

MINISTRY OF HEALTH OF UKRAINE  
ODESA NATIONAL MEDICAL UNIVERSITY

Department of Medical Biology and Chemistry

CONFIRMED by



Vice-rector for scientific and pedagogical work

Eduard BURIACHKIVSKYI

September 1st 2024

WORKING PROGRAM IN THE DISCIPLINE  
«BIOLOGICAL AND BIOORGANIC CHEMISTRY»

**Level of higher education:** second (master's degree)

**Field of knowledge:** 22 «Health care»

**Specialty:** 221 «Dentistry»

**Educational and professional program:** Dentistry

The working program is compiled on the basis of the educational and professional program "Dentistry" for the training of specialists of the second (master's) level of higher education in the specialty 221 "Dentistry" of the field of knowledge 22 "Health care", approved by the Academic Council of ONMedU (minutes No. 10 dated 27.06.2024).

Authors:

Head of the Department, PhD of Medical Sciences, Associate Professor Hennadii STEPANOV

Senior teacher Alina KOSTINA

PhD of Chemical Sciences, Associate Professor Ianina BURDINA


PhD of Chemical Sciences, Associate Professor Alla GREKOVA

PhD of Biological Sciences, Associate Professor Olha STORCHYLO

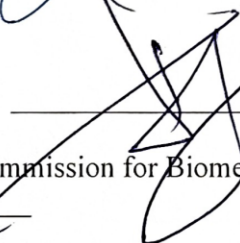
PhD of Biological Sciences, Associate Professor Antonina VASILIEVA

The working program is approved at the meeting of the Department of Medical Biology and Chemistry  
Minutes No. 1 dated 26.08 2024.

Head of the department

  
\_\_\_\_\_ Hennadii STEPANOV

Approved by the guarantor of  
the educational and professional program

  
\_\_\_\_\_ Anatolii HULIUK

Approved by the subject-cycle methodological commission for Biomedical Sciences of ONMedU  
Minutes No. 1 dated 27.08.2024

Head of the subject-cycle methodological commission for Biomedical Sciences of ONMedU  
  
\_\_\_\_\_ Leonid GODLEVSKY

Revised and approved at the meeting of the Department \_\_\_\_\_

Minutes No. \_\_ dated \_\_/\_\_/20\_\_.

Head of the department \_\_\_\_\_ Hennadii STEPANOV

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Head of the department \_\_\_\_\_ Hennadii STEPANOV

### 1. Description of the discipline:

Name of indicators	Field of knowledge, specialty, specialization, level of higher education	Characteristics of the discipline
Total number:	Field of knowledge 22 «Health care»	<i>Full-time (day) education</i> <i>Compulsory discipline</i>
Credits of ECTS:6	Specialty 221 «Dentistry»	<i>Course: 1,2</i>
Hours: 180		<i>Semester: II-III</i>
Content modules: 4	Level of higher education second (master's degree)	<i>Lectures (34 hours)</i>
		<i>Seminars (0 hours)</i>
		<i>Practical classes (86 hours)</i>
		<i>Laboratories (0 hours)</i>
		<i>Independent work (60 hours)</i>
		<i>including individual tasks (0 hours)</i>
		<i>Form of final control – Exam</i>

### 2. The purpose and tasks of the educational discipline, competencies, program learning outcomes

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

**The tasks of the discipline** are the following:

1. Acquisition of knowledge and skills to conduct biochemical research to identify normal and pathological components in biological fluids.
2. Analyze the results of biochemical research for the diagnosis of the most common human diseases.
3. To analyze the biochemical processes of metabolism and its regulation in ensuring the functioning of organs and systems of the human body.

The process of studying the discipline is aimed at forming elements of following competencies:

#### **General competencies:**

- GC 1. Ability to abstract thinking, analysis and synthesis.
- GC 3. Ability to apply knowledge in practical activities.
- GC 11. Ability to work in a team.
- GC 12. Efforts to preserve the environment.

#### **Special competencies are:**

- SC 2. The ability to interpret the results of laboratory and instrumental research.
- SC 6. The ability to determine a rational regimen of work, rest, and diet in patients in the treatment of diseases of the organs and tissues of the oral cavity and maxillofacial region.
- SC 13. The ability to assess the impact of the environment on the state of health of the population (individual, family, population).

**Program learning outcomes** are:

PLO 2- Collect information about the patient's general condition, evaluate the patient's psychomotor and physical development, the condition of the maxillofacial organs, based on the results of laboratory and instrumental studies, evaluate information about the diagnosis (according to list 5).

PLO 3 - Prescribe and analyze additional (mandatory and optional) examination methods (laboratory, X-ray, functional and/or instrumental) according to list 5, of patients with diseases of the organs and tissues of the oral cavity and maxillofacial region for the differential diagnosis of diseases (according to list 2).

PLO 20 - To organize the necessary level of individual safety (own and the persons he cares for) in case of typical dangerous situations in the individual field of activity.

**As a result of studying the discipline, the higher education applicant has to Know:**

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

**Be able:**

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

### 3. The content of the educational discipline

#### Content module 1.

#### **Biologically important classes of bioorganic compounds. Biopolymers and their structural components.**

##### **Theme 1: Classification, nomenclature, isomerism of bioorganic compounds. Nature of chemical bonds. Types of chemical reactions.**

Theory of the structure of organic substances. Classification of organic compounds. Nomenclature of organic compounds: trivial, rational, IUPAC. Isomerism of organic compounds. Electronic shifts in molecules of organic compounds: inductive and mesomeric effects

**Theme 2. Investigation of the reactivity of alkanes, alkenes, arenes.** Alkanes, alkenes, alkynes, arenes. Nomenclature and isomerism. Mechanism of free radical substitution in alkanes. Chemical properties of alkenes. Electrophilic addition to alkenes. Markovnikov's rule and its modern interpretation. Benzenes (electronic and spatial structure). The mechanism of electrophilic substitution in the aromatic ring.

##### **Theme 3. Structure and properties of hydroxo- and oxo-compounds. Biologically active hydroxo- and oxo-compounds.**

Classification, nomenclature and isomerism of hydroxo compounds (alcohols and phenols). Comparative characteristics of acidic properties of alcohols and phenols. Nomenclature and isomerism of aldehydes and ketones. nucleophilic addition to oxo compounds. Medicobiological significance of hydroxo- and oxo-compounds.

##### **Theme 4. Investigation of the reactivity of carboxylic acids and their heterofunctional derivatives (amino alcohols, hydroxy acids, keto acids and phenolic acids). The use of carboxylic acids in medicine.**

Nomenclature and classification of carboxylic acids. Isomerism (structural and optical) of carboxylic acids. Homologous series of saturated monobasic carboxylic acids. Structure of the carboxyl group. Hydroxy acids. Oxoacids. Aromatic acids and their derivatives. Chemical properties of carboxylic acids and their derivatives.

##### **Theme 5. Study of the properties of natural fatty acids. Triglycerides, lipids.**

The main structural components of lipids. Classification of lipids and their biological functions. Features of the structure of the structural components of saponifiable lipids (triacylglycerols): Fats (saturated and unsaturated) and alcohols (polyatomic and monatomic). Chemical properties of lipids. Analytical characteristics of fats.

##### **Theme 6: Phospholipids. Biological significance and structure of the lipid component of biomembranes.**

Classification of complex lipids. Components of complex saponifiable lipids. Phospholipids. Features of the structure. Chemical properties of phospholipids. Other representatives of complex lipids (glycolipids, sphingolipids, cerebrosides, sphingomyelins). Lipid composition of membranes. Biological functions of phospholipids.

##### **Theme 7: Carbohydrates. Structure and chemical properties of monosaccharides.**

Classification of carbohydrates. Isomerism. Tautomeric forms of monosaccharides. Mutarotation. Chemical reactions of monosaccharides with the participation of carbonyl group. Redox reactions as qualitative reactions for the detection of aldehyde group.

##### **Theme 8. Structure and functions of di- and polysaccharides.**

Classification of disaccharides by their ability to redox reactions. Types of glycosidic bonds between monosaccharide residues and their influence on the reactivity of disaccharides. Structure, properties and role in structure formation of maltose and cellobiose polysaccharides, their tautomeric forms. Structure and properties of lactose and sucrose. Sucrose inversion due to hydrolysis. Structure, biological role and use of starch, its components. Structure of amylose and amylopectin. Confirmation structure and secondary structure of amylose. Hydrolysis of starch and qualitative reaction of its determination. Structure and biological role of glycogen and fiber. Their role in the processes of vital activity of the organism.

**Theme 9. Chemical properties of carbohydrates. Qualitative reactions for the determination of carbohydrates.**

Qualitative reactions on the many atomicity of alcohols. Qualitative reactions of opening of aldehyde group. Selivanov reaction on ketones. Qualitative reactions of disaccharides. Reaction of sucrose hydrolysis. Qualitative reaction to starch.

**Theme 10: Study of the amino acid composition of proteins and peptides.**

Nomenclature and classification of amino acids. Structure of the 20 most important  $\alpha$ -amino acids. Isomerism of amino acids. D- and L- genetic series. Physicochemical properties of amino acids. General chemical properties of amino acids (reactions of deamination, transamination, decarboxylation, specific properties of  $\alpha$ -,  $\beta$ -,  $\gamma$ -amino acids). Polycondensation reactions of  $\alpha$ -amino acids with the formation of peptides and proteins.

**Theme 11. Organization of the structure of proteins. Physicochemical properties of proteins. Precipitation reactions of proteins. Denaturation. Qualitative reactions for the determination of amino acids and proteins.**

Biological role of proteins in the body. Physicochemical properties of proteins. Levels of protein structure. Types of bonds. Solubilization of proteins. Denaturation of proteins. Qualitative reactions to amino acids, peptides, proteins.

**Theme 12: Classification, structure and significance of biologically active five- and six-membered heterocyclic compounds with one and two heteroatoms. Condensed heterocycles.**

Classification of heterocycles by cycle size, number and type of heteroatoms. Structure and properties of pyrrole, furan, thiophene. Non-benzene aromatic systems. Biological significance of tetrapyrrole compounds: porphins, porphyrins, heme. Indole and its derivatives, their formation. Thiophene as a structural component of the biotin molecule. Pyrazole. Pyrazolone-5 and its derivatives as drugs (analgin, amidopyrine, antipyrine). Imidazole and its derivatives (histidine and histamine). Five-membered heterocycles with two different heteroatoms: thiazole, oxazole. Thiazole as a structural component of vitamin B1.

Pyridine as an aromatic system. Chemical properties. Pyridine derivatives as medicinal products. Vitamin PP as a component of redox coenzymes NAD and NADP. Pyrimidine and its derivatives (uracil, thymine, cytosine). Tautomeric forms of pyrimidine bases. Barbituric acid. Phenobarbital and veronal as hypnotics and anticonvulsants. Purine and its amino derivatives (adenine, guanine), their tautomeric forms and biological significance. Hydroxy derivatives of purine (hypoxanthine, xanthine, uric acid) and their tautomeric forms.

**Theme 13. Structure and biological role of nucleosides, nucleotides and nucleic acids.**

Nucleosides and nucleotides as products of incomplete hydrolysis of nucleic acids. Nucleosides as medicinal products. Structure of nucleotides - constituent components of nucleic acids (AMP, GMP, UMP, CMF, TMP). Structure and value of 3',5' - c-AMP, its role in the action of hormones on cells.

Nucleic acids - polynucleotides, biopolymers that store, transmit hereditary information and participate in protein biosynthesis. Structure and biochemical functions of DNA. Differences in the structure and functions of DNA and RNA.

## **Content module 2.**

### **General patterns of metabolism.**

#### **Metabolism of carbohydrate and its regulation.**

##### **Theme 14. General characteristics, properties of enzymes.**

General characteristics, properties of enzymes. The protein nature of enzymes. Active, allosteric enzyme centers. Regulation of enzyme activity. Enzyme activators and inhibitors. Coenzymes, their role in catalysis. Coenzyme functions of vitamins. International classification and nomenclature of enzymes. Proenzymes. Activation of proenzymes, role in metabolism. Demonstration-practical work: Determining the structure of enzymes by biuret reaction, Foll's reaction. Determination of amylase activity of saliva and urine in the presence of activator and inhibitor.

##### **Theme 15. Mechanism of action of enzymes. Kinetics of catalysis.**

Basic theories of biocatalysis. Kinetics of catalysis. Methods of qualitative and quantitative determination of enzymes. Intracellular localization of enzymes. Use of enzymes in the clinic (fundamentals of medical enzymology). Enzyme diagnostics and enzyme therapy. Enzymopathies. Demonstration-practical work: Demonstration of enzymograms. Observation of the kinetics of lipase action on milk fat. Effect of bile on lipase activity.

##### **Theme 16. Citric acid cycle.**

Specific and general pathways of catabolism. Citric acid cycle (CAC). Sequence of reactions and characteristics of enzymes. Biological significance of CAC. Bioenergetics of significance. Anaplerotic and amphibolic reactions of CAC. Demonstration-practical work: Detection of milk dehydrogenase. Detection of succinate dehydrogenase in muscles.

##### **Theme 17. Molecular mechanisms of tissue respiration. Peroxide and microsomal oxidation.**

The structure of mitochondria. Molecular organization of Electron transport chain: components; their redox-potential, molecular complexes of the inner mitochondria membranes. Oxidative phosphorylation in the respiratory chain. High energy compounds. Peroxide and microsomal oxidation. Antioxidant system. Demonstration-practical work: Detection of oxidase (tyrosinase) in potatoes. Detection of peroxidase in horseradish extract. Detection of catalase in blood. Quantification of blood catalase (catalase number) according to Bach and Zubkova.

##### **Theme 18. Intracellular catabolism of glucose. Alternative pathways of monosaccharide metabolism.**

Intracellular catabolism of glucose. Glycolysis: reactions. Comparison of glycolysis and alcoholic fermentation. Glycogenolysis, regulation. Differences from glycolysis. Stages of aerobic oxidation of glucose: oxidative decarboxylation of pyruvate. Bioenergetics of the process. Alternative pathways of monosaccharide metabolism. The pentose phosphate pathway of glucose oxidation: scheme, biological significance, features of functioning in various tissues. Metabolic pathways of fructose and galactose conversion: hereditary enzymopathies of their metabolism. Demonstration-practical work: Simulation of the "in vitro" process of glycolysis, determination of end products. Alcoholic fermentation test. Determination of pyruvate content in blood serum. Detection of fructose by the Selivanov reaction.

##### **Theme 19. Gluconeogenesis. Glycogen biosynthesis. Regulation of carbohydrate metabolism.**

Glucose biosynthesis: physiological significance, reactions, regulatory enzymes. Substrates of gluconeogenesis. Glucose-lactate and glucose-alanine cycles. Regulation of glucose metabolism. Glucosemia: normal state and its disorders. Glycogen biosynthesis. Regulation of carbohydrate metabolism. Genetic disorders of glycogen metabolism of (glycogen storage

diseases). Demonstration-practical work: Determination of glucose content in the blood by the Hagedorn-Jenson method. Determination of glycogen in the liver.

**Intermediate control for the semester.**

### **Content module 3.**

#### **Metabolism of lipids, amino acids and its regulation.**

#### **Molecular biology. Biochemistry of intercellular communications.**

#### **Theme 20. The role of lipids in the structure and functions of biological membranes. Oxidation of fatty acids and glycerol.**

The role of lipids in the structure and functions of biological membranes. Molecular mechanisms of lipolysis regulation. Tissue, intracellular metabolism of lipids. Oxidation of fatty acids and glycerol. Energy yield from fatty acid  $\beta$ -oxidation. Demonstration-practical work: Observation of the effect of bile on fat emulsification. Observation of the effect of pancreatic lipase on milk fat with and without bile.

#### **Theme 21. Biosynthesis of glycerol, fatty acids, glycerides and phospholipids. Cholesterol metabolism. Metabolism of acetoacetic acid.**

Biosynthesis of glycerol, fatty acids and glycerides. Formation of phospholipids. Structure, biological role and metabolism of cholesterol. Cholesterol biosynthesis. Disorders of lipid metabolism. Lipoproteins, structure and functions. Metabolism of acetoacetic acid. Ketone bodies. Demonstration-practical work: Determination of total lipids in blood serum by the method of Bang. Qualitative reactions to acetone (iodoformant, nitroprusside). Quantitative determination of acetone in urine by the Rudoy method. Qualitative response to the presence of cholesterol in the brain.

#### **Theme 22. Ways of formation and maintenance of the pool of amino acids in the body. Deamination, decarboxylation, transamination of amino acids.**

Ways of formation and maintenance of the pool of amino acids in the body. Transport of amino acids into cells. Deamination of amino acids. Mechanism of indirect deamination of L-amino acids. Decarboxylation of amino acids: enzymes, physiological significance. Oxidation of biogenic amines. Transamination. Biochemical significance, mechanisms of action of aminotransferases. Diagnostic value of determination of aminotransferases in blood serum. Ammonia metabolism in the human body. Urea. Ways of ammonia formation. Ammonia toxicity and mechanisms of its neutralization. Transport forms of ammonia (glutamine and asparagine). Urea biosynthesis: enzyme reactions, genetic anomalies. Demonstration-practical work: Quantitative determination of nitrogen of ammonium salts in urine by the Model method. Detection of alanine aminotransferase (AlAT) in normal and pathological blood serum.

#### **Theme 23. Ammonia metabolism in the human body.**

Ammonia metabolism in the human body. Urea. Ways of ammonia formation. Ammonia toxicity and mechanisms of its neutralization. Transport forms of ammonia (glutamine and asparagine). Urea biosynthesis: enzyme reactions, genetic anomalies. Demonstration-practical work: Quantitative determination of urea in urine.

#### **Theme 24. Amino acids nitrogen-free skeleton metabolism in the body. Hereditary enzymopathies of amino acid metabolism.**

Ways of metabolism of the nitrogen-free skeleton of amino acids in the human body. Glycogenic and ketogenic amino acids. Special pathways of acyclic amino acids metabolism. Glutathione, its role in the metabolism of organic peroxides. Arginine metabolism, biological role of nitric oxide, NO-synthase. Metabolic features of branched-chain amino acid: participation of coenzyme forms of vitamin B12 in amino acid metabolism. Metabolic pathways of cyclic amino acids. Hereditary enzymopathies of cyclic and aliphatic amino acid metabolism. Demonstration-practical work: Determination of phenyl pyruvate (Fehling's test)

#### **Theme 25. Catabolism and anabolism of purine and pyrimidine nucleotides.**

Nucleotides' metabolism in tissues: purine and pyrimidine nucleotides catabolism. Disorders



of purine metabolism (gout). Purine and pyrimidine nucleotides biosynthesis. Regulation of nucleotide biosynthesis. Deoxyribonucleotide biosynthesis. Formation of thymidine nucleotides: dTMP biosynthesis inhibitors as antitumor agents. Demonstration-practical work: Quantitative determination of uric acid in urine.

**Theme 26. Biosynthesis of nucleic acids. Protein biosynthesis in ribosomes.**

Biosynthesis of nucleic acids. Molecular mechanisms of DNA replication. Stages of synthesis of daughter chains of DNA molecules. Molecular mechanisms of transcription. RNA synthesis stages and enzymes. Processing as a post-transcriptional modification of RNA. Antibiotics as transcription inhibitors. Protein biosynthesis in ribosomes. Genetic code: triplet code structure, its properties. Post-translational modification of peptide chains. Regulation of translation. Regulation of gene expression. Mechanisms of DNA mutations and repairs. Obtaining recombinant DNA, transgenic proteins.

**Theme 27. Hormones general concept. Hypothalamus and pituitary gland hormones. Thyroid and parathyroid glands hormones. Regulation of phosphorus-calcium metabolism.**

Hormones general concept. Classification, mechanisms of action of hormones on target cells. Hormones of the hypothalamus and pituitary gland hormones. Thyroid and parathyroid glands hormones. Structure and synthesis of thyroid hormones. Thyroid gland pathology. Regulation of phosphorus-calcium metabolism. Metabolic disorders of calcium homeostasis. Demonstration-practical work: Study of the nature of hormones using the biuret reaction. Determination of iodine in the thyroid gland.

**Theme 28. Steroid hormones.**

Steroid hormones. Hormones of the adrenal cortex and gonads. Their structure and biochemical mechanisms of action. Demonstration-practical work: Refractometric determination of protein in blood serum.

**Theme 29. Pancreas and adrenal medulla hormones. Local hormones.**

Pancreas and adrenal medulla hormones. Chemical structure and mechanism of action. Hormonal regulation of blood sugar. Local hormones, their structure, biological role. Hormones of the digestive tract. Demonstration-practical work: Determination of sugar in urine with Felling's reagent.

**Content module 4.**

**Biochemistry of tissues and physiological functions.**

**Theme 30. Digestion of carbohydrates, lipids, proteins, nucleoproteins in the gastrointestinal tract. Water-soluble vitamins B1, B2, B6, PP.**

Digestion of carbohydrates, lipids, proteins, nucleoproteins in the gastrointestinal tract. Enzymes, biochemical mechanisms. Chemical composition of gastric and intestinal juice. Hereditary disturbances of digestion. Biochemical characteristics and classification of vitamins. Water-soluble vitamins B1, B2, B6, PP. Their coenzyme role and symptoms of hypovitaminosis. Demonstration-practical work: Determination of all forms of gastric juice acidity. Qualitative reactions to vitamins B1, B2, B6, PP

**Theme 31. Water-soluble vitamins C, biotin, folic acid, B12, pantothenic acid.**

Water-soluble vitamins C, biotin, folic acid, B12, pantothenic acid. Structure, biological role and symptoms of hypovitaminosis. Demonstration-practical work: Quantitative determination of vitamin C in products by the Tillmans method.

**Theme 32. Fat-soluble vitamins.**

Fat-soluble vitamins. Vitamins of groups A, D, E, K. Structure, biological role. Hypo- and hypervitaminosis manifestation. Demonstration-practical work: Qualitative reactions to fat-soluble vitamins A, D, E, K (Vikasol).

**Theme 33. Biochemical characteristics and functions of blood. Blood respiratory function.**

Biochemical characteristics and functions of blood. Biochemical composition of blood plasma. Characteristics of protein fractions of blood. Characteristics of non-protein substances of blood plasma. Residual nitrogen of blood, its components. Diagnostic value of residual nitrogen determination in blood. Lipid transport forms - plasma lipoproteins. Types of hyperlipoproteinemia. The role of lipoproteins in the development of atherosclerosis. Osmotic pressure and acid-base state of blood. Blood buffer systems, hormonal regulation mechanisms, lung and kidney function. Blood respiratory function. Hemoglobin, structure, synthesis in the body. Role in the transport of oxygen and carbon dioxide. Abnormal hemoglobin. Demonstration-practical work: Quantitative determination of blood proteins by biuret and refractometric methods. Serum protein fractionation by the "salting out" method. Determination of erythrocytes osmotic resistance. Determination of hemoglobin content in blood.

**Theme 34. Biochemistry of coagulation, anticoagulation and fibrinolytic blood systems.**

Biochemistry of coagulation, anticoagulation and fibrinolytic blood systems. Functional and biochemical characteristics of the homeostasis system in the human body: coagulation and vascular-platelet hemostasis. Blood coagulation system, characteristics of individual components (coagulation factors). Mechanisms of coagulation. The anticoagulation system of blood, anticoagulants. The role of vitamin K in coagulation reactions. Hereditary disorders of the blood coagulation system. Demonstration-practical work: Determination of fibrinogen concentration in blood plasma. Determination of prothrombin time. Determination of plasma recalcification.

**Theme 35. Biochemical functions of the liver. The role of the liver in the metabolism of bile pigments. Detoxification function of the liver**

Biochemical functions of the liver, its role in the metabolism of carbohydrates, lipids, and proteins. The role of the liver in the metabolism of bile pigments. Hemoglobin catabolism. Pathobiochemistry of jaundice, hereditary (enzymatic) jaundice. Detoxification function of the liver: biotransformation of xenobiotics and endogenous toxins. Types of biotransformations of xenobiotics. Reaction of microsomal oxidation, inducers and inhibitors of microsomal monooxidases. Conjugation reactions in hepatocytes: biochemical mechanisms, functional significance. Demonstration-practical work: Determination of total, direct and indirect bilirubin in blood serum. Determination of hippuric acid and indican in urine.

**Theme 36. Biochemistry of connective tissue.**

General characteristics of the morphology and biochemical composition of connective tissue. Biochemical structure of the intercellular substance of loose fibrous connective tissue: fibers (collagenous, reticular, elastic), the main amorphous substance. Proteins of connective tissue fibers: collagen, elastin. Collagen biosynthesis and fibrillary structures formation. Complex carbohydrates of the main amorphous matrix of connective tissue: glycosaminoglycans (mucopolysaccharides), proteoglycans. Pathochemistry of connective tissue. Biochemical mechanisms of mucopolysaccharidosis and collagenosis, their clinical and biochemical diagnosis.

**Theme 37. Biochemistry of the oral cavity, teeth and saliva.**

Chemical composition of tooth tissue: organic (collagenous, non-collagenous proteins, carbohydrates, lipids, nucleic acids) and mineral components. Mineral metabolism in tooth tissue: mineralization, demineralization, remineralization (specific proteins and enzymes, role of citric acid in calcium metabolism). Chemical composition and biological functions of saliva. Features of mineralization role of saliva in the tooth tissue. Saliva enzymes, their role in digestion. Determination of proteins and enzymes in human saliva under normal and pathological conditions. Regulation of salivation, biochemical basis of salivation disorders. Demonstration-practical work: Determination of lactic acid in saliva. Determination of protein in saliva.

**Theme 38. Muscle biochemistry. Biochemistry of nervous tissue.**

Muscle biochemistry. Features of the chemical composition and metabolism in muscles. Molecular mechanisms of muscle contraction. Bioenergetics of muscle tissue: sources of ATP in muscles. Features of the biochemical composition and metabolism of the nervous system. Biochemical composition of the brain. Energy metabolism of the human brain, the value of aerobic oxidation of glucose. Neurotransmitters: acetylcholine, norepinephrine, dopamine, serotonin.

Molecular basis of bioelectrical processes on neuron membranes. Demonstration-practical work: Determination of creatinine and creatine levels in blood and urine.

**Theme 39. Kidney biochemistry.**

Kidney role in body fluids electrolyte composition and pH regulation. Biochemical mechanisms of the urine formation of the kidneys. Pathobiochemistry of kidneys. Biochemical composition of human urine in normal conditions and under conditions of pathological processes, nephrolithiasis. Clinical and diagnostic significance of urine composition analysis. Demonstration-practical work: Qualitative determination of protein in urine (heating and acid precipitation). Quantitative determination of protein by the Branderg-Stolnikov method. Quantitative determination of glucose in urine using a polarimeter.

**Intermediate control for the semester.**

**4. The structure of the educational discipline**

Themes	Number of hours					
	Total	including				Independent work
		lectures	seminars	practical classes	laboratories	
<b>Content module 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.</b>						
Theme 1: Classification, nomenclature, isomerism of bioorganic compounds. Nature of chemical bonds. Types of chemical reactions	5	2	0	2	0	1
Theme 2. Investigation of the reactivity of alkanes, alkenes, arenes.	3	0	0	2	0	1
Theme 3: Structure and properties of hydroxo- and oxo-compounds. Biologically active hydroxo- and oxo-compounds.	3	0	0	2	0	1
Theme 4. Investigation of the reactivity of carboxylic acids and their heterofunctional derivatives (amino alcohols, hydroxy acids, keto acids)	3	0	0	2	0	1

and phenolic acids). The use of carboxylic acids in medicine.						
Theme 5. Study of the properties of natural fatty acids. Triglycerides. Lipids.	4	1	0	2	0	1
Theme 6. Phospholipids. Biological significance and structure of the lipid component of biomembranes.	4	1	0	2	0	1
Theme 7. Carbohydrates. Structure and chemical properties of monosaccharides.	4	1	0	2	0	1
Theme 8: Structure and functions of di- and polysaccharides.	4	1	0	2	0	1
Theme 9: Chemical properties of carbohydrates. <i>Qualitative reactions for the determination of carbohydrates</i>	4	1	0	2	0	1
Theme 10: Study of the amino acid composition of proteins and peptides.	4	1	0	2	0	1
Theme 11. Organization of the structure of proteins. Physicochemical properties of proteins. Precipitation reactions of proteins. Denaturation. Qualitative	4	1	0	2	0	1

reactions for the determination of amino acids and proteins.						
Theme 12: Classification, structure and significance of biologically active five- and six-membered heterocyclic compounds with one and two heteroatoms. Condensed heterocycles.	4	1	0	2	0	1
Theme 13. Structure and biological role of nucleosides, nucleotides and nucleic acids.	4	0	0	2	0	2
<i>Total by content module 1</i>	50	10	0	26	0	14
<b>Content module 2.</b> <b>General patterns of metabolism.</b> <b>Metabolism of carbohydrates and its regulation.</b>						
Theme 14. General characteristics, properties of enzymes.	5	1	0	2	0	2
Theme 15. Mechanism of action of enzymes. Kinetics of catalysis.	5	1	0	2	0	2
Theme 16. Citric acid cycle.	5	1	0	2	0	2
Theme 17. Molecular mechanisms of tissue respiration. Peroxide and microsomal oxidation.	5	1	0	2	0	2
Theme 18. Intracellular catabolism of glucose. Alternative	6	2	0	2	0	2

pathways of monosaccharide metabolism.						
Theme 19. Gluconeogenesis. Glycogen biosynthesis. Regulation of carbohydrate metabolism.	6	2	0	2	0	2
Intermediate control for the semester.	8	0	0	4	0	4
<i>Total by content module 2</i>	40	8	0	16	0	16
<b>Content module 3.</b>						
<b>Metabolism of lipids, amino acids and its regulation.</b>						
<b>Molecular biology. Biochemistry of intercellular communications.</b>						
Theme 20. The role of lipids in the structure and functions of biological membranes. Oxidation of fatty acids and glycerol.	4	1	0	2	0	1
Theme 21. Biosynthesis of glycerol, fatty acids, glycerides and phospholipids. Cholesterol metabolism. Metabolism of acetoacetic acid.	4	1	0	2	0	1
Theme 22. Ways of formation and maintenance of the pool of amino acids in the body. Deamination, decarboxylation, transamination of amino acids.	4	1	0	2	0	1
Theme 23. Ammonia metabolism in the human body.	3	0	0	2	0	1
Theme 24. Amino acids nitrogen-free	4	1	0	2	0	1

skeleton metabolism in the body. Hereditary enzymopathies of amino acid metabolism.						
Theme 25. Catabolism and anabolism of purine and pyrimidine nucleotides.	4	1	0	2	0	1
Theme 26. Biosynthesis of nucleic acids. Protein biosynthesis in ribosomes.	4	1	0	2	0	1
Theme 27. Hormones general concept. Hypothalamus and pituitary gland hormones. Thyroid and parathyroid glands hormones. Regulation of phosphorus-calcium metabolism.	4	1	0	2	0	1
Theme 28. Steroid hormones.	4	1	0	2	0	1
Theme 29. Pancreas and adrenal medulla hormones. Local hormones.	5	2	0	2	0	1
<i>Total by content module 3</i>	40	10	0	20	0	10
<b>Content module 4.</b>						
<b>Biochemistry of tissues and physiological functions</b>						
Theme 30. Digestion of carbohydrates, lipids, proteins, nucleoproteins in the gastrointestinal tract. Water-soluble vitamins B1, B2, B6, PP.	4	1	0	2	0	1
Theme 31. Water-soluble vitamins C, biotin, folic acid,	4	1	0	2	0	1

B12, pantothenic acid.						
Theme 32. Fat-soluble vitamins.	4	1	0	2	0	1
Theme 33. Biochemical characteristics and functions of blood. Blood respiratory function.	4	1	0	2	0	1
Theme 34. Biochemistry of coagulation, anticoagulation and fibrinolytic blood systems.	5	1	0	2	0	2
Theme 35. Biochemical functions of the liver. The role of the liver in the metabolism of bile pigments. Detoxification function of the liver	5	1	0	2	0	2
Theme 36. Biochemistry of connective tissue.	4	0	0	2	0	2
Theme 37. Biochemistry of the oral cavity, teeth and saliva.	4	0	0	2	0	2
Theme 38. Muscle biochemistry. Biochemistry of nervous tissue.	4	0	0	2	0	2
Theme 39. Kidney biochemistry.	4	0	0	2	0	2
Intermediate control for the semester	8	0	0	4	0	4
<i>Total by content module 4</i>	50	6	0	24	0	20
<i>Individual task</i>	0	0	0	0	0	0
<b>Total hours</b>	180	34	0	86	0	60



## 5. Themes of lectures / seminars / practical classes / laboratories

### 5.1. Themes of lectures

No	Theme	Hours
1.	General provisions of bioorganic chemistry. Features of the structure of bioorganic compounds.	2
2.	Lipids, phospholipids, steroids: properties and biological role. Characterization of phospholipids as functional components of biomembranes.	2
3.	Structure and chemical properties of carbohydrates	2
4.	Proteinogenic amino acids, peptides, proteins: structure, properties, biological role.	2
5.	Heterocyclic compounds as structural components of nucleic acids. The structure of nucleic acids.	2
6.	Biochemistry as a science: biomolecules; metabolic pathways. Enzymes: structure, properties, classification and nomenclature. Kinetics and regulation of enzymatic reactions. Regulatory enzymes. Cofactors and coenzymes. Medical enzymology.	2
7.	Bioenergetics: general pathways of catabolism of carbohydrates, lipids, amino acids. Citric acid cycle. Biological oxidation and oxidative phosphorylation. Electron transport chain in mitochondria.	2
8.	Carbohydrate metabolism: glycolysis, glycogenolysis, oxidative decarboxylation of pyruvate, interconversion of monosaccharides, metabolism of fructose, galactose.	2
9.	Carbohydrate metabolism: Glycogen biosynthesis, pentose phosphate pathway, gluconeogenesis. Enzymopathies of carbohydrate metabolism (glycogen storage diseases). Diabetes mellitus.	2
10.	Lipid metabolism. Catabolism of triacylglycerols: oxidation of fatty acids and glycerol; ketogenesis. Lipid metabolism. Lipogenesis. Cholesterol metabolism. Regulation and pathology of lipid metabolism: obesity, atherosclerosis.	2
11.	Amino acid metabolism. General pathways of amino acid transformation (deamination, transamination, decarboxylation). Ammonia metabolism: urea biosynthesis and its disorders. Special pathways of amino acid transformation; hereditary enzymopathies of amino acid metabolism.	2
12.	Biosynthesis and catabolism of purine and pyrimidine nucleotides. Biosynthesis of nucleic acids: DNA replication; RNA transcription. Protein synthesis in ribosomes. Regulation of protein biosynthesis.	2
13.	Biochemical and molecular biological mechanisms of hormone action; hierarchy of hormones. Hormones of protein-peptide nature.	2
14.	Hormones and bioregulators - derivatives of amino acids; hormones and physiologically active compounds of lipid nature. Local hormones.	2
15.	Biochemistry of human nutrition. Vitamins and micro elements as components of human nutrition. Water-soluble vitamins. Fat-soluble vitamins, bioantioxidants. Exogenous and endogenous hypo- and avitaminosis, hypervitaminosis	2
16.	Chemical composition and functions of blood. Transport of gases by blood. Biochemistry and pathobiochemistry of hemoglobins. Biosynthesis of porphyrins, heme catabolism. Metabolism of bile pigments.	2

17.	Biochemistry of coagulation, anticoagulation and fibrinolytic systems. Violation of coagulation homeostasis	2
	<b>Total</b>	34

## 5.2. Themes of seminars

Seminars are not provided.

## 5.3. Themes of practical classes

No	Theme	Hours
1.	Practical class 1: Classification, nomenclature, isomerism of bioorganic compounds. Nature of chemical bonds. Types of chemical reactions	2
2.	Practical class 2. Types of chemical reactions. Study of the reactivity of alkanes, alkenes, arenes.	2
3.	Practical class 3: Structure and properties of hydroxo- and oxo-compounds. Biologically active hydroxo- and oxo-compounds.	2
4.	Practical class 4. Investigation of the reactivity of carboxylic acids and their heterofunctional derivatives (amino alcohols, hydroxy acids, keto acids and phenolic acids). The use of carboxylic acids in medicine.	2
5.	Practical class 5. Study of the properties of natural fatty acids. Triglycerides. Lipids.	2
6.	Practical class 6. Phospholipids. Biological significance and structure of the lipid component of biomembranes.	2
7.	Practical class 7. Carbohydrates. Structure and chemical properties of monosaccharides.	2
8.	Practical class 8: Structure and functions of di- and polysaccharides.	2
9.	Practical class 9: Chemical properties of carbohydrates. <i>Qualitative reactions for the determination of carbohydrates</i>	2
10.	Practical class 10: Study of the amino acid composition of proteins and peptides.	2
11.	Practical class 11. Organization of the structure of proteins. Physicochemical properties of proteins. Precipitation reactions of proteins. Denaturation. <i>Qualitative reactions for the determination of amino acids and proteins.</i>	2
12.	Practical class 12.: Classification, structure and significance of biologically active five- and six-membered heterocyclic compounds with one and two heteroatoms. Condensed heterocycles.	2
13.	Practical class 13: Structure and biological role of nucleosides, nucleotides and nucleic acids.	2
14.	Practical class 14. General characteristics, properties of enzymes. The protein nature of enzymes. Active, allosteric enzyme centers. Regulation of enzyme activity. Enzyme activators and inhibitors. Coenzymes, their role in catalysis. Coenzyme functions of vitamins. International classification and nomenclature of enzymes. Proenzymes. Activation of proenzymes, role in metabolism. Demonstration-practical work: Determining the structure of enzymes by biuret reaction, Foll's reaction. Determination of amylase activity of saliva and urine in the presence of activator and inhibitor.	2
15.	Practical class 15. Basic theories of biocatalysis. Kinetics of catalysis. Methods of qualitative and quantitative determination of enzymes. Intracellular localization of enzymes. Use of enzymes in the clinic (fundamentals of medical enzymology). Enzyme diagnostics and enzyme	2

	therapy. Enzymopathies. Demonstration-practical work: Demonstration of enzymograms. Observation of the kinetics of lipase action on milk fat. Effect of bile on lipase activity.	
16.	Practical class 16. Specific and general pathways of catabolism. Citric acid cycle (CAC). Sequence of reactions and characteristics of enzymes. Biological significance of CAC. Bioenergetics of significance. Anaplerotic and amphibolic reactions of CAC. Demonstration-practical work: Detection of milk dehydrogenase. Detection of succinate dehydrogenase in muscles.	2
17.	Practical class 17. The structure of mitochondria. Molecular organization of Electron transport chain: components; their redox-potential, molecular complexes of the inner mitochondria membranes. Oxidative phosphorylation in the respiratory chain. High energy compounds. Peroxide and microsomal oxidation. Antioxidant system. Demonstration-practical work: Detection of oxidase (tyrosinase) in potatoes. Detection of peroxidase in horseradish extract. Detection of catalase in blood. Quantification of blood catalase (catalase number) according to Bach and Zubkova.	2
18.	Practical class 18. Intracellular catabolism of glucose. Glycolysis: reactions. Comparison of glycolysis and alcoholic fermentation. Glycogenolysis, regulation. Differences from glycolysis. Stages of aerobic oxidation of glucose: oxidative decarboxylation of pyruvate. Bioenergetics of the process. Alternative pathways of monosaccharide metabolism. The pentose phosphate pathway of glucose oxidation: scheme, biological significance, features of functioning in various tissues. Metabolic pathways of fructose and galactose conversion: hereditary enzymopathies of their metabolism. Demonstration-practical work: Simulation of the "in vitro" process of glycolysis, determination of end products. Alcoholic fermentation test. Determination of pyruvate content in blood serum. Detection of fructose by the Selivanov reaction.	2
19.	Practical class 19. Glucose biosynthesis: physiological significance, reactions, regulatory enzymes. Substrates of gluconeogenesis. Glucose-lactate and glucose-alanine cycles. Regulation of glucose metabolism. Glucosemia: normal state and its disorders. Glycogen biosynthesis. Regulation of carbohydrate metabolism. Genetic disorders of glycogen metabolism of (glycogen storage diseases). Demonstration-practical work: Determination of glucose content in the blood by the Hagedorn-Jenson method. Determination of glycogen in the liver.	2
20.	Practical class 20. Intermediate control for the semester (part 1)	2
21.	Practical class 21. Intermediate control for the semester (part 2)	2
22.	Practical class 22. The role of lipids in the structure and functions of biological membranes. Molecular mechanisms of lipolysis regulation. Tissue, intracellular metabolism of lipids. Oxidation of fatty acids and glycerol. Energy yield from fatty acid $\beta$ -oxidation. Demonstration-practical work: Observation of the effect of bile on fat emulsification. Observation of the effect of pancreatic lipase on milk fat with and without bile.	2
23.	Practical class 23. Biosynthesis of glycerol, fatty acids and glycerides. Formation of phospholipids. Structure, biological role and metabolism of cholesterol. Cholesterol biosynthesis. Disorders of lipid metabolism. Lipoproteins, structure and functions. Metabolism of acetoacetic acid. Ketone bodies. Demonstration-practical work: Determination of total lipids in blood serum by the method of Bang. Qualitative reactions to acetone (iodoformant, nitroprusside). Quantitative determination of acetone in urine by the Rudoy method. Qualitative response to the presence of cholesterol in the brain.	2

24.	Practical class 24. Ways of formation and maintenance of the pool of amino acids in the body. Transport of amino acids into cells. Deamination of amino acids. Mechanism of indirect deamination of L-amino acids. Decarboxylation of amino acids: enzymes, physiological significance. Oxidation of biogenic amines. Transamination. Biochemical significance, mechanisms of action of aminotransferases. Diagnostic value of determination of aminotransferases in blood serum. Demonstration-practical work: Quantitative determination of nitrogen of ammonium salts in urine by the Model method. Detection of alanine aminotransferase (AlAT) in normal and pathological blood serum.	2
25.	Practical class 25. Ammonia metabolism in the human body. Urea. Ways of ammonia formation. Ammonia toxicity and mechanisms of its neutralization. Transport forms of ammonia (glutamine and asparagine). Urea biosynthesis: enzyme reactions, genetic anomalies. Demonstration-practical work: Quantitative determination of urea in urine.	2
26.	Practical class 26. Ways of metabolism of the nitrogen-free skeleton of amino acids in the human body. Glycogenic and ketogenic amino acids. Special pathways of acyclic amino acids metabolism. Glutathione, its role in the metabolism of organic peroxides. Arginine metabolism, biological role of nitric oxide, NO-synthase. Metabolic features of branched-chain amino acid: participation of coenzyme forms of vitamin B12 in amino acid metabolism. Metabolic pathways of cyclic amino acids. Hereditary enzymopathies of cyclic and aliphatic amino acid metabolism. Demonstration-practical work: Determination of phenyl pyruvate (Fehling's test)	2
27.	Practical class 27. Nucleotides' metabolism in tissues: purine and pyrimidine nucleotides catabolism. Disorders of purine metabolism (gout). Purine and pyrimidine nucleotides biosynthesis. Regulation of nucleotide biosynthesis. Deoxyribonucleotide biosynthesis. Formation of thymidine nucleotides: dTMF biosynthesis inhibitors as antitumor agents. Demonstration-practical work: Quantitative determination of uric acid in urine.	2
28.	Practical class 28. Biosynthesis of nucleic acids. Molecular mechanisms of DNA replication. Stages of synthesis of daughter chains of DNA molecules. Molecular mechanisms of transcription. RNA synthesis stages and enzymes. Processing as a post-transcriptional modification of RNA. Antibiotics as transcription inhibitors. Protein biosynthesis in ribosomes. Genetic code: triplet code structure, its properties. Post-translational modification of peptide chains. Regulation of translation. Regulation of gene expression. Mechanisms of DNA mutations and repairs. Obtaining recombinant DNA, transgenic proteins.	2
29.	Practical class 29. Hormones general concept. Classification, mechanisms of action of hormones on target cells. Hormones of the hypothalamus and pituitary gland hormones. Thyroid and parathyroid glands hormones. Structure and synthesis of thyroid hormones. Thyroid gland pathology. Regulation of phosphorus-calcium metabolism. Metabolic disorders of calcium homeostasis. Demonstration-practical work: Study of the nature of hormones using the biuret reaction. Determination of iodine in the thyroid gland.	2
30.	Practical class 30. Steroid hormones. Hormones of the adrenal cortex and gonads. Their structure and biochemical mechanisms of action. Demonstration-practical work: Refractometric determination of protein in blood serum.	2
31.	Practical class 31. Pancreas and adrenal medulla hormones. Chemical structure and mechanism of action. Hormonal regulation of blood sugar. Local	2

	hormones, their structure, biological role. Hormones of the digestive tract. Demonstration-practical work: Determination of sugar in urine with Felling's reagent.	
32.	Practical class 32. Digestion of carbohydrates, lipids, proteins, nucleoproteins in the gastrointestinal tract. Enzymes, biochemical mechanisms. Chemical composition of gastric and intestinal juice. Hereditary disturbances of digestion. Biochemical characteristics and classification of vitamins. Water-soluble vitamins B1, B2, B6, PP. Their coenzyme role and symptoms of hypovitaminosis. Demonstration-practical work: Determination of all forms of gastric juice acidity. Qualitative reactions to vitamins B1, B2, B6, PP	2
33.	Practical class 33. Water-soluble vitamins C, biotin, folic acid, B12, pantothenic acid. Structure, biological role and symptoms of hypovitaminosis. Demonstration-practical work: Quantitative determination of vitamin C in products by the Tillmans method.	2
34.	Practical class 34. Fat-soluble vitamins. Vitamins of groups A, D, E, K. Structure, biological role. Hypo- and hypervitaminosis manifestation. Demonstration-practical work: Qualitative reactions to fat-soluble vitamins A, D, E, K (Vikasol).	2
35.	Practical class 35. Biochemical characteristics and functions of blood. Biochemical composition of blood plasma. Characteristics of protein fractions of blood. Characteristics of non-protein substances of blood plasma. Residual nitrogen of blood, its components. Diagnostic value of residual nitrogen determination in blood. Lipid transport forms - plasma lipoproteins. Types of hyperlipoproteinemia. The role of lipoproteins in the development of atherosclerosis. Osmotic pressure and acid-base state of blood. Blood buffer systems, hormonal regulation mechanisms, lung and kidney function. Blood respiratory function. Hemoglobin, structure, synthesis in the body. Role in the transport of oxygen and carbon dioxide. Abnormal hemoglobin. Demonstration-practical work: Quantitative determination of blood proteins by biuret and refractometric methods. Serum protein fractionation by the "salting out" method. Determination of erythrocytes osmotic resistance. Determination of hemoglobin content in blood.	2
36.	Practical class 36. Biochemistry of coagulation, anticoagulation and fibrinolytic blood systems. Functional and biochemical characteristics of the homeostasis system in the human body: coagulation and vascular-platelet hemostasis. Blood coagulation system, characteristics of individual components (coagulation factors). Mechanisms of coagulation. The anticoagulation system of blood, anticoagulants. The role of vitamin K in coagulation reactions. Hereditary disorders of the blood coagulation system. Demonstration-practical work: Determination of fibrinogen concentration in blood plasma. Determination of prothrombin time. Determination of plasma recalcification.	2
37.	Practical class 37. Biochemical functions of the liver, its role in the metabolism of carbohydrates, lipids, and proteins. The role of the liver in the metabolism of bile pigments. Hemoglobin catabolism. Pathobiochemistry of jaundice, hereditary (enzymatic) jaundice. Detoxification function of the liver: biotransformation of xenobiotics and endogenous toxins. Types of biotransformations of xenobiotics. Reaction of microsomal oxidation, inducers and inhibitors of microsomal monooxidases. Conjugation reactions in hepatocytes: biochemical mechanisms, functional significance. Demonstration-practical work: Determination of total, direct and indirect bilirubin in blood serum. Determination of hippuric acid and indican in urine.	2

38.	Practical class 38. General characteristics of the morphology and biochemical composition of connective tissue. Biochemical structure of the intercellular substance of loose fibrous connective tissue: fibers (collagenous, reticular, elastic), the main amorphous substance. Proteins of connective tissue fibers: collagen, elastin. Collagen biosynthesis and fibrillary structures formation. Complex carbohydrates of the main amorphous matrix of connective tissue: glycosaminoglycans (mucopolysaccharides), proteoglycans. Pathochemistry of connective tissue. Biochemical mechanisms of mucopolysaccharidosis and collagenosis, their clinical and biochemical diagnosis.	2
39.	Practical class 39. Chemical composition of tooth tissue: organic (collagenous, non-collagenous proteins, carbohydrates, lipids, nucleic acids) and mineral components. Mineral metabolism in tooth tissue: mineralization, demineralization, remineralization (specific proteins and enzymes, role of citric acid in calcium metabolism). Chemical composition and biological functions of saliva. Features of mineralization role of saliva in the tooth tissue. Saliva enzymes, their role in digestion. Determination of proteins and enzymes in human saliva under normal and pathological conditions. Regulation of salivation, biochemical basis of salivation disorders. Demonstration-practical work: Determination of lactic acid in saliva. Determination of protein in saliva.	2
40.	Practical class 40. Muscle biochemistry. Features of the chemical composition and metabolism in muscles. Molecular mechanisms of muscle contraction. Bioenergetics of muscle tissue: sources of ATP in muscles. Features of the biochemical composition and metabolism of the nervous system. Biochemical composition of the brain. Energy metabolism of the human brain, the value of aerobic oxidation of glucose. Neurotransmitters: acetylcholine, norepinephrine, dopamine, serotonin. Molecular basis of bioelectrical processes on neuron membranes. Demonstration-practical work: Determination of creatinine and creatine levels in blood and urine.	2
41.	Practical class 41. Kidney role in body fluids electrolyte composition and pH regulation. Biochemical mechanisms of the urine formation of the kidneys. Pathobiochemistry of kidneys. Biochemical composition of human urine in normal conditions and under conditions of pathological processes, nephrolithiasis. Clinical and diagnostic significance of urine composition analysis. Demonstration-practical work: Qualitative determination of protein in urine (heating and acid precipitation). Quantitative determination of protein by the Branderg-Stolnikov method. Quantitative determination of glucose in urine using a polarimeter.	2
42.	Practical class 42. Intermediate control for the semester (part 1)	2
43.	Practical class 43. Intermediate control for the semester (part 2)	2
	<b>Total</b>	<b>86</b>

#### 5.4. Themes of laboratories

Laboratories are not provided.

#### 6. Independent work of the higher education applicant

No	Theme	Hours
1.	Theme 1. Preparation for practical class 1	1
2.	Theme 2. Preparation for practical class 2	1
3.	Theme 3. Preparation for practical class 3	1

4.	Theme 4. Preparation for practical class 4	1
5.	Theme 5. Preparation for practical class 5	1
6.	Theme 6. Preparation for practical class 6	1
7.	Theme 7. Preparation for practical class 7	1
8.	Theme 8. Preparation for practical class 8	1
9.	Theme 9. Preparation for practical class 9	1
10.	Theme 10. Preparation for practical class 10	1
11.	Theme 11. Preparation for practical class 11	1
12.	Theme 12. Preparation for practical class 12	1
13.	Theme 13. Preparation for practical class 13	2
14.	Theme 14. Preparation for practical class 14	2
15.	Theme 15. Preparation for practical class 15	2
16.	Theme 16. Preparation for practical class 16	2
17.	Theme 17. Preparation for practical class 17	2
18.	Theme 18. Preparation for practical class 18	2
19.	Theme 19. Preparation for practical class 19	2
20.	Preparation for practical class 20	2
21.	Preparation for practical class 21	2
22.	Theme 20. Preparation for practical class 22	1
23.	Theme 21. Preparation for practical class 23	1
24.	Theme 22. Preparation for practical class 24	1
25.	Theme 23. Preparation for practical class 25	1
26.	Theme 24. Preparation for practical class 26	1
27.	Theme 25. Preparation for practical class 27	1
28.	Theme 26. Preparation for practical class 28	1
29.	Theme 27. Preparation for practical class 29	1
30.	Theme 28. Preparation for practical class 30	1
31.	Theme 29. Preparation for practical class 31	1
32.	Theme 30. Preparation for practical class 32	1
33.	Theme 31. Preparation for practical class 33	1
34.	Theme 32. Preparation for practical class 34	1
35.	Theme 33. Preparation for practical class 35	1
36.	Theme 34. Preparation for practical class 36	2
37.	Theme 35. Preparation for practical class 37	2
38.	Theme 36. Preparation for practical class 38	2
39.	Theme 37. Preparation for practical class 39	2
40.	Theme 38. Preparation for practical class 40	2
41.	Theme 39. Preparation for practical class 41	2
42.	Preparation for practical class 42	2
43.	Preparation for practical class 43	2
	<b>Total</b>	<b>60</b>

## 7. Teaching methods

**Lecture classes:** lectures using multimedia presentations.

**Practical classes:** conversation, explanation, discussion, discussion of the acute issues; illustration (including multimedia presentations); testing, solving situational tasks and test tasks Krok-1.

**Independent work:**

independent work with recommended basic and additional literature, with electronic information resources, preparation for practical classes; independent work with the bank of test tasks Krok -1.

**8. Forms of control and evaluation methods  
(including criteria for evaluating learning outcomes)**

**Current control:** oral survey, testing, assessment of class activity.

**Final control:** exam.

**Evaluation of the current educational activity in a practical lesson:**

1. Evaluation of theoretical knowledge on the subject of the lesson:

- methods: survey, written work, solving a situational problem, solving test tasks;
- maximum score - 5, minimum score - 3, unsatisfactory score - 2.

2. Evaluation of intermediate control:

- methods: survey, written work, solving a situational problem, solving test problems;
- maximum score - 5, minimum score - 3, unsatisfactory score - 2.

The grade for one practical lesson is the arithmetic average of all components and can only have a whole value (5, 4, 3, 2), which is rounded according to the statistical method.

**Current evaluation criteria for practical class:**

Score	Evaluation criteria
Excellent «5»	The higher education applicant is fluent in the material, takes an active part in discussing and solving the situational problem, knows how to write the main biochemical reactions that occur in the body, determine the main biochemical indicators in biological objects and give them a medical (medico-biological)
Good «4»	The higher education applicant has a good command of the material, participates in the discussion and solution of the situational problem, knows how to write the main biochemical reactions, determine the main biochemical indicators in biological objects and give them a medical and biological evaluation, but allows some insignificant mistakes (inaccuracies) in answering questions.
Satisfactory «3»	The higher education applicant does not have sufficient knowledge of the material, is unsure of participating in the discussion and solution of the situational problem, makes mistakes when writing basic biochemical reactions.
Unsatisfactory «2»	The higher education applicant does not know the material, does not take part in the discussion and solution of the situational clinical problem, has significant gaps in the knowledge of the program material, makes fundamental mistakes when explaining the laws of human metabolism, does not have the necessary practical skills.

Only those higher education applicants who have fulfilled the requirements of the training program in the discipline, have no academic debt, their average score for the current educational activity in the discipline is at least 3.00, and they have passed the test control according to the tests "KROK - 1" at least 90% (50 tasks) are admitted to the final control in the form of an exam. ». The test control of the "KROK-1" tests is conducted in the Educational and Production Complex of Innovative Technologies of Learning, Informatization and Internal Monitoring of the Quality of Education of the University at the last class before the exam.

**Evaluation of the results of the higher education applicant s' training during the final control - exam.**

The method of final control in the form of an exam is unified and involves the use of standardized forms. The number of questions submitted to the exam corresponds to the amount of credits assigned to the study of the academic discipline.



The examinational card form is standardized and consists of structural elements (components): theoretical questions and practical tasks (situational tasks, case-tasks, descriptions, etc.). Theoretical questions are short, simple, understandable and transparent, a complete answer to one theoretical question lasts no more than 5 minutes. Practical tasks are clearly and understandably formulated, a complete answer to one practical question lasts no more than 5 minutes. The timing of the exam is standard - no more than 30 minutes.

Each examinational card is accompanied by a check-list (answer standard), which provides full correlation with the examinational card, contains a similar number of structural elements (components), has answer standards, which are mandatory for providing complete answers to the questions.

During the exam, the higher education applicant receives an examinational card, and the examiners use a check-list for the corresponding card with standard answers and determine which mandatory components of the answer were named or not named by the higher education applicant.

The overall grade for the exam is calculated as the arithmetic average of all grades obtained for answers to theoretical questions and practical tasks on a traditional four-point scale, rounded to two decimal places.

The exam is held in the Educational and Production Complex of innovative Technologies of Learning, Informatization and Internal Monitoring of the Quality of Education of the University during the examination sessions at the end of the semester (autumn and spring) according to the schedule.

### **9. Distribution of points received by higher education applicants of higher education**

The obtained average score for the academic discipline for higher education applicants who have successfully mastered the work program of the academic discipline is converted from a traditional four-point scale to points on a 200-point scale, as shown in the table:

**Conversion table of traditional to multi-point scale**

<b>National score for the discipline</b>	<b>The sum of scores for the discipline</b>
Excellent («5»)	185 – 200
Good («4»)	151 – 184
Satisfactory («3»)	120 – 150
Unsatisfactory («2»)	Less than 120

A multi-point scale (200-point scale) characterizes the actual success of each higher education applicant in learning the educational component. The conversion of the traditional grade (average score for the academic discipline) into a 200-point grade is performed by the information and technical department of the University.

According to the obtained points on a 200-point scale, the achievements of the higher education applicants are evaluated according to the ECTS rating scale. Further ranking according to the ECTS rating scale allows you to evaluate the achievements of higher education applicants about the educational component who are studying in the same course of the same specialty, according to the points they received.

The ECTS scale is a relative-comparative rating, which establishes the higher education applicants' belonging to the group of better or worse among the reference group of fellow higher education applicants (faculty, specialty). An "A" grade on the ECTS scale cannot be equal to an "excellent" grade, a "B" grade to a "good" grade, etc. When converting from a multi-point scale, the limits of grades "A", "B", "C", "D", "E" according to the ECTS scale do not coincide with the limits of grades "5", "4", "3" according to the traditional scale. Higher education applicants who have received grades of "FX" and "F" ("2") are not included in the list of ranked higher education

applicant s. The grade "FX" is awarded to higher education applicants who have obtained the minimum number of points for the current learning activity, but who have not passed the final examination. A grade of "F" is assigned to higher education applicants who have attended all classes in the discipline, but have not achieved a grade point average (3.00) for the current academic activity and are not admitted to the final examination.

Applicants who study at the same course (same specialty), based on the number of points scored in the discipline, are ranked on the ECTS scale as follows:

**Conversion of the traditional grade from the discipline and the sum of points on the ECTS scale**

<b>Score on the ECTS scale</b>	<b>Statistical indicator</b>
A	The best 10% of higher education applicants
B	The next 25% of higher education applicants
C	The next 30% of higher education applicants
D	The next 25% of higher education applicants
E	The next 10% of higher education applicants

### 10. Methodological support

- Working program in the discipline
- Syllabus
- Methodological recommendations for the practical classes in the discipline
- Methodological recommendations for the individual work of higher education applicants
- Multimedia presentations
- Situational tasks
- Tests on the theme

Educational and methodical literature:

- Burdina Y.F., Kuzmina A.V., Grekova A.V. Lipids. Saponified lipids. Triglycerides. Complex lipids. Phospholipids / Educational and methodological manual / Odesa: Astroprint, 2017. – 32 p.
- 2.Burdina Y.F., Kuzmina A.V., Grekova A.V. Carbohydrates - monoses, bioses, polyoses. Their chemical properties / Educational and methodological manual / Odesa: Astroprint, 2017. – 44.
- 3.Grekova A.V., Burdyna Y.F., Kuzmina A.V. Peptides, proteins - composition, structure and properties. / Educational and methodological manual. - Odesa, 2018. - 48 p.
- 4.Grekova A. V., Burdina Y. F., Stepanov G. F. Nomenclature, structure and classification of organic compounds. Types and mechanisms of reactions in organic chemistry: teaching method. manual – Odesa: Astroprint, 2021 – 48 p.
- 5.Burdina Y. F., Grekova A. V., Stepanov G. F. Oxygen-containing organic compounds. Classification, nomenclature, chemical properties: educational method. manual – Odesa: Astroprint, 2021 – 40 p.
- 6.Grekova A. V., Burdina Y. F., Stepanov G. F. Heterocyclic compounds as structural components of drugs and nucleic acids: teaching method. guide – Odesa: Astroprint, 2021 – 52 p.
- 7. Grekova A. V., Burdina Y. F., Stepanov G. F. Biological role and chemical properties of amino acids and proteins: teaching method. manual – Odesa: Astroprint, 2021 – 44 p.
- 8. Burdina Y.F., Grekova A.V., Stepanov G.F. Biological role and chemical properties of carbohydrates: educational method. manual – Odesa: Astroprint, 2021 – 40 p.
- 9. Grekova A. V., Burdina Y. F., Stepanov G. F. Biologically active heterocyclic compounds as components of nucleic acids and drugs: educational method. guide – Odesa: Astroprint, 2022 – 52 p.

## 11. Questions for the final control

1. Bioorganic chemistry as a science: definition, purposes and objectives, sections, research methods. The importance in higher medical education.

2. Classification of organic compounds by structure carbon skeleton and nature of functional groups.

3. The structure of the major classes of bioorganic compounds according to the nature functional groups: alcohols, phenols, thiols, aldehydes, ketones, carboxylic acids, esters, amides, nitro compounds, amines.

4. Nomenclature of organic compounds: trivial, rational, international. Principles of formation of organic compound names of by IUPAC nomenclature: substituent and radical functional.

5. The nature of chemical bonds in organic compounds: hybridization of orbitals, electronic structure of carbon compounds.

6. The spatial structure of bioorganic compounds: stereochemical formulas, configuration and conformation. Stereoisomers: geometrical, optical, rotary (conformers). Optical isomerism, chirality of molecules of organic compounds. D/L- and R/S-stereochemical nomenclature. Enantiomers and diastereoisomers of bioorganic compounds. Relationships between spatial structure and physiological activity of bioorganic compounds.

7. Types of reactions in bioorganic chemistry: classification according to the obtained product (direction) and the reaction mechanism. Examples.

8. Carbonyl compounds in bioorganic chemistry. Chemical properties and biomedical significance of aldehydes and ketones.

9. Carboxylic acids in bioorganic chemistry, their structures and chemical properties. Functional derivatives of carboxylic acids: anhydrides, amides, esters. Decarboxylation reactions. Structure and properties of dicarboxylic acids: oxalic, malonic, succinic, glutaric, fumaric and maleic acids.

10. Lipids, their definition and classification. Fatty acids: palmitic, stearic, oleic, linoleic, linolenic, arachidonic. Simple lipids. Triacylglycerols (neutral fats): structure, physiological significance, hydrolysis.

11. Complex lipids. Phospholipids: phosphatidic acid, phosphatidyl ethanolamine, phosphatidyl choline, phosphatidyl serine. Sphingolipids and glycolipids. The role of complex lipids in the structure of biological membranes.

12. Amines, their nomenclature, and properties. Biomedical significance of biogenic amines (adrenaline, noradrenalin, dopamine, tryptamine, serotonin, histamine) and polyamines (putrescin, cadaverine).

13. Amino alcohols: structure, properties. Biomedical importance of ethanolamine (colamine), choline, acetyl choline.

14. Hydroxyacids in bioorganic chemistry. Structure and properties of mono-carboxylic (lactic and  $\beta$ -hydroxybutyric acids), and dicarboxylic (malic, tartaric) hydroxyacids.

15. Amino acids: structure, stereoisomerism, chemical properties. Biomedical importance of L- $\alpha$ -amino acids. Reactions of biochemical transformations of amino acids: deamination, transamination, and decarboxylation.

16. Amino acid composition of proteins and peptides, classification of natural L- $\alpha$ -amino acids. Chemical and physicochemical properties of proteinogenic amino acids. Ninhydrin test and its significance in the analysis of amino acids.

17. Proteins and peptides: definition, classification and biological functions. Types of bonds between amino acid residues in protein molecules. Peptide bond: formation, structure, biuret reaction.

18. Levels of structural organization of proteins: primary, secondary, tertiary and quaternary structure. Oligomeric proteins. Physical and chemical properties of proteins and their molecular weight. Methods of protein deposition. Denaturation of proteins.

19. Carbohydrates: definition, classification. Monosaccharides: aldoses and ketoses; trioses, tetroses, pentoses, hexoses, heptoses), biomedical significance of some representatives.

20. Monosaccharides: pentoses (ribose, 2-deoxyribose, xylose), hexoses (glucose, galactose, mannose, fructose), their structure and properties. Qualitative reactions of glucose.

21. Structure and properties of monosaccharide derivatives. Amino substituted derivatives: glucosamine, galactosamine. Uronic acid. L-Ascorbic acid (vitamin C). Products of monosaccharide reductions: sorbitol, mannitol.

22. Oligosaccharide: structure, properties. Disaccharides: sucrose, lactose, maltose, their biomedical significance.

23. Polysaccharides. Homopolysaccharides: starch, glycogen, cellulose, dextrans, their structure, hydrolysis, and biomedical significance. Qualitative reaction for starch. Heteropolysaccharides: definition and structure. Structure and biomedical significance of glycosaminoglycans (mucopolysaccharides), hyaluronic acid, chondroitin sulfate, and heparin.

24. Five-membered heterocycles with one heteroatom: pyrrole, furan, thiophene. Biomedical importance of tetrapyrrole compounds like porphins, porphyrins, and heme. Indole and its derivatives, tryptophan and reaction of formation of tryptamine and serotonin. Indoxyl, skatol, skatoxyl and their formation in the process of protein putrefaction in the intestinal tract.

25. Five-membered heterocycles with two nitrogen atoms. Pyrazole, pyrazolone, and pyrazolone-5 derivatives as drugs: antipyrin, amidopyrinum, analgin. Imidazole and its derivatives: histidine, histamine.

26. Five-membered heterocycles with two different heteroatoms: thiazole, oxazole. Thiazole as a structural component of molecule of thiamine (vitamin B<sub>1</sub>).

27. Six-membered heterocycles with a nitrogen atom: pyridine. Nicotinamide (vitamin PP) as fragment of the redox pyridine dinucleotide coenzymes. Pyridoxine and molecular forms of vitamin B<sub>6</sub>.

28. Six-membered heterocycles with two nitrogen atoms. Diazines: pyrimidine, pyrazine, pyridazine. Nitrogen bases, which are pyrimidine derivatives: uracil, cytosine, thymine.

29. Pyrimidine derivatives as drugs: 5-fluorouracil, potassium orotate. Barbituric acid, and barbiturates phenobarbital, veronal as sedatives and anti epileptic agents.

30. Purine and its derivatives. Amino derivatives of purines: adenine, guanine, their tautomeric forms, biochemical importance in the formation of nucleotides and coenzymes. Hydroxy substituted derivatives of purines: hypoxanthine, xanthine, and uric acid. Methylated xanthine derivatives, caffeine, theophylline, theobromine as physiologically active compounds with effect on the central nervous and cardiovascular systems.

31. Nucleosides and nucleotides. Nitrogen bases of purine and pyrimidine rows, comprising natural nucleotides. Minor nitrogen bases.

32. Nucleosides. Nucleotides as phosphorylated derivatives of nucleosides: nucleoside mono-, di- and triphosphates. Nomenclature of nucleosides and nucleotides as components of RNA and DNA. Structure and biochemical functions of free nucleotides: nucleotides, which are coenzymes, and cyclic nucleotides 3',5'-cAMP and 3',5'-cGMP.

33. Nucleic acids, desoxyribonucleic and ribonucleic acids as polynucleotides. Polarity of polynucleotide chains of DNA and RNA. Structure and properties of DNA, nucleotide composition, complementarity of bases. Primary, secondary and tertiary structure of DNA. RNA, its structure, types of RNA and their role in the biosynthesis of proteins.

34. Chemical nature of enzymes. Composition of simple and complex enzymes. Cofactors and coenzymes. Role of coenzymes and apoenzyme in catalysis.

35. Cofactors and coenzymes. Structures and properties. Vitamins as precursors of coenzymes. Examples.

36. Isozymes. Biologic role. Diagnostic importance of isozyme determination.

37. The mechanism of enzyme action. The kinetic of enzymatic catalysis. Dependence of the rate of reaction from concentration of substrate. The kinetic of enzymatic reaction: dependence of the rate of reaction from concentration of enzyme, pH and temperature.

38. The types of activation and inhibition of enzymes. Phosphorylation and dephosphorylation of enzymes. Active site of enzymes. Inhibitors and activators of the enzymes. Competitive and non-competitive inhibition. Medical application of enzyme inhibitors.

39. Allosteric regulation of enzymatic activity. Regulatory enzymes. Feedback regulation of their activity. Covalent modification of enzymes. Cyclic nucleotides (c-AMP, c-GMP) as the regulators of enzyme catalysis and biological functions of cells. Action of the regulation of protein kinases.

40. Enzymotherapy. Principles of diagnostic and treatment. Enzyme diagnostic and enzymotherapy in medicine.

41. General characteristics of energy metabolism. Metabolism: catabolism, anabolism and amphibolic pathways. General and specific pathways of catabolism. Stages of intercellular catabolism of biomolecules: proteins, carbohydrates, lipids.

42. The Citric Acid Cycle (CAC). Location in the cell. Enzymes of CAC. Importance of CAC. Bioenergetics of Citric Acid Cycle. Physiologic importance of CAC.

43. Reactions of biologic oxidation. Types of reactions: dehydrogenase, oxidase, oxygenase reactions and their biologic importance. Tissue respiration. Chemical nature of dehydrogenases. Role of coenzymes in the functions of enzymes. Flavoenzymes. Chemical nature and biochemical role. Cytochromes. Cytochrome oxidase, its chemical nature, the biochemical role and mechanism of participation in the respiratory chain.

44. Synthesis of ATP from ADP. Oxidative phosphorylation, which is coupling with respiratory chain. Index P/O. The chemiosmotic theory of oxidative phosphorylation. ATP synthase of mitochondria. Mechanism of transport of reducing equivalents through the membrane of mitochondria. Shuttle mechanism.

45. Microsomal oxidation. Cytochrome P450 and molecular organization of the electron transport chain.

46. Aerobic and anaerobic oxidation of glucose, natural characteristics of processes

47. Anaerobic oxidation of carbohydrates. Glycolysis. Oxidative-reduction steps of anaerobic glycolysis, its importance. Shuttle mechanism for the transfer of reducing equivalents of NADH.

48. Aerobic oxidation of glucose. The sequence of reactions and enzymes of glycolysis. Oxidative decarboxylation of pyruvate.

49. The comparison of bioenergetics of aerobic and anaerobic oxidation of glucose and glycogen. Pasteur's effect.

50. Pentose phosphate pathway of carbohydrates metabolism. Oxidative and non-oxidative phases. Biological importance of specialities of functioning in various tissues. Biosynthesis and catabolism of glycogen in the liver.

51. Mechanism of reciprocal regulation of glycogenolysis and gluconeogenesis by cAMP dependent cascade phosphorylation of enzymes. The role of adrenaline, glucagon and insulin in the hormonal regulation of glycogen exchange in muscles and liver.

52. Genetic disorders of glycogen metabolism (glycogenosis, aglycogenosis).

53. Gluconeogenesis. Mechanism in the different tissues and organs. Corey's cycle and the glucose alanine cycle.

54. Blood glucose (glucosemia): normoglycemia, hypo- hyperglycemia, glucosuria. Blood diabetes is a pathology of glucose metabolism. Hormonal regulation of blood glucose concentration and exchange.

55. Pentose phosphate pathway of glucose oxidation: scheme of the process and biological significance. Metabolic pathways for the transformation of fructose and galactose; recessary enzymopathies and their metabolism.

56. 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, norepinephrine, glucagon and insulin).

57. Reactions of oxidation of fatty acids (β-oxidation); the role of carnitine in the transport of fatty acids in mitochondria. Energetic activity of the oxidation of fatty acids in cells. Glycerol oxidation: enzymatic reactions, bioenergetics.

58. Ketone bodies. The reactions of biosynthesis and utilization of ketone bodies are of physiological significance. Disruption of the exchange of ketone bodies due to pathology (diabetes of the blood, fasting).

59. Biosynthesis of essential fatty acids: reactions in the biosynthesis of essential fatty acids (palmite) and regulation of the process. Biosynthesis of mono- polyunsaturated fatty acids in the human body. Biosynthesis of triacylglycerols and phosphoglycerates. Metabolism of sphingolipids. Genetic abnormalities in the metabolism of sphingolipids - sphingolipidoses.

60. Cholesterol biosynthesis: reaction scheme, regulation of cholesterol synthesis. Ways of biotransformation of cholesterol: esterification; the release of urinary acids, steroid hormones, vitamin D<sub>3</sub>. Pathologies of lipid metabolism: atherosclerosis, obesity, blood diabetes.

61. Circulatory transport and deposition of lipids in adipose tissue. Lipoprotein lipase in endothelium. Blood plasma lipoproteins: lipid and protein (apoprotein) storage. Hyperlipoproteinemia.

62. The pool of the amino acids in the body. Routes for transport and utilization of amino acids in tissues. Research on the metabolism of carbon skeletons of amino acids in the human body. Glucogenic and ketogenic amino acids.

63. Direct and indirect deamination of high-grade L-amino acids in tissues. Transamination of amino acids: reactions and their biochemical significance, mechanisms of aminotransferases. Decarboxylation of L-amino acids in the human body. Physiological significance of the creation of products. Oxidation of biogenic amines.

64. Ways of creation and release of ammonia in the body. Biosynthesis of meat: sequence of enzyme reactions in biosynthesis, genetic abnormalities of enzymes in the fruit cycle.

65. Biosynthesis and biological role of creatine and creatine phosphate. Glutathione: natural, biosynthesis and biological functions of glutathione.

66. Specialized routes to the metabolism of cyclic amino acids - phenylalanine and tyrosine. Decreased enzyme metabolism of cyclic amino acids - phenylalanine and tyrosine. Exchange of cyclic amino acid tryptophan and its spasmopathic enzyme.

67. Nitrogen bases, nucleosides and nucleotides as the composite components of the nucleic acids. Minor nitrogen bases and nucleotides. Free nucleotides: ATP, NAD<sup>+</sup>, NADP<sup>+</sup>, FAD, FMN, CTP, UTP, 3',5'-cAMP, 3',5'-cGMP, their biochemical functions.

68. Nucleic acids. General characteristics of DNA and RNA, their biological importance in the storage and the transfer of genetic information. Features of DNA and RNA primary structure. Chemical bonds, which are responsible for the formation of nucleic acids primary structure. Secondary structure of DNA, role of hydrogen bonds in its formation (Chargaff's rules, Watson-Crick model), anti-parallelity of strands. Tertiary structure of DNA. Physical and chemical properties of DNA, interaction with cation ligands, formation of nucleosomes.

69. Molecular organization of nuclear chromatin of eukaryotes; nucleosome organization, histone and non-histone proteins. Nucleoproteins: structure, biological functions.

70. Structure, properties and biological functions of RNA. Types of RNA: m-RNA, t-RNA, r-RNA. Features of the different type of RNA structural organization.

71. Biosynthesis of purine nucleotides; scheme of IMP synthesis reactions. Formation of AMP and GMP from IMP, mechanisms of regulation. Catabolism of purine nucleotides, hereditary disturbances of the uric acid metabolism.

72. Biosynthesis of pyrimidine nucleotides; scheme of reactions, regulation of synthesis. Biosynthesis of deoxyribonucleotides. Formation of the thymidine nucleotides.

Inhibitors of TMP synthesis as anti-cancer medicines. Scheme of the pyrimidine nucleotide catabolism.

73. Replication of DNA, its biological importance, and semiconservative mechanism of replication. Sequence of the steps and DNA replication enzymes in prokaryotes and eukaryotes.

74. RNA transcription: prokaryotes and eukaryotes RNA-polymerases, signals of transcription: promoter, initiator and terminator fragments of genome. Processing and post-translational modification of synthesized RNA.

75. Genetic (biologic) code, triplet structure and properties. Transport RNA and transportation of amino acids. Amino acyl-tRNA-synthetases. Steps and mechanism of translation (protein synthesis) in ribosomes: initiation, elongation and termination.

76. Post-translational modification of peptide chains. Regulation of translation. Inhibitors of transcription and translation in prokaryotes and eukaryotes. Antibiotics and interferons, they use in medicine. Diphtheria toxin.

77. Regulation of prokaryote gene expression: regulatory and structural fragments of lactose, Lac-operon, gene regulator, promoter, operator.

78. Gene engineering: construction of recombinant DNA, gene cloning. Genetic engineering of enzymes, hormones, interferons, etc.

79. Mutations: genome, chromosome, gene. Mechanisms of mutagen activity; role of the induced mutations in the origin of the enzymopathy and hereditary human diseases. Biological importance and mechanisms of DNA reparations. Repairation of UV-induced gene mutations: xeroderma pigmentosum.

80. Hormones and their general characteristics. Role of hormones and other bioregulators in the system of the intracellular integration of the human organism functions.

81. Classification of hormones and bioregulators in correspondence of structure and mechanisms of hormone activity.

82. Reaction of the target cells on the hormone action. Membrane (ionotropic, metabotropic) and cytosol receptors. Biochemical systems of the hormonal signals intracellular transfer: G-proteins, and secondary messengers cAMP,  $Ca^{2+}$ -calmodulin, inositol-3-phosphate, and diacylglycerol. Molecular cell mechanisms of the steroid and thyroid hormone activity.

83. Neuropeptides of hypothalamus. Liberins and statins, their mechanisms of activity and biologic role.

84. Hormones of the anterior pituitary gland: somatotropin (GH), prolactin. Pathological processes associated with impaired functions of these hormones. Hormones of the posterior pituitary gland. Vasopressin and oxytocin: biological, biological functions.

85. Insulin: structure, biosynthesis and secretion. Mechanism of insulin activity on the carbohydrate metabolism. Mechanism of insulin activity on the lipid metabolism. Mechanism of insulin activity on the protein and nucleotide metabolism. Glucagon and its mechanisms of activity on the carbohydrate and lipid metabolism.

86. Thyroid hormones, their structures, biological effects of T3 and T4. Disturbances of metabolic processes due to hypo- and hyperthyreosis.

87. Epinephrine, norepinephrine, dopamine, their structure, biosynthesis, physiological effects, biochemical mechanisms of activity. Pathological processes related to the disturbances of hormone functions.

88. Steroid hormones of the suprarenal glands ( $C_{21}$ -steroids), glucocorticoids and mineralocorticoids, their structures and properties. Mechanisms of glucocorticoids activity on the carbohydrate and lipid metabolism.

89. Female sex hormones estrogens, progesterone. Physiological and biochemical effects, related to the ovulation cycle phases. Male sex hormones ( $C_{19}$ -steroids). Physiological and biochemical effects of androgens, regulation of synthesis and secretion.

90. Eicosanoids: biological, biological and pharmacological influences. Aspirin and other non-steroidal anti-inflammatory agents as inhibitors of prostaglandin synthesis.

91. Biochemistry of human nutrition, the food components and nutrients, biological value of certain nutrients. Mechanisms of conversion of nutrients, proteins, carbohydrates, and lipids, in the digestive tract. The saliva, stomach and intestine enzymes. Digestion disorders of certain nutrients in the stomach and intestines, and hereditary enzymopathies of digestive processes. Microelements in human nutrition. Biological functions of certain microelements, and microelement deficiency manifestations.

92. Vitamins in human nutrition. Water-soluble and fat-soluble vitamins; exogenous and endogenous causes of vitamin deficiency.

93. Vitamin B<sub>1</sub> (thiamin): structure, biological properties, mechanism of action, the sources, daily need. Vitamin B<sub>2</sub> (riboflavin): structure, biological properties, mechanism of action, the sources, daily need. Vitamin PP (nicotinic acid, nicotinamide): structure, biological properties, mechanism of action, manifestations of deficiency, sources, the daily need.

94. Vitamin B<sub>6</sub> (pyridoxine): structure, biological properties, mechanism of action, the sources, the daily need. Vitamin B<sub>12</sub> (cobalamin): biological properties, mechanism of action, manifestations of deficiency, sources, the daily need. Vitamin B<sub>c</sub> (Folic Acid): biological properties, mechanism of action, the sources, the daily need.

95. Vitamin H (biotin): biological properties, mechanism of action, the sources, the daily need. Vitamin B<sub>3</sub> (pantothenic acid): biological properties, mechanism of action, the sources, and the daily need. Vitamin C (ascorbic acid): structure, biological properties, mechanism of action, manifestations of deficiency, sources, the daily need. Vitamin P (flavonoids): structure, biological properties, mechanism of action, manifestations of deficiency, sources, the daily need.

96. Vitamin A (retinol, retinal, retinoic acid): biological properties, mechanism of action, manifestations of deficiency, sources, the daily need. Vitamin D<sub>3</sub> (cholecalciferol): biological properties, mechanism of action, manifestations of deficiency, sources, the daily need.

97. Vitamin K (phylloquinone, farnohinon): biological properties, mechanism of action, manifestations of deficiency, sources, the daily need. Vitamin E ( $\alpha$ -tocopherol): biological properties, mechanism of action, manifestations of deficiency, sources, the daily need.

98. Biochemical and physiological functions of blood in the human body. Respiratory function of erythrocytes. Hemoglobin: mechanisms of its' participation in the transport of oxygen and carbon dioxide. Types and pathological forms of human hemoglobin.

99. Buffers of the blood system. Disturbance of the acid-base balance in the body (metabolic and respiratory acidosis, alkalosis). Biochemical storage of human blood. Blood plasma proteins and their clinical and biochemical characteristics.

100. Blood plasma enzymes; significance in enzyme diagnosis of diseases of organs and tissues. Kallikrein-kinin system of blood and tissues. Medicines - antagonists of kinin formation.

101. Non-protein organic compounds of blood plasma. Inorganic components of plasma.

102. Biochemical and functional characteristics of the hemostatic system. Glottal blood system; characteristics of other factors; mechanisms of functioning of the cascade system of laryngeal blood. The role of vitamin K in coagulation reactions; medicinal properties - agonists and antagonists of vitamin K. Anticoagulant blood system; characteristics of anticoagulants. Recession of the process of laryngeal blood. Fibrinolytic blood system. Medicines that influence the process of fibrinolysis.

103. Immunoglobulins; biochemical characteristics of individual classes of human immunoglobulins. Mediators and hormones of the immune system: interleukins; interferons; protein-peptide factors of cell growth and proliferation regulation. Complement system; biochemical components of the human complement system; classical and alternative ways of activation. Biochemical mechanisms of immunodeficiency states.

104. Biochemical functions of the liver: carbohydrate, protein-synthesizing, urea-forming, bile-forming, regulation of blood lipid composition.

105. Detoxification function of the liver; types of biotransformation reactions of xenobiotics and endogenous toxins. Conjugation reactions in hepatocytes: biochemical mechanisms, functional significance.



106. Reactions of microsomal oxidation. Cytochrome P-450; electron transport chains in the membranes of the endoplasmic reticulum of hepatocytes.
107. Metabolism of porphyrins: heme structure; Scheme of biosynthesis reactions of protoporphyrin IX and heme. Hereditary disorders of porphyrin biosynthesis, types of porphyrias.
108. The role of the liver in the exchange of bile pigments. Pathobiochemistry and types of jaundice; biochemical diagnosis of jaundice; hereditary (enzymatic) jaundice. Catabolism of hemoglobin and heme (scheme); formation and structure of bile pigments.
109. Chemical composition of saliva, functions. Features of the mineralizing function of saliva. Salivary enzymes, role in digestion. The role of saliva in the supply of Ca and phosphates to enamel. Differences in composition and biological significance of oral fluid and saliva from salivary gland ducts.
110. Peculiarities of the chemical composition of the tooth (enamel). Ways of getting substances to tooth enamel. Tooth enamel proteins, the role of mineralization. Crystals of fluorapatite, hydroxyapatite, physical and chemical properties, biological role of mineralization. Chemical composition of tooth dentin. Non-collagenous tooth proteins, features of amino acid composition, role in mineralization.
111. The influence of nutrition on the state of teeth, the role of carbohydrates, proteins, trace elements and vitamins. The role of refined food carbohydrates on enamel demineralization.
112. Chemical composition of bone. Bone proteins, role in mineralization. Collagen proteins of teeth and bones. Chemical structure and role. The role of citric acid in calcium metabolism. Theory of bone and tooth mineralization. The role of Ca<sup>2+</sup> binding elements-proteins, phosphates and citric acid in mineralization.
113. The influence of vitamins on the condition and metabolism in the tissues of the oral cavity and teeth. Hormones affecting metabolism in mineralized tissues - calcitonin, parathyroid hormone, somatotrophic hormone.
114. Microelements of fluorine, strontium, etc., their biological significance for the state of teeth and bones.
115. Macroelements: calcium, phosphorus, role in tooth and bone tissue exchange.
116. Water-salt exchange in the body. Intracellular and extracellular water; exchange of water, sodium, potassium. The role of the kidneys in regulating the volume, electrolyte composition and pH of body fluids. Biochemical mechanisms of the urinary function of the kidneys. Biochemical composition of human urine in normal conditions and under conditions of development of pathological processes. Clinical and diagnostic value of urine composition analysis.
117. Renin-angiotensin system of kidneys. Hypotensive drugs - angiotensin-converting enzyme inhibitors.
118. Biochemical composition of muscles. Myofibril proteins: myosin, actin, tropomyosin, troponin. Molecular mechanisms of muscle contraction. Bioenergetics of muscle tissue.
119. Biochemistry of the nervous system. Energy exchange in the human brain. Value of aerobic oxidation of glucose; changes in the conditions of physiological sleep and anesthesia.
120. Biochemistry of neurotransmitters; receptors of neurotransmitters and physiologically active compounds. Brain peptidergic system: opioid peptides, opioid peptide receptors. Disorders of the exchange of brain mediators and modulators in mental disorders. Neurochemical mechanisms of action of psychotropic drugs.

## 12. Recommended literature

### Basic:

1. Gubsky Yu.I., I.V. Nizhenkovska, Korda M.M. Biological and Bioorganic Chemistry: in 2 books. Book 2. Biological Chemistry: textbook. 2021. 544 p.
2. Satyanarayana U. Biochemistry. 5th edition. India 2020. 777 p.

3. Lehninger. Principles of Biochemistry. 7th edition. NY, United States. 2017.
4. Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto. Biochemistry. 8th Revised edition. 2015.
5. Lippincott Illustrated Reviews: Biochemistry. Philadelphia :Wolters Kluwer, 2017. 560 p.
6. Baynes J., Dominiczak M. Medical Biochemistry. 5th Edition. Elsevier, 2018. 712 p.
7. Donald Voet, Judith G. Voet, Charlott W. Pratt. Fundamentals of Biochemistry: Life at the Molecular Level. ISBN: 978-1-118-91840-1 February 2016, 1184 p.

#### **Additional:**

1. William Marshall, Marta Lapsley, Andrew Day, Kate Shipman. Clinical Chemistry. Elsevier, 2020. 432 p.
2. Harper's Illustrated Biochemistry / V.W. Rodwell, D.A. Bender, K.M. Botham et al. – Mc Graw Hill Education, 2015. – 817 p.
3. Storchylo O. V. Membrane digestion and absorption of some nutrients in vitro and in vivo: Revision and analysis of own Data. *Journal of Gastrointestinal & Digestive System*. 2018. Vol. 8. DOI: 10.4172/2161-069X-C1-064 (12th Global Gastroenterologists Meeting and 3rd International Conference on Metabolic and Bariatric Surgery, Barcelona, Spain, 15-16 March 2018).
4. Storchylo O. V. (2019) Mechanisms of radioprotective and radiocorrective effects of dietary phytoadditive of milk thistle fruits. *Environment&Health*. 2019. №1 (90). P. 33-37.  
<https://doi.org/10.32402/dovkil2019.01.033>.
5. Storchylo Olha V. (2019) Mechanisms of the implementation of damage to the functions of the small intestine in two generations of posterity of irradiated rats. *Seventh International Conference on Radiation in Various Fields of Research (RAD 2019)*. June 10-14, 2019|Hunguest Sun Resort|Herceg Novy|Montenegro| [www.rad-conference.org](http://www.rad-conference.org). P.452.  
[https://www.rad-conference.org/Book\\_of\\_Abstracts-RAD\\_2019.pdf](https://www.rad-conference.org/Book_of_Abstracts-RAD_2019.pdf).

### **13. Electronic information resources**

1. <https://info.odmu.edu.ua/chair/biology/>- materials of the Department of Medical Biology and Chemistry
2. <http://libblog.odmu.edu.ua/> - ONMedU library
3. <https://moodle.odmu.edu.ua/login/index.php> - system of electronic testing and electronic journal of ONMedU
4. <http://moz.gov.ua> – Ministry of Health of Ukraine
5. [www.who.int](http://www.who.int) – World Health Organization
6. [www.dec.gov.ua/mtd/home/](http://www.dec.gov.ua/mtd/home/) - State Expert Center of the Ministry of Health of Ukraine
7. <http://bma.org.uk> – British Medical Association
8. [www.gmc-uk.org](http://www.gmc-uk.org) - General Medical Council (GMC)
9. [www.bundesaerztekammer.de](http://www.bundesaerztekammer.de) – German Medical Association