

EUROPEAN MEDICAL UNIVERSITY

“APPROVED”

Vice-rector of EMU,
MD, PhD, DrMedSc, Professor

_____Herman TITOV

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SYLLABUS OF THE EDUCATIONAL DISCIPLINE "BIOLOGICAL CHEMISTRY AND BIOORGANIC CHEMISTRY"

Cycle of Higher Education:	second cycle of higher education (Master's degree)
Field of Study:	22 «Healthcare»
Specialty	221 Dentistry
Educational qualification	Master of Dentistry
Professional qualification	doctor
Educational program of EPP	EPP «Dentistry» 2023
Department	Department of Fundamental Disciplines
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Compilers of the syllabus	Ph.D., Docent Irina Pismenetska

1. Status and structure of the discipline

Discipline status	Mandatory
Discipline code in the educational professional program	EC 6, professional training discipline
Course/semester	2 Course (3-4 semesters),
Scope of the discipline (total number of hours/ number of ECTS credits)	210 hour / 7 ECTS credits
Number of modules	3
Number of content modules	11
Discipline structure	Lectures 18 hours Practical lessons – 94 hours Independent work 98 hours
Language of teaching	English
Form of study	Full-time
Type of final control	Exam

2. Description of the discipline

Brief course summary, relevance.

Biological and bioorganic chemistry – is an academic discipline that provides an understanding of the chemical composition of living organisms and the transformations that the molecules that make up their composition undergo.

Prerequisites: Biological and bioorganic chemistry as an educational discipline:

- is based on the study by applicants of medical biology, biophysics, medical chemistry (inorganic, physical, colloidal chemistry and organic chemistry), morphological disciplines and is integrated with these disciplines;

- creates the foundations for the study of molecular biology, genetics, physiology, pathology, general and molecular pharmacology, toxicology and propaedeutics of clinical disciplines by applicants, which involves the integration of teaching with these disciplines and the formation of skills to apply knowledge of biological and bioorganic chemistry, primarily biochemical processes that take place in the body of a healthy and sick person, in the process of further education and professional activity;

- establishes a basis for clinical diagnostics of the most common diseases, monitoring the course of the disease, monitoring the effectiveness of the use of medicines and measures aimed at preventing the occurrence and development of pathological processes.

The purpose of the course and its significance for professional activity. The purpose of teaching the academic discipline "Biological and Bioorganic Chemistry" is to master the results of biochemical research and changes, biochemical and enzymatic indicators used to diagnose human diseases. The ultimate goal is to master practical skills to analyze biochemical processes of metabolism and its regulation in ensuring the functioning of organs and systems of the human body.

Post-requisites: knowledge, skills and abilities acquired after completing this discipline are necessary for such disciplines as biological and bioorganic chemistry.

3. Learning outcomes.

Program learning outcomes (PLOs) correspond to PLO codes 2.

Code	Integrative learning outcomes
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PLO	
PLO 2	Collect information about the patient's general condition and the condition of the maxillofacial organs, assess the patient's psychomotor and physical development. Based on the comprehensive diagnosis and the results of additional laboratory and instrumental studies, evaluate information regarding the diagnosis (according to list 5).

Learning outcomes for the discipline:

Mastering the discipline ensures that candidates acquire the following **competencies**:

1) *integral competence*: the ability to solve complex tasks and problems in the field of healthcare in the specialty "Dentistry" in professional activities or in the process of training, which involves conducting research and/or implementing innovations and is characterized by uncertainty of conditions and requirements;

2) *general competences (GC)*: codes GC1-3, GC 2, GC 3; GC 6, GC 7, GC 9, GC 10

Code	Characteristics of general competence
GC 1	Ability to think abstractly, analyses and synthesize.
GC 2	Ability to learn and master modern knowledge
GC 3	Ability to apply professional knowledge and practical skills in medical practice.
GC 6	Skills in using information and communication technologies.
GC 7	Ability to search, process and analyze information from various sources.
GC 9	Ability to identify, pose and solve problems.
GC 10	Ability to be critical and self-critical.

3) *special (professional) competencies (SC)*: according to PC codes 2.

Code	Characteristics of special competence
SC 2	Ability to interpret the results of laboratory and instrumental studies.

4. Course content and logistics.

Chapter 1: «Biopolymers and their structural components. General laws of metabolism»	3 semester	Practical lessons №№ 1-9 Themes IW 3 №№ 1-6
Chapter 2: «Metabolism of carbohydrates, lipids, amino acids and its regulation»	3-4 semester	Practical lessons: 3 semester №№ 10-20 4 semester №№ 21-25 Themes IW 3: 3 semester №№ 7-10
Chapter 3: «Molecular biology. Functional biochemistry»	4 semester	Practical lessons №№ 26-38 Themes IW 3 №№ 11-24

5. Content of the discipline

List of lecture topics

№	Topic name	Number of hours
1	Introduction to biochemistry. Biomolecules, their structure and functions. General pathways of catabolism of proteins, carbohydrates, lipids.	2

2	Enzymes: chemical nature, structural and functional organization. Cofactors and coenzymes, coenzyme functions of vitamins.	2
3	Main pathways of regulation of enzymatic processes.	2
4	Tissue respiration: mechanism, significance of the process. Electron transport chain. Oxidative phosphorylation.	2
5	Digestion of carbohydrates. Glycolysis. Anaerobic and aerobic oxidation of glucose. Glucose biosynthesis - gluconeogenesis.	2
6	Glycogen metabolism; pentose phosphate pathway. Regulation and pathology of carbohydrate metabolism. Diabetes mellitus.	2
7	Lipids. Classification. Structure and functions.	2
8	Catabolism of triacylglycerols. Oxidation of fatty acids and glycerol.	2
9	Lipid anabolism. Lipids. Lipoproteins.	2
Всего		18

List of practical training topics

№	Topic name	Number of hours
Chapter 1 "Biopolymers and their structural components. General laws of metabolism"		
Content section 1 «Introduction to biochemistry. General overview of the main biopolymers and their structural components»		
1	Introduction to biochemistry. Biomolecules, their structure and functions. General pathways of catabolism of proteins, carbohydrates, lipids.	2
Content section 2 «Amino acid composition of proteins and peptides. Structural organization of proteins»		
2	Amino acid composition of proteins and peptides. Structural organization of proteins	2
Content section 3 «The main laws of metabolism. Enzymes and coenzymes. Regulation of metabolism»		
3	Enzymes: chemical nature, structural and functional organization. Cofactors and coenzymes, coenzyme functions of vitamins. Nomenclature of enzymes.	2
4	Properties of enzymes. Influence of activators and inhibitors. Determination of enzyme activity.	2
5	Main pathways of regulation of enzymatic processes. Medical enzymology. Test-control "Enzymes".	2
Content section 4. «Molecular foundations of bioenergetics. General pathways of catabolism of carbohydrates, lipids, amino acids»		
6	General pathways of catabolism. Biological oxidation. Enzymes of biological oxidation, their classification and mechanism of action. High-energy compounds. Pathways of ATP synthesis.	2
7	Tissue respiration: mechanism, significance of the process. Electron transport chain. Oxidative phosphorylation.	2
8	Oxidative decarboxylation of pyruvic acid. The tricarboxylic acid cycle: role, regulation, relationship with respiratory chains.	2

9	The relationship between specific and general pathways of protein, carbohydrate and lipid catabolism. Test-control. "Enzymes and biological oxidation".	2
Chapter 2: "Carbohydrate, lipid, and amino acid metabolism and its regulation"		
Content section 5 «Structure, properties and metabolism of carbohydrates. Regulation of carbohydrate metabolism and its disorders»		
10	Classification, structure and functions of biologically important saccharides: mono-, di- and polysaccharides.	2
11	Digestion of carbohydrates. Glycolysis. Anaerobic and aerobic oxidation of glucose.	2
12	Glucose biosynthesis - gluconeogenesis.	2
13	Catabolism and biosynthesis of glycogen. Genetic disorders of glycogen metabolism. Pentose phosphate pathway.	2
14	Regulation and pathologies of carbohydrate metabolism. Blood glucose (glycemia): normoglycemia, hypo- and hyperglycemia, glycosuria. Diabetes mellitus. Fructose and galactose metabolism and its disorders.	2
15	Relationship of general pathways of catabolism with carbohydrate metabolism. Test-control "Enzymes, biological oxidation, carbohydrates".	2
Content section 6 «Structure, properties and metabolism of lipids. Regulation of lipid metabolism and its disorders»		
16	Classification, structure and functions of biologically important lipids: natural fatty acids, simple lipids, phospholipids.	2
17	Lipid digestion. Catabolism of triacylglycerols, its regulation. Oxidation of fatty acids and glycerol. Regulation of these processes.	2
18	Lipid anabolism. Biosynthesis of fatty acids and triacylglycerols. Regulation of these processes.	2
19	Biosynthesis and metabolism of cholesterol. Metabolism of ketone bodies. Bile acids, their role. Blood plasma lipoproteins. Metabolism of phospholipids.	2
20	Pathologies of lipid metabolism: steatorrhea, obesity, atherosclerosis. Test-control. "Lipids".	2
Content section 7 «Amino acid metabolism. Enzymopathies of amino acid metabolism»		
21	Protein digestion. General pathways of amino acid metabolism.	3
22	Pathways of ammonia formation and detoxification. Urea biosynthesis	3
23	Specialized pathways of amino acid metabolism. Pathways of amino acid carbon skeleton metabolism. Synthesis of replaceable amino acids. Metabolism of glycine, serine and arginine.	3
24	Specialized pathways of amino acid metabolism. Metabolism of methionine, cysteine, phenylalanine, tyrosine and tryptophan. Enzymopathologies of amino acid metabolism. Test control "Amino acid metabolism"	3
25	Interrelationship of lipid, carbohydrate and amino acid metabolism. Test control "General laws of metabolism"..	3
Chapter 3: "Hormonal Regulation of Biochemical Processes. Molecular Biology. Functional Biochemistry"		

Content section 8 «Molecular mechanisms of hormone action on target cells. Biochemistry of hormonal regulation of metabolic processes»		
26	Molecular and cellular mechanisms of hormone action on target cells.	3
27	Hormonal regulation of metabolism. Biochemical basis of endocrine pathology.	3
28	Hormonal regulation of water-salt metabolism.	3
29	Hormonal regulation of calcium and phosphorus homeostasis.	3
Content section 9 «Vitamins as nutritional components»		
30	Vitamins as components of nutrition: exogenous and endogenous hypovitaminosis. Water-soluble vitamins.	3
31	Fat-soluble vitamins. Antioxidants. Test control "Hormonal regulation. Vitamins"	3
Content section 10 «Structure and properties of nucleosides, nucleotides, nucleic acids. Nucleotide metabolism and its disorders»;		
32	Chemical properties of nucleosides and nucleotides. Structure and properties of nucleic acids.	3
33	Biosynthesis and catabolism of purine nucleotides. Hereditary disorders of purine nucleotide metabolism.	3
34	Biosynthesis and catabolism of pyrimidine nucleotides. Hereditary disorders of pyrimidine nucleotide metabolism.	3
Content section 11 «Fundamentals of molecular biology. Fundamentals of molecular genetics»		
35	Enzymes and molecular mechanisms of replication - DNA synthesis.	3
36	Enzymes and molecular mechanisms of transcription - RNA synthesis.	3
37	Enzymes and molecular mechanisms of translation - protein biosynthesis on ribosomes. Antibiotics - inhibitors of transcription and translation. Test control "Matrix syntheses"	3
38	Final test control	3
Total		94

List of topics for independent work

№	Topic name	Number of hours
Chapter 1 "Biopolymers and their structural components. General laws of metabolism"		
1	Amino acid composition of proteins and peptides. Structural organization of proteins. General methods and approaches to studying the structure of proteins: electrophoresis, gel filtration, ion exchange chromatography.	4
2	Principles of determining enzyme activity in biological fluids. The role of cofactors and coenzyme vitamins, their active derivatives in the manifestation of catalytic activity of enzymes	4
3	Enzymatic diagnostics. Diagnostic value of determining changes in the quantitative content and activity of isoenzymes in pathologies.	4
4	Determination and explanation of the value of the phosphorylation coefficient for reactions of aerobic oxidation of substrates according to the type of coenzyme or prosthetic group of the enzyme.	4

5	Inhibitors and uncouplers of oxidative phosphorylation and regulation of thermogenesis.	4
6	Anabolic and anaplerotic reactions of the ATP	4
Chapter 2: "Carbohydrate, lipid, and amino acid metabolism and its regulation"		
7	Structure, properties and biological role of di- and polysaccharides. Glycosaminoglycans: structure and biological role of hyaluronic acid, chondroitin sulfates and heparin.	4
8	Hereditary disorders of the biosynthesis of enzymes of glycogen metabolism. Features of the metabolism of carbohydrate components of glycoconjugates and genetic disorders of their metabolism.	4
9	Structure, physicochemical properties and biological role of lipids. Higher fatty acids. Phospholipids. Glycolipids.	4
10	Principles of methods for determining phospholipids in tissue homogenates and total lipids in blood serum. Sphingolipidoses - genetic abnormalities of sphingolipid metabolism. Lysosomal diseases.	4
Chapter 3: "Hormonal Regulation of Biochemical Processes. Molecular Biology. Functional Biochemistry"		
11	Disturbances of hormonal regulation of the exchange of sodium, potassium, chlorine ions. The role of the renin-angiotensin system.	4
12	Distribution of calcium ions in the body, forms of calcium in human blood plasma. Contribution of bone tissue, small intestine and kidneys to calcium homeostasis.	4
13	Classification, structure and significance of biologically important heterocyclic compounds. Structure and biochemical functions of nucleosides, nucleotides and nucleic acids.	4
14	Clinical and biochemical characteristics of disorders of uric acid metabolism. Hereditary disorders of pyrimidine nucleotide metabolism. Orotaciduria.	4
15	Features of molecular organization and expression of the genome in eukaryotes. Diagrams of sequential stages of the replication, transcription and translation processes.	4
16	Genetic engineering. Recombinant DNA. Explanation of molecular mechanisms of regulation in the implementation of genetic information. Assessment of hereditary metabolic disorders (molecular diseases).	5
17	The influence of physiologically active compounds - eicosanoids on the processes of replication, transcription and translation	5
18	Biochemical basis of detoxification processes of xenobiotics and endogenous toxins in the liver	4
19	Evaluation of detoxification function of the liver by biochemical indicators. Characteristics of the liver complex.	4
20	Analysis of differential changes in biochemical indicators of blood and urine (free, conjugated bilirubin) in order to assess the pathobiochemistry of jaundice	4
21	Diagnostic role of proteins of the acute phase of inflammation and indicator enzymes of blood plasma in normal and pathological conditions.	4

22	Assessment of indicators of nitrogen metabolism and changes in the content of nitrogen-containing non-protein components	4
23	Biochemistry of connective tissue. Biochemical mechanisms of the occurrence of mucopolysaccharidoses, collagenoses. Modern methods of their diagnosis.	4
24	Changes in the composition of oral fluid and tissues of the maxillofacial region in dental diseases.	4
Total		98

Topics of the lecture course: reveal problematic issues of the relevant sections of Biological and Bioorganic Chemistry.

Practical classes provide theoretical justification of the main issues of the topic.

Independent work of the applicant involves preparation for practical classes and final control, study of topics for independent extracurricular work, preparation of abstract reports, presentations, tables. Control of mastering the topics of independent extracurricular work is carried out in classes and final control in the discipline.

Individual work includes processing scientific literature, preparation of reviews on the given topics for presentation, performance of scientific and practical research, participation in specialized Olympiads, scientific and practical conferences, competitions of scientific works of applicants.

Calendar plans of practical classes, thematic plan of independent extracurricular work, the scope and directions of individual work are published on the department's website.

Route for obtaining materials: EMU website/Applicant/Department of Fundamental Disciplines/Educational and Methodological Support of the Department/Biological and Bioorganic Chemistry/ or via the link Department of Fundamental Disciplines, discipline "Biological and Bioorganic Chemistry". Access to materials is provided from the applicant's corporate account based on Office 365.

6. Forms and methods of monitoring learning success

Current control in practical classes	Methods: individual oral survey, structured written works, test tasks with the choice of correct answers.
Control of mastering the thematic section of the discipline in intermediate control classes	Methods: oral or written survey, electronic testing, <i>methods of self-control and self-assessment</i> .
Final semester control	According to the regulation on control measures in EMU (regulation of EMU)
Final control of the discipline - <i>exam</i>	Methods: by exam cards in the form of an oral exam, monitoring of acquiring of practical skills (According to the Regulation on control measures in EMU (Regulation of EMU).)
Means of diagnostics of learning success	Theoretical questions, tests, clinically oriented situational tasks, practical tasks, demonstration of practical skills.

7. Evaluation criteria

Knowledge assessment is carried out according to regulation on control measures in EMU (regulation of EMU).

Current control	According to the four-point system of traditional grades: 5 "Excellent", 4 "Good", 3 "Satisfactory", 2 "Unsatisfactory"
Control of practical skills	According to the four-point system of traditional grades
Испит	On a 200-point scale (sum of points for the applicant's current educational activities, the results of the exam and for the successful completion of an individual task, if any) Passed: from 120 to 200 points For current educational activities from 72 to 120 points For the exam from 48 to 80 points Not passed: less than 120 points (see Evaluation scale)
Final control of the discipline	The final control of the students' academic performance is carried out after the completion of the discipline and is implemented in the form of an exam in the 4th semester.
Discipline assessment:	The score on the discipline is determined based on the results of assessment of current activities and is expressed using a fourpoint scale: ("Excellent", "Good", "Satisfactory", "Unsatisfactory"), multi-point scale and ECTS. The assessment in the discipline consists of an assessment of the current academic performance and the result of passing the exam (in points), which is set when evaluating theoretical knowledge and practical skills in accordance with the list defined by the discipline program. The number of points that the applicant scored for current academic. performance in the discipline is defined as the arithmetic mean of the number of points that the applicant received during the study of the discipline (practical, seminar, laboratory classes, etc.). The resulting value of the average traditional rating is converted to points according to the scale of conversion of traditional ratings to rating points. The maximum number of points is 200.

Correspondence of grades on a 200-point scale, a 4-point (traditional) scale and the ECTS scale

200-point scale	4-point scale
180–200	«5» Excellent
140–179	«4» Good
120–139	«3» Satisfactory
0–119	«2» Unsatisfactory
200-point scale	ECTS scale
192–200	A
172–191	B
148–171	C
128–147	D
120–127	E
0–119	F

Discipline/course policy

The student has the right to receive high-quality educational services, access to up-to-date scientific and educational information, qualified advice during the study of the discipline and mastering practical skills. The policy of the department in the provision of Educational Services is student-centred, based on the regulatory documents of the Ministry of Education and the Ministry of Health of Ukraine, the Charter of the EMU and the procedure for providing educational services regulated by the regulation on the organization of the educational process in the EMU and the principles of academic integrity.

Compliance with the EMU schedule, safety precautions in the classroom.

Requirements for preparing for practical classes.

Students should arrive at classes on time, without being late. A student who is more than 10 minutes late for classes is not allowed in and must work it out in accordance with the established procedure. During practical classes, the student must wear a work uniform (medical gown, cap). Students who do not have a work uniform are not allowed to attend classes. The student must follow the safety rules during practical classes and while staying in the Department's premises. When discussing theoretical issues, students should demonstrate tolerance, politeness and respect for their colleagues and the teacher; when performing practical tasks, the workplace should be kept in order and cleaned after completing practical work.

Use of mobile phones and other electronic devices. The use of mobile phones and other electronic devices in the classroom is not allowed, only during Distance Learning, provided that it is technically necessary.

Academic integrity. When studying the discipline, the student should be guided by the following regulations: on academic integrity of EMU (regulation of EMU). In case of violation of the regulations of academic integrity during the current and final controls, the student receives a grade of "2" and must work it out to the teacher in accordance with the established procedure.

Regulation on control measures in EMU (Regulation of EMU).

Skipping classes. Missed classes should be worked out in accordance with the procedure established in the regulations on control measures in the EMU (regulation of EMU) during the time determined by the work schedule (Department of fundamental disciplines) to the teacher on duty. To work out a missed lesson the student must pass a test and answer in writing or verbally the question on the topic of the lesson.

Procedure for admission to the final control in the discipline is given in the regulations on control measures and regulations on the organization of the educational process in the EMU (regulation of EMU) and regulations on control measures in the EMU (regulation of EMU). Students who do not have missed not worked out practical classes and lectures and have received an average traditional grade of at least "3" are allowed to participate in the final control.

Additional individual points. Points are awarded subject to the mandatory participation of the head, head teacher and teacher. These points are encouraging and are added once to the total score of the current academic performance and the result of passing the comprehensive exam. Their total number for one student should not exceed 10, and the final amount of points for an academic discipline should not exceed 200 points.

Individual tasks include:

- 1) writing essays and creating multimedia presentations with reports at meetings of the student scientific group of the department – 3 points;
- 2) participation in the creation of tables, graphological structure, posters on the topics of practical classes – 2 points;
- 3) participation in the student competition in the discipline at the First Stage – 1 point;

- 4) participation/prize-winner of the All-Ukrainian student competition in the discipline - 7/10 points;
- 5) author or co-author of abstracts/article – 2/5 points;
- 6) author or co-author of an oral/information stand report at a scientific conference – 6/3 points;
- 7) author of a student scientific paper accepted for participation or awarded by a diploma of I-III degree in the All – Ukrainian competition of student scientific papers at Stage II - 8 (participation) or 10 (diploma) points.

Resolving conflict issues. If there are misunderstandings and complaints against the teacher due to quality of educational services provided, knowledge assessment, and other conflict situations, the student must first report his/her claims to the teacher. If the conflict issue is not resolved, the student has the right to submit an appeal to the head of the department in accordance with the regulations on consideration of applications from applicants for higher education in EMU (regulation of EMU), Regulations on consideration of applications, complaints, and proposals of students in DMI TNM (regulation of EMU), Regulations on meeting the requirements of the organization of the educational process (regulation of EMU), Regulation on the appeal of the results of the final control of knowledge of applicants for higher education in EMU (regulation of EMU), Regulations on safe educational environment in EMU (regulation of EMU).

Policy in the context of distance learning. The procedure for distance learning is regulated by regulation of EMU. The main training platforms for conducting training sessions are Microsoft Teams, Zoom. The procedure for conducting practical classes and lectures, working out and consultations during Distance Learning is published on the Department's Web page Department of fundamental disciplines. Feedback from the teacher is provided directly during the lesson and/or consultation, and is also possible via email (in case of force majeure) during working hours.

1. Training resources

Educational and methodological support of the discipline is published on the website of the Department (Department of fundamental disciplines). Consultations are held according to the consultation schedule.

2. **Schedule and distribution of groups by teacher** are published on the Department's Web page (Department of fundamental disciplines).
3. **Questions for intermediate and final control of the discipline** are published on the Department's Web page (Department of fundamental disciplines).

8. Literature

1. Medical chemistry: textbook / V.O. Kalibabchuk, V.I. Halynska, L.I. Hryshchenko et al. 7th edition. 2020. 224 p.
2. Országhová Z. TEXTBOOK OF MEDICAL CHEMISTRY. Comenius University in Bratislava. 2018. 302 p.
3. Tsuber V.Y., Kotvytska A.A., Tykhonovych K.V. Medical chemistry / Editor by V.Y. Tsuber. Kyiv. AUS Medicine Publishing. 2022. 392 p.

Information resources:

Basic

1. <https://naurok.com.ua/noviy-sposib-rozv-yazuvannya-zadach-pri-zmishuvanni-rechovin---pravilo-koromislo-ivashini-105568.html>
2. https://elearning.sumdu.edu.ua/free_content/lectured:5df7011dd2ba3fd1467ffc0f892ff9da2731ded5/latest/258393/index.html

Additional

- 1 https://www.youtube.com/watch?v=nTNlwiC10X0&ab_channel=online-studioSumDU
2. https://www.youtube.com/watch?v=E_8zJzIspI4&ab_channel=online-studioSumDU
3. <https://ppt-online.org/639501>
4. <https://svitppt.com.ua/himiya/kislotnoosnovna-rivnovaga-v-biosistemah-buferni-rozchini.html>
5. <https://present5.com/prezentaciya-titruvannya-microsoft-office-power-point/>
6. https://medchem.nuph.edu.ua/wp-content/uploads/2017/12/3_%D0%A2%D0%B8%D1%82%D1%80%D1%83%D0%B2%D0%B0%D0%BD%D0%BD%D1%8F_%D1%83%D0%BA%D1%80.pdf
7. <https://svitppt.com.ua/nauka/fizikohimiya-poverhnevih-yavisch0.html>
8. <http://www.myshared.ru/slide/412108/>
9. <https://en.ppt-online.org/52293>
10. <https://en.ppt-online.org/217723>
11. <https://en.ppt-online.org/228322>
12. <https://www.slideshare.net/kassy2003/ss-41168211>
13. <https://www.slideshare.net/kassy2003/ss-64054845>
14. <https://www.slideshare.net/kassy2003/i-39896803>
15. <https://www.slideshare.net/kassy2003/ss-39896988>
16. <https://www.slideshare.net/kassy2003/iii-39897128>
17. <https://svitppt.com.ua/himiya/himichna-kinetika-ta-rivnovaga.html>
18. <https://www.slideshare.net/kassy2003/ii-39897536>
19. <https://www.slideshare.net/kassy2003/i-39897430>
20. Labster www.labster.com
21. PraxiLabs www.praxilabs.com
22. Virtual Classroom Materials on Organic chemistry <https://www.scienceprofonline.com/chemistry.html>

Responsible for the course

Ph.D., Docent Irina PISMENETSKA

Head of the Department

D.BiolSc, Professor

Svetlana OSTROVSKA