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: 50AB2242604E645208520614FA420034A
Владелец: Жуковец Ирина Валентиновна
Действителен: с 15.04.2025 до 09.07.2026

WORKING PROGRAM

discipline "Bioorganic chemistry in medicine"

Specialty: 31.05.01 General Medicine
Course: 1
Semester: 1
Total hours: 108 hrs.
Total credits: 3 credits .
Control form – credit, 1 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

1. EXPLANATORY NOTE

1.1. Characteristics of the discipline

Modern bioorganic chemistry is a diversified field of knowledge, the foundation of many medical and biological disciplines, primarily biochemistry, molecular biology, genomics , proteomics and bioinformatics , immunology, and pharmacology.

The program is based on a systematic approach to constructing the entire course on a single theoretical basis, based on the concepts of the electronic and spatial structure of organic compounds and the mechanisms of their chemical transformations. The material is presented in the form of 5 sections, the most important of which are: " Theoretical foundations of the structure of organic compounds and factors determining their reactivity", "**Biologically important classes of organic compounds**" and "**Biopolymers and their structural components. Lipids**".

The program is aimed at specialized teaching of bioorganic chemistry in a medical university, in connection with which the discipline is called "bioorganic chemistry in medicine". The profiling of teaching bioorganic chemistry is the consideration of the historical relationship between the development of medicine and chemistry, including organic chemistry, increased attention to classes of biologically important organic compounds (heterofunctional compounds, heterocycles , carbohydrates, amino acids and proteins, nucleic acids, lipids) as well as biologically important reactions of these classes of compounds). A separate section of the program is devoted to the consideration of the pharmacological properties of some classes of organic compounds and the chemical nature of some classes of drugs.

Considering the important role of "oxidative stress diseases" in the structure of modern human morbidity, the program pays special attention to free radical oxidation reactions, detection of end products of free radical lipid oxidation in laboratory diagnostics, natural antioxidants and antioxidant drugs . The program provides for consideration of environmental issues, namely the nature of xenobiotics and the mechanisms of their toxic effect on living organisms.

1.2. Purpose and objectives of the discipline.

The purpose of teaching the discipline: to develop in students an understanding of the role of bioorganic chemistry as the foundation of modern biology, a theoretical basis for explaining the biological effects of bioorganic compounds, the mechanisms of drug action and the creation of new drugs. To lay the foundation for knowledge of the relationship between the structure, chemical properties and biological activity of the most important classes of bioorganic compounds, to teach how to apply the acquired knowledge when studying subsequent disciplines and in professional activities.

Learning objectives of the discipline :

1. Formation of knowledge of the structure, properties and reaction mechanisms of the most important classes of bioorganic compounds, which determine their medical and biological significance.
2. Formation of ideas about the electronic and spatial structure of organic compounds as a basis for explaining their chemical properties and biological activity.
3. Development of skills and practical abilities:
   - classify bioorganic compounds according to the structure of the carbon skeleton and functional groups;
   - use the rules of chemical nomenclature to designate the names of metabolites, drugs, xenobiotics ;
   - determine reaction centers in molecules;
   - be able to carry out high-quality reactions that have clinical and laboratory significance.

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 - specialist in specialty 31.05.01 General Medicine (2020), the discipline "Bioorganic Chemistry

in Medicine" refers to the optional part of block 1. The total workload is 3 credits (108 hours), taught in the 1st semester in the 1st year. Type of control - credit.

The basic knowledge required to study the discipline is formed in a cycle of mathematical and natural science disciplines: physics, mathematics; medical informatics; chemistry; biology; anatomy, histology, embryology, cytology; normal physiology; microbiology, virology.

Discipline "Bioorganic chemistry in medicine" I am a prerequisite for studying the following disciplines: biochemistry; pharmacology; microbiology, virology; immunology; professional disciplines.

Parallel subjects studied to provide interdisciplinary connections within the core curriculum: chemistry, physics, biology.

The discipline "Bioorganic Chemistry in Medicine" consists of five sections, which present the most important and necessary information that determines the educational process.

1. Classification, nomenclature and modern physical and chemical methods for studying bioorganic compounds;
2. Theoretical foundations of the structure of organic compounds and factors determining their reactivity.
3. Biologically important classes of organic compounds.
4. Biopolymers and their structural components. Lipids.
5. Pharmacological properties of some classes of organic compounds. Chemical nature of some classes of drugs.

1.4 Requirements for students

The initial level of knowledge and skills that a student must have when starting to study the discipline "Bioorganic Chemistry in Medicine" corresponds to the requirements for knowledge and skills in organic chemistry for applicants to universities.

Mathematics
Knowledge **:** algebraic operations, logarithmic and power functions;
Skills: perform calculations using mathematical formulas, solve algebraic equations.
Skills: works with mathematical apparatus and computer technology to perform calculations using a known formula, statistical processing of experimental results.
Physics
Knowledge: the fundamentals of the atomic-molecular theory of matter, the basic physical properties of biologically important inorganic and organic substances in various states of aggregation.
Skills **:** predict the interaction of light with matter - transmission, absorption, reflection, scattering .
Skills: works with mathematical apparatus and computer technology to perform calculations of physical quantities characterizing the behavior of substances.
Organic Chemistry
Knowledge: the basic laws of chemical reactions, the properties of the main classes of organic substances, the structure of molecules and the nature of chemical bonds, genetic relationship of classes of organic compounds.
Skills **:** predict the possibilities and results of chemical interactions between substances in aqueous solutions.
Skills: works on computer equipment for modeling the spatial structure of organic molecules.
Biology
Knowledge: genetic code, chemical basis of heredity and variability.
Skills **:** traces the connection between biological and chemical processes occurring in nature and living organisms.
Skills: works with computers to search for necessary information about the chemical and biological role of substances.

1.5 Interdisciplinary links with subsequent disciplines

The knowledge and skills acquired in studying the discipline of bioorganic chemistry in medicine are necessary for studying the following disciplines:

No. p / p	Name of subsequent disciplines	Section numbers of the discipline required for studying subsequent disciplines				
		1	2	3	4	5
1	Chemistry	+	+	+	+	+
2	Biology	+	-	-	+	+
3	Biochemistry	+	+	+	+	+
4	Microbiology, virology	+	+	-	+	+
5	Immunology	+	-	-	-	+
6	Pharmacology	+	+	-	+	+
7	Hygiene	+	-	+	+	+

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.	- mathematical methods for solving intellectual problems and their application in medicine; - the chemical essence of the processes occurring in a living organism at the molecular, cellular, tissue and organ levels; - kinetic laws that determine the course of chemical and biochemical processes; - chemical aspects of the most important biochemical processes in the body: theoretical foundations of bioenergetics, factors influencing the shift in the balance of biochemical processes.	- carry out elementary statistical processing of experimental data; - predict the direction and result of chemical transformations of organic compounds and biologically active substances;	- skills in solving situational problems in all sections of the discipline; - the main scientific methods of cognition used in chemistry: observation, description, measurement, experiment; - basic technologies for transforming information: text and spreadsheet editors, Internet search.
2	**UK-6** Able to identify and implement priorities for one's own activities and ways to improve them based on self-assessment and lifelong learning	**ID UK-6.1.** Assesses his personal, situational, and time resources and uses them optimally to complete the assigned task. **ID UK-6.3.** Conducts critical self-analysis of the results of	- the main mechanisms of reactions of organic compounds; - the main types of oxidation-reduction reactions in life processes. - electronic effects of substituents and their influence on the reactivity of molecules; - acidity and basicity of various	- use chemical, physical and biological equipment; - carry out elementary statistical processing of experimental data; - classify chemical compounds based on their structural formulas; - use IUPAC nomenclature to	- skills of independent work with educational, scientific and reference literature; - skills in solving situational problems in all sections of the discipline; - the main scientific methods of cognition used in chemistry: observation,

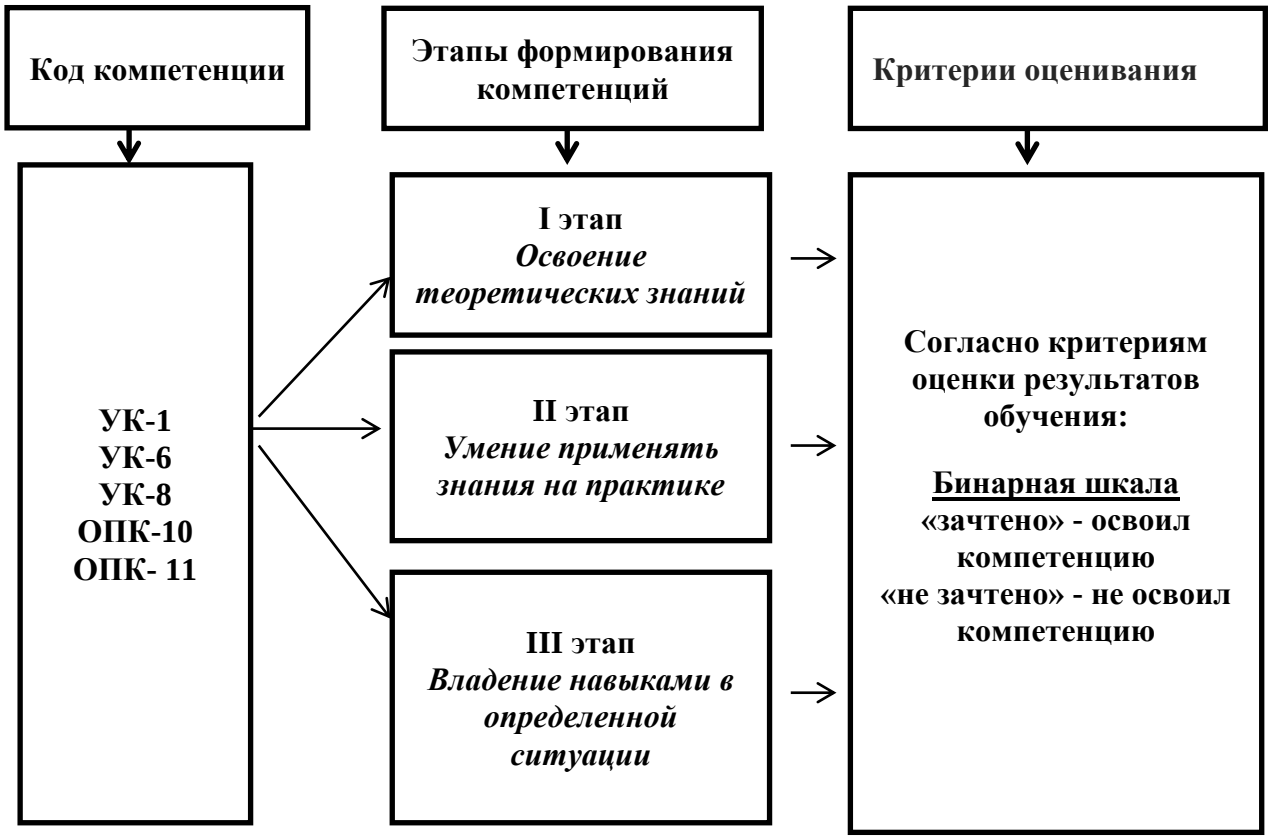
		his/her own activities.	classes of organic compounds, factors determining these properties; - the mechanism of action of the body's buffer systems, their interrelationships and role in maintaining the acid-base balance of the body ; - structure, chemical properties of the main classes of biologically important organic compounds.	create names based on the formulas of typical representatives of biologically important substances and medicinal products.	description, measurement, experiment.
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 rules and work in chemical laboratories with reagents and devices; - properties of water and aqueous solutions; - methods of expressing the concentration of substances in solutions, methods of preparing solutions of a given concentration; - the influence of acid-base properties on the reactivity of organic substances; - chemical methods of analysis in medicine (titrimetric , chromatographic , colorimetric); -pharmacological properties and toxic effects of some classes of organic compounds.	- use chemical, physical and biological equipment; - carry out elementary statistical processing of experimental data; - classify chemical compounds based on their structural formulas; - determine reaction centers in molecules.	- skills for safe work in a chemical laboratory with chemical glassware, reagents, electrical devices; - the main scientific methods of cognition used in chemistry: observation, description, measurement, experiment.
General professional competencies					
4	**OPK-10** Able to understand the principles of operation of modern information	**ID OPK-10.2.** Conducts effective searches for information necessary to solve	- mathematical methods for solving intellectual problems and their application in medicine; - the chemical essence of the	- conduct observations of the course of bioorganic reactions; - use IUPAC nomenclature to create names based on the	- skills of independent work with educational, scientific and reference literature;

	technologies and use them to solve problems of professional activity	problems of professional activity, using legal reference systems and professional pharmaceutical databases.	processes occurring in a living organism at the molecular, cellular, tissue and organ levels; - structure, chemical properties of the main classes of biologically important organic compounds.	formulas of typical representatives of biologically important substances and medicinal products.	- skills in solving situational problems in all sections of the discipline; - basic technologies for transforming information: text and spreadsheet editors, Internet search.
5	**OPK-11** Capable of preparing and applying 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.	- mathematical methods for solving intellectual problems and their application in medicine; - thermodynamic and kinetic laws that determine the course of chemical and biochemical processes; - methods of expressing the concentration of substances in solutions, methods of preparing solutions of a given concentration; - physicochemical methods of analysis in medicine (titrimetric , chromatographic , colorimetric).	- perform calculations based on the results of the experiment, carry out elementary statistical processing of experimental data; - predict the direction and result of physical and chemical processes and chemical transformations of biologically active substances.	- the main scientific methods of cognition used in chemistry; - the ability to interpret the chemical side of laboratory tests; - basic technologies for transforming information: text and spreadsheet editors, Internet search.

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

№ p / p	Section name	Code of the competence being formed
1	Classification, nomenclature and modern physical and chemical methods of studying bioorganic compounds	UK-1, UK-6, UK-8, OPK-10, OPK-11
2	Theoretical foundations of the structure of organic compounds and factors determining their reactivity.	UK-1, UK-6, UK-8, OPK-10, OPK-11
3	Biologically important classes of organic compounds.	UK-1, UK-6, UK-8, OPK-10, OPK-11
4	Biopolymers and their structural components. Lipids.	UK-1, UK-6, UK-8, OPK-10, OPK-11
5	Pharmacological properties of some classes of organic compounds. Chemical nature of some classes of drugs.	UK-1, UK-6, UK-8, OPK-10, OPK-11

1.7 Stages of competencies development and description of assessment scales



1. 8 Forms of training organization and types of control

Form of organization of students' training	**Brief characteristic**
Lectures	Lecture material contains Key And most problematic questions disciplines , most significant V preparation specialist .
Practical classes	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 and exercises followed by discussion , - interactive survey; - execution creative tasks , - discussions, - round table, - brainstorming - online course of the discipline in the Moodle system , - testing in the Moodle system .
Participation in the department's research work, student circle and conferences	- participation in the work of the educational chemical laboratory of the department; - Preparation oral messages and poster presentations for speeches at a student club or scientific conference; - writing theses and abstracts on the chosen scientific field; - preparation of a literature review using educational, scientific, reference literature and Internet sources .
Types control	**Brief characteristic**
Incoming inspection	Testing on the course of organic chemistry (school program). 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 (outside the classroom); oral assessment of the assimilation of theoretical material; control over the technique of performing laboratory work during practical classes; test control in the Moodle system on all topics of the discipline; control assignments (practical and theoretical) on the studied topic.
Interim assessment	The midterm assessment is represented by a test, which students are renting out at the end of I semester a. The test includes testing in the Moodle system , an oral interview using tickets containing three theoretical questions , check of assimilation practical skills And skills .

2. STRUCTURE AND CONTENT OF THE DISCIPLINE

2.1 Scope of the discipline and types of educational activities

No. p / p	Types of educational work	Total hours	Semester I
1	Lectures	20	20
2	Practical classes	52	52
3	Independent work of students	36	36
	Total labor intensity in hours	**108**	**108**
	Total workload in credit units	**3**	**3**

2.2 Thematic plan of lectures and their brief content

№ p / p	Topics and content of lectures	Codes formed competencies	Labor intensity (hours)
1	**Introduction to the subject. History of the development of bioorganic chemistry, its importance for biology and medicine. Classification and nomenclature of bioorganic compounds.** Bioorganic chemistry as a branch of chemistry that studies the structure and mechanism of functioning of biologically important molecules from the standpoint of organic chemistry. Subject, tasks and methods of bioorganic chemistry. Reasons why bioorganic compounds provide biological functions. Organic chemistry is the fundamental basis of bioorganic chemistry. Bioorganic chemistry is the foundation of biological chemistry. Commonalities and differences between the subjects of organic, bioorganic and biological chemistry. The importance of bioorganic chemistry in the system of medical education. The contribution of the domestic school of scientists to the development of bioorganic chemistry. Classification and classification features of organic compounds: the structure of the carbon skeleton and the nature of the functional group. Functional groups, organic radicals. Biologically important classes of organic compounds: alcohols, phenols, thiols , ethers, sulfides, aldehydes, ketones, carboxylic acids and their derivatives, sulfonic acids. Homologous series. Genetic relationships between classes as the basis for chemical evolution. Types of nomenclature: trivial and international (systematic) IUPAC nomenclature. Types of international nomenclature - substitution and radical-functional nomenclature. The importance of knowing the nomenclature of organic compounds for a doctor. Basic algorithms of systematic nomenclature. Elements of structure: parent structure, characteristic functional group, substituents (radicals, minor functional groups, halogens). Seniority of functional groups, their endings as a prefix or main function. Physicochemical methods of isolation and study of organic compounds that are important for	UK-1 UK-6 OPK-10	2

	biomedical analysis: extraction, chromatography, polarimetry , infrared and ultraviolet spectroscopy, mass spectrometry.		
2	**Theory of the structure of organic compounds by A.M.Butlerov. Isomerism as a specific phenomenon of organic chemistry. Spatial representations in organic chemistry.** Theory of the structure of organic compounds by A.M.Butlerov. Basic provisions. Structural formulas. The nature of the carbon atom by its position in the chain. Isomerism as a specific phenomenon of organic chemistry. Types of isomerism. Spatial representations in organic chemistry. The tetrahedral model of the carbon atom. The most important concepts of stereochemistry - conformation and configuration. Stereochemical formulas. Conformations of open chains. Rotation around a single bond as a cause of the emergence of various conformations . Newman projection formulas . Spatial convergence of certain sections of the chain as one of the reasons for the preferential formation of five- and six-membered cycles. Energy characteristics of conformational states: eclipsed , stunted, skewed conformations . Conformations (chair, bath) of cyclic compounds (cyclohexane). Axial and equatorial bonds. Conformations and reactivity of molecules. Factors influencing the conformation of molecules. The significance of conformations of biologically important molecules.	UK-1 UK-6 OPK-10	2
3	**Mutual influence of atoms: causes of occurrence, types and methods of its transfer in molecules of organic compounds. Acidity and basicity of organic compounds.** Conjugation. Conjugation in open chains (Pi-Pi). Conjugated bonds. Diene structures in biologically important compounds: 1,3-dienes (butadiene), polyenes , alpha, beta-unsaturated carbonyl compounds, carboxyl group. Conjugation as a factor in system stabilization. Conjugation energy. Conjugation in arenes (Pi-Pi) and in heterocycles (p-Pi). Aromaticity. Criteria of aromaticity. Aromaticity of benzenoid (benzene, naphthalene, anthracene, phenanthrene) and heterocyclic (furan, thiophene, pyrrole, imidazole, pyridine, pyrimidine, purine) compounds. Widespread occurrence of conjugated structures in biologically important molecules (porphine , heme , etc.). Bond polarization and electron effects (inductive and mesomeric) as a cause of uneven distribution of electron density in a molecule. Substituents - electron donors and electron acceptors . The most important substituents and their electronic effects. Electronic effects of substituents and the reactivity of molecules. The orientation rule in the benzene ring, substituents of the first and second kind. Acidity and	UK-1 UK-6 OPK-10	2

	basicity of neutral molecules of organic compounds with hydrogen-containing functional groups (amines, alcohols, thiols , phenols, carboxylic acids). Acids and bases according to Brønsted-Lowry and Lewis. Conjugate pairs of acids and bases. Acidity and anion stability. Quantitative assessment of the acidity of organic compounds by the values K_a and pK_a. Acidity of various classes of organic compounds. Factors determining the acidity of organic compounds: electronegativity of the non-metal atom (C-H, NH, and OH acids); polarizability of the non-metal atom (alcohols and thiols , thiol poisons); nature of the radical (alcohols, phenols, carboxylic acids). Basicity of organic compounds. n-bases (heterocycles) and pi-bases (alkenes , alkadienes , arenes). Factors determining the basicity of organic compounds: electronegativity heteroatom (O- and N-bases); polarizability of a non-metal atom (O- and S-bases); nature of the radical (aliphatic and aromatic amines). The importance of acid-base properties of neutral organic molecules for their reactivity and biological activity. Hydrogen bond as a specific manifestation of acid-base properties. General patterns of reactivity of organic compounds as a chemical basis for their biological functioning.		
4	**Mechanisms of reactions of organic compounds. Oxidation and reduction of organic compounds.** Classification of reactions of organic compounds by result - substitution, addition, elimination, rearrangement, oxidation-reduction and by mechanism - radical, ionic (electrophilic , nucleophilic). Types of rupture of covalent bonds in organic compounds and the particles formed: homolytic rupture (free radicals) and heterolytic rupture (carbocations and carboanions). Electronic and spatial structure of these particles and factors determining their relative stability. Homolytic reactions of radical substitution in alkanes involving C-H bonds of sp_3 - hybridized carbon atom. Free radical oxidation reactions in living cells. Active (radical) forms of oxygen. Antioxidants. Biological significance. Electrophilic addition reactions (A_e): heterolytic reactions involving pi bonds. Mechanism of ethylene halogenation and hydration reactions. Acid catalysis. Effect of static and dynamic factors on the regioselectivity of reactions. Features of addition reactions of hydrogen-containing substances to the pi-bond in unsymmetrical alkenes . Markovnikov's rule . Features of electrophilic addition to conjugated systems. Electrophilic substitution reactions (S_e): heterolytic reactions involving an aromatic system. The mechanism of electrophilic substitution reactions in arenes. Sigma complexes . Alkylation , acylation , nitration, sulfonation, halogenation reactions of arenes . Orientation rule . Substituents of the first and second kind. Features of	UK-1 UK-6 OPK-10	2

	electrophilic substitution reactions in heterocycles . Orienting effect of heteroatoms . Nucleophilic substitution reactions (S_n) at the sp3-hybridized carbon atom: heterolytic reactions caused by polarization of the sigma bond carbon-heteroatom (halogen derivatives, alcohols). Effect of electronic and steric factors on reactivity of compounds in nucleophilic substitution reactions. Hydrolysis reaction of halogen derivatives . Alkylation reactions of alcohols, phenols, thiols , sulfides, ammonia and amines. Role of acid catalysis in nucleophilic substitution of hydroxyl group. Deamination of compounds with primary amino group. Biological role of alkylation reactions . Elimination reactions (dehydrohalogenation , dehydration). Increased CH-acidity as a cause of elimination reactions accompanying nucleophilic substitution at sp3 - hybridized carbon atom. Nucleophilic addition reactions (An): heterolytic reactions involving - carbon-oxygen pi-bond (aldehydes, ketones). Classes of carbonyl compounds. Representatives . Preparation of aldehydes, ketones, carboxylic acids. Structure and reactivity of the carbonyl group. Effect of electronic and spatial factors. Mechanism of reactions An : the role of protonation in increasing the reactivity of carbonyl . Biologically important reactions of aldehydes and ketones - hydrogenation, oxidation-reduction of aldehydes (dismutation reaction), oxidation of aldehydes, formation of cyanohydrins , hydration, formation of hemiacetals , imines . Aldol reactions addition . Biological significance. Nucleophilic substitution reactions at the sp_2 -hybridized carbon atom (carboxylic acids and their functional derivatives). The mechanism of nucleophilic substitution reactions (S_n) at the sp2-hybridized carbon atom. Acylation reactions - formation of anhydrides, esters, thioesters , amides - and their reverse hydrolysis reactions. Biological role of acylation reactions . Acidic properties of carboxylic acids at the O-H group. Oxidation and reduction reactions of organic compounds. Redox reactions, electron mechanism. Oxidation states of carbon atoms in organic compounds. Oxidation of primary, secondary and tertiary carbon atoms. Oxidizability of various classes of organic compounds. Oxygen utilization pathways in the cell. Energy oxidation. Oxidase reactions. Oxidation of organic substances is the main source of energy for chemotrophs . Plastic oxidation. Oxygenase reactions. Reduction of organic compounds.		
5	**Stereoisomerism . Biologically important heterocycles .** Configuration. Definition. Enantiomerism and diastereomerism as types of configurational isomerism. Chirality of molecules of organic compounds as a cause of optical isomerism. Stereoisomerism of molecules with one center of chirality (enantiomerism). Optical activity. Glyceraldehyde as a configuration standard. Fischer	UK-1 UK-6 OPK-10	2

	projection formulas. D and L-system of stereochemical nomenclature. Concepts of R,S-nomenclature . Stereoisomerism of molecules with two or more centers of chirality : enantiomerism and diastereomerism . Stereoisomerism in a series of compounds with a double bond (pi-diastereomerism). Ci s- and trans-isomers . Stereoisomerism and biological activity of organic compounds. Classification of heterocycles . Five-membered rings with one heteroatom . Pyrrole, furan, thiophene. Tetrapyrrole compounds (porphin , porphyrins , heme - biological role. Indole and its derivatives - tryptophan, tryptamine , serotonin . 5-nitro derivatives of furan - furacilin , furazolidone as bactericidal drugs. Tetrahydrothiophene as a component of vitamin H - biotin. Five-membered cycles with two heteroatoms . Pyrazole, imidazole, thiazole . Imidazole derivatives - histidine and histamine. Derivatives of 5-hydroxypyrazole as antipyretic and analgesic agents (antipyrine, amidopyrine, analgin, butadion). Thiazole derivatives - vitamin B_1 and norsulfazole. Thiazolidine as a component of penicillin antibiotics. Six-membered rings with one heteroatom . Pyridine, quinoline, isoquinoline , acridine. Pyridine derivatives - nicotinic acid and its amide (the basis of the structure of NA D(F) $^+$, participation in biological oxidation), pyridine as the basis of the structure of the analgesic promedol , isonicotinic acid and the anti-tuberculosis drugs tubazid and ftivazid , pyridoxal (vitamin B6). Quinoline derivatives - the alkaloid quinine, the bactericidal drugs enteroseptol and 5-NOC. The isoquinoline nucleus as the basis of opium alkaloids - antispasmodics (papaverine) and analgesics (morphine). Acridine derivatives - disinfectants. Six-membered rings with two heteroatoms . Pyrimidine and its derivatives - uracil , thymine , cytosine as components of nucleic acids. Pyrimidine derivatives - drugs: potassium orotate , methylthiouracil , barbiturates. Participation of pyrimidine in the formation of vitamin B 1. Bicyclic (condensed) heterocycles . Purine and its derivatives - adenine and guanine as components of nucleic acids. Oxyderivatives of purine - hypoxanthine , xanthine , uric acid. Biological role. Definition and classification of vitamins. History of the discovery and study of vitamins. The role of vitamins in vital activity. The need for vitamins and doses of vitamins. Alimentary and secondary avitaminosis and hypovitaminosis. Hypervitaminosis. Individual representatives of fat-soluble and water-soluble vitamins - chemical nature, daily requirement, manifestations of avitaminosis, coenzyme and other roles in the body. Antivitamins. Methods of preventing vitamin deficiency, vitamin preparations, fortification of food products. Alkaloids. Definition. Distribution in nature. Chemical		

	nature and classification. Alkaloids - drugs: derivatives of pyridine, piperidine and pyrrolidine - nicotine, cocaine and atropine, derivatives of xanthine - caffeine, theobromine and theophylline , derivatives of indole - reserpine, strychnine, pilocarpine, derivatives of quinoline - quinine, isoquinoline - morphine and papaverine. Antibiotics. Definition. Distribution in nature. Chemical nature. Penicillins - derivatives of penicillanic acid, cephalosproins - derivatives of cephalosporanic acid, tetracyclines - derivatives of naphthacene, streptomycins - amyloglycosides . Semi-synthetic antibiotics.		
6	**Carbohydrates.** Definition. Classification. Functions. Monosaccharides. Classification. Nomenclature. The most important representatives, structure. Stereoisomerism . D- and L-stereochemical series. Open and cyclic forms (alpha and beta anomers , glycosidic hydroxyl). Fischer formulas and Haworth formulas . Furanoses and pyranoses . The concept of diastereomerism . Epimerism as a special case of diastereomerism . Cycle o- oxotautomerism . Mutarotation. Derivatives of monosaccharides - deoxy sugar (deoxyribose) and amino sugar (glucosamine , galactosamine). Acylation Amino sugars (acetylgalactosamine). Neuraminic and sialic acids. Ascorbic acid. Glycosides. Phosphorus esters of monosaccharides (glucose-6-phosphate, fructose-1,6-diphosphate). Reduction of monosaccharides (xylitol, sorbitol). Oxidation of monosaccharides (glyconic and glycuronic acids). Biological role of individual derivatives of monosaccharides. Oligosaccharides. Disaccharides: maltose, lactose, sucrose. Structure. O-glycosidic bond. Reducing properties. Hydrolysis. Biological role. Polysaccharides. Definition. Classification. Functions. Homopolysaccharides : starch (amylose and amylopectin), glycogen, dextran, cellulose. Pectins (polygalacturonic acid). Heteropolysaccharides : muramin , hyaluronic acid, chondroitin sulfates , heparin. The concept of mixed biopolymers.	UK-1 UK-6 OPK-10	2
7	**Alpha amino acids , peptides and proteins.** Amino acids that are part of proteins. Definition. General formula. Nomenclature. Classification: - by chain nature; - by number of main functional groups; - by additional functional groups; - by physicochemical properties. Individual representatives. Stereoisomerism . Acid-base properties. Chemical properties: reactions of the COOH group - decarboxylation (formation of biogenic amines), formation of salts with bases; reactions of the NH_2 group - deamination (pathway of amino acid breakdown); reactions of the radical - hydroxylation (formation of oxy-derivatives of amino acids). Formation of the peptide bond. Peptides. Definition. Structure of the peptide group. Functions.	UK-1 UK-6 OPK-10	2

	Biologically active peptides: glutathione , oxytocin, vasopressin, glucagon, neuropeptides , kinin peptides , immunoactive peptides (thymosin), inflammatory peptides (diphexin). The concept of cytokines . Peptide antibiotics (gramicidin, actinomycin D, cyclosporin A). Peptide toxins. The relationship of biological effects of peptides with certain amino acid residues. Proteins. Definition. Functions. Levels of protein structure. Primary structure - amino acid sequence. Research methods. Partial and complete hydrolysis of proteins. The importance of determining the primary structure of proteins. Directed site-specific mutagenesis as a method for studying the relationship between the functional activity of proteins and the primary structure. Congenital disorders of the primary structure of proteins - point mutations. Secondary structure and its types (alpha-helix, beta-structure). Tertiary structure. Denaturation . The concept of active centers. Quaternary structure of oligomeric proteins. Cooperative properties. Simple and complex proteins - glycoproteins, lipoproteins, nucleoproteins, phosphoproteins , metalloproteins , chromoproteins .		
8	**Nitrogenous bases, nucleosides, nucleotides and nucleic acids.** Definition of the concepts of nitrogenous base, nucleoside, nucleotide and nucleic acid. Purine (adenine and guanine) and pyrimidine (uracil , thymine , cytosine) nitrogenous bases. Aromatic properties. Resistance to oxidative decomposition as a basis for performing a biological role. Lactam - lactam tautomerism. Minor nitrogenous bases (hypoxanthine , 3-N-methyluracil, etc.). Derivatives of nitrogenous bases - antimetabolites (5-fluorouracil, 6-mercaptopurine). Nucleosides. Definition. Formation of a glycosidic bond between a nitrogenous base and pentose. Hydrolysis of nucleosides. Nucleoside-antimetabolites (arabinoside adenine). Nucleotides. Definition. Structure. Formation of a phosphoester bond during esterification of the C_5 hydroxyl of pentose with phosphoric acid. Hydrolysis of nucleotides. Macroergic nucleotides (nucleoside polyphosphates - ADP, ATP, etc.). Coenzyme nucleotides (NAD+, FAD), structure, the role of vitamins PP and B_2 . Nucleic acids - RNA and DNA. Definition. Nucleotide composition of RNA and DNA. Primary structure. Phosphodiester bond. Hydrolysis of nucleic acids. Definition of the concepts of triplet (codon), gene (cistron), genetic code (genome). International Human Genome Project. Secondary structure of DNA. The role of hydrogen bonds Complementary pairs of nitrogenous bases. Tertiary structure of DNA. Changes in the structure of nucleic acids under the influence of chemicals. The concept of mutagenic substances.	UK-1 UK-6 OPK-10	2

9	**Lipids.** Lipids. Definition, classification. Saponifiable and unsaponifiable lipids. Natural higher fatty acids - components of lipids. The most important representatives: palmitic , stearic, oleic, linoleic , linolenic, arachidonic , eicosapentaenoic , docosahexaenoic (vitamin F). Neutral lipids. Acylglycerols - natural fats, oils, waxes. Artificial edible hydrofats . Biological role of acylglycerols . Phospholipids . Phosphatidic acids. Phosphatidylcholines , phosphatidiethanolamines and phosphatidylserines . Structure. Participation in the formation of biological membranes. Lipid peroxidation in cell membranes. Sphingolipids . Sphingosine and sphingomyelins . Glycolipids (cerebrosides , sulfatides and gangliosides). Unsaponifiable lipids. Terpenes. Mono- and bicyclic terpenes (limonene , pinene , camphor). Conjugated polyenes , vitamin A , carotenoids . Steroids. Cyclopentanoperhydrophenanthrene . Cholesterol, biological role. Cholesterol derivatives - bile acids, steroid hormones. Ergosterol. Vitamin D.	UK-1 UK-6 OPK-10	2
10	**Pharmacological properties of some classes of organic compounds. Chemical nature of some classes of drugs.** Pharmacological properties of some classes of mono- , poly- and heterofunctional compounds (hydrogen halides , alcohols, oxy- and oxoacids , benzene derivatives, heterocycles , alkaloids). Chemical nature of anti-inflammatory drugs, analgesics, antiseptics and antibiotics.	UK-1 UK-6 OPK-10	2
	Total hours:		**20**

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)
	Input control	Testing theoretical knowledge and practical skills developed by the organic chemistry program in secondary (complete) general education institutions.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-10: ID 10.2.	Testing in the Moodle system .	
1	Classification and nomenclature of bioorganic compounds.	**Theoretical part:** Subject and tasks of bioorganic chemistry. Importance of the subject in the education of a physician. Reasons why bioorganic compounds correspond to the provision of biological functions. Classification of bioorganic compounds. Classification features: nature of the carbon skeleton, functional groups. Classes of bioorganic compounds. Homologous series. Genetic relationship of classes as the basis for chemical evolution. Nomenclature of organic compounds. Types of nomenclature: trivial, international or systematic IUPAC. Importance of knowledge of nomenclature for a physician. Basic algorithms of systematic nomenclature. Elements of structure: parent structure, characteristic, functional group, substituents (radicals, minor functional groups, halogens). Seniority of functional groups, their endings as a prefix or main function. **Practical part:** Drawing up reaction schemes based on the genetic relationship of classes of organic compounds.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-10: ID 10.2.	Frontal survey, solving situational problems, testing in the Moodle system .	3.25
2	Spatial structure of bioorganic molecules.	**Theoretical part:** Theoretical foundations of the structure of organic compounds. Theory of A.M. Butlerov. Basic provisions. Structural formulas. The nature of the carbon atom by position in the chain. Isomerism and isomers. Types of isomerism . Spatial representations in organic chemistry. Tetrahedral model of the	UK-1: ID 1.1., 1.2 . UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Frontal survey, solution of situational problems, carrying out an experiment,	3.25

		carbon atom. Configurations of organic molecules. Ball-and-stick models of molecules by A. Kekule . Scale models of Briegleb-Stewart . The concept of conformation . Conformations of open chains using ethane as an example. Conformations of cycles using cyclohexane as an example . Conformation and reactivity of molecules. Factors influencing the conformation of molecules. The significance of conformations of biologically important molecules. Some methods for studying organic compounds . a) Recrystallization. Sublimation. b) Distillation. c) Extraction. d) Filtration (ultra- , gel filtration). d) Ultracentrifugation . e) Rg-structural analysis. g) Spectral methods. **Practical part:** Extraction of vitamin A from carrots. Separation of biological fluids using centrifugation.		testing in the Moodle system .	
3	Mutual influence of atoms in molecules of organic compounds.	**Theoretical part:** Mutual influence of atoms in molecules. How it manifests itself, what are its causes. Give examples. Conjugation. Conjugated bonds. Conjugation as a factor in system stabilization. Conjugation energy . Conjugation in open chains (Pi-Pi). Diene structures in biologically important compounds. Conjugation in arenes (Pi-Pi) and in heterocycles (p-Pi). Aromaticity. The importance of conjugation in cycles in biologically important compounds. Polarization of bonds. Electronic effects - inductive and mesomeric . Substituents - electron donors and electron acceptors . The most important substituents and their electronic effects. Electronic effects of substituents and the reactivity of molecules. The orientation rule in benzene ring, substituents of the first and second type. **Practical part:** Carrying out a qualitative reaction to the Pi-bond.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an experiment, testing in the Moodle system .	3.25
4	Acidity and basicity of organic compounds.	**Theoretical part:** Acidity and basicity of neutral molecules of organic compounds with hydrogen-containing functional groups . Acids and bases according to Brønsted-Lowry . Conjugate pairs of acids and bases.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems,	3.25

		Acidity and anion stability. Quantitative assessment of the acidity of organic compounds by the values of K_a and pK_a. Acidity of various classes of organic compounds. Factors determining the acidity of organic compounds: - electronegativity of a non-metal atom (C-H, NH, and OH acids);- polarizability of the non-metal atom (alcohols and thiols , thiol poisons);- nature of the radical (alcohols, phenols, carboxylic acids). Basicity of organic compounds. n- and pi-bases . Factors determining the basicity of organic compounds: - electronegativity heteroatom (O- and N-bases); - polarizability of a non-metal atom (O- and S-bases); - the nature of the radical (aliphatic and aromatic amines). The importance of acid-base properties of neutral organic molecules. **Practical part:** Basic properties of pyridine. Amphoteric properties of AMC.		performing an experiment, testing in the Moodle system .	
5	Mechanisms of reactions of organic compounds.	**Theoretical part:** Classification of reactions of organic compounds by their mechanism. Homolytic and heterolytic reactions. Concept - radical, electrophile and nucleophile . Homolytic radical reactions. Biological significance. Electrophilic addition and substitution reactions. Alkenes , arenes. Nucleophilic substitution reactions at SP^3 hybridized carbon atom. Alcohols, thiols , amines. Elimination reactions. Reaction mechanism. Nucleophilic addition and substitution reactions in carbonyl compounds. Reaction mechanism. **Practical part:** Obtaining ethyl chloride .	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an experiment, testing in the Moodle system .	3.25
6	Oxidation and reduction of organic compounds.	**Theoretical part:** Oxidation of organic matter is the main source of energy for chemotrophs . Redox reactions. Oxidation states of carbon atoms in organic compounds . Oxidation of primary, secondary and tertiary carbon atoms. Oxidizability of various classes of organic	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an	3.25

		compounds. Oxygen utilization pathways in the cell. Energy oxidation. Oxidase reactions. Plastic oxidation. Oxygenase reactions. Reduction of organic compounds. **Practical part:** Quantitative determination of dienes conjugates . Quantitative determination of malonic dialdehyde . Detection of peroxides in diethyl ether.		experiment, testing in the Moodle system .	
7	Control Job.	**Test** on the sections " Classification, nomenclature and modern physicochemical methods for studying bioorganic compounds" and " Theoretical foundations of the structure of organic compounds and factors determining their reactivity".	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. OPK-10: ID 10.2.	Interview, problem solving and exercises, testing in the Moodle system .	3.25
8	Heterofunctional bioorganic compounds. Stereoisomerism .	**Theoretical part:** Definition of heterofunctional compounds. The most important classes. Significance in life. Amino alcohols . Oxy acids . Oxoacids . Amino acids. Optical isomerism-enantiomerism . Chirality of molecules of organic compounds as a cause of optical isomerism. Enantiomers with one chirality center . Oxyacids . Oxyacid key. Absolute and relative configuration of enantiomers . D and L isomers. Right- and left-handed isomers. Racemates. Enantiomers with several chirality centers . Tartaric acid. Diastereomerism , biological significance. Benzene derivatives as drugs. **Practical part:** Evidence of the presence of two carboxyl groups in tartaric acid.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, carrying out an experiment, testing in the Moodle system .	3.25
9	Biologically important heterocycles .	**Theoretical part:** Classification of heterocycles . Five-membered cycles with one heteroatom . Five-membered heterocycles with two heteroatoms . Six-membered heterocycles with one heteroatom . Six-membered heterocycles with two heteroatoms . Bicyclic (condensed)	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an	3.25

		heterocycles . Alkaloids. Antibiotics. **Practical part:** Oxidation-reduction properties of alkaloids.		experiment, testing in the Moodle system .	
10	Carbohydrates. Classification. Monosaccharides.	**Theoretical part:** Definition and classification of carbohydrates. Biological functions of carbohydrates. Monosaccharides. Definition. Classification. Representatives of pentoses: ribose, deoxyribose ; hexoses: glucose, galactose, fructose . Stereoisomerism , right and left stereochemical series; diastereomers , enantiomers . Open and cyclic forms of sugars: α- and β- anomers . Glycosidic hydroxyl. Derivatives of monosaccharides . Amino sugars . Acylation amino sugars . Oxidation of monosaccharides . Glycolic and glycuronic acids. Phosphoric esters of monosaccharides . Neuraminic and sialic acids . acids. **Practical part:** Evidence of the presence of hydroxyl groups in glucose. Reduction of copper hydroxide by glucose in an alkaline medium. Lack of reducing capacity in sucrose.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an experiment, testing in the Moodle system .	3.25
11	Carbohydrates. Disaccharides. Homo- and heteropolysaccharides .	**Theoretical part:** of polysaccharides. Disaccharides (maltose, lactose, sucrose). Homopolysaccharides (starch, glycogen, fiber, dectran) . Glycosidic bonds. Hydrolysis . Heteropolysaccharides , synonyms. Dimers - structural units, glycosidic bonds (hyaluronic acid, chondroitin sulfate , heparin, muramin , pectins). The concept of complex biopolymers (proteoglycans , (glycoproteins). **Practical part:** Qualitative reaction to starch. Hydrolysis of starch in an acidic medium.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an experiment, testing in the Moodle system .	3.25
12	Alpha amino acids , peptides and proteins.	**Theoretical part:** Alpha-amino acids . Definition, meaning. Nomenclature of amino acids. Classification of amino acids. Individual representatives:	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

		glycine, alanine , leucine, serine , cysteine , aspartic (asparagine), glutamic (glutamine), lysine, phenylalanine , tryptophan, histidine. Stereoisomerism . Acid-base properties. Chemical properties. Decarboxylation , deamination and hydroxylation reactions . Formation of peptide bond. Peptides and their biological role. Proteins. Functions. Levels of structure. Simple and complex proteins. **Practical part:** Ninhydrin reaction for alpha-amino acids . Xanthoprotein reaction for aromatic amino acids. Detection of peptide bonds in proteins – biuret reaction.	OPK-10: ID 10.2.	problems, performing an experiment, testing in the Moodle system .	
13	Nitrogenous bases, nucleosides , nucleotides and nucleic acids.	**Theoretical part:** Nitrogenous bases (pyrimidine and purine). Aromaticity. Lactim-lactam tautomerism. Complementarity of bases. Hydrogen bonds in complementary base pairs. Nucleosides. Hydrolysis. Nucleosides – antibiotics. Nucleotides. Mononucleotides. Structural components, nature of bonds. Hydrolysis. Polynucleotides . Primary structure of nucleic acids. Nucleotide composition of DNA and RNA. Concept of secondary structure of nucleic acids. Modified nitrogenous bases (fluorouracil , mercaptopurine) - antimetabolites (principle of chemical similarity). **Practical part:** Evidence of the purine structure of uric acid.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an experiment, testing in the Moodle system .	3.25
14	Lipids.	**Theoretical part:** Classification of lipids . Soapable lipids. Natural higher fatty acids: palmitic, stearic, oleic , linoleic , linolenic, arachidonic , vit.F. Neutral lipids. Acylglycerols , natural fats, oils, waxes. Artificial food hydrofats . Biological significance of acylglycerols . Phospholipids . Classification. Phosphatidic acid. Phosphatidylethanolamines , phosphatidylserine ,	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing experiment, testing in the Moodle system	3.25

		phosphatidylcholine . Sphingolipids . Sphingosine , sphingomyelin . The concept of glycolipids. Phospholipids , glycolipids, components of the structure of cell membranes. Peroxidation of fatty acids in cell membranes. Terpenes. Mono- and bicyclic terpenes (limonene , pipene , camphor). Conjugated polyenes . Vit . A. Steroids. Cyclopentanoperhydrophenanthrene . Cholesterol, biological role. Cholesterol derivatives - bile acids, steroid hormones, ergosterols, vitamins D. Cardiac glycosides. **Practical part:** Detection of insoluble calcium salts of higher carboxylic acids. Proof of unsaturation of terpenes. Detection of carotenoids in carrots.		.	
15	Pharmacological properties of some classes of organic compounds. Chemical nature of some classes of drugs.	**Theoretical part:** Pharmacological properties of some classes of organic compounds: Hydrocarbons. Mono- and polyfunctional compounds (alcohols, phenols, aldehydes and ketones, carboxylic acids, ethers, esters, thiols , amines. Heterofunctional compounds (oxyacids , amino acids, benzene derivatives as drugs - benzoic acid, p-aminophenol derivatives , PABA derivatives, sulfanilic and salicylic acids, heterocycles , carbohydrates). Chemical nature of some classes of drugs. Anesthetics. Hypnotics and anticonvulsants. Psychotropic drugs. Painkillers (analgesics) . Anti-inflammatory and antipyretic drugs. Neurotransmitters . Antihistamines . Drugs that improve myocardial blood supply. Hypercholesterolemic drugs. Diuretics. Hormonal drugs. Vitamins. Enzymes. Parenteral nutrition agents . Plasma-substituting and detoxifying solutions. Metabolic process stimulants . Antioxidants and antihypoxants . Drugs for the prevention and treatment of radiation sickness. Antimicrobial drugs-antibiotics. Antiviral and antitumor drugs. Antiseptics. **Practical part:**	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2.	Frontal survey, solving situational problems, performing an experiment, testing in the Moodle system .	3.25

		Color reactions of salicylic acid and its esters. Color reactions of antipyrine and amidopyrine.			
16	Credit lesson	The interim assessment includes: - assessment of knowledge of theoretical material; - testing in the Moodle system ; - testing the acquisition of practical skills and abilities.	UK-1: ID 1.1., 1.2. UK-6: ID 6.1., 6.3. UK-8: ID 8.4. OPK-10: ID 10.2. OPK-11: ID 11.3., 11.4.	Interview, problem solving and exercises, testing in the Moodle system .	3.25
		Total hours:			**52**

2.4 Interactive forms of learning

In order to activate students' cognitive activity, **interactive teaching methods** (interactive surveys, discussions, work in small groups, computer testing, etc.), participation in the work of the chemical laboratory, educational research and scientific research work are widely used in practical classes.

No. p\ p	The topic of practical classes, lectures	Labor intensity in hours	Interactive forms training	Labor intensity in hours, in % of the lesson
1	Classification and nomenclature of bioorganic compounds.	3.25	Interactive survey Testing in Moodle	20 min., 033 hours, 10%. 15 min (0.1 hour) / 10%
2	Spatial structure of bioorganic molecules.	3.25	Interactive survey Testing in Moodle	20 min., 033 hours, 10%. 15 min (0.1 hour) / 10%
3	Mutual influence of atoms in molecules of organic compounds.	3.25	Discussion Testing in Moodle	30 min. 0.5 hours 15%. 15 min (0.1 hour) / 10%
4	Acidity and basicity of organic compounds.	3.25	Interactive survey Testing in Moodle	20 min 0.33 hours 10% 15 min (0.1 hour) / 10%
5	Mechanisms of reactions of organic compounds.	3.25	Interactive survey Testing in Moodle	20 min 0.33 hours 10% 15 min (0.1 hour) / 10%
6	Oxidation and reduction of organic compounds.	3.25	Discussion Testing in Moodle	30 min. 0.5 hours, 15%. 15 min (0.1 hour) / 10%
7	Test on the sections " Classification, nomenclature and modern physicochemical methods of studying bioorganic compounds" and " Theoretical foundations of the structure of organic compounds and factors determining their reactivity"	3.25	Testing in Moodle Solution situational tasks and exercises followed by discussion .	30 min., 0.5 hours, 15%. 30 min., 0.5 hours, 15%.
8	Heterofunctional bioorganic compounds. Stereoisomerism .	3.25	Brainstorming Testing in Moodle	30 min., 0.5 hours, 15%. 15 min (0.1 hour) / 10%
9	Biologically important heterocycles .	3.25	Interactive survey Testing in Moodle	20 min., 033 hours, 10%. 15 min (0.1 hour) / 10%

10	Carbohydrates. Classification. Monosaccharides.	3.25	Interactive survey Testing in Moodle	20 min., 033 hours, 10%. 15 min (0.1 hour) / 10%
11	Carbohydrates. Disaccharides. Homo- and heteropolysaccharides .	3.25	Round table Testing in Moodle	30 min. 0.5 hours 15%.
12	Alpha amino acids , peptides and proteins.	3.25	Interactive survey Testing in Moodle	20 min., 033 hours, 10%. 15 min (0.1 hour) / 10%
13	Nitrogenous bases, nucleosides, nucleotides and nucleic acids.	3.25	Discussion. Testing in Moodle	30 min. 0.5 hours 15%. 15 min (0.1 hour) / 10%
14	Lipids.	3.25	Interactive survey Testing in Moodle	20 min., 033 hours, 10%. 15 min (0.1 hour) / 10%
15	Pharmacological properties of some classes of organic compounds. Chemical nature of some classes of drugs.	3.25	Interactive survey Testing in Moodle	20 min., 033 hours, 10%. 15 min (0.1 hour) / 10%
16	Credit lesson	3.25	Testing in Moodle Oral interview for tickets.	30 min. 0.5 hours 15%. 40 min (0.25 hour) / 27.4%

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 evaluation criteria - completeness and correctness: correct, accurate answer; correct, but incomplete or inaccurate answer; incorrect answer; no answer.

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

of students in mastering the topics of the discipline "Bioorganic Chemistry in Medicine" 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"

Incoming inspection

It is carried out with the purpose of testing individual knowledge, skills, and abilities of students necessary for successful mastery of the discipline. It is carried out in outside of school hours in the form of testing on the course organic chemistry (school program) in the system " Moodle " http://194.186.41.210/course/index.php?categoryid=25 . The test control includes 70 questions.

Current control

Current control includes initial and final control of knowledge.

Initial control **is** carried out by the teacher at the beginning of each lesson in the form of a frontal survey, solving problems and exercises.

Final control – includes control over the technique of performing a chemical experiment and drawing up a protocol , testing in the Moodle system (http://194.186.41.210/course/index.php?categoryid=25).

The final grade during the current knowledge assessment is given on the day of the lesson, as the arithmetic mean result for all types of activities provided for in the given lesson by the work program of the discipline.

Criteria for assessing the oral response

“5” (excellent) – the student demonstrates deep and complete knowledge of the educational material, does not allow inaccuracies or distortions of facts when presenting, presents the material in a logical sequence, is well oriented in the presented material, and can provide justification for the judgments expressed.

“4” (good) - the student has mastered the educational material in full, is well oriented in the educational material, presents the material in a logical sequence, but makes inaccuracies when answering.

“3” (satisfactory) – the student has mastered the basic principles of the topic of the practical lesson, but when presenting the educational material, he/she makes inaccuracies, presents it incompletely and inconsistently, requires leading questions from the teacher to present it, and has difficulty substantiating the judgments expressed.

“2” (unsatisfactory) – the student has fragmented and unsystematic knowledge of the educational material, is unable to distinguish between the main and the secondary, makes mistakes in defining basic concepts, distorts their meaning, and cannot independently present the material.

Assessment criteria for the practical part

“5” (excellent) – the student has fully mastered the practical skills and abilities provided for by the course work program.

“4” (good) – the student has fully mastered the practical skills and abilities provided for in the course program, but makes some inaccuracies.

“3” (satisfactory) – the student has only some practical skills and abilities.

“2” (unsatisfactory) – the student demonstrates the performance of practical skills and abilities with gross errors.

Criteria and assessment of independent extracurricular work:

- 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 (ability to apply theoretical knowledge in practice) competencies;
- 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 the abstract:

- 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”.

Working off disciplinary debts.

1. 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.
2. 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.
3. 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 grade of "5" for this class, provided that he submits a report on the completion of mandatory extracurricular independent work on the topic of the missed class.

Criteria for assessing midterm assessment.

Midterm assessment (credit) is designed to assess the degree of achievement of planned learning outcomes upon completion of the study of a discipline and allows for an assessment of the level and quality of its mastery by students .

Success in mastering the discipline is assessed as “passed” or “failed”.

A student can claim to receive a "pass" in a discipline "automatically" if he/she has won a prize in disciplinary or interdisciplinary Olympiads (university, regional) and has an average score for the current academic performance of at least 4.8 points. A student can refuse the "automatic" grade and take the test together with the group on a general basis.

Interim assessment is carried out through a system of passing a test in 3 stages:

1. Test control of theoretical knowledge in the system " Moodle ". Access mode: (http://194.186.41.210/course/index.php?categoryid=25 .) The test control of theoretical knowledge in the Moodle system is compiled according to the working program of the discipline, includes 100 questions.
2. Oral interview with tickets containing three theoretical questions.
3. Completion of practical skills, writing structural formulas of drugs.

Based on the assessments for the current control of knowledge, skills, and abilities in practical classes, the average score of current academic performance is calculated, which is recorded in the educational (electronic) journal. The assessment for the current control of knowledge is taken into account during the midterm assessment. During the midterm assessment, the final assessment is established as the arithmetic mean result for all stages of the test.

Binary scale of midterm assessment

Stages	Mark out of 5 point scale	Binary scale
Test control in the system " Moodle "	3-5	**passed**
Complete completion of the practical part of the course	3-5	
Delivery of practical skills (control of the formation of competencies)	3-5	
Test control in the system " Moodle "	2	**not credited**
Complete completion of the practical part of the course	2	
Delivery of practical skills (control of the formation of competencies)	2	

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 action, begins with students outside of class time when preparing for a practical lesson, and ends during class. All subsequent stages are carried out during class.

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.

Extracurricular independent work of students

No. p / p	Topic of a practical lesson or topic of a section of a discipline	Time for student preparation for the lesson	Forms of extracurricular independent work of a student	
			Mandatory and the same for all students	At the student's choice (summary of topics)
1	Introduction to the subject. Classification and nomenclature of bioorganic compounds	3 h	Solving problems, solving tests, preparing for oral examination	Independently study the physical and chemical methods of isolation and research organic compounds of importance for biomedical analysis.
2	The main types of chemical reactions in the functioning of living systems.	8 h	Solving problems, solving tests, preparing for oral examination	Radical (homolytic) reactions as the basis of molecular diseases. Ligand substitution reactions .

3	Chirality of molecules of organic compounds as a cause of optical isomerism. Stereoisomerism of molecules with one chirality center (enantiomerism). Optical activity.	6 h	Solving problems, solving tests, preparing for oral examination	Glyceraldehyde as a configuration standard. Fischer projection formulas. D and L-System of Stereochemical Nomenclature. Stereoisomerism and Biological Activity of Organic Compounds.
4	Biologically active high-molecular substances (structure, properties, participation in the functioning of living systems).	6 h	Solving problems, solving tests, preparing for oral examination	Selected methods of analysis. Determination of the molecular weight of high-molecular compounds, separation chromatography, spectrophotometry .
5	Biologically active low-molecular organic substances (structure, properties, participation in the functioning of living systems).	2 h	Solving problems, preparing for oral examination	Biologically important heterocyclic compounds. Pyrimidine derivatives - drugs: potassium orotate , methylthiouracil , barbiturates. Participation of pyrimidine in the formation vit . B 1 .
6	Credit lesson	2 h	Preparation on theoretical issues (lectures, basic and additional literature, methodological recommendations). Preparation for testing in the Moodle system and solving situational problems.	-
Labor intensity in hours		**32 hours**	**32 hours**	**4 hours**
Total labor intensity (in hours)			**36 hours**	

2.7 Research (project) work

Research (project) work students is a mandatory section of the study of the discipline and is aimed at the comprehensive formation of universal and general professional competencies of students. Involves the study of specialized literature and other scientific and technical information on the achievements of domestic and foreign science and technology in the relevant field of knowledge, participation in scientific research, etc.

The goal is to develop students' scientific research skills, learn to find the necessary literature, formulate the purpose and objectives of the research, and work with electronic resources (international electronic databases).

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.

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.

Criteria for assessing students' research (project) work:

- - the material on the research results in the report is presented in detail, the specialized literature is well-developed, scientific and technical information on the achievements of domestic and foreign science and technology in the relevant field of knowledge is studied - "passed".
- - the material on the research results in the report is not presented accurately enough, the special literature is poorly studied, the scientific and technical information on the achievements of domestic and foreign science and technology in the relevant field of knowledge is not studied - "failed".

3. EDUCATIONAL, METHODOLOGICAL, MATERIAL, TECHNICAL AND INFORMATION SUPPORT OF DISCIPLINE

3.1 Main literature:

1. Tyukavkina N. A. Bioorganic Chemistry: textbook / N. A. Tyukavkina , Yu. I. Baukov , S. E. Zurabyan . - Moscow: GEOTAR-Media , 2024. - 416 p. - ISBN 978-5-9704-8434-0. - Text: electronic // Electronic Library System "Student Consultant": - URL: https://www.studentlibrary.ru/book/ISBN9785970484340.html - Access mode: by subscription.

- 2. Tyukavkina , N. A. Bioorganic Chemistry : A Guide to Practical Classes: A Textbook / edited by N. A. Tyukavkina . - Moscow : GEOTAR-Media , 2020. - 176 p. - ISBN 978-5-9704-

5600-2. - Text : electronic // EBS “Student Consultant”: [website]. - URL : https://www.studentlibrary.ru/book/ISBN9785970456002.html (date of access: 26.04.2023). - Access mode : by subscription.

3.2 Further reading:

1. Yakovlev, I. P. Organic chemistry. Typical tasks. Decision algorithm / Yakovlev I. P. - Moscow : GEOTAR-Media , 2018. - 640 p. - ISBN 978-5-9704-4429-0. - Text : electronic // EBS “Student Consultant”: [website]. - URL : https://www.studentlibrary.ru/book/ISBN9785970444290.html (date of access: 24.02.2025). - Access mode : by subscription.

1.3 Educational and methodological materials prepared by 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 of DV RUMC, Vladivostok).

Electronic and digital technologies:

1. **Online course on the subject** "Bioorganic Chemistry in Medicine" in the EIS FSBEI HE Amur State Medical Academy (http://194.186.41.210/course/index.php?categoryid=25).

Characteristics of modules in electronic information and educational course

Educational	Controlling
Theoretical (lecture) material, video experiments, scientific and educational films	Methodological recommendations for students on independent extracurricular work.
Methodological recommendations for students for practical classes. Methodological recommendations for solving problems and exercises on the topics of the discipline.	List of recommended topics for abstracts and guidelines for abstract design.
Reference material, tables of standard values.	Tests of entrance, current and final knowledge control.

2. **Multimedia presentations** (Microsoft Power Point 2016), to lecture-type classes, (http://194.186.41.210/course/index.php?categoryid=25 .) according to the thematic plan of lectures.

3. **Video materials:**

	Multimedia materials	

1	Stonik V.A. (TIBOC DSC SB RAS) “Natural compounds – the basis of medicines and biologically active food supplements.”	Author's presentation as a ppt file
2	Stonik V.A. (TIBOC DSC SB RAS). "Pacific Institute of Bioorganic Chemistry DSC SB RAS".	Author's presentation as a ppt file
3	Borodin E.A. (ASMA) "Fundamentals of IFA"	Author's presentation as a ppt file
4	Borodin E.A. (ASMA) "Fundamentals of PCR".	Author's presentation as a ppt file
5	Borodin E.A. (ASMA) "Human Genome. Genomics , Proteomics and Bioinformatics ".	Author's presentation as a ppt file
6	Pivovarova E.N. (ICG SB RAMS) “The role of gene expression regulation in the development of human pathologies”.	Author's presentation as a ppt file
7	Skoblov M.Yu. (Medical and Genetic Research Center of the Russian Academy of Medical Sciences) “Structural and functional analysis of human genome transcription”.	Author's presentation as a ppt file
8	Skoblov Yu.S. (IBOCh RAS) "Radioactive isotopes in physicochemical biology".	Author's presentation as a ppt file

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, scientific research (project) work students
1.2	centrifuge tubes	2000	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.3	glass sticks	100	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.4.	flasks of various volumes (for conducting analyses)	200	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.5	large volume flasks - 0.5- 2,0 л. (for preparing working solutions)	30	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.6	beakers of various volumes (for conducting analyses)	120	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.7	large volume beakers - 0.2-2,0 л(for preparing working solutions)	50	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.8	flasks of various volumes	2000	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.9	filter funnels of different diameters	200	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.10	glassware for special purposes (for distillation,		Chemical experiments and analyses in practical classes, scientific research (project) work students

	extraction, chromatography, etc.).		
1.11	alcohol lamps	30	Chemical experiments and analyses in practical classes, scientific research (project) work students
	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, scientific research (project) work students
1.14	crucibles	20	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.15	evaporating cups	20	Chemical experiments and analyses in practical classes, scientific research (project) work students
	Measuring utensils:		
1.16	measuring flasks of various volumes	100	Preparation of reagents for practical classes, Chemical experiments and analyses in practical classes, scientific research (project) work students
1.17	graduated cylinders of various volumes	40	Preparation of reagents for practical classes, Chemical experiments and analyses in practical classes, scientific research (project) work students
1.18	measuring cups of various volumes	30	Preparation of reagents for practical classes, Chemical experiments and analyses in practical classes, scientific research (project) work students
1.19	measuring pipettes for different volumes (including micropipettes)	2000	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.20	mechanical automatic fixed volume dispensers	15	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.21	mechanical automatic variable volume dispensers	2	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.22	electronic automatic variable volume dispenser	1	Chemical experiments and analyses in practical classes, scientific research (project) work students
1.23	variable volume microsyringes	5	Chemical experiments and analyses in practical classes, scientific research (project) work students
2	**Technical equipment:**		
2.1	test tube racks	100	Chemical experiments and analyses in practical classes, scientific research (project) work students
2.2	pipette stands	15	Chemical experiments and analyses in practical classes, scientific research (project) work students
2.3	metal tripods	15	Chemical experiments and analyses in practical classes, scientific research (project) work students
	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, scientific research (project) work students
2.8	Refrigerators with freezers "Chinar " " Biryusa", " Stinol "	5	Storage of chemical reagents, solutions and biological material for practical classes, research (project) work
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, research (project) work students
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	Demonstration of the sedimentation analysis method in practical classes, research (project) work students
3.6	Refrigerated ultracentrifuge CR-K24D (Germany)	1	Demonstration of the sedimentation analysis method in practical classes, research (project) work students
3.7	CLR	1	Demonstration of the sedimentation analysis method in practical classes, research (project) work students
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, research (project) work students
3.10	Thermometers	10	control during chemical analysis in practical classes, research (project) work students
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, research (project) work students
4.2	Gel electrophoresis apparatus	1	Demonstration of the method of separating blood serum lipoproteins in practical classes, research (project) work students
4.3	Equipment for column chromatography		the method of separating proteins using chromatography in practical classes, research (project) work students
4.4	Thin layer chromatography equipment.		the TLC method for separating lipids in practical classes, research (project) work students
	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, research (project) work students

4.6	KFK-2	1	Measurement of light absorption of colored solutions using colorimetric methods for determining the content of analytes in practical classes, research (project) work students
4.7	KFK-3	1	Measurement of light absorption of colored solutions using colorimetric methods for determining the content of analytes in practical classes, research (project) work students
4.8	Photometer “SOLAR”	1	Measurement of light absorption of colored solutions using colorimetric methods for determining the content of analytes in practical classes, research (project) work students
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, research (project) work students
4.10	Clinical spectrophotometer " Shimadzu - 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, research (project) work students
4.11	High-performance liquid chromatograph " Milichrom - 4".	1	of the HPLC method (practical classes, research (project) work students)
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, research (project) work students
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 , research (project) work students
	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 , research (project) work students
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 outside of class time - during practical classes, independent

			work of students, research (project) work students
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 library " CyberLeninka "	CyberLeninka is a scientific electronic library built on 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.	with free access	https://cyberleninka.ru/
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	A resource of the Russian Ministry of Health that	link to download	https://cr.minzdrav.gov.ru/#!/

Rubricator	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.	the application	
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 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.	free access	https://rucml.ru/
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.

I . Commercial software products		
1	MS Operating System Windows 7 Pro	License number 48381779
2	Operating system MS Windows 10 Pro , MS Office	CONTRACT R No. 142 A from 25.12.2019
3	MS Office	Number licenses : 43234783, 67810502, 67580703, 64399692, 62795141, 61350919
4	Kaspersky Endpoint Security for business Extended	Agreement No. 977/20 dated 12/24/2020
5	1C: PROF University	LICENSE AGREEMENT No. 2191 dated 15.10.2020
6	1C: PROF Library	LICENSE AGREEMENT No. 2281 dated 11.11.2020
II . Freely distributed software		
1	Google Chrome	Freely distributed Distribution terms: h ttps :// play . google . com / about / play - terms / index . html
2	Browser « Yandex »	Freely distributed License agreement for the use of the Yandex Browser software https :// yandex . ru / legal / browser_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 /

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

1. Electronic library of medical literature – https://www.books-up.ru/ru/entrance/97977feab00ecfbf9e15ca660ec129c0/
2. Electronic library, news on chemistry : http://www.chemlib.ru/
3. Album of multimedia illustrations: http://www.orgchem.ru/album.htm

4. Types of buffer systems of the body. Chemical buffer systems: https://dommedika.com/phisiology/528.html

4. ASSESSMENT TOOLS FUND

4.1. Current test control (input, initial, output), final.

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

Test assignments in the Moodle system http://194.186.41.210/course/index.php?categoryid=25 . include 70 questions.

1. AS A RESULT OF THE REACTION OF PHENOL WITH FORMALIN, THE FOLLOWING IS FORMED
   1) phenol formaldehyde resin
   2) phenylmethyl ether
   3) phenyl formate
   4) diphenyl ether

2.THE INTERACTION OF BROMETHANE WITH METALLIC SODIUM IS CALLED THE REACTION:
   1) Wurtz
   2) Zinina
   3) Wagner
   4) Kucherova

3. IN ALKENE MOLECULES THE DOUBLE BOND BETWEEN ATOMS INCLUDES :
   1) one σ and one π bond
   2) 2π-connections
   3) 2 σ bonds
   4) one ionic and one covalent bond

Answers: 1-1, 2-1, 3-1.

4.1.2 Examples of test tasks for final control (with standard answers)

Tests in the system « Moodle » http://194.186.41.210/course/index.php?categoryid=25 . on all studied topics of the discipline. Total number of tests - 350.

Examples of test tasks for lesson No. 4 “Acidity and basicity of organic molecules”.

1. SELECT THE CHARACTERISTIC FEATURES OF BRØNSTED-LOWRY ACIDS:
   1) increase the concentration of hydrogen ions in aqueous solutions
   2) increase the concentration of hydroxide ions in aqueous solutions
   3) are neutral molecules and ions - proton donors
   4) are neutral molecules and ions - proton acceptors
   5) do not affect the reaction of the environment

2. INDICATE THE FACTORS AFFECTING THE ACIDITY OF ORGANIC MOLECULES:
   1) electronegativity heteroatom
   2) polarizability heteroatom
   3) nature of the radical
   4) ability to dissociate
   5) solubility in water

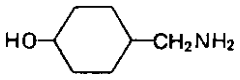
3. CHOOSE THE STRONGEST BRØNSTED ACIDS FROM THE LISTED COMPOUNDS:
   1) alkanes
   2) amines

3) alcohols
4) thiols
5) carboxylic acids

Answers: 1. - 3, 5; 2. - 1, 2, 3; 3. - 3, 5.

4. 1.3 Examples of situational tasks of current control (with standard answers)

1. Determine the parent structure in the compound:

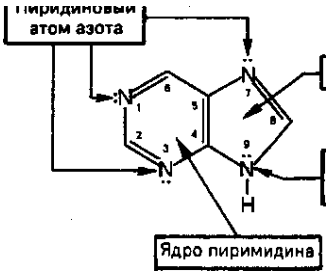


Solution. The choice of the parent structure in the structural formula of an organic compound is regulated in the IUPAC substitution nomenclature by a number of sequentially applied rules (see Textbook, 1.2.1). Each subsequent rule is applied only when the previous one does not allow an unambiguous choice to be made. Compound I contains aliphatic and alicyclic fragments. According to the first rule, the structure to which the senior characteristic group is directly bound is chosen as the parent structure . Of the two characteristic groups present in compound I (OH and NH), the senior is the hydroxyl group. Therefore, the parent structure will be the structure of cyclohexane, which is reflected in the name of this compound - 4-aminomethylcyclohexanol.

2. The basis of a number of biologically important compounds and drugs is a condensed heterocyclic system of purine, including pyrimidine and imidazole nuclei. What explains the increased resistance of purine to oxidation?

ABOUT

Imidazole core



Pyrrole nitrogen atom

Solution. Aromatic compounds have high conjugation energy and thermodynamic stability. One of the manifestations of aromatic properties is resistance to oxidation, although "externally" aromatic compounds have a high degree of unsaturation , which usually causes a tendency to oxidation. To answer the question posed in the problem statement, it is necessary to establish whether purine belongs to aromatic systems.

Purine

According to the definition of aromaticity, a necessary (but not sufficient) condition for the emergence of a conjugated closed system is the presence in the molecule of a flat cyclic σ-skeleton with a single π electron cloud. In the purine molecule, all carbon and nitrogen atoms are in the state of sp^2 - hybridization, and therefore all σ-bonds lie in the same plane. Due to this, the π orbitals of all atoms included in the cycle are located perpendicular to the plane of the σ - skeleton and parallel to each other, which creates conditions for their mutual overlap with the formation of a single closed delocalized ti-electron system that encompasses all the atoms of the cycle (circular conjugation).

Aromaticity is also determined by the number of π-electrons, which must correspond to the formula 4/7 **+2** , where ***π*** — a series of natural numbers 0 , 1, 2, 3, etc. (Huckel's rule). Each carbon atom and the pyridine nitrogen atoms in positions 1, 3, and 7 contribute one p-electron to the conjugated system , and the pyrrole nitrogen atom in position 9 contributes an unshared pair of electrons. The conjugated system of purine contains 10 π-electrons, which corresponds to Huckel's rule at ***p*** =2.

Thus, the purine molecule has an aromatic character and this is associated with its resistance to oxidation.

of heteroatoms in the purine cycle leads to uneven distribution of the π - electron density. The pyridine nitrogen atoms exhibit electron-acceptor character and reduce the electron density on the carbon atoms. In this connection, the oxidation of purine, generally considered as the loss of electrons by the oxidizing compound, will be even more difficult compared to benzene.

4.1.4 Examples of test tasks for the final assessment (with standard answers)

Test assignments in the Moodle system http://194.186.41.210/course/index.php?categoryid=25 . include 100 questions.

1. BIOORGANIC CHEMISTRY STUDY:
   structure, composition, properties of organic substances
   1) metabolism
   2) elemental composition of organic substances
   3) 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 ORGANIC COMPOUNDS ARE:
   1) the nature of the hydrocarbon skeleton and functional group
   2) presence of heteroatom
   3) aromaticity
   4) nature of connection

Answers: 1-1, 2-1, 3-1.

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

1. Ability to classify organic compounds by the structure of the carbon skeleton and the nature of functional groups.
2. Ability to compose formulas by names and name typical representatives of biologically important substances and drugs by structural formula.
3. Ability to identify functional groups, acidic and basic centers, conjugated and aromatic fragments in molecules to determine the chemical behavior of organic compounds.
4. Ability to predict the direction and result of chemical transformations of organic compounds.
5. Possession of skills to independently work with educational, scientific and reference literature; conduct searches and make general conclusions.
6. Possession of skills in handling chemical glassware.
7. Possession of safe work skills in a chemical laboratory and the ability to handle caustic, poisonous, volatile organic compounds, work with burners, alcohol lamps and electric heating devices.

4.3 List of questions for the test

1. Subject and tasks of bioorganic chemistry. Importance in medical education.
2. Elemental composition of organic compounds as a reason for their compliance with the provision of biological processes.
3. Classification of organic compounds. Classes, general formulas, functional groups, individual representatives.
4. Nomenclature of organic compounds. Trivial names. IUPAC replacement nomenclature.
5. Main functional groups. Parental structure. Substituents. Seniority of groups, substituents. Names of functional groups and substituents as a prefix and ending.
6. Theoretical foundations of the structure of organic compounds. Theory of A.M.Butlerov. Structural formulas. Structural isomerism. Chain and position isomers.
7. Spatial structure of organic compounds. Stereochemical formulas. Molecular models. The most important concepts in stereochemistry are configurations and conformations of organic molecules.
8. Conformations of open chains - eclipsed , stunted, skewed. Energy and reactivity of various conformations .
9. Conformations of cycles using cyclohexane as an example (chair and bath). Axial and equatorial bonds.
10. Mutual influence of atoms in molecules of organic compounds. Its causes, types of manifestation. Effect on reactivity of molecules.
11. Conjugation. Conjugated systems, conjugated connections. Pi-pi conjugation . in dienes . Conjugation energy. Stability of conjugated systems (vitamin A).
12. Conjugation in arenes (pi-pi conjugation). Aromaticity. Huckel's rule. Benzene, naphthalene, phenanthrene. Reactivity of the benzene ring.
13. Conjugation in heterocycles (p-pi and pi-pi conjugation using pyrrole and pyridine as an example). Stability of heterocycles - biological significance using tetrapyrrole compounds as an example.
14. Polarization of bonds. Causes. Polarization in alcohols, phenols, carbonyl compounds, thiols . Effect on the reactivity of molecules.
15. Electronic effects. Inductive effect in molecules containing sigma bonds . Sign of the inductive effect.
16. Mesomeric effect in open chains with conjugated pi bonds using 1,3-butadiene as an example.
17. Mesomeric effect in aromatic compounds.
18. Electron-donating and electron-withdrawing substituents.
19. Substituents of the first and second kind. Orientation rule in the benzene ring.
20. Acidity and basicity of organic compounds. Acids and bases of the Brendsteth-Lowry system . Acid-base pairs - conjugate acids and bases. K_a and pK_a - quantitative characteristics of the acidity of organic compounds. The importance of acidity for the functional activity of organic molecules.
21. Acidity of various classes of organic compounds. Factors determining the acidity of organic compounds are the electronegativity of the non-metal atom bound to hydrogen, the polarizability of the non-metal atom, and the nature of the radical bound to the non-metal atom.
22. Organic bases. Amines. Reason for basicity . Effect of radical on basicity of aliphatic and aromatic amines.
23. Classification of reactions of organic compounds by their mechanism. Concepts of homolytic and heterolytic reactions.
24. Substitution reactions of radical type in alkanes . Free radical oxidation in living organisms. Active forms of oxygen.

25. Electrophilic addition of alkenes . Formation of pi-complexes, carbocations . Hydration and hydrogenation reactions.
26. Electrophilic substitution in the aromatic ring. Formation of intermediates sigma complexes . Benzene bromination reaction .
27. Nucleophilic substitution in alcohols. Dehydration reactions, oxidation of primary and secondary alcohols, formation of esters.
28. Nucleophilic addition of carbonyl compounds. Biologically important reactions of aldehydes: oxidation, formation of hemiacetals when interacting with alcohols.
29. Nucleophilic substitution in carboxylic acids. Biologically important reactions of carboxylic acids.
30. Oxidation of organic compounds, biological significance. Degree of oxidation of carbon in organic molecules. Oxidizability of different classes of organic compounds.
31. Energy oxidation. Oxidase reactions.
32. Non-energetic oxidation. Oxygenase reactions.
33. The role of free radical oxidation in the bactericidal action of phagocytic cells.
34. Restoration of organic compounds. Biological significance.
35. Polyfunctional compounds. Polyhydric alcohols - ethylene glycol, glycerin, xylitol, sorbitol, inositol. Biological significance. Biologically important reactions of glycerin - oxidation, formation of esters.
36. Dibasic dicarboxylic acids: oxalic, malonic , succinic, glutaric . The transformation of succinic acid into fumaric is an example of biological dehydrogenation.
37. Amines. Classification: - by the nature of the radical (aliphatic and aromatic); - by the number of radicals (primary, secondary, tertiary, quaternary ammonium bases); - by the number of amino groups (mono- and diamines). Diamines: putrescine and cadaverine.
38. Heterofunctional compounds. Definition. Examples. Peculiarities of manifestation of chemical properties.
39. Amino alcohols : ethanolamine , choline, acetylcholine. Biological significance.
40. Oxyacids . Definition. General formula. Classification. Nomenclature. Isomerism. Representatives of monocarboxylic oxyacids : lactic, beta-hydroxybutyric , gamma-hydroxybutyric ; dicarboxylic: malic, tartaric; tricarboxylic: citric; aromatic: salicylic.
41. Chemical properties of oxyacids : by carboxyl, by hydroxy group , dehydration reactions of alpha, beta and gamma isomers, differences in reaction products (lactides , unsaturated acids, lactones).
42. Stereoisomerism . Enantiomers and diastereomers . Chirality of molecules of organic compounds as a cause of optical isomerism.
43. Enantiomers with one chirality center (lactic acid). Absolute and relative configuration of enantiomers . Oxyacid key. D and L glyceraldehyde. D and L isomers. Racemates.
44. Enantiomers with several chirality centers . Tartaric and mesotartaric acids.
45. Stereoisomerism and biological activity of stereoisomers.
46. Cis- and trans-isomerism using fumaric and maleic acids as an example.
47. Oxoacids . Definition. Biologically important representatives: pyruvic , acetoacetic, oxaloacetic . Keto-enol tautomerism using pyruvic acid as an example.
48. Amino acids. Definition. General formula. Isomers of the amino group position (alpha a- , beta-, gamma-). Biological significance of alpha-amino acids . Representatives of beta- , gamma- and other isomers (beta-aminopropionic , gamma-aminobutyric , epsilon-aminocaproic). Dehydration reaction of gamma - isomers with the formation of cyclic lactones.
49. Heterofunctional benzene derivatives as the basis of medicines. Derivatives of p-aminobenzoic acid - PABA (folic acid, anesthesin). PABA antagonists - derivatives of sulfanilic acid (sulfonamides - streptocide).

50. Heterofunctional benzene derivatives - drugs. Derivatives of p-aminophenol (paracetamol), derivatives of salicylic acid (acetylsalicylic acid), p-aminosalicylic acid - PAS.
51. Biologically important heterocycles . Definition. Classification. Features of structure and properties: conjugation, aromaticity, stability, reactivity. Biological significance.
52. Five-membered heterocycles with one heteroatom and their derivatives. Pyrrole (porphine , porphyrins , heme), furan (medicines), thiophene (biotin).
53. Five-membered heterocycles with two heteroatoms and their derivatives. Pyrazole (5-oxo derivatives), imidazole (histidine), thiazole (vitamin B_1 -thiamine).
54. Six-membered heterocycles with one heteroatom and their derivatives. Pyridine (nicotinic acid - participation in oxidation-reduction reactions, vitamin B6 - pyridoxal), quinoline (5-NOC), isoquinoline (alkaloids).
55. Six-membered heterocycles with two heteroatoms . Pyrimidine (cytosine , uracil , thymine).
56. Condensed heterocycles . Purine (adenine , guanine). Purine oxidation products are hypoxanthine , xanthine , uric acid).
57. Alkaloids. Definition and general characteristics. Structure of nicotine and caffeine.
58. Carbohydrates. Definition. Classification. Functions of carbohydrates in living organisms.
59. Monosaccharides . Definition. Classification. Representatives.
60. Pentoses. Representatives - ribose and deoxyribose . Structure, open and cyclic formulas. Biological significance.
61. Hexoses. Aldoses and ketoses . Representatives.
62. Open formulas of monosaccharides . Determination of stereochemical configuration. Biological significance of monosaccharide configuration .
63. Formation of cyclic forms of monosaccharides . Glycosidic hydroxyl. Alpha and beta anomers . Haworth formulas .
64. Derivatives of monosaccharides . Phosphorus esters, gluconic and glycuronic acids, amino sugars and their acetyl derivatives.
65. Maltose. Composition, structure, hydrolysis and significance.
66. Lactose. Synonym. Composition, structure, hydrolysis and meaning.
67. Sucrose. Synonyms. Composition, structure, hydrolysis and meaning.
68. Homopolysaccharides . Representatives. Starch, structure, properties, hydrolysis products, significance.
69. Glycogen. Structure, role in the animal organism.
70. Fiber. Structure, role in plants, importance for humans.
71. Dextrans. Composition, structure, importance for microorganisms. Polyglucin .
72. Heteropolysaccharides . Synonyms. Functions. Representatives. Structural feature - dimeric links, composition. 1,3- and 1,4- glycosidic bonds.
73. Hyaluronic acid. Composition, structure, properties, importance in the body.
74. Chondroitin sulfate . Composition, structure, importance in the body.
75. Muramin . Composition, meaning.
76. Alpha-amino acids . Definition. General formula. Nomenclature. Classification. Individual representatives. Stereoisomerism .
77. Chemical properties of alpha-amino acids . Amphotericity, decarboxylation reactions , deamination , hydroxylation in the radical, formation of peptide bond.
78. Peptides. Individual peptides. Biological role.
79. Proteins. Protein functions. Levels of structure.
80. Nitrogenous bases of nucleic acids are purines and pyrimidines. Modified nitrogenous bases are antimetabolites (fluorouracil , ercaptopurine).
81. Nucleosides. Nucleoside antibiotics. Nucleotides. Mononucleotides in nucleic acids and free nucleotides - coenzymes.

82. Nucleic acids. DNA and RNA. Biological significance. Formation of phosphodiester bonds between mononucleotides. Levels of nucleic acid structure.
83. Lipids. Definition. Biological role. Classification.
84. Higher carboxylic acids - saturated (palmitic, stearic) and unsaturated (oleic, linoleic , linolenic and arachidonic).
85. Neutral fats - acylglycerols . Structure, meaning. Animal and vegetable fats. Hydrolysis of fats - products, meaning. Hydrogenation of vegetable oils, artificial fats.
86. Glycerophospholipids . Structure: phosphatidic acid and nitrogenous bases. Phosphatidylcholine .
87. Sphingolipids . Structure. Sphingosine . Sphingomyelin .
88. Steroids. Cholesterol - structure, meaning, derivatives: bile acids and steroid hormones.
89. Terpenes and terpenoids . Structure and biological significance. Representatives.
90. Fat-soluble vitamins. General characteristics.
91. Anesthetic agents. Diethyl ether. Chloroform. Meaning.
92. Medicines that stimulate metabolic processes.
93. Sulfonamides, structure, meaning. White streptocide.
94. Antibiotics.
95. Anti-inflammatory and antipyretic agents. Paracetamol. Structure. Value.
96. Antioxidants. Characteristics. Value.
97. Thiols . Antidotes.
98. Anticoagulants. Characteristics. Significance.
99. Barbiturates. Characteristics.
100. Analgesics. Meaning. Examples. Acetylsalicylic acid (aspirin).
101. Antiseptics. Meaning. Examples. Furacilin . Characteristic. Meaning.
102. Antiviral drugs.
103. Diuretics.
104. Means for parenteral nutrition.
105. PABK, PAS. Structure. Characteristic. Meaning.
106. Iodoform. Xeroform. Meaning.
107. Polyglucin . Characteristic. Meaning
108. Formalin. Characteristic. Meaning.
109. Xylitol, sorbitol. Structure, meaning.
110. Resorcinol. Structure, meaning.
111. Atropine. Meaning.
112. Caffeine. Structure. Meaning
113. Furacilin . Furazolidone . Characteristic. Meaning.
114. GABA, GHB, succinic acid. Structure. Value.
115. Nicotinic acid. Structure, meaning