma proteins, non-protein nitrogen-containing and nitrogen-free blood components. Blood acid-base status and its regulation.	2
28	Research of coagulation, anticoagulation and fibrinolytic system of blood. Biochemical regularities of implementation of immune processes.	2
29	The role of the liver in the metabolism of carbohydrates, lipids, and proteins. Exchange of end products of heme catabolism. Pathobiochemistry of jaundice.	2
30	Study of detoxification function of the liver. Processes of biotransformation of xenobiotics and endogenous toxins. Microsomal oxidation, cytochrome P-450. Basics of pharmaceutical biochemistry.	2
31	Research on the metabolism of water and mineral salts.	2
32	Study of the urinary function of the kidneys. Biochemical composition of human urine in normal and pathological conditions. Drugs used to correct kidney dysfunction.	2
33	Biochemistry of muscle tissue. Pharmaceuticals used for the correction of disorders of muscle tissue.	2
34	Biochemistry of nervous tissue. Pharmaceuticals used for the correction of disorders of nervous tissue.	2
35	Biochemistry of connective tissue. Pharmaceuticals used to correct disorders in the connective tissue.	2
	Total	70

6. Thematic plan of student`s individual work

№	Topic	Hours	Control
1	Modern methods of biochemical research. The contribution of scientists of the Department of Biochemistry of Danylo Halytsky Lviv National Medical University to the development of biological chemistry.	3	
2	Modern methods of separation and purification of protein mixtures used for the separation of enzymes. Examples and their characteristics.	3	
3	The use of inhibitors of enzymatic catalysis as pharmaceuticals. Examples and their characteristics.	3	
4	The use of isoenzymes in enzymodiagnosis of diseases. The use of enzymes as pharmaceuticals in diseases of the digestive system, purulent-necrotic processes, as fibrinolytic drugs, etc.	3	
5	Regulation of hematopoietic processes by coenzyme forms of vitamins B ₁₂ and folic acid.	3	
6	Vitamin-like substances and their role in metabolism.	3	
7	The role of the most important metabolites of amphibolic pathways (glucose-6-phosphate, pyruvate, α -ketoglutarate, acetyl-S-CoA, succinyl-S-CoA, etc.) and TCA cycle intermediates in the integration of metabolic processes.	3	
8	The mechanism of disruption of ATP synthesis under the conditions of the action of pathogenic factors of chemical, biological and physical origin on the body.	3	
9	Peculiarities of the regulation of glycolysis in normal and pathological conditions. The molecular basis of the Pasteur and Crabtree effect.	3	
10	Causes and manifestations of congenital and acquired disorders of the pentose phosphate cycle. Disruption of fructose and galactose metabolism.	3	

11	Principles of regulation of glycogen metabolism. Biochemical basis of development; classification and features of the course of mucopolysaccharidoses.	3	Current control in practical classes	
12	Diagnostic methods and principles of biochemical correction of diabetes. Biochemical base and modern pharmaceuticals used for the treatment of diabetes.	3		
13	Peculiarities of molecular mechanisms of regulation of lipid metabolism. The role of hormones in regulation of lipid metabolism.	2		
14	Metabolism of sphingolipids and causes of its disturbance.	3		
15	Biological functions of polyunsaturated fatty acids, sources and their use as pharmaceuticals. Carnitine and its role in fatty acid metabolism.	3		
16	Modern antihyperlipidemic pharmaceuticals and their use in the regulation of lipid metabolism disorders.	3		
17	Metabolism of glutathione and creatine and their role in cell metabolism. Metabolism of tryptophan, threonine, serine, glycine and branched chain amino acids, disturbance of their metabolism.	3		
18	Disturbance of the urea cycle.	2		
19	Aminoaciduria: causes of development and pharmacological correction.	2		
20	Biochemical functions of free nucleotides.	2		
21	Hereditary and acquired disorders of metabolism of nucleotides.	2		
22	General concepts and significance of recombinant DNA technologies (genetic engineering).	3		
23	The effect of antibiotics and other pharmaceuticals on matrix syntheses in the cell. The use of medicines in the symptomatic treatment of coronavirus disease.	3		
24	Protein-peptide factors of tissue growth and proliferation.	3		
25	The use of the radioimmunoassay method in the quantitative determination of hormones.	2		
26	Myoglobin and its role in the functioning of muscle tissue.	2		
27	Fractional composition of blood plasma proteins in normal and pathological conditions.	2		
28	Modern anticoagulant drugs and their use.	2		
29	Hereditary disorders of hemoglobin metabolism.	2		
30	Tolerance to medicines.	2		
31	Hormonal mechanisms of regulation of water-mineral metabolism and kidney functions.	2		
32	The effect of pharmaceuticals on kidney function and physicochemical properties of urine.	2		
33	Biochemistry of muscle tissue. Molecular mechanisms and biochemical manifestations of muscle tissue metabolism disorders.	2		
34	Nervous biochemistry. Molecular mechanisms and biochemical manifestations of nervous tissue metabolism disorders. The effect of pharmaceuticals on the functions of the nervous system.	2		
35	The influence of pharmaceuticals on the functions of connective tissue.	2		
	Total	90		

7. Individual tasks

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. Tasks for individual work

Tasks for independent work are mandatory tasks highlighted in workbooks, which the student must prepare for each lesson; taking notes, filling out a workbook, studying vocabulary, studying subtopics that do not require explanation.

9. Teaching methods

- methods of organization and implementation of educational and cognitive activities (explanatory and illustrative; reproductive);
- methods of stimulation and motivation of educational and cognitive activity (problematic presentation; partially research);
- methods of control and self-control for the effectiveness of educational and cognitive activities.

The methods of educational activity according to the curriculum are:

- lectures,
- practical classes,
- student's individual work (SIW)

The structure of practical work includes a control work and a practical part.

The control work is conducted in the form of test control (20 tests) and theoretical questions (3 questions).

Practical work is carried out in the form of laboratory works, situational problems, multimedia presentations, using the case method.

Independent work is checked and discussed in a practical lesson.

10. Control methods:

Methods of oral control and self-control:

- Individual survey;
- Frontal survey;
- Programmed survey.

Methods of written control and self-control:

- Control written work;
- Control test tasks

During the study of the discipline "Biological Chemistry", all types of student activities are subject to control, both current (at each class) and final (credit).

1. *Current control* of the theoretical preparation of sections in the form of a test or survey is carried out during classroom training. Practical classes are evaluated on a traditional four-point scale.

Assessment of current educational activities. During the evaluation of mastery of each topic for the current educational activity, the student is given grades on a 4-point (traditional) scale, taking into account the approved evaluation criteria for the relevant discipline. At the same time, all types of work provided by the educational program are taken into account. The student must receive a grade in each topic. Forms of assessment of current educational activities should be standardized and include control of theoretical and practical training. Estimates given on a traditional scale are converted into points.

The grade "5" is given if the student is capable of independent study of the material; establishes and substantiates cause-and-effect relationships; is able to apply the studied material to make own reasoned judgments in practical activities; independently finds information (in scientific literature, mass media, Internet, uses computer programs, etc.); solves professional orientation tasks independently, freely uses terminology; independently solves and performs 91-100% of the total number of tests.

The grade "4" is given if the student has mastered most of the educational material, is able to reproduce it with some inconsistencies, has stable skills in working with the text of the textbook, can independently master most of the given material, formulates basic concepts, gives examples, knows basic terms; confirms the expressed judgment with one or two arguments; performs practical tasks independently, completes them without drawing complete conclusions; answers lack logic; performs 75-90% of the total number of tests.

A student receives **grade "3"** if he knows more than half of the educational material, is able to reproduce it with the help of the teacher, can highlight and remember the main provisions of the educational material, can confirm part of the answers with examples; performs practical tasks, prepares them and formulates conclusions in accordance with the purpose of the research; performs 50-74% of tests.

The grade "2" is given if the student attends classes, reproduces its topic and some concepts, is unable to complete practical work and complete it, completes less than 50% of tests.

The theoretical component involves testing or interviewing students on the topic of the lesson, checking and evaluating extracurricular (independent) work. Control of practical training is conducting an experiment, writing a protocol and drawing up relevant conclusions. The student's independent work (working on topics that are not included in the classroom work), provided by the work curriculum, is evaluated at the end of the study of the chapter, and is included in the chapter rating.

2. *Final control (credit)* for full-time and part-time education is conducted in the form of an exam according to the schedule.

11. The final control

The final control of studying success in the final test consists of the final test and theoretical questions.

During the study of the academic discipline "Biological Chemistry", control tools are conducted, which include current and final semester control. According to the curriculum, the form of final control is an exam.

Current control is carried out during practical classes and aims to check students' assimilation of educational material.

Current control of educational activities is carried out at each lesson in accordance with specific goals, as well as during the individual work of the teacher with the student for those topics that the student works on independently.

Control includes:

1. Oral survey of students - individual, frontal.
2. Students' written answers to standard test tasks, including 20 tests. Each test task has one correct answer out of five suggested (format A).
3. Completion of written tasks in the format of three questions. Tasks are presented in the form of sequences of transformations of bioorganic compounds, a list of certain biochemical indicators, filling in tables, drawing up a scheme, writing equations of chemical reactions, etc.
4. Solving of situational tasks in oral and written form.
5. Control of student's independent work. Points for SIW are awarded upon successful defense during an oral or written examination.
6. Control of the performance of practical (laboratory) work and preparation of the protocol of the practical session. The quality of performance is assessed by the teacher during the practical session.

Assessment of current educational activities. During the evaluation of the mastery of each topic for the current educational activity, the student is given grades on a 4-point (traditional) scale. At the same time, all types of work provided by the educational program are taken into account. The student must receive a grade in each topic. Forms of assessment of current educational activities should be standardized and include control of theoretical and practical training. Estimates given on a traditional scale are converted into points.

Assessment of final control.

The assessment for the exam consists of assessment of test tasks and assessment of theoretical tasks (including practical skills).

For theoretical questions, the student receives:

The grade "**excellent**" student gets if he answered the written theoretical tasks without errors (including practical skills), justified the results obtained, that is: comprehensively and deeply mastered the educational program material; fully possesses theoretical knowledge and practical skills.

The grade is "**good**" if student made some minor mistakes in the answers to written theoretical tasks (including practical skills) but did not fully justify the data obtained.

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

The grade is "**unsatisfactory**" if gross mistakes were made in the answers to the written tasks or no answers were given at all.

12. Scheme of calculation and distribution of points received by students

For disciplines for which the form of final control is an exam:

The maximum number of points that a student can score for the current educational activity for admission to the exam (differentiated credit) is 120 points.

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

The calculation of the number of points is made on the basis of the grades received by the student on a 4-point (national) scale during the study of the discipline, by calculating the arithmetic mean (CA), rounded to two decimal places. The obtained value is converted into points on a multi-point scale as follows:

$$X = (CA \times 120) / 5$$

For convenience, a calculation table on a 200-point scale is provided: For convenience, a calculation table on a 200-point scale is provided:

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

4-score scale	200-score scale	4.33	104	3.58	86
5	120	4.29	103	3.54	85
4.95	119	4.25	102	3.49	84
4.91	118	4.2	101	3.45	83
4.87	117	4.16	100	3.41	82
4.83	116	4.12	99	3.37	81
4.79	115	4.08	98	3.33	80
4.75	114	4.04	97	3.29	79
4.7	113	3.99	96	3.25	78
4.66	112	3.95	95	3.2	77
4.62	111	3.91	94	3.16	76
4.58	110	3.87	93	3.12	75
4.54	109	3.83	92	3.08	74
4.5	108	3.79	91	3.04	73
4.45	107	3.74	90	3	72
4.41	106	3.7	89	Less than 3	Insufficiently
4.37	105	3.66	88		

Student's individual work is evaluated during the ongoing control of the topic in the corresponding lesson. The learning of topics that are assigned only to independent work is controlled during the final control.

The final control is carried out to evaluate the results of training at a certain educational and qualification level and at individual completed stages according to the national scale and the ECTS scale. Final control includes semester control and student certification.

The semester exam is a form of final control of the student's assimilation of theoretical and practical material from a separate academic discipline for the semester, which is conducted as a control event. A student is considered admitted to the semester exam in the academic discipline if he attended all the practical lessons provided for in the educational program for the discipline, completed all types of work provided for in the work program of this educational discipline and during its study during the semester scored several points not less than the minimum (72 points).

The semester exam is conducted in written form during the exam session, according to the schedule. The form of the examination should be standardized and include control of theoretical and practical training.

Evaluation criteria for test tasks:

Less than 25 tests - "unsatisfactory";

25-30 tests - "satisfactory";

31-36 tests - "good";

37-40 tests - "excellent".

Correct answer to 1 test - 1 point.

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

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

Evaluation criteria for theoretical tasks:

Each of the five theoretical tasks is evaluated from 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.

The grade "excellent" (75-80 points) is awarded to a student who gave correct answers to 37-40 standardized tests, answered written theoretical tasks without errors (including practical skills), substantiated the results obtained (38-40 points), i.e.: comprehensive and deeply mastered the curriculum material; fully possesses theoretical knowledge and practical skills

The grade of "good" (62 - 74 points) is given to a student who gave correct answers to 31 - 36 standardized tests, made some minor mistakes in answers to written theoretical tasks (including practical skills), but did not fully justify the data obtained (31 - 37 points).

The grade of "satisfactory" (50 - 61 points) is given to a student who gave correct answers to 25 - 31 standardized tests, made significant mistakes in answers to written theoretical tasks (including practical skills) (25 - 30 points).

The grade of "unsatisfactory" is given to a student who gave correct answers to fewer than 25 standardized tests, made gross mistakes in answers to written assignments, or did not answer them at all.

The maximum number of points a student can score while taking the exam is 80.

The minimum score for the exam is at least 50.

The subject grade is defined as the sum of points for the current educational activity (at least 72) and points for the exam (at least 50).

Under the conditions of the pandemic, the exam is conducted remotely using the MISA system in the form of test control according to the schedule. Exam duration – 2 academic hours (90 minutes). Test control includes 40 tests with one correct answer and 40 tests with several correct answers (4 correct answers out of 8).

Evaluation criteria for test tasks:

Критерії оцінки тестових завдань:

Correct answer to 1 test with one correct answer - 1 point.

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

Tests with many correct answers are evaluated:

- 1 correct answer – 0,25 points;

- 2 correct answers – 0,5 points;

- 3 correct answers – 0,75 points;

- 4 correct answers - 1 point.

- incorrect answer(s) - 0 points.

The maximum number of points a student can score while taking the exam is 80.

The minimum number of points when passing the exam is not less than 50.

Points from the discipline are independently converted both to the ECTS scale and to the 4-point scale. Points from the ECTS scale are not converted into a 4-point scale and vice versa. Points of students studying in one specialty, considering the number of points scored in the discipline, are ranked on the ECTS scale as follows:

ECTS assessment	Statistical indicator
A	The best 10% of students
B	The next 25% of students
C	The next 30% of students
D	The next 25% of students
E	The last 10% of students

Discipline points for students who have successfully completed the program are converted to a traditional 4-point scale according to the absolute criteria listed in the table below:

Points in the discipline	Mark 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

The ECTS grade is not converted to the traditional scale, as the ECTS scale and the four-score scale are independent. The objectivity of the assessment of students' educational activity is checked by statistical methods (correlation coefficient between the ECTS grade and the grade on the national scale).

Rating scale: national and ECTS

The sum of points for all types of educational activities	Evaluation on a national scale	
	for an exam, course project (work), practice	for credit
200-170	excellent	counted
169-140	good	
139-114	satisfactory	
>114	unsatisfactory with the possibility of reassembly	not counted with the possibility of retaking
>114	unsatisfactory with mandatory re-study of the discipline	not credited with mandatory repeated study of the discipline

13. Methodological support: educational content (synopsis or extended lecture plan), plans for practical (seminar) classes, tasks for laboratory work, student's independent work, questions, problems, tasks or cases for current and final control of students' knowledge and skills, comprehensive control work, after attestation monitoring of acquired knowledge and skills in the academic discipline.

14. Recommended literature

Main:

- Gubsky Yu. Bioorganic and biological chemistry. Book 2. Biological chemistry. Second edition. Medicine 2021. 500 p.
- Harper's Illustrated Biochemistry 30th edition / V. W. Rodwell et al.; NY: McGraw-Hill Education, 2015. 817 p.
- Satyanarayana U., Chakrapani U. Biochemistry. Fifth edition, N.Delhy: Elsevier, co-published with Book and Allied, 2017. 788 p.
- Gubsky Yu. Biological Chemistry. Nova Knyha, Vinnytsia, 2017. 487 p.
- Nelson D. L., Cox M. M. Lehninger Principles of Biochemistry. 8-th edition. W. H. Freeman and Company, New York, 2021. 1328 p.
- Swanson T. A., Kim S. I., Glucksman M. J. Biochemistry, Molecular Biology, and Genetics 5th edition / Lippincott Williams & Wilkins, 2010. 380 p.
- McKee T., McKee J. R. Biochemistry. The molecular basis of life. Seventh edition. Oxford University Press, 2019. 448 p.
- Lippincott Illustrated Reviews: Biochemistry. Denise R. Ferrier. Seventh edition. Wolters Kluwer, 2017. 2224 p.
- MCQs in biochemistry 2nd edition / A. Ya. Sklyarov et al.: Lviv: Danylo Halytsky Lviv National Medical University Press, 2020. 319 p.
- MCQs in biochemistry / A. Ya. Sklyarov et al.: Lviv: Danylo Halytsky Lviv National Medical University Press, 2012. 308 p.

Optional:

- Textbook of Biochemistry for Medical Students by Vasudevan D.M., Sreekumari S., Kannan Vaidyanathan. Seventh edition. Jaypee Brothers Medical Pub, 2013. 791 p.

12. Chatterjea M. N., Rana Shinde. Textbook of Medical Biochemistry. Eighth edition. Jaypee Brothers Medical Pub, 2012. 894 p.
13. Nelson D. L., Cox M. M. Lehninger Principles of Biochemistry. Seventh edition. W.H. Freeman and Company, New York, 2017. 1328 p.
14. Trudy McKee, James R. McKee. Biochemistry. The molecular basis of life. Sixth edition. Oxford University Press, 2015. 928 p.
15. Peter Ronner. Netter's Essential Biochemistry. Elsevier, 2018. 482 p.
16. Ronner P. Netter's Essential Biochemistry. Elsevier, 2018. 482 p
17. Tymoczko J.L., Berg J.M., Stryer L. Biochemistry: A Short Course. W. H. Freeman; Third edition, 2015. 896 p.
18. Lieberman M. Marks' Basic Medical Biochemistry: A Clinical Approach. LWW; 5th edition. 2017. P. 1008
19. Lorch M. Biochemistry: A Very Short Introduction. Oxford University Press. 2021. 160 p.
20. Oraby S. Biochemistry for medical students and postgraduates. Twelfth Edition. – 2013. – Part 1. – 248 p.
21. Copeland R. A. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis. - Wiley-VCH, Inc. – 2000. – 412 p.
22. Toy E.C., Seifert W. E., Strobel H. W., Harms K. P. “Case Files in Biochemistry. 2nd edition” – 2008. – 488 p.
23. Moore J. T., Langley R.H. Biochemistry For Dummies. For Dummies; 3rd edition. 2022. 368 p.
24. Miesfeld R. L., McEvoy M. M. Biochemistry. W. W. Norton & Company; Second edition. 2021. 1392 p.
25. Pratt Ch., Cornely K. Essential Biochemistry. Wiley; 5th edition. 2021. 816 p
26. 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 KROK-1 <http://testcentr.org.ua/>