Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA named after Patrice Lumumba
RUDN University

Institute of Medicine

educational division (faculty/institute/academy) as higher education programme developer

COURSE SYLLABUS

Bioorganic Chemistry

course title

Recommended by the Didactic Council for the Education Field of:

31.05.01 General Medicine

field of studies / speciality code and title

The course instruction is implemented within the professional education programme of higher education:

General Medicine

higher education programme profile/specialisation title

2023-2024

1. COURSE GOAL(s)

The goal of the course "Bioorganic Chemistry" is to equip students with the systematic 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. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the course (module) "Bioorganic Chemistry" is aimed at the development of the following competences /competences in part: GC-6, GPC-3

Table 2.1. List of competences that students acquire through the course study

Competence code	**Competence**	**Indicators of Competence Formation** (within the framework of this discipline)
GC-6	Should be able to identify and implement the priorities of their own activities and ways to improve them based on self-assessment and lifelong learning	GC -6.1. Readiness to evaluate and control their resources and their limits (personal, situational, temporary), uses them optimally for the successful completion of the assigned task
GPC-3	Should be able to counter doping in sports and fight against it	GPC-3.2 Should be 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.

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course refers to the core/variable/elective* component of (B1) block of the higher educational programme curriculum.

* - Underline whatever applicable.

Within the higher education programme students also master other (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course study.

Table 3.1. The list of the higher education programme components/disciplines that contribute to the achievement of the expected learning outcomes as the course study results

Competence code	**Competence descriptor**	**Previous courses/modules***	**Subsequent courses/modules***
GC-6	To be able to identify and implement the priorities of their own activities and ways to improve them based on self-assessment and lifelong learning	Physics Chemistry Introduction to the Specialty	Psychology and Pedagogy Biochemistry Medical Enzymology

Competence code	Competence descriptor	Previous courses/modules*	Subsequent courses/modules*
GPC-3	To be able to counter doping in sports and fight against it	Chemistry	Psychiatry, Medical Psychology

* To be filled in according to the competence matrix of the higher education programme.

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the course "Biorganic Chemistry" is 2 credits (72 academic hours).

*Table 4.1. Types of academic activities during the periods of higher education programme mastering (**full-time training**)**

Type of academic activities		Total academic hours	Semesters/training modules			
			2			
Contact academic hours		*68*	***68***			
including:						
Lectures (LC)		-	**-**			
Lab work (LW)		68	**68**			
Seminars (workshops/tutorials) (S)		-	**-**			
Self-studies		*4*	***4***			
Evaluation and assessment (exam/passing/failing grade)		*-*	**-**			
Course workload	academic hours	**72**	**72**			
	credits	**2**	**2**			

5. COURSE CONTENTS

Table 5.1. Course contents and academic activities types

Course module title	Course module contents (topics)	Academic activities types
Module 1. Introduction. Hydrocarbons.	Topic 1.1. Introduction. 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. 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	LW

Course module title	Course module contents (topics)	Academic activities types
	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.	
Module 2. Functional compounds	Topic 2.1. 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.	LW
	Topic 2.2. 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. Amino alcohols. Ethanolamine in nature. Novocaine, choline, acetylcholine. p-Aminophenol. Analgesic drugs derived from it..	LW
	Topic 2.3 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.	LW

Course module title	Course module contents (topics)	Academic activities types
	Topic 2.4. 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.	LW
	Topic 2.5. Hydroxy-Acids and Oxo-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. Salicylic acid and its derivatives. Aspirin Aldegido- and keto acids. Nomenclature. Chemical properties aldegido- and keto acids. Pyruvic acid.	LW
	Topic 2.6. Amino acids 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,	LW

Course module title	Course module contents (topics)	Academic activities types
	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. p-Amino benzoic acid and its derivatives benzocaine and procaine. Sulfanilic acid. Sulfa drugs. p-Aminosalicylic acid.	
Module 3. Bio-polymers and their components	Topic 3.1. 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.	LW
	Topic 3.2. Carbohydrates. Monoses Carbohydrates in nature. Sagnificanse of 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. Monose reactions by functional groups. Glucose, mannose, galactose, fructose, ribose, and deoxyribose; being in nature and biological significance.Vitamin C.	LW
	Topic 3.3. Bioses and polysaccharides Oligo and polymaccharides. Restorative and non-reducing disaccharides: sucrose, maltose, cellobiose, lactose. Polysaccharides: starch, glycogen, cellulose, pectins. Heteropolysaccharides: chondroitin sulfates, heparin, hyaluronic acid.	LW
Module 4. Biologically important heterocycles	Topic 4.1. Biologically important heterocyclic systems.	LW

Course module title	Course module contents (topics)	Academic activities types
	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. 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.	

* - to be filled in only for **full** -time training: *LC - lectures; LW - lab work; S - seminars.*

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Type of academic activities	**Classroom equipment**	**Specialised educational / laboratory equipment, software, and materials for course study** (if necessary)
Lab work	Educational chemical laboratory for group laboratory-type classes, individual consultations, monitoring, intermediate certification, independent work	Room 623 is equipped with a set of specialized furniture; specialized equipment of the chemical laboratory: ventilation hood cabinet SHVP-4 (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 sizes, 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 Room 620 is equipped with a set of specialized furniture; specialized equipment of the chemical laboratory: ventilation hood cabinet SHVP-4 (4 pcs.), rotary

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
		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, thermal blower Steinel, UV lamp Spectroline EB-280C, chemical glassware, refrigerator; there is wi-fi Room 800 is equipped with a set of specialized furniture; specialized equipment of the chemical laboratory: ventilation hood cabinet SHVP-4 (4 pcs.), drying cabinet PE-4610, electronic laboratory scales, chromatograph, combined laboratory bathhouse BKL, gas burners, gas cylinders, chemical glassware; there is wi-fi
Self-studies	An auditorium for independent work of students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with	FFMEN Reading Room Ordzhonikidze D.3. Coworking area Monday - Friday 10.00 –

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
	access to the EIOS.	22.00 Reading room of the main building of the RUDN Coworking area Monday - Saturday 9.00 - 23.00 Hall No. 2 Monday - Thursday 10.00 - 17.45 Friday 10.00 - 16.45 Hall No. 6 Monday - Thursday 10.00 - 17.45 Friday 10.00 - 16.45

* - the audience for independent work of students is indicated **MANDATORY**!

7. RESOURCES RECOMMENDED FOR COURSE STUDY

Main readings:

1. Zurabyan S.E.
Fundamentals of bioorganic: 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

2. B. S. Bahl, Arun Bahl. A Textbook of Organic Chemistry. S. Chand & Company LTD.Ram Nagar, New Delhi-110 055, 1997.

3. L. G. Voskressenky, A. V. Listratova, A. V. Varlamov. “Bioorganic Chemistry for Medicine Students. Lectures”, Moscow, Peoples’ Friendship University of Russia, 2015

Additional readings:

1. Reinhard Bruckner “Advanced Organic Chemistry” Academic Press.

2. Francis A. Carey, Richard J. Sundberg “Advanced Organic Chemistry” Springer, 2008

Internet sources:

1. Electronic libraries (EL) of RUDN University and other institutions, to which university students have access on the basis of concluded agreements:

- RUDN Electronic Library System (RUDN ELS) http://lib.rudn.ru/MegaPro/Web
- EL "University Library Online" http://www.biblioclub.ru

- EL "Yurayt" http://www.biblio-online.ru
- EL "Student Consultant" www.studentlibrary.ru
- EL "Lan" http://e.lanbook.com/
- EL "Trinity Bridge"

2. Databases and search engines:

- electronic foundation of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- Scopus abstract database http://www.elsevierscience.ru/products/scopus/

*Training toolkit for self- studies to master the course *:*

1. The set of lectures on the course "Bioorganic Chemistry"

* The training toolkit for self- studies to master the course is placed on the course page in the university telecommunication training and information system under the set procedure.

8. ASSESSMENT TOOLKIT AND GRADING SYSTEM* FOR EVALUATION OF STUDENTS' COMPETENCES LEVEL UPON COURSE COMPLETION

The assessment toolkit and the grading system* to evaluate the competences formation level (GC-6, GPC-3) upon the course study completion are specified in the Appendix to the course syllabus.

* The assessment toolkit and the grading system are formed on the basis of the requirements of the relevant local normative act of RUDN University (regulations / order).

DEVELOPERS:

Senior Lecturer Department of Organic Chemistry		**Listratova A. V.**
position, department	signature	name and surname
Head of Organic Chemistry Department		**Voskressensky L. G.**
position, department	signature	name and surname
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HEAD OF EDUCATIONAL DEPARTMENT:
Organic Chemistry

Department

name of department	signature	name and surname

HEAD
OF HIGHER EDUCATION PROGRAMME:
First Deputy Director of
Medical Institute for academic affairs **Radysh I.V.**

position, department	signature	name and surname