MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS
EDUCATIONAL INSTITUTION
BELARUSIAN STATE MEDICAL UNIVERSITY

APPROVED
by First Vice-Rector, Professor
_____ I.N.Moroz
27. 06. 2023
Reg. # UD-091-023/23edu.

BIOORGANIC CHEMISTRY

Curriculum of educational institution
in the educational discipline for the specialty:

7-07-0911-01 «General Medicine»

2023

Curriculum is based on the educational program «Bioorganic Chemistry», approved 27.06.2023, registration # УД-091-023/2324/уч.; on the educational plan in the specialty 7-07-0911-01 «General Medicine», approved 17.05.2022, registration # 7-07-0911-01/2324/mf.

COMPILERS:

O.N.Ryneiskaya, the Head of the Bioorganic Chemistry Department of the Educational Institution «Belarusian State Medical University», PhD, Associate Professor;

I.V.Romanovsky, Professor of the Bioorganic Chemistry Department of the Educational Institution «Belarusian State Medical University», PhD, Professor;

E.M.Ermolenko, Senior lecturer of the Bioorganic Chemistry Department of the Educational Institution «Belarusian State Medical University»

RECOMMENDED FOR APPROVAL:

by the Department Bioorganic Chemistry of the Educational Institution «Belarusian State Medical University»
(protocol # 13 of 12.05.2023);

by the Scientific and Methodological Council of the Educational Institution «Belarusian State Medical University»
(protocol # 6 of 27.06.2023)

EXPLANATORY NOTE

«Bioorganic Chemistry» – the academic discipline of the Chemical Module, which contains systematized scientific knowledge about the structure and mechanisms of functioning of biological important molecules by methods of organic chemistry.

The aim of the discipline «Bioorganic Chemistry» is the formation of basic professional competencies, which are based on scientific knowledge about the interrelations between the structure and the chemical properties of biological important organic compounds as base of the metabolism essence understanding.

The objectives of the discipline «Bioorganic Chemistry» are to form students' scientific knowledge about:

the structures of the biological important organic compounds;

the typical mechanisms of chemical reactions of poly- and heterofunctional organic compounds in vitro for understanding of enzyme catalysis in vivo;

the factors influencing on thermodynamic stability of organic molecules;

the principles of synthesis and organization of biological macromolecules (in vitro and in vivo);

skills and abilities necessary for solving situations of predicting the properties of organic compounds, the direction and result of their chemical transformations.

The knowledge, skills, and abilities acquired during the study of the academic discipline «Bioorganic Chemistry» are necessary for successful mastering of the following academic disciplines: «Biological Chemistry», «Medical Biology and General Genetics», «Normal Physiology», «Pharmacology», «General Hygiene», «Microbiology, Virology, Immunology», «Radiation Medicine and Ecology».

Studying the educational discipline «Bioorganic Chemistry» should ensure the formation of students' basic professional competencies:

BPC. Assess the properties of natural and synthetic organic compounds, potentially dangerous substances for the human body, predict their behavior in different biological environment.

As a result of studying the discipline «Bioorganic Chemistry» the student should

know:

rules of international chemical nomenclature (IUPAC); fundamental concepts of theoretical organic chemistry as a basis for understanding the structure and reactivity of organic compounds involved in vital processes;

structure, chemical properties and biological significance of poly- and heterofunctional compounds involved in vital processes and being structural components of lipids, polysaccharides, proteins, nucleic acids, complex biopolymers;

principles of organization of macromolecules to understand the basics of their functioning using stereochemical concepts;

fundamentals of stereochemistry (chirality, enantiomerism, diastereomerism) necessary for understanding the specificity of complementary interaction at the molecular level of an enzyme and a substrate, a hormone and a receptor, etc.;

conditions for the generation of free radicals, including reactive oxygen species, the reaction mechanism of free-radical oxidation of unsaturated fatty acids, which underlies lipid peroxidation, the chemical basis of the antioxidant action of biologically active substances containing phenolic hydroxyl, thiol group;

the molecular basis of the action of antiseptics and disinfectants, which are alcohols, phenols, aldehydes, quaternary ammonium compounds, etc.;

be able to:

classify organic compounds according to the structure of the carbon skeleton and the nature of functional groups;

isolate functional groups, determine reaction centers, conjugated and aromatic fragments in molecules to predict the chemical behavior of organic compounds;

determine hydrophilic and hydrophobic areas in the structure of biologically significant molecules, their ability to be distributed in the body's environments;

qualitatively assess the acid-base properties of organic compounds involved in life processes, medicines, as well as substances potentially dangerous to the human body;

predict the direction and result of chemical transformations of organic compounds;

perform simple chemical experiments with subsequent analysis and presentation of the results;

master:

skills of quantitative reactions exercise on the most important functional groups of the organic compounds;

safe operation skills in the chemical laboratory: handling with chemical tableware, burner, poisonous and volatile substances.

Total number of hours for the study of the discipline is 108 academic hours. Classroom hours according to the types of studies: lectures - 12 hours (including 4 hours of supervised student independent work), laboratory classes - 54 hours, student independent work (self-study) – 42 hours.

Intermediate assessment is carried out according to the syllabus of the specialty in the form of a graded credit (1 (2) semester).

Form of higher education – full-time.

ALLOCATION OF ACADEMIC TIME ACCORDING TO SEMESTERS OF STUDY

Code, name of the specialty	semester	Number of academic hours						Form of intermediate assessment
		total	in-class	including			out-of-class self-studies	
				lectures (including supervised indenendent work)	supervised student independent work	laboratory studies		
1-79 01 01 «General Medicine»	1 (2)	108	66	12	4	54	42	graded credit

THEMATIC PLAN

Section (topic) name	Number of class hours	
	lectures	laboratory practicals
1. Theoretical bases of structure and general regularities of the organic compounds reactivity	**2**	**21**
1.1. Introduction. Classification and nomenclature of organic compounds	-	3
1.2. Chemical bond and interference of atoms in the organic molecule	-	3
1.3. Spatial structure of organic compounds and stereoisomerism	2	3
1.4. Reactivity of hydrocarbons	-	3
1.5. Reactivity of alcohols, phenols, thiols, amines. Acid-base properties of organic compounds	-	3
1.6. Reactivity of aldehydes and ketones	-	3
1.7. Reactivity of carboxylic acids and their functional derivatives	-	3
2. Biologically important heterofunctional compounds	**2**	**6**
2.1. Poly- and heterofunctional compounds, involved in life processes and underlying the most important drugs groups	2	3
2.2. Biologically active heterocyclic compounds. Alkaloids	-	3
3. Biopolymers and their structural fragments. Low molecular bioregulators	**8**	**27**
3.1. Carbohydrates	2	6
3.2. Amino acids	1	3
3.3. Peptides and proteins	1	3
3.4. Nucleic acids	-	3
3.5. Lipids	2	3
3.6. Low molecular bioregulators	2	9
Total hours	**12**	**54**

CONTENT OF THE EDUCATIONAL MATERIAL

1. Theoretical bases of structure and general regularities of the organic compounds reactivity

1.1. Introduction. Classification and nomenclature of organic compounds

A brief historical sketch of the bioorganic chemistry development. Place of Bioorganic Chemistry in medical education as one of the medical and biological cycle disciplines. Objectives of bioorganic chemistry as an academic discipline in medical schools. Objects studied bioorganic chemistry.

Classification of organic carbon compounds in the skeleton structure and functional groups nature. Main classes of organic compounds.

Basic rules of organic compounds IUPAC nomenclature; substitution and radical functional nomenclature.

1.2. Chemical bond and interference of atoms in the organic molecule

Electronic structure of carbon atom. Hybridization of atomic orbitals. Types of hybridization. Types of chemical bonds in organic compounds. Main characteristics of covalent σ-and π-bonds. Hydrogen bonds.

Conjugation. Types of conjugation: π, π and p, π. Conjugation systems with opened chain: 1,3-dienes, polyenes, allyl ions and allyl radical. Cyclic conjugation systems. Aromaticity. Huckel`s rule of aromaticity. Energy of conjugation. Thermodynamic stability of biologically important molecules with opened and closed conjugated systems.

Mutual influence of atoms in the molecule: inductive and mesomeric electronic effects of substituents. Electron-donating and electron-withdrawing substituents. The electron density distribution within the molecule. Reaction centers.

1.3. Spatial structure of organic compounds and stereoisomerism

Configuration and conformation as ways to describe the spatial structure of the molecule. Contact the spatial structure of the carbon atoms hybridization type. Molecular models, stereochemical formulas, projection Fisher formulas, formulas Newman.

Chirality. Chiral molecules. The asymmetric carbon atom. Enantiomerism. Optical activity. Relative D-and L-stereochemical nomenclature system. Glyceraldehyde as a configuration standard. The concept of the R, S-nomenclature. Stereoisomers molecules with one, two or more centers of chirality: σ-enantiomerism and diastereomerism. Meso forms. Racemic mixtures. The concept of the racemic mixtures separation methods. π-Diastereomerism of unsaturated compounds.

Contact the spatial structure of a compound with its biological activity. Fisher's theory, Koshlenda's theory. Complementarity.

Conformation of acyclic compounds. Types of strain in the molecule: the torsion strain and van der Waals strain. Energy characteristic of alkane conformations. Angular strain and conformation of five-and six-membered cyclic compounds, their energy characteristics. Axial and equatorial bonds. 1,3-Diaxial interaction inversion of cycle. Chair conformation of cyclic α- and β-forms of D-glucose participating in the construction of starch and cellulose.

1.4. Reactivity of hydrocarbons

The reaction mechanism concept. Substrate, reagent, the reaction center. Classification of organic reactions according to result (substitution, addition, elimination, rearrangement, oxidation-reduction, salt formation). Radical and ionic reactions. Types of reagents: radical, electrophilic, nucleophilic, acidic, basic. Homolytic cleavage of the covalent bond and the concept of free radicals and chain reactions. Heterolytic break of a covalent bond; carbocations and carboanions. Electronic and spatial structure of the particles formed in homolysis and heterolysis; factors contributing to their relative stability.

Reactivity of saturated hydrocarbons. Radical substitution reactions. Mechanism of radical substitution reactions. Regioselectivity. Pathways of radical species formation: photolytic, thermal decomposition, redox reactions involving metal ions of variable valence. Concept of chain processes. The role of free radical reactions in biological oxidation processes. Reactive oxygen species, peroxides.

Electrophilic addition reactions of alkenes. The mechanism of the hydration reaction, acid catalysis. Effect of static and dynamic factors on the regioselectivity of addition reactions. Markovnikov rule. Features of electrophilic addition to conjugated systems: hydration α, β- unsaturated carboxylic acids.

Qualitative reaction detection of multiple bonds in the analyzed object.

Electrophilic substitution reactions in aromatic compounds. Reaction mechanism, the role of catalyst in the formation of electrophilic particle. Effect of substituents on the aromatic nucleus in the reactivity of the electrophilic substitution reactions. Orienting effect of the substituents. Alkylation and halogenation reactions *in vivo*.

Oxidation reactions of aromatic compounds *in vivo* as a way of increasing the hydrophilicity and the excretion of xenobiotics.

1.5. Reactivity of alcohols, phenols, thiols, amines. Acid-base properties of organic compounds

Reaction centers in the molecules of alcohols, phenols, thiols, amines. Acidity and basicity in accordance with the theories of Bronsted and Lewis. Quantitative and qualitative characteristics of the organic compounds acidic and basic properties. General regularities of the changes in acidic or basic properties in relation to the nature of the atoms in the acidic or basic centers, electronic effects of the substituents at these centers and solvation effects. Toxicity of strong acids and bases. Amphoteric properties. Hydrogen bond as a specific manifestation of acid-base properties. Hydrogen bonds in the structure of biopolymers. Ionization organic acids and bases depending on pH. The role of ionization in the biological activity manifestation.

The general mechanism of nucleophilic substitution at the sp^3-hybridized carbon atom. Mono- and bimolecular reactions. Stereochemistry of nucleophilic substitution reactions. Nucleophilic substitution of the hydroxyl group in alcohols. Acid catalysis. The alkylation reaction of alcohols, amines, thiols. Alkylation *in vivo*. Competitive mono- and bimolecular reactions of elimination of the alcohol. Biologically important dehydration reactions hydroxyl-containing compounds.

Oxidation of alcohols, thiols, phenols. Biological oxidation with coenzyme NAD^+. Hydride transfer in the system of NAD^+ - NADH. Compounds containing thiol group, phenolic hydroxyl as antioxidants.

1.6. Reactivity of aldehydes and ketones

Reaction centers of aldehydes, ketones. Nucleophilic addition reactions. The overall reaction mechanism. Addition of water, alcohols, amines. Formation of cyclic hemiacetals. Aldol reaction addition. Reversibility of nucleophilic addition. The biological significance of reactions acetalization, aldol cleavage, reaction with amines. Toxicity of aldehydes. Use of aldehydes as disinfectants and sterilization capability.

Oxidation and reduction reactions of carbonyl compounds *in vitro* and *in vivo*.

Qualitative reactions on aldehyde group. Reactions of acetone detection.

1.7. Reactivity of carboxylic acids and their functional derivatives

Reaction centers in the molecules of carboxylic acids. The acidic properties of carboxylic acids. The general mechanism of nucleophilic substitution at the sp^2-hybridized carbon atom of the carboxylic acids and their functional derivatives. Forming reaction and hydrolysis of the carboxylic acids functional derivatives: anhydrides, esters, amides. Acylating ability of the carboxylic acids functional derivatives. Comparative characteristics of the carboxylic acids esters and thioesters acylating ability; their biological significance. Acetyl coenzyme A. Biologically important acylation reaction involving acyl phosphates. The phosphorylation reactions concept.

Amides of carboxylic acids. Features of the amide group structure. Acid-base properties of the amides. Benzoic acid amide: hippuric acid. Functional derivatives of carbonic acid: full (urea) and unfull (carbamic acid) amides; their acid -base properties of biological significance. Biuret. Use in medicine urethanes, acids and ureides and ureidoacids. Iminourea, its biologically important derivatives: creatine, creatine phosphate.

2. Biologically important heterofunctional compounds

2.1. Poly- and heterofunctional compounds, involved in life processes and underlying the most important drugs groups

Classification of poly- and heterofunctional compounds. Acid-base properties. Typical reactivity of poly- and heterofunctional compounds. Specific properties due to the mutual influence groups chelation polyhydric alcohols, α- amino-alcohols, α-amino acids, and intramolecular (from γ- and δ-hydroxyaldehyde, γ- and δ-hydroxy- and amino acid dicarboxylic acid with a carbon number of 4 or 5) and intermolecular (from α-hydroxy and amino acids) cyclization. Cyclic hemiacetals, cyclic anhydrides, lactones, lactams, lactides, diketopiperazines. Decarboxylation reactions. Elimination reactions of the β-hydroxy- and β-amino acids. Tautomerism: keto-enol and the lactam-lactam.

Polyhydric alcohols: ethylene glycol, glycerol, inositol, xylitol, sorbitol. Esters of polyhydric alcohols with inorganic acids (nitroglycerin, glycerol and inositol phosphates) and higher fatty acids. The dehydration of glycerol by heating to form

acrolein. Qualitative reaction to diol moiety. The concept of the crown ethers as complexing agents election.

Phenols: hydroquinone, resorcinol, catechol. Oxidation of phenols. Involvement of the quinone-hydroquinone bio oxidation processes. Phenols as antioxidants. Tocopherols.

Dicarboxylic acids: oxalic, malonic, succinic, glutaric, fumaric. Dehydrogenation of succinic acid to form fumarate.

Amino alcohols: 2-aminoethanol, choline. Choline formation of L-serine. Acetylcholine. Catecholamines: dopamine, norepinephrine, epinephrine.

Hydroxy acids: lactic, malic, tartaric, citric acid. Oxidation of lactic and malic acids with coenzyme NAD^+. Citric acid. Using citrate for preserving blood. The dehydration of citric acid *in vivo*.

Oxo acids: pyruvic, acetoacetic, oxaloacetic, α-ketoglutaric acid. The condensation reaction of oxaloacetic acid and decarboxylation reactions acetyl coenzyme A. β-Ketobutyric acid and oxidative decarboxylation of pyruvic acid. Keto-enol tautomerism of oxaloacetic acid.

β-Hydroxybutyrate, β-ketobutyric acid, acetone-representatives of ketone bodies, their biological and diagnostic value.

Salicylic acid and its derivatives, acetylsalicylic acid, methyl salicylate, phenyl salicylate.

p-Aminobenzoic acid and its derivatives having anesthetic action: benzocaine, procaine. p-Aminobenzoic acid as a structural component of folic acid. Modern anesthetics.

Sulfanilic acid and its amide. Sulfa drugs. The notion of antimetabolites.

2.2. Biologically active heterocyclic compounds. Alkaloids

Heterocycles with one heteroatom: pyrrole, thiophene, furan, indole, pyridine, quinoline. Heterocycles with several heteroatoms: pyrazole, imidazole, pyrimidine, purine. Electronic and spatial structure of the pyrrole and pyridine nitrogen atoms. Aromaticity of heterocycles, π-rich and π-deficient aromatic system. Effect on the reactivity of the hetero pyrrole and pyridine in electrophilic substitution reactions. The electron density distribution in molecules pyrrole and pyridine. Acid-base properties of heterocyclic compounds.

Tetrapyrrole compounds porphine and its derivatives - porphyrins. Aromaticity biological significance.

Furan. Tetrahydrofuran. Furfural, 5-nitrofurane derivatives.

Thiophene. Biotin as tetrahydrothiophene derivative.

Indole - a structural component of the biogenic amines serotonin, tryptamine and a number of biologically active substances of plant origin.

Imidazole. Prototropic tautomerism. Intermolecular hydrogen bonds. Imidazole - a structural component of the biogenic amine histamine. Participation imidazole in acidic and basic catalysis of reactions *in vivo*.

Pyrazole. Drugs based on pyrazolone-5.

Biologically important pyridine derivatives: nicotinamide, pyridoxal, medicaments based izonikotinic acid. Participation of nicotinamide in hydride transfer reactions in biological oxidation.

Quinoline and drugs based on it.

Pyrimidine. Vitamin B1. Barbituric acid and its derivatives, tautomerism of barbituric acid and its derivatives.

Hydroxypurine: hypoxanthine, xanthine, uric acid, and their tautomeric forms. Uric acid salts.

The notion of alkaloids.

3. Biopolymers and their structural fragments. Low molecular bioregulators

3.1. Carbohydrates

Monosaccharides classification: aldoses, ketoses; pentoses, hexoses. Stereoisomers of monosaccharides. D- and L-stereochemical series. Open and cyclic forms. Furanoses and pyranoses; α- and β-anomers. Fisher and Haworth formulas. Cyclo-oxo-tautomerism. Mutarotation. Conformation of the monosaccharides pyranose forms. The structure of the most important pentoses representatives (D-ribose, 2-deoxy-D-ribose, D-xylose); hexoses (D-glucose, D-mannose, D-galactose, D-fructose). Amino sugars (D-glucosamine, D-mannosamine, D-galactosamine) and their properties. Neuraminic acid, sialic acid.

Physical properties of monosaccharides.

Chemical properties. Nucleophilic substitution at the anomeric center in the monosaccharides cyclic forms. O-and N-glycosides. Hydrolysis of the glycosides. Biologically important phosphorylation reactions of monosaccharides. Reducing properties of aldoses. Oxidation of monosaccharides: glykonic, glykaric, glukuronic acids. Reduction of monosaccharides: xylitol, sorbitol, mannitol; their use in medicine. Epimerization reaction of monosaccharide. Nucleophilic addition to the the glucose open form carbonyl group (reaction of protein glycation). Ascorbic acid: structure and properties.

The biological significance of monosaccharides and their derivatives.

General characteristics and classification of polysaccharides. Oligosaccharides. Disaccharides: maltose, lactose, lactulose, sucrose, cellobiose. Structure, cyclo-oxo-tautomerism. Reducing properties. Hydrolysis. Conformational structure of maltose, cellobiose, lactose. Role of oligosaccharides in the groups formation of lactose non-pathogenic microflora in the intestines, necessary for normal digestion.

Polysaccharides. Homo-and heteropolysaccharides. Gomopolisaharidy starch (amylose, amylopectin), glycogen, dextran, cellulose. Primary structure, hydrolysis. The concept of the secondary structure (amylose, cellulose). Pectins (polygalacturonic acid). Plasma-substituting solutions on the starch and dextran basis.

Heteropolysaccharides: hyaluronic acid, chondroitin sulfates. The primary structure. Concept of mixed biopolymers: proteoglycans, glycoproteins, glycolipids.

3.2. Amino acids

Amino acids that make up proteins. Classification of proteinogenic amino acids according to different criteria: by acid-base properties, chemical nature of the radical and the substituents contained therein (aliphatic, aromatic, heterocyclic containing hydroxyl, amino, carboxyl or amide group, sulfur-containing); the radicals nature (hydrophilic and hydrophobic). Structure, nomenclature. Stereoisomers. Acid-base properties, bipolar structure. Essential amino acids.

Methods for preparing α- amino acids the hydrolysis of proteins, synthesis of α-halogenated carboxylic acids. Reductive amination and transamination reactions. Pyridoxal catalysis.

The chemical properties of α-amino acids as heterofunctional compounds. Esterification reaction, acylation, alkylation, deamination, imine formation. Qualitative reactions of α- amino acids.

Biologically important reactions of α-amino acids. Decarboxylation of α-amino acids - the way to the formation of biogenic amines and bioregulators: ethanolamine, histamine, tryptamine, serotonin, dopamine, γ-aminobutyric acid, their biological significance. Concept of neurotransmitters. Oxidative and non-oxidative deamination. Hydroxylation reaction (tyrosine → phenylalanine, tyrosine → 3,4-dihydroxyphenylalanine, tryptophan → 5-hydroxytryptophan, proline → 4-hydroxyproline), participation of ascorbic acid in hydroxylation reactions of amino acids. Deamination of amino acids. Oxidation of cysteine. Disulfide bond.

3.3. Peptides and proteins

Peptides. Electronic and spatial structure of the peptide bond. Hydrolysis of the peptides. Individual representatives of the peptides: aspartame, glutathione, neuropeptides, insulin.

Establishment of the peptides primary structure. The concept of the artificial peptide synthesis strategy.

The primary structure of proteins. The concept of the secondary, tertiary (domains) and quaternary structures; mechanism of their formation; folding. Hemoglobin, heme. The concept of the complex proteins.

3.4. Nucleic acids

Nucleic bases: pyrimidine (uracil, thymine, cytosine) and purine (adenine, guanine). Aromatic properties. Lactim-lactam tautomerism. Deamination.

Nucleosides. Nucleotides. Structure of mononucleotides involving the nucleic acids. Nomenclature. Hydrolysis of nucleotides.

The primary structure of nucleic acids. Phosphodiester bond. Ribonucleic and deoxyribonucleic acids. The nucleotide composition of DNA and RNA. The hydrolysis of nucleic acids. The structure and properties of the m-RNA, r-RNA, si-RNA.

The concept of the DNA secondary structure. The role of hydrogen bonds in the secondary structure formation. Complementarity of nucleic bases. Hydrogen bonds in the nucleic bases complementary pairs. Stacking interaction.

Drugs on the basis of modified nucleobases. Chemical similarity principle. Changes in the structure of nucleic bases under the influence of chemical mutagens, ultraviolet radiation and radiation.

Nucleoside mono- and polyphosphates. AMP, ADP, ATP. The role of ATP. Energy bond. Cyclic nucleotites (cAMP and cGMP) as second messengers in the regulation of cell metabolism. The coenzymes concept. The structure of NAD^+ and $NADP^+$ phosphate. System NAD^+ - NADH; hydride transfer as one of the obiological oxidation reactions stages - reduction with this system.

3.5. Lipids

Classification. Biological significance. Neutral fats. The concept of the waxes structure. The main natural higher fatty acids contained in the lipid composition: palmitic, stearic, oleic, linoleic, linolenic and arachidonic. Features unsaturated higher fatty acids, ω-nomenclature. The free fatty acids role in energy supply and thermoregulation.

Phospholipids. Phosphatidylserines and phosphatidylethanolamines, phosphatidylcholines (lecithins), phosphatidylinositols – structural components of cell membranes. The composition concept and surfactant role.

Sphingolipids and glycolipids, their role in nerve fibers myelination.

Rancidity of fats - the free-radical chain process as a model of unsaturated fatty acids peroxide oxidation in cell membranes, its mechanism and biological role. The role of membrane lipid peroxidation in implementing the environmental factors damaging effect. The antioxidant defense systems concept.

3.6. Low molecular bioregulators

The concept of biologically active compounds. The value of the spatial structure and physico-chemical properties of bioregulators to their interaction with the receptor, and performing an action at the molecular level.

Steroids. Gonane (sterane, cyclopentaneperhydrophenantrene): stereochemistry 5α- and 5β- sterane skeleton. The physical properties. Primordial structure of steroids: oestrane, androstane, pregnane, cholane, cholestane.

Steroid hormones. Estrogens, androgens, progestins, corticosteroids. Structure, biological role.

Bile acids: cholic, glycocholic, taurocholic; reaction with taurine and glycine. Biological role.

Cholesterol – representative of sterols, its conformational structure. Properties, role in metabolism and membrane structure in the cardiovascular disease development. 7-Dehydrocholesterol, converting to vitamin D_3.

Ergosterol, its transformation into ergocalciferol. The vitamins D role in the regulation of calcium-phosphorus metabolism.

Alkaloids. Classification on alkaloid containing plant species and chemical structure of the incoming heterocycles. Alkaloids poisons and medicines. The structure and effect of nicotine on the human body, quinine, papaverine, morphine, atropine. Methylated xanthine derivatives: theobromine, theophylline, caffeine and their use in medical practice.

ACADEMIC DISCIPLINE CURRICULAR CHART

Section, topic #	Section (topic) name	number of hours			Self-studies	Form of control
		lectures	supervised student independent work	laboratory practicals		
1.	**Theoretical bases of structure and general regularities of the organic compounds reactivity**	**2**	**1**	**21**	**14**	
1.1.	Introduction. Classification and nomenclature of organic compounds	-	-	3	2	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
1.2.	Chemical bond and interference of atoms in the organic molecule	-	-	3	2	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
1.3.	Spatial structure of organic compounds and stereoisomerism	2	1	3	2	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
1.4.	Reactivity of hydrocarbons	-	-	3	2	Interview, tests, control questioning; accounts of classroom (home) practical

						exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
1.5.	Reactivity of alcohols, phenols, thiols, amines. Acid-base properties of organic compounds	-	-	3	2	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
1.6.	Reactivity of aldehydes and ketones	-	-	3	2	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
1.7.	Reactivity of carboxylic acids and their functional derivatives. Concluding class «Theoretical fundamentals of basic classes of organic compound structure and reactivity»		-	3	2	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests, final test
2.	**Biologically important heterofunctional componnds**	**2**	**1**	**6**	**6**	
2.1.	Poly- and heterofunctional compounds, involved in life processes and underlying the most important drugs groups	2	1	3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
2.2.	Biologically active heterocyclic compounds. Alkaloids	-	-	3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense;

						electronic tests
3.	**Biopolymers and their structural fragments. Low molecular bioregulators**	**8**	**2**	**27**	**22**	
3.1.	Carbohydrates. Monosaccharides	2	0,5	3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
3.1.	Carbohydrates. Oligo- and polysaccharides			3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
3.2.	Amino acids	2	0,5	3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
3.3.	Peptides and proteins			3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
3.4.	Nucleic acids	-	-	3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests

3.5.	Lipids	2	0,5	3	3	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
3.6.	Low molecular bioregulators. Steroids: estrogens, androgens, progestins and corticosteroids	2	0,5	3	4	Interview, tests, control questioning; accounts of classroom (home) practical exercises with oral defense; accounts of laboratory work with oral defense; electronic tests
	Concluding class «Biopolymers and their structural components»	-	-	3	-	Conference reports, article publications, electronic tests, final test
	Concluding class «Structure and properties some classes of organic compounds. Biopolymers and their structural components, lipids, low molecular bioregulators»	-	-	3	-	Electronic tests, final test, graded credit
	Total hours	**12**	**4**	**54**	**42**	

INFORMATION AND INSTRUCTIONAL UNIT

LITERATURE

Basic (relevant):

1. Bioorganic Chemistry : textbook for international students / O. N. Ryneiskaya [et al.]. – 2nd edition – Minsk : New knowledge, 2020. – 174 p.
2. Bioorganic Chemistry : textbook for international students / O. N. Ryneiskaya [et al.]. – 1st edition – Minsk : New knowledge, 2018. – 174 p.

Additional:

3. Bioorganic chemistry : manual for dental students / O. N. Ryneiskaya, E. M. Ermolenko, S. V. Hlinnik – Minsk : BSMU, 2021. – 112 p.
4. Gubskyi, Y. Bioorganic chemistry : textbook for students of medical universities. – Vinnytsya : Nova Knyha, 2019. - 224 p.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

The time given for independent work can be used by student to:
taking notes on the educational literature;
preparation for laboratory classes;
preparation for the graded credit (exam) in the academic discipline;
performing research and creative tasks;
making a review of scientific literature on a given topic;
preparation of thematic reports, abstracts of presentations;
design of information and demonstration materials (stands, posters, graphs, tables, newspapers, etc.);
production of the educational models, tutorials;
compilation of a thematic selection of literary sources, Internet sources.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF SUPERVISED STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

Main forms of supervised student independent work:
preparation and presentation of abstracts;
presentation of reports;
studying topics and problems that have not been discussed at the lectures;
computer testing;
preparation of tests for the organization of mutual assessment;
preparation of didactic materials;
participation in active forms of education.

Control of supervised student independent work is carried out in the form of:

computer testing;
test paper;
final class, colloquium in the form of an oral interview, written work, testing;
discussion of abstracts;
assessment of an oral reply to a question, presentation, report or problem solving;
checking up abstracts;
individual interview.

LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms are used for competences assessment:

Oral form:
interviews;
conference reports.

Written form:
tests;
control questioning;
final tests;
article publications.

Oral-written form:
accounts of classroom practical exercises with oral defense;
accounts of home practical exercises with oral defense;
accounts of laboratory work with oral defense;
credit.

Technical form:
electronic tests.

LIST OF AVAILABLE TEACHING METHODS

Traditional method (lecture, laboratory practicals);
Active (interactive) methods:
Problem-Based Learning (PBL);
Team-Based Learning (TBL);
Research-Based Learning (RBL).

LIST OF PRACTICAL SKILLS

1. Classification of organic compounds according to the structure of the carbon skeleton and the nature of functional groups.
2. Compilation of structural formulas and names of representatives of biologically important substances and drugs using chemical nomenclature.

3. Isolation of functional groups, determination of reactivity centers, conjugated and aromatic fragments in molecules to predict the chemical behavior of organic compounds.

4. Determination of hydrophilic and hydrophobic parts in the structure of biologically significant molecules, the ability of these molecules to be distributed in the environments of the human body.

5. Qualitative assessment of the acid-base properties of organic compounds involved in vital processes, drugs, as well as drugs that are potentially dangerous to the human body.

6. Prediction of the reactivity of organic compounds based on the electronic and spatial structure, recording chemical reaction schemes.

7. Implementation of the planned chemical experiment with subsequent analysis and presentation of the results.

8. Carrying out qualitative reactions on the most important functional groups of organic compounds.

9. Carrying out safe work in a chemical laboratory: handling chemical glassware, a burner, toxic and volatile substances.

LIST OF EQUIPMENT USED

Fume hoods, laboratory glassware, reagents, alcohol lamps, laboratory scales, water bath, blackboard, computer, TV-set.

LIST OF LECTURES

1. Spatial structure of organic compounds and stereoisomerism.
2. Poly- and heterofunctional compounds, involved in life processes and underlying the most important drugs groups.
3. Carbohydrates.
4. Amino acids, peptides and proteins.
5. Lipids.
6. Low molecular bioregulators.

LIST OF LABORATORY (PRACTICAL) STUDIES

1. Introduction. Classification and nomenclature of organic compounds.
2. Chemical bond structure and atom effects in the organic molecules.
3. Spatial structure of organic molecules. Stereoisomerism, its role for biological activity demonstration.
4. Reactivity of hydrocarbons.
5. Reactivity of alcohols, phenols, thiols, amines. Acid-base properties of organic compounds.
6. Reactivity of aldehydes and ketones.
7. Reactivity of carboxylic acids and their functional derivatives. Concluding class «Theoretical fundamentals of basic classes of organic compound structure and reactivity».

8. Poly- and heterofunctional compounds, involved in life processes and underlying the most important drugs groups.
9. Biologically active heterocyclic compounds. Alkaloids.
10. Carbohydrates. Monosaccharides.
11. Carbohydrates. Oligo- and polysaccharides.
12. Amino acids.
13. Peptides and proteins.
14. Nucleic acids.
15. Lipids.
16. Low-molecular bioregulators.
17. Concluding class «Biopolymers and their structural components».
18. Concluding class «Structure and properties some classes of organic compounds. Dental materials of organic origin. Biopolymers and their structural components, lipids, low molecular bioregulators».

PROTOCOL OF THE CURRICULUM APPROVAL BY OTHER DEPARTMENTS

Title of the discipline requiring approval	Department	Amendments to the curriculum in the academic discipline	Decision of the department, which designed the curriculum (date, protocol #)
1. Biological chemistry	Biological chemistry	No suggestions	protocol # 12 of 12.05.2023
2. Medical chemistry	General chemistry	No suggestions	protocol # 12 of 12.05.2023

COMPILERS/AUTHORS:

Head of the Bioorganic chemistry Department, Educational Institution «Belarusian State Medical University», PhD, Associate Professor _____ O.N.Ryneiskaya

Professor of the Bioorganic chemistry Department, Educational Institution «Belarusian State Medical University», PhD, Professor _____ I.V.Romanovsky

Senior lecturer of the Bioorganic chemistry Department, Educational Institution «Belarusian State Medical University» _____ E.M.Ermolenko

Curriculum content, composition and accompanying documents comply with established requirements.

Dean of the Medical Faculty of International Students of the Educational Institution «Belarusian State Medical University» O.S.Ishutin
16.06. 2023

Methodologist of Educational Institution «Belarusian State Medical University»
16.06. 2023 S.V.Zaturanova