FEDERAL STATE BUDGETARY
EDUCATIONAL INSTITUTION OF HIGHER EDUCATION
"AMUR STATE MEDICAL ACADEMY"
MINISTRY OF HEALTH OF THE RUSSIAN FEDERATION

AGREED
Vice-Rector for Academic Affairs,

_____N.V. Loskutova

April 17, 2025

Decision of the CCMC
April 17, 2025

ProtocolNo. 7

APPROVED
by decision of the Academic Council of the FSBEI HE Amur SMA of the Ministry of Health of the Russian Federation
April 22, 2025

Protocol No. 15

Acting Rector of the FSBEI HE Amur SMA of the Ministry of Health of the Russian Federation

_____I.V. Zhukovets

April 22, 2025

ДОКУМЕНТ ПОДПИСАН
ЭЛЕКТРОННОЙ ПОДПИСЬЮ

Сертификат: 50AB2A2604654528852614FA420034A
Владелец: Жуковец Ирина Валентиновна
Действителен: с 15.04.2025 до 09.07.2026

EDUCATIONAL PROGRAM

discipline "Biochemistry"

Specialty: 31.05.01 General Medicine
Course: 1, 2
Semester: 2, 3
Total hours: 252 hrs.
Total credits: 7 credit units
Control form: examination, 3 semester

Blagoveshchensk, 2025

The educational program of the discipline is designed in accordance with the requirements of the Federal State Educational Standard of Higher Education - specialist in specialty 31.05.01 General Medicine, approved by the order of the Ministry of Education and Science of Russia dated 08.12.2020 No. 988 (registered with the Ministry of Justice of Russia on 08.26.2020 No. 59493), BPEP HE (2021).

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APPROVED at the meeting of the Department of Chemistry,
Protocol No.14 dated April 9, 2025

Head of the Department of Chemistry, Holder of an Advanced Doctorate in Medical Sciences, Professor, E.A. Borodin

Conclusion of the Expert Commission on the review of the Educational Programs:
Protocol No. 2 dated April 16, 2025

Expert of the expert commission,
Ph.D. of Engineering Sciences _____ E.A. Utochkina

APPROVED at the meeting of the CMC No. 1: Protocol No. 7 dated April16, 2025
Chairman of the CMC No. 1
Holder of the Advanced Doctorate in Medical Sciences,
Professor _____ E.A. Borodin

AGREED: Dean of the Faculty of Medicine,
Ph.D. of Medical Sciences _____ N.G. Brush
April 17, 2025

CONTENT

I. EXPLANATORY NOTE

1.1. Characteristics of the discipline

Modern biochemistry is a branched field of knowledge, including a number of sections. The most important of them are bioorganic chemistry, dynamic biochemistry, molecular biology, functional biochemistry. Medical biochemistry has also formed as an independent branch, including all the above sections, and not only in the part that relates to human health and diseases.

Medical biochemistry studies the molecular basis of human physiological functions, molecular mechanisms of disease pathogenesis (molecular pathology), biochemical basis of disease prevention and treatment, biochemical methods of disease diagnostics and monitoring of treatment effectiveness. Biochemistry, together with such medical and biological disciplines as biology and general genetics, normal human anatomy, histology, normal physiology, forms students' knowledge of the structure and functioning of a healthy organism, and together with pathophysiology, pathoanatomy and pharmacology - knowledge of the essence of general pathological processes and the most common diseases, the mechanisms of drug action.

Biochemistry, unlike related theoretical disciplines, studies life phenomena at the molecular level. Knowledge of biochemistry is fundamental in the education of a doctor, serves as a basis for studying subsequent theoretical disciplines and the formation of clinical thinking of a doctor in medical departments.

1.2. Purpose and objectives of the discipline.

The purpose of teaching the discipline: to form in students knowledge about the chemical essence of life phenomena, to teach them to apply knowledge about the chemical composition and biochemical processes occurring in the human body, as characteristics of the norm and signs of diseases, when studying subsequent disciplines and in professional activities.

Learning objectives of the discipline:

1) Formation of knowledge about the molecular organization and molecular mechanisms of functioning of living things. In teaching biochemistry, formula material occupies a significant place, but it is only a tool for cognition, it increases the clarity of learning, because chemical formulas contain a short form of recording a lot of information about complex phenomena. Based on familiarity with the formula material, the student should be able to write down in words the schemes of transformations, their sequence and regulation, name metabolites that have key diagnostic and pathological significance.
2) Developing the ability to apply knowledge about chemical composition and biochemical processes as characteristics of the norm or signs of disease when studying subsequent disciplines and in practical work.
3) Formation of initial practical skills in biochemical diagnostic informatics and analytics, knowledge of the principles of basic clinical and biochemical analyses, mastery of express methods of biochemical analysis, the ability to select adequate research methods and interpret the results obtained.

1.3. The place of the discipline in the structure of the main professional educational program of higher education.

In accordance with the Federal State Educational Standard of Higher Education - a specialist in the specialty 31.05.01 General Medicine (2020), the discipline " Biochemistry" refers to the basic part, block 1 and is taught in the 1st and 2nd years. The total workload of the discipline is 252 hours (7 credit units). Of these, 144 classroom hours, 72 hours are allocated for independent work. Form of control - exam, III semester **.**

Students are trained on the basis of continuity of knowledge and skills acquired in courses in chemistry, bioorganic chemistry in medicine, bioinorganic and biophysical chemistry in medicine.

The discipline "Biochemistry" is a prerequisite for studying the disciplines:

- pathophysiology, clinical pathophysiology;
- pharmacology;
- microbiology, virology;
- immunology;
- professional disciplines.

Parallel courses studied to ensure interdisciplinary connections within the core part of the curriculum:

- biology;
- physiology,
- histology, embryology and cytology.

The discipline "Biochemistry" consists of three sections, which present the most important and necessary information that determines the educational process.

1. Static biochemistry.
2. Dynamic biochemistry.
3. Functional biochemistry.

1.4 Requirements for students

Chemistry
Knowledge **: atomic** structure , nature of chemical bonds, types of bonds, classes of chemical substances, types of reactions, catalysis, reaction of the environment in aqueous solutions and buffer systems, chemical thermodynamics.
Skills: use chemical equipment, perform calculations based on experimental results, conduct basic statistical processing of experimental data .
Skills: working with chemical glassware (pipettes, burettes, test tubes).
Bioorganic chemistry in medicine
Knowledge: structure and properties of the main classes of natural bioorganic compounds, international nomenclature of organic compounds, genetic relationships of classes of organic substances, spatial representations in organic chemistry (conformations and configurations of organic molecules, stereoisomerism), mutual influence of atoms in molecules of organic compounds (electronic effects, conjugation), types of chemical bonds in bioorganic compounds, acidity and basicity of organic molecules, basic mechanisms of reactions of organic compounds.
Skills **:** give names to organic compounds using substitution nomenclature.
Skills: ability to identify acidic and basic centers in molecules of organic compounds.
Physics
Knowledge: structure of the atom. Electrical potentials. Ultraviolet, visible and infrared regions of the spectrum. Interaction of light with matter - transmission, absorption, reflection, scattering. Polarized light. Principles of physical and chemical methods of analysis, device structure (centrifugation, electrophoresis, photometry). The nature of electrochemical processes occurring on cell membranes, the main properties of biological membranes, devices, devices used in chemical analysis.
Skills **:** conduct basic statistical analysis, predict changes in the energy state of substances in the process of chemical interaction, properties of aqueous solutions.
Skills: work with measuring equipment, basic mathematical apparatus and computer technology to carry out calculations of physical quantities characterizing the behavior of substances.

Biology
Knowledge: ideas about life as a special form of existence of matter, the basic properties of living organisms, cell theory, genetic code, the basics of heredity and variability, the basic forms of breakdowns of the genetic apparatus, hereditary enzymopathies.
***Skills* :** trace the connection between biological and chemical processes occurring in nature and living organisms
Skills: probabilities of manifestation of hereditary traits (formal genetics).
Latin
Knowledge: terminology .
***Skills* :** use Latin terms to name biochemical characteristics.
Skills: use of the prefixes hyp o - , hyper -, etc. to characterize biochemical processes.
Foreign languages
Knowledge: basic vocabulary and grammar of foreign languages.
***Skills* :** working with foreign literature.
Skills: use knowledge of foreign languages to work with international electronic databases.

1.5 Interdisciplinary links with subsequent disciplines

The knowledge, skills and abilities acquired in the biochemistry course are necessary for studying subsequent disciplines:

No. p / p	**Name of subsequent disciplines**	**Section numbers of the discipline required for studying subsequent disciplines**		
		1	**2**	**3**
1	Biology	+	+	+
2	Normal Physiology	+	+	+
3	Pathophysiology, clinical pathophysiology	+	+	+
4	Pharmacology, clinical pharmacology	+	+	+
5	Hygiene	+	+	
6	Microbiology, virology	+	+	

1. 6 Requirements for the results of mastering the discipline

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

No. p / p	Code and name of competence	Code and the name of the indicator of achievement of competence	As a result of studying the academic discipline, the student must:		
			Know	**Be able to**	**To own**
Universal competencies					
1	**UK-1** Capable of carrying out a critical analysis of problematic situations based on a systems approach and developing an action strategy	**ID UK-1.1.** Analyzes a problem situation as a system, identifying its components and the connections between them. **ID UK-1.2.** Identifies gaps in information needed to solve problem situations and designs processes to eliminate them.	– the biochemical essence of biological processes, the structure and properties of the main classes of biologically important compounds, the main metabolic pathways of their transformation; – fundamentals of the structural organization and functioning of the main biomacromolecules of the cell, subcellular organelles; fundamentals of the mechanisms of intermolecular interaction.	– explain the molecular mechanisms of maintaining homeostasis under various influences of internal and external factors; – explain the molecular mechanisms of metabolic disorders that occur in some hereditary and acquired diseases, using knowledge of the main pathways of transformation of proteins, nucleic acids, carbohydrates and lipids in the human body.	– the ability to analyze the importance of biochemistry for solving medical and biological problems; – the ability to interpret the results of biochemical tests used in clinical laboratory diagnostics.
2	**UK-6** Able to identify and implement priorities for one's own activities and	**ID UK-6.1.** Assesses his personal, situational, and time resources and uses them	– biochemical essence of biological processes, structure and properties of the main	– to select biochemical methods of analysis that are adequate to the goals and objectives of the study;	– the ability to analyze the importance of biochemistry for

	ways to improve them based on self-assessment and lifelong learning	optimally to complete the assigned task. **ID UK-6.3.** Conducts critical self-analysis of the results of one's own activities.	classes of biologically important compounds, the main metabolic pathways of their transformation .	– to observe the course of chemical reactions and draw reasonable conclusions; – use the basic concepts and methods of biochemistry to characterize the state of "health" and "disease", diagnose diseases and evaluate the effectiveness of treatment.	solving medical and biological problems; – skills in biochemical diagnostics of common diseases.
3	**UK-8** Able to create and maintain in everyday life life and professional activities safe living conditions for the preservation of the natural environment, ensuring sustainable development of society, including in the event of a threat or occurrence of emergency situations and military conflicts	**ID UK-8.4.** Possesses skills for safe work in chemical, physical, biological laboratories and the ability to handle caustic, poisonous, volatile organic compounds, work with burners, spirit lamps and electric heating devices, animals.	– safety regulations and work in chemical laboratories with reagents and devices; – the biochemical essence of biological processes, the structure and properties of the main classes of biologically important compounds, the main metabolic pathways of their transformation.	– use chemical, physical and biological equipment; – explain the methods of neutralizing toxic substances in the body, using knowledge of the mechanisms of neutralizing endogenous substances and foreign compounds.	– skills in working in a chemical laboratory with reagents, chemical glassware, and measuring equipment.
General professional competencies					
4	**OPK-5** Capable of assessing morphofunctional, physiological states and pathological processes in the human body to solve professional problems	**ID OPK-5.1.** Knows the functional systems of the human body, their regulation and self-regulation when interacting with the external environment under normal conditions and during pathological processes.	– mechanisms of enzymatic catalysis; features of the enzymatic composition of organs; basic principles of diagnosis and treatment of diseases associated with	– o explain the therapeutic action of certain drugs using knowledge of the molecular processes and structures that are the target of these drugs ; – analyze possible routes of drug administration into the body, using knowledge of	– the ability to interpret the results of biochemical tests used in clinical laboratory diagnostics ; – skills in conducting biochemical

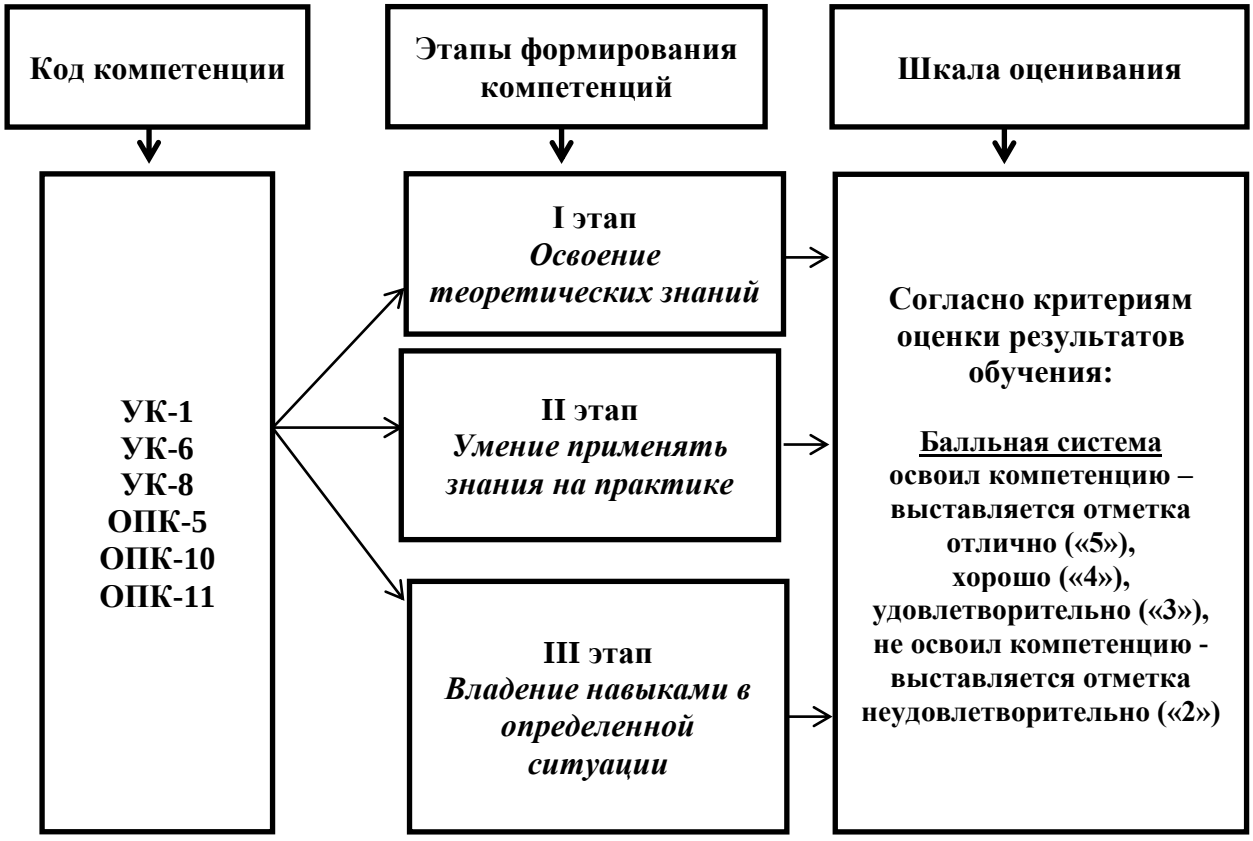
		ID OPK-5.3. Knows the indicators of the morphofunctional and physiological state of a healthy person and can measure/determine them.	impaired enzyme functioning ; – fundamentals of bioenergetics, molecular mechanisms of biooxidation , main metabolic pathways for the formation of substrates for mitochondrial and extramitochondrial oxidation systems; – the main molecular mechanisms regulating the metabolism of carbohydrates, lipids, proteins, amino acids, nucleotides, principles of hormone action; – Features of metabolism of the liver, blood, intercellular matrix, connective, nervous and muscle tissues .	the processes of digestion and absorption, and the biotransformation of drugs in the body; – evaluate data on the chemical composition of biological fluids to characterize the norm and signs of diseases; – use the basic concepts and methods of biochemistry to characterize the state of “health” and “disease”, diagnose diseases and evaluate the effectiveness of treatment.	analyses used in biochemical laboratory diagnostics, basic scientific methods of cognition used in biochemistry: observation, description, measurement, experiment.
5	**OPK-10** Able to understand the principles of operation of modern information technologies and use them to solve problems of professional activity	**ID OPK-10.2.** Conducts effective searches for information necessary to solve problems of professional activity, using legal reference systems and professional pharmaceutical databases.	– modern information capabilities for establishing the chemical and physicochemical essence of processes; – principles of biochemical analysis, diagnostically	– select biochemical methods of analysis that are adequate to the goals and objectives of the study; – use modern information capabilities to establish the chemical and physicochemical essence of processes;	– basic technologies for transforming information: text and spreadsheet editors, Internet search; – skills for independent work with educational,

			significant indicators of blood and urine composition in a healthy person and when these indicators change under pathological conditions; terminology characterizing changes in biochemical indicators; – bioinformatics algorithms .	– interpret the results of biochemical tests used in clinical laboratory diagnostics; – to observe the course of chemical reactions and draw reasonable conclusions; – work with international electronic databases on biology, medicine and bioinformatics .	scientific and reference literature.
6	**OPK-11** Capable prepare and apply scientific, scientific-production, design, organizational-managerial and regulatory documentation in the healthcare system	**ID OPK 11.3.** Interprets and applies data from physical, chemical, mathematical and other natural science concepts and methods to solve professional problems. **ID OPK-11.4.** Conducts scientific and practical research, analyzes information using the historical method and prepares publications based on the research results.	– the biochemical essence of biological processes, the structure and properties of the main classes of biologically important compounds, the main metabolic pathways of their transformation ; – bioinformatics algorithms .	– to select biochemical methods of analysis that are adequate to the goals and objectives of the study ; – interpret the results of biochemical tests used in clinical laboratory diagnostics; – to observe the course of chemical reactions and draw reasonable conclusions; – work with international electronic databases on biology, medicine and bioinformatics .	– basic technologies for transforming information: text and spreadsheet editors, Internet search; – skills for independent work with educational, scientific and reference literature.

Sections of the discipline and the code of the competence being formed

№ p / p	Section name	Code of the competence being formed
1	Static biochemistry.	UK-1, UK-6, UK-8, OPK-5, OPK-10, OPK-11
2	Dynamic biochemistry	UK-1, UK-6, UK-8, OPK-5, OPK-10, OPK-11
3	Functional biochemistry	UK-1, UK-6, UK-8, OPK-5, OPK-10, OPK-11

1.7 Stages of competence development and assessment scale



1.8 Forms of organization of students' training

Forms of organization of student training: lectures, laboratory classes (classroom work) and independent work (classroom and extracurricular).

Teaching methods: in order to implement the competence-based approach, it is recommended to use interactive forms of classes in the educational process in the form of solving situational problems, problem-based conversations, experimental proof of the proposed assumptions with subsequent conclusions; writing reports (including in foreign languages), writing essays; solving computational problems. The level of mastery of practical skills by the student is assessed during laboratory experiments, in final classes, including the final class on practical skills, and during the test.

Form of organization of students' training	Brief description
Lectures	Lecture material contains Key And most problematic questions disciplines , most significant V preparation specialist .
Laboratory exercises	Intended For analysis (consolidation) of theoretical provisions And control over their assimilation With subsequent application received

	knowledge V in the course study of the topic.
Interactive forms of learning	Solution situational tasks With subsequent discussion , implementation creative assignments , discussions .
Participation in the department's research work, student circle and conferences	Preparation oral messages and poster presentations for speeches on circle , scientific conference, abstracts , review literary And Internet sources
Types of control	**Brief description**
Incoming inspection	Testing on the course of bioorganic chemistry. The results of the entrance control are systematized, analyzed and used by the teaching staff of the department to develop measures to improve and update the methods of teaching the discipline.
Current control	Checking assignments completed independently (out of class), oral assessment of the assimilation of theoretical material; control over the technique of completion during practical classes; test control; control assignments (practical and theoretical) on the topic studied.
Border control	Scheduled colloquiums upon completion of the study of large sections of the program (see Appendix). Credit for practical skills. (Questions on diagnostic informatics and assignments on diagnostic analytics) (see Appendix).
Interim assessment	Presented by the exam, which students are renting out at the end of III Semester A. The exam includes preliminary testing in the Moodle system and an oral interview on tickets containing three theoretical questions and a situational task on laboratory diagnostics.

II . STRUCTURE AND CONTENT OF THE DISCIPLINE

2.1 Scope of the discipline and types of educational activities

Type of academic work	**Total hours**	**Semesters**	
		2nd semester	**3rd semester**
Lectures	4 0	2 0	2 0
Laboratory exercises	104	52	52
Independent work of students	72	36	36
Form of interim assessment	Exam		36
Total labor intensity in hours	**252**	**108**	**144**
Total workload in credit units	**7**	**3**	**4**

2.2 Thematic plan of lectures and their content

№ p / p	Topics and content of lectures	Codes of formed competencies	Labor intensity (hour.)
1	**Introduction to the subject. History of development and main branches of biochemistry.** Subject and tasks of biological chemistry. Place of biochemistry among other biological disciplines. Biochemistry as a molecular level of studying living things. Distinctive features of living organisms are metabolism and energy with the environment, ability to self-reproduce, high level of structural organization. Main sections of biochemistry: static, dynamic and functional biochemistry. Molecular biology. Biochemistry and medicine.	UK-1 UK-6 OPK-5 OPK-10	2
2	**Amino acids are structural components of proteins. Polypeptide theory of protein structure. Diversity and specificity of proteins. Physicochemical properties and levels of structural organization of proteins.** History of protein studies . Elemental composition of proteins. Amino acids - structural components of proteins. Polypeptide theory of protein structure. Proteins are highly organized bioorganic compounds, the most important components of living matter and the basis of life. Diversity of proteins. Physicochemical properties of proteins. Molecular weight, size and shape of protein molecules. Globular and fibrillar proteins. Solubility, ionization, hydration, precipitation from solutions. Color reactions. Methods of isolating individual proteins: precipitation with salts and organic solvents, chromatography, gel filtration , electrophoresis, crystallization. Levels of structural organization of proteins. Primary structure of proteins. Dependence of biological properties of proteins on primary structure. Species specificity of primary structure of proteins. Conformations of polypeptide chains in proteins (secondary and tertiary structures). Weak intramolecular interactions in the polypeptide chain - hydrogen bond, electrostatic and hydrophobic interactions. Disulfide bonds. Dependence of biological properties of proteins on secondary and tertiary structure. Denaturation of proteins, its reversibility. Quaternary structure of proteins. Features of biological activity of proteins with quaternary structure - cooperative changes in conformation protomers (using hemoglobin as an example in comparison with myoglobin).	UK-1 UK-6 OPK-5 OPK-10	2

	Biological functions of proteins. Plastic role and dynamic functions. Ability to specific interactions ("recognition") as the basis of biological functions of all proteins. Complementarity of the structure of the protein binding center to the structure of the ligand . Structural proteins. Proteins - enzymes, receptors, transport proteins, antibodies, protein hormones, contractile proteins. Diversity of structurally and functionally different proteins. Differences in the protein composition of organs and tissues, changes in ontogenesis and pathology.		
3	**Classification of proteins. Simple proteins. Complex proteins. Chromium o- , glyco- , lipo- , phospho- and metalloproteins .** Classification of proteins. Simple and complex proteins. Simple proteins: albumins, globulins, protamines, histones, prolamins , glutelins . Blood serum albumins and globulins, properties and functions, separation methods, diagnostic value of blood serum protein fractions. Complex proteins. Apoproteins and prosthetic groups. The nature of prosthetic groups. Chromoproteins . Hemoglobin and myoglobin. Heme is a representative of porphyrin pigments . Globin structure, chain types - alpha a- , beta-, gamma, theta- , epsilon- , zeta- , etc. Features of hemoglobin oxygenation as a protein with a quaternary structure. Hemoglobin derivatives - ox i- , carboxy- and methemoglobin. Hemoglobin types HbA , HbA2, HbF (physiological significance). Variations in the primary structure and properties of hemoglobin. Abnormal hemoglobins - HbS , HbC , etc. Hemoglobinopathies and thalassemias. Lipoproteins. Apoproteins and lipids of lipoproteins. Main classes, composition, transport functions, physiological and pathological significance. Phosphoproteins **(milk caseinogen)** . Metalloproteins . Glycoproteins.	UK-1 UK-6 OPK-5 OPK-10	2
4	**Complex proteins nucleoproteins. Molecular bases of matrix syntheses.** Nucleoproteins. Chemical nature, localization in the cell, physiological role. Nucleic acids DNA and RNA. Nucleotides. Components of nucleotides - purine and pyrimidine nitrogenous bases, pentoses. Nucleotide composition of RNA and DNA. Chargaff's rules . Primary structure of nucleic acids, biological role. Species differences. Molecular basis of concepts: genetic code - genome, gene - cistron, triplet - codon, anticodon. Identity of DNA of all cells of a multicellular organism. Secondary structure of RNA, types of RNA. Double helix of DNA, complementary polynucleotide chains. Tertiary structure of DNA - supercoiling . Plasmid DNA.	UK-1 UK-6 OPK-5 OPK-10	2

	The direction of reading genetic information: DNA - > mRNA -> protein is the basic postulate of molecular biology. DNA biosynthesis (replication). DNA-dependent DNA polymerase and RNA-dependent DNA polymerase (revertase). DNA synthesis and cell cycle phases. DNA damage and repair. RNA biosynthesis (transcription). RNA polymerase . The concept of primary transcript , post-transcriptional modifications of RNA, splicing . Biosynthesis of proteins. The concept of one gene - one protein. Collinearity of the gene and the polypeptide chain. Degeneracy of the genetic code. Assembly of polypeptide chains on the mRNA matrix on ribosomes (translation). Transfer RNAs as adaptors . The role of the tRNA anticodon . Post-translational changes in proteins: formation of oligomers, partial proteolysis , inclusion of non-protein components, formation of SS-bridges, modification of amino acids (hydroxylation , glycosylation , carboxylation , etc.). Self-assembly of multimolecular protein structures: polyenzyme complexes, cellular organelles, viral particles, collagen fibers. Half-life of different proteins. Features of antibody biosynthesis. Regulation of protein biosynthesis. The concept of operon and regulation at the transcription level. Switching genes on and off as a mechanism of cellular differentiation. Antibiotics - inhibitors of nucleic acid and protein synthesis. Genetic engineering and biotechnology. International Human Genome Project. The concept of recombinant DNA and recombinant proteins - second-generation bioproducts . Biotechnological production of insulin, STH. Molecular mechanisms of genetic variability. Point mutations: substitutions, deletions , insertions of nucleotides. The concept of mutagens. Genetic heterogeneity in the human population. Protein polymorphism, examples (hemoglobins). Molecular diseases.		
5	**History of discovery, general properties and structure of enzymes. Kinetics of enzymatic catalysis.** Enzymes are biological catalysts of protein nature. The concept of a substrate. The diversity of enzymes. The history of the discovery and study of enzymes. Chemical nature: one- and two-component enzymes. The concepts of apoenzyme, cofactor (coenzyme), holoenzyme . The role of vitamins as coenzymes (B_1 , B_2 , B_5 , B_6). Cofactors are metal ions. Complex enzymes - isoenzymes, multienzyme complexes. Specific properties due to the protein nature of enzymes - thermolability , sensitivity to pH , specificity of action, high catalytic activity. Classification and nomenclature of enzymes. Energy scheme of a chemical reaction, the concept of the energy barrier of a reaction and activation energy, the role of a catalyst. Features of enzyme catalysis. Kinetics of enzymatic reactions.	UK-1 UK-6 OPK-5 OPK-10	2

	Dependence of the rate of an enzymatic reaction on temperature, pH of the medium, concentration of the substrate and enzyme. Michaelis-Menten equation , physical meaning of Michaelis constant as a measure of enzyme affinity to substrate. Formation of enzyme-substrate complexes. Specificity of enzyme action - absolute and relative. Fisher's ("key to lock") and Koshland's (induced conformity) theories . Active and regulatory (allosteric) centers of enzymes. Allosteric enzymes - cooperative conformational changes protomers during binding of substrate and modulators. Isoenzymes - features of structure and catalytic properties using lactate dehydrogenase isoenzymes as an example .		
6	**Regulation of enzyme activity in the cell. Organ-specific enzymes. Enzymes in medicine - enzyme diagnostics and enzyme therapy .** Activators and inhibitors of enzymes. Types of inhibitors: reversible and irreversible, competitive and non-competitive. Endogenous inhibitors - antienzymes. Medicines - enzyme inhibitors. Regulation of enzyme activity in the cell: activation of proenzymes by limited proteolysis , chemical modification (phosphorylation-dephosphorylation), allosteric regulation by activators and inhibitors, feedback regulation (" retroinhibition "), induction and repression of enzyme synthesis, changes in the isoenzyme composition of tissue, compartmentalization of enzymes in the cell. Enzymes in medicine - enzyme diagnostics and enzyme therapy . Differences in enzyme composition of organs and tissues. Organ-specific enzymes, blood plasma enzymes. Changes in enzyme activity in diseases. Hereditary enzymopathies. Determination of enzyme activity , units of activity and amount of enzymes. Diagnostic value of enzyme determination in blood plasma (serum). Topical diagnostics. Application of enzymes for treatment of diseases. Immobilized enzymes. Application of enzymes as analytical reagents in laboratory diagnostics (determination of glucose, ethanol, uric acid, urea). Enzyme immunoassay and its varieties - ELISA and EMIT.	UK-1 UK-6 OPK-5 OPK-10	2
7	**Sources, transfer and accumulation of energy in the cell. Endergonic and exergonic processes. Macroergic substances . Biological oxidation.** Sources, transfer and accumulation of energy in the cell. Energy exchange - the unity of endergonic and exergonic processes. Energy-dependent (endergonic) processes in a living cell. Macroergic compounds and electrochemical potentials - two forms of energy storage in the cell. The relationship of concepts: energy exchange, biological oxidation, tissue respiration. Biological oxidation (tissue respiration) is the way to provide energy to chemotrophic organisms . Similarities and differences	UK-1 UK-6 OPK-5 OPK-10	2

	between combustion and tissue respiration. The contribution of M.V. Lomonosov and A.L. Lavoisier to understanding the nature of combustion and tissue respiration. The role of A.N. Bach and V.I. Palladin in the development of the theory of biological oxidation. Modern concepts of biological oxidation. Dehydrogenation of substrates and oxidation of hydrogen to water is the main source of energy for ATP synthesis.		
8	**Mitochondrial electron transport chain. Oxidative phosphorylation . Regulation and disorders of the respiratory chain. Microsomal oxidation. Reactive oxygen species. Antioxidants and the antioxidant system of tissues. Energy metabolism disorders.** Mitochondrial electron transport chain. Oxidative phosphorylation . Regulation of the respiratory chain. Characteristics of respiratory chain carriers. Dehydrogenases and primary hydrogen acceptors: NAD^+ and FAD. Terminal oxidation: ubiquinone , cytochromes , cytochrome oxidase . Structural organization of respiratory chain carriers in the mitochondrial membrane. Oxidation-reduction (" red-ox ") potentials. The difference in oxidation-reduction potentials of oxygen and oxidized substrates is the source of energy released during tissue respiration. Oxidative phosphorylation - coupling with respiration and accumulation of energy in the cell. Chemiosmotic hypothesis of coupling by P. Michel , its experimental confirmation in the works of V. P. Skulachev. P / O coefficient . Accumulation of energy under conditions of anaerobic dehydrogenation of substrates - substrate phosphorylation . Regulation of the electron transport chain by changing the concentration of ADP - respiratory control. Uncoupling of tissue respiration and oxidative phosphorylation . Uncouplers and inhibitors of tissue respiration. Thermoregulatory function of respiration. The electron transport chain as part of the respiratory system - inhalation of atmospheric oxygen (external respiration), binding of oxygen to hemoglobin, transport of oxygen by blood to tissues, utilization of oxygen in the respiratory chain. Microsomal oxidation. Monooxygenase enzyme system of endoplasmic membranes reticulum . Cytochrome P-450. Hydroxylation reactions . Role in anabolic reactions. Detoxification xenobiotics . Ethanol oxidation. Energy metabolism disorders in hypoxic conditions and vitamin deficiencies in vitamins B5 (PP) and B2 . Oxygen toxicity. Concepts of active forms of oxygen and free radical oxidation reactions. Antioxidant system of tissues and its main components. Antioxidants as free radical traps. Manifestations of vitamin deficiencies.	UK-1 UK-6 OPK-5 OPK-10	2

9	**Hormones and non-hormonal bioregulators . Hormones that penetrate and do not penetrate into the cell. Hormone receptors. Secondary messengers of hormones. Hormones of the hypothalamus and pituitary gland.** Humoral regulation of cell behavior and metabolism. Distinctive features of hormones: action through the blood, fairly long circulation in the bloodstream, distant nature of action, specific action on "target cells", strong biological response to a minimal amount of hormone. Classic endocrine glands. Endocrine function of various organs and tissues. A wide range of biologically active substances - hormones, growth factors and cell behavior (cytokines), neurotransmitters . Individual non-hormonal bioregulators . Chemical nature of hormones. Hormonal axis of the body: CNS - hypothalamus - pituitary gland - peripheral glands - target cells. Hormones that penetrate and do not penetrate the cell. Hormone receptors. Distinctive features of receptors are high affinity for the ligand , signal amplification during transduction. Receptors of protein-peptide hormones, steroid hormones and neurotransmitters - features of the structure and signal transmission into the cell. The role of G proteins. The mechanism of signal amplification during transmission into the cell. Intracellular mediators of hormone action: cyclic nucleotides, inositol triphosphate , diacylglycerols , Ca^{2+} ions . Cellular responses to hormones: 1) change in enzyme activity (activation, inhibition); 2) change in the number of enzymes in the cell (induction, repression of synthesis, destruction); 3) change in the permeability of cell membranes; 4) direct biological responses. Hormones of the hypothalamus and pituitary gland. Hypothalamic hormones - releasing factors (liberins and statins). Chemical nature. Effect on the secretion of pituitary hormones. Adenohypophyseal (tropic) hormones: STH, TSH, ACTH, prolactin, FSH, LH. Chemical nature and mechanism of action of tropic hormones. Effect on peripheral glands and metabolism. Intermediate lobe hormone - MSH. Neurohypophyseal peptides : vasopressin and oxytocin. Biological effects and mechanisms of action. Endocrine disorders in hypo- and hyperproduction of pituitary hormones.	UK-1 UK-6 OPK-5 OPK-10	2
10	**Hormones of the thyroid and parathyroid glands, pancreas, adrenal glands and sex glands.** Hormones of peripheral glands. Hormones of the thyroid and parathyroid glands . Thyroxine - biosynthesis, effect on oxidative processes, manifestations of hypo - and hyperfunction: myxedema , cretinism , Graves' disease, endemic goiter. Calcitonin and parathyroid hormone . Chemical nature and effect on calcium and phosphate metabolism. Regulation of calcium and phosphate content in the blood. Pancreatic hormones insulin and glucagon. Chemical nature. Mechanism of action. Regulation	UK-1 UK-6 OPK-5 OPK-10	2

	of blood glucose. Diabetes mellitus. Lifestyle and risk factors. Adrenal hormones. Adrenaline: biosynthesis, biological effects and mechanism of action. Corticosteroids - glucocorticoids . Chemical nature, biosynthesis from cholesterol, effect on carbohydrate and mineral metabolism. The concept of gluconeogenesis . Sex hormones androgens and estrogens and progestins . Effect on metabolism. Prostaglandins, thromboxanes and leukotrienes . Kinine system. Gastrointestinal hormones. Neuropeptides . Enkephalins and endorphins .		
11	**Introduction to metabolism. Digestion and absorption of carbohydrates. Glycogen metabolism in the liver. Pathways of glucose breakdown in the cell.** Stages in metabolism - digestion of nutrients, absorption of digestion products, metabolism in tissues (specific and general pathways of catabolism, biosynthesis of complex organic molecules from simple precursors), removal of end products of metabolism from the body. Methods of studying metabolism. Chemistry and digestion of carbohydrates. The main carbohydrates of animal organisms, their content in tissues, biological role. Glucose, glycogen, glycosaminoglycans - hyaluronic acid, chondroitin sulfates , heparin. Neuraminic and sialic acids. Proteoglycans of connective tissue. Glycoproteins and glycolipids of cell membranes - receptors and antigens. The main carbohydrates of food. Polysaccharides. Disaccharides. Monosaccharides . Digestion of food carbohydrates. Enzymes. Absorption. Glycogen is a reserve polysaccharide. Biosynthesis, role of insulin, UD F- glucose. Enzymes of glycogen mobilization. Activation of glycogen phosphorylase by adrenaline and glucagon. Adenylate cyclase , c-AMP , protein kinases . Congenital disorders of glycogen metabolism - glycogenoses and aglycogenoses . General characteristics of glucose breakdown pathways in the cell. Dichotomous and apotomic breakdown. Aerobic and anaerobic breakdown. End products. Significance.	UK-1 UK-6 OPK-5 OPK-10	2
12	**Anaerobic breakdown of glucose. Aerobic breakdown of glucose.** Anaerobic breakdown of glucose - glycolysis. General scheme and three stages of glycolysis. Sequence of reactions, enzymes. Dichotomy. Glycolytic Oxyreduction . Pyruvate as a hydrogen acceptor NADH, lactate formation . Substrate phosphorylation . ATP balance. Localization in the cell and physiological significance of glycolysis. Tissues with a predominance of the glycolytic type of glucose breakdown. The role of anaerobic isoforms lactate dehydrogenases - LDH $_5$ and LDH $_4$. Regulation of glycolysis, irreversible stages. Glycolytic shunt in erythrocytes, 2,3-DPG - allosteric regulator of oxygenation Hv .	UK-1 UK-6 OPK-5 OPK-10	2

	The concept of " glycogenolysis ". Fermentation, similarities and differences with glycolysis. Aerobic breakdown of glucose. Aerobic breakdown of glucose to CO_2 and H_2O . General characteristics, three stages. Pyruvate formation stage - aerobic glycolysis. Pasteur effect. Glycerophosphate shuttle mechanism of hydrogen transfer (NADH) from the cytosol to mitochondria. Crabtree effect in cancer cells. Oxidative decarboxylation pyruvate . Pyruvate dehydrogenase complex, the role of vitamins B_1 , B_2 and lipoic acid , vitamin deficiencies. Formation of acetyl-CoA . Acetyl-CoA as a universal metabolite. Tricarboxylic acid cycle . Sequence of reactions, enzymes. Formation of CO_2 , NADH, $FADH_2$. Relationship of the tricarboxylic acid cycle with the respiratory chain. Oxidative and substrate phosphorylation . Energy balance of the tricarboxylic acid cycle and aerobic breakdown of glucose. Anabolic functions of the tricarboxylic acid cycle. Anaplerotic reactions. Regulation of the tricarboxylic acid cycle. Disturbances of the tricarboxylic acid cycle in hypoxia.		
13	**Pentose cycle. Gluconeogenesis . Regulation and pathology of carbohydrate metabolism. Enzymopathies of carbohydrate metabolism. Biochemical bases of diabetes mellitus.** Pentose cycle. Glucose biosynthesis. Pentose phosphate (apotomic) pathway of glucose breakdown. Oxidative reactions to the stage of rubulose-5-phosphate. Formation of ribose-5-phosphate. Summary equation, formation of NADPH, pentose. Distribution and physiological significance. Glucose biosynthesis (gluconeogenesis) from lactic acid, pyruvate . Relationship between glycolysis and gluconeogenesis (Cori cycle). Gluconeogenesis from glycogenic amino acids and glycerol of fats. Glucocorticoids and gluconeogenesis . Regulation and pathology of carbohydrate metabolism. Allosteric mechanisms of regulation of aerobic, anaerobic pathways of glucose breakdown and gluconeogenesis . Regulation of blood sugar levels. The role of the liver, central nervous system, hormones. Glucose tolerance test (GTT). Diabetes mellitus - metabolic disorders and main biochemical manifestations. Disorders of monosaccharide and disaccharide metabolism. Mucopolysaccharidoses .	UK-1 UK-6 OPK-5 OPK-10	2
14	**Chemistry, digestion and absorption of lipids. Transport of lipids in the body.** Lipid chemistry. Definition and classification of lipids. The most important lipids of human tissues. Reserve lipids (fats) and membrane lipids (complex lipids). Lipids of human tissues. Reserve and protoplasmic lipids, composition and structure. Digestion, absorption and transport of lipids in the body. Dietary fats, physiological role, digestion. The role of bile acids and lipase. Absorption of digestion products. Choleic acids. Disorders of digestion	UK-1 UK-6 OPK-5 OPK-10	2

	and absorption of fats. Resynthesis glycerolipids in the intestinal wall, formation of chylomicrons and transport of triglycerides in the lymph and blood. Alimentary hyperlipidemia . Lipoprotein adipase . Cholesterol transport. Transport forms of lipids - lipoproteins of blood plasma. Characteristics of individual classes of lipoproteins. Atherogenic (LDL) and antiatherogenic (HDL) lipoproteins. Tissue receptors of lipoproteins. Receptor -mediated transport of cholesterol, disorders in familial hypercholesterolemia . The role of the liver in the formation and secretion of lipoproteins. Lipotropic factors.		
15	**Lipid breakdown in tissues. Beta-oxidation of fatty acids. Synthesis of fatty acids, ketone bodies, cholesterol, triglycerides and phospholipids .** Breakdown of fats in tissues. Reservation and mobilization of triglycerides in adipose tissue. Activation of tissue lipases by adrenaline and glucagon. The role of insulin. Transport of fatty acids by albumins. Physiological role of reservation and mobilization of fats, disorders in obesity. Oxidation of fatty acids. Activation of fatty acids and transport into mitochondria, the role of carnitine . Theory of beta-oxidation , sequence of reactions, enzymes. Hydrogen acceptors in oxidation of fatty acids. The fate of acetyl-CoA . Relationship of fatty acid oxidation with the TCA cycle and the respiratory chain. Energetics of fatty acid oxidation. CO_2 requirement , role of biotin. Fatty acid synthetase - multienzyme complex. Sequence of reactions and enzymes, formation of palmitic acid. Elongases and desaturases of the endoplasmic reticulum . Biosynthesis and use of acetoacetic acid. Ketogenesis , physiological significance. Pathways of formation and use of acetyl-CoA in the cell. Biosynthesis of triglycerides and phospholipids . Role of phosphatidic acid.	UK-1 UK-6 OPK-5 OPK-10	2
16	**Structure and functions of biological membranes. Regulation and pathology of lipid metabolism. Modern concepts of biochemical mechanisms of atherosclerosis development.** Lipid Bilayer - the basis of the membrane structure. Barrier and matrix functions of the lipid bilayer . Phospholipids and cholesterol are the main lipid components of the bilayer . Structural role of cholesterol in the cell plasma membrane. Minor components - glycolipids. Role in reception. Membrane proteins - enzymes, receptors, carriers, ion channels. Glycoproteins of the plasma membrane, role in intercellular contacts. General properties of membranes: liquid crystalline state of lipids, asymmetry of composition and physicochemical properties, selective permeability, active and passive transport. Features of the plasma membrane: high content of cholesterol and sphingomyelin ,	UK-1 UK-6 OPK-5 OPK-10	2

	presence of specific receptors, participation in intercellular contacts, endocytosis and exocytosis . Membranes of mitochondria, cell nucleus, lysosomes and endoplasmic reticulum . Membranes and diseases. The main mechanisms of membrane damage in pathological conditions: activation of lipid peroxidation and phospholipases . Disorders of phospholipid metabolism . Sphingolipidoses . Biosynthesis of cholesterol from acetate. Main stages. Hydroxymethylglutaryl-CoA : reductase is a key enzyme, and mevalonic acid is a key metabolite in the biosynthesis of cholesterol. Regulation of HMG-CoA activity reductases . Oxidation of cholesterol into bile acids and steroid hormones is the main route of cholesterol removal from the body. Metabolic and structural role of cholesterol in the body. The role of cholesterol in the origin of cholelithiasis. Hypercholesterolemia and modern concepts of the biochemical mechanisms of atherosclerosis development. Biochemical diagnostics of atherosclerosis. Biochemical principles of hypercholesterolemia and atherosclerosis treatment.		
17	**Digestion of proteins. Absorption of digestion products. Transport of amino acids into the cell. General reactions of amino acid metabolism. Neutralization of ammonia. Biochemical mechanisms of neutralization of toxic substances.** Dynamic state of proteins in the body. Protein reserves. Cathepsins . Antiproteases . Nitrogen balance, its types. Protein norm in nutrition. Completeness of proteins. Rational nutrition. Parenteral nutrition. Protein hydrolysates . Digestion of proteins and absorption of amino acids. Digestion of proteins. Proteases of the gastrointestinal tract - exo- and endopeptidases . Endopeptidases : pepsin, trypsin, chymotrypsin, elastase . Exopeptidases : carboxypeptidase , aminopeptidases , dipeptidases . Substrate specificity of individual proteases. Activation of inactive protease precursors by limited proteolysis . Digestion of proteins in the stomach. The role of hydrochloric acid. Digestion in the small intestine. Absorption of amino acids. Gastrointestinal hormones. Diagnostic value of gastric juice analysis. Types of gastric juice acidity. Amino acid metabolism in tissues. The fate of absorbed amino acids. Transport of amino acids into cells, gamma-glutamyl transpeptidase . General pathways of amino acid metabolism. Transamination . Transaminases . The coenzyme role of vitamin B6 . The biological significance of transamination reactions . ALT and AST are organ-specific enzymes, the diagnostic value of determining transaminase activity in blood serum. Deamination of amino acids, types. Oxidative deamination , the role of glutamate	UK-1 UK-6 OPK-5 OPK-10	2

	dehydrogenase . Indirect deamination . Formation and pathways for neutralizing ammonia. Formation of dicarboxylic acid amides. Renal glutaminase , activation in acidosis. Excretion of ammonium salts by the kidneys. Urea synthesis in the liver (Krebs ornithine cycle) is the main pathway for neutralizing ammonia in humans. Sequence of reactions, enzymes. Origin of urea nitrogen atoms. Impaired urea synthesis and excretion. Residual blood nitrogen, changes in liver and kidney diseases, diagnostic value. Decarboxylation of amino acids. Biogenic amines: histamine, serotonin , gamma-aminobutyric acid, catecholamines. Biological role. Neutralization of biogenic amines, monoamine oxidase . The fate of alpha-keto acids , reductive amination . Glycogenic and ketogenic amino acids. Complexity of the concept of "toxicity". Foreign (xenobiotics) and endogenous toxic substances. General principles of neutralization of toxic substances of hydrophobic nature - oxidation and conjugation. Monooxygenase system of membranes of endoplasmic reticulum of the liver. Cytochrome P-450, the multiplicity of its isoforms . Hydroxylation reactions . Conjugation reactions with glucuronic acid, glycine, taurine , sulfuric acid, albumins. Tissue proteolysis and medium-weight molecules. Reactive oxygen species and their role in cell damage. Chemical carcinogenesis. Antioxidant system of tissues and its main components. Excretory function of the kidneys as one of the most important detoxification mechanisms . The work of the immune system - neutralization of foreign macromolecules.		
18	**Metabolism of individual amino acids. Enzymopathies of amino acid metabolism. Interrelation of carbohydrate, lipid and protein metabolism. Biochemical bases of rational nutrition.** Metabolism of individual amino acids. Peculiarities of glycine and cysteine metabolism (participation in oxidation-reduction reactions). Metabolism of methionine. Transmethylation . Synthesis of creatine, adrenaline, phosphatidylcholines . Transfer of one-carbon groups during syntheses, the role of tetrahydrofolic acid. Manifestations of folic acid deficiency, antivitamins of folic acid - sulfonamides. Metabolism of phenylalanine and tyrosine. Synthesis of catecholamines, melanin, thyroxine. Congenital metabolic disorders - phenylketonuria , alkaptonuria and albinism. Biochemical defects, manifestations, diagnosis and prevention. Other hereditary disorders of amino acid metabolism. Metabolism of dicarboxylic amino acids. Metabolism of tryptophan - serotonin and kynurenine pathways. Formation of nicotinic acid and its role. acid cycle in metabolism. Synthesis of glucose from amino acids and glycerol of fats (gluconeogenesis). Biosynthesis of amino acids from carbohydrates and fats (glyco- and ketogenic amino acids).	UK-1 UK-6 OPK-5 OPK-10	2

	Biosynthesis of fats from carbohydrates. Inability to synthesize glucose from fatty acids in humans. Changes in metabolism during starvation. The problem of nutrition in the modern world and human health. Rational nutrition **.** Overeating. The main components of human food: carbohydrates, fats, proteins. Daily requirement, energy value, role in nutrition. Partial interchangeability of nutrients and its biochemical bases: glyco- and ketogenic amino acids, common metabolites and pathways of switching the metabolism of carbohydrates, proteins and fats. Changes in metabolism during starvation. The problem of protein deficiency and ways to solve it. Essential nutritional factors: essential amino acids, polyunsaturated fatty acids (vitamin F), vitamins. Mineral substances of food, trace elements. Regional pathologies associated with a deficiency of individual nutritional factors (trace elements, amino acids). The importance of rational nutrition for the prevention of diseases (diabetes mellitus, atherosclerosis, obesity, etc.).		
19	**Chromoprotein metabolism. Nucleoprotein metabolism .** Chromoprotein metabolism . Heme synthesis , main stages and key metabolites. Need for iron and vitamins. Iron metabolism. Transferrin and ferritin . Extrinsic and intrinsic Castle factors. Heme synthesis disorders - anemias (Fe^{2+} - deficiency , B_{12} -deficiency, B_c -deficiency). Porphyria and porphyrinuria . Hemoglobin breakdown. Sequence of reactions. Formation of indirect bilirubin. Conjugation of indirect bilirubin with glucuronic acid in the liver. Glucuronyl transferase . Pigments of blood, bile, urine and feces. Hyperbilirubinemia (jaundice): hemolytic , obstructive , hepatocellular . Jaundice of newborns. Diagnostic value of determining bilirubin and other bile pigments in the blood and urine. Nucleoprotein metabolism. Degradation of nucleic acids. Nucleases of the digestive tract and tissues. Degradation of purine nucleotides . Uric acid is the end product of purine breakdown. Concepts of purine nucleotide biosynthesis, origin of purine nucleus atoms. Inosinic acid as a precursor of adenylic and guanylic acids. Concepts of breakdown and biosynthesis of pyrimidine nucleotides. Orotic acid. Nucleotide metabolism disorders. Gout. Xanthinuria . Orotaciduria .	UK-1 UK-6 OPK-5 OPK-10	2
20	**Acid-base balance. Water-mineral metabolism. Biochemistry of muscles, nervous and connective tissue. Biochemistry of immunity.** Acid-base balance (ABS). Reaction of the environment of cells and the most important biological fluids. Constancy of ABS indicators. Physicochemical and physiological mechanisms of ABS regulation. Blood buffer systems. The mechanism of action of buffer systems. Physiological	UK-1 UK-6 OPK-5 OPK-10	2

	mechanisms - respiratory control, excretory function of the kidneys. Interaction of physicochemical and physiological mechanisms of ABS regulation. ABS disorders: acidosis and alkalosis, types (metabolic, respiratory, compensated, uncompensated). ABS study in the clinic. The role of water in life. Intracellular water, water of extracellular fluids, water bound by colloids. The most important mineral components of human tissues. The most important intra- and extracellular ions. Ionic pumps of the cell plasma membrane, active transport of ions and the emergence of electrochemical potentials on cell membranes. Sodium and potassium metabolism. Physiological role of Na^+ and K^+ ions . (Na^+ ,K^+)- ATPase , occurrence of resting and action potentials, maintenance of osmotic pressure and volume of cells and extracellular fluids, renal mechanisms of acid-base balance regulation, role of Na+ gradient in active transport of glucose and amino acids). Regulation of Na^+ , K^+ and water metabolism by antidiuretic hormone, aldosterone, ACTH, renin -angiotensin system and insulin. Water metabolism disorders - hypo- and hyperhydration . Calcium and phosphate metabolism. Mineral composition of bone tissue. The role of Ca^{2+} in blood clotting, the occurrence of the action potential and muscle contraction, and skeletal mineralization. Ca 2+ ions are a secondary messenger in the effect of biologically active substances on cells. Ca^{2+} -ATPases of the sarcoplasmic reticulum and the plasma membrane of the cell. The role of Ca 2+ ions in the activation of phospholipases and lipid peroxidation. Regulation of calcium and phosphate metabolism by calcitonin , parathyroid hormone , and vitamin D_3 . Disorders of calcium and phosphate metabolism - rickets (biochemical basis). The most important proteins of myofibrils: myosin, actin, actomyosin, tropomyosin , troponin . Molecular structure of myofibrils. Biochemical mechanisms of muscle contraction. Energy supply of muscle contractions, preference for aerobic glycolysis. The role of ketone bodies and fatty acids as the main energy substrates of the myocardium. Creatine phosphate is the main macroerg of muscle tissue, creatine kinase is an organ-specific enzyme of muscle tissue, its role in topical diagnostics. Biochemical changes in muscular dystrophies and muscle denervation . Creatinuria . Problems of neurochemistry . Chemical composition of nervous tissue. Biochemical mechanisms of occurrence of resting and action potentials. Molecular mechanisms of synaptic transmission. Choline and adrenergic synapses. Other mediators: dopamine, serotonin , GABA, histamine, glycine, glutamic acid. Regulatory neuropeptides - endorphins , enkephalins , etc. Features of energy metabolism in		

	nervous tissue - high intensity, exceptional role of aerobic breakdown of glucose. Toxic effect of keto acids on nervous tissue. Chemical composition of connective tissue. Proteins of connective tissue fibers - collagen, elastin. Features of amino acid composition. Glucosaminoglycans and proteoglycans - components of the interstitial substance. Hyaluronidase - role in inflammation. Changes in connective tissue during aging, collagenoses, wound healing. Diagnostic value of oxyprolinuria . The main proteins of the immune system (immunoglobulin superfamily): immunoglobulins (antibodies), T-receptors, proteins of the major histocompatibility complex (MHC). The structure of antibodies. Specificity of interaction with antigen. The mechanism of formation of antibody genes in the process of lymphocyte differentiation. Concepts of the structure and functions of T-receptors and MHC proteins. Mechanisms of neutralization of foreign macromolecules, bacteria, viruses, and one's own mutant cells. The concept of compliment. The role of active oxygen species in the bactericidal action of phagocytic leukocytes. Primary and secondary immune response. The reaction of the immune system to a transplant. Mechanisms of the occurrence and manifestation of immunodeficiency .		
Total hours			**40**

2.3 Thematic plan of practical classes and their content.

No. p / p	Name of the topics of practical classes	Contents of practical classes	Codes being formed competencies and indicators their achievements	Types of control	Labor intensity (hours)
	Incoming inspection	Solving test tasks and problems	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-10: ID 10.2.	Testing via Moodle outside of class time	
1	Chemistry of proteins and amino acids.	**Theoretical part:** Subject and tasks of biochemistry. Definition of the concept of proteins as high-molecular compounds and components of living things. Definition of proteins by F. Engels as the basis of life. Diversity of proteins. Proteins of animal and plant origin. Specificity of proteins. Biological functions of proteins. Amino acids are structural components of proteins. Classification, structure, general properties. 20 amino acids that make up natural proteins. Essential amino acids. Complete and incomplete proteins. Formation of peptide bonds in proteins. **Practical part:** Color reactions for proteins and amino acids. Determination of the amino acid composition of a number of food products.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
2	Structural organization of proteins. Physicochemical properties. Precipitation reactions.	**Theoretical part:** Types of bonds in proteins. Primary structure. Species specificity. Conformation of peptide chains (secondary and tertiary structures). Biological activity of proteins. Denaturation. Quaternary structure. Cooperation of protomers . Features of biological properties of proteins with quaternary structure. Biological functions of proteins. Specific interactions of the protein binding site and ligands , as well as biological functions of proteins. Molecular weight of proteins. Sizes and shapes of protein	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-1 1: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25

		molecules. Globular and fibrillary proteins. Proteins as colloids: dialysis, solubility, dissociation, amphotericity, isoelectric point. **Practical part:** Precipitation of proteins with mineral acids and heavy metal salts Separation of albumins and globulins of egg white and blood serum by the salting out method .			
3	Coursework "My biochemical passport".	**Theoretical part:** Blood as a type of connective tissue. Blood as a mirror of metabolism. Diagnostic value of blood testing. **Practical part:** Taking blood from a vein. Quantitative determination of hemoglobin in the blood by the hemichrome method . Obtaining blood serum.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
4	Classification of proteins. Simple proteins.	**Theoretical part:** Classification of proteins. Nomenclature. The most important representatives of simple proteins. Blood plasma proteins Classification of proteins by functions. Representatives. Natural peptides. Hydrolysis of simple proteins. Types, importance, application. Chromatography. **Practical part:** Quantitative determination of total protein in blood serum by the biuret method.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
5	Complex proteins. Chromium o- , glyco- , lipo- , phospho- and metalloproteins .	**Theoretical part:** Classification of complex proteins. Nature of prosthetic groups. Main classes of complex proteins. Chromoproteins. Hemoglobin, heme , globin. Specificity of hemoglobins. Human blood hemoglobins: HbA, HbA2 , fetal. Abnormal hemoglobins. Hemoglobinopathies and alasseemias . Derivatives of hemoglobin: oxy- , carbo-, carboxy- , methemoglobin. Lipoproteins , classes, chemical composition, physiological role. Glycoproteins, composition, examples. Phosphoproteins .	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25

		Practical part: Solving problems to determine the nature of complex proteins based on hydrolysis products.			
6	Molecular bases of matrix syntheses. Complex proteins nucleoproteins.	**Theoretical part:** Nucleoproteins . Nucleic acids. Structure of nucleic acids: polynucleotides , mononucleotides, nucleosides. Components of nucleic acids, purine and pyrimidine bases, pentoses, phosphate. Mononucleotides, structure, role in the body. Macroergic mononucleotides . Cyclic mononucleotides. Structural and functional properties of DNA and RNA. Molecular basis of the mechanism of matrix syntheses - biosynthesis of DNA, RNA, protein. Genetic engineering and biotechnology. Recombinant DNA and proteins. **Practical part:** Hydrolysis of yeast nucleoprotein.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
7	Colloquium on the sections “Structure and functions of proteins and amino acids”, “Molecular bases of matrix syntheses”.	**Border control** .	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2.	Border control.	3.25
8	Vitamins (laboratory work).	**Theoretical part:** Definition and classification of vitamins. History of discovery and study of vitamins. The role of vitamins in the life process. Need for vitamins and doses of vitamins. Individual representatives of fat-soluble vitamins - chemical nature, daily requirement, manifestations of vitamin deficiency (A, D, E, K). Water-soluble vitamins, individual representatives, chemical nature, daily requirement, manifestations of vitamin deficiency, coenzyme function (B_1, B_2, B_3, PP, B_6, Bc , B_{12}). Alimentary and secondary vitamin deficiencies and hypovitaminoses. 7. Methods of preventing	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25

		vitamin deficiency, vitamin preparations, fortification of food products. **Practical part:** Qualitative reactions to vitamins $_{B1}$, B2 , A and E in food products. Quantitative determination of vitamin C in food products.			
9	Chemical nature, structure and properties of enzymes.	**Theoretical part:** History of the discovery and study of enzymes. Features of enzymatic catalysis. Chemical nature of enzymes. Cofactors , coenzymes. Coenzyme role of vitamins. Properties of enzymes as biocatalysts. Nomenclature and classification of enzymes. Kinetics of enzymatic reactions. Units of measurement of enzyme activity. **Practical part:** Determination of the specificity of action, thermolability , and optimum pH of salivary amylase.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
10	Enzymes. Mechanism of action and regulation of activity. Activators and inhibitors of enzymes. Application of enzymes in medicine.	**Theoretical part:** Structure and mechanism of action of enzymes. Active and regulatory centers. Activators and inhibitors of enzymes. Antienzymes. Quaternary structure of allosteric enzymes. Interactions of protomers . Isoenzymes. Regulation of enzyme activity in the cell. Differences in the enzyme composition of tissues. Organ-specific enzymes. Changes in enzyme activity in ontogenesis and diseases. Enzymes in medicine. Enzymopathy, diagnostics, treatment. Immobilized enzymes. **Practical part:** Quantitative determination of ALT activity in blood serum by colorimetric method.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
11	Energy exchange. Sources, transfer and accumulation of energy in the cell.	**Theoretical part:** Definition of energy exchange. Interrelation of metabolism and energy. Energy sources for humans (chemotrophs). Processes of energy consumption in the body. In what process is energy released. Tissue respiration. History of the doctrine. Differences between external and tissue respiration. End products of tissue	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3.,	Frontal survey, solving situational problems, performing an experiment,	3.25

		respiration. In what process is energy accumulated in the body? Macroergic compounds and electrochemical potentials are two forms of energy storage in the cell. The source of energy released during oxidation is the difference in the rare earth potentials of the oxidizer and reducer. Explain using the example of oxidation of H_2 to H_2O . **Practical part:** Quantitative determination of catalase activity in the blood.	11.4.	ongoing monitoring	
12	Mitochondrial electron transport chain. Oxidative phosphorylation . Microsomal oxidation. Energy metabolism disorders and hypoxic states.	**Theoretical part:** Respiratory chain. Characteristics of dehydrogenases and cytochromes . Sequence of hydrogen and electron transfer. Oxidative phosphorylation . Energy coupling. Oxidative phosphorylation coefficient. R / O. Substrate phosphorylation . Uncoupling of respiration and phosphorylation . Thermoregulation. Regulation of tissue respiration. Respiratory control. Energy metabolism disorders. Oxygen toxicity. Antioxidant system of tissues , its main components. Monooxygenase enzyme system of endoplasmic reticulum membranes. reticulum . Cytochrome P-450, biological role, significance. Hydroxylation reactions . Role in anabolic reactions. Detoxification xenobiotics . Ethanol oxidation. Dioxygenase reactions, biological role, significance. **Practical part:** Solving situational problems on energy metabolism disorders.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
13	Colloquium on the sections "Enzymes", "Energy exchange, biological oxidation".	**Border control** .	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2.	Border control.	3.25
14	Hormones. General endocrinology. Hormones of the hypothalamus and pituitary gland.	**Theoretical part:** Definition of the concepts of biologically active substances, hormones, endocrine glands. Characteristic features and chemical nature of hormones. Hormone receptors. Mechanism of action of hormones. 3 groups of hormones and receptors. Intracellular mediators of hormone action. Pituitary hormones,	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3.,	Frontal survey, solving situational problems, performing an	3.25

	Hormones of the thyroid, parathyroid, and pancreas glands.	chemical nature. Mechanism of secretion regulation. Scheme: hypothalamus (releasing factors) - pituitary gland (tropic hormones) peripheral glands. Effect on metabolism. Thyroid hormones. Chemical nature. Changes in metabolism during hyper- and hypofunction of the gland. Endemic goiter and its prevention. Parathyroid hormones. Chemical nature. Effect on metabolism. Pancreatic hormones. Chemical nature. Regulation of biosynthesis and excretion. Effect on metabolism. Use in medicine. **Practical part:** Solving situational problems on hypo- and hyperfunction of hormones of the pituitary gland, thyroid and pancreas.	11.4.	experiment, ongoing monitoring	
15	Hormones of the adrenal glands and sex glands.	**Theoretical part:** Hormones of the adrenal medulla, chemical nature, regulation of their biosynthesis and secretion. Mechanism of action of adrenaline, role of c-AMP in activation of phosphorylase , effect on metabolism, clinical use. Hormones of the adrenal cortex: mineralocorticoids , structure, effect on metabolism. Clinical use. Hormones of the sex glands, chemical nature, effect on metabolism. Hormones, characteristics, examples. Prostaglandins, chemical nature and their role in regulation of metabolism. **Practical part:** Solving situational problems on hypo- and hyperfunction of adrenal hormones. Qualitative reaction to adrenaline with ferric chloride.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
16	Colloquium on the section "Hormones".	**Border control**	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2.	Border control	3.25
17	Chemistry, Digestion and Absorption of Carbohydrates. Glycogen Metabolism in the	**Theoretical part:** Biological role of carbohydrates. Carbohydrate requirements of young children. Carbohydrates of the body and food. Mono- , di- and polysaccharides. Digestion and absorption of carbohydrates in the gastrointestinal tract. Age-related features of digestion and	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an	3.25

	Liver	absorption of carbohydrates in children. Bifidus factor. The fate of absorbed glucose. Glycogen biosynthesis, the role of insulin, UDP-glucose . Features of glycogen metabolism in the ante- and neonatal periods . Glycogen mobilization, activation of phosphorylase by adrenaline, glucagon, the role of c-AMP , protein kinase . Physiological significance of glycogen synthesis and breakdown. The role of the liver and hormones in blood sugar regulation. Hereditary pathologies of glycogen synthesis and breakdown. **Practical part:** Quantitative determination of glucose content in blood serum by the glucose oxidase method.	OPK-11: ID 11.3., 11.4.	experiment, ongoing monitoring	
18	Anaerobic and aerobic breakdown of glucose.	**Theoretical part:** Anaerobic breakdown of carbohydrates - glycolysis, glycogenolysis . Three stages of glycolysis. Substrate phosphorylation . Localization in the cell. Irreversible reactions. Regeneration of NAD^+ - a condition of anaerobic glycolysis, energy value. The importance of anaerobic glycolysis in ontogenesis. Alcohol fermentation, balance equation, similarities and differences with glycolysis. Aerobic breakdown of glucose. Specific stage - oxidative Decarboxylation of PVC. The role of vitamins $B1_{,\ vitamin}$ B1 deficiency . Shuttle mechanism of NADH transfer from the cytosol to MTX. Tricarboxylic acid cycle. Sequence of reactions. Enzymes, coenzymes, vitamins $_{B1}$, B2 , B5 . The role of OXYGEN, end products, energy balance. Energy balance of aerobic glucose breakdown. Regulation of the Krebs cycle, allosteric activators, inhibitors. Connection of the TCA cycle with the respiratory chain. Disturbances in the activity of the TCA cycle, $_{hypoenergetic}$ states . **Practical part:** Qualitative reaction to lactic acid. Solving situational problems on disorders of the Krebs cycle and mitochondrial respiratory chain under hypoxic conditions.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25

19	Apotomic pathway of glucose breakdown. Glucose biosynthesis (gluconeogenesis). Regulation and pathology of carbohydrate metabolism.	**Theoretical part:** Glucose biosynthesis, gluconeogenesis , importance in fetal metabolism, regulation. Pentose , apotomic pathway of glucose breakdown, physiological role, importance for newborns. Regulation of carbohydrate metabolism at the cellular and molecular levels . Hormonal regulation . and ochemical bases of diabetes mellitus in children. Biochemical diagnostics. TSH. Enzymopathies: glycogenoses , aglycogenoses , mucopolysaccharidoses , galactosemia , fructosemia . **Practical part:** Determination of gly-NvA $_{1.}$ Determination of glucose and acetone in urine.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
20	Colloquium on the section "Chemistry, functions and metabolism of carbohydrates".	**Border control**	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2.	Border control	3.25
21	Chemistry, digestion, absorption and transport of lipids in the body. Breakdown of lipids in tissues	**Theoretical part:** Definition of the term "lipids". The importance of lipids in vital activity (plastic and energetic role). Characteristics of the lipid composition of the diet and the lipid needs of children of different ages. Classification of lipids, representatives. Triglycerides , structure, synonyms. Fatty acids, classification, representatives, structure. Fat constants: melting point, saponification number, acid number, iodine number. Brown adipose tissue, its structure, composition, functions. Phosphatides , classification, representatives, structure. Cholesterol, its esters. Bile acids. Digestion and absorption of lipids along the gastrointestinal tract in the postnatal period. The importance of bile. Absorption of lipids. Resynthesis of specific lipids. Transport of lipids in the body. Blood lipoproteins . Fat depot. Brown adipose tissue, its structure, composition, functions. Protoplasmic lipids. Breakdown of lipids in tissues. Tissue lipase, activation by adrenaline. Fatty	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25

		acid oxidation. Blood cholesterol content (normal). **Practical part:** Quantitative determination of total cholesterol content in blood serum by enzymatic method.			
22	Lipid biosynthesis. Regulation and disorders of lipid metabolism. Structure and functions of biological membranes.	**Theoretical part:** Biosynthesis of fatty acids. Synthesis of triglycerides and glycerophospholipids . Biosynthesis of cholesterol, oxidation of cholesterol, formation of bile acids. Activity of the process in children. Ketogenesis . Resistance and tendency to ketosis in children. Chemical composition and fluid - mosaic model of the structure of biological membranes. Barrier and matrix function of the lipid bilayer . Age-related features of the composition, structure and function of biomembranes . Passive transfer, facilitated diffusion and active transport of substances and ions through biological membranes. The main mechanisms of membrane damage in pathological conditions. Disorders of triglyceride metabolism in childhood. Disorders of cholesterol metabolism. The role of cholesterol in the origin of cholelithiasis and atherosclerosis. Features of cholesterol metabolism in childhood. **Practical part:** Quantitative determination of HDL P- cholesterol content in blood serum by enzymatic method. Calculation of atherogenicity index .	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
23	Colloquium on the sections “Chemistry and metabolism of lipids”, “Structure and functions of biological membranes”.	**Border control**	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2.	Border control	3.25
24	Digestion and absorption of proteins.	**Theoretical part:** Biological role of proteins in children's organism. Positive and negative nitrogen balance. Criticism of the concept of protein	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4.	Frontal survey, solving situational	3.25

		minimum. Protein standards in children's nutrition. Characteristics of protein diet of children of different ages. Social, technological problems. Completeness of proteins. Protein deficiency. Kwashiorkor . Age characteristics of protein digestion processes in the gastrointestinal tract. Activation of enzymes. Absorption of digestion products. Protein putrefaction in the intestine, detoxification in the liver. Gastric juice, composition, disorders. Analysis of gastric juice. **Practical part:** Qualitative reactions to pathological components of gastric juice. Determination of acidity of gastric juice.	OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	problems, performing an experiment, ongoing monitoring	
25	General pathways of amino acid metabolism in tissues.	**Theoretical part:** The fate of absorbed amino acids. Blood plasma proteins. Transport of AMC into cells. Pathways of AMC conversion in tissues. Transamination , chemistry, enzymes, participation of vitamin B6 , role of dicarboxylic ketones and amino acids. Clinical significance of transaminases . Deamination : direct , indirect, types of reactions for determining AMC. Decarboxylation . Pathways of ammonia neutralization in different tissues. Glutamine , asparagine. Role of amides, renal glutaminase . Synthesis of urea in the liver. Final nitrogen products excreted in urine . Residual nitrogen in the blood. Diagnostic value. **Practical part:** Quantitative determination of urea content in blood by enzymatic method.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
26	Metabolism of individual amino acids. Interrelation of carbohydrate, lipid and amino acid metabolism.	**Theoretical part:** Metabolism of glycine, cysteine, glutamic , aspartic acids, arginine. Metabolism of phenylalanine . Phenylketonuria . Metabolism of tyrosine, DOPA, melanin, alkaptonuria . Metabolism of tryptophan, histidine. Biogenic amines. Metabolism of methionine. Transmethylation : syntheses, methylation of drugs and xenobiotics . Tetrahydrofolic acid (THF) and synthesis of one-carbon groups. Sulfonamides .	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25

		Antimetabolites. Metabolism of nitrogen-free residue of amino acids. Glycogenic amino acids, gluconeogenesis , influence of glucocorticoids . Ketogenic amino acids, metabolic disorders in obesity and starvation. Acetyl-CoA is a key point of metabolism. **Practical part:** Qualitative reaction for phenylpyruvic acid.			
27	Chromoprotein metabolism.	**Theoretical part:** Chromoproteins of the human body. Role. Hemoproteins . Heme synthesis . Porphyrinuria , porphyria . Iron metabolism. Anemia, antianemic vitamins. Hemoglobin breakdown. Bile pigments. Direct and indirect bilirubin. Diagnosis of jaundice . Jaundice of newborns. **Practical part:** Quantitative determination of total, direct and indirect bilirubin in blood serum by the Van den Bergh method .	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
28	Nucleoprotein metabolism .	**Theoretical part:** purine biosynthesis ribonucleotides . Features of the biosynthesis of pyrimidine ribonucleotides . Features of deoxyribonucleotide biosynthesis. Breakdown of purine and pyrimidine nucleotides. End products. Pathology of purine metabolism. Diagnostic value of uric acid determination. The concept of glutamine antimetabolites in antiviral and antitumor therapy. **Practical part:** Quantitative determination of uric acid content in the blood.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, performing an experiment, ongoing monitoring	3.25
29	Colloquium on the sections "Metabolism of proteins and amino acids", " Interrelationship between the metabolism of carbohydrates, lipids and amino acids".	**Border control**	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2.	Border control	3.25

30	Acid-base state.	**Theoretical part:** Definition of the concept "Acid-base state" . r H of biological fluids. Regulation of "KOS", buffer systems, physiological control. Buffer systems, mechanism of action, basic equation. Interaction of buffer systems and physiological mechanism. Respiratory function of the lungs and excretory function of the kidneys. Activation of glutaminase in acidosis. Violations of "KOS". Acidosis, alkalosis, types, causes. Study of "KOS" in the clinic. Norm of "KOS" indicators. Diagnostic value of "KOS" indicators. The role of water in vital activity. Intracellular water, water of extracellular fluids, water bound by colloids. The most important mineral components of human tissues. The most important intracellular ions. Ion pumps of the cell plasma membrane, active transport of ions and the emergence of electrochemical potentials on cellular membranes . Sodium and potassium metabolism. Physiological role of Na^+ and K^+ ions . (Na^+ ,K^+)- ATPase , occurrence of resting and action potentials, maintenance of osmotic pressure. Regulation of water-salt metabolism by antidiuretic hormone, aldosterone, ACTH, renin-angiotensin system and insulin. Disturbance of water metabolism – hypo- and hyperhydration . Metabolism of calcium and phosphates, biological role of calcium, regulation. Disturbances of calcium phosphate metabolism. **Practical part:** Solving situational problems on violations of the chemical environment.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, current control	3.25
31	Blood biochemistry (laboratory work).	**Theoretical part:** Diagnostic value of determining enzyme activity in blood serum. The most important enzyme indices of blood. Origin of blood enzymes. Determination of transaminase activity . Differential diagnostic value. Norms of indices. Physiological role, methods of determination, diagnostic value of the following indices: glucose, TSH, total protein, protein fractions, hemoglobin, residual	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, current control	3.25

		nitrogen, bilirubin, cholesterol, HDL-C. **Practical part:** Quantitative determination of AST activity in blood serum by colorimetric method. Qualitative reaction to blood.			
32	Urine biochemistry (laboratory work).	**Theoretical part:** Urine as a biological fluid, its importance. Amount of urine, conditions in which diuresis changes, causes. Normal components of urine, pH , density. Pathological components of urine. Diagnostic value of urine analysis, name three groups of diseases for which urine analysis is important. Glucosuria , causes, types, methods for detecting sugar in urine. Ketonuria , causes, reactions for analysis. Proteinuria, causes, types, reaction for analysis. Hematuria, causes, reactions for analysis. Detection of bile pigments in urine. **Practical part:** Determination of physical and chemical properties of urine (pH , density), express analysis of pathological components of urine (glucose, protein, blood, ketone bodies). Quantitative determination of protein content in urine by precipitation with sulfosalicylic acid.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-5: ID 5.1, 5.3. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solving situational problems, current control	3.25
Total hours					**104**

2. 4 Interactive forms of learning

interactive methods are widely used in practical classes. training (interactive survey, work in small groups, computer testing, etc.), participation in the work of a chemical laboratory, educational research and scientific research work.

No. p\ p	Topic of practical lesson, lecture	Labor intensity in hours	Interactive forms of learning	Labor intensity in hours, in % of the lesson
1	Chemistry of proteins and amino acids.	3.25		
2	Structural organization of proteins. Physicochemical properties. Precipitation reactions.	3.25	Interactive survey	20 min., 0.33 hours, 10%.
3	Coursework "My biochemical passport".	3.25	Discussion	30 min., 0.5 hours 15%.
4	Classification of proteins. Simple proteins.	3.25	Interactive survey	
5	Complex proteins. Chromium o- , glyco- , lipo- , phospho- and metalloproteins .	3.25	Interactive survey	20 min., 0.33 hours, 10%
6	Complex proteins nucleoproteins. Molecular bases of matrix syntheses.	3.25	Discussion	30 min., 0.5 hours, 15%.
7	Colloquium on the sections “Structure and functions of proteins and amino acids”, “Molecular bases of matrix syntheses”.	3.25	Discussion	30 min., 0.5 hours, 15%.
8	Vitamins (laboratory work).	3.25	Brainstorming	30 min., 0.5 hours, 15%.
9	Chemical nature, structure and properties of enzymes.	3.25	Interactive survey	20 min., 0.33 hours, 10%.
10	Enzymes. Mechanism of action and regulation of activity. Activators and inhibitors of enzymes. Application of enzymes in medicine.	3.25	Interactive survey	20 min., 0.33 hours, 10%.
11	Energy exchange. Sources, transfer and accumulation of energy in the cell.	3.25	Round table	30 min., 0.5 hours 15%.
12	Mitochondrial electron transport chain. Oxidative phosphorylation . Microsomal oxidation. Energy metabolism disorders and hypoxic conditions.	3.25	Interactive survey	20 min., 0.33 hours, 10%.
13	Colloquium on the sections "Enzymes", "Energy exchange, biological oxidation".	3.25	Discussion	30 min., 0.5 hours, 15%.
14	Hormones. General endocrinology. Hormones of the hypothalamus and pituitary gland. Hormones of the thyroid, parathyroid, and pancreas glands.	3.25	Interactive survey	20 min., 0.33 hours, 10%.
15	Hormones of the adrenal glands and sex glands.	3.25	Interactive survey	20 min., 033 hours, 10%.
16	Colloquium on the section "Hormones".	3.25		20 min., 0.33 hours, 10%.
17	Chemistry, Digestion and Absorption of Carbohydrates. Glycogen Metabolism in the Liver	3.25	Interactive survey	20 min., 0.33 hours, 10%.
18	Anaerobic and aerobic breakdown of	3.25	Interactive	20 min.,

	glucose.		survey	033 hours, 10%.
19	Apotomic pathway of glucose breakdown. Glucose biosynthesis (gluconeogenesis). Regulation and pathology of carbohydrate metabolism.	3.25	Round table.	30 min., 0.33 hours, 10%.
20	Colloquium on the section "Chemistry, functions and metabolism of carbohydrates".	3.25	Discussion.	30 min., 0.5 hours 15%.
21	Chemistry, digestion, absorption and transport of lipids in the body. Breakdown of lipids in tissues	3.25	Brainstorming.	30 min., 0.5 hours 15%.
22	Lipid biosynthesis. Regulation and disorders of lipid metabolism. Structure and functions of biological membranes.	3.25	Discussion.	30 min., 0.5 hours 15%.
23	Colloquium on the sections “Chemistry and metabolism of lipids”, “Structure and functions of biological membranes”.	3.25	Discussion.	30 min., 0.5 hours 15%.
24	Digestion and absorption of proteins.	3.25	Interactive survey	20 min., 0.33 hours, 10%.
25	General pathways of amino acid metabolism in tissues.	3.25	Interactive survey	20 min., 0.33 hours, 10%.
26	Metabolism of individual amino acids. Interrelation of carbohydrate, lipid and amino acid metabolism.	3.25	Training	10 min., 0.16 hours, 5%.
27	Chromoprotein metabolism.	3.25	Round table	30 min. 0.33 hours, 10%.
28	Nucleoprotein metabolism .	3.25	Interactive survey.	20 min., 033 hours, 10%.
29	Colloquium on the sections "Metabolism of proteins and amino acids", " Interrelationship between the metabolism of carbohydrates, lipids and amino acids".	3.25	Discussion.	30 min., 0.5 hours 15%.
30	Acid-base state.	3.25	Solving situational problems.	30 min., 0.33 hours, 10%.
31	Blood biochemistry (laboratory work).	3.25	Discussion.	30 min., 0.33 hours, 10%.
32	Urine biochemistry (laboratory work).	3.25	Discussion.	30 min., 0.33 hours, 10%.

2.5 Criteria for assessing students' knowledge

The assessment of learning outcomes is carried out in accordance with the “Regulations on the system for assessing the learning outcomes of students of the Federal State Budgetary Educational Institution of Higher Education Amur State Medical Academy of the Ministry of Health of Russia.

The basis for determining the level of knowledge, skills, and abilities are the assessment criteria - completeness and correctness:

- correct, precise answer;
- correct but incomplete or imprecise answer
- incorrect answer; no answer.

When assigning marks, the classification of errors and their quality are taken into account:

- gross errors;
- similar errors;
- minor errors; shortcomings.

The success of students in mastering the topics of the discipline "Biochemistry" is determined by the quality of mastering knowledge, skills and practical abilities; the assessment is given on a five-point scale: "5" - excellent, "4" - good, "3" - satisfactory, "2" - unsatisfactory.

Evaluation criteria

Quality of development	Mark on a 5-point scale
90 - 100%	"5"
80 - 89%	"4"
70 - 79%	"3"
less than 70%	"2"

Types of performance monitoring:

Entrance control is carried out with the purpose of checking individual knowledge, skills, and abilities of students necessary for successful mastery of the lesson topic.

It is carried out by the teacher in the first lesson in the form of testing in the Moodle system http://194.186.41.210/course/index.php?categoryid=25 .

Current control

Initial control - is carried out with the purpose of checking the knowledge, skills, and abilities of students necessary for successful mastering of the topic of the lesson. It is carried out by the teacher at the beginning of each lesson in the form of an oral survey, including control questions of the methodological development for self-training of students on the topics of the discipline and solving problems and exercises.

Output control – is intended to check the knowledge, skills and abilities acquired in the lesson. It is carried out in the form of performing an experiment, drawing up a protocol and computer testing.

The final grade during the current knowledge control is set as the arithmetic mean result for all types of activities provided for in this lesson of the discipline's work program. It is set on the day of the lesson for all students who are present at the lesson, since everyone must show how they have mastered the knowledge, skills and abilities of the topic.

Midterm control – is carried out with the purpose of checking the knowledge, skills, and abilities of students necessary for the successful mastery of a certain section of the program. It is carried out by the teacher in the form of a colloquium, which provides for an oral interview with the student on the questions included in the ticket

The criteria for assessing the results of extracurricular independent work of a student are:

- the level of student mastery of the educational material;
- the completeness and depth of general educational concepts, knowledge and skills on the topic being studied, to which this independent work relates;
- development of universal and general professional competencies (ability to apply theoretical knowledge in practice).

Assessment for independent work:

Completion of the initial control task (extracurricular self-study)

- the problems were solved correctly, the exercises were completed, and the test assignments were answered accurately – “passed”.
- Problems were not solved correctly, exercises were not completed correctly, test questions were not answered accurately – “failed”.

Preparation of abstracts:

- the abstract is written quite competently, the material is presented in detail, the abstract is formatted according to the requirements – “passed”.
- the abstract is not written competently enough, the material is not presented in detail, the abstract design does not meet the requirements – “failed”.

Preparation of reports for interactive classes and on students’ research (project) work:

- the material in the report is presented in detail, the educational material is well developed (based on lecture notes, educational and scientific literature) – “passed”.
- the material in the report is presented incorrectly, the educational material is poorly developed (based on lecture notes, educational and scientific literature) – “fail”.

Procedure for liquidation of current debt

If a student misses a class for a valid reason, he/she has the right to make it up and receive the maximum grade provided for by the course work program for that class. A valid reason must be documented.

If a student misses a class for an unjustified reason or receives a "2" mark for all activities in the class, he/she is required to make it up. In this case, the mark received for all activities is multiplied by 0.8.

If a student is excused from a class at the request of the dean's office (participation in sports, cultural and other events), then he is given a "pass" for this class, provided that he submits a report on the completion of mandatory extracurricular independent work on the topic of the missed class.

Intermediate assessment - the basis for determining the level of knowledge, skills, and abilities is the assessment criterion - completeness and correctness: correct, accurate answer; correct, but incomplete or inaccurate answer; incorrect answer; no answer.

of students ' mastery of the discipline, practical skills and abilities is assessed , characterized by a qualitative assessment and is assessed on a 5-point system.

Assessment criteria for midterm assessment

Stages	Mark out of 5 point scale	Binary scale
Test control in the system " Moodle "	3-5	**5 - "excellent"** **4 - "good"** **3 – “satisfactory”**
Complete completion of the practical part of the course (oral interview on questions included in the examination ticket)	3-5	
Delivery of practical skills (control of the formation of competencies)	3-5	
Test control in the system " Moodle "	2	**2 – “unsatisfactory”**
Complete completion of the practical part of the course (oral interview on questions included in the examination ticket)	2	
Delivery of practical skills (control of the formation of competencies)	2	

When assigning marks, it is necessary to take into account the classification of errors and their quality: gross errors; similar errors; non-gross errors; shortcomings.

Characteristics of digital assessment:

"5" - the student receives if he/she demonstrates a deep and complete mastery of the content of the educational material, correctly and logically presents the answer, is able to connect theory with practice,

express and substantiate his/her judgments, and formulates independent conclusions and generalizations when answering. Has mastered all the practical skills and abilities provided for by the working program of the discipline.

"4" - the student receives if he/she has fully mastered the educational material, navigates the studied material consciously, applies knowledge to solve practical problems, correctly states the answer, but the content and form of the answer have some inaccuracies or the answer is incomplete. He/she has mastered all the practical skills and abilities provided by the program, but allows for some inaccuracies.

"3" - the student receives if he/she demonstrates knowledge and understanding of the main provisions of the educational material, but presents it incompletely, inconsistently, makes inaccuracies, and is unable to substantiate his/her judgments. He/she has only some practical skills and abilities provided by the program.

"2" - the student receives if he has fragmentary, unsystematic knowledge, is unable to distinguish between the main and the secondary, presents the material in a disorderly and uncertain manner, cannot apply knowledge to solve practical problems. Performs practical skills and abilities with gross errors or there was no attempt to demonstrate his theoretical knowledge and practical skills.

Interim assessment is carried out through a 3-stage exam system:

1. **Test control of theoretical knowledge in the system " Moodle "** (http://194.186.41.210/course/index.php?categoryid=25 .). Test control of theoretical knowledge in the system " Moodle " is compiled according to the working program of the discipline, includes 200 questions.
2. **An oral interview on the questions included in the examination ticket,** containing three theoretical questions and a situational task on laboratory diagnostics.
3. **Passing practical skills.** Controlled by a separate question in the examination ticket, assessment scale "passed", "failed".

A student can automatically qualify for an “excellent” grade if he/she has won a prize in disciplinary or interdisciplinary university or regional Olympiads and has an average score of at least 4.8 points based on the current academic performance.

2.6 Independent work of students: in-class and out-of-class.

The organization of independent classroom work of students is carried out with the help of methodological instructions for students, which contain educational goals, a list of the main theoretical questions for study, a list of practical work and the methodology for conducting it, instructions for the presentation of the results obtained, their discussion and conclusions, assignments for self-control with standard answers, a list of recommended literature.

From 1/4 to 1/2 of the practical lesson time is allocated for independent work of students: conducting research, recording results, discussing them, formulating conclusions, completing individual assignments. The preparatory stage, or the formation of an approximate basis for actions, begins with students outside of class time when preparing for the practical lesson, and is completed during the lesson. All subsequent stages are carried out during the lesson. The stage of materialized actions (solving problems using an algorithm or without an algorithm, with an unknown answer in advance) is carried out independently. The teacher, if necessary, provides consultation, provides assistance and simultaneously monitors the quality of students' knowledge and their ability to apply existing knowledge to solve assigned problems.

№ p\ p	Topic of the practical lesson	Time for students to prepare for the lesson	Forms of extracurricular independent work of students	
			Mandatory and equal for all students	At the student's choice
1.	Chemistry of proteins and	2 hours	Work with recommended literature. Completing a written assignment to learn the	Make a presentation on

	amino acids		structural elements of the polypeptide chain, classifying amino acids by different , writing tripeptides .	the classification of amino acids.
2.	Structural organization of proteins. Physicochemical properties. Precipitation reactions	2 hours	Work with recommended literature. Completion of a written assignment to learn the types of bonds in proteins, levels of structural organization of proteins, interaction of protomers in oligomeric proteins, physical and chemical properties of proteins, precipitation and denaturation reactions of proteins, types of protein fractionation.	
3.	Coursework "My biochemical passport".	2 hours	Working with the information block on completing the coursework "My Biochemical Passport" and the textbook "Biochemical Diagnosis. Studying biological fluids used in biochemical laboratory diagnostics, methods of obtaining whole blood, plasma and blood serum, and the chemical composition of blood. Designing the first pages in the notebook "My Biochemical Passport".	
4	Classification of proteins. Simple proteins.	2 hours	Work with recommended literature. Completion of a written assignment on the assimilation of qualitative reactions to protein, the nature of protein hydrolysis and its types, intermediate and final products of protein hydrolysis, the importance of protein hydrolysis, classification of proteins.	Make a presentation "Simple proteins"
5.	Complex proteins. Chromium o- , glyco- , lipo- , phospho- and metalloproteins .	2 hours	Work with recommended literature. Completion of a written assignment to establish protein classes based on their hydrolysis products, study of the physiological role of individual classes of complex proteins, protein fractionation methods, and the qualitative hemoglobin reaction.	Make a presentation: " Blood plasma lipoproteins "
6.	Molecular bases of matrix syntheses. Complex proteins nucleoproteins.	2 hours	Work with recommended literature. Completion of a written assignment on the establishment of nucleoproteins , nucleotides and nucleosides by the products of their hydrolysis, writing formulas of individual nucleotides and their components, cyclic forms of nucleotides, studying complementary pairs of nitrogenous bases, the biological role of individual mononucleotides, mastering the direction of reading genetic information, individual stages of protein biosynthesis, the essence of genetic engineering and biotechnology.	Make a DNA model
7.	Colloquium on	2 hours	Working with recommended literature.	

	the sections “Structure and functions of proteins and amino acids”, “Molecular bases of matrix syntheses”.		*Preparing abstracts on proposed topics, conducting information searches in various sources of information, including access to the INTERNET and working with English-language databases on chemistry, biology and medicine. Preparing computer presentations in the program " Microsoft Power Point ».	
8.	Vitamins (laboratory work).	2 hours	Work with recommended literature. Completion of a written assignment - filling in a table with information on the classification of vitamins, their chemical nature, manifestations of vitamin deficiencies, the coenzyme role and daily requirement for individual vitamins. Solving situational problems to determine vitamin deficiencies based on the observed clinical picture of the disease.	Make a scientific review on vitamins.
9.	Chemical nature, structure and properties of enzymes.	2 hours	Work with recommended literature. Completion of a written assignment on proof of the protein nature of enzymes, general properties, nomenclature and classification of enzymes.	Make a presentation: "Properties of enzymes"
10.	Enzymes. Mechanism of action and regulation of activity. Activators and inhibitors of enzymes. Application of enzymes in medicine.	2 hours	Work with recommended literature. Completion of a written assignment on graphic representation of various types of regulation of enzyme activity, coenzyme role of a number of vitamins, kinetics of enzymatic catalysis, diagnostic significance of determination of enzyme activity and use of enzymes as medicines.	Make a stand "The use of enzymes in medicine"
11.	Energy exchange. Sources, transfer and accumulation of energy in the cell.	2 hours	Work with recommended literature. Completion of a written assignment on the characteristics of ex o- and endergonic processes, comparative characteristics of combustion and tissue respiration processes, writing chemical formulas of dehydrogenase coenzymes .	Make a presentation: "Energy Exchange"
12.	Mitochondrial electron transport chain. Oxidative phosphorylation. Microsomal oxidation. Energy metabolism disorders and hypoxic states.	2 hours	Work with recommended literature. Completion of a written assignment on the features of the respiratory chain during oxidation of carbohydrates and fatty acids, the role of vitamins and their derivatives in the work of electron carriers of the respiratory chain, features of electron transfer in the mitochondrial respiratory chain and redox chains of the endoplasmic reticulum . Solving problems on ATP	Make a presentation: "The role of hypoxia in the development of the pathological process."

			consumption during physical exertion and ATP formation in the respiratory chain using various respiratory substrates.	
13.	Colloquium on the sections "Enzymes", "Energy exchange, biological oxidation".	2 hours	Review of the material studied in the sections “Enzymes” and “Energy Exchange”, solving situational problems and *- writing abstracts on the proposed topics (see above).	
14.	Hormones. General endocrinology. Hormones of the hypothalamus and pituitary gland. Hormones of the thyroid, parathyroid, and pancreas glands.	2 hours	Work with recommended literature. Completion of a written assignment on issues of general endocrinology, chemical nature, biological effects and mechanism of action of hormones of the specified endocrine glands. Solution of situational problems on hormonal regulation disorders in a number of diseases.	
15.	Hormones of the adrenal glands and sex glands.	2 hours	Work with recommended literature. Completion of a written assignment on the chemical nature, biological effects and mechanism of action of hormones of the adrenal glands and sex glands . Solving situational problems on hormonal regulation disorders in a number of diseases.	Make a presentation: "Prostaglandins"
16.	Colloquium on the section "Hormones".	2 hours	Review of the material covered in the section, solving situational problems and *writing essays on the proposed topics (see above).	
17.	Chemistry, Digestion and Absorption of Carbohydrates. Glycogen Metabolism in the Liver	2 hours	Work with recommended literature. Completion of a written assignment on the formulas of individual carbohydrates, their biological role, characteristics of carbohydrates in food and enzymes involved in their digestion, physiological significance and chemistry of the processes of synthesis and breakdown of glycogen.	Make a literature review: "Food carbohydrates.
18.	Anaerobic and aerobic breakdown of glucose.	2 hours	Work with recommended literature. Completion of a written assignment on the features of glucose conversion and ATP synthesis during aerobic and anaerobic breakdown, energy efficiency of individual stages of glucose breakdown, the fate of NADH during aerobic breakdown and glycolysis, regulation of the Krebs cycle.	
19.	Apotomic pathway of glucose	2 hours	Work with recommended literature. Completing a written assignment on sources of glucose for the body, comparing	Make a presentation: "Diabetes

	breakdown. Glucose biosynthesis (gluconeogenesis). Regulation and pathology of carbohydrate metabolism.		glycolysis and gluconeogenesis , the role of the pentose cycle, hormonal regulation. Solving situational problems on carbohydrate metabolism disorders (diabetes mellitus, enzymopathies).	mellitus".
20.	Colloquium on the section "Chemistry, functions and metabolism of carbohydrates".	2 hours	Review of the material covered in the section, solving situational problems and *writing essays on the proposed topics (see above).	
21.	Chemistry, digestion, absorption and transport of lipids in the body. Breakdown of lipids in tissues	2 hours	Work with recommended literature. Completion of a written assignment on the classification of lipids, writing formulas of individual lipid representatives, characterization of the digestion of gastrointestinal lipids and the role of bile acids in this process, transport forms of lipids in the blood and mobilization of reserve fats.	Make a presentation: "Gastrointestinal hormones".
22.	biosynthesis . Regulation and disorders of lipid metabolism. Structure and functions of biological membranes.	2 hours	Work with recommended literature. Completion of a written assignment on the conditions of lipogenesis and lipolysis , the structure and functions of cell membranes, the role of cholesterol, LDL and HDL in the development of atherosclerosis, solving situational problems on lipid metabolism disorders.	Make a presentation: "Pathology of lipid metabolism"
23.	Colloquium on the sections “Chemistry and metabolism of lipids”, “Structure and functions of biological membranes”.	2 hours	Review of the material studied in the section, solving situational problems and *writing essays on the proposed topics (see above).	
24.	Digestion and absorption of proteins.	2 hours	Work with recommended literature. Completion of a written assignment to define the concept and types of nitrogen balance, digestion of proteins in the stomach and intestines, characteristics of individual gastrointestinal proteases, and disturbances in the acidity of gastric juice.	Make a presentation: " Proteolysis "
25.	General pathways of	2 hours	Work with recommended literature. Completion of a written assignment on	

	amino acid metabolism in tissues.		reactions of deamination , transamination and decarboxylation of amino acids, reductive amination of keto acids, ways of neutralizing ammonia in the human body. Solution of situational problems on violations of amino acid transformations in pathology.	
26.	Metabolism of individual amino acids. Interrelation of carbohydrate, lipid and amino acid metabolism.	2 hours	Work with recommended literature. Completion of a written assignment on the features of the metabolism of glycine, aromatic, sulfur-containing and dicarboxylic amino acids, congenital disorders of amino acid metabolism, the relationship between the metabolism of carbohydrates, lipids and amino acids, glycogenic and ketogenic amino acids.	
27.	Chromoprotein metabolism.	2 hours	Work with recommended literature. Completion of a written assignment on the chemistry of the processes of heme synthesis and breakdown , factors necessary for heme synthesis , diseases associated with impaired synthesis and breakdown of heme . Solving situational problems on various types of jaundice .	Make a presentation: "Types of anemia"
28.	Nucleoprotein metabolism .	2 hours	Work with recommended literature. Completion of a written assignment on reactions of synthesis and decay of purine and pyrimidine nucleotides, specific metabolites, the role of vitamins, pathology of purine nucleotide metabolism (gout).	Make a presentation: "Violation of pigment metabolism"
29.	Colloquium on the sections "Metabolism of proteins and amino acids", " Interrelationship between the metabolism of carbohydrates, lipids and amino acids".	2 hours	Review of the material covered in the section, solving situational problems and *writing essays on the proposed topics (see above).	
30.	Acid-base state.	2 hours	Work with recommended literature. Completion of a written assignment on the assimilation of buffer systems of blood and tissues, the role of kidneys and lungs in the regulation of acid-base balance. Solving situational problems on acid-base balance disorders in the clinic.	Review the scientific literature on "KOS"
31.	Blood biochemistry (laboratory	2 hours	Working with the textbook "Biochemical Diagnosis", reviewing the physiological role, physiological values of blood content	Make a stand: "Biochemical blood

	work).		and diagnostic value of determining the most important biochemical indicators in the blood, compiling situational tasks on the disruption of enzyme activity in a number of diseases.	parameters"
32.	Urine biochemistry (laboratory work).	2 hours	Working with the textbook "Biochemical Diagnosis", filling in a table containing information on physiological and pathological components of urine, qualitative reactions to pathological components of urine, the role of "dry chemistry" methods in urine analysis.	
	Total:	**72 hours**	**68 hours**	**4 hours**

2.7 Research (project) work

Research (project) work is a mandatory section of the discipline, aimed at on formation of universal and general professional competencies students .

The goal is to develop students' scientific research skills, learn to find the necessary literature, formulate the purpose and objectives of the research, work with electronic resources (international electronic databases), and examine their own health based on the results of a biochemical study of their own blood.

Tasks:

1) for necessary scientific information in international electronic databases (E-library.ru , PubMed , WOS , Scopus) ,
2) meet:
   - international bioinformatics databases (NCBI , UNIPROT , PDB , SwissProt);
   - bioinformatics algorithms for alignment of primary and tertiary protein structures (Alignment , BLAST);
   - modeling of tertiary structures of proteins (SWISS - MODEL , Himera , etc.),
3) improvement in traditional forms of work
   - writing abstracts on selected topics;
   - attendance and presentation of a report (oral or poster) at a meeting of a student scientific circle, an educational-theoretical and scientific conference;
   - participation in experimental research of department staff;
   - preparation of scientific articles and abstracts for publication, including in foreign languages.
4) complete the coursework "My biochemical passport".

The topics of the work are selected taking into account the scientific direction of the department and are carried out in the form of mastering modern methods of searching for the necessary scientific information in international electronic databases (E-library.ru , PubMed , WOS , Scopus) , familiarization with the international bioinformatics databases NCBI, UNIPROT, PDB, SwissProt and bioinformatics algorithms for aligning primary and tertiary structures of proteins (Alignment , BLAST) , modeling tertiary structures of proteins (SWISS - MODEL , Himera , etc.), as well as in the form of traditional forms - writing abstracts on selected topics, attendance and presentation of a report (oral or poster) at a meeting of a student scientific circle, educational-theoretical and scientific conference, participation in experimental research of the department staff, preparation of abstracts of reports for publication, including in foreign languages.

An important area of students' research work in studying biochemistry is the completion of the course work "My Biochemical Passport", aimed at students mastering the basics of biochemical laboratory diagnostic informatics and analytics.

During the third lesson, venous blood samples are taken from students who wish to participate in the work and who do not have contraindications (sexually transmitted diseases, viral hepatitis, etc.).

Students work with a block of information containing information on biological fluids used in laboratory diagnostics: blood, plasma and blood serum, and methods of obtaining them. In the same lesson, students determine the content of hemoglobin in their own blood samples using the hemichrome method. After blood clotting and obtaining serums , the obtained samples are stored in a frozen state throughout the entire study of biochemistry. When studying the relevant topics of the program, students determine the content of total protein, glucose, cholesterol and its fractions, aminotransferase activity in samples of their own blood serum, and master methods of express analysis of blood and urine.

The work helps students master the basics of biochemical laboratory diagnostics, namely the diagnostic significance of determining biochemical parameters of blood and urine, and acquire certain skills in the field of biochemical analytics. Students learn to interpret the results obtained.

Determining biochemical parameters in their own blood samples increases students' interest in completing the work and encourages them to read additional literature. Students who do not donate blood also complete a coursework project, determining biochemical parameters in their classmates' blood samples.

During the work, information on biochemical informatics and analytics, as well as the results obtained, are recorded in a special notebook. At the end of the year, during the exam, the examiner has the opportunity to talk to the student about the results of his work.

The publication of the teaching aid "Biochemical Diagnosis. Physiological Role and Diagnostic Value of Biochemical Parameters of Blood and Urine" prepared by the department facilitates the work. The latest fourth edition of the aid (2020) is recommended by the Coordinating Council for the Field of Education "Healthcare and Medical Sciences" as a teaching aid for students studying in the following specialties: 060101 65 - General Medicine, 06103 65 - Pediatrics. The electronic version of the aid (2020) is recommended for use in the Far Eastern medical universities of the Far Eastern Medical University of the Moscow Regional Medical Center (Vladivostok).

III . EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

3.1 Main literature

- 1. Severin , E. S. Biochemistry: textbook / ed. E. S. Severina . - 5th ed. , rev . and additional - Moscow: GEOTA R- Media , 2019. - 768 p. - ISBN 978-5-9704-4881-6. - Text : electronic // Electronic Library System "Student Consultant": [website]. - URL : https://www.studentlibrary.ru/book/ISBN9785970448816.html (date of access: 08.11.2024). - Access mode : by subscription.
- 2. Borodin E. A. Biochemical diagnosis (physiological role and diagnostic value of biochemical components of blood and urine): a tutorial / E. A. Borodin. - 5th ed., revised and enlarged. - Blagoveshchensk : Amur State Medical Academy, 2019 .-- 160 p . - Text : electronic // EBS " Bukap ": [site]. - URL: https://www.books-up.ru/ru/book/biohimicheskij-diagnoz-fiziologicheskaya-rol-i-diagnosticheskoe-znachenie-biohimicheskih-komponentov-krovi-i-mochi-13086088 / (date of access: 03/28/2023). - Access mode : by subscription.
- 3. Borodin, E. A. Biochemistry and clinical laboratory diagnostics : a tutorial / E. A. Borodin. - Blagoveshchensk : Amur State Medical Academy of the Ministry of Health of the Russian Federation, 2021. - 183 p. - Text : electronic // Lan: electronic library system. - URL: https://e.lanbook.com/book/192845 (date accessed: 03/28/2023). - Access mode: for authorized users.

3.2 Further reading

- 1. Biochemistry Workshop: Textbook / I.M. Tyupaev , A.A. Chelnokov, L.A. Egorova, D.A. Gladchenko . - Velikiye Luki: VLGAFK, 2021. - 144 p. - ISBN 978-5-6043884-8-8. - Text: electronic // Lan: electronic library system. - URL: https://e.lanbook.com/book/186404
- 2. Biological chemistry with exercises and problems: textbook / edited by S. E. Severin , A. I. Glukhov . - 3rd ed. , stereotyped. - Moscow : GEOTAR-Media , 2023. - 624 p. - ISBN 978-5-9704-7208-8. - Text : electronic // EBS “Student Consultant”: [website]. - URL : https://www.studentlibrary.ru/book/ISBN9785970472088.html (date of access: 01.12.2022). - Access mode : by subscription.
- 3. Blood and lymph. Hematopoiesis: a tutorial / L.R. Mutoshvili , O.B. Zhdanova, I.I. Okulova [et al.]. - Kirov: Kirov State Medical University, 2021. - 121 p. - Text: electronic // Lan: electronic library system. - URL: https://e.lanbook.com/book/243851
- 4. Basics of Biochemistry = Basics of biochemistry : a textbook / N.E. Petushok, A.G. Vinitskaya , A.A. Maslovskaya [et al.]; edited by V.V. Lelevich. - Grodno: GrSMU , 2021. - 400 p. - ISBN 978-985-595-326-6. - Text: electronic // Lan: electronic library system. - URL: https://e.lanbook.com/book/237335

3.3 Educational and methodological support of the discipline prepared by the staff of the department

Educational aids (Educational Methodology):

1. Borodin E.A. Biochemical diagnosis (physiological role and diagnostic value of biochemical parameters of blood and urine). Study guide approved by the Coordinating Council for the field of education "Healthcare and Medical Sciences", Blagoveshchensk, 2020 (http://194.186.41.210/course/index.php?categoryid=25 .).
2. Borodina G.P., Borodin E.A. Biochemical diagnosis (physiological role and diagnostic value of biochemical parameters of blood and urine). (http://194.186.41.210/course/index.php?categoryid=25 .) Multimedia electronic teaching aid. Blagoveshchensk, 2020 (stamp DV RUMC, Vladivostok).

Electronic and digital technologies:

1. **Online course on the subject** "Biochemistry" in the EIS FGBOU VO Amur State Medical Academy (http://194.186.41.210/course/index.php?categoryid=25).

2. **Multimedia presentations** (Microsoft Power Point 2016), to lecture-type classes, (http://194.186.41.210/course/index.php?categoryid=25 .) .
   Presentation topics:
   - Biochemistry and Life. What does biochemistry study?
   - Protein chemistry.
   - Protein biosynthesis. Genetic engineering.
   - Methods of genetic engineering.
   - Bioinformatics and medical-biological problems.
   - Bioinformatics and computer-aided drug design.
   - Personalized medicine is medicine of the 21st century.
   - Enzymes.
   - Energy exchange.
   - Hormones.
   - Lipids and their role in life.
   - Cholesterol of biological membranes. Role in physiology and pathology of cells.
   - Biological membranes.
   - Lipid metabolism disorders.

– Biochemical studies in cardiovascular diseases .

3. **Electronic teaching aids:**
Borodina G.P., Borodin E.A. Biochemical diagnosis (physiological role and diagnostic value of biochemical parameters of blood and urine). (http://194.186.41.210/course/index.php?categoryid=25 .) Multimedia electronic teaching aid. Blagoveshchensk, 2020 (stamp DV RUMC, Vladivostok).

3.4 Equipment used for the educational process

1	**Chemical glassware:**		
	Name	Quantity	Form of use
	Glassware:		
1.1	chemical test tubes	5000	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.2	centrifuge tubes	2000	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.3	glass sticks	100	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.4.	flasks of various volumes (for conducting analyses)	200	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.5	large volume flasks - 0.5- 2,0 л. (for preparing working solutions)	30	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.6	beakers of various volumes (for conducting analyses)	120	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.7	large-volume beakers - 0.2-2,0 л(for preparing working solutions) –	50	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.8	flasks of various volumes	2000	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.9	filter funnels of different diameters	200	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.10	glassware for special purposes (for distillation, extraction, chromatography, etc.).		Chemical experiments and analyses in practical classes, UIRS, NIRS
1.11	alcohol lamps	30	Chemical experiments and analyses in practical classes, UIRS, NIRS
	Porcelain dishes		
1.12	glasses of different volumes (0.2-2.0 l)	30	Preparation of reagents for practical classes
1.13	mortars and pestles		Preparation of reagents for practical classes, chemical experiments and analyses in practical classes, UIRS, NIRS
1.14	crucibles	20	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.15	evaporating cups	20	Chemical experiments and analyses in practical classes, UIRS, NIRS

	Measuring utensils:		
1.16	measuring flasks of various volumes	100	Preparation of reagents for practical classes, Chemical experiments and analyses in practical classes, UIRS, NIRS
1.17	graduated cylinders of various volumes	40	Preparation of reagents for practical classes, Chemical experiments and analyses in practical classes, UIRS, NIRS
1.18	measuring cups of various volumes	30	Preparation of reagents for practical classes, Chemical experiments and analyses in practical classes, UIRS, NIRS
1.19	measuring pipettes for different volumes (including micropipettes)	2000	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.20	mechanical automatic fixed volume dispensers	15	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.21	mechanical automatic variable volume dispensers	2	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.22	electronic automatic variable volume dispenser	1	Chemical experiments and analyses in practical classes, UIRS, NIRS
1.23	variable volume microsyringes	5	Chemical experiments and analyses in practical classes, UIRS, NIRS
2	**Technical equipment:**		
2.1	test tube racks	100	Chemical experiments and analyses in practical classes, UIRS, NIRS
2.2	pipette stands	15	Chemical experiments and analyses in practical classes, UIRS, NIRS
2.3	metal tripods	15	Chemical experiments and analyses in practical classes, UIRS, NIRS
	Heating devices :		
2.4	drying cabinets	3	Drying chemical glassware, conducting chemical analyses
2.5	air thermostats	2	Thermostating the incubation mixture when determining enzyme activity in practical classes
2.6	water thermostats	2	Thermostating the incubation mixture when determining enzyme activity in practical classes
2.7	electric stoves	3	Preparation of reagents for practical classes, chemical experiments and analyses in practical classes, UIRS, NIRS
2.8	Refrigerators with freezers "Chinar", "Biryusa", " Stinol "	5	Storage of chemical reagents, solutions and biological material for practical classes, UIRS, NIRS
2.9	Cabinets for storing chemical reagents	8	Storage of chemical reagents
2.10	Metal safe	1	Storage of toxic reagents and ethanol
3	**General purpose equipment:**		
	Scales:		
3.1	analytical dampers (ADV-200)	2	Gravimetric analysis in practical classes, UIRS, NIRS
3.2	torsion	3	Preparation of reagents for practical classes
3.3	technical	3	Preparation of reagents for practical classes
3.4	electronic	1	Preparation of reagents for practical classes
	Centrifuges:		
3.5	OPN-3	5	the sedimentation analysis method at practical occupied , UIRS and NIRS

3.6	Refrigerated ultracentrifuge CR-K24D (Germany)	1	the sedimentation analysis method at practical occupied , UIRS and NIRS
3.7	CLR	1	the sedimentation analysis method at practical occupied , UIRS and NIRS
3.8	Magnetic stirrers	2	Preparation of reagents for practical classes
3.9	Electric distiller DE-10	1	Obtaining distilled water for the preparation of reagents for practical classes, UIRS and NIRS
3.10	Thermometers	10	Temperature control during chemical analysis in practical classes, UIRS, NIRS
3.11	Hydrometer set	1	Measuring the density of solutions
4	**Special purpose equipment:**		
4.1	Paper Electrophoresis Apparatus	1	Demonstration of the method of electrophoresis of blood serum proteins in practical classes, UIRS, NIRS
4.2	Gel electrophoresis apparatus	1	Demonstration of the method of separating serum lipoproteins in practical classes, research
4.3	Equipment for column chromatography		Demonstration of the method of protein separation using chromatography in practical classes, research
4.4	Thin layer chromatography equipment.		Demonstration of the TLC method for separating lipids in practical classes, research
	Measuring equipment:		
	Photoelectric colorimeters :		
4.5	KFK-2MP	3	Measurement of light absorption of colored solutions using colorimetric methods for determining the content of analytes in practical classes, UIRS, NIRS
4.6	KFK-2	1	Measurement of light absorption of colored solutions using colorimetric methods for determining the content of analytes in practical classes, UIRS, NIRS
4.7	KFK-3	1	Measurement of light absorption of colored solutions using colorimetric methods for determining the content of analytes in practical classes, UIRS, NIRS
4.8	Photometer “SOLAR”	1	Measurement of light absorption of colored solutions using colorimetric methods for determining the content of analytes in practical classes, UIRS, NIRS
4.9	Spectrophotometer SF 16	1	Measurement of light absorption of solutions in the visible and UV spectral regions using spectral methods for determining the content of analytes and enzyme activity in practical classes, UIRS, NIRS
4.10	Clinical spectrophotometer « Schimadzu - CL–770 ”	1	Measurement of light absorption of solutions in the visible and UV spectral regions using spectral methods for determining the content of analytes and enzyme activity in practical classes, UIRS, NIRS
4.11	High-performance liquid chromatograph " Milichrom - 4".	1	Demonstration of the HPLC method (practical classes, UIRS, NIRS)
4.12	Polarimeter	1	Demonstration of optical activity of enantiomers , polarimetric method for determining glucose in practical classes
4.13	Refractometer	1	Demonstration of the refractometric method for determining

			protein content in practical classes
4.14	pH meters	3	Preparation of buffer solutions, demonstration of buffer action in practical classes, UIRCHS, NIRS
5	**Projection equipment:**		
5.1	Multimedia projector and laptop	2	Demonstration of multimedia presentations, photo and video materials during lectures and practical classes, during independent work of students, during UIRS and RRS
	Slide projectors:		Demonstration of slides during lectures and practical classes
5.2	"Pelen g- automatic"	2	
5.3	"Pelen G - semiautomatic"	1	
5.4	" Svityaz "	1	
5.6	A device for demonstrating transparent films (overhead) and a film projector.		Assigned to the morphological educational building. Demonstration of illustrative material during lectures, during UIRS and RRS
6	**Computing technology:**		
6.1	Departmental network of personal computers with Internet access	1	Access to educational resources of the INTERNET (national and international electronic databases on chemistry, biology and medicine) for teachers of the department and students during and after school hours - during practical classes, independent work of students, UIRS and RRS
6.2	Personal computers of the department staff	8	Creation of printed and electronic didactic materials by the department's teachers in the course of educational and methodological work, and use of electronic teaching aids in the course of students' independent work
6.3	Computer class for 10 seats	1	Programmed testing of students' knowledge during practical classes, tests and exams (current, midterm and final assessment of students' knowledge)

3.5. Professional databases, information and reference systems, electronic educational resources.

Resource name	Resource Description	Access	Resource address
Electronic library systems			
"Student consultant. Electronic library of the medical university"	For students and teachers of medical and pharmaceutical universities. Provides access to electronic versions of textbooks, teaching aids and periodicals.	Remote access after registration under the university profile	https://www.studentlibrary.ru/
Reference and information system " MedBaseGeotar ".	The reference and information system " MedBaseGeotar " is intended for practicing medical specialists, researchers, teachers, postgraduate students, residents, senior students, and healthcare managers for the rapid search, selection, and reading of medical literature necessary for work in a single data source.	Remote access after registration under the university profile	https://mbasegeotar.ru/pages/index.html
EBS « Bookup »	Large medical library - information and educational platform for the joint use of electronic educational, educational and methodological publications of medical universities of Russia and the CIS countries	Remote access after registration under the university profile	https://www.books-up.ru/
EBS "Lan"	Network electronic library of medical universities - an electronic database of educational and scientific works on medical topics, created for the purpose of implementing network forms of professional educational programs, open access to educational materials for partner universities	Remote access after registration under the university profile	https://e.lanbook.com/
Scientific electronic	CyberLeninka is a scientific electronic library built on	with free access	https://cyberleninka.ru/

library " CyberLeninka "	the paradigm of open science (Open Science), the main objectives of which are the popularization of science and scientific activity, public control over the quality of scientific publications, the development of interdisciplinary research, a modern institute of scientific review, increasing the citation of Russian science and building a knowledge infrastructure. Contains more than 2.3 million scientific articles.		
Oxford Medicine Online	A collection of Oxford medical publications, bringing together over 350 titles into a single, cross-searchable resource. Publications include The Oxford Handbook of Clinical Medicine and The Oxford Textbook of Medicine , the electronic versions of which are constantly updated.	with free access	http://www.oxfordmedicine.com
Human Biology Knowledge Base	Reference information on physiology , cell biology , genetics , biochemistry , immunology , pathology . (Resource of the Institute of Molecular Genetics of the Russian Academy of Sciences .)	free access	http://humbio.ru/
Medical online library	Free reference books, encyclopedias, books, monographs, abstracts, English-language literature, tests.	free access	https://www.medlib.ru/library/library/books
Information systems			
Clinical Guidelines Rubricator	A resource of the Russian Ministry of Health that contains clinical recommendations developed and approved by medical professional non-profit organizations of the Russian Federation, as well as methodological guidelines, nomenclatures and other reference materials.	link to download the application	https://cr.minzdrav.gov.ru/#!/
Federal Electronic Medical Library (FEMB)	The Federal Electronic Medical Library is part of the unified state information system in the field of healthcare as a reference system . FEMB was created on the basis of the funds of the Central Scientific Medical Library named after I.M. Sechenov.	with free access	https://femb.ru/
Russian Medical Association	Professional Internet resource. Objective: to promote effective professional activity of medical personnel. Contains the charter, personnel, structure, rules of entry, information about the Russian Medical Union.	free access	http://www.rmass.ru/
Web-medicine	The site presents a catalog of professional medical resources, including links to the most authoritative subject sites, journals, societies, as well as useful documents and programs. The site is intended for doctors, students, employees of medical universities and scientific institutions.	with free access	http: // webmed.irkutsk.ru /
Databases			
World Health Organization	The site contains news, statistics on countries that are members of the World Health Organization, fact sheets, reports, WHO publications and much more.	free access	http://www.who.int/ru/
Ministry of Science and Higher Education of the Russian Federation	The website of the Ministry of Science and Higher Education of the Russian Federation contains news, newsletters, reports, publications and much more	free access	http://www.minobrnauki.gov.ru
Ministry of Education of the Russian Federation	The website of the Ministry of Education of the Russian Federation contains news, newsletters, reports, publications and much more	free access	https://edu.gov.ru/
Federal portal "Russian education"	A single window for access to educational resources. This portal provides access to textbooks on all branches of medicine and health care.	free access	http: // www . edu.ru /
Polpred.com	Electronic library system Business media. Media Review	free access	https://polpred.com/news
Bibliographic databases			
Database "Russian Medicine"	It is created in the Central Scientific and Methodological Library and covers the entire collection, starting from	free access	https://rucml.ru/

	1988. The database contains bibliographic descriptions of articles from domestic journals and collections, dissertations and their abstracts, as well as domestic and foreign books, collections of institute proceedings, conference materials, etc. Thematically, the database covers all areas of medicine and related areas of biology, biophysics, biochemistry, psychology, etc.		
PubMed	A text database of medical and biological publications in English. The PubMed database is an electronic search engine with free access to 30 million publications from 4,800 indexed journals on medical topics. The database contains articles published from 1960 to the present day, including information from MEDLINE, PreMEDLINE , NLM. Each year, the portal is replenished with more than 500 thousand new works.	free access	https :// pubmed . ncbi . nlm . nih . gov /
eLIBRARY.RU	eLIBRARY.RU platform provides electronic versions of more than 2,000 Russian scientific and technical journals, including more than 1,000 open access journals.	Full functionality of the site is available after registration	http://elibrary.ru/defaultx.asp
Electronic library of dissertations (RSL)	Currently, the Electronic Library of Dissertations of the Russian State Library contains more than 919,000 full texts of dissertations and abstracts.	free access	http://diss.rsl.ru/?menu=disscatalog/
Medline .r u	Medical and biological portal for specialists. Biomedical journal.	with free access	https://journal.scbmt.ru/jour/index
Official Internet portal of legal information	The single official state information and legal resource in Russia	free access	http://pravo.gov.ru/

3.6 . Licensed and freely distributed software used in the educational process.

List of software (commercial software products)

No. p / p	List of software (commercial software products)	Details of supporting documents
1.	MS Operating System Windows 7 Pro	License number 48381779
2.	MS Operating System Windows 10 Pro	CONTRACT No. UT-368 from 09.21.2021
3 .	MS Office	License number: 43234783, 67810502, 67580703, 64399692, 62795141, 61350919
4.	Kaspersky Endpoint Security for business – Standard Russian Edition . 50-99 Node 1 year Educational Renewal License	Agreement No. 7 AA dated 02/07/2025
5.	1C Accounting and 1C Salary	LICENSE AGREEMENT 612/L dated 02.02.2022 (additional licenses)
6.	1C: PROF University	LICENSE AGREEMENT No. KrTsB-004537 dated 12/19/2023
7.	PROF Library	LICENSE AGREEMENT No. 2281 dated 11.11.2020
8.	Consultant Plus	Contract No. 41AA dated 12/27/2024
9.	Contour .Tolk	Agreement No. K213753/24 dated 13.08.2024
10.	E-learning environment 3KL(Russian Moodle)	Agreement No. 1362.5 dated November 20, 2024
11.	Astra Linux Common Edition	Agreement No. 142 A dated September 21, 2021
12.	Information system "Plans"	Agreement No. 2873-24 dated June 28, 2024
13.	1C: Document Management	Agreement No. 2191 dated 10/15/2020
14.	R7-Office	Agreement No. 2 KS dated 12/18/2020
15.	License "OS ROSA CHROME workstation"	Agreement No. 88A dated 08/22/2024
16.	Alt Virtualization Server 10 (for secondary specialized and higher professional education)	Agreement No. 14AK dated 09/27/2024
17.	Dr.Web Desktop Security Suite Comprehensive protection + Control Center for 12 months.	Agreement No. 8 dated October 21, 2024
18.	Software "Schedule for educational institutions"	Agreement No. 82A dated July 30, 2024

List of freely distributed software

No. p / p	List of freely distributed software	Links to license agreement
1.	Browser " Yandex "	Freely distributed License agreement for the use of Yandex Browser programs https://yandex.ru/legal/browser_agreement/
2.	Yandex.Telemost	Freely distributed License Agreement for the Use of Programs https://yandex.ru/legal/telemost_mobile_agreement/
3.	Dr.Web CureIt !	Freely distributed License Agreement: https://st.drweb.com/static/new-www/files/license_CureIt_ru.pdf
4.	OpenOffice	Freely distributed License: http://www.gnu.org/copyleft/lesser.html
5.	LibreOffice	Freely distributed License: https://ru.libreoffice.org/about-us/license/
6.	VK Calls	Freely distributed https://vk.com/license
7.	Kaspersky Free Antivirus	Freely distributed https://products.s.kaspersky-labs.com/homeuser/Kaspersky4Win2021/21.16.6.467/english-0.207.0/3830343439337c44454c7c4e554c4c/kis_eula_en-in.txt

3.7. Resources of the information and telecommunications network "Internet"

- The e-mail address of the Amur State Medical Academy library should be replaced with https://amurgma.ru/obuchenie/biblioteki/biblioteka-amurskoy-gma/
- The e-mail address of the Electronic Library System "Student Consultant" should be replaced with https://www.studentlibrary.ru

IV . ASSESSMENT TOOLS FUND

4.1. Current test control, final.

4.1.1 Examples of entrance control test tasks (with standard answers)

Tests in the system « Moodle » http://194.186.41.210/course/index.php?categoryid=25 . Total number of tests - 100.

1. BIOORGANIC CHEMISTRY STUDIES:
    1. structure, composition, properties of organic substances
    2. metabolism
    3. elemental composition of organic substances
    4. energy exchange
2. ORGANOGENIC ELEMENTS ARE:
    1. C, H, O, N, S, P
    2. N, S, P , Cu , C
    3. C, Cu , O N, S, P
    4. N, O, Si , Cu , C
3. THE MOST GENERAL CLASSIFICATION FEATURES OF ORGANIC COMPOUNDS ARE:
    1. the nature of the hydrocarbon skeleton and functional group
    2. presence of heteroatom
    3. aromaticity
    4. nature of connection

Answer standards **:** 1 - 1; 2 - 1; 3 - 1.

4.1.2 Examples of test tasks for current control (with standard answers).
Tests in the system " Moodle " http://194.186.41.210/course/index.php?categoryid=25
Total number of tests - 200.

1. CONTINUE THE SENTENCE "THE SPECIFICITY OF ENZYME ACTION IS DETERMINED BY..."
    1. By decreasing the activation energy
    2. The nature of the coenzyme
    3. Structure of the active center
    4. Structure of the regulatory center
    5. The action of activators and inhibitors
2. WHICH ENZYME IS CHARACTERISTIC OF ABSOLUTE SPECIFICITY OF ACTION?
    1. Pepsin
    2. Trypsin
    3. Amylase
    4. Urease
    5. Lipase
3. WHICH INDICATOR CHARACTERIZES THE AFFINITY OF AN ENZYME TO A SUBSTRATE?
    1. Reaction speed
    2. Maximum reaction speed
    3. Reaction rate constant
    4. Michaelis constant
    5. Equilibrium constant

Answer samples **:** 1 - 3; 2 - 4; 1 - 4.
4.1.3 Examples of midterm assessment test tasks (with standard answers)
Tests in the system " Moodle " http://194.186.41.210/course/index.php?categoryid=25 .
Total number of tests - 200.

1. WHICH AMINO ACIDS IS A MONOAMINODICARBOXYLIC ACIDS?
    1. Glycine
    2. Arginine
    3. Valin
    4. Glutamic
    5. Serene
2. SPECIFY THE PROPERTIES FOR METHIONINE
    1. Contains a labile methyl group
    2. Polarity
    3. Sour character
    4. Gives a Foley reaction
    5. Replaceability
3. WHICH AMINO ACID PROVIDES THE ACIDIC NATURE OF PROTEINS?
    1. Lysine
    2. Glutamic
    3. Arginine
    4. Alanine
    5. Cysteine

Answer standards **:** 1 - 4; 2 - 1; 1 - 2.

4.1.4 Examples of test tasks for the final assessment (with standard answers)
Tests in the system " Moodle " http://194.186.41.210/course/index.php?categoryid=25 .
Total number of tests - 200.

1. WHICH FUNCTION IS NOT CHARACTERISTIC OF BLOOD PLASMA PROTEINS:
    1. Oxygen transport
    2. Regulation of osmotic pressure
    3. Amino acid reserve
    4. Transport of various substances
2. IN WHICH AMINO ACIDS REACTIONS ARE AMINES FORMED?
    1. decarboxylation
    2. transamination
    3. deamination
    4. reductive amination
3. WHAT IS NOT A WAY TO DECONTAMINATE AMMONIA IN THE BODY
    1. decomposition into hydrogen and nitrogen
    2. formation of amides of dicarboxylic acids
    3. urea synthesis
    4. reductive amination

Answer standards **:** 1 - 1; 2 - 1; 3 - 1.

4.2 Situational tasks, exercises

Task 1. A 28-year-old man complains of excess weight, increased appetite, and general weakness. On examination: grade III obesity . On examination: fasting glycemia is 5.2 mmol /l, 2 hours after the glucose tolerance test - 8.1 mmol /l. Diuresis is 1.3 liters. Your conclusion.

Answer: The man has impaired glucose tolerance.

Problem 2. A 48-year-old woman complains of periodic dry mouth and moderate thirst. Her medical history shows that she has had one birth, the baby weighs –4 кг 200 г. On examination: grade I obesity . On examination: fasting glycemia – 5.6 mmol /l, repeated – 6.6 mmol /l. Provide an evaluative interpretation of the analysis results.

Answer: The woman may have latent diabetes. It is necessary to measure the fasting blood glucose level several times and perform a glucose tolerance test.

Task 3. Patient S., 20 years old, complains of dry mouth, thirst, frequent urination, weight loss. He notes a deterioration in his health after the flu. During examination: fasting glycemia is 10.2 mmol / l, sugar up to 2% is detected in the urine, no acetone. Repeatedly: glycemia is 12.5 mmol / l, sugar up to 2.5% in the urine, acetone "+". Daily diuresis is 3.2 liters. Provide an evaluative interpretation of the examination results.

Answer: The patient has manifest diabetes mellitus.

4.3 List of practical skills that a student should have after mastering the discipline.

Students should know the normal values of the following indicators in the blood, the principles of methods for their determination, diagnostic value, and be able to interpret the results of the analysis:

1. Determination of hemoglobin in the blood by the methemoglobin cyanide method.
2. Determination of total protein in blood serum by the biuret method using a ready-made reagent kit.
3. Determination of protein fractions of blood serum by paper electrophoresis.
4. Determination of blood glucose by the glucose oxidase method, TSH, construction of sugar curves.

5. Determination of cholesterol in the blood using the Ilk method and the enzymatic method.
6. low- and high-density lipoprotein cholesterol .
7. Determination of residual nitrogen in blood with Nessler reagent .
8. Determination of blood urea (" Urotest ").
9. Determination of bilirubin and fractions in blood serum using a reagent kit.
10. transaminase activity AST and ALT in the blood using a reagent kit.
11. Students should be able to perform rapid urine analysis to detect pathological components, know the diagnostic value and interpretation of the results.
12. Detection of glucose, acetone, protein, and blood in urine.

4.4 List of questions for the exam

1. Subject and objectives of biochemistry.
2. Amides of dicarboxylic acids, structure, formation, role. Renal glutaminase , activation in acidosis.
3. Bile acids, examples, structure, meaning.
4. The most important signs of life from the standpoint of biochemistry. Metabolism as a unity of assimilation and dissimilation processes, synonyms, essence.
5. Proteins, structure, characteristics of secondary and tertiary structure.
6. Mononucleotides, synonyms, structure, examples, meaning.
7. Enzymes, classification and nomenclature, examples.
8. Carbohydrates of the body, characteristics, examples, meaning.
9. Tricarboxylic acid cycle, general characteristics.
10. Proteins, primary structure, methods of its study.
11. Enzymes, regulation of action, allosteric activators and inhibitors.
12. Macroergs , characteristics. ATP, structure, value.
13. Enzymes, the importance of determining activity in the clinic. Organ-specific enzymes.
14. Glucose, meaning. Paths of transformation in the body.
15. The structure of hemoglobin, derivatives and varieties.
16. Protein specificity and its causes.
17. Structure of complex enzymes. Apoenzyme and coenzyme, their nature and role in enzymatic catalysis.
18. Glycogenolysis , process characteristics, enzymes.
19. Heterotrophic and autotrophic organisms, differences in nutrition and energy sources.
20. General reactions of amino acid metabolism.
21. Glucose, aerobic pathway of conversion.
22. Coenzymes and cofactors , examples, chemical nature, importance of vitamins.
23. Triglycerides , catabolism, general scheme of transformations.
24. End products of nitrogen metabolism, examples. The fate of ammonia.
25. Enzymes, characteristics, specificity of action, examples.
26. Structural polysaccharides (hyaluronic , chondroitin sulfuric acids) – composition, characteristics, value. Hyaluronidase .
27. Digestion and absorption of proteins in the gastrointestinal tract. Disorders.
28. Mechanism of action of insulin.
29. Triglycerides , biosynthesis, starting materials.
30. Transamination , characteristics, examples, enzymes, significance. History of the discovery of enzymes (A.E. Braunstein). The role of vitamin B_6 .
31. DNA, RNA, types, structure, meaning, biosynthesis. Genetic engineering and biotechnology.
32. Enzymes. General properties of enzymes as biocatalysts of protein nature.
33. Acid -base state, definition of the concept. Buffer systems of blood.
34. Peptides, structure, properties, nomenclature. Biologically active peptides.
35. Endergonic and exergonic reactions, characteristics, examples of reactions.
36. Metabolism of phenylalanine and tyrosine. Violations.

37. Classification of amino acids. Examples.
38. Fatty acids - main classes, beta-oxidation, transformation scheme.
39. Acid -base imbalances in the body.
40. The main sections and directions of biochemistry: bioorganic, dynamic, functional, molecular biology, their tasks.
41. Enzymes. Active and regulatory centers.
42. Triglycerides . Scheme of catabolism.
43. Thyroid hormones, chemical nature, meaning.
44. Thyrotoxic and endemic goiter, myxedema, manifestations.
45. Glycolysis, essence of the process, transformation scheme, meaning.
46. Triglycerides , localization in the body, energy value.
47. Enzymes, chemical nature, general characteristics.
48. Glucose biosynthesis – gluconeogenesis . Essence, significance, regulation.
49. Triglycerides , metabolic disorders - hypertriglyceridemia , obesity, fatty liver, ketosis .
50. Methods for studying the amino acid composition of proteins (hydrolysis, chromatography).
51. Hormones that penetrate and do not penetrate into the cell. Intracellular mediators of hormone action.
52. Ketogenesis . Ketone bodies.
53. Molecular weight of proteins, methods of determination.
54. Glycolytic oxidoreduction . Substrate phosphorylation during glycolysis. Mineral composition of the body, characteristics, examples, meaning. Regulation of mineral metabolism.
55. Proteins, physical and chemical properties (dispersity, amphotericity, hydrophilicity).
56. Krebs cycle, characteristics of dicarboxylic acids, sequence of reactions.
57. Cholesterol transport in the body. Cholesterol metabolism disorders.
58. The importance of biochemistry for the clinical thinking of a physician.
59. Proteins, quaternary structure. Cooperative properties of oligomeric proteins on the example of hemoglobin oxygenation .
60. Bile pigments, origin, types, meaning of definition.
61. Genetic code, biochemical essence, meaning.
62. Pentose cycle, transformation scheme, meaning.
63. Types of gastric acidity disorders.
64. Dehydrogenases , characteristics, structure, significance. The role of vitamins PP and B_2 .
65. Biosynthesis of blood plasma proteins. Physiological functions of individual blood plasma proteins.
66. Bile, composition, meaning. Causes of digestive disorders in cholecystitis.
67. Simple proteins - proteins. Main classes.
68. Dependence of the rate of enzymatic reactions on the concentration of the substrate, the amount of enzyme, temperature, pH . Krebs cycle, characteristics, synthesis of citric acid.
69. The place of biochemistry among other biological disciplines.
70. Complex proteins – proteids. Characteristics, structure, nature of prosthetic groups, classification.
71. Glycolysis, dichotomy reaction, formation of trioses , their structure, aldolase .
72. Proteins, classification by particle shape, examples of proteins.
73. Degradation of purine nucleosides. Gout.
74. Diabetes mellitus, metabolic state, glucose tolerance test.
75. Vitamins, general characteristics, examples, importance in metabolism. Hypo- and avitaminosis.
76. Glycogen biosynthesis in the liver, transformation scheme, significance. Pancreatic juice, composition, significance. Causes of digestive disorders in pancreatitis.
77. Flavin enzymes, characteristics of the prosthetic group. Vitamin B2 , importance in metabolism.
78. Regulation of blood glucose levels.
79. Biosynthesis of cholesterol.
80. Content of concepts: energy metabolism, biological oxidation, tissue respiration.
81. Glycogen breakdown in the liver – glycogenolysis . Reaction scheme, regulation, significance.
82. Blood, chemical composition, characteristics of blood plasma proteins.

83. Dynamic state of proteins in the body, characteristics.
84. Biosynthesis of fatty acids, transformation scheme. The importance of biotin.
85. Types of gastric juice acidity. Norm.
86. Compartmentalization of metabolism in the cell, essence, meaning.
87. Deamination , types, significance. Fate of the nitrogen-free residue.
88. Common products between individual types of metabolism, examples, meaning.
89. Anabolism, synonyms, characteristics, essence of the process, examples of violations.
90. Oxidative transformation of beta-hydroxybutyric acid to final products, transformation scheme.
91. Physiological mechanisms of acid-base balance regulation - the role of the lungs and kidneys.
92. Enzyme inhibitors: reversible, irreversible, competitive.
93. Alcoholic fermentation, essence, transformation scheme, balance equation.
94. Water, importance in life, water exchange, regulation.
95. Proteins, methods of fractionation (salting out , electrophoresis, Sephadex). Clinical significance of protein electrophoresis.
96. Antioxidant system of tissues, its main components.
97. Protein rotting in the intestines, detoxification, the importance of FAFS.
98. Isoenzymes, characteristics. Lactate dehydrogenase isoenzymes , diagnostic value.
99. Structural organization of the respiratory chain. Characteristics of cytochromes .
100. Heme synthesis . Main stages. Disorders - prorphyria and porphyrinuria .
101. Biochemistry and medicine (the importance of biochemistry for the formation of clinical thinking of a physician).
102. Violation of energy metabolism. Inhibitors and uncouplers of respiration and phosphorylation .
103. Glycolysis and fermentation, similarities and differences, balance equations. Nucleoside triphosphates , structure, examples, meaning.
104. Glycogenosis and aglycogenosis , characteristics of conditions, causes.
105. Breakdown of hemoglobin. Direct and indirect bilirubin.
106. Hormones of the posterior pituitary gland, chemical nature, biological effects. The relationship of the Krebs cycle with the respiratory chain.
107. Biosynthesis of purine nucleotides. Causes of increased need for folic acid during pregnancy.
108. Oxidative phosphorylation , essence, meaning. Uncoupling of respiration and phosphorylation .
109. Hormones of the anterior pituitary gland, chemical nature, tropic action, significance.
110. The fate of the nitrogen-free residue of amino acids. Glycogenic and ketogenic amino acids.
111. The use of enzymes in medicine.
112. Catabolism of PVC to CO_2 and H_2O , main stages.
113. NAD - structure, meaning.
114. Quantitative characteristics of enzyme activity, units of measurement.
115. Acetyl-CoA as a central metabolite.
116. The importance of the liver in metabolism.
117. Complete and incomplete proteins, characteristics, examples.
118. Microsomal oxidation (hydroxylation reactions). Oxidation of cholesterol, products.
119. Gastric juice, composition, meaning.
120. Abnormal hemoglobins. Hemoglobinopathies .
121. Oxidation of ethanol in the liver. Biochemical basis of addiction to alcohol.
122. Regulation of acid-base balance in the body. Blood buffer systems.
123. Vitamin B_1 , coenzyme role, metabolic disorders in avitaminosis.
124. Chemical nature of hormones, main classes.
125. Transport forms of lipids - lipoproteins of blood plasma. Main classes, role in transport of triglycerides and cholesterol.
126. Classification of amino acids, representatives, replaceable and essential amino acids.
127. Mineralocorticoids . Chemical nature, role in metabolism.
128. Lipids and proteins of cell membranes, their functions and role.
129. Glucocorticoids , chemical nature, role in metabolism.

130. Oxidative decarboxylation of PVC. Significance, reactions, coenzymes.
131. Antianemic vitamins. Castle factors .