



**MINISTRY OF HEALTH OF UKRAINE
NATIONAL UNIVERSITY OF PHARMACY
Faculty of Medical and Pharmaceutical Technologies
Department Biological Chemistry**

Biological Chemistry

**WORK PROGRAM
of a course**

training for Master

field of knowledge 22 Public Health

in specialty 226 Pharmacy

of educational program Pharmacy for foreign students (Language of instruction – English)

specialization _____

Work program of a course of Biological Chemistry
in specialty 226 Pharmacy of educational program Pharmacy for foreign students (Language of
instruction – English for applicants for higher education 3rd year of study.

Educational course team:

prof. Kravchenko V.M., the head of the Biological Chemistry
Department, Professor, D.Sc.
ass. prof. Krasilnikova O.A., ass. prof., Ph.D.

Work program has been considered and approved at the Department Meeting

Record from « ____ » _____ 20__ № ____

Head of the Biological Chemistry Department
Prof. _____

Kravchenko V.M.

Work program has been approved at the meeting of the Methodical Commission
on medical and biological disciplines

Record from « ____ » _____ 20__ № ____

Head of Specialized Committee _____

Prof. Zupanets I.A.

1. The Description of the Course

The language of the study: english

Course Status: Subject Biological chemistry according to the plan of study is included to the list of compulsory subjects for Master degree students in specialty 226 Pharmacy of educational program Pharmacy for foreign students (Language of instruction – English for applicants for higher education 3rd year of study).

Entrance qualification for studying the course: Biological chemistry as discipline to study: is based on students' knowledge of inorganic, analytic, physical and colloid, organic chemistry, botany, physiology and microbiology, and is integrated with such disciplines; supplies students with basic information on clinic biochemistry, laboratory diagnostics, biotechnology, that supposes certain integration of teaching with these disciplines and formation of skills to apply knowledge on biochemistry in the process of further education and in professional activity;

The purpose statements of studying the course «Biological chemistry» are chemical and physico-chemical processes, and the development and functioning of living systems of all levels of the organization as a result of these processes.

Information volume of academic course. To study the course is given **180 hours** **6,0** ECTS credits

2. Objectives and tasks of the course

The objective of teaching the course «Biological Chemistry» is to train pharmacists-specialists with a significant amount of theoretical and practical knowledge about the chemical bases of life: the chemical composition of organic compounds and natural metabolic processes in the human body.

The **main tasks** of the course «Biological Chemistry» is the formation of knowledge about the structure of compounds that make up living organisms and the relationship with their biochemical functions; the formation of a modern understanding of the principles of the structural organization of the main classes of biomacromolecules — proteins, nucleic acids, etc .; formation of knowledge of the patterns of release, accumulation and energy consumption in biological systems; the formation of knowledge about the main metabolic pathways in the body, their interrelation and molecular mechanisms of regulation; formation of knowledge of the molecular basis of the transfer of genetic information, protein biosynthesis and mechanisms of their regulation; acquaintance with modern methods of biochemical diagnostics of the state of body metabolism; the formation of the skills of scientific analysis and synthesis of phenomena and facts observed; providing a theoretical basis for the study of other biomedical disciplines: pharmacology, pharmacotherapy with pharmacokinetics, clinical pharmacology, and individual pharmaceutical disciplines.

2. Competence and planned educational outcomes

The course «Biological Chemistry» provides acquisition of competencies by applicants for higher education:

- knowledge of the composition and structure of chemicals in living matter;
- knowledge of chemical and physico-chemical processes, the result of which is the development and functioning of living systems at all levels of the organization;
- the ability based on this knowledge to understand the mechanisms of action of drugs and the main ways of enzymatic transformation of drugs;

- the ability in their professional activities to adjust patient therapy and provide information about pharmaceutical products.

As a result of studying the course, the applicant for higher education will be able to *know*:

composition, structural organization, physico-chemical properties, methods for isolation and purification of proteins;

- classification and characterization of simple and complex proteins, the value of the most important representatives;

- classification, structure, physico-chemical properties and functions of carbohydrates and lipids, the value of the value of the most important representatives;

- the importance of vitamins for the human body, their classification and nomenclature, their chemical structure, signs of hypo-and avitaminosis;

- pharmaceutical preparations of vitamins and their derivatives;

- the chemical nature of enzymes and their properties as biocatalysts, as well as the classification and nomenclature of enzymes, the specificity of their action;

- mechanisms of influence of drugs on the enzymatic processes in the body

- the value of the endocrine system for the human body, as well as the classification, chemical nature and properties of hormones;

- pharmaceutical preparations of natural hormones and their synthetic analogues;

- biochemical basis of biosignaling and reception. The mechanisms of signal transmission into the cell;

- types of biological oxidation, the structural organization of mitochondria;

- the main processes of carbohydrate metabolism and the factors affecting them;

- the role and mechanisms of action of non-hormonal hypoglycemic drugs and insulin preparations

- the main processes of lipid metabolism and the factors affecting them;

- mechanisms of action of the main lipid-lowering drugs;

- the main metabolic processes of amino acids, the factors affecting them;

- common pathologies associated with impaired metabolism of amino acids and ways to correct them

- the main pathways for the decomposition and synthesis of heme chromoproteins, as well as nitrogenous bases (nucleosides, nucleotides) of nucleic acids;

- the main metabolic processes of medicinal compounds in the human body.

do:

- explain the importance of biochemistry for pharmacy;

- analyze the composition, structural organization, physico-chemical properties, methods for isolation and purification of proteins;

- to interpret the numerous functions and biological properties of proteins and peptides;

- explain the classification and characterization of proteins, the meaning of individual representatives;

- analyze the composition and structure of carbohydrates and lipids, their classification.

Explain the biological significance of carbohydrates and lipids, their distribution;

- explain the chemical structure, classification, biological functions of carbohydrates and lipids

- analyze the hypotheses of the mechanism of action of enzymes, stages of enzymatic catalysis, types of inhibition of the work of enzymes

- analyze the effect of drug compounds on the activity of enzymes taking into account their structure;

- analyze the body's energy resources, the phases of release of energy from nutrients;

- to interpret the main provisions of the chemosmotic hypotheses of the mechanism of oxidative phosphorylation, the effect of various (including medicinal) factors on the oxidation of substances and the formation of ATP

- analyze the hormonal regulation of carbohydrate metabolism, its violation in diabetes mellitus
- explain the role of non-hormonal hypoglycemic drugs and insulin preparations
- analyze the main mechanisms of action of lipid-lowering drugs;
- analyze ways of using free amino acids in the human body (processes of transamination, deamination, decarboxylation of amino acids; stages of urea biosynthesis)
- to interpret the course of the processes of decomposition and synthesis of heme chromoproteins, as well as nitrogenous bases (nucleosides, nucleotides) of nucleic acids;
- analyze the nature of the disorders in jaundice, porphyria and gout in the human body;
- analyze ways of multiplying and transmitting hereditary information;
- explain the properties of the genetic code
- explain the symptoms of hypo- and avitaminosis and their correction mechanisms
- interpret the mechanisms of the modifying action of hormones on metabolic processes in target cells;
- analyze the use of natural hormones and their synthetic analogues as pharmaceuticals for the purpose of treating endocrine gland function disorders.

have:

- technologies of biochemical analysis and evaluation of its results.
- methods for the quantitative determination of proteins, glucose, cholesterol, bilirubin and urea in serum;
- methods of analysis of biomolecules - amino acids, carbohydrates, lipids and vitamins;
- technologies for analyzing the composition of complex biomolecules;
- methods for determining the activity of enzymes
- technologies of interpretation of results obtained on the basis of biological chemistry methods.

• 2. Structure of the course

Names of content modules and topics	The amount of hours					
	the whole amount	full time study				
		including				
		1	sem.	p.l.	lab.	self-study
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>
Module 1. General principles of cellular metabolism organisation						
Content module 1. Structure and functions of biomolecules						
Topic 1. Introduction in Biochemistry. Amino Acids, Peptides, Proteins.	9	1		4		4
Topic 2. Levels of Protein Structure. Physical-chemical properties of Proteins.	11	1		4		6
Topic 3. Carbohydrates and Lipids: Structure, Classification and Functions. Protein Complexes with Carbohydrates and Lipids.	10	2		4		4
Topic 4. Conjugated Proteins: Hemoproteins, Metalloproteins, Phosphoproteins Nucleoproteins and Nucleic Acids: Structure,	10	2		4		4

Functions, Biological Role. Final conceptual module control CM1						
The whole amount of hours for the content module 1	40	6		16		18
Content module 2. General principles of cellular metabolism organisation						
Topic 5. Nomenclature and Classification of the Vitamins. Fat-soluble Vitamins. Water- soluble Vitamins. Interaction of Vitamins. Vitamin Products.	10	2		4		4
Topic 6. Enzymes: Structure, Nomenclature, Classification. Enzyme Kinetics. Catalytic Mechanisms. Enzyme Regulation.	12	2	2	4		4
Topic 7. Introduction into Metabolism. Citric Acid Cycle. Electron transport chain (ETC). Oxidative Phosphorylation. Inhibitors of ETC and Uncouplers. Microsomal oxidation. Non-enzymatic oxidation.	16	4	2	4		6
Topic 8. Pharmaceutical Biochemistry. Biogenic Compounds and Xenobiotics as Medicinal Preparations. Enzymes of Drug Metabolism. Pharmacokinetics and Excretion of Medicinal Preparations. Final conceptual module control CM2	10	2	2	2		4
The whole amount of hours for the content module 2	50	10	6	16		18
The final test 1	2			2		
The whole amount of hours for the module 1	90	16	6	32		36
Module 2. Metabolism and its regulation						
Content module 3. Principles of cell signaling						
Topic 9. Principles of Cell Signaling. Pathways of Intracellular Signal Transduction.	5,5	0,5		2		3
Topic 10. Hormones and Neuromediators. Endocrine Glands. Classification of Hormones. Hyper- and Hypofunctions of Endocrine Glands. Endocrine Glands Functional Disorders and There	5,5	0,5		2		3

Correction. Final conceptual module control CM3						
The whole amount of hours for the content module 3	11	1		4		6
Content module 4. Some metabolic processes						
Topic 11. Carbohydrate Metabolism, Its Regulation and Pathology.	8,25	1		4		3,25
Topic 12. Lipid Metabolism, Its Regulation and Pathology.	7	1		4		2
Topic 13. General Amino Acid Pathways, Their Regulation and Pathology.	19	3		8		9
Topic 14. Transfer of Genetic Information. Protein Biosynthesis in the Cell. Mechanisms of Protein Biosynthesis Regulation. Antibiotics. Final conceptual module control CM4	9	2		4		3
The whole amount of hours for the content module 4	45,25	7		24		14,25
The final test 2	4			4		
The whole amount of hours for the module 2	56,25	8	-	28		20,25
Examination	33,75					33,75
<i>The whole amount of hours for the course</i>	180	24	6	60		90

3. Contents of the course

Module 1. General principles of cellular metabolism organisation

Content module 1. Structure and functions of biomolecules

Topic 1. Introduction in Biochemistry. Amino Acids, Peptides, Proteins.

Entry into biochemistry. Features of the flow of chemical reactions in a living organism. General characteristics of proteins. The chemical structure of peptides and proteins. Classification and structure of amino acids. Peptides. Natural peptides.

Topic 2. Levels of Protein Structure. Physical-chemical properties of Proteins.

The structure and levels of protein organization. The primary structure of the protein. The secondary structure of the protein. Nativitorinna structure and domain proteins. Tertiary structure of proteins. Quaternary structure. Functions of proteins. Physico-chemical properties of proteins. Isolation and purification of proteins. Molecular mass. Amphoteric properties of proteins. Isoelectric point (IET). The solubility of the protein. Salting out. Colloidal properties of proteins. Osmotic properties of proteins. Dialysis. Denaturation.

Topic 3. Carbohydrates and Lipids: Structure, Classification and Functions. Protein Complexes with Carbohydrates and Lipids.

Structure and function of carbohydrates. Definition and function of carbohydrates. Carbohydrate classification. Characteristics and biological functions of individual groups of carbohydrates. Structure and function of lipids. General biological characterization and

function of lipids. Characteristics and biological functions of individual classes of neutral and phospholipids. General characteristics and biological role of carbohydrate complexes with proteins: glycoproteins and proteoglycans. Lipoproteins: structure, function, participation in the process of atherogenesis.

Topic 4. Conjugated Proteins: Hemoproteins, Metalloproteins, Phosphoproteins Nucleoproteins and Nucleic Acids: Structure, Functions, Biological Role.

Final conceptual module control CM1

Definition and classification of complex proteins. Chromoproteins. Hemoproteins. Phosphoproteins. Metalloproteins. Nucleoproteins. General characteristics of nucleic acids structure: nitrogenous bases, nucleosides and nucleotides. The structure of the polynucleotide chain. Deoxyribonucleic acid. Ribonucleic acid.

Content module 2. General principles of cellular metabolism organisation

Topic 5. Nomenclature and Classification of the Vitamins. Fat-soluble Vitamins. Water-soluble Vitamins. Interaction of Vitamins. Vitamin Products.

Classification and nomenclature of vitamins. Exogenous and endogenous causes of vitamin deficiency. Water soluble vitamins. Vitamin-like water-soluble substances. Fat soluble vitamins. Vitamin-like fat-soluble substances. Using vitamin preparations in the prevention and treatment of diseases. The interaction of vitamins.

Topic 6. Enzymes: Structure, Nomenclature, Classification. Enzyme Kinetics. Catalytic Mechanisms. Enzyme Regulation.

The concept of enzymes. Nomenclature and classification of enzymes. Structural and functional organization of enzymes. The mechanism of action of enzymes. Kinetics of enzymatic reactions. The specificity of enzymes. Regulation of enzyme activity. Units of enzyme activity, methods for their determination. Multiple molecular forms of enzymes. Isozymes. Polyenzyme systems. Immobilized enzymes and their use. The value of enzymes for medicine.

Topic 7. Introduction into Metabolism. Citric Acid Cycle. Electron transport chain (ETC). Oxidative Phosphorylation. Inhibitors of ETC and Uncouplers. Microsomal oxidation. Non-enzymatic oxidation.

Entry into bioenergy. Macroergic compounds. Stages of catabolic pathways in the human body. Biological oxidation reactions. Tissue breathing. The structure and function of the respiratory chain. Oxidizing Phosphorylation. The mechanism of communication of respiration and phosphorylation in mitochondria. Other types of biological oxidation. Antioxidant protection.

Topic 8. Pharmaceutical Biochemistry. Biogenic Compounds and Xenobiotics as Medicinal Preparations. Enzymes of Drug Metabolism. Pharmacokinetics and Excretion of Medicinal Preparations. Final conceptual module control CM2

Biogenic and alien compounds as drugs. Membrane transport and distribution and removal of drugs. Intermediate (tissue, cellular) metabolism of drugs. Oxidation by microsomal enzymes. Biochemical transformation of drugs in the body. The main reactions of transformation of medicinal substances (reactions 1 and 2 phases). Factors affecting the metabolism of drugs.

Final module control 1.

Module 2. Metabolism and its regulation

Content module 3. General principles of cellular metabolism organisation

Topic 9. Principles of Cell Signaling. Pathways of Intracellular Signal Transduction.

Means of transmitting the signal from cell to cell. Receptors. Types of cell receptors. The effector pathway for the activation of G-protein bound (metabotropic) receptors. Intracellular mediators. Signaling pathway using tyrosine kin receptors. Inhibitors of receptor tyrosine kinases.

Topic 10. Hormones and Neuromediators. Endocrine Glands. Classification of Hormones. Hyper- and Hypofunctions of Endocrine Glands. Endocrine Glands Functional Disorders and Their Correction. Final conceptual module control CM3

Mechanisms of action of hormones. Dysfunctions of the endocrine glands and their pharmacocorrection. General characteristics of hormones, their classification. Mechanisms of action of

hormones. Hormones of the central endocrine glands. Hormones of peripheral endocrine glands. Eicosanoids. Drugs in the correction of the functions of the endocrine glands.

The whole amount of hours for the content module 3

Content module 4. Some metabolic processes

Topic 11. Carbohydrate Metabolism, Its Regulation and Pathology.

Ways to use glucose in humans. Digestion of carbohydrates food. Anaerobic carbohydrate metabolism. Chemical reactions of glycolysis (glycogenolysis).

The fate of pyruvate (the formation of ethanol, lactate and acetate-CoA). Cycle of three carboxylic acids. Pentose phosphate cycle. Biosynthesis of carbohydrates in the tissues. Regulation and pathology of carbohydrate metabolism

Topic 12. Lipid Metabolism, Its Regulation and Pathology.

Digestion of lipids in the digestive tract. Bile acids. Intracellular lipid hydrolysis. Glycerol oxidation. Oxidation of fatty acids. Ketogenesis. Chemistry of the synthesis and catabolism of ketone bodies. Biosynthesis of lipids in tissues. Regulation and pathology of lipid metabolism.

Topic 13. General Amino Acid Pathways, Their Regulation and Pathology.

Digestion of proteins in the stomach and small intestine. Amino Acid Absorption Ways of metabolism of amino acids. Protein rotting in the intestines. Ways of forming a stock of free amino acids in the cell and further directions for the use of amino acids. Intracellular transformation of amino acids. Ammonia exchange, ways of neutralization of amino acids. Specialized pathways for the exchange of amino acids. Proteins and amino acids as pharmaceuticals. Digestion of gemprotein and nucleoproteins in the gastrointestinal tract, absorption of hydrolysis products. Exchange gemproteiniv. Heme biosynthesis. The breakdown of hemoglobin, the formation of bile pigments and their fate in the digestive tract. Heme biosynthesis disorders. Violation of bilirubin elimination. The exchange of nucleoproteins. Synthesis of uric acid. Pyrimidinium and purine biosynthesis, the formation of mononucleotides and nucleosides. Disruption of purine and pyrimidinium catabolism. Gout. Lesch-Nyhan syndrome. Drugs - inhibitors of the biosynthesis of purine nucleotides.

Topic 14. Transfer of Genetic Information. Protein Biosynthesis in the Cell. Mechanisms of Protein Biosynthesis Regulation. Antibiotics.

Types of transfer of genetic information. Replication and DNA repair. Molecular basis of transcription. Genetic code. The structure and chemical composition of ribosomes. Stages of protein biosynthesis. Inhibitors of protein biosynthesis. The mechanism of action of antibiotics. Drugs that enhance protein biosynthesis. Regulation of protein biosynthesis. Mutations. Molecular pathology. Principles of treatment and prevention of molecular diseases.

Final conceptual module control CM4

The final test 2

Examination

2. Names of lectures

№	Name of topic	The amount of hours
		full time study
1	Topic 1. Introduction in Biochemistry. Amino Acids, Peptides, Proteins.	1
2	Topic 2. Levels of Protein Structure. Physical-chemical properties of Proteins.	1
3	Topic 3. Carbohydrates and Lipids: Structure, Classification and Functions. Protein Complexes with Carbohydrates and Lipids.	2
4	Topic 4. Conjugated Proteins: Hemoproteins, Metalloproteins, Phosphoproteins Nucleoproteins and Nucleic Acids: Structure, Functions, Biological Role.	2

5	Topic 5. Nomenclature and Classification of the Vitamins. Fat-soluble Vitamins. Water-soluble Vitamins. Interaction of Vitamins. Vitamin Products.	2
6	Topic 6. Enzymes: Structure, Nomenclature, Classification. Enzyme Kinetics. Catalytic Mechanisms. Enzyme Regulation.	2
7	Topic 7. Introduction into Metabolism. Citric Acid Cycle. Electron transport chain (ETC). Oxidative Phosphorylation. Inhibitors of ETC and Uncouplers. Microsomal oxidation. Non-enzymatic oxidation.	4
8	Topic 8. Pharmaceutical Biochemistry. Biogenic Compounds and Xenobiotics as Medicinal Preparations. Enzymes of Drug Metabolism. Pharmacokinetics and Excretion of Medicinal Preparations.	2
9	Topic 9. Principles of Cell Signaling. Pathways of Intracellular Signal Transduction.	0,5
10	Topic 10. Hormones and Neuromediators. Endocrine Glands. Classification of Hormones. Hyper- and Hypofunctions of Endocrine Glands. Endocrine Glands Functional Disorders and There Correction.	0,5
11	Topic 11. Carbohydrate Metabolism, Its Regulation and Pathology.	1
12	Topic 12. Lipid Metabolism, Its Regulation and Pathology.	1
13	Topic 13. General Amino Acid Pathways, There Regulation and Pathology.	3
14	Topic 14. Transfer of Genetic Information. Protein Biosynthesis in the Cell. Mechanisms of Protein Biosynthesis Regulation. Antibiotics.	2
The whole amount of hours		24

3. Topics of seminars

№	Name of topic	The amount of hours
		full time study
1	Topic 1. Introduction in Biochemistry. Amino Acids, Peptides, Proteins.	-
2	Topic 2. Levels of Protein Structure. Physical-chemical properties of Proteins.	-
3	Topic 3. Carbohydrates and Lipids: Structure, Classification and Functions. Protein Complexes with Carbohydrates and Lipids.	-
4	Topic 4. Conjugated Proteins: Hemoproteins, Metalloproteins, Phosphoproteins Nucleoproteins and Nucleic Acids: Structure, Functions, Biological Role.	-
5	Topic 5. Nomenclature and Classification of the Vitamins. Fat-soluble Vitamins. Water-soluble Vitamins. Interaction of Vitamins. Vitamin Products.	-
6	Topic 6. Enzymes: Structure, Nomenclature, Classification. Enzyme Kinetics. Catalytic Mechanisms. Enzyme Regulation.	2
7	Topic 7. Introduction into Metabolism. Citric Acid Cycle. Electron transport chain (ETC). Oxidative Phosphorylation. Inhibitors of ETC and Uncouplers. Microsomal oxidation. Non-enzymatic oxidation.	2
8	Topic 8. Pharmaceutical Biochemistry. Biogenic Compounds and Xenobiotics as Medicinal Preparations. Enzymes of Drug	2

	Metabolism. Pharmacokinetics and Excretion of Medicinal Preparations.	
9	Topic 9. Principles of Cell Signaling. Pathways of Intracellular Signal Transduction.	-
10	Topic 10. Hormones and Neuromediators. Endocrine Glands. Classification of Hormones. Hyper- and Hypofunctions of Endocrine Glands. Endocrine Glands Functional Disorders and There Correction.	-
11	Topic 11. Carbohydrate Metabolism, Its Regulation and Pathology.	-
12	Topic 12. Lipid Metabolism, Its Regulation and Pathology.	-
13	Topic 13. General Amino Acid Pathways, There Regulation and Pathology.	-
14	Topic 14. Transfer of Genetic Information. Protein Biosynthesis in the Cell. Mechanisms of Protein Biosynthesis Regulation. Antibiotics.	-
The whole amount of hours		6

4. Topics of practical lessons

№	Name of topic	The amount of hours
		full time study
1	Topic 1. Introduction in Biochemistry. Amino Acids, Peptides, Proteins.	4
2	Topic 2. Levels of Protein Structure. Physical-chemical properties of Proteins.	4
3	Topic 3. Carbohydrates and Lipids: Structure, Classification and Functions. Protein Complexes with Carbohydrates and Lipids.	4
4	Topic 4. Conjugated Proteins: Hemoproteins, Metalloproteins, Phosphoproteins Nucleoproteins and Nucleic Acids: Structure, Functions, Biological Role.	4
5	Topic 5. Nomenclature and Classification of the Vitamins. Fat-soluble Vitamins. Water-soluble Vitamins. Interaction of Vitamins. Vitamin Products.	4
6	Topic 6. Enzymes: Structure, Nomenclature, Classification. Enzyme Kinetics. Catalytic Mechanisms. Enzyme Regulation.	4
7	Topic 7. Introduction into Metabolism. Citric Acid Cycle. Electron transport chain (ETC). Oxidative Phosphorylation. Inhibitors of ETC and Uncouplers. Microsomal oxidation. Non-enzymatic oxidation.	4
8	Topic 8. Pharmaceutical Biochemistry. Biogenic Compounds and Xenobiotics as Medicinal Preparations. Enzymes of Drug Metabolism. Pharmacokinetics and Excretion of Medicinal Preparations.	-
9	Final test 1	2
10	Topic 9. Principles of Cell Signaling. Pathways of Intracellular Signal Transduction.	2
11	Topic 10. Hormones and Neuromediators. Endocrine Glands. Classification of Hormones. Hyper- and Hypofunctions of Endocrine Glands. Endocrine Glands Functional Disorders and There Correction.	2

12	Topic 11. Carbohydrate Metabolism, Its Regulation and Pathology.	4
13	Topic 12. Lipid Metabolism, Its Regulation and Pathology.	4
14	Topic 13. General Amino Acid Pathways, Their Regulation and Pathology.	8
15	Topic 14. Transfer of Genetic Information. Protein Biosynthesis in the Cell. Mechanisms of Protein Biosynthesis Regulation. Antibiotics.	4
16	Final test 2	4
The whole amount of hours		60

5. Topics of laboratorial lessons

It is not provided by the curriculum

6. Self-study work

№	Name of topic	The amount of hours
		full time study
1	Topic 1. Introduction in Biochemistry. Amino Acids, Peptides, Proteins.	4
2	Topic 2. Levels of Protein Structure. Physical-chemical properties of Proteins.	6
3	Topic 3. Carbohydrates and Lipids: Structure, Classification and Functions. Protein Complexes with Carbohydrates and Lipids.	4
4	Topic 4. Conjugated Proteins: Hemoproteins, Metalloproteins, Phosphoproteins Nucleoproteins and Nucleic Acids: Structure, Functions, Biological Role.	4
5	Topic 5. Nomenclature and Classification of the Vitamins. Fat-soluble Vitamins. Water-soluble Vitamins. Interaction of Vitamins. Vitamin Products.	4
6	Topic 6. Enzymes: Structure, Nomenclature, Classification. Enzyme Kinetics. Catalytic Mechanisms. Enzyme Regulation.	6
7	Topic 7. Introduction into Metabolism. Citric Acid Cycle. Electron transport chain (ETC). Oxidative Phosphorylation. Inhibitors of ETC and Uncouplers. Microsomal oxidation. Non-enzymatic oxidation.	4
8	Topic 8. Pharmaceutical Biochemistry. Biogenic Compounds and Xenobiotics as Medicinal Preparations. Enzymes of Drug Metabolism. Pharmacokinetics and Excretion of Medicinal Preparations.	4
9	Topic 9. Principles of Cell Signaling. Pathways of Intracellular Signal Transduction.	3
10	Topic 10. Hormones and Neuromediators. Endocrine Glands. Classification of Hormones. Hyper- and Hypofunctions of Endocrine Glands. Endocrine Glands Functional Disorders and Their Correction.	3
11	Topic 11. Carbohydrate Metabolism, Its Regulation and Pathology.	3,25
12	Topic 12. Lipid Metabolism, Its Regulation and Pathology.	2
13	Topic 13. General Amino Acid Pathways, Their Regulation and Pathology.	9

14	Topic 14. Transfer of Genetic Information. Protein Biosynthesis in the Cell. Mechanisms of Protein Biosynthesis Regulation. Antibiotics.	3
The whole amount of hours		56,25

7. Tasks for self-study work

Independently using the recommended sources of information to provide answers and explanations to the following questions on topics Semantic module. The corresponding control is organized individually by the teacher.

The structure and function of biomolecules.

1. Call the qualitative reaction to the amino group of proteinogenic amino acids. Indicate the qualitative response to the aromatic ring of cyclic amino acids. Indicate the qualitative reaction for the sulfur-containing amino acids and the reagent with which this reaction is carried out.

2. Natural peptides: main groups, representatives. Carnosine, anserine, glutathione, opioid peptides; their organ localization, chemical characteristics, functions. Name the amino acid composition of glutathione and carnosine. What peptide formed in the central nervous system simulates the effect of morphine and is used for analgesia?

3. Name the drug used for parenteral protein nutrition. Indicate what is included in its composition. Give examples of these amino acids with the writing of their structural formulas.

4. Name the erythrocyte protein, has a quaternary structure. To give an example of an oligomeric protein, it has a supramolecular structure.

5. Name the connective tissue protein that regulates vascular permeability. Specify the process of co- and post-translational modifications that ensures its maturation.

6. Name the amino acid that provides the buffer properties of hemoglobin in the blood.

7. Electrophoretic distribution of plasma proteins. In which fraction does interferon move?

8. Name the drug with denaturing effect, which is used as an astringent for intestinal diseases.

9. Name the reducing disaccharides and write their structural formulas. What is the peculiarity of the structure that the sucrose properties do not have? Write the structural formula of sucrose. What is Fehling's reaction based on? Why, after incubating sucrose with an extract from yeast, does it give a positive Fehling reaction?

10. What components of membranes are synthesized with the participation of polyunsaturated fatty acids? At which pathology is recommended to use fats containing these fatty acids?

11. What fatty acids are essential for humans? Which pharmaceutical contains essential fatty acids?

12. What substances prevent fatty degeneration of the liver? Give examples with the writing of their chemical formulas. What is the mechanism of their lipotropic action? Do products and preparations contain lipotropic compounds? Specify the compound that is part of the curd and is involved in the repair of erythrocyte membranes. Mechanism of action. Is it involved in the synthesis of membrane components? What pathologies are recommended to use this product?

13. What lack of substances can cause a violation of fat absorption? For what purpose in case of secretory insufficiency of the pancreas with enzyme preparations, it is recommended to take preparations of bile acids? Write the structural formula of one of the bile acids? Name the function of bile acids.

14. What compound is a precursor for the synthesis of both triacylglycerols and phosphoglycerides? The presence of which compounds interferes with the synthesis of triacylglycerols? Give examples.

15. Which surface compound is used as an emulsifier in the manufacture of food? Write its chemical formula. Explain how its emulsifying properties are determined. What class of compounds does it belong to?

16. What is the derivative of hemoglobin formed by carbon monoxide poisoning? What determines its high toxicity? What hemoglobin derivative is not able to add oxygen? How is it formed? What properties does it show? Which compound binds well to cyanides and is used in cyanide poisoning? The content of which derivative of hemoglobin rises in the blood during hypercapnia?

17. What is the change in hemoglobin structure that causes hemoglobin S? How to change its physical, chemical and functional properties? What disease does it cause? Hemoproteins that oxidize: characteristics, major representatives and biological functions. The role of catalase.

18. Which glycosaminoglycan is the main component of cartilage and is used in the treatment of diseases of the joints?

19. How does heparin affect antithrombin III? In soft tissues, is it mostly localized? The use of heparin in medical practice.

20. Which pharmaceutical composition includes hyaluronidase? The use of hyaluronic acid in medical practice.

21. Which of the lipoprotein fractions is synthesized in the liver and transports endogenous lipids? Which fraction transports cholesterol from peripheral tissues to the liver?

22. The elevated blood level of which lipoproteins provide bilisuvaty shade of blood, and after its sedimentation forms a white layer on the surface? Explain the answer.

23. What transport protein is a carrier of iron in the blood? In case of violation of the synthesis of which protein, the release of ionized copper with urine is observed, its deposition in organs and tissues?

24. Name and write formulas of antimetabolites of purine and pyrimidine nitrogenous bases. Indicate their practical application in medicine. Describe the mechanism of action. Specify the mechanism of action of 5-fluorouracil; whose enzyme action blocks this antimetabolite? With the formation of which compound is the antitumor effect of 5-fluorouracil related?

25. Composition of chromatin. Characteristics of proteins that make up chromatin. The presence of which amino acids provides the electrochemical properties of these proteins?

Introduction into Metabolism.

1. What class is the enzyme that catalyzes the transfer of a phosphoric acid residue from one substrate to another?

2. Which class includes enzymes that cleave hydrogen atoms from different substrates?

3. What class is succinate dehydrogenase?

4. What class of enzymes do ester bonds cleave in triacylglycerol molecules?

5. Which class includes enzymes that carry out enteral transformations of substances?

6. What amino acid residues are most often included in the active centers of enzymes?

7. Theories explaining the mechanism of interaction of the enzyme with the substrate.

8. Explain the basis of the use of ethanol as a treatment for methyl alcohol poisoning.

9. Which pancreatic enzymes are secreted in an inactive form and are activated by limited proteolysis? Specify the pharmaceuticals used in acute pancreatitis.

10. Which metabolite is a competitive succinate dehydrogenase inhibitor? Explain what this inhibition is based on.

11. Name drugs that are competitive acetylcholinesterase inhibitors; explain the mechanism of their inhibitory action, indicate the purpose for which they are used in medical practice.

12. What enzyme deficiency is observed during cessation of breathing caused by the administration of a drug that causes muscle relaxation?

13. The mechanism of action of sulfa drugs.

14. How do mercury, lead, arsenic on the activity of enzymes?

15. Name compounds that are non-competitive acetylcholinesterase inhibitors. Their application in medical practice and agriculture.
16. Which enzyme has pyrophos? The mechanism of its action.
17. What enzyme needs to be reactivated in case of poisoning with organophosphorus compounds?
18. Which activity of enzymes and isoenzymes in the blood is observed in liver pathologies?
19. Determination of the activity of which enzyme is a marker indicator of early diagnosis of muscular dystrophy?
20. The change in the activity of which enzyme in the blood is a marker for pancreatitis?
21. What is the immobilized enzyme used to treat purulent wounds? What is the reason for this?
22. What form of enzymes is widely used in the pharmaceutical industry in the synthesis of new antibiotics?
23. Name the ligand that is used to obtain amylase from the pancreas by affinity chromatography?
24. Name the pharmaceutical preparation used to treat leukemia, indicate the mechanism of its action.
25. On the basis of which enzyme is Streptodekaza made? Its use in medicine.
26. Name the enzyme exhibiting fibrinolytic activity.
27. What process violation occurs during hypoxia? How is it shown?
28. Substances that affect the processes of tissue respiration. Dehydrogenase inhibitors: examples and mechanism of action.
29. What is the purpose of the drug isoniazid in clinical practice? What enzymes does it affect?
30. Name the drug that is used in clinical practice for cyanide poisoning treatment.
31. What is oligomycin used in clinical practice? Does it affect the process?
32. Does the area of the respiratory chain affect the sleeping pills of the barbiturate class? What enzyme do they inhibit? Call the metabolic disorders that occur when barbiturates poisoning, their causes.
33. How does antimycin A affect the tissue respiration process? What is the link of the respiratory chain?
34. Name the substances that inhibit the enzyme cytochrome oxidase?
35. What high dose of hormone causes hyperthermia? What is the reason for it?
36. Describe the processes of microsomal oxidation of substances. Write a scheme of monooxygenase chain microsomes.
37. Name the main components that make up the monooxygenase system of the endoplasmic reticulum. With what reaction does this system neutralize toxic substances?
38. What is the first phase of neutralization of xenobiotics? In which organ does it flow most intensively?
39. Which enzyme class of oxidoreductases is involved in the process of microsomal oxidation?
40. By what process does the inclusion of the oxygen atom in the substrate molecule occur during the neutralization of xenobiotics?
41. Specify a compound that stimulates the metabolism of drugs in the liver microsomes, what is the effect?
42. Describe the processes of free radical oxidation of substances. Prooxidants and antioxidants. Give a definition, give examples. Their biological significance.
43. Indicate the role of superoxide dismutase in the antioxidant protection of body cells.
44. What is the role of the enzyme catalase in the process of free radical oxidation of substances?
45. Call the vitamins that can stop the development of a chain of free radical reactions.

46. By the content of which the compound can be assessed the state of the antioxidant system of the body?

47. What compounds play the main role in the bactericidal action of leukocytes?

48. Why is hyperbaric oxygenation applied during hypoxia, can it be dangerous for brain tissue? What process can be activated when applying this method?

Principles of Cell Signaling.

1. Eicosanoids; Chemical characteristics, biological role, pharmaceuticals.

2. Tissue hormones. Callicrein-kinins system.

3. Biological regulators - amino acids derivatives (APUD-system): histamine, serotonin, catecholamineergic agonists.

Some metabolic processes

1. What is the value of human cellulose intake for human digestion? Can it be subject to complete hydrolysis in the human digestive tract?

2. Indicate which defect of the enzyme leads to impaired lactose degradation and which enzyme is used for diet therapy with milk intolerance in children.

3. Which activity determination with pancreatic enzymes is used to make a diagnosis of "pancreatitis"?

4. What is the normal level of serum glucose? Define the concepts of hypoglycemia and hyperglycemia. For the treatment of which diseases is artificial hypoglycemic coma used? Is the organ most sensitive to hypoglycemia? What is the purpose of determining blood glucose tolerance? What is the dynamics of changes in the level of glucose in the blood of a healthy person?

5. With a violation of the synthesis of which enzyme is associated galactosemia disease? The process is blocked and what consequences does this have for the infant's body? Describe the clinical signs of this disease.

6. What reaction does the allosteric enzyme hexokinase catalyze? Is the substance an inhibitor of its activity? What other liver enzyme catalyzes the same reaction and at what concentrations of glucose does its activity induce?

7. What drugs are prescribed to suppress gluconeogenesis in diabetes mellitus? What hormones stimulate the process of gluconeogenesis?

8. Features of lipid digestion in children.

9. Indicate separately that the chemical bond cleaves phospholipase A2. What products are formed during this reaction? Name the substance that is contained in the venom of snakes and when it enters the human body causes hemolysis of red blood cells. Can A2 phospholipase be present in snake venom? What is the role of tissue phospholipase A2 in the synthesis of prostaglandins?

10. What are the complexes with bile acids, which form fatty acids with more than 14 carbon atoms, called? Describe the hepato-intestinal circulation of bile acids.

11. What amount of products of hydrolysis of fats increases in the blood with increased secretion of adrenaline (for example, with pheochromocytoma)?

12. Indicate which compound is common to the process of glycolysis and the further conversion of glycerin, and is also a precursor of lipid synthesis.

13. What pathologies can lead to the development of ketosis and ketoacidosis?

14. What compounds belong to lipotropic factors? Why does their inadequate intake develop a fatty degeneration of the liver? Which of the lipotropic factors are used as drugs that stimulate the regeneration of the liver?

15. Types of nitrogen balance. The principle of the method of determining the nitrogen balance. Briefly indicate the reasons that lead to changes in the nitrogenous balance of the body.

16. Specify a hormone that activates the secretion of hydrochloric acid in the stomach.

17. Describe the mechanism of action of ranitidine. Features of protein digestion in newborns.

18. Write the reaction of the synthesis of indoxylsyrchanoi acid. The diagnostic value of indican detection in the urine. What amino acid and when conjugated with which does benzoic acid form in the human body? What is the diagnostic purpose for the determination of hippuric acid in the urine?
19. Name the drugs GABA. Under what pathological conditions do they apply?
20. What drugs are used to correct depressive conditions and what is their mechanism of action?
21. Diagnostic value of determination of ALT and AST.
22. Enzymes hydrolyze nucleic acids, mononucleotides and nucleosides, and what connections do they have?
23. What are the characteristic features of uro-proporphyrin (Gunther's disease) and acute porphyria intermittent?
24. Transformation of bile pigments in the digestive tract. Violations in this process can cause dysbacteriosis, including provoked by the long-term supply of antibiotics?
25. Which compound, a precursor of the synthesis of pyrimidine nucleotides, is used as a medicine for the treatment of muscular dystrophy? What drugs are used to treat disorders of the synthesis of pyrimidine bases?
26. What compound, is an intermediate metabolite of purine nucleotide synthesis, is used in the complex therapy of heart diseases? What are the consequences of a hereditary violation of the synthesis of pyrimidine bases and drugs used to treat this pathology?
27. Name the drug that is used to treat gout, and indicate its mechanism of action.

8. Individual tasks

It is not provided by the curriculum

9. Criteria and evaluation order of educational outcomes

The current control is carried out on each laboratory and seminar lesson according to the specific goals of the topic. The final modular control is carried out with a maximum of 40 points, a minimum of 25 points. Incentive (additional) points: performance of an individual task, participation in SSS and scientific student conferences, etc. - up to 10 points. Rating from the module (discipline) does not exceed 100 points. A module is considered surrendered if a student has scored from 60 to 100 points. Evaluation of current educational activities (conducted at each seminar lesson) includes the control of theoretical knowledge, practical skills. The control of mastering the content modules (PM) is carried out at the latest seminars of studying the topics of content modules according to the schedule for the current academic year. Only you are candidates for higher education who have completed all types of work envisaged by the curriculum (spent missed all seminars, etc.) are allowed to control the CM. A means of controlling content modules is computer testing.

The control of mastering the content modules (CM) is carried out at the latest seminars the topics of content modules according to the schedule for the current academic year. Only candidates who have completed all types of work envisaged by the curriculum (reworked all missed classes, seminars, etc.) are allowed to control the CM. A means of controlling the content module is computer testing. The final module control (FMC) is carried out at the end of the study of each module in the final control classes. Only those applicants of higher education who scored for the current activity in the conclusion of the current module, at least 36 points (the sum of points for each current occupation and control of the content modules) are admitted to the FMC. The total amount of FMC is a maximum of 40 points. FMC is considered enrolled if the applicant of higher education scored at least 25 points.

Monitoring the level of preparation of applicants for higher education consists of two stages: a written theoretical survey, a ticket consists of 4 theoretical questions and testing using the SUNRAW program (100 tests each). For one theoretical question, a candidate for higher education is given a score from 0 to a score of 5 points, an average of from 0 to 20 points.

Scoring for answering multiple choice questions starts with the 81st test and is charged at 1 point for the test, so the maximum number of points is: 20. The total number of points for the FMC is the arithmetic sum of these two problems.

When developing evaluation criteria, the completeness and correctness of the answer to the questions is taken. In addition, the ability of applicants for higher education to differentiate, integrate and unify knowledge is taken into account.

The scheme of scoring current and final modular control are shown in the table (see table).

Module 1

Current assessment and self-study								Final module control	Total
Content module 1				Content module 2				40	100
T1	T2	T3	T4; CMC1	T5	T6	T7	T8; CMC2		
-	10	5	10	10	10	10	5		

Module 2

Current assessment and self-study						Final module control	Total	
Content module 1			Content module 2			40	100	
T9	T10;CMC3		T11	T12	T13			T14; CMC4
5	10		10	10	15			10

The applicant for higher education for the current control of knowledge may receive a minimum of 36, and a maximum of 60 points. Evaluation of current educational activities includes the control of theoretical and practical knowledge and skills. The applicant who received the minimum number of points is allowed to the final modular control. The maximum number of points that an applicant for higher education can receive when passing the final modular control is 40 points, and the minimum is 25 points. The student can also receive up to 10 additional points for participating in the student scientific community, speaking at a scientific conference, preparing a report, performing an individual task, etc. The overall rating for 1 Module does not exceed 100 points.

The discipline "Biological Chemistry" is studied for 2 semesters and consists of 2 modules. Upon completion of the study of the discipline for each search engine of higher education the arithmetic average of the number of points is calculated, he received in each module. Scoring and their evaluation is carried out according to the following scheme:

Total amount of points	ECTS score	National scale score
Module 1+Module 2		
2		
90-100	A	excellent
82-89	B	good
74-81	C	
64-73	D	satisfactory
60-63	E	
35-59	FX	unsatisfactory with the possibility of retake
0-34	F	unsatisfactory without the possibility of retake

Applicants who score 60 or more points are allowed to take the exam. The exam is held in writing and is considered passed if the applicant received from 60 to 100 points. Successful mastering of the discipline provides that the applicant of higher education has shown

knowledge:

composition, structural organization, physico-chemical properties, methods for isolation and purification of proteins;

- classification and characterization of simple and complex proteins, the value of the most important representatives;

- classification, structure, physico-chemical properties and functions of carbohydrates and lipids, the value of the value of the most important representatives;

- the importance of vitamins for the human body, their classification and nomenclature, their chemical structure, signs of hypo- and avitaminosis;

- pharmaceutical preparations of vitamins and their derivatives;

- the chemical nature of enzymes and their properties as biocatalysts, as well as the classification and nomenclature of enzymes, the specificity of their action;

- mechanisms of influence of drugs on the enzymatic processes in the body

- the value of the endocrine system for the human body, as well as the classification, chemical nature and properties of hormones;

- pharmaceutical preparations of natural hormones and their synthetic analogues;

- biochemical basis of biosignaling and reception. The mechanisms of signal transmission into the cell;

- types of biological oxidation, the structural organization of mitochondria;

- the main processes of carbohydrate metabolism and the factors affecting them;

- the role and mechanisms of action of non-hormonal hypoglycemic drugs and insulin preparations

- the main processes of lipid metabolism and the factors affecting them;

- mechanisms of action of the main lipid-lowering drugs;

- the main metabolic processes of amino acids, the factors affecting them;

- common pathologies associated with impaired metabolism of amino acids and ways to correct them

- the main pathways for the decomposition and synthesis of heme chromoproteins, as well as nitrogenous bases (nucleosides, nucleotides) of nucleic acids;

- the main metabolic processes of medicinal compounds in the human body.

skills:

- explain the importance of biochemistry for pharmacy;

- analyze the composition, structural organization, physico-chemical properties, methods for isolation and purification of proteins;

- to interpret the numerous functions and biological properties of proteins and peptides;

- explain the classification and characterization of proteins, the meaning of individual representatives;

- analyze the composition and structure of carbohydrates and lipids, their classification.

Explain the biological significance of carbohydrates and lipids, their distribution;

- explain the chemical structure, classification, biological functions of carbohydrates and lipids

- analyze the hypotheses of the mechanism of action of enzymes, stages of enzymatic catalysis, types of inhibition of the work of enzymes

- analyze the effect of drug compounds on the activity of enzymes taking into account their structure;

- analyze the body's energy resources, the phases of release of energy from nutrients;

- to interpret the main provisions of the chemosmotic hypotheses of the mechanism of oxidative phosphorylation, the effect of various (including medicinal) factors on the oxidation of substances and the formation of ATP

- analyze the hormonal regulation of carbohydrate metabolism, its violation in diabetes mellitus
- explain the role of non-hormonal hypoglycemic drugs and insulin preparations
- analyze the main mechanisms of action of lipid-lowering drugs;
- analyze ways of using free amino acids in the human body (processes of transamination, deamination, decarboxylation of amino acids; stages of urea biosynthesis)
- to interpret the course of the processes of decomposition and synthesis of heme chromoproteins, as well as nitrogenous bases (nucleosides, nucleotides) of nucleic acids;
- analyze the nature of the disorders in jaundice, porphyria and gout in the human body;
- analyze ways of multiplying and transmitting hereditary information;
- explain the properties of the genetic code
- explain the symptoms of hypo- and avitaminosis and their correction mechanisms
- interpret the mechanisms of the modifying action of hormones on metabolic processes in target cells;
- analyze the use of natural hormones and their synthetic analogues as pharmaceuticals for the purpose of treating endocrine gland function disorders.

attainments:

- technologies of biochemical analysis and evaluation of its results.
- methods for the quantitative determination of proteins, glucose, cholesterol, bilirubin and urea in serum;
- methods of analysis of biomolecules - amino acids, carbohydrates, lipids and vitamins;
- technologies for analyzing the composition of complex biomolecules;
- methods for determining the activity of enzymes
- technologies of interpretation of results obtained on the basis of biological chemistry methods.

The scale of assessment of the discipline on the results of the exam:

Points obtained on the exam	ECTS score	National scale score
90-100	A	excellent
82-89	B	good
74-81	C	
64-73	D	satisfactory
60-63	E	
35-59	FX	unsatisfactory with the possibility of retake
0-34	F	unsatisfactory without the possibility of retake

10. Forms of progress and final tests of academic achievements

Types of control that are used in the process of teaching the discipline:

1. Current control is the control of the level of theoretical training of a student to conduct research in the form of a penny or written answer, solving a situational problem, computer testing;
2. The Content module control is the control of mastering the amount of knowledge that was received by a student during the content module. It can be carried out in the written form or computer testing.
3. The final modul control is the control of mastering the material obtained by the applicant of higher education during the module. It is conducted in the form of written work and/or computer testing.

4. The exam is the control of mastering the discipline material. Form of conducting - written control.

14. Teaching course materials

1. Work program of the discipline.
2. Calendar-themed plans for lectures and practical exercises.
3. Criteria for assessing the knowledge and skills of applicants for higher education.
4. Methodical materials of computer presentations of lectures.
5. The list of theoretical questions to the current and final module control.
6. Collection of test tasks for the discipline.
7. Package of tickets for control of mastering meaningful modules, final module control.
8. Package tickets integrated control work.
9. Guidelines for the discipline for teachers.
10. Methodical recommendations for practical exercises.
11. Methodical recommendations of independent work of applicants for higher education.
12. Methodical recommendations on how to prepare for the classroom quality control of independent work of applicants for higher education by correspondence course.
13. Guidelines for the preparation of the final module control.
14. Workbook for laboratory work.

15. Reading suggestions

The main reading suggestions

1. Biological Chemistry: Textbook for the self-study of students / A.L. Zagayko, L.M. Voronina, G.B. Kravchenko, K.V. Strel'chenko.– Kharkiv: NUPh; Original, 2011. - 264p.
2. Clinical biochemistry: An illustrated colour text / A. Gaw, M.J. Murphy, R.A. Cowan and oth. – ELSEVIER Ltd., 2008.- 179p.
3. Textbook of biochemistry: with clinical correlations / edited by Thomas M. Devlin.- John Wiley & Sons, Inc., 2011. - 1204p.

Supplementary reading suggestions

4. Lieberman M., Marks A. Marks' basic medical biochemistry: a clinical approach. – Lippincott Williams & Wilkins, a Wolters Kluwer business., 2009. – 1011p.
5. Bhagavan N.V., Chung-Eun H. Essentials of medical biochemistry: with clinical cases. – ELSEVIER Inc., 2011. – 581p.

16. Electronic resources

1. Biological Chemistry Department Site: <http://biochem.nuph.edu.ua/>.
2. NPhU Library: e-mail library@nuph.edu.ua
3. Distance Learning Site <http://www.pharmel.kharkiv.edu/>.