

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

SUMY STATE UNIVERSITY

Medical Institute

Department of Biophysics, Biochemistry, Pharmacology and Biomolecular Engineering

BIOLOGICAL AND BIOORGANIC CHEMISTRY

Higher education level	The Second
Major: study programme	222 Medicine

Approved by Quality Council of the Institute
(Faculty)

Protocol dated _____ № _____

Chairman of the Quality Council of the Institute
(Faculty)

_____ Primova Liudmyla
Oleksandrivna

DATA ON REVIEWS AND APPROVAL

Author

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Review of the course descriptor	<hr style="border: 0; border-top: 1px solid black; margin-bottom: 5px;"/> <hr style="border: 0; border-top: 1px solid black; margin-top: 5px;"/>
Considered and approved at the meeting of the Department of Biophysics, Biochemistry, Pharmacology and Biomolecular Engineering	Protocol dated _____ № _____ Head of the Department _____ Sukhodub Leonid Fedorovych

Data on the review:

Year	№ Annex with the description of amendments made	Amendments considered and approved			
		Approved by the work group of study programme, protocol №	Head of the study programme, signature	Approved by the Department, date and protocol №	Head of the Department

SYLLABUS

1. General information on the course

Full course name	Biological and Bioorganic Chemistry
Full official name of a higher education institution	Sumy State University
Full name of a structural unit	Medical Institute. Department of Biophysics, Biochemistry, Pharmacology and Biomolecular Engineering
Author(s)	Hrebenyk Liudmyla Ivanivna, Chorna Inna Valentynivna
Cycle/higher education level	The Second Level Of Higher Education, National Qualifications Framework Of Ukraine – The 7th Level, QF-LLL – The 7th Level, FQ-EHEA – The Second Cycle
Semester	18 weeks across 3 semester, 20 weeks across 4 semester
Workload	The scope consists of 6 credits ECTS, 180 hours, including 134 hours of work with lecturer (22 hours of lectures, 112 hours of laboratory work), 46 hours of self-study).
Language(s)	English

2. Place in the study programme

Relation to curriculum	Compulsory course available for the students of the specialty 222 "Medicine"
Prerequisites	Medical Chemistry, Medical and Biological Physics, Human Anatomy, Histology, Cytology and Embryology, Medical Biology
Additional requirements	There are no specific requirements
Restrictions	There are no specific restrictions

3. Aims of the course

The aim of the course is to form a system of special knowledge of the basic biochemical processes that occur in the body of a healthy person, and metabolic disorders of basic biomolecules in the presence of pathologies; conducting biochemical research and evaluating their results with the interpretation of clinical and diagnostic value for the implementation of further research and innovation activities in compliance with the principles of bioethics and academic integrity.

4. Contents

Module 1. Basic aspects of metabolism
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Topic 1 Control of the knowledge initial level. Adoption of principles of biochemical laboratory research performance. Justification and clinical diagnostic value of biochemical indices changes.

The definition of biochemistry as a science. A place of biochemistry among other medical and biological subjects. Achievements and prospects of the development of biochemistry, theoretical and molecular biology, biotechnology, gene engineering. A purpose of biochemical laboratory researches; estimation criteria of laboratory methods: principles of collection of research materials, errors of laboratory diagnostics. Chemical composition of living organisms (biotic), their features as compared with the objects of abiotic environment. Chemical composition of human organism. Biochemical components of cells (biomolecules), their biochemical functions. The major classes of biomolecules. The general characteristic of cyclic compounds, proteins, lipids, carbohydrates, nucleic acids; features of chemical composition and structure, biological functions.

Topic 2 Methods of studying amino acid composition of biological liquids.

The general characteristics and biological functions of proteins and peptides. Amino acid composition of proteins and peptides: structure, classification and physical and chemical properties of amino acids. The formation of peptide bonds. Levels of protein structure. Chemical bonds in protein molecules. Methods of study of amino acids and proteins in the biological liquids. The colour reactions of amino acids and proteins. Methods of chromatography for separation of amino acids.

Topic 3 Physical and chemical properties of proteins. Methods of extraction and separation of proteins. Classification of proteins. Characteristics of simple proteins and natural peptides.

Physical and chemical properties of proteins. The amphoteric nature. The isoelectric point (pI). Solubility of proteins. Thermodynamic stability of proteins and denaturation. Methods of protein separation, fractionation, and the analysis of a structure; reactions of sedimentation of proteins and practical application of these reactions; methods of centrifugation and chromatography; electrophoretic methods; methods of studying amino acid composition and structure of proteins and peptides. Classifications of proteins. The general characteristics of simple proteins, their functions. Natural peptides. The general characteristics of these molecules (structure and functions).

Topic 4 Classification, structural features and research methods of complex proteins. Study of the structure, functions and physical and chemical properties of nucleic acids.

Complex proteins: the classification, representatives of each class, the content in the organism and functions. Nucleotides: the structure, nomenclature, biological functions. Minor nitrogenous bases and nucleotides. Free nucleotides, participating in metabolic reactions. Cyclic nucleotides. Nucleic acids: features of structural organization, biological functions of DNA and RNA. Experimental, proving the genetic role of DNA (phenomenon of transformation). Study methods for the composition and structural features of complex proteins.

Topic 5 Structure, physical and chemical properties and classification of enzymes. Methods of enzyme activity definition.

Enzymes as biological catalysts of metabolism. General properties of enzymes. The nomenclature of enzymes and the classification of them in accordance with the type of reaction. The structure of enzymes; oligomeric enzymes; multienzyme complexes. Cofactors and coenzymes. The structure and properties of coenzymes; vitamins as predecessors in the biosynthesis of coenzymes. Classification of coenzymes in accordance with the chemical nature and the type of reaction which they catalyse. Methods of separation of enzymes, their fractionation (ultracentrifugation, chromatography, electrophoresis) and analysis of the enzyme activity.

Topic 6 The definition of enzyme activity and mechanisms of their action. Kinetics of enzyme catalysis. Cofactors and coenzymatic vitamins', functions in the catalytic activity of enzymes.

Mechanisms of enzyme action: thermodynamics lowers enzyme catalysis, active centres of enzymes. Hypotheses of E. Fisher and D. Koshlend. The sequence of stages of a catalysis. Methods of the enzyme activity definition. The basic principles of the definition. Spectrophotometric methods of the enzyme activity definition and the visualization of the results of the enzyme reaction. Units of the enzyme activity measurement and the amount of enzymes: international units, the katal, specific activity of enzyme. Kinetics of enzyme reactions: the reaction rate dependence on the concentration of enzyme and substrate, pH and temperature. Michaelis-Menten constant (K_m), its semantic value. The Michaelis-Menten equation processing by the method of double reciprocal coordinates (Lineweaver-Burk equation). Use of K_m for the characteristic of enzyme activity and the provision of probability of metabolic processes in a cell.

Topic 7 Regulation of enzymatic processes and the analysis of the enzyme pathology origin. Medical enzymology.

Regulation of enzyme processes. Activators and inhibitors. Types of enzyme activity inhibition. Reversible (competitive and noncompetitive) and nonreversible inhibition of enzymes. Physiologically active compounds and xenobiotics as reversible and nonreversible inhibitors of enzymes. Ways and mechanisms of regulation of enzyme processes. Use of test definition of isoenzymes in the diagnostics. Use of enzymes in medicine: enzymes in clinical diagnosis; enzymes as laboratory reagents; therapeutic uses of enzymes. Inhibitors of enzymes as drugs. The disturbance of enzyme processes: hereditary and acquired pathologies of enzymes; congenital disorders of metabolism and their clinical and laboratory diagnostics.

Topic 8 Metabolism: general characteristics. Stages of aerobic catabolism. Tissue respiration

General aspects of metabolism: catabolic, anabolic and amphibolic pathways of metabolism. Interrelation of the energy production and use processes in the living systems. Exergonic and endergonic biochemical reactions; the functions of ATP and other energy-rich phosphates. The stages of aerobic catabolism of biomolecules in an organism. Endocellular localization of enzymes and metabolic pathways; compartmentation of metabolic processes in a cell. Biological oxidation and tissue respiration. Reactions of biological oxidation: types of reactions (dehydrogenase, oxydase, oxygenase) and their biological value. Enzymes and coenzymes of biological oxidation: pyridine-linked and flavine-linked dehydrogenases, cytochromes.

Topic 9 TCA cycle: general characteristics, reactions, regulation, and energetic balance.

General characteristics of TCA cycle: a scheme of the sequence of reactions, characteristics of enzymes, biochemical value. Enzymatic reactions of TCA cycle. Features of

Topic 10 Mechanisms of biological oxidation, oxidative phosphorylation and ATP synthesis. Electron transport chain (ETC).

Pathways of ATP synthesis in cells: substrate-level and oxidative phosphorylation. Enzymes of biological oxidation: pyridine-, flavine-linked dehydrogenases, cytochromes. Molecular organization of mitochondrial chain of biological oxidation: components of respiratory chain, their redox potential; molecular complexes of the electron transport chain (ETC). Pathways that include reductive equivalents into mitochondrial ETC. Oxidative phosphorylation: coefficient of oxidative phosphorylation, points of coupling of oxidation and phosphorylation.

Topic 11 Basic principles of chemiosmotic theory. The analysis of the action of inhibitors and uncouplers of the oxidative phosphorylation.

Chemiosmotic theory of oxidative phosphorylation: the explanation of a molecular mechanism of ATP generation. Basic postulates of Mitchell's chemiosmotic theory. ATP synthase of mitochondria: the structure and principles of work. F₀ and F₁ subunits of ATP synthase: their functional value. Conditions of the effective association of oxidation and phosphorylation in mitochondria. Electron transport inhibitors (rotenone, antimycin A, cyanides, carbon monoxide) and ATP synthase (oligomycin). Uncoupling of the oxidative phosphorylation (2,4-dinitrophenol, thyroid hormones, free fatty acids), their biomedical value. Blocking of ATP synthesis in conditions of pathogenic factors of chemical, biological and physical origin action on the organism. Microsomal oxidation: cytochrome P450, the molecular organization of microsomal redox - chain. Active forms of the oxygen and their mechanism - based inactivation.

Topic 12 Examination submodule 1 "Basic aspects of metabolism" (computer test).

The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 1.

Topic 13 Examination submodule 1 "Basic aspects of metabolism" (theory).

Control of theoretical knowledge of the themes of the submodule 1 by methods of oral or written control is important for systematization of the mastered information, its generalization and use it for the solution of clinical cases and the interpretation of indices of biochemical analyses of blood and urine.

Module 2. Carbohydrate and lipid metabolism and its regulation

Topic 14 Digestion of carbohydrates. Glycolysis as an anaerobic oxidation of carbohydrates.

Classification, structure and role of carbohydrates (mono- and oligosaccharides, homo- and heteropolysaccharides; glycosides, amino sugars). Anaerobic glycolysis: reactions, localization in the cell, biological role. Regulation of glycolysis, key reactions, energy balance. Glycolytic redox cycle: pyruvate as the hydrogen acceptor during oxygen deficiency. Diagnostic value of determination of LDH activity in blood serum.

Topic 15 Aerobic glucose oxidation.

Stages of aerobic glucose oxidization. Oxidative decarboxylation of pyruvate. Structure, function, reactions and mechanisms of activity regulation of pyruvate dehydrogenase multi-enzyme complex. Comparative characteristics of the energy effect of aerobic and anaerobic oxidization of glucose. Pasteur effect. Shuttle mechanisms for the glycolytic NADH • H⁺ transporting from the cytosol to mitochondria under aerobic conditions.

Topic 16 Catabolism and biosynthesis of glycogen. Regulation of glycogen metabolism. Metabolism of glycoconjugates.

Glycogen degradation and biosynthesis: enzymatic reactions of glycogenesis and glycogenolysis. Cascade mechanisms of cAMP-dependent regulation of glycogen phosphorylase and glycogensynthetase activity. Hormonal regulation of glycogen metabolism in muscles and liver. Genetic disorders of enzymes of glycogen metabolism: glycogen storage diseases, aglycogenesis. Metabolism of carbohydrate components of glycoconjugates. Biosynthesis of O- and N-linked glycoproteins. Enzymes of glycoconjugate catabolism. Genetic disorders of glycoconjugate metabolism. Mucopoly- saccharidoses, gangliosidoses (or sphingolipidoses).

Topic 17 Gluconeogenesis and alternative pathways of carbohydrate metabolism. Definition methods of glucose concentration in blood.

Gluconeogenesis (GNG) is biosynthesis of glucose: physiology significance, substrates, enzymatic reactions, regulatory enzymes, energy of the process. Lactate and alanine as substrates of GNG: glucose-lactate (Cori cycle) and glucose-alanine cycles. Pentose phosphate pathway of glucose oxidation (Hexose monophosphate (HMP) shunt): biological role, sequence of reactions, feature of functioning in different tissues. Metabolic pathways and enzymatic reactions of fructose transformation in the human organism. Metabolic pathways and enzymatic reactions of galactose metabolism in the human body. Hereditary enzymopathies of pentose phosphate pathway, fructose and galactose metabolism.

Topic 18 Mechanisms of metabolic and hormonal regulation of glucose metabolism and its concentration in blood. Biochemistry of diabetes mellitus.

Hormones are regulators of glucose metabolism - glucagon, epine- phrine (adrenalin), corticosteroids, growth hormone, insuline: ef- fects and mechanisms of influence on the glucose level in blood. Normal concentration of glucose in the blood. Factors that provide the normal blood glucose concentration. Causes of hypo- and hyperglycemia. Glucosuria. Diabetes mellitus: insulin dependent and insulin independent forms; clinical and biochemical characteristics. Laboratory tests for the diagnosis of diabetes mellitus: glucose- tolerance test, double sugar loading test, determination of glycosylated hemoglobin (HbA1c) and fructosamine.

Topic 19 Test on situational tasks from “Step-1”: “ Basic aspects of metabolism”.

Test questions for Step-1 examination according to topics: Enzymes: structure, functions and general properties. Bioenergetics and energy metabolism. Metabolism of carbohydrates.

Topic 20 General characteristics of lipids. Lipids of biomembranes. Lipolysis and its regulation.

Lipids: structure, classification, biological functions of the basic classes. Composition of lipids – saturated and unsaturated fatty acids: physical and chemical properties, content in human tissues. Catabolism of triacylglycerols: sequence of reactions, mechanisms of regulation of tryglycerol lipase (TAG-lipase) activity. Hormonal regulation of lipolysis.

Topic 21 Beta-oxidation of fatty acids. Ketone body metabolism research.

Oxidation of fatty acids: biological role, stages, mechanism of activation of fatty acids. Role of carnitine in the transport of fatty acids into the mitochondria. The sequence of enzymatic reactions of beta-oxidation. Energy effect of beta-oxidation of fatty acids. Biosynthesis and utilization of ketone bodies (ketolysis), their physiological significance. Metabolism of ketone body in pathologic conditions. Mechanisms of ketoacidosis in diabetes mellitus and starvation.

Topic 22 Biosynthesis of fatty acids, triacylglycerols and complex lipids . Determination of total phospholipid concentration in blood serum.

Biosynthesis of saturated fatty acids: metabolic sources, regulation of the process, the sequence of enzymatic reactions of palmitate synthesis. Elongation of saturated fatty acids, formation of mono- and polyunsaturated fatty acids in an organism. Biosynthesis of triacylglycerols (TAG): substrates, the sequence of reactions, enzymes. Biosynthesis of phospholipids in human tissues. The concept of lipotropic factors. Metabolism of sphingolipids. Genetic anomalies of sphingolipid metabolism – sphingolipidosis. Lysosomal storage disorders: Niemann-Pick disease, GM1 gangliosidosis, Tay-Sachs disease / GM2 gangliosidosis, Gaucher disease.

Topic 23 Cholesterol biosynthesis and biotransformation. Blood lipoproteins.

Biosynthesis of cholesterol: metabolic precursors, the sequence of reactions of synthesis, mechanisms of regulation. Pathways of cholesterol biotransformation: esterification, formation of bile acids, steroid hormones, vitamin D₃, body cholesterol excretion. The role of cytochrome P-450 in the biotransformation of physiologically active steroids. Transport of lipids. TAG resynthesis in the enterocytes. Classes of blood lipoproteins: chemical composition, formation, biological role, methods of separation, apoproteins.

Topic 24 Metabolism in adipocytes. Metabolism of glycerol. Biochemistry of unsaturated fatty acids.

Biosynthesis of unsaturated fatty acids: formation of monounsaturated fatty acids; features of transformations of polyunsaturated fatty acids. Vitamin F: daily requirement, sources, biological role, the consequences of deficiency. Features of lipogenesis and lipolysis in adipose tissue and their interaction with the metabolism of carbohydrates. Hormonal regulation of processes. Features of glycerole metabolism: sequence of catabolic reactions, energy effect, participation in anabolic reactions.

Topic 25 Regulation and disorders of lipid metabolism. Interrelations between lipid and carbohydrate metabolism.

Regulatory mechanisms of the major pathways of lipid metabolism. Hormonal regulation of lipid metabolism. Disturbance of lipid metabolism in diabetes mellitus. Metabolic causes of fatty liver disease development. Disorders of cholesterol metabolism: biochemical mechanisms in the development of gallstone disease. Hyperlipoproteinemia: classification, general characteristics. Hyperalphalipoproteinemia. Role of atherogenic lipoproteins in the development of atherosclerosis. Biochemistry of obesity. Interrelationship between lipids and carbohydrate metabolism.

Topic 26 Examination submodule 2 “Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation” (computer test).

The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 2.

Topic 27 Examination submodule 2 “Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation” (theory).

Control of theoretical knowledge of the themes of the submodule 2 by methods of oral or written control is important for systematization of the mastered information, its generalization and practical application.

Module 3. Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications

Topic 28 Metabolism of simple proteins and amino acids. Common pathways of amino acids transformation.

The protein digestion in the gastrointestinal tract. Pathways of formation and using of a pool of free amino acids in the human body. Pathways of catabolism of free amino acids to end products. Deamination of amino acids: types of deamination, sequence of reactions. Glutamate dehydrogenase reaction, its value and regulation. Transamination of amino acids: reactions, biochemical value, the mechanism of action of aminotransferases. The mechanism of indirect deamination of amino acids. Decarboxylation of amino acids: enzymes, physiological value. Oxidation of biogenic amines. Diagnostic significance of definition of aminotransferases activity.

Topic 29 Metabolism of ammonia in human body. Ammonia detoxification and synthesis of urea.

The sources of ammonia in an organism. Toxicity of ammonia and pathways of its neutralization. Transport of ammonia. Biosynthesis of urea: a biological role, regulation, localization, sequence of reactions. Interrelation of the ornithine cycle with transformation of fumarate and aspartic acids in the citric acid cycle. Genetic disorders of the urea cycle enzymes. Hyperammonemia.

Topic 30 Specialized pathways of cyclic and acyclic amino acids metabolism.

Metabolism of the carbon chain of amino acids. Metabolism of aromatic and heterocyclic amino acids. Metabolism of sulfur containing amino acids. Biological role of SAM. Synthesis of creatine and creatinine. Diagnostic significance of definition of creatinine in blood serum. Biological role of glutathione. Metabolism of arginine. Formation and biological role of NO. Metabolism of branched-chain amino acids. Biological role of vitamins B12 and H in metabolism of amino acids. Metabolism of glycine and serine. Biological role of tetrahydrofolate in metabolism of amino acids.

Topic 31 Disorders of nitrogen metabolism. Biosynthesis of porphyrins.

Disorders of amino acids metabolism (phenylketonuria, alcaptonuria, albinism, maple syrup urine disease, Hartnup)

Topic 32 Biosynthesis and catabolism of purine and pyrimidine nucleotides. Determination of the final products of their metabolism.

Sources of separate atoms in the purine ring. Synthesis of purine nucleotides de novo: localization, sequence of reactions, regulation. Biosynthesis of AMP, GMP, ATP, GTP. The pathways of purine bases reutilization in the tissues. Catabolism of purine nucleotides. Formation of uric acid. Catabolism of pyrimidine nucleotides. Synthesis of pyrimidine nucleotides: sequence of reactions, regulation. Biosynthesis of deoxyribonucleotides. Formation of thymidine nucleotides, dTMP biosynthesis inhibitors as antitumor agents. Disorders of nucleotide metabolism: gout, Lesch-Nyhan syndrome, orotic aciduria.

Topic 33 DNA replication and RNA transcription.

Biological role of DNA replication. Semi-conservative mechanism of DNA replication; scheme of the Meselson – Stahl experiment. General scheme of replication fork. Enzymes of DNA replication in prokaryotes and eukaryotes. Molecular mechanisms of DNA replication: topological problems (topoisomerases, helicases); anti parallel strands of DNA; Okazaki fragments. Formation of new strands of DNA. Biological role of primer. Transcription: stages and mechanism. RNA polymerases of prokaryotes and eukaryotes. Processing of RNA. Role of snRNA in RNA splicing. Replication of the genome of viruses. Inhibitors of transcription.

Topic 34 Protein biosynthesis on the ribosomes. Antibiotics as inhibitors of transcription and translation Regulation of gene expression. Molecular mechanisms of mutations. DNA repair. Recombinant DNA.

The genetic code, its properties. Translation: basic components of protein synthesis system, stages and mechanism. Posttranslational modification of proteins. Antibiotics and toxins as inhibitors of protein synthesis. Biochemical mechanisms of antiviral action of interferons. Regulation of gene expression in prokaryotes: induction and repression. Structure of Lac-operon E.Coli. Regulation of gene expression in eukaryotes. Amplification of genes (metallothioneins, dihydrofolate reductase). Molecular mechanisms of DNA repair. Repair of UV-induced gene mutations; xeroderma pigmentosum. Polymerase chain reaction (PCR); its biomedical application. Biotechnology involving recombinant DNA.

Topic 35 Molecular-cellular mechanisms of protein-peptide, catecholamines, steroid hormones action.

Hormones and bioregulators in the system of intercellular integration of functions in an organism and their chemical nature. Classification of hormones. Mechanism of regulation of hormones synthesis and secretion. Targets organs, receptors and second messengers of hormones. Mechanism of action of polypeptide hormones and epinephrine. Mechanism of action of steroid and thyroid hormones. Radioimmunological method of definition of hormones concentration in blood.

Topic 36 Biochemical effects of protein-peptide and gastrointestinal tract hormones.

Hormones of hypothalamus: structure, the mechanism of action, biological role. Growth hormone (somatotrophin) is hormone of anterior pituitary gland: structure, metabolic role, regulation and disorder of hormone secretion. Tropic hormones of pituitary gland are prolactin (mammothrophin), gonadotrophins – follicle stimulating hormone (FSH), luteinizing hormone (LH): metabolic role, mechanism of action, regulation and disorder of hormones secretion. Thyrotrophin (TSH) is tropic hormone of pituitary gland: metabolic role, mechanism of action, regulation and disorder of hormones secretion. Adrenocorticotrophic hormone (ACTH) is tropic hormone of pituitary gland: metabolic role, the mechanism of action, regulation and disorder of hormones secretion. Biological role of the products of processing of Pro-opiomelanocortin (POMC). Hormones of posterior pituitary gland are vasopressin and oxytocin: mechanism of action, metabolic role, clinical importance. Insulin is hormone of pancreas: structure, biosynthesis and catabolism, mechanism of action, metabolic role, clinical aspects. Glucagon is hormone of pancreas: structure, biosynthesis and catabolism, mechanism of action, metabolic role. Hormones that regulate the utilization of nutrients are gastrin, secretin, cholecystokinin.

Topic 37 Hormonal regulation of metabolism and cellular functions by thyroid hormones and catecholamines. Biochemical effects of eicosanoids.

Hormones of the thyroid gland: structure, biosynthesis, the mechanism of action, biochemical effects, disorders of T3 and T4 secretion. Adrenal medullar hormones: structure, biosynthesis, the mechanisms of action, metabolic role, disorders of hormones secretion. Biogenic amines – dopamine, serotonin, melatonin, histamine: structure, biosynthesis, biochemical and physiological effects. Eicosanoids: classification, chemistry, biosynthesis and catabolism. Functions of prostaglandins, prostacyclins, thromboxanes, leukotriens and lipoxine. Clinical aspects. Inhibitors and activators of prostaglandin synthesis.

Topic 38 Biochemical effects of steroid hormones. Hormonal regulation of calcium and phosphate homeostasis.

Steroid hormones: classification, biosynthesis, the mechanism of action. Glucocorticoids: the biochemical effects, disorders of secretion. Mineralocorticoids: the biochemical effects, disorders of secretion. Renin – angiotensin – aldosterone system. Androgens, estrogens and progesterone: the biochemical and physiological effects, regulation of synthesis and secretion, disorders of secretion. Clinical application of analogs and antagonists of hormones of the gonads. Biological role of Ca^{2+} in the body; molecular forms of calcium in human plasma. The role of bone tissue, small intestine and kidneys in calcium homeostasis. Hormones that regulate calcium and phosphate homeostasis – calcitonin, parathyroid hormone, 1,25-dihydroxycholecalciferol (calcitriol): metabolism, the mechanism of action, the biochemical and physiological effects, disorders of secretion. Clinical and biochemical characteristics of disturbances of calcium homeostasis (rickets, osteoporosis).

Topic 39 Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (computer test).

The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 3.

Topic 40 Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (theory).

Control of theoretical knowledge of the themes of the submodule 3 by methods of oral or written control is important for systematization of the mastered information, its generalization and practical application.

Module 4. Biochemistry of tissues and physiological functions

Topic 41 Water soluble vitamins: B1, B2, B5, B6, B12, C, PP, H, Bc, P. Functional role in metabolism. Methods for determination of vitamin C.

The general characteristic of vitamins as components of a diet. Classification and the nomenclature of vitamins. Biological role of vitamins in a human organism. Coenzyme function of vitamins. Avitaminosis, hypovitaminosis, hypervitaminosis: causes, general principles of prevention and treatment. Biochemical characteristics of water-soluble vitamins (B1, B2, B3, B6, B12, C, B5, H, BC, P): chemical structure, metabolism, biochemical role, coenzymes, daily requirement, the basic dietary sources, deficiency manifestations, clinical application.

Topic 42 Biochemical effects and methods for determining the fat-soluble vitamins. Determination of macro-and trace elements in biological material.

Biochemical characteristic of the fat-soluble vitamins (A, D, E, K, F): chemical structure, biological properties, the daily requirement, sources, role in metabolism, metabolism and mechanism of action. Deficiency diseases of fat-soluble vitamins, hypervitaminosis. The antioxidant properties of fat-soluble vitamins. Vitamin-similar substances: structure and role in metabolism. Antivitamins: mechanisms of action, use in medicine. The biological role of water and its redistribution in the body. Regulation and disturbance of water-salt balance. Biological functions of macroelements (Na, K, Ca, Mg, P) and manifestations of deficiency. The role of trace elements in human nutrition, manifestations of trace elements deficiency. Biological role and metabolism of iron in the body.

Topic 43 Physiological and biochemical functions of blood: buffer system, acid-base status. Respiratory function of erythrocytes.

General characteristics of the physiological and biochemical functions of blood. Respiratory function of erythrocytes. Haemoglobin: structure and properties. Participation of haemoglobin in transportation of oxygen and carbon dioxide. Pathobiochemistry of haemoglobin: variants and pathological forms. Disorders of haemoglobin structure: thalassems and haemoglobinopathies. Acid-base balance (ABB) of the human body. Mechanisms of regulation and support of ABB: buffer systems of blood, lung and kidney function. The forms of disorders of acid-base balance and indexes of ABB. Metabolism in an erythrocyte. Types of hypoxia, the mechanisms of its occurrence, laboratory diagnostics.

Topic 44 Plasma proteins, acute-phase of inflammation proteins, indicator enzymes.

Plasma proteins and their clinical-biochemical characteristics. Separation of blood proteins on fractions. Proteinogram of blood proteins in normal and under pathological conditions. Components of nonspecific resistance of the organism and proteins of "acute phase" of inflammatory processes. Plasma enzymes and their importance in the enzyme diagnosis of diseases of internal organs. Kallikrein-kinin system.

Topic 45 Blood composition: non-protein organic components. Plasma lipoproteins. Coagulation and fibrinolytic systems of blood. Pathology of hemostasis. Biochemistry of immune processes and biochemical mechanisms of immunodeficiency.

Non-protein nitrogen components of blood. Azotemia. Clinical, biochemical and diagnostic significance of determination of urea, creatine, creatinine and bilirubin concentration in blood serum. Nonnitrous organic compounds of blood. Classes of lipoproteins. Lipoproteinemias. Inorganic blood components. Functional and biochemical characteristics of the hemostatic system in humans. Characteristics of the main components of the blood coagulation system: the blood clotting cascade, internal and external pathways of coagulation. Role of vitamin K in coagulation reactions. Drugs - agonists and antagonists of vitamin K. Hereditary disturbances of blood coagulation. Functional characterization of the components of the anti-coagulation blood system - heparin, antithrombin III, citric acid, prostacyclin. Role of vascular endothelium. Fibrinolytic system of blood: the stages and components of fibrinolysis. Drugs with fibrinolytic activity. Blood coagulation, thrombosis and fibrinolysis in atherosclerosis and hypertension. General characteristics of the immune system, cellular and biochemical components. Immunoglobulins: structure, functions and mechanisms of regulation of synthesis and properties of individual classes. Neurotransmitters and hormones of the immune system, cytokines. Biochemical components of the complement system: the classical and alternative mechanisms of activation. Biochemical mechanisms of immunodeficiency.

Topic 46 Biochemical functions of liver. Determination of activity of sorbitol dehydrogenase and gamma-glutamylpeptidase in blood serum.

Homeostatic role of the liver in the metabolism of the whole organism. Biochemical functions of hepatocytes. Carbohydrate liver function and its disorders. Liver function in the regulation of lipid composition of the blood. Liver function in the metabolism of proteins. Role of liver in the synthesis of urea. Role of liver in the metabolism of vitamins and minerals. Biochemical composition of bile and its formation in the liver. Role of liver in the metabolism of bile pigments. Disorders of biochemical processes in the liver under some diseases.

Topic 47 The role of liver in the metabolism of bile pigments. Pathobiochemistry of jaundice. Biotransformation of xenobiotics and endogenous toxic substances.

Catabolism of haemoglobin. Metabolism of bile pigments. Patochemistry of jaundice: haemolytic, parenchymal, obstructive jaundice. Hereditary diseases of metabolism of bile pigments. Biochemical tests in the diagnosis of jaundice. Detoxification function of the liver: biotransformation of xenobiotics and endogenous toxins. The phases and types of reactions of biotransformation of foreign compounds in the liver. Inducers and inhibitors of microsomal monooxygenases. The conjugation reactions in hepatocytes: biochemical mechanisms, functional significance. Electron transport chains of microsomal oxidation in the endoplasmic reticulum. Genetic polymorphism and regulation of synthesis of cytochrome P450. Nature of the drugs tolerance.

Topic 48 Test on situational tasks from "Step-1": IV semester.

Test questions from the base of the license exam "Step-1" on the topics: Biochemistry and metabolism of amino acids, proteins and nucleic acids. Metabolism and function of lipids. Biochemistry of hormones and neurotransmitters. Metabolism of porphyrins. Biochemistry of blood and urine. Biochemistry of vitamins and digestion. Functional biochemistry.

Topic 49 Functional activity in the kidneys. Chemical composition of urine.

Water-salt metabolism in the body. Features of the chemical composition of intracellular and extracellular fluids. Features of metabolism in the kidney. The role of the kidney in the regulation of electrolyte composition and pH of body fluids. Mechanism of urine synthesis in the kidneys. Hormonal regulation of water-salt balance and kidney function. Renin-angiotensin system. Antihypertensive drugs as inhibitors of angiotensin-converting enzyme. Biochemical composition of urine in norm and under pathology. Diagnostic significance of urine analysis. Urolithiasis: conditions of stone formation, their chemical composition and preventive measures. Clinical and biochemical changes in various kidney diseases. Diagnostics of chronic renal failure.

Topic 50 Biochemical transformations in the muscles. Determination of serum creatinine.

Chemical composition of skeletal muscles. Proteins of myofibrils: myosin, actin, tropomyosin, troponin. Molecular organization of thick and thin filaments. Molecular mechanisms of muscle contraction. Bioenergy of muscle tissue: sources of ATP in the muscle; synthesis of creatine and creatine phosphate. Cell organization, the features of metabolism and bioenergetic processes in the myocardium. Regulation of cardiomyocytes contraction. Metabolic disorders in the coronary vessels and cardiac muscle in acute myocardial. Biochemical diagnosis of diseases of the myocardium. Pathobiochemistry of muscle (myopathies). Pathobiochemistry of hypertension. Damage of the heart in some diseases.

Topic 51 Features of chemical composition and metabolism in the connective tissue. Determination of sialic acids in blood serum.

Chemical composition of connective tissue. Proteins of fibers of connective tissue are collagen and elastin. Biosynthesis of collagen and formation of fibrillar structures. Glycosaminoglycans as the complex carbohydrates of connective tissue. Role of glycosaminoglycans in the formation of the basic substance of loose connective tissue. Metabolism of proteoglycans. Pathobiochemistry of connective tissue. Biochemical mechanisms of development of mucopolysaccharidoses and collagenoses, their clinical and biochemical characteristics.

<p>Topic 52 Features of chemical composition and metabolism in the nervous tissue.</p> <p>Chemical composition of nervous tissue: the features of the changes in ontogenesis. Myelin: chemical composition, role in the functioning of the nervous tissue. Metabolism of carbohydrates, lipids, proteins and amino acids in the nervous tissue. Features of energy metabolism. Formation and inactivation of neurotransmitters, their role in the functioning of the nervous system. Receptors for neurotransmitters and physiologically active compounds. Biochemical basis of memory. Neurochemical mechanisms of action of psychotropic drugs.</p>
<p>Topic 53 Test of situational tasks from "Step-1": III - IV semesters.</p> <p>Test questions from the base of the license exam "Step-1" on the topics of the course for the year.</p>
<p>Topic 54 Examination submodule 4 "Biochemistry of tissues and physiological functions" (computer test).</p> <p>The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 4.</p>
<p>Topic 55 Examination submodule 4 "Biochemistry of tissues and physiological functions" (theory).</p> <p>Control of theoretical knowledge of the themes of the submodule 4 by methods of oral or written control is important for systematization of the mastered information, its generalization and practical application.</p>
<p>Topic 56 Interrelation of metabolism in organs and body systems.</p> <p>Coordination of metabolic processes in the body. Systems of integration. Hormonal regulation of metabolism, anabolic and catabolic hormones. Stages of biomolecules cleavage. The total energy supply of various metabolic processes. The relationship of carbohydrate, lipid and protein metabolisms. Common precursors and intermediates. Relationship of metabolism in separate organs and tissues. Disorders of coordination of metabolic processes. The development of pathologies.</p>

5. Intended learning outcomes of the course

After successful study of the course, the student will be able to:

LO1	Be able to explain and use knowledge about the main metabolic processes that occur in the human body, in making informed decisions about its health, and in identifying the leading clinical symptoms and syndromes.
LO2	Demonstrate the possession of theoretical knowledge and practical skills to determine the basic biochemical parameters of human blood and urine, followed by evaluation and interpretation of research results taking into account the reference values of these indicators to assess the condition of organs and systems of the patient.
LO3	Apply knowledge of the fundamental laws of metabolic processes in the human body to interpret the clinical picture and for the differential diagnosis of diseases.
LO4	To substantiate the expediency of using the optimal set of biochemical studies for the diagnosis of the most common human diseases and the establishment of a final clinical diagnosis.

LO5	Be able to conduct information retrieval using modern information technology to use knowledge about metabolic processes in the human body in solving practical problems.
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6. Role of the course in the achievement of programme learning outcomes

Programme learning outcomes achieved by the course.

For 222 Medicine:

PO1	To detect and identify the leading clinical symptoms and syndromes (according to the List 1); to establish the most probable nosological or syndromic preliminary clinical diagnosis of diseases (according to the List 2) using standard methods, preliminary data of the patient's anamnesis, patient's examination data, and knowledge about a human, his organs and systems.
PO2	To collect information about the patient's general condition; to assess the patient's psychomotor and physical development and the state of organs and systems of the body; to assess information on the diagnosis (according to the List 4) based on laboratory and instrumental findings.
PO3	To order and analyze additional (mandatory and optional) examinations (laboratory, radiological, functional and/or instrumental) (according to the List 4) in order to perform a differential diagnosis of diseases (according to the List 2).
PO4	To establish a final clinical diagnosis at a medical institution under control of a supervising doctor by means of informed decision and logical analysis of the obtained subjective and objective data of clinical and additional examinations, and differential diagnosis, following the relevant ethical and legal norms (according to the List 2).
PO5	To detect the key clinical syndrome or the reason for patient's condition severity (according to the List 3) via informed decision and evaluation of the person's state under any circumstances (at home, in the street, at a healthcare facility), including under emergency and military operation conditions, in the field, with a lack of information and limited time.
PO18	To search for the necessary information in the professional literature and databases; to analyze, evaluate, and apply this information. To apply modern digital technologies, specialized software, statistical methods of data analysis to solve complex health problems.

7. Teaching and learning activities

7.1 Types of training

Topic 1. Control of the knowledge initial level. Adoption of principles of biochemical laboratory research performance. Justification and clinical diagnostic value of biochemical indices changes.

pr.tr.1 "Control of the knowledge initial level. Adoption of principles of biochemical laboratory research performance. Justification and clinical diagnostic value of biochemical indices changes." (full-time course)

The definition of biochemistry as a science. A place of biochemistry among other medical and biological subjects. Achievements and prospects of the development of biochemistry, theoretical and molecular biology, biotechnology, gene engineering. A purpose of biochemical laboratory researches; estimation criteria of laboratory methods: principles of collection of research materials, errors of laboratory diagnostics. Chemical composition of living organisms (biotic), their features as compared with the objects of abiotic environment. Chemical composition of human organism. Biochemical components of cells (biomolecules), their biochemical functions. The major classes of biomolecules. The study of this topic involves theoretical work in the classroom with a discussion of safety when working in a biochemical laboratory, demonstration of basic instruments and equipment.

Topic 2. Methods of studying amino acid composition of biological liquids.

pr.tr.2 "Methods of studying amino acid composition of biological liquids." (full-time course)

The general characteristics and biological functions of proteins and peptides. Amino acid composition of proteins and peptides: structure, classification and physical and chemical properties of amino acids. The formation of peptide bonds. Levels of protein structure. Chemical bonds in protein molecules. Methods of study of amino acids and proteins in biological liquids. The color reactions of amino acids and proteins. Methods of chromatography for separation of amino acids. The study of this topic involves theoretical work in the classroom and the use of virtual simulations (laboratory work "Color reactions to proteins and amino acids") with a subsequent discussion of the results.

Topic 3. Physical and chemical properties of proteins. Methods of extraction and separation of proteins. Classification of proteins. Characteristics of simple proteins and natural peptides.

lect.1 "Biological chemistry as a science: object, objectives, objects of study. Proteins and peptides: biological function, structure, levels of structural organization. Enzymes: structure, properties, classification." (full-time course)

Biological chemistry as a science: object, objectives, objects of study. The molecular composition of living organisms. Proteins and peptides: biological function, structure, levels of structural organization. Enzymes: structure, properties, classification. Regulation of metabolic processes: regulatory enzymes. Cofactor, and coenzymes. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.3 "Physical and chemical properties of proteins. Methods of extraction and separation of proteins. Classification of proteins. Characteristics of simple proteins and natural peptides." (full-time course)

Physical and chemical properties of proteins. The amphoteric nature. The isoelectric point (pI). Solubility of proteins. Thermodynamic stability of proteins and denaturation. Methods of protein separation, fractionation, and the analysis of a structure; reactions of sedimentation of proteins and practical application of these reactions; methods of centrifugation and chromatography; electrophoretic methods; methods of studying amino acid composition and structure of proteins and peptides. Classifications of proteins. The general characteristics of simple proteins, their functions. Natural peptides. The general characteristics of these molecules (structure and functions). The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results.

Topic 4. Classification, structural features and research methods of complex proteins. Study of the structure, functions and physical and chemical properties of nucleic acids.

pr.tr.4 "Classification, structural features and research methods of complex proteins. Study of the structure, functions and physical and chemical properties of nucleic acids." (full-time course)

Complex proteins: the classification, representatives of each class, the content in the organism and functions. Nucleotides: the structure, nomenclature, biological functions. Minor nitrogenous bases and nucleotides. Free nucleotides, participating in metabolic reactions. Cyclic nucleotides. Nucleic acids: features of structural organization, biological functions of DNA and RNA. Experimental, proving the genetic role of DNA (phenomenon of transformation). Study methods for the composition and structural features of complex proteins. The study of this topic involves theoretical work in the classroom and the use of virtual simulations (laboratory work "Isolation and analysis of nucleic acids") with a subsequent discussion of the results.

Topic 5. Structure, physical and chemical properties and classification of enzymes. Methods of enzyme activity definition.

pr.tr.5 "Structure, physical and chemical properties and classification of enzymes. Methods of enzyme activity definition." (full-time course)

Enzymes as biological catalysts of metabolism. General properties of enzymes. The nomenclature of enzymes and the classification of them in accordance with the type of reaction. The structure of enzymes; oligomeric enzymes; multienzyme complexes. Cofactors and coenzymes. The structure and properties of coenzymes; vitamins as predecessors in the biosynthesis of coenzymes. Classification of coenzymes in accordance with the chemical nature and the type of reaction which they catalyze. Methods of separation of enzymes, their fractionation (ultracentrifugation, chromatography, electrophoresis) and analysis of the enzyme activity. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results.

Topic 6. The definition of enzyme activity and mechanisms of their action. Kinetics of enzyme catalysis. Cofactors and coenzymatic vitamins', functions in the catalytic activity of enzymes.

pr.tr.6 "The definition of enzyme activity and mechanisms of their action. Kinetics of enzyme catalysis. Cofactors and coenzymatic vitamins', functions in the catalytic activity of enzymes." (full-time course)

Mechanisms of enzyme action: thermodynamics lowers enzyme catalysis, active centres of enzymes. Hypotheses of E. Fisher and D. Koshlend. The sequence of stages of a catalysis. Methods of the enzyme activity definition. The basic principles of the definition. Spectrophotometric methods of the enzyme activity definition and the visualization of the results of the enzyme reaction. Units of the enzyme activity measurement and the amount of enzymes: international units, the katal, specific activity of enzyme. Kinetics of enzyme reactions: the reaction rate dependence on the concentration of enzyme and substrate, pH and temperature. Michaelis-Menten constant (K_m), its semantic value. The Michaelis-Menten equation processing by the method of double reciprocal coordinates (Lineweaver-Burk equation). Use of K_m for the characteristic of enzyme activity and the provision of the probability of metabolic processes in a cell. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results.

Topic 7. Regulation of enzymatic processes and the analysis of the enzyme pathology origin. Medical enzymology.

pr.tr.7 "Regulation of enzymatic processes and the analysis of the enzyme pathology origin. Medical enzymology." (full-time course)

Regulation of enzyme processes. Activators and inhibitors. Types of enzyme activity inhibition. Reversible (competitive and noncompetitive) and nonreversible inhibition of enzymes. Physiologically active compounds and xenobiotics as reversible and nonreversible inhibitors of enzymes. Ways and mechanisms of regulation of enzyme processes. Use of test definition of isoenzymes in the diagnostics. Use of enzymes in medicine: enzymes in clinical diagnosis; enzymes as laboratory reagents; therapeutic uses of enzymes. Inhibitors of enzymes as drugs. The disturbance of enzyme processes: hereditary and acquired pathologies of enzymes; congenital disorders of metabolism and their clinical and laboratory diagnostics. The study of this topic involves theoretical work, solving situational problems, performing laboratory work and discussing the results of research, and using virtual simulation (watching movies) with subsequent discussion.

Topic 8. Metabolism: general characteristics. Stages of aerobic catabolism. Tissue respiration

lect.2 "Bioenergetics: General ways of catabolism. The tricarboxylic acid cycle. Regulation reactions of the TCA. Bioenergy TCA. Bioenergetics: biological oxidation and oxidative phosphorylation. Electron transport chain in mitochondria." (full-time course)

Bioenergetics: General ways of catabolism. The tricarboxylic acid cycle. Regulation reactions of the TCA. Bioenergy TCA. Bioenergetics: biological oxidation and oxidative phosphorylation. Electron transport chain in mitochondria. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.8 "Metabolism: general characteristics. Stages of aerobic catabolism. Tissue respiration" (full-time course)

General aspects of metabolism: catabolic, anabolic and amphibolic pathways of metabolism. Interrelation of the energy production and use processes in the living systems. Exergonic and endergonic biochemical reactions; the functions of ATP and other energy-rich phosphates. The stages of aerobic catabolism of biomolecules in an organism. Endocellular localization of enzymes and metabolic pathways; compartmentation of metabolic processes in a cell. Biological oxidation and tissue respiration. Reactions of biological oxidation: types of reactions (dehydrogenase, oxydase, oxygenase) and their biological value. Enzymes and coenzymes of biological oxidation: pyridine-linked and flavine-linked dehydrogenases, cytochrome. The study of this topic involves theoretical work and using virtual simulation (watching movies) with subsequent discussion.

Topic 9. TCA cycle: general characteristics, reactions, regulation, and energetic balance.

pr.tr.9 "TCA cycle: general characteristics, reactions, regulation, and energetic balance." (full-time course)

General characteristics of TCA cycle: a scheme of the sequence of reactions, characteristics of enzymes, biochemical value. Enzymatic reactions of TCA cycle. Features of functioning of alpha-ketoglutarate dehydrogenase multi-winter complex. Substrate phosphorylation reaction in the citric acid cycle. The total balance of ATP molecules (energy balance) formed during the functioning of the cycle. Anaplerotic and amphibolic reactions of the citric acid cycle. The study of this topic involves theoretical work and using virtual simulation (watching movies) with subsequent discussion.

Topic 10. Mechanisms of biological oxidation, oxidative phosphorylation and ATP synthesis. Electron transport chain (ETC).

pr.tr.10 "Mechanisms of biological oxidation, oxidative phosphorylation and ATP synthesis. Electron transport chain (ETC)." (full-time course)

Pathways of ATP synthesis in cells: substrate-level and oxidative phosphorylation. Enzymes of biological oxidation: pyridine-, flavine-linked dehydrogenases, cytochromes. Molecular organization of mitochondrial chain of biological oxidation: components of respiratory chain, their redox potential; molecular complexes of the electron transport chain (ETC). Pathways that include reductive equivalents into mitochondrial ETC. Oxidative phosphorylation: coefficient of oxidative phosphorylation, points of coupling of oxidation and phosphorylation. The study of this topic involves theoretical work, consideration of case studies and the use of virtual simulation (watching movies) with further discussion.

Topic 11. Basic principles of chemiosmotic theory. The analysis of the action of inhibitors and uncouplers of the oxidative phosphorylation.

pr.tr.11 "Basic principles of chemiosmotic theory. The analysis of the action of inhibitors and uncouplers of the oxidative phosphorylation." (full-time course)

Chemiosmotic theory of oxidative phosphorylation: the explanation of a molecular mechanism of ATP generation. Basic postulates of Mitchell's chemiosmotic theory. ATP synthase of mitochondria: the structure and principles of work. F₀ and F₁ subunits of ATP synthase: their functional value. Conditions of the effective association of oxidation and phosphorylation in mitochondria. Electron transport inhibitors (rotenone, antimycin A, cyanides, carbon monoxide) and ATP synthase (oligomycin). Uncoupling of the oxidative phosphorylation (2,4-dinitrophenol, thyroid hormones, free fatty acids), their biomedical value. Blocking of ATP synthesis in conditions of pathogenic factors of chemical, biological and physical origin action on the organism. Microsomal oxydation: cytochrome P450, the molecular organization of microsomal redox - chain. Active forms of the oxygen and their mechanism - based inactivation. The study of this topic involves theoretical work, consideration of situational tasks, and the use of virtual simulation (performing virtual laboratory work "Determination of blood catalase"), followed by a discussion of the results.

Topic 12. Examination submodule 1 "Basic aspects of metabolism" (computer test).

pr.tr.12 "Examination submodule 1 "Basic aspects of metabolism" (computer test)." (full-time course)

The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 1. The lesson involves using computer testing, subject to quarantine restrictions - the use of the online platform Mix.SumDU.

Topic 13. Examination submodule 1 "Basic aspects of metabolism" (theory).

pr.tr.13 "Examination submodule 1 "Basic aspects of metabolism" (theory)." (full-time course)

Control of theoretical knowledge of the themes of the submodule 1 by methods of oral or written control is important for systematization of the mastered information, its generalization and use it for the solution of clinical cases and the interpretation of indices of biochemical analyses of blood and urine.

Topic 14. Digestion of carbohydrates. Glycolysis as an anaerobic oxidation of carbohydrates.

lect.3 "Carbohydrate metabolism 1: glycolysis, aerobic oxidation of glucose; glycogenolysis and glycogen biosynthesis." (full-time course)

Carbohydrate metabolism 1: glycolysis, aerobic oxidation of glucose; glycogenolysis and glycogen biosynthesis. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.14 "Digestion of carbohydrates. Glycolysis as an anaerobic oxidation of carbohydrates." (full-time course)

Classification, structure and role of carbohydrates (mono- and oligosaccharides, homo- and heteropolysaccharides; glycosides, amino sugars). Anaerobic glycolysis: reactions, localization in the cell, biological role. Regulation of glycolysis, key reactions, energy balance. Glycolytic redox cycle: pyruvate as the hydrogen acceptor during oxygen deficiency. Diagnostic value of determination of LDH activity in blood serum. The study of this topic involves theoretical work, case studies and the use of virtual simulation (virtual laboratory work "Determination of amylase activity in serum by the Caraway's method"), followed by discussion of the results.

Topic 15. Aerobic glucose oxidation.

pr.tr.15 "Aerobic glucose oxidation." (full-time course)

Stages of aerobic glucose oxidization. Oxidative decarboxylation of pyruvate. Structure, function, reactions and mechanisms of activity regulation of pyruvate dehydrogenase multi-enzyme complex. Comparative characteristics of the energy effect of aerobic and anaerobic oxidization of glucose. Pasteur effect. Shuttle mechanisms for the glycolytic NADH • H⁺ transporting from the cytosol to mitochondria under aerobic conditions. The study of this topic involves theoretical work, consideration of case studies and the use of virtual simulation (watching movies) with further discussion.

Topic 16. Catabolism and biosynthesis of glycogen. Regulation of glycogen metabolism. Metabolism of glycoconjugates.

pr.tr.16 "Catabolism and biosynthesis of glycogen. Regulation of glycogen metabolism. Metabolism of glycoconjugates." (full-time course)

Glycogen degradation and biosynthesis: enzymatic reactions of glycogenesis and glycogenolysis. Cascade mechanisms of cAMP-dependent regulation of glycogen phosphorylase and glycogensynthetase activity. Hormonal regulation of glycogen metabolism in muscles and liver. Genetic disorders of enzymes of glycogen metabolism: glycogen storage diseases, aglycogenesis. Metabolism of carbohydrate components of glycoconjugates. Biosynthesis of O- and N-linked glycoproteins. Enzymes of glycoconjugate catabolism. Genetic disorders of glycoconjugate metabolism. Mucopoly- saccharidoses, gangliosidoses (or sphingolipidoses). The study of this topic involves theoretical work, consideration of case studies and the use of virtual simulation (watching movies) with further discussion.

Topic 17. Gluconeogenesis and alternative pathways of carbohydrate metabolism. Definition methods of glucose concentration in blood.

lect.4 "Metabolism of carbohydrates - 2: alternative ways of monosaccharide metabolism: pentosephosphate cycle; the metabolism of fructose, galactose. Gluconeogenesis. Regulation of metabolism of carbohydrates. Diabetes" (full-time course)

Metabolism of carbohydrates - 2: alternative ways of monosaccharide metabolism: pentosephosphate cycle; the metabolism of fructose, galactose. Gluconeogenesis. Regulation of metabolism of carbohydrates, entzymopaties of carbohydrate metabolism. Diabetes. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online). The study of this topic involves theoretical work, consideration of case studies and the use of virtual simulation (watching movies) with further discussion.

pr.tr.17 "Gluconeogenesis and alternative pathways of carbohydrate metabolism. Definition methods of glucose concentration in blood." (full-time course)

Gluconeogenesis (GNG) is biosynthesis of glucose: physiology significance, substrates, enzymatic reactions, regulatory enzymes, energy of the process. Lactate and alanine as substrates of GNG: glucose-lactate (Cori cycle) and glucose-alanine cycles. Pentose phosphate pathway of glucose oxidation (Hexose monophosphate (HMP) shunt): biological role, sequence of reactions, feature of functioning in different tissues. Metabolic pathways and enzymatic reactions of fructose transformation in the human organism. Metabolic pathways and enzymatic reactions of galactose metabolism in the human body. Hereditary enzymopathies of pentose phosphate pathway, fructose and galactose metabolism. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results.

Topic 18. Mechanisms of metabolic and hormonal regulation of glucose metabolism and its concentration in blood. Biochemistry of diabetes mellitus.

pr.tr.18 "Mechanisms of metabolic and hormonal regulation of glucose metabolism and its concentration in blood. Biochemistry of diabetes mellitus." (full-time course)

Hormones are regulators of glucose metabolism - glucagon, epinephrine (adrenalin), corticosteroids, growth hormone, insulin: effects and mechanisms of influence on the glucose level in blood. Normal concentration of glucose in the blood. Factors that provide the normal blood glucose concentration. Causes of hypo- and hyperglycemia. Glucosuria. Diabetes mellitus: insulin dependent and insulin independent forms; clinical and biochemical characteristics. Laboratory tests for the diagnosis of diabetes mellitus: glucose-tolerance test, double sugar loading test, determination of glycosylated hemoglobin (HbA1c) and fructosamine. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results.

Topic 19. Test on situational tasks from "Step-1": "Basic aspects of metabolism".

pr.tr.19 "Solving of situational tasks from "Step-1" on the topics of the submodules "Basic aspects of metabolism" and "Metabolism of carbohydrates" ("Step-1, III semester)" (full-time course)

Test questions from the base of the license exam "Step-1" on the topics of the third semester. The lesson involves using computer testing, subject to quarantine restrictions - the use of the online platform Mix.SumDU.

Topic 20. General characteristics of lipids. Lipids of biomembranes. Lipolysis and its regulation.

lect.5 "Metabolism of lipids: catabolism of triacylglycerols; fatty acid oxidation. The ketogenesis." (full-time course)

Metabolism of lipids: catabolism of triacylglycerols; fatty acid oxidation. The ketogenesis.

pr.tr.20 "General characteristics of lipids. Lipids of biomembranes. Lipolysis and its regulation." (full-time course)

Lipids: structure, classification, biological functions of the basic classes. Composition of lipids – saturated and unsaturated fatty acids: physical and chemical properties, content in human tissues. Catabolism of triacylglycerols: sequence of reactions, mechanisms of regulation of triacylglycerol lipase (TAG-lipase) activity. Hormonal regulation of lipolysis. The study of this topic involves theoretical work, consideration of situational tasks and the use of virtual simulation (virtual laboratory work "Determination of the concentration of phospholipids in the serum"), followed by discussion of the results.

Topic 21. Beta-oxidation of fatty acids. Ketone body metabolism research.

pr.tr.21 "Beta-oxidation of fatty acids. Ketone body metabolism research." (full-time course)

Oxidation of fatty acids: biological role, stages, mechanism of activation of fatty acids. Role of carnitine in the transport of fatty acids into the mitochondria. The sequence of enzymatic reactions of beta-oxidation. Energy effect of beta-oxidation of fatty acids. Biosynthesis and utilization of ketone bodies (ketolysis), their physiological significance. Metabolism of ketone body in pathologic conditions. Mechanisms of ketoacidosis in diabetes mellitus and starvation. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies).

Topic 22. Biosynthesis of fatty acids, triacylglycerols and complex lipids . Determination of total phospholipid concentration in blood serum.

lect.6 "Biosynthesis of lipids: fatty acids, triacylglycerols, phospholipids. Cholesterol: biological functions, biosynthesis, transformation. Transport, deposition of lipids. Regulation and disorders of lipid metabolism: obesity, atherosclerosis." (full-time course)

Biosynthesis of lipids: fatty acids, triacylglycerols, phospholipids. Cholesterol: biological functions, biosynthesis, transformation. Transport, deposition of lipids. Regulation and disorders of lipid metabolism: obesity, atherosclerosis. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.22 "Biosynthesis of fatty acids, triacylglycerols and complex lipids . Determination of total phospholipid concentration in blood serum." (full-time course)

Biosynthesis of saturated fatty acids: metabolic sources, regulation of the process, the sequence of enzymatic reactions of palmitate synthesis. Elongation of saturated fatty acids, formation of mono- and polyunsaturated fatty acids in an organism. Biosynthesis of triacylglycerols (TAG): substrates, the sequence of reactions, enzymes. Biosynthesis of phospholipids in human tissues. The concept of lipotropic factors. Metabolism of sphingolipids. Genetic anomalies of sphingolipid metabolism – sphingolipidosis. Lysosomal storage disorders: Niemann-Pick disease, GM1 gangliosidosis, Tay-Sachs disease / GM2 gangliosidosis, Gaucher disease. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies).

Topic 23. Cholesterol biosynthesis and biotransformation. Blood lipoproteins.

pr.tr.23 "Cholesterol biosynthesis and biotransformation. Blood lipoproteins." (full-time course)

Biosynthesis of cholesterol: metabolic precursors, the sequence of reactions of synthesis, mechanisms of regulation. Pathways of cholesterol biotransformation: esterification, formation of bile acids, steroid hormones, vitamin D₃, body cholesterol excretion. The role of cytochrome P-450 in the biotransformation of physiologically active steroids. Transport of lipids. TAG resynthesis in the enterocytes. Classes of blood lipoproteins: chemical composition, formation, biological role, methods of separation, apoproteins. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies)

Topic 24. Metabolism in adipocytes. Metabolism of glycerol. Biochemistry of unsaturated fatty acids.

pr.tr.24 "Metabolism in adipocytes. Metabolism of glycerol. Biochemistry of unsaturated fatty acids." (full-time course)

Biosynthesis of unsaturated fatty acids: formation of monounsaturated fatty acids; features of transformations of polyunsaturated fatty acids. Vitamin F: daily requirement, sources, biological role, the consequences of deficiency. Features of lipogenesis and lipolysis in adipose tissue and their interaction with the metabolism of carbohydrates. Hormonal regulation of processes. Features of glycerole metabolism: sequence of catabolic reactions, energy effect, participation in anabolic reactions. The study of this topic involves theoretical work in the classroom, case studies, using virtual simulation (watching movies), and with future discussions.

Topic 25. Regulation and disorders of lipid metabolism. Interrelations between lipid and carbohydrate metabolism.

pr.tr.25 "Regulation and disorders of lipid metabolism. Interrelations between lipid and carbohydrate metabolism." (full-time course)

Regulatory mechanisms of the major pathways of lipid metabolism. Hormonal regulation of lipid metabolism. Disturbance of lipid metabolism in diabetes mellitus. Metabolic causes of fatty liver disease development. Disorders of cholesterol metabolism: biochemical mechanisms in the development of gallstone disease. Hyperlipoproteinemia: classification, general characteristics. Hyperalphalipoproteinemia. Role of atherogenic lipoproteins in the development of atherosclerosis. Biochemistry of obesity. Interrelationship between lipids and carbohydrate metabolism. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results.

Topic 26. Examination submodule 2 “Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation” (computer test).

pr.tr.26 "Examination submodule 2 “Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation” (computer test)." (full-time course)

The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 2. The lesson involves using computer testing, subject to quarantine restrictions - the use of the online platform Mix.SumDU.

Topic 27. Examination submodule 2 “Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation” (theory).

pr.tr.27 "Examination submodule 2 "Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation" (theory)." (full-time course)

Control of theoretical knowledge of the themes of the submodule 2 by methods of oral or written control is important for systematization of the mastered information, its generalization and practical application.

Topic 28. Metabolism of simple proteins and amino acids. Common pathways of amino acids transformation.

lect.7 "Amino acids metabolism: common pathways of amino acids metabolism. Metabolism of ammonia. Urea cycle. Specific pathways of amino acids metabolism." (full-time course)

Amino acids metabolism: common pathways of amino acids metabolism. Metabolism of ammonia. Urea cycle. Specific pathways of amino acids metabolism. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.28 "Metabolism of simple proteins and amino acids. Common pathways of amino acids transformation." (full-time course)

The protein digestion in the gastrointestinal tract. Pathways of formation and using of a pool of free amino acids in the human body. Pathways of catabolism of free amino acids to end products. Deamination of amino acids: types of deamination, sequence of reactions. Glutamate dehydrogenase reaction, its value and regulation. Transamination of amino acids: reactions, biochemical value, the mechanism of action of aminotransferases. The mechanism of indirect deamination of amino acids. Decarboxylation of amino acids: enzymes, physiological value. Oxidation of biogenic amines. Diagnostic significance of the definition of aminotransferases activity. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 29. Metabolism of ammonia in human body. Ammonia detoxification and synthesis of urea.

pr.tr.29 "Metabolism of ammonia in human body. Ammonia detoxification and synthesis of urea." (full-time course)

The sources of ammonia in an organism. Toxicity of ammonia and pathways of its neutralization. Transport of ammonia. Biosynthesis of urea: a biological role, regulation, localization, sequence of reactions. Interrelation of the ornithine cycle with transformation of fumarate and aspartic acids in the citric acid cycle. Genetic disorders of the urea cycle enzymes. Hyperammonemia. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 30. Specialized pathways of cyclic and acyclic amino acids metabolism.

pr.tr.30 "Specialized pathways of cyclic and acyclic amino acids metabolism." (full-time course)
Metabolism of the carbon chain of amino acids. Metabolism of aromatic and heterocyclic amino acids. Metabolism of sulfur containing amino acids. Biological role of SAM. Synthesis of creatine and creatinine. Diagnostic significance of definition of creatinine in blood serum. Biological role of glutathione. Metabolism of arginine. Formation and biological role of NO. Metabolism of branched-chain amino acids. Biological role of vitamins B12 and H in metabolism of amino acids. Metabolism of glycine and serine. Biological role of tetrahydrofolate in metabolism of amino acids. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 31. Disorders of nitrogen metabolism. Biosynthesis of porphyrins.

pr.tr.31 "Disorders of nitrogen metabolism. Biosynthesis of porphyrins." (full-time course)
Disorders of amino acids metabolism (phenylketonuria, alcaptonuria, albinism, maple syrup urine disease, Hartnup) The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 32. Biosynthesis and catabolism of purine and pyrimidine nucleotides. Determination of the final products of their metabolism.

pr.tr.32 "Biosynthesis and catabolism of purine and pyrimidine nucleotides. Determination of the final products of their metabolism." (full-time course)
Sources of separate atoms in the purine ring. Synthesis of purine nucleotides de novo: localization, sequence of reactions, regulation. Biosynthesis of AMP, GMP, ATP, GTP. The pathways of purine bases reutilization in the tissues. Catabolism of purine nucleotides. Formation of uric acid. Catabolism of pyrimidine nucleotides. Synthesis of pyrimidine nucleotides: sequence of reactions, regulation. Biosynthesis of deoxyribonucleotides. Formation of thymidine nucleotides, dTMP biosynthesis inhibitors as antitumor agents. Disorders of nucleotide metabolism: gout, Lesch-Nyhan syndrome, orotic aciduria. The study of this topic involves theoretical work in the classroom, case studies, using virtual simulation (watching movies) with future discussion.

Topic 33. DNA replication and RNA transcription.

pr.tr.33 "DNA replication and RNA transcription." (full-time course)
Biological role of DNA replication. Semi-conservative mechanism of DNA replication; scheme of the Meselson – Stahl experiment. General scheme of replication fork. Enzymes of DNA replication in prokaryotes and eukaryotes. Molecular mechanisms of DNA replication: topological problems (topoisomerases, helicases); anti parallel strands of DNA; Okazaki fragments. Formation of new strands of DNA. Biological role of primer. Transcription: stages and mechanism. RNA polymerases of prokaryotes and eukaryotes. Processing of RNA. Role of snRNA in RNA splicing. Replication of the genome of viruses. Inhibitors of transcription. The study of this topic involves theoretical work in the classroom, using virtual simulation (watching movies) with future discussion.

Topic 34. Protein biosynthesis on the ribosomes. Antibiotics as inhibitors of transcription and translation Regulation of gene expression. Molecular mechanisms of mutations. DNA repair. Recombinant DNA.

pr.tr.34 "Protein biosynthesis on the ribosomes. Antibiotics as inhibitors of transcription and translation Regulation of gene expression. Molecular mechanisms of mutations. DNA repair. Recombinant DNA." (full-time course)

The genetic code, its properties. Translation: basic components of protein synthesis system, stages and mechanism. Posttranslational modification of proteins. Antibiotics and toxins as inhibitors of protein synthesis. Biochemical mechanisms of antiviral action of interferons. Regulation of gene expression in prokaryotes: induction and repression. Structure of Lac-operon E.Coli. Regulation of gene expression in eukaryotes. Amplification of genes (metallothioneins, dihydrofolate reductase). Molecular mechanisms of DNA repair. Repair of UV-induced gene mutations; xeroderma pigmentosum. Polymerase chain reaction (PCR); its biomedical application. Biotechnology involving recombinant DNA. The study of this topic involves theoretical work in the classroom, using virtual simulation (watching movies) with future discussion.

Topic 35. Molecular-cellular mechanisms of protein-peptide, catecholamines, steroid hormones action.

lect.8 "Biochemical and molecular biological mechanisms of action of hormones. Hormones and bio-regulators – amino acid derivatives; hormones and biologically active compounds of lipid origin." (full-time course)

Biochemical and molecular biological mechanisms of action of hormones. Hormones and bio-regulators – amino acid derivatives; hormones and biologically active compounds of lipid origin. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.35 "Molecular-cellular mechanisms of protein-peptide, catecholamines, steroid hormones action." (full-time course)

Hormones and bioregulators in the system of intercellular integration of functions in an organism and their chemical nature. Classification of hormones. Mechanism of regulation of hormones synthesis and secretion. Targets organs, receptors and second messengers of hormones. Mechanism of action of polypeptide hormones and epinephrine. Mechanism of action of steroid and thyroid hormones. Radioimmunological method of definition of hormones concentration in blood. The study of this topic involves theoretical work in the classroom, using virtual simulation (watching movies) with future discussion.

Topic 36. Biochemical effects of protein-peptide and gastrointestinal tract hormones.

pr.tr.36 "Biochemical effects of protein-peptide and gastrointestinal tract hormones." (full-time course)

Hormones of hypothalamus. Growth hormone (somatotrophin) is hormone of anterior pituitary gland. Tropic hormones of pituitary gland are prolactin (mammotrophin), gonadotrophins – follicle stimulating hormone (FSH), luteinizing hormone (LH): metabolic role, mechanism of action, regulation and disorder of hormones secretion. Thyrotrophin (TSH) is tropic hormone of pituitary gland: metabolic role, mechanism of action, regulation and disorder of hormones secretion. Adrenocorticotrophic hormone (ACTH) is tropic hormone of pituitary gland: metabolic role, the mechanism of action, regulation and disorder of hormones secretion. Biological role of the products of processing of Pro-opiomelanocortin (POMC). Hormones of posterior pituitary gland are vasopressin and oxytocin: mechanism of action, metabolic role, clinical importance. Insulin is hormone of pancreas: structure, biosynthesis and catabolism, mechanism of action, metabolic role, clinical aspects. Glucagon is hormone of pancreas: structure, biosynthesis and catabolism, mechanism of action, metabolic role. Hormones that regulate the utilization of nutrients are gastrin, secretin, cholecystokinin. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 37. Hormonal regulation of metabolism and cellular functions by thyroid hormones and catecholamines. Biochemical effects of eicosanoids.

pr.tr.37 "Hormonal regulation of metabolism and cellular functions by thyroid hormones and catecholamines. Biochemical effects of eicosanoids." (full-time course)

Hormones of the thyroid gland: structure, biosynthesis, the mechanism of action, biochemical effects, disorders of T3 and T4 secretion. Adrenal medullar hormones: structure, biosynthesis, the mechanisms of action, metabolic role, disorders of hormones secretion. Biogenic amines – dopamine, serotonin, melatonin, histamine: structure, biosynthesis, biochemical and physiological effects. Eicosanoids: classification, chemistry, biosynthesis and catabolism. Functions of prostaglandins, prostacyclins, thromboxanes, leukotriens and lipoxine. Clinical aspects. Inhibitors and activators of prostaglandin synthesis. The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 38. Biochemical effects of steroid hormones. Hormonal regulation of calcium and phosphate homeostasis.

pr.tr.38 "Biochemical effects of steroid hormones. Hormonal regulation of calcium and phosphate homeostasis." (full-time course)

Steroid hormones: classification, biosynthesis, the mechanism of action. Glucocorticoids: the biochemical effects, disorders of secretion. Mineralocorticoids: the biochemical effects, disorders of secretion. Renin – angiotensin – aldosterone system. Androgens, estrogens and progesterone: the biochemical and physiological effects, regulation of synthesis and secretion, disorders of secretion. Clinical application of analogs and antagonists of hormones of the gonads. Biological role of Ca²⁺ in the body; molecular forms of calcium in human plasma. The role of bone tissue, small intestine and kidneys in calcium homeostasis. Hormones that regulate calcium and phosphate homeostasis – calcitonin, parathyroid hormone, 1,25-dihydroxycholecalciferol (calcitriol): metabolism, the mechanism of action, the biochemical and physiological effects, disorders of secretion. Clinical and biochemical characteristics of disturbances of calcium homeostasis (rickets, osteoporosis). The study of this topic involves theoretical work in the classroom, case studies, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 39. Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (computer test).

pr.tr.39 "Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (computer test)." (full-time course)

The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 3. The lesson involves using computer testing, subject to quarantine restrictions - the use of the online platform Mix.SumDU.

Topic 40. Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (theory).

pr.tr.40 "Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (theory)." (full-time course)

Control of theoretical knowledge of the themes of the submodule 3 by methods of oral or written control is important for systematization of the mastered information, its generalization and practical application.

Topic 41. Water soluble vitamins: B1, B2, B5, B6, B12, C, PP, H, Bc, P. Functional role in metabolism. Methods for determination of vitamin C.

pr.tr.41 "Water soluble vitamins: B1, B2, B5, B6, B12, C, PP, H, Bc, P. Functional role in metabolism. Methods for determination of vitamin C." (full-time course)

The general characteristic of vitamins as components of a diet. Classification and the nomenclature of vitamins. Biological role of vitamins in a human organism. Coenzyme function of vitamins. Avitaminosis, hypovitaminosis, hypervitaminosis: causes, general principles of prevention and treatment. Biochemical characteristics of water-soluble vitamins (B1, B2, B3, B6, B12, C, B5, H, BC, P): chemical structure, metabolism, biochemical role, coenzymes, daily requirement, the basic dietary sources, deficiency manifestations, clinical application. The study of this topic involves theoretical work, laboratory work and discussion of research results, case study (team working).

Topic 42. Biochemical effects and methods for determining the fat-soluble vitamins. Determination of macro- and trace elements in biological material.

pr.tr.42 "Biochemical effects and methods for determining the fat-soluble vitamins. Determination of macro-and trace elements in biological material." (full-time course)

Biochemical characteristic of the fat-soluble vitamins (A, D, E, K, F): chemical structure, biological properties, the daily requirement, sources, role in metabolism, metabolism and mechanism of action. Deficiency diseases of fat-soluble vitamins, hypervitaminosis. The antioxidant properties of fat-soluble vitamins. Vitamin-similar substances: structure and role in metabolism. Antivitamins: mechanisms of action, use in medicine. The biological role of water and its redistribution in the body. Regulation and disturbance of water-salt balance. Biological functions of macroelements (Na, K, Ca, Mg, P) and manifestations of deficiency. The role of trace elements in human nutrition, manifestations of trace elements deficiency. Biological role and metabolism of iron in the body. The study of this topic involves theoretical work, laboratory work and discussion of research results, case study (team working). Execution of virtual simulation - laboratory work "Determination of inorganic phosphate content in blood serum".

Topic 43. Physiological and biochemical functions of blood: buffer system, acid-base status. Respiratory function of erythrocytes.

lect.9 "Respiratory function of erythrocytes. The buffer systems. The acid-base status. Biochemical functions of blood. Biochemical composition of blood. Biochemistry of coagulation and fibrinolytic systems of blood. Biochemistry of immune processes" (full-time course)

Respiratory function of erythrocytes. The acid-base status. The buffer systems. Biochemical functions of blood. Normal and pathological biochemical composition of blood. Biochemistry of coagulation and fibrinolytic systems of blood. Biochemistry of immune processes. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.43 "Physiological and biochemical functions of blood: buffer system, acid-base status. Respiratory function of erythrocytes." (full-time course)

General characteristics of the physiological and biochemical functions of blood. Respiratory function of erythrocytes. Haemoglobin: structure and properties. Participation of haemoglobin in transportation of oxygen and carbon dioxide. Pathobiochemistry of haemoglobin: variants and pathological forms. Disorders of haemoglobin structure: thalassemy and haemoglobinopathies. Acid-base balance (ABB) of the human body. Mechanisms of regulation and support of ABB: buffer systems of blood, lung and kidney function. The forms of disorders of acid-base balance and indexes of ABB. Metabolism in an erythrocyte. Types of hypoxia, the mechanisms of its occurrence, laboratory diagnostics. The study of this topic involves theoretical work, case study (team working).

Topic 44. Plasma proteins, acute-phase of inflammation proteins, indicator enzymes.

pr.tr.44 "Plasma proteins, acute-phase of inflammation proteins, indicator enzymes." (full-time course)

Plasma proteins and their clinical-biochemical characteristics. Separation of blood proteins on fractions. Proteinogram of blood proteins in normal and under pathological conditions. Components of nonspecific resistance of the organism and proteins of "acute phase" of inflammatory processes. Plasma enzymes and their importance in the enzyme diagnosis of diseases of internal organs. Kallikrein-kinin system. The study of this topic involves theoretical work, case studies (team working), performing virtual simulation - laboratory work "Determination of cholinesterase activity in blood serum".

Topic 45. Blood composition: non-protein organic components. Plasma lipoproteins. Coagulation and fibrinolytic systems of blood. Pathology of hemostasis. Biochemistry of immune processes and biochemical mechanisms of immunodeficiency.

pr.tr.45 "Blood composition: non-protein organic components. Plasma lipoproteins. Coagulation and fibrinolytic systems of blood. Pathology of hemostasis. Biochemistry of immune processes and biochemical mechanisms of immunodeficiency." (full-time course)

Non-protein nitrogen components of blood. Clinical, biochemical and diagnostic significance of determination of urea, creatine, creatinine and bilirubin concentration in blood serum. Nonnitrous organic compounds of blood. Classes of lipoproteins. Lipoproteinemias. Inorganic blood components. Functional and biochemical characteristics of the hemostatic system in humans. Characteristics of the main components of the blood coagulation system: the blood clotting cascade, internal and external pathways of coagulation. Fibrinolytic system of blood: the stages and components of fibrinolysis. Drugs with fibrinolytic activity. Blood coagulation, thrombosis and fibrinolysis in atherosclerosis and hypertension. General characteristics of the immune system. Neurotransmitters and hormones of the immune system, cytokines. The study of this topic involves theoretical work, case studies (team working), virtual simulation - laboratory work "Quantitative determination of lactic acid in serum by the method of Buchner."

Topic 46. Biochemical functions of liver. Determination of activity of sorbitol dehydrogenase and gamma-glutamylpeptidase in blood serum.

lect.10 "Biochemical functions of the liver. Biotransformation of endogenous toxic compounds and xenobiotics. Biochemistry of jaundices." (full-time course)

Biochemical functions of the liver. Biotransformation of endogenous toxic compounds and xenobiotics. Biochemistry of jaundices. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.46 "Biochemical functions of liver. Determination of activity of sorbitol dehydrogenase and gamma-glutamylpeptidase in blood serum." (full-time course)

Homeostatic role of the liver in the metabolism of the whole organism. Biochemical functions of hepatocytes. Carbohydrate liver function and its disorders. Liver function in the regulation of lipid composition of the blood. Liver function in the metabolism of proteins. Role of liver in the synthesis of urea. Role of liver in the metabolism of vitamins and minerals. Biochemical composition of bile and its formation in the liver. Role of liver in the metabolism of bile pigments. Disorders of biochemical processes in the liver under some diseases. The study of this topic involves theoretical work, laboratory work and discussion of research results, case study (team working).

Topic 47. The role of liver in the metabolism of bile pigments. Pathobiochemistry of jaundice. Biotransformation of xenobiotics and endogenous toxic substances.

pr.tr.47 "The role of liver in the metabolism of bile pigments. Pathobiochemistry of jaundice. Biotransformation of xenobiotics and endogenous toxic substances." (full-time course)

Catabolism of haemoglobin. Metabolism of bile pigments. Patochemistry of jaundice: haemolytic, parenchymal, obstructive jaundice. Hereditary diseases of metabolism of bile pigments. Biochemical tests in the diagnosis of jaundice. Detoxification function of the liver: biotransformation of xenobiotics and endogenous toxins. The phases and types of reactions of biotransformation of foreign compounds in the liver. Inducers and inhibitors of microsomal monooxygenases. The conjugation reactions in hepatocytes: biochemical mechanisms, functional significance. Electron transport chains of microsomal oxidation in the endoplasmic reticulum. Genetic polymorphism and regulation of synthesis of cytochrome P450. Nature of the drugs tolerance. The study of this topic involves theoretical work, case studies (team working), virtual simulation - laboratory work "Quantitative determination of total, direct and indirect bilirubin in blood serum".

Topic 48. Test on situational tasks from "Step-1": IV semester.

pr.tr.48 "Test on situational tasks from "Step-1": IV semester." (full-time course)

Test questions from the base of the license exam "Step-1" on the topics: Biochemistry and metabolism of amino acids, proteins and nucleic acids. Metabolism and function of lipids. Biochemistry of hormones and neurotransmitters. Metabolism of porphyrins. Biochemistry of blood and urine. Biochemistry of vitamins and digestion. Functional biochemistry. The lesson involves using computer testing, subject to quarantine restrictions - the use of the online platform Mix.SumDU.

Topic 49. Functional activity in the kidneys. Chemical composition of urine.

pr.tr.49 "Functional activity in the kidneys. Chemical composition of urine." (full-time course)

Water-salt metabolism in the body. Features of the chemical composition of intracellular and extracellular fluids. Features of metabolism in the kidney. The role of the kidney in the regulation of electrolyte composition and pH of body fluids. Mechanism of urine synthesis in the kidneys. Hormonal regulation of water-salt balance and kidney function. Renin-angiotensin system. Antihypertensive drugs as inhibitors of angiotensin-converting enzyme. Biochemical composition of urine in norm and under pathology. Diagnostic significance of urine analysis. Urolithiasis: conditions of stone formation, their chemical composition and preventive measures. Clinical and biochemical changes in various kidney diseases. Diagnostics of chronic renal failure. The study of this topic involves theoretical work, case studies (team working), virtual simulation - laboratory work "Determination of serum creatinine by the Popper method".

Topic 50. Biochemical transformations in the muscles. Determination of serum creatinine.

lect.11 "Biochemistry of muscles. Biochemistry of connective tissue." (full-time course)

Biochemistry of muscles. Biochemistry of connective tissue. Teaching is conducted in the form of interactive multimedia lectures (in the presence of quarantine - online).

pr.tr.50 "Biochemical transformations in the muscles. Determination of serum creatinine." (full-time course)

Chemical composition of skeletal muscles. Proteins of myofibrils: myosin, actin, tropomyosin, troponin. Molecular organization of thick and thin filaments. Molecular mechanisms of muscle contraction. Bioenergy of muscle tissue: sources of ATP in the muscle; synthesis of creatine and creatine phosphate. Cell organization, the features of metabolism and bioenergetic processes in the myocardium. Regulation of cardiomyocytes contraction. Metabolic disorders in the coronary vessels and cardiac muscle in acute myocardial. Biochemical diagnosis of diseases of the myocardium. Pathobiochemistry of muscle (myopathies). Pathobiochemistry of hypertension. Damage of the heart in some diseases. The study of this topic involves theoretical work in the classroom, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 51. Features of chemical composition and metabolism in the connective tissue. Determination of sialic acids in blood serum.

pr.tr.51 "Features of chemical composition and metabolism in the connective tissue. Determination of sialic acids in blood serum." (full-time course)

Chemical composition of connective tissue. Proteins of fibers of connective tissue are collagen and elastin. Biosynthesis of collagen and formation of fibrillar structures. Glycosaminoglycans as the complex carbohydrates of connective tissue. Role of glycosaminoglycans in the formation of the basic substance of loose connective tissue. Metabolism of proteoglycans. Pathobiochemistry of connective tissue. Biochemical mechanisms of development of mucopolysaccharidoses and collagenoses, their clinical and biochemical characteristics. The study of this topic involves theoretical work in the classroom, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 52. Features of chemical composition and metabolism in the nervous tissue.

pr.tr.52 "Features of chemical composition and metabolism in the nervous tissue." (full-time course)

Chemical composition of nervous tissue: the features of the changes in ontogenesis. Myelin: chemical composition, role in the functioning of the nervous tissue. Metabolism of carbohydrates, lipids, proteins and amino acids in the nervous tissue. Features of energy metabolism. Formation and inactivation of neurotransmitters, their role in the functioning of the nervous system. Receptors for neurotransmitters and physiologically active compounds. Biochemical basis of memory. Neurochemical mechanisms of action of psychotropic drugs. The study of this topic involves theoretical work in the classroom, performing laboratory work and discussing research results, using virtual simulation (watching movies) with future discussion.

Topic 53. Test of situational tasks from "Step-1": III - IV semesters.

pr.tr.53 "Test of situational tasks from "Step-1": III - IV semesters." (full-time course)

Test questions from the base of the license exam "Step-1" on the topics of the course for the year. The lesson involves using computer testing, subject to quarantine restrictions - the use of the online platform Mix.SumDU.

Topic 54. Examination submodule 4 "Biochemistry of tissues and physiological functions" (computer test).

pr.tr.54 "Examination submodule 4 "Biochemistry of tissues and physiological functions" (computer test)." (full-time course)

The computer test is an important element of control of the evaluation of practical skills, that students have for studying the themes of the submodule 4. The lesson involves using computer testing, subject to quarantine restrictions - the use of the online platform Mix.SumDU.

Topic 55. Examination submodule 4 "Biochemistry of tissues and physiological functions" (theory).

pr.tr.55 "Examination submodule 4 "Biochemistry of tissues and physiological functions" (theory)." (full-time course)

Control of theoretical knowledge of the themes of the submodule 4 by methods of oral or written control is important for systematization of the mastered information, its generalization and practical application.

Topic 56. Interrelation of metabolism in organs and body systems.

pr.tr.56 "Interrelation of metabolism in organs and body systems." (full-time course)

Coordination of metabolic processes in the body. Systems of integration. Hormonal regulation of metabolism, anabolic and catabolic hormones. Stages of biomolecules cleavage. The total energy supply of various metabolic processes. The relationship of carbohydrate, lipid and protein metabolisms. Common precursors and intermediates. Relationship of metabolism in separate organs and tissues. Disorders of coordination of metabolic processes. The development of pathologies. The study of this topic involves theoretical work and case studies (team working).

7.2 Learning activities

LA1	Performing laboratory work (including virtual) in the classroom and presentation of results
LA2	Solving situational problems in practical classes by groups of students.
LA3	Performing tasks of independent work on all topics of practical classes.
LA4	E-learning and testing in systems (Mix.SumDU, Meet and in the format of the YouTube channel).
LA5	Self-study
LA6	Preparation for testing on the basis of the license exam "Step 1".
LA7	Preparation for tests and surveys on current and final control over the content modules 1-4.
LA8	Preparation for practical classes and laboratory workshops.
LA9	Processing of the results of collective tasks (homework and classroom), which are prepared by groups of 4-5 students in accordance with the topic of practical training.
LA10	Viewing videos in practical classes.
LA11	Work with textbooks and relevant information sources.

LA12	Processing of collective project's tasks, which are prepared independently and the results are presented at the lecture-conference.
LA13	Individual research project (student research paper, article, abstract, etc.)

8. Teaching methods

Course involves learning through:

TM1	Interactive lectures
TM2	Case-study
TM3	Lecture-conference
TM4	Method of video demonstrations
TM5	Educational game
TM6	Exploratory laboratory work (learning through research) - Research-based learning (RBL).
TM7	Educational discussion / debate
TM8	Preparation for current and final control measures.
TM9	Team-based learning (TBL).
TM10	Brain storm

Lectures provide students with basic materials for the study of human biochemistry in normal and in pathology. Lectures are complemented by practical classes that give students the opportunity to demonstrate knowledge of biochemistry. The use of scientific animated films allows you to visualize the processes that occur in the body at the molecular level. Case-study analysis provides an opportunity to apply biochemical knowledge for a reasoned assessment of changes in metabolic processes in pathologies. Independent learning will be facilitated by preparation for practical classes and tasks in the "Workbook" during the study of the whole course, work in small groups to prepare presentations in practical classes, lectures-conferences with further analysis and discussion of the results. The use of discussions, debates, elements of editument promotes the development of creative thinking and optimizes the search for the most optimal algorithms for solving complex practical problems.

GC 1. Ability to abstract thinking, analysis, and synthesis. GC 2. Ability to learn, master modern knowledge, and apply the knowledge in practice. GC 3. Knowledge and understanding of the subject area and professional activity comprehension. GC 5. Ability to make reasoned decisions; teamwork ability; interpersonal skills. GC 7. Ability to use information and communication technologies.

9. Methods and criteria for assessment

9.1. Assessment criteria

ECTS	Definition	National scale	Rating scale
	Outstanding performance without errors	5 (Excellent)	$170 \leq RD \leq 200$

	Above the average standard but with minor errors	4 (Good)	$140 \leq RD < 169$
	Fair but with significant shortcomings	3 (Satisfactory)	$120 \leq RD < 139$
	Fail – some more work required before the credit can be awarded	2 (Fail)	$0 \leq RD < 119$

9.2 Formative assessment

FA1	Testing
FA2	Interviews and oral comments of the teacher
FA3	Discussion and self-correction of laboratory work performed by students
FA4	Checking the results of experiments
FA5	Examination and evaluation of written theoretical tasks
FA6	Solving situational tasks
FA7	Performing individual tasks in the "Workbook"

9.3 Summative assessment

SA1	Current academic performance: oral or written assessment of theoretical knowledge and practical skills, case studies, testing.
SA2	Final control: exam

Form of assessment:

4 semester		200 scores
SA1. Current academic performance: oral or written assessment of theoretical knowledge and practical skills, case studies, testing.		120
	Oral and / or written questioning, case studies, current computer testing, testing on the basis of the license exam "Step 1"	120
SA2. Final control: exam		80
	written exam	80

Form of assessment (special cases):

4 semester		200 scores
SA1. Current academic performance: oral or written assessment of theoretical knowledge and practical skills, case studies, testing.		120
	conducting practical classes and testing in the online format using the Mix.SumDU and Google Meet platforms under quarantine restrictions	120
SA2. Final control: exam		80
	conducting the exam in the online format using the Mix.SumDU and Google Meet platforms under quarantine restrictions	80

III semester: Rating of students' academic performance is assessed according to the traditional 4-point system. The calculated arithmetic mean scores for testing and the theoretical part are recalculated into points at the end of the semester by multiplying by a factor (9.6 - for testing, 14.4 - for the theoretical part). The sum of all points obtained for the semester is the result of assessing the current academic performance of students. The amount of points for semester's academic performance must be at least 120.0. Students who received less than 120 points on their academic performance must improve their result by retaking theoretical questions ("List of questions to raise the point on academic performance": III semester - 70 questions). IV semester: The final point in this semester is the result of the written exam, which includes material 1-4 content modules (for III and IV semesters). Students are allowed to take the exam if they complete the conditions of the regulations and if they get points for the year's academic performance - not less than 72.0. (The annual recalculation coefficient for academic performance) is 0.6: $120.0 \cdot 0.6 = 72$. Students who received less than 72.0 on their academic performance during the year must improve their point to a required minimum by retaking the theoretical course from the required list of questions ("List of questions to improve the point on academic performance" in the 4th semester, 70 questions). Incentive points are added to the assessment of the discipline for implementation of an individual research project (defense of student science work 12 points, speech at the conference 5 points, poster presentation at the conference 4 points, the report at the final lecture-conference on the discipline 5 points, abstract reports at the conference 3 points). The total score in the discipline may not exceed 200 points.

10. Learning resources

10.1 Material and technical support

MTS1	Laboratory equipment and reagents: spectrophotometer, thermostat, water bath, scales, alcoholic lamp, fume hoods, automatic mini-analyzers for determining basic blood and urine indicators, chemical reagent solutions.
MTS2	Devices: projectors, screens, smart boards.
MTS3	Library funds
MTS4	Computers and software to support distance learning, and virtual laboratory work.

10.2 Information and methodical support

Essential Reading	
1	Biological chemistry/ Yu. I. Gubskiy. - 3-nd. ed. - Vinnitsa : Nova Knyha, 2020. - 488 p.
2	Ferrier. D. R. Lippincott Illustrated Reviews: Biochemistry / D. R. Ferrier. – South Asian Edition. – Wolters Kluwer, 2020. – 950 p.
Supplemental Reading	
3	USMLE Step 1: Biochemistry and Medical Genetics: Lecture Notes / Editors S. Turco, R. Lane, R.M. Harden. — New York : Kaplan, 2019. — 409 p.
4	Methodical instructions for practical lessons on discipline “Biological chemistry” : in two parts / L. O. Primova, L. I. Hrebenyk, I. V. Chorna, N. M. Inshyna. – Sumy : SumSU, 2020. – Part 2. – 124 p.

5	Biological Chemistry. Methodical instructions for practical lessons. Module 1 "Basic aspects of metabolism. Metabolism of carbohydrates, lipids and its regulation"/ L.O. Primova, L.I. Grebenik, I.Y. Vysotskyi. – Sumy : SumSU, 2015. - Part 1. - 94p.
6	Chatterjea M. N. Textbook of medical biochemistry / M. N. Chatterjea, Rana Shinde. – 8th edition. – New Delhi : Jaypee, 2012. – 894 p.
7	Bender D. A. Harper's illustrated biochemistry / D.A. Bender, K.M. Botham, P.J. Kennelly, P.A. Weil. - 30th edition. - Lange Medical Books / McGraw-Hill, 2017. - 821 p.
8	Lieberman M. A. Marks' Basic Medical Biochemistry: A Clinical Approach / Michael A. Lieberman, Alisa Peet. – 5th edition. – Wolters Kluwer, 2017. – 1008 p.
9	Vasudevan D. M. Textbook of Biochemistry for Medical Students / D. M. Vasudevan, S. Sreekumari, Kannan Vaidyanathan. – Jaypee Brothers Medical Publishers, 2013. – 792 p.
10	Marks Dawn B. Biochemistry / Dawn B. Marks. – 3th edition. – Baltimore, Philadelphia : Williams & Wilkins, 2014. – 345 p.
11	Lieberman M. A. BRS Biochemistry, Molecular Biology, and Genetics / Michael A. Lieberman, Rick Ricer. – Lippincott Williams & Wilkins, 2013. – 461 p.

COURSE DESCRIPTOR

№	Topic	Total, hours	Lectures, hours	Workshops (seminars), hours	Labs, hours	Self-study of the material, hours	Individual tasks, hours
full-time course form of study							
Module 1. Basic aspects of metabolism							
1	Control of the knowledge initial level. Adoption of principles of biochemical laboratory research performance. Justification and clinical diagnostic value of biochemical indices changes.	2	0	2	0	0	0
2	Methods of studying amino acid composition of biological liquids.	2	0	2	0	0	0
3	Physical and chemical properties of proteins. Methods of extraction and separation of proteins. Classification of proteins. Characteristics of simple proteins and natural peptides.	4	2	2	0	0	0
4	Classification, structural features and research methods of complex proteins. Study of the structure, functions and physical and chemical properties of nucleic acids.	3	0	2	0	1	0
5	Structure, physical and chemical properties and classification of enzymes. Methods of enzyme activity definition.	3	0	2	0	1	0
6	The definition of enzyme activity and mechanisms of their action. Kinetics of enzyme catalysis. Cofactors and coenzymatic vitamins', functions in the catalytic activity of enzymes.	3	0	2	0	1	0
7	Regulation of enzymatic processes and the analysis of the enzyme pathology origin. Medical enzymology.	3	0	2	0	1	0
8	Metabolism: general characteristics. Stages of aerobic catabolism. Tissue respiration	4	2	2	0	0	0
9	TCA cycle: general characteristics, reactions, regulation, and energetic balance.	3	0	2	0	1	0
10	Mechanisms of biological oxidation, oxidative phosphorylation and ATP synthesis. Electron transport chain (ETC).	3	0	2	0	1	0
11	Basic principles of chemiosmotic theory. The analysis of the action of inhibitors and uncouplers of the oxidative phosphorylation.	3	0	2	0	1	0
12	Examination submodule 1 "Basic aspects of metabolism" (computer test).	2	0	2	0	0	0
13	Examination submodule 1 "Basic aspects of metabolism" (theory).	4	0	2	0	2	0
Module 2. Carbohydrate and lipid metabolism and its regulation							
1	Digestion of carbohydrates. Glycolysis as an anaerobic oxidation of carbohydrates.	5	2	2	0	1	0

№	Topic	Total, hours	Lectures, hours	Workshops (seminars), hours	Labs, hours	Self-study of the material, hours	Individual tasks, hours
2	Aerobic glucose oxidation.	3	0	2	0	1	0
3	Catabolism and biosynthesis of glycogen. Regulation of glycogen metabolism. Metabolism of glycoconjugates.	3	0	2	0	1	0
4	Gluconeogenesis and alternative pathways of carbohydrate metabolism. Definition methods of glucose concentration in blood.	5	2	2	0	1	0
5	Mechanisms of metabolic and hormonal regulation of glucose metabolism and its concentration in blood. Biochemistry of diabetes mellitus.	3	0	2	0	1	0
6	Test on situational tasks from “Step-1”: “Basic aspects of metabolism”.	2	0	2	0	0	0
7	General characteristics of lipids. Lipids of biomembranes. Lipolysis and its regulation.	5	2	2	0	1	0
8	Beta-oxidation of fatty acids. Ketone body metabolism research.	3	0	2	0	1	0
9	Biosynthesis of fatty acids, triacylglycerols and complex lipids . Determination of total phospholipid concentration in blood serum.	5	2	2	0	1	0
10	Cholesterol biosynthesis and biotransformation. Blood lipoproteins.	3	0	2	0	1	0
11	Metabolism in adipocytes. Metabolism of glycerol. Biochemistry of unsaturated fatty acids.	3	0	2	0	1	0
12	Regulation and disorders of lipid metabolism. Interrelations between lipid and carbohydrate metabolism.	3	0	2	0	1	0
13	Examination submodule 2 “Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation” (computer test).	2	0	2	0	0	0
14	Examination submodule 2 “Basic aspects of metabolism. Carbohydrate and lipid metabolism and its regulation” (theory).	3	0	2	0	1	0
Module 3. Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications							
1	Metabolism of simple proteins and amino acids. Common pathways of amino acids transformation.	5	2	2	0	1	0
2	Metabolism of ammonia in human body. Ammonia detoxification and synthesis of urea.	3	0	2	0	1	0
3	Specialized pathways of cyclic and acyclic amino acids metabolism.	3	0	2	0	1	0
4	Disorders of nitrogen metabolism. Biosynthesis of porphyrins.	3	0	2	0	1	0

№	Topic	Total, hours	Lectures, hours	Workshops (seminars), hours	Labs, hours	Self-study of the material, hours	Individual tasks, hours
5	Biosynthesis and catabolism of purine and pyrimidine nucleotides. Determination of the final products of their metabolism.	3	0	2	0	1	0
6	DNA replication and RNA transcription.	3	0	2	0	1	0
7	Protein biosynthesis on the ribosomes. Antibiotics as inhibitors of transcription and translation Regulation of gene expression. Molecular mechanisms of mutations. DNA repair. Recombinant DNA.	3	0	2	0	1	0
8	Molecular-cellular mechanisms of protein-peptide, catecholamines, steroid hormones action.	5	2	2	0	1	0
9	Biochemical effects of protein-peptide and gastrointestinal tract hormones.	3	0	2	0	1	0
10	Hormonal regulation of metabolism and cellular functions by thyroid hormones and catecholamines. Biochemical effects of eicosanoids.	3	0	2	0	1	0
11	Biochemical effects of steroid hormones. Hormonal regulation of calcium and phosphate homeostasis.	3	0	2	0	1	0
12	Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (computer test).	2	0	2	0	0	0
13	Examination submodule 3 "Metabolism of proteins. Molecular biology. Biochemistry of intercellular communications" (theory).	4	0	2	0	2	0
Module 4. Biochemistry of tissues and physiological functions							
1	Water soluble vitamins: B1, B2, B5, B6, B12, C, PP, H, Bc, P. Functional role in metabolism. Methods for determination of vitamin C.	3	0	2	0	1	0
2	Biochemical effects and methods for determining the fat-soluble vitamins. Determination of macro-and trace elements in biological material.	3	0	2	0	1	0
3	Physiological and biochemical functions of blood: buffer system, acid-base status. Respiratory function of erythrocytes.	5	2	2	0	1	0
4	Plasma proteins, acute-phase of inflammation proteins, indicator enzymes.	3	0	2	0	1	0
5	Blood composition: non-protein organic components. Plasma lipoproteins. Coagulation and fibrinolytic systems of blood. Pathology of hemostasis. Biochemistry of immune processes and biochemical mechanisms of immunodeficiency.	3	0	2	0	1	0

№	Topic	Total, hours	Lectures, hours	Workshops (seminars), hours	Labs, hours	Self-study of the material, hours	Individual tasks, hours
6	Biochemical functions of liver. Determination of activity of sorbitol dehydrogenase and gamma-glutamylpeptidase in blood serum.	5	2	2	0	1	0
7	The role of liver in the metabolism of bile pigments. Pathobiochemistry of jaundice. Biotransformation of xenobiotics and endogenous toxic substances.	3	0	2	0	1	0
8	Test on situational tasks from "Step-1": IV semester.	2	0	2	0	0	0
9	Functional activity in the kidneys. Chemical composition of urine.	3	0	2	0	1	0
10	Biochemical transformations in the muscles. Determination of serum creatinine.	5	2	2	0	1	0
11	Features of chemical composition and metabolism in the connective tissue. Determination of sialic acids in blood serum.	3	0	2	0	1	0
12	Features of chemical composition and metabolism in the nervous tissue.	2	0	2	0	0	0
13	Test of situational tasks from "Step-1": III - IV semesters.	2	0	2	0	0	0
14	Examination submodule 4 "Biochemistry of tissues and physiological functions" (computer test).	2	0	2	0	0	0
15	Examination submodule 4 "Biochemistry of tissues and physiological functions" (theory).	4	0	2	0	2	0
16	Interrelation of metabolism in organs and body systems.	2	0	2	0	0	0
<i>Total (full-time course form of study)</i>		<i>180</i>	<i>22</i>	<i>112</i>	<i>0</i>	<i>46</i>	<i>0</i>

	<p>UNIVERSITY POLICIES FOR THE COURSE «Biological and Bioorganic Chemistry»</p> <p>Higher education level The Second Level Of Higher Education, National Qualifications Framework Of Ukraine – The 7th Level, QF-LLL – The 7th Level, FQ-EHEA – The Second Cycle Major: Educational programme 222 Medicine Year of study 2022 Semester 3, 4 semester Mode of study full-time course Language of instruction English</p>
Teacher(s)	Hrebenyk Liudmyla Ivanivna, Chorna Inna Valentynivna
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Time and room for giving consultations	Offline consultation: room 303 and 314 every Monday from 3 to 4:20 pm https://biochem.med.sumdu.edu.ua/index.php?option=com_content&view=article&id=78&Itemid=91&lang=en
Links to online educational platforms	https://mix.sumdu.edu.ua/ Google Meet
Syllabus	http://pg.cabinet.sumdu.edu.ua/report/syllabus/1423731
Channels for maintaining contact with the group for receiving and working on materials	Announcements about the discipline will be posted on the website of the department https://biochem.med.sumdu.edu.ua/index.php?lang=en Channels of communication with the teacher: - teacher's email, - communication through a personal cabinet https://cabinet.sumdu.edu.ua , - Mix.SumDU platform https://mix.sumdu.edu.ua
POLICIES	
Attendance policy	Attendance is mandatory. Under objective circumstances (availability of permission from the dean's office) training can take place individually (online). To receive the credit or admission to the exam, the topics of all missed practical classes must be worked out for a positive mark.
Assessment policy	The rating of students' academic performance is assessed according to the traditional 4-point system. The calculated arithmetic mean scores for testing and the theoretical part are recalculated into points at the end of the semester by multiplying by a factor (9.6 - for testing, 14.4 - for the theoretical part). The sum of all points obtained for the semester is the result of assessing the current academic performance of students. The number of points for the semester's academic performance must be at least 120.0. Students who received less than 120 points on their academic performance must improve their results by retaking theoretical questions ("List of questions to raise the point on academic performance": III semester - 70 questions). IV semester: The final point in this semester is the result of the written exam, which includes material 1-4 content modules (for III and IV semesters). Students are allowed to take the exam if they complete the conditions of the regulations and if they get points for the year's academic performance - not less than 72.0. (The annual recalculation coefficient for academic performance) is 0.6: $120.0 \cdot 0.6 = 72$. Students who received less than 72.0 on their academic performance during the year must improve their point to a required minimum by retaking the theoretical course from the required list of questions ("List of questions to improve the point on academic performance" in the 4th semester, 70 questions).
Deadlines and course retake policy	Deadlines and the number of reworks of the written exam are determined by the dean's office according to the schedule
Assessment appeals policy	The results of the module and semester assessment are subject to appeal. A student must lodge an appeal to the director/dean on the day of certification or after announcing the results, but no later than the next working day. The appeal commission is established by the director/dean's order. The appeal commission's decision may change the grade in case of violations revealed during the attestation.
Academic integrity policy	Participants must complete all tasks according to the course requirements independently. Participants are not allowed to cheat during the written module or summative test. The assignments should not contain plagiarism, facts of fabrication, falsification, cheating. Manifestations of other types of academic dishonesty determined by the Academic Integrity policy are also unacceptable. If a teacher reveals violations of academic integrity by students during the course, the former have the right to take one of the following actions: - to reduce points by up to 40% for practical assignments; - to give recommendations for improving and resubmitting mandatory homework assignments with the reduction of points by up to 25%; - to not accept mandatory homework assignments without the right to resubmit; - set a date for retaking the written module or the summative test with a reduction of points by up to 15%; - to not allow to retake the written module or the summative test.

Alignment of learning outcomes with teaching and learning activities and assessment

For 222 Medicine:

Competences/ learning outcomes	Learning outcomes	Types of training	Learning activities	Teaching methods	Material and technical support	Methods and criteria for assessment
PO1, PO2, PO3, PO4, PO5	LO1	lect.2-lect.11, pr.tr.5-pr.tr.56	LA1, LA2, LA3, LA4, LA5, LA6, LA7, LA8, LA9, LA10, LA11, LA12, LA13	TM1, TM2, TM3, TM4, TM5, TM6, TM7, TM8, TM9, TM10	MTS1, MTS2, MTS3, MTS4	SA1, SA2
PO1, PO2, PO3, PO4, PO5	LO2	lect.1-lect.11, pr.tr.1-pr.tr.56	LA1, LA2, LA6, LA7, LA9, LA12, LA13	TM1, TM2, TM3, TM4, TM5, TM6, TM7, TM9, TM10	MTS1, MTS2, MTS3, MTS4	SA1, SA2
PO1, PO2, PO3, PO4, PO5, PO18	LO3	lect.1-lect.11, pr.tr.1-pr.tr.56	LA1, LA2, LA3, LA5, LA8, LA9, LA10, LA11, LA12, LA13	TM1, TM2, TM3, TM4, TM5, TM6, TM7, TM8, TM9, TM10	MTS1, MTS2, MTS3, MTS4	SA1, SA2
PO2, PO3, PO4, PO5, PO18	LO4	lect.2-lect.11, pr.tr.5-pr.tr.56	LA1, LA2, LA3, LA4, LA5, LA8, LA10, LA11, LA12	TM1, TM2, TM4, TM5, TM6, TM7, TM8, TM9, TM10	MTS1, MTS2, MTS3, MTS4	SA1, SA2
PO4, PO18	LO5	lect.1-lect.11, pr.tr.1-pr.tr.56	LA2, LA3, LA4, LA5, LA6, LA7, LA8, LA11, LA12, LA13	TM1, TM2, TM3, TM6, TM8	MTS1, MTS2, MTS3, MTS4	SA1, SA2