Ministry of Healthcare of Ukraine
Poltava State Medical University

Department of biological and bioorganic chemistry

SYLLABUS
BIOLOGICAL AND BIOORGANIC CHEMISTRY

Compulsory discipline

level of higher education	the second (master's) level of higher education
field of knowledge	22 «Healthcare»
specialty	221 «Dentistry»
academic qualification	Master of Dentistry
professional qualification	Dentist
educational and professional program	221 «Dentistry»
mode of study	full-time
course(s) and semester(s) of study of the discipline	I course, II semester, II course, III-IV semesters

Poltava – 2024

THE INFORMATION ABOUT LECTURERS WHO DELIVER THE ACADEMIC DISCIPLINE

Surname, name, patronymic of the lecturer (lecturers), scientific degree, academic title	Bilets Maryna Volodymyrivna, PhD, Assoc. Prof., Khmil Dmutro Oleksandrovych, PhD, Kotvytska Alina Anatoliyivna, Tykhonovych Kseniia Volodymyrivna
Profile of the lecturer (lecturers)	https://en.pdmu.edu.ua/education/departments/bio-him
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Department page on the PSMU website	https://en.pdmu.edu.ua/education/departments/bio-him

MAIN CHARACTERISTICS OF THE ACADEMIC DISCIPLINE

The scope of the academic discipline (module)

The number of credits / hours– 8,0/240, of which:

Lectures (hours) - 32

Practical classes (hours) - 96

Self-directed work (hours). - 112

Type of control **Exam**

The policy of the academic discipline

The policy of the discipline "Biological and Bioorganic Chemistry" is determined by a system of requirements to which lecturers of the department pay attention to the recipients for higher education when studying the discipline and is based on the principles of academic integrity. First of all, these are the requirements for the rules of conduct: attending classes without delay, turning off the phones during the class, as this distracts from the learning process and does not allow to objectively assess the recipient. The recipients for higher education should prepare for practical classes in advance, during the class they should take an active part in the discussion of the topic, using the acquired knowledge. Much attention is paid to the inadmissibility of the use of additional sources of information during practical classes, final module control or semester exam. Timely attendance of classes without passes is the key to successful mastering of material on biological and bioorganic chemistry.

When organizing the educational process at the Department of Biological and Bioorganic Chemistry, lecturers and students act in accordance with:

Regulation on the organization of the educational process at Poltava State Medical University.

Regulation on the academic integrity of recipients of higher education and employees of Poltava State Medical University.

Regulation on the organization and methods for assessment of educational activities of higher education recipients at Poltava State Medical University.

Regulation on the organization of self-directed work of students at Poltava State Medical University.

Regulation on the appeal claim for the results of final control of academic performance for recipients of higher education.

The procedure of the re-crediting academic disciplines, determining of academic difference, and the procedure for passing academic difference in PSMU are defined in the “Regulations on the procedure of re-crediting academic disciplines and determining of the academic difference in Poltava State Medical University”.

Regulations on non-formal and informal education of participants in the educational process of the Poltava State Medical University.

The above documents can be found on the academic office:

REGULATORY DOCUMENTS
(https://www.pdmu.edu.ua/n-process/department-npr/normativni-dokumenti)

Description of the academic discipline (summary):

The discipline of "Biological and bioorganic chemistry" is taught for first and second year students for three semesters. Students study the chemical nature of the substances that make up the human body, the metabolism of these substances, the reality of these transformations with the activity of the body and tissues, the mechanisms of regulation of these processes in normal and pathological conditions. The discipline includes sections: static biochemistry (chemical composition of substances), dynamic (metabolism and its regulation), dynamic biochemistry (features of the transformation of substances in different tissues and organs).

Pre-requisites and post-requisites of an academic discipline (interdisciplinary links)

Biological and bioorganic chemistry as academic discipline:

Biological and bioorganic chemistry as an academic discipline:

Prerequisites: is based on the study by students of Latin and medical terminology, human anatomy, histology, cytology and embryology, medical chemistry.

Postrequisites: a) lays the foundations for the study by students of pathophysiology, pharmacology, 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 occur in the body of a healthy and sick person, in the process of further study and professional activity;
b) lays the foundations for clinical diagnostics of the most common diseases, monitoring the course of the disease, monitoring the effectiveness of the use of medicines and measures aimed at the prevention of pathological processes.

The purpose and objectives of the academic discipline:
- the purpose of studying the academic discipline "Biological and Bioorganic Chemistry" is to study biomolecules and the molecular organization of cellular structures, general patterns of enzymatic catalysis and biochemical dynamics of the transformation of the main classes of biomolecules (amino acids, carbohydrates, lipids, nucleotides, porphyrins, etc.), molecular biology and genetics of information 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.

– the main objectives of studying the discipline are:
- mastering the knowledge and skills to conduct biochemical studies to identify normal and pathological components in biological fluids. Analyze the results of biochemical studies for the diagnosis of the most common human diseases.
- analyze the biochemical processes of metabolism and its regulation in ensuring the functioning of organs and systems of the human body.
- the ultimate goal is to master the knowledge of the biochemical properties and metabolism of basic biomolecules in the human body in normal and pathological conditions. Conducting biochemical studies in biological fluids and evaluating the results with the interpretation of clinical diagnostic significance.

Competences and learning outcomes in accordance with the academic and professional program, the formation of which is facilitated by the discipline (integral, general, special)

According to the requirements of the Educational Professional Program, the discipline provides students with the acquisition of competencies:
- *integrated:*

• ability to solve complex tasks and problems in the field of healthcare in the specialty "Dentistry" in professional activities or in the process of study, which involves conducting research and/or implementing innovations and is characterized by uncertainty of conditions

- *general:*

• • ability to abstract thinking, analysis and synthesis;
• ability to apply knowledge in practical activities ability to apply knowledge in practical activities;
• ability to communicate in English. Ability to use international Greco-Latin terms, abbreviations and clichés in professional oral and written speech.
• skills in using information and communication technologies.
• ability to search, process and analyze information from various sources.
• ability to adapt and act in a new situation.
• ability to act socially responsible and consciously.
• ability to exercise one's rights and obligations as a member of society, to realize the values of a civil (free democratic) society and the need for its sustainable development, the rule of law, the rights and freedoms of man and citizen in Ukraine.

- *special (professional, subject):*

ability to collect medical information about the patient and analyze clinical data;
• ability to maintain regulatory medical documentation;

• processing of state, social and medical information.

Program learning outcomes:
• Collect information about the patient's general condition, assess the patient's psychomotor and physical development, the condition of the maxillofacial organs, and evaluate information about the diagnosis based on the results of laboratory and instrumental studies
• Analyze the epidemiological situation and carry out measures of mass and individual, general and local drug and non-drug prevention of dental diseases.
• Analyze and evaluate state, social and medical information using standard approaches and computer information technologies.
• Form goals and determine the structure of personal activity based on the results of the analysis of certain social and personal needs.
• Be aware of and be guided in their activities by civil rights, freedoms and obligations, and increase the general educational cultural level.

Learning outcomes of the academic discipline:
upon completing their study in the academic discipline, students **must know:**
• The structure of bioorganic compounds and their biological functions that 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 the occurrence of pathological processes in the human body.
• Features of the diagnosis of the physiological state of the body and the development of pathological processes based on biochemical studies.
• Features of the structure and transformations in the body of bioorganic compounds, as the basis of their pharmacological action as medicines.
• Biochemical and molecular foundations of the physiological functions of cells, organs and systems of the human body.
• The functioning of enzymatic processes that occur in membranes and organelles to integrate 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.

Integrative final results of program of training, the formation of which is favored by the educational discipline:
the student should **be able to:**
The structure of bioorganic compounds and their biological functions that 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 the occurrence of pathological processes in the human body.
• Features of the diagnosis of the physiological state of the body and the development of pathological processes according to biochemical studies.
• Features of the structure and transformations in the body of bioorganic compounds, as the basis of their pharmacological action as medicines.
• Biochemical and molecular foundations of the physiological functions of cells, organs and systems of the human body.
• The functioning of enzymatic processes that occur in membranes and organelles to integrate 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.

Thematic plan of lectures, specifying the basic issues, which are considered at the lecture

Item No.	Names of topics	Number of hours
Module 1. Biological and Bioorganic Chemistry		
Content module 1. Static biochemistry. Enzymology. Bioenergetics.		
1	**Biomolecules are structural components of the cell. Structural hierarchy in the molecular organization of cells.** Cell – structural and functional unit of the organism. Cell structure, concept of "cell organelle". Chemical composition and functions of cell organelles (nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes). Supramolecular complexes, their chemical structure and biological role (membranes, chromatin, ribosomes, microtubules). Structural components of macromolecules, structure, functions, biological role (glucose, pentose, amino acids, higher fatty acids, nitrogenous bases). Chemical structure, properties, biological role of macromolecules (proteins, polysaccharides, complex lipids, nucleic acids).	2
2	**Structure, physical and chemical properties of enzyme proteins. Regulation of enzymatic processes.** Enzymes as biological catalysts of metabolic reactions. The structure of enzyme proteins. Simple and complex enzymes. Methods for isolating enzymes from bioobjects. Specificity of enzyme action. Regulation of enzymatic processes. Regulation of enzyme activity by changing the catalytic activity of the enzyme: a) allosteric regulation of enzyme activity; b) covalent modification of enzymes; c) activation of enzymes by limited proteolysis; d) action of regulatory effector proteins (calmodulin, proteinases, proteinase inhibitors, cyclic nucleotides). Regulation of enzyme activity by changing the amount of enzyme. Inhibitors, enzyme activators.	2
3	**Cofactors and coenzyme forms of vitamins role in the catalytic activity of enzymes.** Coenzymes. Structure and properties of coenzymes. Characteristics and properties of coenzyme forms of vitamins B2, PP, B6. Acylation coenzyme (coenzyme-A) is a derivative of pantothenic acid. Biological properties of vitamin B3, mechanism of action. Coenzymes are derivatives of folic acid. Vitamin Bc (folic acid): biological properties, mechanism of action. Lipoic acid: coenzyme in the reactions of oxidative decarboxylation of ketoacids and aerobic oxidation of glucose. Coenzyme thiamine diphosphate. Vitamin B1 (thiamine): structure, biological properties, mechanism of action. Coenzyme carboxybiotin. Vitamin H (biotin): biological properties, mechanism of action. Coenzymes are derivatives of vitamin B12. Vitamin B12 (cobalamin): biological properties, mechanism of action.	2
4	**Fundamental patterns of metabolism. Common pathways of proteins, carbohydrates, lipids transformation.** Metabolic pathways. Define the concepts of catabolic, anabolic and amphibolic pathways of metabolism. Exergonic and endergonic reactions. Three common stages of biomolecules catabolism.	2

	Pathways of ATP synthesis in cells: substrate and oxidative phosphorylation. Formation of ATP in cells under anaerobic and aerobic conditions. Advantages of aerobic oxidation of nutrient compounds. Reactions of biological oxidation: types of reactions (dehydrogenase, oxidase, oxygenase) and their biological significance. Tissue respiration. Molecular complexes of the inner membranes of mito chondria: NADH-coenzyme Q-reductase; succinate-coenzyme Q-reductase; coenzyme Q-cytochrome c-reductase; cytochrome c-oxidase. Pathways of inclusion of reducing equivalents in the respiratory chain of mitochondria. Oxidative phosphorylation. Mitochondrial ATP synthetase, structure and principles of functioning. FO and F1 subunits of ATP synthetase, their functional significance. Chemiosmotic theory of oxidative phosphorylation – molecular mechanism of ATP generation in the process of biological oxidation.	
Content module 2. Dynamic biochemistry.		
1	**Metabolism of carbohydrates -1. Glycolysis, aerobic oxidation of glucose; alternative ways of monosaccharide metabolism.** Anaerobic oxidation of glucose – glycolysis: enzymatic reactions of glycolysis, energetics, regulation. Stages of aerobic oxidation of glucose, oxidative decarboxylation of pyruvate, Multienzyme pyruvate dehydrogenase complex – features of functioning with the participation of three enzymes and five coenzymes. Comparative characteristics of bioenergetics of aerobic and anaerobic oxidation of glucose. Glucose biosynthesis - gluconeogenesis: physiological significance, enzymatic reactions, regulatory enzymes. Pentose phosphate pathway (PPP) of glucose oxidation; scheme, biological significance, features of functioning in different tissues. Metabolic pathway and enzymatic reactions of fructose conversion in the human body. Hereditary enzymopathies are associated with genetic defects in the synthesis of enzymes of fructose metabolism – fructose intolerance, fructosemia. and galactose – galactosemia.	2
2	**Metabolism of carbohydrates - 2. Glycogen metabolism; gluconeogenesis. Regulation and carbohydrate metabolism pathology. Diabetes mellitus.** Glycogen breakdown and biosynthesis: enzymatic reactions of glycogenesis and glycogenolysis; cascade mechanisms of cAMP-dependent regulation of glycogen phosphorylase and glycogen synthase activities. Hormonal regulation of glycogen metabolism in muscles and liver. Hormones - regulators of glucose metabolism (glucagon, adrenaline, glucocorticoids, somatotropin, insulin - effects and mechanisms of influence on the level of glycemia).	2
3	**Lipid metabolism.** Pathways of lipid metabolism. Adipocytes of adipose tissue and their role in lipid metabolism and bioenergy processes in the body. The catabolism of triacylglycerols: reactions; mechanisms of regulation of triglyceride lipase activity. Neurohumoral regulation of lipolysis with the participation of adrenaline, norepinephrine, glucagon, insulin. The biosynthesis of triacylglycerols. Cholesterol biosynthesis: metabolic precursors; reaction. Regulation of cholesterol synthesis. Ways of biotransformation of cholesterol: esterification; the formation of bile acids, steroid hormones, vitamin D3; excretion of cholesterol from the body. The role of cytochrome P-450 in the biotransformation of physiologically active steroids. Pathologies of lipid metabolism. Atherosclerosis: development mechanisms, the role of genetic factors. Atherosclerosis as an autoimmune process.	4
4	**Amino acid metabolism.** Pathways of formation and maintenance of a pool of free amino acids in the human body. General pathways of free amino acids metabolism. Pathways of formation of ammonia. Ammonia toxicity and mechanisms of its neutralization. Circulatory transport of ammonia (glutamine, alanine). Urea biosynthesis: enzymatic reactions, genetic defects of urea synthesis enzymes (enzymes).	2
Content module 3. Functional biochemistry		
1	**Hormones: biochemical and molecular-biological mechanisms of**	2

	hormone action; protein and peptide hormones. Hormones and other bioregulators in the system of intercellular integration of the functions of the human body, their chemical nature, classes of hormones: protein-peptide hormones; hormones - derivatives of amino acids; steroid hormones; bioregulators are derivatives of arachidonic acid. Synthesis and secretion of hormones. Cyclicity of hormonal secretion in the human body. Circulatory transport of hormones. Targets of hormonal action; types of cell responses to hormones. Hormone receptors: membrane (ionotropic, metabotropic) and cytosolic receptors. Biochemical systems of intracellular transduction of hormonal signals.	
2	**Biochemistry of blood. Respiration function of erythrocytes.** Physiological and biochemical functions of blood. Respiratory function of red blood cells. Hemoglobin: structure, properties, mechanisms of participation in the transport of oxygen and carbon dioxide. Variants of human hemoglobins; molecular disorders in the structure of hemoglobins (hemoglobinoses) - hemoglobinopathies, thalassemias. The acid-base balance of the human body. Mechanisms of regulation and maintenance of the acid-base balance: blood buffer systems, lung and kidney function.	2
3	**Biochemical functions of the liver. Biochemistry of jaundices. Biotransformation of foreign compounds in the liver.** Homeostatic role of the liver in the metabolism. Biochemical functions of hepatocytes. Carbohydrate, lipid-regulating, protein, urea-educational, pigment, bile-forming liver functions. The biochemical composition of bile. The role of the liver in the exchange of bile pigments. Hemoglobin catabolism: rupture of the tetra-pyrrole heme ring, decomposition of verdoglobin, conversion of biliverdin to bilirubin, formation of bilirubin-diglucuronide, excretion into bile. Pathobiochemistry of jaundice; hemolytic, parenchymal, obstructive.	2
4	**Biochemistry of the connective tissue. Biochemistry of the bone tissue. Factors of osteoporosis risk.** General characteristics of the morphology and biochemical composition of connective tissue. The biochemical structure of the intercellular substance of loose fibrous connective tissue fibers (collagenic, reticular, elastic) is the main amorphous substance. Proteins of connective tissue fibers collagen, elastin, glycoproteins and proteoglycans. Collagen biosynthesis and the formation of fibrillar structures. Complex carbohydrates of the main amorphous matrix of connective tissue are glycosine minoglycans (mucopolysaccharides). Pathobiochemistry of connective tissue. Biochemical mechanisms of development of mucopolysaccharidoses and collagenoses, their clinical and biochemical diagnostics. Chemical composition and metabolism of the bone tissue. Hormonal regulation of the bone tissue metabolism. Biochemical tests in diagnostics of bone tissue diseases.	2
5	**Biochemistry of the dental tissues.** Chemical composition of tooth tissues. Features of chemical composition of enamel. Chemical composition of dentine. Chemical composition of cementum. Describe the emetabolism in tooth tissues. Hormonal regulation of metabolism in tooth tissues. Role of vitamins in the metabolism of tooth tissues. Describe the processes of mineralisation in tooth tissues. Initiators of mineralisation. Features of mineralisation of enamel and difference between dentine and cementum. Remineralisative action of saliva.	2
6	**Biochemistry of the saliva.** Notions "saliva" and "oral fluid". Salivary glands and peculiarities of protein components of secretion. Biological role of saliva. Physical and chemical properties of saliva. Inorganic saliva components, their properties and role for tooth metabolism. Organic saliva components, their properties, role. Characteristics of saliva buffer properties, pH changes and their consequences. Main mechanisms of the nervous and humoral regulation of salivation; dependence of saliva composition on the nervous regulation, state of internal environment. Describe the role of humoral factors in regulation of saliva composition: hormones of hypophysis, adrenal glands. Features of composition of gingival fluid.	2

	Changes of biochemical composition of gingival fluid at stomatological diseases.	
7	**Biochemical mechanisms of the main stomatological diseases development.** Dental deposits (dental plaque, dental calculus). Biochemical bases of caries development. Biochemical bases of periodontal disease development. Role of diet in the development and prevention of caries. Explain the significance of drinking-water fluorination as an effective method of caries prevention. Explain the changes of saliva chemical composition diabetes mellitus, periodontitis and infectious processes. To tell about the change of enzymes activity of mixed saliva at pathology of mouth cavity organs. Give the explanation of enzyme and antienzyme (antiproteinase) drugs in therapy of mouth cavity organs diseases. Fluorine intoxication as a main etiological factor of fluorosis development. Changes of enamel mineral phase composition at fluorosis. Role of local and general factors in periodontal disease development.	2
	Total	**32**

Thematic plan of practical classes by modules and content modules, specifying the basic issues, which are considered at the practical class

Thematical plan of practical classes

Item no.	Names of topics	Number of hours
Module 1. Biological and Bioorganic Chemistry		
Content module 1. Static biochemistry. Enzymology. Bioenergetics.		
1	**Biomolecules are structural components of the cell. Structural hierarchy in the molecular organization of cells.** Cell – structural and functional unit of the organism. Cell structure, concept of "cell organelle". Chemical composition and functions of cell organelles (nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes). Supramolecular complexes, their chemical structure and biological role (membranes, chromatin, ribosomes, microtubules). Structural components of macromolecules, structure, functions, biological role (glucose, pentose, amino acids, higher fatty acids, nitrogenous bases). Chemical structure, properties, biological role of macromolecules (proteins, polysaccharides, complex lipids, nucleic acids).	2
2	**Study of the properties of natural higher fatty acids. Simple and complex lipids.** Biological functions of lipids. Higher fatty acids as components of lipids. Physiological significance of hydrolysis of neutral lipids. The role of phospholipids in the construction of biomembranes. Classification of complex lipids. Physicochemical properties of phospholipids. Structure, properties, functions of cholesterol.	2
3	**Study of the structure and functions of carbohydrates.** Classification of carbohydrates. Isomerism. Tautomeric forms of monosaccharides. Chemical reactions of monosaccharides with the participation of a carbonyl	2

	group: redox reactions (qualitative for the detection of an aldehyde group). Formation of glycosides, their role in the construction of oligo- and polysaccharides, nucleosides, nucleotides and nucleic acids. Phosphoric esters of glucose and fructose, their importance in the metabolic transformations of carbohydrates. Ascorbic acid, as a derivative of hexoses, the biological role of vitamin C. Structure, properties of sucrose, lactose, maltose. Classification of disaccharides according to their ability to redox reactions. Two types of bonds between monosaccharide residues and their effect on the reactivity of disaccharides. Classification of polysaccharides. Structure and biological role of glycogen, fiber, its role in the processes of vital activity of the organism. Heteropolysaccharides. The role of glucuronic acid, glucosamine, and galactosamine in the formation of heteropolysaccharides.	
4	**Study of chemical properties of nucleosides and nucleotides, nucleic acids.** Characteristics of nucleotides and nucleosides. Structure of nucleotides: AMP, GMP, UMP, CMP, d-TMP. Structure and significance of 3',5'-c-AMP, its role in the action of hormones on cells. Phosphorylated derivatives of nucleotides, significance of ADP and ATP. Participation of nucleotides in the structure of coenzymes. Biological role of DNA. Principle of structure of DNA, primary and spatial structure, types of chemical bond. Principle of structure of RNA, primary and spatial structure, types of chemical bond. Types of RNA: mRNA, rRNA, tRNA, their structural organization and biological role. Role of the principle of complementarity.	2
5	**Study of the amino acid composition of proteins and peptides.** Classification of amino acids by the structure of the carbon chain, by the ability to synthesize in the body and by the polarity of the radical. Optical properties of amino acids. Acid-base properties of amino acids Write the equation of the decarboxylation reactions of amino acids with the formation of biogenic amines (phenylalanine, serine, histidine, tryptophan) and explain their physiological functions. Write the scheme of the deamination and transamination reactions of amino acids and explain their physiological role. Write the scheme of the equation of the reactions of the formation of glutamic and aspartic acid amides and explain their physiological significance. The mechanism of peptide bond formation.	2
6	**Study of the structural organization of proteins.** Primary, secondary, tertiary, quaternary structure, types of bonds that stabilize these structures. Simple and complex proteins. Electrochemical properties of proteins, the concept of the isoelectric state of proteins and the isoelectric point (pI). Classification of proteins depending on the nature of the prosthetic group and spatial shape: globular and fibrillar. Protein denaturation.	2
7	**Study of the structure, physical and chemical properties of enzyme proteins. Mechanism of enzymes of action, kinetics of enzymatic catalysis.** Enzymes as biological catalysts of metabolic reactions. Structure of enzyme proteins. Simple and complex enzymes. Apoenzyme, cofactor. Oligomeric	2

	protein-enzymes, multienzyme complexes. Membrane-associated enzymes. Physicochemical properties of enzymes. Electrochemical properties, solubility. Dependence of reaction rates on pH and temperature. Specificity of enzyme action. Mechanisms of enzyme action. Thermodynamic laws of enzymatic catalysis. Active sites of enzymes. Differences in the structure of active sites in simple and complex enzymes. Enzymatic transformation of substrates under the catalytic action of an enzyme using the example of the action of chymotrypsin. Sequence of stages of the catalytic process. Kinetics of enzymatic reactions. Dependence of reaction rates on the concentration of the enzyme and substrate.	
8	**Units of measurement of enzymes catalytic activity. Classification of enzymes by type of chemical reactions.** Methods for determining enzyme activity. Units of measurement of enzyme activity (katal, international units, specific activity). Enzyme nomenclature. International classification and nomenclature of enzymes by type of reactions (examples for each class of enzymes).	2
9	**Study of the enzymatic processes regulation.** Regulation of enzymatic processes. Regulation of enzyme activity by changing the catalytic activity of the enzyme: a) allosteric regulation of enzyme activity; b) covalent modification of enzymes; c) activation of enzymes by limited proteolysis; d) action of regulatory effector proteins (calmodulin, proteinases, proteinase inhibitors, cyclic nucleotides). Regulation of enzyme activity by changing the amount of enzyme. Inhibitors, enzyme activators. Reversible and irreversible inhibition of enzymes. Physiologically active compounds and xenobiotics as reversible (competitive and non-competitive) and irreversible inhibitors of enzymes. Isoenzymes - multiple molecular forms of proteins. Proenzymes (zymogens).	2
10	**Medical enzymology.** Medical enzyme diagnostics. Modern aspects of enzyme diagnostics: cellular, secretory and excretory enzymes. Isoenzymes in enzyme diagnostics, tissue specificity of enzyme distribution. Changes in the activity of plasma and serum enzymes as diagnostic indicators of the development of pathological processes in the body. Application of enzyme diagnostics in cardiology, hepatology, nephrology, urology, oncology, pulmonology, orthopedics, etc. (examples). Enzymopathology. Violations of the course of enzymatic processes: hereditary and acquired enzymopathies. Inborn errors of metabolism and their clinical and laboratory research. Enzymotherapy in medical practice. Use of enzymes as medicines (examples). Pharmacological use of enzymes of the gastrointestinal tract; coagulation and fibrinolytic systems of the blood, kallikrein-kinin and renin-angiotensin systems. The use of enzyme inhibitors in medicine.	2
11	**Study of the cofactors and coenzyme forms of vitamins role in the catalytic activity of enzymes (coenzyme forms of vitamins B2, PP, B6).** Coenzymes. Structure and properties of coenzymes. Structure and properties of coenzymes. Classification of coenzymes by chemical nature. Classification of coenzymes by the type of reaction catalyzed:	2

	a) coenzymes that are carriers of hydrogen atoms and electrons; b) coenzymes that are carriers of chemical groups; c) coenzymes of synthesis, isomerization and cleavage of carbon-carbon bonds. Characteristics and properties of coenzyme forms of vitamins B2, PP, B6.	
12	**Study of the cofactors and coenzyme forms of vitamins role in the catalytic activity of enzymes (coenzyme forms of vitamins B_1, B_3, B_c H, lipoic acid).** Acylation coenzyme (coenzyme-A) – a derivative of pantothenic acid. Biological properties of vitamin B3, mechanism of action. Coenzymes – derivatives of folic acid. Vitamin Bc (folic acid): biological propertie mechanism of action. Lipoic acid: coenzyme in the reactions of oxidative decarboxylation of ketoacids ar aerobic oxidation of glucose. Coenzyme thiamine diphosphate. Vitamin B1 (thiamine): structure, biological prop mechanism of action. Coenzyme carboxybiotin. Vitamin H (biotin): biological prop mechanism of action. Coenzymes – derivatives of vitamin B12. Vitamin B12 (cobalamin): biological properties, mechanism of action.	2
13	**Fundamental patterns of metabolism. Common pathways of proteins, carbohydrates, lipids transformation. Study of the tricarboxylic acid cycle functions.** Metabolic pathways. Define the concepts of catabolic, anabolic and amphibolic metabolic pathways. Exergonic and endergonic reactions. Three common stages of catabolism of biomolecules. Stage 1 – breakdown of complex macromolecules into simple components. Stage 2 – intracellular catabolism of carbohydrates, lipids and amino acids. Acetyl-CoA – the common end product of the second stage of intracellular metabolism of carbohydrates, lipids and amino acids. Stage 3 – oxidation of acetyl-CoA to final metabolites – CO2 and H2O. General characteristics of the CTC and the electron transport system in mitochondrial membranes (tissue respiration) and coupling with oxidative phosphorylation. General characteristics of the tricarboxylic acid cycle. Regulation of the tricarboxylic acid cycle.	2
14	**Bioenergetic processes: biological oxidation, oxidative phosphorylation.** The relationship between the processes of energy formation and consumption in living systems. Pathways of ATP synthesis in cells. Reactions of biological oxidation. Molecular organization of the mitochondrial chain of biological oxidation. Oxidative phosphorylation. Mitochondrial ATP synthetase. Chemiosmotic theory of oxidative phosphorylation - molecular mechanism of ATP generation in the process of biological oxidation. Conditions for effective coupling of oxidation and phosphorylation in mitochondria. Causes and consequences of hypoergosis. Respiratory control. Oxidative phosphorylation coefficient. Inhibitors and uncouplers of tissue respiration.	2
15	Final control of content module 1 "Static biochemistry. Enzymology. Bioenergetics"	2
Content module 2. Dynamic biochemistry.		
1	**Biochemistry of carbohydrates. Digestion of carbohydrates. The metabolic pathways of glucose.** Carbohydrates: definition, classification, properties, biological role of carbohy	2

	Carbohydrates as cariogenic compounds (levan, dextran - the basis of dental plaque Metabolic pathways of glucose conversion. Daily requirement for carbohydrates. Criteria for the usefulness of carbohydrates. Digestion of carbohydrates. Enzymes of cavity and membrane digestion of carbohy Features of monosaccharide absorption. Disorders of digestion and absorpt carbohydrates.	
2	**Anaerobic oxidation of glucose. Gluconeogenesis.** General characteristics of anaerobic glucose oxidation. Sequence of reactions and enzymes of glycolysis. Glycolytic oxidation-reduction: substrate phosphorylation and shuttle mechanisms of glycolytic NADH oxidation. Pasteur effect. Regulation of glycolysis. Alcoholic and other types of fermentation. Ways of utilization of lactic acid. Causes and consequences of hyperlactatemia. What is the process called "gluconeogenesis"? In which tissues does it actively occur? Physiological significance of gluconeogenesis. Metabolic pathway of gluconeogenesis; irreversible reactions of glycolysis, reactions and enzymes that allow them to be bypassed. Compartmentalization of the conversion of pyruvate to phosphoenolpyruvate. Substrates of gluconeogenesis. Lactate and alanine as substrates of gluconeogenesis. Glucose-lactate cycle (Cori cycle). Glucose-alanine cycle. Metabolic and hormonal regulation of gluconeogenesis. Regulatory enzymes. Itsenko-Cushing's disease (steroid diabetes).	2
3	**Aerobic oxidation of glucose.** Stages of aerobic oxidation of glucose. Oxidative decarboxylation of pyruvate. Multienzyme pyruvate dehydrogenase complex - features of functioning with the participation of three enzymes and the fifth coenzyme. Overall equation of the process. Comparative characteristics of bioenergetics of aerobic and anaerobic oxidation of glucose. Pasteur effect - switching from anaerobic to aerobic oxidation of glucose, features of regulation. Shuttle mechanisms of oxidation of glycolytic NADH. Malate-aspartate shunt of transport of reducing equivalents of glycolytic NADH in mitochondria under aerobic conditions. Causes and consequences of hyperpyruvatemia.	2
4	**Alternate pathways of monosaccharide metabolism.** Biological value and features of functioning of pentose-phosphate pathway for different tissues. Sequence of ferment reactions of PPhP: a) oxidative stage; b) stage of isomeric transformations. 2Infringement of pentose-phosphate pathway of an exchange of glucose in erythrocytes: enzymopathy of glucose-6-phosphate-dehydrogenase. Explain a biological role of glucuronate way of oxidation of glucose; on concrete examples explain its structural role and a role in neutralization of toxic substances. Write a structure of glucuronic acid, UBP-glucuronic acid, hexosamine (glucosamine or galactosamine). Metabolic way and ferment reactions of transformation of fructose in the person organism. Hereditary enzymopathies, connected to genetic defects of enzymes synthesis of	2

	fructose metabolism – intolerance of fructose (fructosemia). Metabolic way and ferment reactions of transformation of galactose in the person organism. Hereditary enzymopathies, connected to genetic defects of enzymes synthesis of a galactose metabolism – galactosemia.	
5	**Analysis of catabolism and biosynthesis of glycogen. Regulation of glycogen metabolism.** Structure of glycogen and its biological role. Explain mechanisms of biosynthesis of glycogen (reactions, enzymes). Genetic infringements of enzyme systems of glycogen synthesis, the characteristic of the most widespread aglycogenoses. Explain biochemical mechanisms of disintegration of glycogen in a liver and muscles: reactions, enzymes, a biological role. What are the differences of glycogen disintegration in a liver and muscles? Hormonal regulation of an exchange of glycogen: the cascade mechanism of regulation of activity c-AMP-depending glycogen phosphorylase and glycogen synthetase. Genetic infringements of process of disintegration of glycogen (glycogenoses).	2
6	**Analysis of mechanisms of metabolic and hormone regulation of carbohydrate metabolism.** Mechanisms of hypoglycemic effect of insulin. The mechanism of influence on a carbohydrate exchange of glucagon, adrenaline, glucocorticoids. Normoglycemia: mechanisms of its support. Hypoglycemia: the reasons of occurrence and a consequence for an organism. Hyperglycemia – the reasons and complications Clinical-biochemical characteristic. Diagnostic criteria of a diabetes mellitus: a) glucose-tolerant test;b) double sugar loading.c) glycosilative HbA_{C1}.	2
7	**Lipid biochemistry. Lipid digestion. Metabolic pathways of triacylglycerols, higher fatty acids, complex lipids, cholesterol.** Lipids: definition, properties, classification, biological role of lipids. General characteristics of lipid digestion. Enzymes, biochemical mechanisms of lipid digestion in individual parts of the digestive tract. Composition of bile. Biochemical mechanisms of the development of gallstone disease. Biochemical changes in lipid metabolism in disorders of the stomach and intestines and their clinical and biochemical diagnostics. Disorders of the secretory function of the pancreas in acute and chronic pancreatitis, their clinical and biochemical characteristics. Types of steatorrhea: pancreatic steatorrhea (pancreatic lipase deficiency in pancreatitis), hepatogenic steatorrhea (bile deficiency in the intestine), enterogenic steatorrhea (inhibition of lipolysis enzymes and triacylglycerol resynthesis in the intestine).	2
8	**Transportation forms of lipids.** To name classes of lipoproteins of blood plasma, their value. To characterize qualitative and quantitative structure of lipoproteins of blood plasma. Classes of apoproteins, their biological role. Formation of transport forms of lipoproteins of blood. Quantitative and qualitative changes of blood lipoproteins at their circulation in blood and cells. The clinical-biochemical characteristic of primary and secondary	2

	lipoproteinemias by WHO classification. Principles of laboratory diagnostics of dislipoproteinemias.	
9	**Analysis of catabolism and biosynthesis of triacylglycerols. Determination of molecular mechanisms of regulation of lipolysis. Metabolism of complex lipids.** Biological functions of the main classes of lipids: energetic, structural, regulatory. Catabolism of triacylglycerols in adipocytes of adipose tissue: sequence of reaction, mechanisms of regulation of triglyceridlipase activity. Neuro-humoural regulation of lipolysis with participation of adrenaline, noradrenaline, glucagon and insulin. Oxidation of glycerol: enzyme reactions, bio-energetics. Biosynthesis of triacylglycerols. Adipocytes of adipose tissue and their role in lipid exchange and bioenergetic processes in organism. Pathochemistry of obesity. Complex lipids/ biosynthesise of phospholipids/ What lipotropic factors (irreplaceable components of meal) are necessary for synthesis of phosphotedylcholine? Infringement of an exchange of compound lipids – steatosis of liver. Sphingolipidoses: a) Illness of Nimane-Peak. b) Illness of the Tay-Sachs. c) Illness of Gaucher's.	2
10	**Analysis of metabolism of fatty acids and ketone bodies.** Oxidation of fatty acids (β-oxidation) a) Activation of fatty acids; b) Role of carnitine in transport of fatty acids in mitochondria; c) Sequence of ferment reactions. Biosynthesis of the supreme fatty acids, metabolic sources. Biosynthesis of the saturated fatty acids (palmitate). Synthesis of malonyl-CoA. Features of fatty acids synthase structure, acetyl-transport protein. Sources of NADPH for biosynthesis of fatty acids.Regulation of biosynthesis of fatty acids. Elongation of the saturated fatty acids. Formation of mono- and poly-unsaturated fatty acids. Physiological value. Biological role of compound lipids.Biosynthesis of phospotedylcholine. Energetics of β-oxidation of fatty acids. Oxidation of glycerol. Ketone bodies. Reactions of biosynthesis and recycling of ketone bodies, their physiological value. Metabolism of ketone bodies in conditions of a pathology. Mechanisms of superfluous rising of the contents of ketone bodies at a diabetes mellitus and starvation. Consequences of ketosis.	2
11	**Biosynthesis and biotransformation of cholesterol. Analysis of deficiencies of lipid metabolism: steatorrhea, atherosclerosis, obesity.** Biological role of cholesterol. Circulatory transport of cholesterol. Norm of the contents of cholesterol in whey of blood. Transport of cholesterol, change in system of lipoproteins at a pathology, their functional value. The scheme of reactions of cholesterol synthesis. Key reaction of biosynthesis.	2

	Regulation of cholesterol synthesis. The mechanism of cholesterol etherification . Biosynthesis of bile acids from cholesterol.Biosynthesis of steroid hormones from cholesterol.Formation of vitamin D_3 from cholesterol. Mechanisms of development of an atherosclerosis.Mechanisms of obesity development.Infringement of lipid exchange at a diabetes mellitus (macroangiopathies, ketosis), mechanisms of their development. Steatorrhea, the mechanism of its development.	
12	**Biochemistry of amino acids. Protein digestion. The concept of "nitrogen balance", types of nitrogen balance.** What determines the food value of proteins. Concepts: nitrogen balance, positive and negative nitrogen balance, protein attrition coefficient. The role of studying them for substantiating the norms of protein nutrition. Based on what conditions were the norms of protein nutrition established? The chemical composition of gastric juice in normal and pathological conditions. The biological role of hydrochloric acid. Normal values of gastric juice acidity, "debit-hour" of free HCl, principles of their determination. Pathological changes in gastric juice acidity: hypo- and hyperchlorhydria, achlorhydria, achilia. The mechanism of activation of proteolytic enzymes. Features of the intestinal and membrane digestion of proteins in the intestine. Proteolytic enzymes of intestinal juice. Absorption of amino acids.	2
13	**Analysis of amino acid metabolism (transamination, deamination, decarboxylation). Analysis of amino acid metabolism (transamination, deamination, decarboxylation).** Ways of obtaining of free amino acids in tissues. Ways of using of free amino acids in tissues. Transamination of amino acids: reactions and their biochemical value. To write the equation of reamination reactions of glutamic acid and pyruvate. The mechanism of aminotransferases action. Direct and indirect of deamination of free L-amino acids in tissues. Decarboxylation of L-amino acids in the organism of the person. Physiological value of the formed products. Oxidation of biogenic amines. To explain molecular mechanisms of toxic influence of ammonia on an organism. Circulatory transport of ammonia. Explain 4 molecular mechanisms of urgent neutralization of ammonia. What ways of use by an organism of the formed nitrogenous products exist? What processes deliver free ammonia at the first stage of synthesis of urea? Write the reactions of glutamine and carbomailphosphate synthesis. To give a general characteristic of process of biosynthesis of urea, chemism of reactions, the name of enzymes. Primary and secondary hyperamoniemias (the reasons and consequences). Explain changes of protein exchange at uremia, hepatic and kidney insufficiency, radiation sickness. Name the digital values of the contents in norm in blood of ammonia, urea, daily their allocation with urine. At disease of what organs and systems is it necessary for the doctor to appoint the analysis for the contents of urea in blood and urine?	2
14	**Biosynthesis of glutathione and creatine. Analysis of intermediate products of porphyrin biosynthesis and their accumulation at porphyries.** Ways of ammonia formation.Biological role of creatinphosphate.Biosynthesis of creatine.Precursors of creatine biosynthesis.Features of the second stage of	2

	creatine biosynthesis – transmetilation of glycociamine (guadenine acetate). Sources of CH_3 - groups.Reaction of creatine phosphorylation. Clinical value of determination of the creatine and creatinine contents in blood and urine.Clinical value of creatine phosphokinase determination. Isoforms of creatine phosphokinase Precursors of glutathione biosynthesis.Role of glutathione in an exchange of organic peroxides. Porphyrins: structure, biological role. Reactions of protoporphyrin IX biosynthesis; formation of heme. Regulation of porphyrins synthesis. Hereditary infringements of an porphyrins exchange (enzymopathies): erythropoetic porphiria, hepatic porphyrias, neurologic infringements, photodermatites.	
15	**Research into the biosynthesis and catabolism of purine and pyrimidine nucleotides. Determination of the end products of their metabolism.** Purine nucleotide biosynthesis. Pyrimidine nucleotide biosynthesis. Deoxyribonucleotide biosynthesis. Hereditary disorders of uric acid metabolism. Clinical and biochemical characteristics of hyperureemia; gout; Lesch-Nyhan syndrome.	2
16	**Final control of the content module 2 "Dynamic Biochemistry"**	
	Content module 3. Functional biochemistry	
1	**Study of molecular-cellulary mechanisms of action of peptide and protein hormones on target cells. Hormones of hypothalamus and hypophysis.** Cyclicity of hormonal secretion in the organism. Circulatory transport of hormones. Targets of hormones: types of cell reactions to hormone action. Hormone receptors: membrane (ionotropic, metabotropic) and cytosolic receptors. Biochemical systems of endocellular transduction of hormone signals. . Classification of protein-peptide hormones. Molecular-cellular action mechanisms of protein-peptide hormones. Cascade systems of transduction of bioregulator chemical signal: receptors → G-protein → secondary intermediates → protein kinases. Messenger functions of cyclic nucleotides, Ca^{+2}/calmodulin system, phosphoinositols. Serine, threonine and tyrosine protein kinases and effectory functions of cells Hormones of hypothalamic-hypophysial system. Liberins and statins of hypothalamus. Hormones of anterior pituitary. Group of growth hormone (somatotropin) – prolactin – chorionic somatotropin, pathological processes caused by infringement of STH function, somatomedins, prolactin. Group of glycoproteids – tropic hormones of hypophysis (thyrotropin, gonadotropin – FSH, LH, chorionic gonadotropin). Family of proopiomelanocortin (POMC) – products of POMC processing (adrenocorticotropin, lipotropins, endorphins). Hormones of the pituitary posterior lobe. Vasopressin (antidiuretic hormone); diseases caused by infringement of ADH production (diabetes mellitus, insipidus, Parhon syndrome). Oxytocin.	2
2	**Study of molecular-cellulary mechanisms of action of steroid hormones on target cells. Steroid hormones.**	2

	Chemical nature and action mechanism of steroid hormones on the target cell. Action mechanism of glucocorticoids and mineralcorticoids in metabolism. Hyper- and hypofunction of adrenal cortex. Sex hormones. Hormones of adrenal cortex in stress reactions. Methods of biochemical diagnostics of functioning of adrenal cortex and sex glands.	
3	**Study of the role of thyroid hormones and biogenic amines in regulation of metabolic processes.** Structure and biosynthesis of thyroid hormones. Write their structural formulas. Explain molecular-cellular mechanisms of action of thyroid hormones. Biological effects of T_3 and T_4. Pathology of the thyroid gland, infringements of metabolic processes at hyper- and hypo-thyreosis. Catecholamines (epinephrine, norepinephrine, dopamine): structure, biosynthesis, physiological effects, biochemical mechanisms of action. Indolamines (serotonin, melatonin): structure, biosynthesis, physiological effects, biochemical mechanisms of action. Histamine: structure, biosynthesis, physiological effects, biochemical mechanisms of action. Receptors of biogenic amines; receptor action of mediciness, antagonists of histamine receptors.	2
4	**Hormones of the pancreas and gastrointestinal tract** Insulin – structure, biosynthesis and secretion. The effect of insulin on the metabolism of carbohydrates, lipids, amino acids and proteins. Growth-stimulating effects of insulin; growth factors and oncoproteins. Glucagon – structure, mechanism of action. The effect of glucagon on metabolism. Metabolic disorders in diabetes mellitus. Biochemical diagnostics of pancreatic diseases. Gastrin – structure, biological functions.. Cholecystokinin – structure, physiological effects. Secretin – structure, properties.	2
5	**Hormonal regulation of calcium homeostasis.** Distribution of Ca^{2+} in organism; molecular forms of calcium in blood plasma. Role of the bone tissue, small intestine and kidneys in calcium homeostasis. Parathyroid hormone – structure, mechanism of hypercalcemic action. Calcitriol: biosynthesis, influence to absorption of Ca^{2+} and phosphates in intestine. Calcitonin: structure, effect on calcium and phosphate metabolism. Clinical-biochemical characteristic of calcium homeostasis infringements (rickets, osteoporosis).	2
6	**Study of the functional role of fat-soluble vitamins in metabolism and realization of cell functions.** Classification of vitamins. Exogeneous and endogeneous hypo- and avitaminosises. Use of vitamin preparations in prevention and treatment of diseases. Vitamins as components of nutrition. Biochemical mechanisms of participation of fat-soluble vitamins A, E, K, F, D in metabolism. Biochemical manifestations of deficiency of vitamins A, D, E, K. Biochemical manifestations of hypervitaminoses A, D. Mechanism of antioxidant action of vitamins.Concept of physiological antioxidant system.	2
7	**Study of blood plasma proteins: proteins of acute inflammation phase, own enzymes and indicator enzymes.** Practical study of determination of C-reactive protein in blood plasma. Proteins	2

	of blood plasma and their clinical-biochemical characteristics. Components of the nonspecific resistance system and test proteins of "acute phase " (PAPh) of inflammatory processes. Enzymes of blood plasma and their value in enzymodiagnostics of diseases of internal organs. The kallikrein-kinin system (KKS).	
8	**Study of acid-base state of blood and respiratory function of erythrocytes. Pathological hemoglobins.** Hemoglobin: structure, properties. Mechanism of hemoglobin participation in transport of oxygen and carbon dioxide. Variants of hemoglobins; molecular infringements of hemoglobin structure – hemoglobinopathies, thalassemias. Mechanisms of regulation and maintenance of acid-base state: buffer systems of blood; functions of lungs and kidneys. Parameters of acid-base balance which are measured in clinic. Mechanisms of regulation and maintenance of acid-base state: buffer systems of blood; functions of lungs and kidneys. Metabolic alkalosis and acidosis, mechanisms of their occurrence. Respiratory alkalosis and acidosis, their mechanisms. Parameters of acid-base balance which are measured in clinic. Mechanisms of hypoxia. Methods of laboratory diagnostics of hypoxias.	2
9	**Study of nitrogen balance and non-protein nitrogen containing components of blood – end products of geme catabolism.** Norm of residual nitrogen in blood plasma. Clinical value of its determination. Composition of residual nitrogen. Origin, norms and clinical value of determination: urea, ammonia, uric acid, creatine, creatinine, indican, amino acids, bilirubin. Causes of retention and production azotemias, their relationship with certain forms of organ and system pathology. What components of residual nitrogen are characteristic for different kinds of azotemias? . Scheme of hemoglobin and heme catabolism. Structure of bile pigments. Norms of their concentration in blood plasma, urine, feces. 3 Clinical value of determination of bile pigments.	2
10	**Biochemistry of the liver.** Carbohydrate (glycogenic) function of the liver. Protein synthesis and urea synthesis function of the liver. Biochemical mechanisms of development of hepatic encephalopathy . Role of the liver in regulation of lipid composition of blood. Bile formation function of the liver. Biochemical composition of bile. Changes of biochemical parameters at acute hepatites caused by viruses or alcoholic intoxication, their estimation for diagnostics. Changes of biochemical parameters at chronic hepatites, cirrhosis, bile-stone diseases, dyskinesia and cholecystitis, their diagnostic estimation. Relationship of infringements of excretory functions of the liver and infringements of digestion processes in the intestine, diagnostics of these infringements. Role of the liver in metabolism of bile pigments. Catabolism of hemoglobin. Hemolytic (prehepatic), hepatocellular (hepatic), obturative (posthepatic) jaundices. Enzymic, hereditary jaundices: of Crigler-Najjar syndrome, Gilbert's syndrome, Dubin-Johnson's syndrome, jaundices of newborns. Biotransformation of	2

	xenobiotics and endogenic toxins. Reactions of microsomal oxidation. Inductors and inhibitors of microsomal monooxygenases. Reactions of conjugation in hepatocytes: biochemical mechanisms, functional role. Genetic polymorphism and inducibility of cytochrome P_{P450} synthesis. Occurrence and nature of development of tolerance to medical drugs. Formation of indole and stages of its neutralization. Clinical value of indican determination in blood and urine?	
11	**Kidney biochemistry** Explain functions of the kidneys in the organism, their role in maintenance of water and electrolyte balance, constancy of osmotic pressure, pH, excretion of end-products of metabolism. Explain role of the kidneys in synthesis of regulatory substances (renin-angiotensin-aldosterone system), metabolism of creatine and formation of calcitriol. Mechanism of formation of primary urine in the nephron glomerulus. Chemical composition of primary urine. Creatinine clearance. Mechanism of secondary urine formation. Regulation of urine formation. Features of energy metabolism in the kidneys. Explain molecular mechanisms of renal regulation of ABE (acid-base equilibrium). Basic physical and chemical properties of urine. Name main organic and mineral components of urine, quantity of their daily excretion. . With examples explain value of analysis of urine for revealing pathology of the kidneys, estimation of their function, diagnosis and prognosis of diseases of other organs and systems. Biochemical structure of urine in pathological processes. Clinical diagnostic value of analysis of urine composition. Biochemical characteristics of kidney clearance and kidney threshold, their diagnostic value. Clinical biochemical changes at glomerulonephritis, amiloidosis, pyelonephritis, acute kidney deficiency. Diagnostics of chronic kidney deficiency. Characteristics of conditions of formation of kidney stones, their chemical composition and prevention.	2
12	**Biochemistry of muscle tissue.** Ultrastructure and biochemical structure of myocytes. Molecular mechanisms of muscle contraction: modern understanding of interaction of muscle filaments. Cellular organization and features of cardiac muscle. Damage of heart at some diseases. Pathobiochemistry of hypertonic disease and other diseases.	2
13	**Biochemistry of connective tissue. Biochemistry of bone tissue.** General characteristic of morphology and biochemical structure of the connective tissue. Biosynthesis of collagen. Distribution of different glycosaminoglycans in the organs and tissues. Pathobiochemistry of the connective tissue. Chemical composition and metabolism of the bone tissue. Hormonal regulation of the bone tissue metabolism. . Biochemical tests in diagnostics of bone tissue diseases.	2
14	**Biochemistry of the dental tissues.** Chemical composition of tooth tissues. Features of chemical composition of enamel. Chemical composition of dentine. Chemical composition of cementum. Describe the emetabolism in tooth tissues. Hormonal regulation of metabolism in tooth tissues. Role of vitamins in the metabolism of tooth tissues. Describe the processes of mineralisation in tooth tissues. Initiators of mineralisation.	2

	Features of mineralisation of enamel and difference between dentine and cementum. Remineralisative action of saliva.	
15	**Biochemistry of the saliva.** Notions "saliva" and "oral fluid". Salivary glands and peculiarities of protein components of secretion. Biological role of saliva. Physical and chemical properties of saliva. Inorganic saliva components, their properties and role for tooth metabolism. Organic saliva components, their properties, role. Characteristics of saliva buffer properties, pH changes and their consequences. Main mechanisms of the nervous and humoral regulation of salivation; dependence of saliva composition on the nervous regulation, state of internal environment. Describe the role of humoral factors in regulation of saliva composition: hormones of hypophysis, adrenal glands. Features of composition of gingival fluid. Changes of biochemical composition of gingival fluid at stomatological diseases.	2
16	**Biochemical mechanisms of the main stomatological diseases development.** Dental deposits (dental plaque, dental calculus). Biochemical bases of caries development. Biochemical bases of periodontal disease development. Role of diet in the development and prevention of caries. Explain the significance of drinking-water fluorination as an effective method of caries prevention. Explain the changes of saliva chemical composition diabetes mellitus, periodontitis and infectious processes. To tell about the change of enzymes activity of mixed saliva at pathology of mouth cavity organs. Give the explanation of enzyme and antienzyme (antiproteinase) drugs in therapy of mouth cavity organs diseases. Fluorine intoxication as a main etiological factor of fluorosis development. Changes of enamel mineral phase composition at fluorosis. Role of local and general factors in periodontal disease development.	2
17	**Biochemistry of nervous tissue. Solving of situation and tests problems.** Features of biochemical composition and metabolism of the nervous system. Chemical composition of the brain. Energy metabolism in the brain. Neurotransmitters and receptors of neurotransmitters, physiologically active compounds.	2
	Exam	
	Total	**96**

Self-preparatory work

Item no.	Names of topics	Number of hours
Module 1. Biological and Bioorganic Chemistry		
1	Preparation for practical classes and final tests of content modules (content modules 1 and 2) - theoretical preparation training of the practical skills	58
2	Exam preparation	12
3	Elaboration of topics that are not part of the classroom lesson plan with an indication of the main issues that should be studied:	42
Content module 1. Static biochemistry. Enzymology. Bioenergetics.		
1	**Classification, nomenclature, isomerism of bioorganic compounds. Nature of chemical bonds.** Classes of organic compounds and functional groups corresponding to them. Priority of functional groups and their names. Trivial nomenclature. International nomenclature (INN). Radical-functional nomenclature. Structural isomerism (structural isomerism). Spatial isomerism (stereoisomerism) Configurational isomerism: optical, geometric and conformational isomers. Schematic representation of the distribution of electrons on atomic orbitals of a carbon atom. The first valence state of a carbon atom (sp3-hybridization). The second and third valence states of a carbon atom (sp2- and sp-hybridization). σ- and π-bonds in organic compounds. Electronegativity of atoms. Distribution of electron density in organic molecules: inductive effect; mesomeric effect.	6
2	**Types of chemical reactions. Study of the reactivity of alkanes, alkenes, arenes, alcohols, phenols, amines.** Chemical properties of alkanes. Radical substitution near a saturated carbon atom (SR). Representatives of alkenes, alkadienes and alkynes. Features of their structure and chemical properties. Electrophilic addition to unsaturated compounds (AE). General characteristics and electronic structure of aromatic hydrocarbons, their chemical properties. Electrophilic substitution in aromatic compounds (SE). Influence of substituents on the reactivity of arenes Structure of alcohols and phenols, their representatives, physical and chemical properties of hydroxy compounds. Nucleophilic substitution near a saturated carbon atom (SN). Polyatomic acyclic and cyclic alcohols. Aliphatic and aromatic amines: representatives and their structure. Chemical properties of amines: reactions of amines as nucleophilic reagents. Aniline: its pharmacological and biological derivatives.	6
3	**Study of the chemical properties of aldehydes and ketones.** Characterize the structure of the carbonyl group, name and write down the formulas and names of common aldehydes and ketones. Nucleophilic addition reactions (AN) to aldehydes of such compounds as water, cyanides, alcohols, amines. Aldol condensation reaction and its significance for carbon chain elongation. Oxidation and reduction reactions of aldehydes and ketones. Qualitative reactions for the detection of the aldehyde group (Tollens, Trommer, Fehling), their significance in clinical laboratories. Disproportionation reaction (dismutation, Cannizzaro reaction). Haloform reactions of aldehydes and ketones. Iodoform test and its use for analytical purposes.	6
4	**Study of the chemical properties of carboxylic acids.**	6

	Explain the classification of carboxylic acids. Name individual representatives of monocarboxylic acids. Nucleophilic substitution reactions (SN) near the sp2-hybridized carbon atom of the oxo group. Esterification reactions and their biochemical significance. Amidation reactions and their biochemical significance. Chemical properties. Biological significance of individual representatives (oxalic, malonic, succinic, glutaric, fumaric).	
Content module 2. Dynamic biochemistry.		
5	**Research on lipid metabolism disorders: steatorrhea, atherosclerosis, obesity.** Catabolism of triacylglycerols and biosynthesis in adipose tissue adipocytes. Neurohumoral regulation of lipolysis and lipidogenesis with the participation of adrenaline, noradrenaline, glucagon and insulin. Adipocytes of adipose tissue and their role in lipid metabolism and bioenergetic processes in the body. Pathochemistry of obesity. Biological role of complex lipids. Biosynthesis of phosphatidylcholine. What lipotropic factors (essential food components) are necessary for the synthesis of phosphatidylcholine? Mechanisms of atherosclerosis development. Mechanisms of obesity development. Lipid metabolism disorders in diabetes mellitus (macroangiopathy, ketosis), mechanisms of their development. Steatorrhea, mechanism of development.	4
Content module 3. Functional biochemistry		
6	**DNA replication and RNA transcription.** Biological role of DNA replication. Essence of the DNA replication discovery by D.Watson and F.Crick (1953). Half-conservative mechanism of replication; the scheme of Meselson - Stahl experiment. General scheme of DNA biosynthesis. Enzymes of DNA replication. Molecular mechanisms of DNA: topological problems (Okazaki fragments). General scheme of transcription; coding and non-coding chains of DNA. RNA polymerases. Stages and enzymes of RNA synthesis. Signals of transcription: promotor, initial, termination sites of genome. Processing as posttranscriptional modification of RNA. Antibiotics – inhibitors of transcription.	6
7	**Biosynthesis of proteins in ribosomes. Initiation, elongation and termination in the synthesis of polypeptide chain. Inhibitory action of antibiotics.** Genetic code. Ribosomal protein synthesis system Stages and mechanisms of translation. Posttranslation modification of peptide chains. Regulation of translation. Effect of physiologically active compounds on processes of transcription and translation.	4
8	**Analysis of mutation mechanisms, DNA reparation. Principles of synthesis of recombinatory DNA, transgenic proteins.** Mutations: genomic, chromosomal, gene (point). Biochemical mechanisms of chemical mutagen action – nitrogenous base analogues, deaminative, alkylating agents, ultraviolet and ionizing radiation. Role of inductive mutations in occurrence of enzymopathies and hereditary diseases. . Biological role and mechanisms of DNA reparation. Reparation of UV-induced gene mutations: xeroderma pigmentosum. Genetic engineering. Recombinant DNA designing: general concepts, biomedical importance. Technology of gene transplantation and obtaining of hybrid DNA molecules; application of restriction endonucleases. Cloning of genes to obtain biotechnological medicines and for diagnostics.	4
	Total	**112**

List of theoretical questions for preparation for the final tests of the content modules and the exam.

Content module 1. Static biochemistry. Enzymology. Bioenergetics. *

1. Classification of organic compounds by the structure of the carbon radical and the nature of the functional groups.
2. The structure of the most important classes of bioorganic compounds by the nature of the functional groups: alcohols, phenols, thiols, aldehydes, ketones, carboxylic acids, esters, amides, nitro compounds, amines. Nomenclature of organic compounds: trivial, rational, international. Principles of formation of names of organic compounds according to the IUPAC nomenclature: substituents, radical-functional.
3. The nature of the chemical bond in organic compounds: hybridization of orbitals, electronic structure of carbon compounds.
4. Spatial structure of bioorganic compounds: stereochemical formulas; configuration and conformation. Stereoisomers: geometric, optical, rotational (conformers).
5. Types of reactions in bioorganic chemistry: classification by result (direction) and reaction mechanism. Examples.
6. Carbonyl compounds in bioorganic chemistry. Chemical properties and biomedical significance of aldehydes and ketones.
7. Carboxylic acids in bioorganic chemistry: structure and chemical properties; functional derivatives of carboxylic acids (anhydrides, amides, esters). Decarboxylation reactions.
8. Lipids: definition, classification. Higher fatty acids: palmitic, stearic, oleic, linoleic, linolenic, arachidonic. Simple lipids. Triacylglycerols (neutral fats): structure, physiological significance, hydrolysis.
9. Complex lipids. Phospholipids: phosphatidic acid, phosphatidylethanolamine, phosphatidylcholine, phosphatidylserine. Sphingolipids. Glycolipids. The role of complex lipids in the construction of biomembranes.
10. Amines: nomenclature, properties. Biomedical significance of biogenic amines (adrenaline, noradrenaline, dopamine, tryptamine, serotonin, histamine) and polyamines (putrescine, cadaverine).
11. Amino alcohols: structure, properties. Biomedical significance of ethanolamine (colamine), choline, acetylcholine.
12. Hydroxy acids in bioorganic chemistry: structure and properties of monocarboxylic (lactic and β-hydroxybutyric), dicarboxylic (malic, tartaric) hydroxy acids.
13. Amino acids: structure, stereoisomerism, chemical properties. Biomedical significance of L-α-amino acids. Reactions of biochemical transformations of amino acids: deamination, transamination, decarboxylation.
14. Amino acid composition of proteins and peptides; classification of natural L-α-amino acids. Chemical and physicochemical properties of proteinogenic amino acids. Ninhydrin reaction, its significance in the analysis of amino acids.
15. Proteins and peptides: definition, classification, biological functions. Types of bonds between amino acid residues in protein molecules. Peptide bond: formation, structure; biuret reaction. Levels of structural organization of proteins: primary, secondary, tertiary and quaternary structures. Oligomeric proteins. Physicochemical properties of proteins; their molecular weight. Precipitation methods. Denaturation of proteins.
16. Carbohydrates: definition, classification. Monosaccharides (aldoses and ketoses; trioses, tetroses, pentoses, hexoses, heptoses), biomedical significance of individual representatives. Monosaccharides: pentoses (ribose, 2-deoxyribose, xylose), hexoses (glucose, galactose, mannose, fructose) - structure, properties. Qualitative reactions to glucose.
17. Oligosaccharides: structure, properties. Disaccharides (sucrose, lactose, maltose), their biomedical significance.
18. Polysaccharides. Homopolysaccharides: starch, glycogen, cellulose, dextrins – structure, hydrolysis, biomedical significance. Qualitative reaction to starch.
19. Heteropolysaccharides: definition, structure. Structure and biomedical significance of glycosaminoglycans (mucopolysaccharides) – hyaluronic acid, chondroitin sulfates, heparin.

20. Purine and its derivatives. Amino derivatives of purine (adenine, guanine), their tautomeric forms; biochemical significance in the formation of nucleotides and coenzymes. Hydroxy derivatives of purine: hypoxanthine, xanthine, uric acid. Methylated derivatives of xanthine (caffeine, theophylline, theobromine) as physiologically active compounds with effects on the central nervous and cardiovascular systems.
21. Nucleosides, nucleotides. Nitrogenous bases of the purine and pyrimidine series, which are part of natural nucleotides. Minor nitrogenous bases. Nucleosides. Nucleotides as phosphorylated derivatives of nucleosides (nucleoside mono-, di- and triphosphates). Nomenclature of nucleosides and nucleotides as components of RNA and DNA.
22. Nucleic acids (deoxyribonucleic, ribonucleic) as polynucleotides. Polarity of polynucleotide chains of DNA and RNA.
23. Structure and properties of DNA; nucleotide composition, complementarity of nitrogenous bases. Primary, secondary and tertiary structure of DNA.
24. RNA: structure, types of RNA and their role in protein biosynthesis.
25. Enzymes: definition; properties of enzymes as biological catalysts. Classification and nomenclature of enzymes, characteristics of individual classes of enzymes.
26. Structure and mechanisms of action of enzymes. Active and allosteric (regulatory) centers.
27. Cofactors and coenzymes. Structure and properties of coenzymes; vitamins as precursors in the biosynthesis of coenzymes. Coenzymes: types of reactions catalyzed by individual classes of coenzymes.
28. Vitamin B1 (thiamine): structure, biological properties, mechanism of action.
29. Vitamin B2 (riboflavin): structure, biological properties, mechanism of action.
30. Vitamin PP (nicotinic acid, nicotinamide): structure, biological properties, mechanism of action.
31. Vitamin B6 (pyridoxine): structure, biological properties, mechanism of action.
32. Vitamin B12 (cobalamin): biological properties, mechanism of action.
33. Vitamin Bc (folic acid): biological properties, mechanism of action.
34. Vitamin H (biotin): biological properties, mechanism of action.
35. Vitamin B3 (pantothenic acid): biological properties, mechanism of action.
36. Vitamin C (ascorbic acid): structure, biological properties, mechanism of action.
37. Vitamin P (flavonoids): structure, biological properties, mechanism of action.
38. Isoenzymes, features of structure and functioning, importance in the diagnosis of diseases.
39. Mechanisms of action and kinetics of enzymatic reactions: dependence of reaction rate on substrate concentration, pH and temperature. Enzyme activators and inhibitors: examples and mechanisms of action. Types of enzyme inhibition: reversible (competitive, non-competitive) and irreversible inhibition.
40. Regulation of enzymatic processes. Pathways and mechanisms of regulation: allosteric enzymes; covalent modification of enzymes.
41. Enzymopathies – congenital (hereditary) defects in the metabolism of carbohydrates, amino acids, porphyrins, purines.
42. Enzymodiagnosis of pathological processes and diseases.
43. Enzymotherapy – the use of enzymes, their activators and inhibitors in medicine.
44. Metabolism – general patterns of catabolic and anabolic processes. Common stages of intracellular catabolism of biomolecules: proteins, carbohydrates, lipids.
45. Tricarboxylic acid cycle. Localization, sequence of enzymatic reactions, significance in metabolism. Energy balance of the tricarboxylic acid cycle. Physiological significance of CTC reactions.
46. Biological oxidation reactions; types of reactions (dehydrogenase, oxidase, oxygenase) and their biological significance. Tissue respiration. Enzymes of biological oxidation in mitochondria: pyridine-, flavin-dependent dehydrogenases, cytochromes.
47. Sequence of components of the mitochondrial respiratory chain. Molecular complexes of the inner membranes of mitochondria. Oxidative phosphorylation: points of electron transport and phosphorylation coupling, oxidative phosphorylation coefficient

48. Chemiosmotic theory of oxidative phosphorylation, mitochondrial ATP synthase. Electron transport inhibitors and uncouplers of oxidative phosphorylation.

Content module 2. Dynamic biochemistry.*

1. Anaerobic oxidation of glucose. Sequence of reactions and enzymes of glycolysis. Aerobic oxidation of glucose. Stages of conversion of glucose to CO2 and H2O.
2. Oxidative decarboxylation of pyruvate. Enzymes, coenzymes and sequence of reactions in a multienzyme complex.
3. Comparative characteristics of bioenergetics of aerobic and anaerobic oxidation of glucose, Pasteur effect.
4. Phosphorolytic pathway of glycogen breakdown in the liver and muscles. Regulation of glycogen phosphorylase activity.
5. Glycogen biosynthesis: enzymatic reactions, physiological significance. Regulation of glycogen synthase activity.
6. Mechanisms of reciprocal regulation of glycogenolysis and glycogenesis due to cascade cAMP-dependent phosphorylation of enzyme proteins. The role of adrenaline, glucagon and insulin in the hormonal regulation of glycogen metabolism in muscles and liver. Genetic disorders of glycogen metabolism (glycogenoses, aglycogenoses).
7. Gluconeogenesis: substrates, enzymes and physiological significance of the process. Glucose-lactate (Cori cycle) and glucose-alanine cycles.
8. Blood glucose (glucosemia): normoglycemia, hypo- and hyperglycemia, glucosuria. Diabetes mellitus - pathology of glucose metabolism.
9. Hormonal regulation of blood glucose concentration and metabolism.
10. Pentose phosphate pathway of glucose oxidation: process scheme and biological significance.
11. Metabolic pathways of fructose and galactose conversion; hereditary enzymopathies of their metabolism.
12. Catabolism of triacylglycerols in adipocytes of adipose tissue: sequence of reactions, mechanisms of regulation of triglyceride lipase activity. Neurohumoral regulation of lipolysis with the participation of adrenaline, noradrenaline, glucagon and insulin).
13. Fatty acid oxidation reactions (β-oxidation); the role of carnitine in the transport of fatty acids in mitochondria.
14. Glycerol oxidation: enzymatic reactions, bioenergetics.
15. Ketone bodies. Reactions of biosynthesis and utilization of ketone bodies, physiological significance. Disturbances of ketone body metabolism under pathological conditions (diabetes mellitus, starvation).
16. Biosynthesis of higher fatty acids: reactions of biosynthesis of saturated fatty acids (palmitate) and regulation of the process. Biosynthesis of mono- and polyunsaturated fatty acids in the human body.
17. Biosynthesis of triacylglycerols and phosphoglycerides.
18. Biosynthesis of cholesterol: reaction scheme, regulation of cholesterol synthesis.
19. Pathways of cholesterol biotransformation: esterification; formation of bile acids, steroid hormones, vitamin D3.
20. Lipoproteins of blood plasma: lipid and protein (apoproteins) composition. Hyperlipoproteinemias.
21. Pathologies of lipid metabolism: atherosclerosis, obesity, diabetes.
22. Transamination of amino acids: reactions and their biochemical significance, mechanisms of action of aminotransferases.
23. Direct and indirect deamination of free L-amino acids in tissues.
24. Decarboxylation of L-amino acids in the human body. Physiological significance of the formed products. Oxidation of biogenic amines.
25. Pathways of formation and neutralization of ammonia in the body. Urea biosynthesis: sequence of enzymatic reactions of biosynthesis, genetic anomalies of urea cycle enzymes.
26. General pathways of metabolism of carbon skeletons of amino acids in the human body. Glucogenic and ketogenic amino acids.

27. Biosynthesis and biological role of creatine and creatine phosphate.
28. Glutathione: structure, biosynthesis and biological functions of glutathione
29. Specialized pathways of metabolism of cyclic amino acids – phenylalanine and tyrosine. Hereditary enzymopathies of metabolism of cyclic amino acids – phenylalanine and tyrosine.
30. Porphyrin metabolism: structure of heme; scheme of reactions of biosynthesis of protoporphyrin IX and heme.
31. Biosynthesis of purine nucleotides: scheme of reactions of synthesis of IMP; formation of AMP and GMP; mechanisms of regulation.
32. Biosynthesis of pyrimidine nucleotides: scheme of reactions; regulation of synthesis.
33. Biosynthesis of deoxyribonucleotides. Formation of thymidyl nucleotides; inhibitors of biosynthesis of dTMP as antitumor agents.
34. Purine nucleotide catabolism; hereditary disorders of uric acid metabolism.
35. Scheme of pyrimidine nucleotide catabolism.
36. Biochemistry of human nutrition: components and nutritional compounds of normal nutrition; biological value of individual nutrients.
37. Mechanisms of transformation of nutrients (proteins, carbohydrates, lipids) in the digestive tract. Stomach and intestinal enzymes.
38. Disorders of digestion of individual nutrients in the stomach and intestines; hereditary enzymopathies of digestive processes.

Content module 3. Functional biochemistry*.

1. DNA replication: biological significance; semi-conservative replication mechanism. Sequence of stages and enzymes of DNA replication in prokaryotes and eukaryotes.
2. RNA transcription: RNA polymerases of prokaryotes and eukaryotes, transcription signals (promoter, initiator and terminator regions of the genome).
3. Processing - post-transcriptional modification of newly synthesized m-RNAs.
4. Genetic (biological) code; triplet structure of the code, its properties.
5. Transport – t-RNA and activation of amino acids. Aminoacyl-t-RNA synthetases.
6. Stages and mechanisms of translation (protein biosynthesis) in ribosomes: initiation, elongation and termination.
7. Post-translational modification of peptide chains. Regulation of translation.
8. Mutations: genomic, chromosomal, gene; mechanisms of action of mutagens; the role of induced mutations in the occurrence of enzymopathies and hereditary human diseases.
9. Biological significance and mechanisms of DNA repair. Repair of UV-induced gene mutations: pigmentary xeroderma.
10. Hormones: general characteristics; the role of hormones and other bioregulators in the system of intercellular integration of human body functions.
11. Classification of hormones and bioregulators: correspondence of the structure and mechanisms of action of hormones.
12. The reaction of target cells to the action of hormones. Membrane (ionotropic, metabotropic) and cytosolic receptors.
13. Biochemical systems of intracellular transmission of hormonal signals: G-proteins, secondary mediators (cAMP, Ca2+/calmodulin, IF3, DAG).
14. Molecular and cellular mechanisms of action of steroid and thyroid hormones.
15. Hypothalamic hormones – liberins and statins.
16. Hormones of the anterior pituitary gland: somatotropin (STG), prolactin. Pathological processes associated with dysfunction of these hormones.
17. Hormones of the posterior pituitary gland. Vasopressin and oxytocin: structure, biological functions.
18. Insulin: structure, biosynthesis and secretion; effect on the metabolism of carbohydrates, lipids, amino acids and proteins. Growth-stimulating effects of insulin.
19. Glucagon: regulation of carbohydrate and lipid metabolism.

20. Thyroid hormones: structure, biological effects of T4 and T3. Metabolic disorders in hypo- and hyperthyroidism.
21. Catecholamines (adrenaline, noradrenaline, dopamine): structure, biosynthesis, physiological effects, biochemical mechanisms of action.
22. Steroid hormones of the adrenal cortex (C21-steroids) - glucocorticoids and mineralocorticoids; structure, properties.
23. Female sex hormones: estrogens, progesterone. Physiological and biochemical effects; relationship with the phases of the ovulation cycle.
24. Male sex hormones (C19-steroids). Physiological and biochemical effects of androgens; regulation of synthesis and secretion.
25. Hormonal regulation of calcium homeostasis in the body. Parathyroid hormone, calcitonin, calcitriol.
26. Vitamin A (retinol, retinal, retinoic acid): biological properties, mechanism of action, deficiency symptoms, sources, daily requirement.
27. Vitamin K (phylloquinone, farnoquinone): biological properties, mechanism of action, deficiency symptoms, sources, daily requirement.
28. Vitamin E (□-tocopherol): biological properties, mechanism of action, deficiency symptoms, sources, daily requirement.
29. Vitamin D3 (cholecalciferol): biological properties, mechanism of action, deficiency symptoms, sources, daily requirement.
30. Biochemical and physiological functions of blood in the human body. Respiratory function of erythrocytes.
31. Hemoglobin: mechanisms of participation in the transport of oxygen and carbon dioxide. Variants and pathological forms of human hemoglobins.
32. Blood buffer systems. Violation of acid-base balance in the body (metabolic and respiratory acidosis, alkalosis).
33. Biochemical composition of human blood. Blood plasma proteins and their clinical and biochemical characteristics.
34. Blood plasma enzymes; importance in enzyme diagnostics of diseases of organs and tissues.
35. Non-protein organic compounds of blood plasma. Inorganic plasma components.
36. Biochemical functions of the liver: carbohydrate, protein synthesizing, urea-forming, bile-forming, regulation of blood lipid composition.
37. Detoxification function of the liver; types of reactions of biotransformation of xenobiotics and endogenous toxins.
38. Microsomal oxidation reactions. Cytochrome P-450; electron transport chains in the membranes of the endoplasmic reticulum of hepatocytes.
39. Conjugation reactions in hepatocytes: biochemical mechanisms, functional significance.
40. The role of the liver in the metabolism of bile pigments. Pathobiochemistry of jaundice; types of jaundice; hereditary (enzymatic) jaundice.
41. The role of the kidneys in the regulation of the volume, electrolyte composition and pH of body fluids. Biochemical mechanisms of the urine-forming function of the kidneys.
42. Biochemical composition of human urine in normal and pathological conditions. Clinical and diagnostic significance of urine composition analysis.
43. Biochemical composition of muscles. Myofibril proteins: myosin, actin, tropomyosin, troponin.
44. Molecular mechanisms of muscle contraction. The role of Ca2+ ions in the regulation of muscle contraction and relaxation.
45. Bioenergetics of muscle tissue; sources of ATP; the role of creatine phosphate in providing energy for muscle contraction.
46. Structure and functions of collagen. Stages of collagen synthesis.
47. Biological role of saliva. Physicochemical properties and micellar structure of saliva (micelle scheme).

48. Organic and inorganic components of saliva, general characteristics. Protective mechanisms of saliva. Buffer systems of oral fluid.
49. Regulation and mechanism of saliva secretion. Forms of salivary secretion disorders.
50. Gingival fluid, chemical composition, biological role. Clinical assessment of the composition of gingival fluid.
51. Enamel, chemical composition. Enamel proteins, general characteristics, biological role.
52. Inorganic components of enamel. Biochemical mechanisms of enamel mineralization.
53. Dentin, features of chemical composition. Types of dentin.
54. Cement, features of chemical composition.
55. Dental pulp, functions, structure.
56. Dental caries, general characteristics of cariogenic factors. Biochemical factors of tooth resistance to caries.
57. Biochemical foundations of caries prevention and treatment.
58. Dental plaque, stages of formation. The role of microorganisms in the formation of dental plaque.
59. Dental calculus, chemical composition, mechanism of formation.
60. Fluoride in drinking water, importance for the occurrence of caries. Mechanism of influence of water fluoridation on enamel resistance. Dental fluorosis, general characteristics.
61. Biochemical mechanisms of development of periodontal tissue diseases.
62. Biochemistry of the nervous system: features of the biochemical composition and metabolism of the brain.

63. Energy metabolism in the human brain. The importance of aerobic oxidation of glucose; changes in conditions of physiological sleep and anesthesia.
64. Biochemistry of neurotransmitters; receptors of neurotransmitters and physiologically active compounds.

Note - * Questions of content modules 1-3 are included in the list of questions for preparing for the exam!

List of practical skills for the final tests of content modules and the exam.
Content module 1. Static biochemistry. Enzymology. Bioenergetics.

1. Why is there a need to renew formalin during long-term storage of anatomical preparations? What property of aldehydes and the reaction are the basis for reducing the pH of formalin.
2. The iodoform test for acetone is positive. Draw a conclusion.
3. How and why will the color of the KMnO4 solution change when oleic acid is added?
4. Why is Wagner's reaction to fat unsaturation qualitative? Analyze the results.
5. Does glucosuria or fructosuria give a positive reaction with Fehling's reagent? Explain.
6. Why do glucose and lactose interact differently with Fehling's reagent on the one hand and sucrose on the other? Explain the results.
7. What is the qualitative reaction to starch? Draw conclusions.
8. What does a positive test for ketonuria indicate? Name ketone bodies.
9. Evaluate qualitative reactions to amino acids and proteins: xanthoprotein; ninhydrin; Fole; biuret. How and why do different colors of solutions appear?
10. Suggest a reaction that will allow you to distinguish peptides from proteins.
11. Evaluate the effect of ammonium sulfate, trichloroacetic and sulfasalicylic acids on proteins. Give an argument and name the types of protein precipitation.
12. How and why will the composition of nucleic acids change during their hydrolysis? Determine the components of the hydrolysate. Draw conclusions.
13. Clinical significance of determining the activity of amylase and lipase in blood serum. To which class of enzymes do they belong?
14. Clinical significance of determining the activity of creatine phosphokinase in blood serum. Isoforms of creatine phosphokinase.

15. Clinical significance of determining LDH in blood serum. Write the reaction catalyzed by LDH, name the isoforms.
16. Clinical determination of ALT and AST in blood serum. To which class of enzymes do they belong and what coenzyme is part of them?
17. Which isoform of creatine phosphokinase must be determined in blood serum for the diagnosis of myocardial infarction. To which class does the enzyme belong?
18. List the cardiospecific enzymes used in the enzymatic diagnosis of myocardial infarction.
19. List the hepatospecific enzymes for the enzymatic diagnosis of hepatocyte cytolytic syndrome.
20. Name the enzyme – a marker of osteogenesis. To which class of enzymes does it belong?
21. Name the enzyme – a marker of bone tissue resorption. To which class of enzymes does it belong?
22. Causes and consequences of hypoergosis (cell energy deficiency).
23. Clinical significance of determining citric acid in biological material.
24. For the diagnosis of diseases of which organ is creatine phosphokinase BB isoform determined and where?
25. Carbon monoxide poisoning causes death. It is an inhibitor of which complex of the respiratory chain?

Content module 2. Dynamic biochemistry.

1. Serum glucose content. Causes and consequences of hyper- and hypoglycemia.
2. Clinical significance of determining ketone bodies in serum and urine. Causes and consequences of ketosis.
3. Clinical significance of determining pyruvic acid content in biological fluids.
4. What is the normal cholesterol content in human blood? Clinical significance. Causes of primary and secondary hypercholesterolemia.
5. Clinical significance of determining amylase and lipase activity in serum. To which class of enzymes do they belong?
6. Write the transamination of alanine with α-ketoglutaric acid. Clinical significance of determining transaminase activity in blood.
7. Clinical significance of determining creatine phosphokinase activity in serum. Isoforms of creatine phosphokinase.
8. Clinical significance of LDH determination in serum. Write the reaction catalyzed by LDH, name the isoforms.
9. Causes and consequences of hyperlactatemia.
10. Causes of glucosuria. Renal threshold for glucose.
11. Draw glycemic curves of the glucose tolerance test in normal and latent diabetes mellitus.
12. Clinical significance of HbA1c determination (glycosylated hemoglobin).
13. Biochemical diagnostics of types of hyperlipoproteinemia according to WHO.
14. Clinical significance of urea concentration determination in serum.
15. Daily urea excretion. Clinical significance.
16. Causes and consequences of hyperammonemia.
17. Causes of hypo- and hypercreatininemia.
18. Causes of hypo- and hypercreatininuria.
19. Causes of porphyria. Draw a diagram of heme synthesis.
20. In which disease is Fehling's test (FeCl3) in urine positive?
21. Biochemical diagnostics of diabetes mellitus.
22. Uric acid content in blood serum. Clinical significance of the analysis.

Content module 3. Functional biochemistry.*

1. Explain the antitumor effect of antibiotics. Can all antibiotics be used as antitumor?
2. Explain the mechanism of action of interferons.
3. Explain the mechanism of action of diphtheria toxin.

4. Explain the molecular mechanisms of mutations. What are the most common mutagens do you know?
5. Determination of the acidity of gastric contents: total acidity, free and bound hydrochloric acid.
6. Detection of pathological components in gastric contents: lactic acid, "blood pigments". In what pathological conditions in the stomach are they detected?
7. Quantitative assessment of the proteinogram and general patterns of its changes in pathological processes (acute and chronic inflammation, liver disease, kidney disease)
8. Clinical significance of determining the "acute phase" proteins of inflammation and their role in the system of nonspecific resistance.
9. Fibrinogen content in blood plasma. Clinical significance of the analysis.
10. Biochemical indicators of the study of the acid-base state of the blood.
11. The norm of residual nitrogen (RN) in blood serum and its clinical significance. Types of azotemia.
12. The content of bilirubin and its fractions in blood serum. Clinical significance of the analysis.
13. Biochemical diagnostics of cytolytic syndrome of hepatocytes.
14. Biochemical diagnostics of cholestatic syndrome.
15. Biochemical diagnostics of liver failure.
16. Biochemical criteria for determining impaired detoxification function of the liver. Mechanisms of development of hepatic encephalopathy.
17. Biochemical diagnostics of impaired glomerular filtration rate.
18. Biochemical blood test in a patient with renal failure.
19. Biochemical analysis of urine in a patient with renal failure.
20. Investigation of pathological components of urine: proteinuria, hematuria.
21. Investigation of pathological components of urine: glucosuria, ketonuria.
22. Investigation of pathological components of urine: urobilinuria, bilirubinuria.
23. Clinical and biochemical diagnostics of collagenoses.
24. Clinical and biochemical diagnostics of mucopolysaccharidoses.
25. Modern methods of diagnosing bone tissue diseases (markers of osteogenesis and resorption).
Note - * Questions of content modules 1-3 are included in the list of questions for preparing for the exam!

The form of final control of academic performance

Exam.

The system of continuous and final control

Control measures include incoming, continuous and final control.

Incoming control is carried out at the beginning of the study of "Biological and Bioorganic Chemistry" in order to determine the recipients for higher education to master it. The control is carried out by means of test tasks.

Continuous control is carried out by scientific and pedagogical staff of the Department of Biological and Bioorganic Chemistry during practical classes. Current control should be carried out in the form of oral interviews, solving situational tasks, written control, written or software computer testing in practical classes.

Forms of continuous control during practical classes at the department of biological and bioorganic chemistry:

- Oral survey. Verification of answers to questions during self-preparation for a practical lesson.
- Solution of tests I and II levels and tests for the licensed exam "Krok 1" with an explanation of the correct answer.

- Laboratory work according to the algorithm.

At each practical lesson, the success of each student is evaluated on a four-point (traditional) scale.

Final control of the content module - a form of final control, which consists in assessing the assimilation by the higher education applicant of the educational material from the content module 1 and content module 2.

Exam - a form of final control of the assimilation by the higher education applicant of the theoretical and practical material from "Biological and bioorganic chemistry".

General characteristics of control measures

The final evaluation of learning outcomes in "Biological and Bioorganic Chemistry" is carried out on a single 200-point scale. The assessment of the learner corresponds to the ratio of the level of professional and general competencies established in the assessment to the planned learning outcomes. The standardized generalized criteria for assessing the knowledge of higher education seekers are described in “Regulation on the organization and methods for assessment of educational activities of higher education recipients at Poltava State Medical University”.

https://www.pdmu.edu.ua/storage/department-npr/docs_links/NMQ6RVrpAGYuKpw1JoSJaApnMMMwbKdxQN9FC2hu.pdf

Final Control of content module

Final control of content module is carried out upon completion of the study of software content module 1 and content module 2 and is carried out at the last practical lesson of the module. Compilation and re-compilation of the final module control is carried out in accordance with the "Regulation on the organization of the educational process at Poltava State Medical University "

Before conducting the final control of content module, the average student score is calculated: the sum of all grades for all practical classes, divided by the number of classes.

The final control is allowed for **t**he recipients for higher education who attended all the lecture and practical classes or worked out the missed classes in the prescribed manner, completed all the requirements of the curriculum and scored is not less than 3,0. The recipients for higher education is obliged to retake “2” if the average grade point for current performance for the module does not reach the minimum (3.0 points) for admission to the final control.

Algorithm of the final control of content module:

The recipients for higher education will get examination cards. Cards for final control 1 consist of 3 questions (2 theoretical and 1 - practical). Examination cards for final control 2 consist of 4 questions (3 theoretical and 1 - practical). Each question is evaluated on a traditional, 4-point score. Then, the arithmetic mean of the three responses is calculated. The list of questions for the final control of the corresponding content module is indicated above and is provided to the applicants at the beginning of the study of the corresponding content module.

Applicants who received an unsatisfactory grade for the final control of the content module are obliged to rewrite it. Unsatisfactory evaluation of the final control of the module is a reason for not being allowed to take the exam at the end of studying the discipline.

Conducting the exam.

The recipients for higher education take the exam during the summer exam session provided by the curriculum and “Regulation on the organization and methods for assessment of educational activities of higher education recipients at Poltava State Medical University”: https://www.pdmu.edu.ua/storage/department-npr/docs_links/NMQ6RVrpAGYuKpw1JoSJaApnMMMwbKdxQN9FC2hu.pdf

The exam according to a separate schedule, which is approved by the First Vice-Rector for Academic Affairs and Reseach. The schedule of examinations is brought to the notice of scientific and pedagogical workers of the Department of Biological and Bioorganic Chemistry and applicants for higher education not later than one month before the examination session.

Before the exam, the Department of Biological and Bioorganic Chemistry must organize consultations. The schedule of pre-examination consultations, time and place of the examination the department informs the students not later than 2 weeks before the examination session.

The recipients for higher education are allowed for the exam, who do not have unfinished missed classes, scored a minimum of at least 3,0, final control of contemt module 1 and 2.

The recipients for higher education who have received an average score of performance from 4.5 to 5.0 and they automatically get the score according to Regulation on the organization and methods for assessment of educational activities of higher education recipients at Poltava State Medical University": https://www.pdmu.edu.ua/storage/department-npr/docs_links/NMQ6RVrpAGYuKpw1JoSJaApnMMMwbKdxQN9FC2hu.pdf

A student who is exempted from taking the exam must be present at the exam. In case of disagreement with the assessment, the specified category of higher education applicants will take the exam according to general rules.

The algorithm for conducting of* semester final attestation*:

1. Solve the 20 tasks from the Krok 1 licensed exam database in a computer format. Each task is evaluated at 1 point (the maximum number of points scored is 20).

2. Give an answer to 2 theoretical questions and one practical (maximum 20 x 3 = 60 points). The maximum number of points for SFA is 80, the minimum is 50.

The maximum number of points scored at the SPA - 80, the minimum - 50.

Exam is accepted on a commission basis, in accordance with the "Regulations on the examination commission". Examinations are open and public. Grades obtained during the exam by the attested persons are set out in the "Statement of final semester control" and in the individual plans of the recipients.

In addition, the results of the exam edition appeared in the "Journal of the recipients for higher education assessment and performance" and the individual recipient curriculum.

The retaking of the exam is allowed no more than twice. The recipients who fail the exam may be expelled from the university.

Teaching methods

- *Verbal* (lecture, explanation, story, conversation, briefing, s**olving situational tasks**).
- *Visual* (observation, illustration and demonstration of laboratory experiments).
- *Practical* (performing laboratory and practical work, conducting a scientific experiment in a research laboratory).
- *Methods of testing* and evaluating knowledge, skills.

Control methods

Oral interrogation allows you to control not only knowledge, but also verbal ability, helps to correct speech errors. Reproduction of the material contributes to its better memorization, the active use of scientific concepts. Used in practical exercises. The following types of questions are used in the oral interrogation: reproductive (involving the reproduction of the studied); reconstructive (require the application of knowledge and skills in slightly changed conditions); creative (application of knowledge and skills in significantly changed, non-standard conditions, transfer of the mastered principles of proof to performance of more difficult tasks). In addition, the birds are the main, additional and auxiliary.

A written survey helps to determine the level of assimilation of the material, but the possibility of cheating should be excluded and the recipients for higher education should be carefully monitored during this survey. Written works require a sufficiently large amount of time for the teacher to check. It is used during the final modular control and in practical exercises.

Testing as a standardized assessment method that meets the new goals and objectives of higher medical education and contributes to the individualization and controllability of the educational

process and is designed to ensure the quality of training of the future doctor. Tests of different difficulty levels are used to assess the initial, current and final level of knowledge.

Method of self-control. It allows students to realize their mistakes, correct them and understand why it is necessary to master certain knowledge.

Self-assessment method. Provides an objective assessment of the recipient's results.

Methodical support

1. Calendar and thematic plans of lectures and practical classes.
2. Syllabus, educational and control computer programs for test control of knowledge of higher education students on each topic of practical training, final control of the content module, exam.
3. Algorithms for laboratory work.
4. Lists of recommended literature.
5. Tests of various difficulty levels.
6. Tests from the bank license exam "Krok-1".
7. Multimedia presentations of lectures.

Recommended reading

Basic

1. Biological and Bioorganic Chemistry : textbook : in 2 books. Book 1. Bioorganic Chemistry / B.S. Zimenkovsky, V.A. Muzychenko, I.V Nizhenkovska, G.O. Syrova ; edited by B.S. Zimenkovsky, I.V Nizhenkovska. — 3rd edition. — Kyiv : AUS Medicine Publishing, 2020. — 288 p.
2. Biological and Bioorganic Chemistry: in 2 books. Book 2. Biological Chemistry /Yu.Gubsky, I.V. Nizhenkovska, M.M. Korda et al. ; edited by Yu.Gubsky, I.V.Nizhenkovska. – Kyiv:AUS Medicine Publishing, 2020.- 544 p.
3. Gubsky Yu. Biological chemistry: textbook. – Vinnytsia: Nova Knyha, 2017. – 488 p.

Supplementary

1. Hordiienko L.P., Bilets M.B., Neporada K.S. Biological chemistry: collection tascs. Poltava, 2018. 148 p.
2. Harper`s Biochemistry. R.K.Murray, D.K.Granner, P.A.Mayes, V.W.Rodwell. Prentice-Hall International Inc., 2010. – 1134 p.
3. Koolman J. Color Atlas of Biochemistry, 3rd Edition / J.Koolman, K.-H. Rom. – Stuttgart. New York. – Thieme Verlag. — 2012. – 506 p.
4. Lehninger A. Principles of Biochemistry / Lehninger A. – New York. – W.H.Freeman and Company. – 2005. – 1010 p.
5. Pamela C.Champe Lippincott's Illustrated Reviews: Biochemistry, 3rd Edition / Pamela C.Champe and Richard A.Harvey. – Baltimore, Lippincott Williams & Wilkins, MD ©, 2005. – 534p.
6. Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto Biochemistry - New York. - Macmillan Learning, - 2015. – 135 p.

Information resources

www.pdmu.edu.ua
https://www.pdmu.edu.ua
https://cosmolearning.org/courses/biochemistry-i/video-lectures/
https://podcasts.ox.ac.uk/keywords/biochemistry

https://www.studocu.com/latam/document/universidad-de-el-salvador/bioquimica/lecture-notes-clinical-biochemistry-9th-ed-booksmedicos/11891840

Official sites of High medical schools of Ukraine:

1. Bogomolets National Medical University - www / nmu.edu.ua - Kiev.
2. Bukovinian State Medical University - https://www.bsmu.edu.ua/en/main/ - Chernivtsi
3. Danylo Halytsky Lviv National Medical University - https://new.meduniv.lviv.ua/en/ - Lviv
4. Donetsk National Medical University - http://mmf.dsmu.edu.ua - Kropivnitskiy
5. Dnipro State Medical University - https://study.dmu.edu.ua - Dnipro.
6. I. Horbachevsky Ternopil National Medical University.- https://www.tdmu.edu.ua/en/ – Тернопіль.
7. Ivano-Frankivsk National Medical University - https://www.ifnmu.edu.ua/en/ - Ivano-Frankivsk
8. Kharkiv National Medical University - https://knmu.edu.ua/en/ - Kharkiv.
9. Luhansk State Medical University - https://www.lsmu.edu.ua/en/ – Rivne.
10. National Pirogov Memorial Nedical University - https://www.vnmu.edu.ua/en– Vinnytsya
11. . Zaporizhzhya State Medical University - https://int.zsmu.edu.ua - Zaporizhzhia
12. . Odessa National Medical University - https://onmedu.edu.ua/?lang=en – Odessa.

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