Federal State Autonomic Educational Institution of Higher Education
«Peoples' Friendship University of Russia»

Medical Institute

Recommended MCSD

ACADEMIC COURSE WORKING PROGRAM

Course name

Bioorganic Chemistry

Recommended for the direction of training (specialty)

31.05.01 General Medicine

Program (profile, specialization)

General medicine

1. Objectives and discipline problems:

The objective of the course of bioorganic chemistry is in the formation of the system of knowledge about the laws in the chemical behavior of the main classes of organic compounds in relation to their structure in order to use this knowledge as a basis for study at the molecular level, the processes occurring in the living organisms.

2. Place of the discipline in the PLO structure:

Discipline «Bioorganic Chemistry» is a variative part of the block 2 (block2).

Table 1 shows the preceding and subsequent disciplines aimed at creating competencies discipline in accordance with the matrix of competencies OP HE structure.

Table 1.

Preceding and following the discipline aimed at creating competencies

№ п/п	Code and title of competence	Precceding disciplines	Parallel disciplines	Following disciplines
Universal Competence Category				
UC-6. Being able to identify and implement the priorities of their own activities and the ways of improving them based on self-assessment and lifelong learning		Physics Chemistry Biology	Biology	Biology
General Professional Competence Category				
GPC-3. Being able to counter doping in sports and fight against it		Chemistry	Physical training and sports	Physical training and sports

3. Requirements for the results of the development in the discipline:

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

Competencies

Competencies	Name of Competency	Parts of competencies
UC-6	Being able to identify and implement the priorities of their own activities and the ways of improving them based on self-assessment and lifelong learning	UC-6.1. Assessing their own resources and their (personal, contextual, time) limits; using them in an optimal way to successfully perform the assigned task.
GPC-3	Being able to counter doping in sports and fight against it	GPC-3.2. Being able to analyze biochemical, physical and chemical, and molecular and biological mechanisms of the development of pathological processes in the cells of the athlete's body tissues when taking prohibited drugs; defining the principles of the biochemical processes when taking illegal drugs.

4. Volume of discipline and types of study

General credit value of the discipline is 2 credit units.

Type of study load	Total hours	Semesters			
		2			

Class hours (total)		**68**	**68**			
Include:		-	-			
Lectures		-	-			
Practical training (PT)			-			
Seminars (S)			-			
Laboratory research (LR)		68	68			
Independent work (total)		**4**	**4**			
Total labor input	hours	**72**	**72**			
	Credit Unit	**2**	**2**			

5. Content of the discipline

5.1. The content of the discipline sections

№ п/п	Name of the section of discipline	Contents of the section
1	**Introduction.** **Hydrocarbons.**	1. Bioorganic chemistry as a field of science that studies the structure and mechanisms of functioning of biologically active molecules from the standpoint of organic chemistry. Organic chemistry is the fundamental basis of bioorganic chemistry. The main laws of the theory of chemical structure. Isomerism. Classes of organic compounds. Hybridization of the carbon atom. 2. Reactivity of hydrocarbons. Radical substitution reactions in saturated hydrocarbons. Electrophilic addition reactions in alkenes, reaction mechanism on the example of hydration, acid catalysis. Addition of hydrogen halides, halogens, sulfuric acid. Regioselectivity of electrophilic addition reactions. Markovnikov's rule. Electrophilic substitution reactions with the participation of aromatic substrates by the example of alkylation. Effect of substituents on the reactivity of benzene derivatives. The orienting influence of the deputies. Qualitative reactions for detecting multiple connections in the analyzed object.
2	**Heterofunctional compounds**	1. Alcohols (alcohols and alkanols). Atomicity of alcohols. The hydrogen bond. Reactivity of alcohols. Preparation of ethers and esters. Ethylene glycol. Glycerol. Ethers and oils. Nitroglycerine. Phenol. The acidic properties of phenol. Methods for preparation of phenol. 2.Amines. The main properties of amines. Influence of electronic effects of substituents on the basic properties of amines. The salt formation. Acylation and alkylation of amines. Reaction with nitrous acid. Diamines. Ethylenediamine, putrescine, cadaverine, hexamethylenediamine - their biological importance and application. p-Aminophenol. Analgesic drugs derived from it. Salicylic acid. Aspirin. p-Amino benzoic acid and its derivatives benzocaine and procaine. Sulfanilic acid.

		Sulfa drugs. p-Aminosalicylic acid. The amino alcohols. Ethanolamine in nature. Novocaine, choline, acetylcholine. 3. Aldehydes and ketones. Electronic structure of the carbonyl group. Reaction of the carbonyl group and α-hydrogen in oxo-compounds . Acetals and ketals. The mechanism of their formation. Reactions of oxo-compounds with nitrogen-containing nucleophiles. The reaction mechanism. Urotropin. Aldol and crotonic condensation. Preparation of acetaldol and crotonaldehyde. The mechanism of the condensation reaction. Paraldehyde, paraformaldehyde, chloral hydrate. Dialdehydes and diketones. Acetylacetone. Keto-enol tautomerism. 4. Carboxylic acids. The structure of the carbonyl group. Influence of electronic effects of substituents on the hydrocarbon residue on the strength of acids. Reactions of carboxylic acids on the carboxyl group and α-position. Derivatives of carboxylic acid salts, halides, anhydrides, amides, nitriles, esters. Methods for preparation and properties. Natural higher fatty acid (HFA): palmitic, stearic, oleic, linoleic, linolenic, arachidonic. Lipids and phospholipids. Enzymatic hydrolysis of fats. Acid oxidation in the body. Fragments of phosphoric acid in the nucleic acid and adenosine. Phosphatides. Lecithin and cephalins. Dicarboxylic acids: oxalic, malonic, succinic, glutaric and adipic. Their behavior during heating. Hydroxy-Acids. Structure and nomenclature of hydroxy-acids. Reaction of alcohol and carboxylic groups. Transformation under the heating. Lactic acid formation during lactic acid fermentation, and in the muscles. The conversion of lactic acid to pyruvic during metabolism. Malic, tartaric and citric acid. Examples optical isomers of lactic and tartaric acids. Configuration chirality chiral center, the enantiomers. Absolute and relative configuration. D-L and R-S nomenclature. Aldegido- and keto acids. Nomenclature. Chemical properties aldegido- and keto acids. Pyruvic acid. 5. p-Aminophenol. Analgesics, obtained on its basis. Salicylic acid. Aspirin. p-Aminobenzoic acid and its derivatives anesthesin and novocaine. Sulfanilic acid. Sulfonamide preparations. p-Aminosalicylic acid. 6. Amino alcohols. Ethanolamine in nature. Novocaine, choline, acetylcholine. 7. Hydroxy acids. Structure and nomenclature hydroxy acids. Reactions in alcohol and carboxyl groups. Heating transformations. Dairy acid, formed during lactic acid fermentation and in the muscles. Conversion of lactic acid into pyruvic in metabolism. Apple, wine and citric acid. Optical isomerism on

		examples of lactic and tartaric acids. Configuration, chirality, chiral center, enantiomers. Absolute and relative configuration. D-L and R-S nomenclature. 8. Aldehyde and keto acids. Nomenclature. Chemical properties of aldehyde and keto acids. Pyruvic acid. Functional derivatives of carbonic acid - urethanes, ureides, urea. Guanidine. Chemical properties of urea (hydrolysis, salt formation, reaction with nitrogenous acid, biuret formation, alkylation, acylation). Biuret reaction. Barbituric acid and its derivatives. Lactam-lactam tautomerism. 9. Amino acids that make up proteins: classification, structure, nomenclature, stereoisomerism, acid-base properties (the formation of a bipolar ion). Education α-amino acids from keto acids: reductive amination and transamination reactions (pyridoxal catalysis). Chemical properties amino acids. Biologically important reactions α-amino acids: deamination (oxidative and non-oxidative), hydroxylation, decarboxylation of α-amino acids (formation colamine, histamine, tryptamine). Acid-basic properties of amino acids. Transformations α-amino acids in the body. Optical isomerism α-amino acids.
3.	**Bio-polymers and their components**	1. Peptides and proteins. Hydrolysis of peptides. Determination of the amino acid sequence (methods of Edman, Senger, dance). Non-biological synthesis of peptides with protection and activation of functional groups, removal of protection. Primary structure of proteins. Partial and complete hydrolysis. The concept of complex proteins. Glycoproteins, lipoproteins, nucleoproteins, phosphoproteins. 2. Carbohydrates. Carbohydrates in nature. Value carbohydrates. Photosynthesis. Monosaccharides. Cyclo-chain tautomerism. D- and L- rows. Classification, structure, the names of the most important representatives of monosaccharides. Fischer's formulas, Haworth's formulas, conformational formulas of pyranose cycles. Furanose and pyranose. α- and β- anomers. Cyclo-oxo tautomerism. Conformation of pyranose forms. Glucose, mannose, galactose, fructose, ribose, 2-deoxyribose, xylose. Nucleophilic substitution at the anomeric center. O- and N-glycosides. Monoz reactions by functional groups. Glucose, mannose,

		galactose, fructose, ribose, and deoxyribose; being in nature and biological significance. Vitamin C. 3. Oligo and polymaccharides. Restorative and non-reducing disaccharides: sucrose, maltose, cellobiose, lactose. Polysaccharides: starch, glycogen, cellulose, pectins. Heteropolysaccharides: chondroitin sulfates, heparin, hyaluronic acid.
4	**Biologically important heterocycles**	Biologically important heterocyclic systems. Heterocycles with one heteroatom: pyrrole, indole, pyridine, quinoline. The concept of the structure of porphyrin and heme. Pyridine derivatives - nicotinamide, pyridoxal. Heterocycles with several heteroatoms: pyrazole, imidazole, thiazole, pyrazine, pyrimidine, purine (tautomerism for example imidazole). Barbituric acid and derivatives of it. Barbituric acid, tautomeric forms. Barbiturates. Hydroxypuriny: hypoxanthine, xanthine, uric acid. Biotin, the concept of structure, biorol. Heterocyclic compounds. Azoles - pyrrole, pyrazole, imidazole, thiazole and drugs based on them. Indole. Biologically active compounds containing an indole cycle. Pyridine, quinoline, isoquinoline. Nicotinic acid and its amide (vitamin PP) as a structural unit of the co-enzymes NAD and NADP. Isonicotinic acid, promedol, 8-hydroxyquinoline. Pyrimidine. Pyrimidine bases that make up DNA and RNA, vitamin B1. Carbonic acid derivatives. Tranquilizers and sleeping pills on their basis.
5	**Nucleotides and nucleic acids.**	Nucleic acids. Nucleobases: pyrimidine - uracil, thymine, cytosine; purine - adenine, guanine. Lacto-lactam tautomerism. Nucleosides. Nucleotides. Ribonucleic and deoxyribonucleic acids. The nature and position of the connections between mononucleotide moieties. The secondary structure of DNA. Complementarity heterocyclic nucleotide bases. The role of hydrogen bonds in the formation of the secondary structure of DNA. Types of RNA. The concept of RNA secondary structure. The role of RNA in protein biosynthesis.

5.2. Sections of disciplines and types of classes

№ п/п	**Name of section**	**Lectures**	**Practice**	**Lab. works**	**Seminars**	**Student Work**	**Total**
1	Introduction. Hydrocarbons.			7			7
2	Heterofunctional compounds			35		2	37

3	Bio-polymers and their components			12		1	13
4	Biologically important heterocycles			6		1	9
5	Nucleotides and nucleic acids.			5		1	6
	Total			**68**		**4**	**72**

6. Laboratory Studies

During laboratory studies the main theoretical issues are discussed in detail, revised. The qualitative (logical) problems, the appropriate content of the practice session, are solved. Conduct laboratory work with the theoretical analysis of each test, its value for the qualitative detection and clinical diagnostics. In the classroom, students also answer questions from the current control work, to give them individually on index cards.

№ п/п	№ discipline section	Themes of practical training (seminars)	Workload (hours)
1.	1	Laboratory work №1. Introduction. Nomenclature of hydrocarbons. Alkanes.	4
2.	1	Laboratory work № 2. Alkenes. Laboratory work №3 Alkynes.	4
3.	2	Laboratory work №4. Dienes. Arenes. Electrophilic substitution reactions. Orientation Rules.	3
4.	2	Test № 1 - “ Hydrocarbons”.	4
5.	2	Laboratory work № 5. Alkyl halides.	4
6.	2	Laboratory work № 6. Alcohols, phenols.	3
7.	2	Laboratory work № 7. Aldehydes and ketones.	4
8.	1,2	Laboratory work № 7. Aldehydes and ketones. (continuation). Amines.	4
9.	2	Test № 2 - “ Alkyl halides, alcohols, phenols, aldehydes, ketones, amines”.	4
10.	2	Laboratory work № 8. Carboxylic acids. Lipids.	4
11.	2,3	Laboratory work № 8. The concept of optical isomers. Hydroxy Acids. Keto acids.	4
12.	3	Laboratory work № 8. Amino acids. Proteins.	3
13.	3	Test №3 - “Organic acids and their derivatives. Hydroxy acids. Keto acids. Amino acids”.	4
14.	4	Laboratory work № 9. Monosaccharides (stereochemistry and chemical properties). Bioses. Polysaccharides	4
15.	4,5	Test № 4. Monose. Bioses. Polysaccharides	3
16.	2,3,4,5	Test № 5. (all sections)	4
17.	1-5	Final assessment	4
18.	1-5	Final Grade	4

	Total		68

7. Practical training (seminars) *(if available)*

It is not provided by the curriculum

8. Material and technical support of the discipline:

Educational laboratories: 623, 800, 620, 612.

Fulfillment of the laboratory works is carried out in specially equipped educational laboratories. Laboratories of organic chemistry are equipped with standard equipment: a set of special glassware, a set of necessary chemicals, a set of molecular models Dreydinga, saccharimeter portable, polarimeter Abbe refractometer, analytical balances, and distiller. All the equipment in the laboratories is sufficiently modern. The students have access to electronic versions of the lecture course, homework, tests.

room 612: a set of specialized furniture; hardware: BENQ MX661 projector, NEC NP40 projector, motorized screen for projectors, tables; there is wi-fi.
An educational chemical laboratory for conducting group laboratory-type classes, individual consultations, monitoring, intermediate certification, independent work:
room 623: a set of specialized furniture; specialized equipment of the chemical laboratory: fume hood ШВП-4 (4 pcs.), exhaust hood ШВП-2 (4 pcs.), rotary evaporator Hei-value digital G3B, rotary evaporator IKA, digital devices for determining the melting point SMP10; electronic laboratory scales AND EK-610, MK-M mantles of different volumes, drying cabinet PE-4610, magnetic stirrer MRHei-Mix S, magnetic stirrer with heating MRHei-Standart, refractometer, combined laboratory bath BKL, vacuum chemical station PC3001 VARIO-pro , circulating cooler Rotacool Mini, rotary vane vacuum pump RZ2.5, chemical membrane vacuum pump MZ2CNT, Steinel thermal blower, Spectroline EB-280C UV lamp, electronic vacuum controller with CVC3000 detect Vacuumbrand valve, chemical ware, refrigerator; there is wi-fi

An educational chemical laboratory for group laboratory-type classes, individual consultations, monitoring, intermediate certification, independent work:
room 620: a set of specialized furniture; specialized equipment of the chemical laboratory: fume hood ШВП-4 (6 pcs.), rotary evaporator Hei-value digital G3B, rotary evaporator IKA, digital devices for determining the melting point SMP10, electronic laboratory scales AND EK-610, MK-M mantles of different volumes , drying cabinet PE-4610, magnetic stirrer MRHei-Mix S, magnetic stirrer with heating MRHei-Standart, refractometer, combined laboratory bath BKL, vacuum chemical station PC3001 VARIO-pro. rotary vane vacuum pump RZ2.5, membrane vacuum chemical pump MZ2CNT, Steinel thermal blower, Spectroline EB-280C UV lamp, chemical glassware, refrigerator; there is wi-fi

An educational chemical laboratory for group laboratory-type classes, individual consultations, monitoring, intermediate certification, independent work:
room 800: a set of specialized furniture; specialized equipment of the chemical laboratory: fume hood ШВП-4 (4 pcs.), drying cabinet PE-4610, electronic laboratory scales, chromatograph, combined laboratory bath BKL, gas burners, gas cylinders, chemical dishes; there is wi-fi

9. Information support of the discipline:

a) Software

1. OS Windows XP, Vista, 7, software OpenOffice.org (or MS Office 2003, 2007), Internet search systems FireFox or Explorer, Opera, or other, software.

b) Databases, information and searching services. Methodological materials on the TUIS RUDN website (course work program, lecture materials, methodological support for laboratory studies, materials for preparing for tests and tests). https://esystem.rudn.ru/course/view.php?id=7137

- Organic Chemistry Portal
  http://www.organic-chemistry.org/
- The Blue Book
  http://www.acdlabs.com/iupac/nomenclature/
- http://www.chem.ucalgary.ca/courses/351/Carey5th/Carey.html
- http://www.chemguide.co.uk/orgpropsmenu.html

10. Educational and methodical support of the discipline:

a) The main literature

- Zurabyan S.E.
  Fundamentals of bioorganic chemistry: textbook for medical students / S.E. Zurabyan.. - Moscow : GEOTAR-Media, 2019. - 304 p. : ill.. - ISBN 978-5-9704-4990-5.
  http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=464603&idb=0
- B. S. Bahl, Arun Bahl. A Textbook of Organic Chemistry. S. Chand & Company LTD.Ram Nagar, New Delhi-110 055, 1997.
- L. G. Voskressenky, A. V. Listratova, A. V. Varlamov. "Bioorganic Chemistry for Medicine Students. Lectures", Moscow, Peoples' Friendship University of Russia, 2015

b) Additional literature

- Reinhard Bruckner "Advanced Organic Chemistry" Academic Press.
- Francis A. Carey, Richard J. Sundberg "Advanced Organic Chemistry" Springer, 2008

11. Guidelines for students on the development of the discipline:

Students are required to visit the laboratory classes, weekly consultation, to take mandatory participation in the attestation and test trials, to do the tasks of the teacher assignments.

Rules for the appearance of the laboratory work in the workbook.

FORM AND CONTENT OF THE WORKBOOK of students for the laboratory work of BIOORGANIC CHEMISTRY

Laboratory work №
Name of the laboratory work:

№	Description of	Equation of reaction	Observation	Conclusion

	experiment			

- For the writing reports on the implementation of laboratory work is necessary to have a separate notebook, which must have the name of the student and the group number.
- The report must have the date of execution of the work, its name and objective. In the end it must be concluded and noted the success of the task and achieve the goal.
- All observations made during the laboratory work immediately recorded in the workbook. It is necessary to mark the change of the observed characteristics of the systems studied (state of aggregation, temperature, color, transparency, viscosity and so on. D.). Record the results in a table. Erroneous entries should not gloss over the proofreader - simply cross out one line. Do all records legible.

Safety: (Using of rubber gloves, glasses, etc. during of the fulfillment of the work.)
GENERAL REMARKS: Notes in the workbook are recommended to keep on the right page of the notebook, leaving the left page for computing devices circuits, discussion of reaction mechanisms with the teacher and other issues.

Rules for the fulfillment of written tests:
To check the assimilation of theoretical knowledge, laboratory works and homeworks, the students must complete five written tests.
• Tests are performed on the items in a separate notebook, which is listed on the cover (the name of discipline, surname and initials of the student, the specialty and the course). The student must put the number of the test and the date of it.
• Tests are performed in black or blue ink. Each task should be recorded completely.

12. Fund of assessment tools on educational discipline “Bioorganic Chemistry”

Materials for assessing the level of mastering the educational material of the discipline "Bioorganic Chemistry" (evaluation materials), including a list of competencies with an indication of the stages of their formation, a description of indicators and criteria for evaluating competencies at various stages of their formation, a description of the assessment scales, standard control tasks or other materials , necessary for the assessment of knowledge, abilities, skills and (or) experience of activities that characterize the stages of the formation of competencies in the process of mastering the educational program, methodological materials that determine the procedures for assessing knowledge, skills, skills and (or) experience of activities that characterize the stages of formation of competencies in full and are available for students on the discipline page at TUIS RUDN.

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