

APPROVED



The first vice-rector for scientific
and pedagogical work
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**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 221 “Stomatology”**

for students of II year of dentistry faculty

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.

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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 221 "Dentistry"
Master of Dentistry educational program

DESCRIPTION OF THE EDUCATIONAL DISCIPLINE

The study of biological chemistry is carried out during the III - IV semesters of the 2nd year of study.

Biological chemistry as an educational discipline:

- is based on students' study of medical biology, biophysics, medical chemistry (bioorganic, bioinorganic, physical and colloidal chemistry), morphological disciplines and is integrated with these disciplines;
- lays the foundations for students 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 activity;
- lays the foundations for clinical diagnosis of the most common diseases, monitoring the course of the disease, control over the effectiveness of the use of medicines and measures aimed at preventing the occurrence and development of pathological processes;

The structure of the academic discipline	Number of credits, hours, of them				Study year /semester	Type of control
	Total	Auditory		SIW		
		Lectures (hours)	Practice (hours)			
Subjects: Biological chemistry	5 credits 150 hours	16	59	75	2 nd year (III-IV semester)	Exam
according to semesters						
	3 credits 90 hours	8	33	49	III semester	
	2 credits 60 hours	8	26	26	IV semester	Exam

The subject of study of the academic discipline is the chemical composition of living organisms (the human body) and the biochemical transformations to which the molecules that make up them are subject.

Interdisciplinary connections: normal anatomy, histology, biology, organic chemistry, normal physiology, microbiology.

1. The purpose and tasks of the educational discipline.

1.1. The purpose of teaching the educational discipline "Biological Chemistry" is the study of biomolecules and the molecular organization of cell structures, the general laws of enzymatic catalysis and the biochemical dynamics of the transformation of the main classes of biomolecules (amino acids, carbohydrates, lipids, nucleotides, porphyrins, etc.), molecular biology and the genetics of informative macromolecules (proteins and nucleic acids), i.e. molecular mechanisms of heredity and implementation of genetic information, hormonal regulation of metabolism and biological functions of cells, biochemistry of special physiological functions.

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

2.1.1. mastering the knowledge and skills to conduct biochemical research to identify normal and pathological components in biological fluids;

2.1.2. analyze the results of biochemical research for the diagnosis of the most common human diseases;

2.1.3. to analyze the biochemical processes of metabolism and its regulation in ensuring the functioning of organs and systems of the human body.

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 abstract thinking, analysis and synthesis.
- Knowledge and understanding of the subject area and understanding of professional activity.
- Ability to apply knowledge in practical activities.
- Ability to communicate in the national language both orally and in writing.
- Ability to communicate in English.
- Skills in using information and communication technologies.
- Ability to search, process and analyze information from various sources.
- Ability to identify, pose and solve problems.
- Ability to be critical and self-critical.
- Ability to work in a team.
- The ability to act socially responsibly and consciously.

special (professional, subject):

- Ability to collect medical information about the patient and analyze clinical data.
- Ability to interpret the results of laboratory and instrumental research.
- Ability to diagnose: determine preliminary, clinical, final, accompanying diagnosis, emergency conditions.

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

Matrix of competences

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
1.	2	3	4	5	6
General competences					
1.	Ability to abstract thinking, analysis and synthesis.	Know methods of analysis, synthesis and further modern learning.	Be able to analyze information, make informed decisions.	Establish appropriate connections to achieve goals.	Be responsible for the timely acquisition of modern knowledge.
2.	Knowledge and understanding of the subject area and understanding of professional activity.	Know the ways of acquiring basic knowledge, know the methods of applying this knowledge in professional activity.	Be able to use knowledge in practice, when communicating .	Establish vertical and horizontal connections depending on the practical situation.	Be responsible for the timely acquisition of basic general and professional knowledge.
3.	The ability to apply knowledge in practical situations.	To know the methods of applying knowledge when solving practical issues.	Be able to use knowledge in various practical situations.	Establish connections vertically and horizontally depending on the practical situation.	To be responsible for the timeliness of decisions made in these situations.
4.	Ability to communicate in the national language, both speaking and writing.	Know the Ukrainian language.	Be able to write, read and speak in Ukrainian.	Use language knowledge for communication and personal development.	Be responsible for perfect command of the Ukrainian language.
5.	Ability to communicate in English.	Know English.	Be able to write, read and speak English.	Use knowledge of the language for communication and personal development.	Be responsible for the possession and correct interpretation in English.

6.	Skills in using information and communication technologies.	Know the methods of obtaining information and ways of using it.	Be able to analyze information.	Establish appropriate connections to achieve goals.	Be responsible for handling information.
7.	The ability to search for processing and analysis of information from various sources.	To know the techniques of searching and processing of information sources.	To be able to analyze information received from various sources.	To establish connections to ensure quality analysis of information.	To be responsible for the correct analysis of received information.
9	The ability to identify, pose and solve problems.	To know the ways of performing assigned tasks.	To be able to define the goal and task. To be persistent and conscientious in solving problems.	To establish interpersonal relationships for the effective performance of tasks and to solve problems.	To be responsible for the high-quality performance of assigned tasks.
10	The ability to be critical and self-critical.	To know and be aware of the problem, to notice facts that contradict one's own opinion.	To be able to apply a scientific approach to the information received, to be able to summarize and analyze it.	The ability to be aware independence introspection, purposefulness and self-organization.	Be responsible for formulating judgments regarding the truthfulness and reality of statements or answers regarding problem solving.
11	The ability to work in a team.	To know the ways of obtaining knowledge, skills, and abilities when working in a team.	To be able to apply the acquired knowledge, skills, abilities and personal qualities, abilities, values for team work.	The ability to cooperate with one's knowledge, skills and abilities for team work.	To be responsible for team work.
13	Ability to act socially responsibly and consciously	Know your social and public rights and responsibilities.	. Form your civic consciousness, be able to act in accordance with it.	Ability to convey your public and social position.	Be responsible for your civic position and activities.

Special (professional, subject) competences

1.	Ability to collect medical information about the patient and analyze clinical data	Have specialized knowledge.	Be able to use knowledge to analyze medical information and clinical data.	Ability to analyze medical information and clinical data.	Be responsible for the correct collection of medical information and analysis of clinical data.
2.	The ability to interpret the results of laboratory and instrumental studies.	To know the principles of conducting laboratory biochemical and instrumental studies.	To be able to justify the results of laboratory biochemical and instrumental research.	Use professional terms competently in the scientific community.	Be responsible for competent interpretation of laboratory biochemical and instrumental research.

3.	Ability to diagnose: determine preliminary, clinical, final and concomitant diagnoses, emergency conditions.	Know the main ones biochemical and molecular bases of pathological states of organs and systems of the human body.	To be able to apply the acquired knowledge when establishing a diagnosis of a person.	To analyze the manifestations of certain pathologies in order to establish the correct diagnosis and emergency conditions.	To be responsible for the quality of the performance of professional duties, including for establishing the correct diagnosis.
4.	The ability to determine the rational regime of work, rest and diet in patients in the treatment of diseases of the organs and tissues of the oral cavity and maxillofacial region.	Know the principles of developing a diet, work and rest regime of a person and the principles of their correction in the maxillofacial area.	Be able to analyze the manifestations of diseases of the oral cavity in order to prescribe the correct diet, work and rest regime.	Ability to use the acquired knowledge to establish the correct work, rest and diet regime.	To be responsible for prescribing a work, rest and diet regimen appropriate to the pathology.

Learning outcomes:

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

- Highlight and identify leading clinical symptoms and syndromes (according to list 1); according to standard methods, using the previous data of the patient's history, data of the patient's examination, knowledge about the person, his organs and systems, establish a probable nosological or syndromic preliminary clinical diagnosis of a dental disease (according to list 2).
- Collect information about the patient's general condition, evaluate the patient's psychomotor and physical development, the condition of the maxillofacial organs, based on the results of laboratory and instrumental studies, evaluate information about the diagnosis (according to list 5).
- Prescribe and analyze additional (mandatory and optional) examination methods (laboratory, x-ray, functional and/or instrumental) according to list 5, of patients with diseases of organs and tissues of the oral cavity and maxillofacial region for differential diagnosis of diseases (according to list 2).
- Plan and implement dental disease prevention measures among the population to prevent the spread of dental diseases.
- Analyze and evaluate government, social and medical information using standard approaches and computer information technologies.
- Follow a healthy lifestyle, use self-regulation and self-control techniques.
- To be aware of and be guided in one's activities by civil rights, freedoms and duties, to raise the general educational cultural level.

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

5 ECTS credits of 150 hours are assigned to the study of the academic discipline.

Topic 1. Biochemistry as a science, objects of study and tasks of biochemistry, methods of biochemical research.

1. Biochemistry as a science. The place of biochemistry among other medical and biological disciplines.
2. Objects of study and tasks of biochemistry. The leading role of biochemistry in establishing the molecular mechanisms of the pathogenesis of human diseases.
3. Connection of biochemistry with other biomedical sciences. Medical biochemistry. Clinical biochemistry. Biochemical laboratory diagnostics.
4. History of biochemistry; development of biochemical research in Ukraine.
5. Structural and functional components of cells, their biochemical functions. Classes of biomolecules. Their hierarchy and origin.
6. Contribution of scientists of the Department of Biochemistry of the Lviv National Medical University to the development of biological chemistry.
7. Basic methods of biochemical research:
 - optical methods in biochemistry (photoelectrocolorimetry, spectrometry, spectrophotometry, fluorescence analysis);
 - electrophoresis (horizontal, disc electrophoresis, isoelectric focusing, immunoelectrophoresis);
 - chromatography (affinity, ion-exchange, thin-layer, gas, gel chromatography);
 - polarography;
 - manometric and radioisotope methods;
 - immunoenzymatic methods;
 - polymerase chain reaction, its application in scientific and practical research.
8. Principles of collection and preservation of material for laboratory research. Errors in research.

Topic 2. Investigation of physicochemical properties and structure of enzyme proteins. Mechanism of action and kinetics of enzymatic catalysis.

1. Physicochemical properties of protein-enzymes: surface charge of the molecule, solubility, thermodynamic stability of protein-enzyme molecules, precipitation, denaturation, interaction with ligands and its functional significance.
2. Simple and complex protein-enzymes, prosthetic groups of complex protein-enzymes (cofactors, coenzymes).

3. Structure of enzymes: active, regulatory (allosteric) centers.
4. Levels of structural organization of enzymes. Multienzyme complexes, enzymatic ensembles, multifunctional enzymes, their advantages.
5. Nomenclature and classification of enzymes. Types of reactions catalyzed by individual classes of enzymes.
6. Mechanism of action and kinetics of enzymatic reactions: dependence of the reaction rate on temperature, pH of the medium, substrate concentration.
7. Specificity of enzyme action.
8. Intracellular localization of enzymes, tissue (organ) specificity of enzymes. Saliva enzymes.
9. Isoenzymes, multiple molecular forms of enzymes.
10. Principles and methods of detecting enzymes in biological objects. Units of activity and amount of enzymes.

Topic 3. Regulation of enzymatic processes. Medical enzymology.

1. Enzyme activators and inhibitors: examples and mechanisms of their action.
2. Types of enzyme inhibition: reverse (competitive, non-competitive) and irreversible.
3. Regulation of enzymatic processes. Ways and mechanisms of regulation: allosteric enzymes, covalent modification of enzymes, proteolytic activation of enzymes (limited proteolysis).
4. Cyclic nucleotides (cAMP, cGMP) as regulators of enzymatic reactions and biological functions of the cell.
5. Enzymopathies are congenital (hereditary) defects in the metabolism of carbohydrates, amino acids, porphyrins, and purines.
6. Enzyme diagnosis of pathological processes and diseases.
7. Enzymotherapy – use of enzymes, their activators and inhibitors in medicine.

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

1. Classification of coenzymes according to their chemical nature and the type of reaction they catalyze.
2. Vitamins, as irreplaceable biologically active components necessary for the human body. The history of the discovery of vitamins. Development of vitaminology in Ukraine.
3. Causes of exo- and endogenous hypo- and vitamin deficiency.
4. Vitamins B1 and B2, their structure, biological role, sources for humans, daily requirement. Signs of hypovitaminosis.
5. Structure, properties of vitamin H and pantothenic acid. Their participation in metabolism, main sources, daily need. The role of CoA in exchange processes.
6. Antianemic vitamins (B12, folic acid), their structure, participation in metabolism, human sources, daily need, signs of hypovitaminosis.
7. Vitamins B6 and PP, their structure, biological role, human sources, daily requirement, signs of hypovitaminosis.
8. Vitamins C and P, their structure, biological role, sources for humans, daily requirement. Functional relationship between vitamin P and vitamin C. Manifestations of deficiency in the human body.
9. Use of water-soluble vitamins in dental practice.
10. Vitamins of group D, structure, biological role, daily need, sources for humans, signs of hypo- and hypervitaminosis, vitamin deficiency.
11. Vitamin A, structure, biological role, daily requirement, sources for humans, signs of hypo-hypervitaminosis.
12. Vitamins E, F, structure, biological role, sources for humans, mechanism of action, daily requirement, signs of deficiency, application in medicine.
13. Antihemorrhagic vitamins (K2, K3) and their water-soluble forms, structure, biological role, sources for humans, mechanism of action, daily requirement, signs of deficiency, application in medicine.
14. Use of fat-soluble vitamins in dental practice.
15. Provitamins, antivitamins. Mechanism of action and application in practical medicine.
16. Vitamin-like substances, their structure and role.

Topic 5. Basic patterns of metabolism. Research on the functioning, regulation and energy value of the tricarboxylic acid cycle.

1. Concept of metabolism of substances and energy. Characteristics of catabolic, anabolic and amphibolic pathways of metabolism, their importance.
2. Exergonic and endergonic biochemical reactions; the role of ATP and other macroergic phosphates in their coupling.
3. Intracellular localization of metabolic pathways, compartmentalization of metabolic processes in the cell.
4. Methods of studying metabolism.
5. Catabolic pathways of exchange of biomolecules: proteins, carbohydrates, lipids, their characteristics.

6. Tricarboxylic acid cycle (intracellular localization of TCA enzymes; sequence of TCA reactions; characteristics of TCA enzymes and coenzymes; substrate phosphorylation reactions in TCA; influence of allosteric modulators on TCA regulation; energy balance of tricarboxylic acid cycle).
7. Anaplerotic and amphibolic reactions of TCA.

Topic 6. Molecular basis of bioenergetics.

1. Reactions of biological oxidation; types of reactions (dehydrogenase, oxidase, oxygenase) and their biological significance. Tissue respiration.
2. Pyridine-dependent dehydrogenases. The structure of NAD⁺ and NADPH⁺. Their importance in oxidation and reduction reactions.
3. Flavin-dependent dehydrogenases. Building of FAD and FMN. Their role in oxidation and reduction reactions.
4. Cytochromes and their role in tissue respiration. The structure of their prosthetic group.
5. The sequence of the components of the mitochondrial respiratory chain. Molecular complexes of the inner membranes of mitochondria.
6. Oxidative phosphorylation: coupling points of electron transport and phosphorylation, coefficient of oxidative phosphorylation.
7. Chemiosmotic theory of oxidative phosphorylation, mitochondrial ATP synthetase.
8. Inhibitors of electron transport in the respiratory chain of mitochondria.
9. Uncouplers of electron transport and oxidative phosphorylation in the respiratory chain of mitochondria.

Topic 7. Anaerobic glucose oxidation research.

1. Digestion of carbohydrates in the digestive tract: glycolytic enzymes of the pancreas and small intestine, their mechanism of action. Absorption of carbohydrate hydrolysis products in the small intestine.
2. Hereditary enzymopathies of digestive processes (insufficiency of disaccharidases, violation of membrane transport of hexoses, absorption of glucose and galactose).
3. Glucose as an important metabolite of carbohydrate metabolism: a general scheme of the sources and pathways of glucose transformation in the body.
4. Anaerobic oxidation of glucose. Sequence of reactions and enzymes of glycolysis.
5. Glycolytic oxidoreduction: phosphorylation substrates and shuttle mechanisms of glycolytic NADH oxidation.
6. Alcoholic fermentation, enzymatic reactions. The reactions are common and distinct for glycolysis and fermentation.

Topic 8. Investigation of aerobic oxidation of glucose and alternative ways of monosaccharide metabolism.

1. Stages of aerobic oxidation of glucose.
2. Oxidative decarboxylation of pyruvate. Enzymes, coenzymes and the sequence of reactions in the multienzyme pyruvate dehydrogenase complex.
3. Comparative characteristics of bioenergetics of aerobic and anaerobic oxidation of glucose. The Pasteur effect.
4. Pentose phosphate pathway of glucose oxidation: scheme of the process and biological significance.
5. Metabolic ways of converting fructose and galactose; hereditary enzymopathies of their metabolism.

Topic 9. Study of glycogen metabolism. Biosynthesis of glucose – gluconeogenesis.

1. Biosynthesis of glycogen: enzymatic reactions, physiological significance. Regulation of glycogen synthetase activity.
2. The phosphorolytic pathway of glycogen cleavage in the liver and muscles. Regulation of glycogen phosphorylase activity.
3. Mechanism of reciprocal regulation of glycogenolysis and glycogenesis due to cascading cAMP-dependent phosphorylation of enzyme proteins.
4. The role of adrenaline, glucagon and insulin in hormonal regulation of glycogen metabolism in muscles and liver.
5. Genetic disorders of glycogen metabolism (glycogenosis and aglycogenosis).
6. Gluconeogenesis: substrates, enzymes, reactions and physiological significance of the process.
7. Relationship between glycolysis and gluconeogenesis (Cori cycle). Glucose-lactate, glucose-alanine cycles.

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

1. Biochemical processes that ensure a stable level of glucose in the blood. The role of different pathways of carbohydrate metabolism in the regulation of blood glucose levels.
2. Hormonal regulation of carbohydrate metabolism (insulin - structure, mechanism of action, role in carbohydrate metabolism; adrenaline and glucagon - mechanisms of their regulatory action on carbohydrate metabolism).
3. Characteristics of normo-, hyper-, hypoglycemia and glucosuria.

4. Insulin-dependent and non-insulin-dependent forms of diabetes mellitus.
5. Characteristics of biochemical disorders in diabetes.
6. Biochemical tests for the assessment of diabetes mellitus.
7. Violation of carbohydrate metabolism during fasting.

Topic 11. Investigation on the metabolism of triacylglycerols and complex lipids. Lipolysis and its regulation.

1. Digestion of lipids in the digestive tract: lipolytic enzymes of the pancreas and small intestine, their mechanism of action. Absorption of lipid hydrolysis products in the small intestine. Disorders of lipid digestion in the digestive tract (steatorrhea, its types).
2. Biological functions of simple and complex lipids in the human body.
3. Participation of lipids in the construction and functioning of biological cell membranes. Liquid-mosaic model of biomembranes. Liposomes, their use in medicine.
4. Circulatory transport and deposition of lipids in adipose tissue. Endothelial lipoprotein lipase.
5. Catabolism of triacylglycerols in adipocytes of adipose tissue: sequence of reactions, mechanisms of regulation of triglyceride lipase activity.
6. Biosynthesis of triacylglycerols.
7. Neurohumoral regulation of lipolysis with the participation of adrenaline, norepinephrine, glucagon and insulin.
8. Biosynthesis of phospholipids, the importance of phosphatidic acid.
9. Metabolism of sphingolipids. Genetic abnormalities of sphingolipid metabolism - sphingolipidoses. Lysosomal diseases.

Topic 12. β -Oxidation and biosynthesis of fatty acids. Exchange of ketone bodies.

1. Reactions of β -oxidation of fatty acids: localization of the process; activation of fatty acids; the role of carnitine in the transport of fatty acids in mitochondria; sequence of enzymatic reactions and energy cost of β -oxidation of fatty acids.
2. Glycerol oxidation: enzymatic reactions, bioenergetics.
3. Biosynthesis of higher fatty acids: localization of the process; metabolic sources of fatty acid synthesis; stages of synthesis of saturated fatty acids; characteristics of the fatty acids synthetase, the value of acyl-transporting protein, biotin; sources of NADPH; sequence of enzymatic reactions of biosynthesis of higher fatty acids; regulation of the biosynthesis process at the level of acetyl-CoA-carboxylase and fatty acid synthetase; elongation of saturated fatty acids; biosynthesis of mono- and polyunsaturated fatty acids in the human body.
4. Metabolism of ketone bodies: enzymatic reactions of biosynthesis of ketone bodies; reactions of utilization of ketone bodies, energy value; metabolism of ketone bodies in conditions of pathology; mechanisms of excessive increase in the content of ketone bodies in diabetes and starvation; concepts - ketoacidosis, ketonemia, ketonuria.

Topic 13. Study of biosynthesis and biotransformation of cholesterol. Pathologies of lipid metabolism.

1. Cholesterol biosynthesis in the human body: localization of this process, significance; stages of cholesterol synthesis; enzymatic reactions of mevalonic acid synthesis; regulation of cholesterol synthesis.
2. Cholesterol biotransformation pathways (esterification, formation of bile acids and steroid hormones, synthesis of vitamin D₃, excretion from the body).
3. Atherosclerosis: mechanisms of development, role of genetic factors, hypercholesterolemia, WHO classification.
4. Violation of lipid metabolism in diabetes.
5. Pathological processes of lipid metabolism that lead to the development of obesity. Fatty hepatosis, lipotropic factors.
6. Blood plasma lipoproteins: lipid and protein (apoprotein) composition. Hyperlipoproteinemia.

Topic 14. General pathways of amino acid transformations in tissues.

1. Digestion of proteins in the digestive tract. Chemical composition of gastric juice; biochemical mechanisms of stimulating the release and action of enzymes (pepsin, gastrin, renin).
2. Formation mechanism and role of hydrochloric acid. Acidity of gastric juice and forms of its expression. Quantitative indicators in normality and pathology by the pH-metry method. Mechanisms of stimulation of release of hydrochloric acid.
3. Digestion of proteins in the small intestine: proteolytic enzymes of the pancreas and small intestine, their mechanism of action. Absorption of protein hydrolysis products in the small intestine.
4. Decay of proteins in the large intestine.
5. Ways of formation and maintenance of the pool of free amino acids in the human body. General ways of conversion of free amino acids.
6. Types of amino acid deamination reactions and their final products. Mechanism of oxidative deamination of amino acids. L- and D-amino acid oxidases. Their enzymatic activity, specificity of action.

7. Glutamate dehydrogenase: structure of the enzyme, mechanism of the glutamate dehydrogenase reaction, biological significance.
8. Transamination of amino acids, substrates for transamination reactions. The mechanism of the transamination reaction. Transaminases. Localization of transaminases in organs and tissues. The clinical and diagnostic value of determining the activity of transaminases.
9. Decarboxylation of amino acids. Decarboxylases. Formation of biogenic amines (α -aminobutyric acid, histamine, serotonin, dopamine). Decarboxylation of amino acids in the process of protein decay in the intestine. Oxidation of biogenic amines.

Topic 15. Study of the processes of ammonia detoxification and urea biosynthesis. Synthesis of glutathione and creatine.

1. Ways of ammonia formation. Ammonia toxicity and mechanisms of its neutralization. Circulatory transport of ammonia (glutamine, alanine).
2. Urea biosynthesis: localization of the ornithine cycle; enzymatic reactions; sources of ammonia; energy supply.
3. Genetic defects of enzymes (enzymopathy) of urea synthesis.
4. Glutathione: structure, biosynthesis, biological functions, role in the exchange of organic peroxides.
5. Biosynthesis and biological role of creatine and creatine phosphate, formation of creatinine, clinical and biochemical significance of disorders of their metabolism.

Topic 16. Investigation of specialized pathways of amino acid metabolism in tissues.

1. General pathways of metabolism of carbon skeletons of amino acids in the human body. Glucogenic and ketogenic amino acids.
2. Exchange of glycine and serine; the role of tetrahydrofolate (H₄-folate) in the transfer of one-carbon fragments, dihydrofolate reductase inhibitors as antitumor agents.
3. Features of the exchange of amino acids with branched chains; participation of coenzyme forms of vitamin B₁₂ in the metabolism of amino acids.
4. Exchange of sulfur-containing amino acids; methylation reactions
5. Arginine exchange; biological role of nitric oxide, NO-synthase.
6. Exchange of tryptophan: kynurenine and serotonin pathways. Hereditary enzymopathies.
7. Specialized metabolic pathways of cyclic amino acids phenylalanine and tyrosine, sequence of enzymatic reactions. Hereditary enzymopathies.

Topic 17. Catabolism and biosynthesis of purine and pyrimidine nucleotides. Determination of the final products of their metabolism.

1. Biosynthesis of purine nucleotides: scheme of IMP synthesis reactions; formation of AMP and GMP. Regulation of biosynthesis of purine nucleotides according to the principle of negative feedback (retroinhibition).
2. Biosynthesis of pyrimidine nucleotides: scheme of reactions, regulation of synthesis.
3. Biosynthesis of deoxyribonucleotides. Formation of thymidyl nucleotides; dTMP biosynthesis inhibitors as antitumor agents.
4. Catabolism of purine nucleotides.
5. Hereditary disorders of uric acid metabolism. Clinical and biochemical characteristics of hyperuricemia, gout, Lesch-Nyhan syndrome.
6. Scheme of catabolism of pyrimidine nucleotides. Orotaciduria.

Topic 18. Study of DNA replication and RNA transcription. Protein biosynthesis. Analysis of mutation mechanisms.

1. DNA replication: biological significance, semi-conservative mechanism of replication.
2. Sequence of stages and enzymes of DNA replication in prokaryotes and eukaryotes.
3. RNA transcription: RNA polymerases of prokaryotes and eukaryotes, transcription signals (promoter, initiator and terminator regions of the genome).
4. Processing – post-transcriptional modification of newly synthesized mRNAs.
5. Transport tRNAs and activation of amino acids. Aminoacyl-tRNA synthetases.
6. Stages and mechanisms of translation (protein biosynthesis) in ribosomes: initiation, elongation and termination.
7. Post-translational modification of peptide chains. Broadcast regulation.
8. Inhibitors of transcription and translation in prokaryotes and eukaryotes: antibiotics and interferons - their use in medicine; diphtheria toxin.
9. Regulation of prokaryotic gene expression: regulatory and structural regions of the lactose (Lac-) operon (regulatory gene, promoter, operator).

10. Gene (point) mutations: role in the occurrence of enzymopathies and hereditary human diseases. Biochemical mechanisms of action of chemical mutagens.

Topic 19. Study of the molecular and cellular mechanisms of action of protein hormones on target cells.

1. Hormones: general characteristics; the role of hormones and other bioregulators in the system of intercellular integration of human body functions.
2. Classification of hormones; correspondence of the structure and mechanisms of action of hormones.
3. Reaction of target cells to the effect of hormones. Membrane (ionotropic, metabotropic) and cytosolic receptors.
4. Biochemical systems of intracellular transmission of hormonal signals: G-proteins, secondary mediators (cAMP, Ca²⁺/calmodulin, IP3, DAG, protein kinases C, A), their role.
5. Hormones of the hypothalamus - liberins and statins. Functional relationship between hypothalamus and pituitary gland.
6. Hormones of the anterior lobe of the pituitary gland: somatotropin, prolactin. Pathological processes associated with dysfunction of these hormones.
7. Hormones of the posterior lobe of the pituitary gland. Vasopressin and oxytocin: structure, biological functions.
8. Pancreatic hormones. Insulin – structure, biosynthesis and secretion; influence on the metabolism of carbohydrates, lipids, amino acids and proteins. Growth-stimulating effects of insulin.
9. Glucagon. Chemical nature and biological action of the hormone.
10. Catecholamines (adrenaline, norepinephrine, dopamine): structure, biosynthesis, biological effects, biochemical mechanisms of action.
11. Regulation of phosphate-calcium metabolism. Parathyroid hormone – structure, mechanism of hypercalcemic action. Calcitriol: biosynthesis; influence on the absorption of Ca²⁺ and phosphates in the intestine. Calcitonin - structure, influence on calcium and phosphate metabolism.
12. Clinical and biochemical characteristics of calcium homeostasis disorders (rickets, osteoporosis). Hyperparathyroidism and hypoparathyroidism.

Topic 20. Molecular and cellular mechanisms of action of steroid and thyroid hormones. Biologically active eicosanoids.

1. Steroid hormones: nomenclature, classification. The structure of receptors for steroid hormones. Molecular and cellular mechanism of action of steroid hormones.
2. Steroid hormones of the adrenal cortex (C₂₁-steroids) – cortisol, corticosterone. Biochemical effects of corticosteroids. Glucocorticoids; the role of cortisol in the regulation of gluconeogenesis; anti-inflammatory properties of glucocorticoids. Itsenko-Cushing's disease.
3. Mineralocorticoids; the role of aldosterone in the regulation of water-salt metabolism; aldosteronism
4. Steroid hormones of gonads. Female sex hormones: estrogens - estradiol, estrone (C₁₈ steroids), progesterone (C₂₁ steroids); biochemical effects; connection with the phases of the menstrual cycle; regulation of synthesis and secretion.
5. Male sex hormones (androgens) – testosterone, dihydrotestosterone (C₁₉-steroids); physiological and biochemical effects, regulation of synthesis and secretion.
6. Thyroid hormones. Structure and biosynthesis of thyroid hormones. Biological effects of T₄ and T₃. Pathology of the thyroid gland; features of metabolic process disorders under conditions of hyper- and hypothyroidism. Mechanisms of occurrence of endemic goiter and its prevention.
7. Eicosanoids: structure, biological and pharmacological properties. Aspirin and other nonsteroidal anti-inflammatory drugs as inhibitors of prostaglandin synthesis.

Topic 21. Investigation of intermediate products of heme biosynthesis and their accumulation in porphyrias.

1. Porphyrins: nomenclature; structure of hemoglobin and myoglobin.
2. Reactions of heme biosynthesis. Regulation of the process.
3. Hereditary disorders of porphyrin metabolism (porphyria).
4. Hemoglobin: properties, types of hemoglobin.
5. Hemoglobin derivatives.
6. Mechanisms of hemoglobin participation in the transport of oxygen and carbon dioxide.
7. The participation of hemoglobin in the regulation of the acid-base state of the blood.
8. Pathological forms of human hemoglobins.
9. Hemoglobinoses: hemoglobinopathy and thalassemia.

Topic 22. Investigation of proteins and non-protein nitrogen-containing components of blood. Blood buffer systems.

1. General characteristics of the protein composition of blood. Factors influencing the content of proteins in blood plasma: hyper-, hypo- and dysproteinemia, paraproteinemia.
2. Albumins and globulins. Electrophoresis of blood plasma proteins.
3. Proteins of the acute phase of inflammation and their clinical and biochemical characteristics.
4. Enzymes of blood plasma: importance in enzymodiagnosics of diseases of organs and tissues.
5. Kallikrein-kinin system of blood and tissues. Medicines are antagonists of kinin formation.
6. Non-protein organic compounds of blood plasma. Inorganic components of blood plasma.
7. Blood buffer systems. Violation of the acid-base balance in the body (metabolic and respiratory acidosis, alkalosis).

Topic 23. Study of coagulation, anticoagulation and fibrinolytic systems of blood. Biochemical regularities of implementation of immune processes.

1. Functional and biochemical characteristics of the hemostasis system in the human body; vascular-platelet and coagulation hemostasis.
2. Mechanisms of activation and functioning of the cascade blood coagulation system; internal and external ways of coagulation. The role of vitamin K in coagulation reactions (carboxylation of glutamic acid into carboxyglutamic acid, role in calcium binding). Medicines - agonists and antagonists of vitamin K.
3. Hereditary and acquired disorders of vascular-platelet and coagulation hemostasis.
4. Anticoagulant blood system, characteristics of anticoagulants.
5. Fibrinolytic blood system: stages and components of fibrinolysis. Medicines affecting fibrinolysis processes. Plasminogen activators and plasmin inhibitors.
6. Immunoglobulins: structure, biological functions, mechanisms of regulation of immunoglobulin synthesis. Biochemical characteristics of individual classes of human immunoglobulins.
7. Mediators and hormones of the immune system: interleukins, interferons, protein-peptide factors regulating cell growth and proliferation.
8. Biochemical components of the human complement system; classical and alternative (properdin) activation mechanisms.
9. Biochemical mechanisms of immunodeficiency states: primary (hereditary) and secondary immunodeficiencies.

Topic 24. Study of the exchange of end products of heme catabolism.

1. The homeostatic role of the liver in the metabolism of the entire organism. Biochemical functions of hepatocytes. Carbohydrate (glycogenous), lipid-regulating, protein-synthesizing, urea-forming, pigment-forming, bile-forming functions of the liver. Biochemical composition of bile.
2. The role of the liver in the exchange of bile pigments.
3. Catabolism of hemoglobin, conversion of bilirubin.
4. Pathobiochemistry of jaundice; hereditary (enzymatic) and acquired jaundice

Topic 25. Study of processes of biotransformation of xenobiotics and endogenous toxins in the liver.

1. Detoxification function of the liver. Stages of biotransformation of xenobiotics and endogenous toxins.
2. Reactions of microsomal oxidation; inducers and inhibitors of microsomal monooxygenases.
3. Biological role of cytochrome P-450. Electron transport chains in the membranes of the endoplasmic reticulum of hepatocytes.
4. Conjugation reactions in hepatocytes: (with glucuronic and sulfuric acids, glycine, by methylation and acetylation) – biochemical mechanisms, functional significance.

Topic 26. Water-salt metabolism in the body. Study of normal and pathological components of urine.

1. Water-salt metabolism in the body. Intracellular and extracellular water. Metabolism of water, sodium, potassium ions.
2. The role of trace elements in the metabolic processes of the human body. Biological functions of iodine, bromine, fluorine, copper, manganese, zinc, cobalt, selenium, iron. Trace element deficiency.
3. The role of macronutrients in the metabolic processes of the human body. Biological functions of calcium, phosphorus, chlorine, magnesium. Manifestations of insufficiency.
4. Metabolic role of sodium and potassium. Mechanism of functioning of Na⁺-K⁺-ATPase.
5. Renin-angiotensin system of kidneys. Biochemical mechanisms of renal hypertension. Hypotensive drugs - angiotensin-converting enzyme inhibitors.
6. The role of the kidneys in regulating the volume, electrolyte composition, and pH of body fluids. Biochemical mechanisms of the urinary function of the kidneys (filtration, reabsorption, secretion and excretion). Biochemical characteristics of renal clearance and renal threshold, their diagnostic significance.

7. Physico-chemical properties of urine: amount, color, smell, transparency, reaction (pH), its dependence on the composition of food.
8. Biochemical composition of human urine in normal conditions and under conditions of development of pathological processes. Clinical and diagnostic value of urine composition analysis.

Topic 27. Biochemistry of connective tissue. Study of metabolism of bone tissue.

1. General characteristics of the morphology and biochemical composition of connective tissue. Biochemical features of intercellular substance of connective tissue.
2. Proteins of connective tissue fibers – collagens. Biosynthesis and breakdown of collagen.
3. Structure and properties of non-collagen proteins (elastin, large and small proteoglycans).
4. Non-collagen proteins with special properties (fibronectin, integrins, laminins, vitronectin, tenascin, thrombospondin).
5. Complex carbohydrates of the main amorphous matrix of connective tissue - glycosaminoglycans (mucopolysaccharides). Mechanisms of participation of glycosaminoglycan molecules (hyaluronic acid, chondroitin, dermatan, keratan sulfates) in the construction of the main substance of connective tissue. Distribution of various glycosaminoglycans in human organs and tissues.
6. Biochemical mechanisms of mucopolysaccharidoses and collagenoses, their clinical and biochemical diagnosis.
7. Organization and chemical structure of bone tissue.
8. Biochemical mechanisms of bone formation and physiological regeneration.
9. Regulation of metabolism in bone tissue: systemic and local factors, markers of bone tissue metabolism.
10. Reaction of bone tissue to dental implants.

Topic 28. Study of the biochemical composition and functions of saliva.

1. Regulation of saliva secretion. The mechanism of saliva production.
2. Functions of human saliva (digestive, protective, mineralizing, anti-caries).
3. Quantitative indicators of saliva secretion in normal and pathological conditions.
4. Density, viscosity and pH of saliva in normal and pathological conditions.
5. Organic substances of saliva - proteins and enzymes, their role in ensuring the functions of saliva. Changes in the pathology of the organs of the oral cavity and the body as a whole.
6. Non-protein nitrogenous components of saliva, carbohydrates and lipids.
7. Saliva hormones, their role in the regulation of metabolic processes in the oral cavity and the body as a whole.
8. Inorganic components of saliva (micro- and macroelements), their changes in pathology of oral cavity organs.
9. Protective mechanisms of saliva when smoking.

Topic 29. Study of the biochemical composition of tooth tissues: organic and mineral components. Amelogenesis.

1. General characteristics of the chemical composition of tooth tissues (enamel, dentin, cementum, pulp).
2. Inorganic substances of enamel: concepts of enamel prisms, types of apatites, their properties and biological role.
3. Organic enamel substances (specific proteins, peptides, carbohydrates, lipids).
4. Peculiarities of the chemical composition of dentin, its structural and functional organization. Tooth cement.
5. Pulp – peculiarities of biochemical composition and metabolism.
6. Amelogenesis. The processes of mineralization and demineralization are the basis of the mineral exchange of tooth tissues. Enamel permeability.
7. The role of vitamins A, D, E, K, C in the regulation of tooth tissue mineralization processes.
8. Hormonal regulation of tooth tissue mineralization processes.
9. Surface formations on teeth under normal conditions (cuticle, pellicle) and pathology (plaque and calculus).
10. Biochemical changes in tooth tissues during caries.
11. The importance of fluorine for caries and fluorosis.
12. Composition of gingival fluid and its changes in periodontal pathology.

3. The structure of the academic discipline

Topic	Lectures (hours)	Practice (hours)	SIW (hours)	SIW (hours)
Topic 1. Biochemistry as a science, objects of study and tasks of biochemistry, methods of biochemical research.	-	2	8	
Topic 2. Investigation of physicochemical properties and structure of enzyme proteins. Mechanism of action and kinetics of enzymatic catalysis.	2	2	5	
Topic 3. Regulation of enzymatic processes. Medical enzymology.		2	-	

Topic 4. Study of the role of cofactors and coenzyme vitamins. The role of water- and fat-soluble vitamins in the metabolism of living organisms.		3	9	
Topic 5. Basic patterns of metabolism. Research on the functioning, regulation and energy value of the tricarboxylic acid cycle.	-	2	3	
Topic 6. Molecular basis of bioenergetics.		2	1	
Topic 7. Anaerobic glucose oxidation research.	2	2	1	
Topic 8. Investigation of aerobic oxidation of glucose and alternative ways of monosaccharide metabolism.		2	3	
Topic 9. Study of glycogen metabolism. Biosynthesis of glucose – gluconeogenesis.		2	2	
Topic 10. Study of mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Diabetes mellitus.		2	1	
Topic 11. Investigation on the metabolism of triacylglycerols and complex lipids. Lipolysis and its regulation.	2	2	5	
Topic 12. β -Oxidation and biosynthesis of fatty acids. Exchange of ketone bodies.		2		
Topic 13. Study of biosynthesis and biotransformation of cholesterol. Pathologies of lipid metabolism.		2	2	
Topic 14. General pathways of amino acid transformations in tissues.	2	2	4	
Topic 15. Study of the processes of ammonia detoxification and urea biosynthesis. Synthesis of glutathione and creatine.		2	1	
Topic 16. Investigation of specialized pathways of amino acid metabolism in tissues.		2	4	
Topic 17. Catabolism and biosynthesis of purine and pyrimidine nucleotides. Determination of the final products of their metabolism.	2	2	0,5	
Topic 18. Study of DNA replication and RNA transcription. Protein biosynthesis. Analysis of mutation mechanisms.	-	2	2	
Topic 19. Study of the molecular and cellular mechanisms of action of protein hormones on target cells.	2	2	1	
Topic 20. Molecular and cellular mechanisms of action of steroid and thyroid hormones. Biologically active eicosanoids.	-	2	1	
Topic 21. Investigation of intermediate products of heme biosynthesis and their accumulation in porphyrias.		2		
Topic 22. Investigation of proteins and non-protein nitrogen-containing components of blood. Blood buffer systems.		2	1	
Topic 23. Study of coagulation, anticoagulation and fibrinolytic systems of blood. Biochemical regularities of implementation of immune processes.	2	2	1	
Topic 24. Study of the exchange of end products of heme catabolism.	2	2	-	
Topic 25. Study of processes of biotransformation of xenobiotics and endogenous toxins in the liver.		2	-	
Topic 26. Water-salt metabolism in the body. Study of normal and pathological components of urine.		2	2	
Topic 27. Biochemistry of connective tissue. Study of metabolism of bone tissue.		2	17	
Topic 28. Study of the biochemical composition and functions of saliva.		2	0,5	
Topic 29. Study of the biochemical composition of tooth tissues: organic and mineral components. Amelogenesis.		2		
<i>Total hours 150/5.0 ESTS credits</i>	<i>16</i>	<i>59</i>	<i>75</i>	
<i>Final control</i>				<i>Exam</i>

4. Thematic plan of lectures on the discipline "Biological Chemistry"

No.	Topic	hours
1	Biochemistry as a science. Enzymes. Regulation of enzymatic processes. Enzymology.	2
2	Carbohydrate metabolism and its regulation. Pathology of carbohydrate metabolism.	2

3	Lipid metabolism and its regulation. Pathology of lipid metabolism.	2
4	General pathways of amino acid metabolism. Metabolism of specific amino acids, its regulation. Pathology of amino acid metabolism.	2
5	Molecular biology and genetics in Biochemistry.	2
6	Biochemistry of hormones: molecular and cellular mechanisms of action; biochemical effects; pathology of the endocrine system.	2
7	Biochemistry of coagulation, anticoagulation and fibrinolytic blood systems and their disorders.	2
8	Liver biochemistry: metabolism of end products of heme catabolism; biotransformation of xenobiotics and endogenous toxins.	2
	Total	16

5. Thematic plan of practice on the discipline "Biological Chemistry"

No.	Topic	hours
1	Biochemistry as a science, objects of study and tasks of biochemistry, methods of biochemical research.	2
2	Investigation of physicochemical properties and structure of enzyme proteins. Mechanism of action and kinetics of enzymatic catalysis.	2
3	Regulation of enzymatic processes. Medical enzymology.	
4.	Study of the role of cofactors and coenzyme vitamins. The role of water- and fat-soluble vitamins in the metabolism of living organisms.	3
5	Basic patterns of metabolism. Research on the functioning, regulation and energy value of the tricarboxylic acid cycle.	2
6	Molecular basis of bioenergetics.	2
7	Anaerobic glucose oxidation research.	2
8	Investigation of aerobic oxidation of glucose and alternative ways of monosaccharide metabolism.	2
9	Study of glycogen metabolism. Biosynthesis of glucose – gluconeogenesis.	2
10	Study of mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Diabetes mellitus.	2
11	Investigation on the metabolism of triacylglycerols and complex lipids. Lipolysis and its regulation.	2
12	β -Oxidation and biosynthesis of fatty acids. Exchange of ketone bodies.	2
13	Study of biosynthesis and biotransformation of cholesterol. Pathologies of lipid metabolism.	2
14	General pathways of amino acid transformations in tissues.	2
15	Study of the processes of ammonia detoxification and urea biosynthesis. Synthesis of glutathione and creatine.	2
16	Investigation of specialized pathways of amino acid metabolism in tissues.	2
17	Catabolism and biosynthesis of purine and pyrimidine nucleotides. Determination of the final products of their metabolism.	2
18	Study of DNA replication and RNA transcription. Protein biosynthesis. Analysis of mutation mechanisms.	2
19	Study of the molecular and cellular mechanisms of action of protein hormones on target cells.	2
20	Molecular and cellular mechanisms of action of steroid and thyroid hormones. Biologically active eicosanoids.	2
21	Investigation of intermediate products of heme biosynthesis and their accumulation in porphyrias.	2
22	Investigation of proteins and non-protein nitrogen-containing components of blood. Blood buffer systems.	2
23	Study of coagulation, anticoagulation and fibrinolytic systems of blood. Biochemical regularities of implementation of immune processes.	2
24	Study of the exchange of end products of heme catabolism.	2
25	Study of processes of biotransformation of xenobiotics and endogenous toxins in the liver.	2
26	Water-salt metabolism in the body. Study of normal and pathological components of urine.	2
27	Biochemistry of connective tissue. Study of metabolism of bone tissue.	2
28	Study of the biochemical composition and functions of saliva.	2
29	Study of the biochemical composition of tooth tissues: organic and mineral components. Amelogenesis.	2
	Total	59

6. Individual work:

No.	Topic	hours	Type of control
1.	History of biochemistry; development of biochemical research in Ukraine.	2	Current control in practical classes
2.	Connection of biochemistry with other biomedical sciences. Medical biochemistry. Clinical biochemistry. Biochemical laboratory diagnostics.	1	
3.	Structural and functional components of cells, their biochemical functions. Classes of biomolecules. Their hierarchy and origin.	2	
4.	Contribution of scientists of the Department of Biochemistry of the Lviv National Medical University to the development of biological chemistry.	1	
5.	Principles of collection and preservation of material for laboratory research. Errors in research.	2	
6.	Salivary enzymes: their specificity and role.	2	
7.	Levels of structural organization of enzymes. Multienzyme complexes, enzymatic ensembles, multifunctional enzymes, their advantages.	1	
8.	Principles and methods of detecting enzymes in biological objects. Units of activity and amount of enzymes.	2	
9.	Vitamins as irreplaceable biologically active components necessary for the human body. The history of the discovery of vitamins. Development of vitaminology in Ukraine.	3	
10.	Causes of exo- and endogenous hypo- and vitamin deficiency.	1	
11.	Use of water- and fat-soluble vitamins in dental practice.	1	
12.	Provitamins, antivitamins. Mechanism of action and application in practical medicine.	2	
13.	Vitamin-like substances, their structure and role.	2	
14.	Methods of studying metabolism.	1	
15.	Intracellular localization of metabolic pathways, compartmentalization of metabolic processes in the cell.	2	
16.	The structure of NAD ⁺ and NADPH ⁺ . Their importance in oxidation and reduction reactions. The structure of FAD and FMN. Their role in oxidation and reduction reactions.	1	
17.	Hereditary enzymopathies of digestive processes (insufficiency of disaccharidases, violation of membrane transport of hexoses, absorption of glucose and galactose).	1	
18.	The Pasteur effect.	0,5	
19.	Glucose-alanine cycle.	0,5	
20.	The pentose phosphate pathway of glucose oxidation: the reaction scheme of the process.	2	
21.	The role of adrenaline, glucagon and insulin in the hormonal regulation of glycogen metabolism in muscles.	2	
22.	Characteristics of normo-, hyper-, hypoglycemia and glucosuria, their causes.	1	
23.	Biological functions of simple and complex lipids in the human body (reserve, energy, participation in thermoregulation, biosynthetic).	1	
24.	Participation of lipids in the construction and functioning of biological membranes of cells. Liquid-mosaic model of biomembranes.	1	
25.	Disorders of lipid digestion in the digestive tract (steatorrhea, its types).	1	
26.	Liposomes, their structure and vectors of use in medicine.	1	
27.	Lysosomal diseases: causes, clinical and biochemical characteristics.	1	
28.	Pathological processes of lipid metabolism that lead to the development of obesity.	1	
29.	Disorders of lipid metabolism in diabetes mellitus.	1	
30.	Formation mechanism and role of hydrochloric acid. Acidity of gastric juice and forms of its expression. Quantitative indicators in normality and pathology by the pH-metry method. Mechanisms of stimulation of release of hydrochloric acid.	2	
31.	Decay of proteins in the large intestine.	1	
32.	Transaminases. Localization of transaminases in organs and tissues. The clinical and diagnostic value of determining the activity of transaminases.	1	
33.	Genetic defects of enzymes (enzymopathy) of urea synthesis.	1	
34.	The role of tetrahydrofolate (H ₄ -folate) in the transfer of one-carbon fragments, dihydrofolate reductase inhibitors as antitumor agents.	2	

35.	Participation of coenzyme forms of vitamin B12 in the metabolism of amino acids.	1	
36.	Clinical and biochemical significance of disorders of creatine and creatine phosphate metabolism.	1	
37.	Orotaciduria: causes, types, clinical and biochemical characteristics.	0,5	
38.	Inhibitors of transcription and translation in prokaryotes and eukaryotes: antibiotics and interferons - their use in medicine; diphtheria toxin.	1	
39.	Gene (point) mutations: role in the occurrence of enzymopathies and hereditary human diseases. Biochemical mechanisms of action of chemical mutagens.	1	
40.	Response of target cells to the action of hormones. Membrane (ionotropic, metabotropic) and cytosolic receptors.	1	
41.	Aspirin and other nonsteroidal anti-inflammatory drugs as inhibitors of prostaglandin synthesis.	1	
42.	Enzymes of blood plasma: value in enzymodiagnosis of diseases of organs and tissues.	1	Current control in practical classes
43.	Immunoglobulins: structure, biological functions, mechanisms of regulation of immunoglobulin synthesis. Biochemical characteristics of individual classes of human immunoglobulins.	1	
44.	Biochemical mechanisms of the urinary function of the kidneys (filtration, reabsorption, secretion and excretion).	1	
45.	Physico-chemical properties of urine: amount, color, smell, transparency, reaction (pH), its dependence on the composition of food.	1	
46.	Protective mechanisms of saliva when smoking.	0,5	
47.	Reaction of bone tissue to dental implants.	1	
48.	The importance of fluoride for caries and fluorosis.	0,5	
49.	Myofibril proteins: myosin, actin, tropomyosin, troponin. Molecular organization of thick and thin filaments.	1	
50.	Muscle extractives, nitrogenous and non-nitrogenous, their chemical nature and role.	1	
51.	Molecular mechanisms of muscle contraction: modern ideas about the interaction of muscle filaments. The role of Ca ²⁺ ions in the regulation of contraction and relaxation of skeletal and smooth muscles.	1	
52.	Bioenergetics of muscle tissue. Macroergic compounds of muscles. Structure, formation and role of ATP, creatine phosphate, creatine phosphokinase, sources of ATP in muscles; the role of creatine phosphate in providing energy for muscle contraction.	1	
53.	Biochemical changes in muscles during pathology.	1	
54.	Features of the biochemical composition and metabolism of the brain: chemical composition of the brain, neurospecific proteins and lipids (gangliosides, cerebroside, cholesterol), features of the amino acid composition of the brain, the role of the glutamic acid system.	1	
55.	Energy metabolism in the human brain.	0,5	
56.	Biochemistry of neurotransmitters (acetylcholine, norepinephrine, dopamine, serotonin, excitatory and inhibitory amino acids), their role in the transmission of nerve impulses and memory regulation.	2	
57.	Receptors for neurotransmitters and physiologically active compounds.	2	
58.	Peptidergic system of the brain.	1	
59.	Opioid peptides (enkephalins, endorphins, dynorphins) and their receptors.	1	
60.	Disorders of the exchange of brain mediators and modulators in mental disorders.	1	
61.	Biochemical mechanisms underlying human neuropsychiatric diseases (alcoholism, drug addiction, Alzheimer's disease, multiple sclerosis, Parkinson's disease, epilepsy).	2	
	The number of hours of independent work on the discipline	75	

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. Teaching methods

The methods of educational activity according to the curriculum are:

- lectures,

- practical classes,
- individual students work (SIW)

The topics of the lecture course reveal the problematic issues of the relevant sections of biological chemistry. Practical classes according to the methodology of their organizations are laboratory because they include:

- laboratory studies to identify certain classes of bioorganic compounds based on the properties of their functional groups;
- carrying out qualitative reactions and evaluating indicators during laboratory research of solutions;
- research of the functions of organs and tissues, and the organism as a whole in experiments on animals, isolated organs, cells, as well as on models or on the basis of experiments recorded in video films, motion pictures, presented in computer programs and other educational technologies;
- studies of clinical and biochemical indicators of intermediate intermediates and end products of metabolism in the body's main fluids under normal conditions and during the development of pathological processes;
- solving situational problems (estimation of clinical and biochemical parameters characterizing the functions and parameters of homeostasis, as well as establishment of mechanisms of regulation of metabolic processes, etc.), which have an experimental or clinical and biochemical direction.

In practical classes, students are recommended to write down the protocols of the conducted research, where to indicate the purpose of the research, the course of work or the name of the method, the results of the research and the conclusions.

Mastery of the topic is monitored in practical classes in accordance with specific goals. Such means of diagnosing the level of students' preparation as test control, answers to theoretical questions (three), solving situational problems, conducting laboratory research and interpreting and evaluating their results, control of practical skills are used.

9. Control methods:

- Type of control: current, final
- Form of final control: exam
- Evaluation criteria

10. Current control is carried out during training sessions and is aimed at checking students' assimilation of educational material (it is necessary to describe the forms of current control during training sessions on a 4-point (national) scale). Forms of assessment of current educational activities are standardized and include control of theoretical and practical training.

Controls include:

1. Oral survey of students.
2. Students' written answers to standard test tasks, including 20 tests. 18 test tasks have one correct answer out of five offered (format A), 2 tests have 4 correct answers out of 8 distractors.
3. Completion of written tasks in the amount of three questions. Tasks are presented in the form of chains 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. Performance of practical (laboratory) work, preparation of the protocol of the practical session.

On-line monitoring 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.

Controls include:

1. Oral survey of students.
2. Students' written answers to standard test tasks, including 20 tests. 18 test tasks have one correct answer out of five offered (format A), 2 tests have 4 correct answers out of 8 distractors in the mixed system.
3. Performance of practical (laboratory) work: students watch a video of the performance of practical work, if necessary, carry out calculations, draw a conclusion, draw up a protocol of the practical session.

The performance of the student's independent work is carried out in a practical session when mastering the topics. SIW is credited upon successful defense during an oral or written examination.

10.1. 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 for by the educational program are taken into account. The student must receive a grade in each topic. Estimates given on a traditional scale are converted into points. The average grade for the year must not be lower than "3" (which, converted to a multi-point scale, is at least 72 points).

An **"excellent" grade** is awarded to a student who took an active part in discussing the most difficult questions on the topic of the lesson, gave at least 90% correct answers to standardized test tasks, answered written tasks without errors, completed practical work and issued a protocol.

A **grade of "good"** is given to a student who participated in the discussion of the most difficult questions on the topic, gave at least 75% correct answers to standardized test tasks, made some minor mistakes in answers to written tasks, completed practical work and issued a report.

A **grade of "satisfactory"** is given to a student who did not participate in the discussion of the most difficult questions on the topic, gave at least 60% correct answers to standardized test tasks, made significant mistakes in answers to written tasks, completed practical work and issued a protocol.

The **grade "unsatisfactory"** is given to a student who did not participate in the discussion of the most difficult questions on the topic, gave less than 60% correct answers to standardized test tasks, made gross mistakes in the answers to written tasks or did not give answers to them at all, did not complete practical work and did not issue a protocol.

Table 1

Assessment of test control from 20 test tasks

Number of correct answers	Score
19 – 20	"5"
17 – 18	"4"
14 – 16	"3"
less than 14	"2"

Evaluation of current educational activities in distance learning mode.

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 for by the educational program are taken into account. The student must receive a grade in each topic. Estimates given on a traditional scale are converted into points. The average grade for the year must not be lower than "3" (which, converted to a multi-point scale, is at least 72 points).

An **"excellent" grade** is awarded to a student who took an active part in discussing the most difficult questions on the subject of the class, gave at least 90% correct answers to standardized test tasks, answered oral tasks without errors, and completed a protocol of practical work.

A **grade of "good"** is given to a student who participated in the discussion of the most difficult questions on the topic, gave at least 75% correct answers to standardized test tasks, made some minor mistakes in answering oral tasks, and drew up a protocol of practical work.

A **grade of "satisfactory"** is given to a student who did not participate in the discussion of the most difficult questions on the topic, gave at least 60% correct answers to standardized test tasks, made significant mistakes in answers to oral tasks, and drew up a protocol for practical work.

A **grade of "unsatisfactory"** is given to a student who did not participate in the discussion of the most difficult questions on the topic, gave less than 60% correct answers to standardized test tasks, made gross mistakes in answers to oral tasks or did not give answers to them at all, did not draw up a practical protocol work.

Table 1.1

Assessment of test control from 20 test tasks

Number of correct answers	Score
19 – 20	"5"
17 – 18	"4"
14 – 16	"3"
less than 14	"2"

11. The final control is carried out in the form of an exam upon completion of the study of the discipline and lasts 3 academic hours.

Students are admitted to the exam who have completed all types of work provided in the curriculum, and when studying the discipline have scored at least the minimum number of points, and also have no missed lectures and practical classes. The form of the exam is standardized and includes control of theoretical and practical training:

- written answers to 40 standard test tasks, each of which has one correct answer out of five offered (format A). 40 minutes are allotted for writing the test control (based on 1 test per 1 minute);
- written standardized answers to 5 tasks in the form of chains of transformations of bio-organic compounds, a list of certain biochemical indicators, completed tables, drawing up schemes, writing equations of chemical

reactions from all topics of the module (1 - 4 questions); description of the principles of the methods and the clinical-diagnostic value of determining biochemical parameters (5 questions). Duration – 95 minutes.

The final control in the on-line mode is carried out in the form of an exam upon completion of the study of the discipline and lasts 80 minutes.

Students are admitted to the exam who have completed all types of work provided for in the curriculum, and have scored at least the minimum number of points while studying the discipline, as well as not having unworked lectures and practical classes. The form of the exam is standardized and includes control of theoretical and practical training in the form of tests:

- *written answers to 40 standard test tasks, each of which has one correct answer out of five offered (format A). 40 minutes are allotted for writing the test control (based on 1 test per 1 minute);*
- *written answers to 40 difficult test tasks, each of which has four correct answers out of eight offered (format A). 40 minutes are allotted for writing the test control (based on 1 test per 1 minute).*

11. 1. Assessment of final control.

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

Evaluation criteria for test tasks:

Less than 25 tests - "unsatisfactory";

25-30 tests - "satisfactory";

31 – 36 tests - "good";

37-40 tests - "excellent".

The 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 6 to 8 points:

Less than 5 points - "unsatisfactory" - the student made gross mistakes in answers to written tasks or did not answer them at all;

5 points - "satisfactory" - the student made significant mistakes in answers to written theoretical tasks (including practical skills);

7 points - "good" - the student made some minor mistakes in answers to written theoretical tasks (including practical skills), or did not fully justify them;

8 points - "excellent" - the student comprehensively and deeply mastered the educational program material; fully possesses theoretical knowledge and practical skills.

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

A 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).

A 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).

A 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 exam is considered passed if the student scored at least **50 points**. The maximum number of points is 80 points.

Evaluation of final control in online mode

The grade for the exam is assigned based on the result of the test tasks (including practical skills).

Evaluation criteria for test tasks:

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

The correct answer to 1 complex test with four correct answers is 1 point, of which:

Three correct answers out of four - 0.75 points

Two correct answers out of four - 0.5 points

One correct answer out of four is 0.25 points

No correct answer - 0 points

If a student gives an incorrect answer along with the correct answers (one, two, three), such a test is evaluated at 0 points.

An "excellent" grade is awarded to a student who gave correct answers to **91 - 100 correct answers**

A grade of "good" is given by correct answers for **80-90% of correct answers**

A grade "satisfactory" was given by correct answers for **60-79% of correct answers**

A grade of "unsatisfactory" is given to a student who gave correct answers to **less than 60% of the correct answers**.

The exam is considered passed if the student scored at least 50 points. The maximum number of points is 80 points.

1. Scheme of accrual and distribution of points received by students:

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:

$$X = (CA \times 200)/5$$

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

Table 2

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		
		3.62	87		

Independent work of students is evaluated during the ongoing control of the topic in the corresponding session. The learning of topics that are assigned only to independent work is controlled during the final control.

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).

Determining the number of points that the student scored in the discipline

The maximum number of points assigned to students upon mastering the discipline is 200 points (including 120 points for current educational activity, 80 points based on the results of the exam).

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, taking into account the number of points scored in the discipline, are ranked on the ECTS scale as follows:

Table 3

ECTS assessment	Statistical indicator
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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

Ranking with the assignment of grades "A", "B", "C", "D", "E" is carried out for students of this course who are studying in one specialty and have successfully completed the study of the discipline. Students who receive grades of FX, F ("2") are not listed as ranked students. Students with an FX grade automatically receive an "E" grade after retaking.

Discipline scores for students who have successfully completed the program are converted into a traditional 4-point scale according to the absolute criteria, which are given in the table below:

Table 4

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

13. Methodological support:

- multimedia lecture presentation, video lecture;
- methodical development of a practical lesson for teachers;
- tasks for independent work;
- questions, problems, assignments or cases for current and final control of students' knowledge and skills.

14. Recommended literature.

Main:

1. Gubsky Yu. Bioorganic and biological chemistry. Book 2. Biological chemistry. Second edition. Medicine 2021. 500 p.
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. Gubsky Yu. Biological Chemistry. Nova Knyha, Vinnytsia, 2017. 487 p.
5. Lippincott Illustrated Reviews: Biochemistry. Denise R. Ferrier. Seventh edition. Wolters Kluwer, 2017. 2224 p.
6. MCQs in biochemistry 2nd edition / A. Ya. Sklyarov et al.: Lviv: Danylo Halytsky Lviv National Medical University Press, 2020. 319 p.
7. MCQs in biochemistry / A. Ya. Sklyarov et al.: Lviv: Danylo Halytsky Lviv National Medical University Press, 2012. 308 p.

Optional:

8. Textbook of Biochemistry for Medical Students by Vasudevan D.M., Sreekumari S., Kannan Vaidyanathan. Seventh edition. Jaypee Brothers Medical Pub, 2013. 791 p.
9. Chatterjea M.N., Rana Shinde. Textbook of Medical Biochemistry. Eighth edition. Jaypee Brothers Medical Pub, 2012. 894 p.
10. Nelson D.L., Cox M.M. Lehninger Principles of Biochemistry. Seventh edition. W.H. Freeman and Company, New York, 2017. 1328 p.
11. Trudy McKee, James R. McKee. Biochemistry. The molecular basis of life. Sixth edition. Oxford University Press, 2015. 928 p.
12. Peter Ronner. Netter's Essential Biochemistry. Elsevier, 2018. 482 p.

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

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