Federal State Budgetary Educational Institution of Higher Education
"Privolzhsky Research Medical University"
Ministry of Health of the Russian Federation

APPROVED
Vice-Rector for Academic Affairs
I.S. Bogomolova
31 August 2021

# WORKING PROGRAM

Name of the academic discipline: **BIOLOGICAL CHEMISTRY**

Specialty: **33.05.01 PHARMACY**

Qualification: **PHARMACIST**

Department: **BIOCHEMISTRY named after G.Ya. GORODISSKAYA**

Mode of study: **FULL-TIME**

Labor intensity of the academic discipline: **252 academic hours**

Nizhny Novgorod
2021

The working program has been developed in accordance with the Federal State Educational Standard for the specialty 33.05.01 PHARMACY approved by Order of the Ministry of Science and Higher Education of the Russian Federation No. 219, dated of March 27, 2018.

**Developers of the working program:**
Erlykina Elena Ivanovna, Doctor of Biological Sciences, Professor, Head of the Department of Biochemistry named after G.Ya. Gorodisskaya
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The program was reviewed and approved at the department meeting (protocol No.12, 27.08.2021)
Head of the Department,
Doctor of Biological Sciences, Professor _____ (Erlykina E.I.)
(signature)

27 August 2021

AGREED
Deputy Head of EMA ph.d. of biology _____ Lovtsova L.V.

27 August 2021

**1. The purpose and objectives of mastering the academic discipline biological chemistry** (hereinafter – the discipline):

1.1. The purpose of mastering the discipline:

Participation in forming the relevant competencies:

GPC-1 – to be able to use basic biological, physical-chemical, chemical, mathematical methods for the development, research and examination of medicines, the manufacture of medicinal products.

GPC-1.2. - applies basic physical-chemical and chemical analysis methods for the development, research and examination of medicinal products and medicinal plant raw materials.

GPC-2 - able to apply knowledge about morphofunctional features, physiological conditions and pathological processes in the human body to solve professional tasks.

GPC-2.1. - analyzes the pharmacokinetics and pharmacodynamics of medicines based on knowledge about morphofunctional features, physiological conditions and pathological processes in the human body

GPC-2.2. - explains the main and side effects of drugs, the effects of their combined use and interaction with food, taking into account morphofunctional features, physiological conditions and pathological processes in the human body.

**1.2. Tasks of the discipline:**

1. to ensure the assimilation of knowledge on the structural organization of the main biomacromolecules of the cell, the molecular foundations of metabolism and energy, the functional biochemistry of individual specialized tissues and organs, the mechanisms of their regulation, the understanding of molecular processes that are possible targets for the action of drugs in their intake and transformations in the body;

2. to develop in students the ability to use the knowledge, skills and abilities gained in the course of biochemistry for the effective formation of the professional abilities of a pharmacist, assessing the information content of the results of biochemical analyzes, successful participation in educational and research work and the development of new drugs;

3. to form the skills of analytical work with information (educational, scientific, reference literature and other sources), with information technologies, diagnostic research methods.

**1.3. Requirements to the deliverables of mastering the discipline**

As a result of completing the discipline, the student should

**Know:**

- rules of work and safety precautions in chemical laboratories, with reagents, instruments;
- structure and biochemical properties of the main classes of biologically important compounds;
- principles of biochemical analysis, application of biochemistry methods in the production and analysis of drugs;
- structure and biochemical properties of the main classes of biologically important compounds, the main metabolic pathways of their transformation and regulation;
- the role of cell membranes and their transport systems in the metabolism in the body;
- chemical and biological essence of the processes occurring in the body at the molecular and cellular levels;
- principles of biochemical analysis;
- application of biochemistry methods in the production and analysis of drugs.

**Be able to:**

– use measuring equipment when performing biochemical studies;

– use knowledge to analyze the essence of general pathological processes and the mechanism of action of drugs;

– apply the acquired knowledge in the study of subsequent professional disciplines;

– determine the content of some components of protein, carbohydrate and lipid

metabolism in blood and biological fluids;

– independently work with educational, scientific, popular science literature, the Internet for professional activities.

**Possess:**

- methods of working with medical and technical equipment;
- basic information conversion technologies: text, spreadsheet editors, Internet techniques for professional activities;
- some methods for determining the content of amino acids, proteins, lipids, carbohydrates, which are used in pharmacoanalysis.

**2. Position of the academic discipline in the structure of the General Educational Program of Higher Education (GEP HE) of the organization.**

2.1. The discipline biological chemistry refers to the core part of Block 1 of GEP HE (33.05.01 PHARMACY).

The discipline is taught in 4 semester of the second year of study and in 5 semester of the third year of study.

**2.2. The following knowledge, skills and abilities formed by previous academic disciplines are required for mastering the discipline:**

1. Social sciences.
2. Physics.
3. Biology.
4. Inorganic and organic chemistry.
5. Physiology with anatomy fundamentals.

**2.3. Mastering the discipline is required for forming the following knowledge, skills and abilities for subsequent academic disciplines:**

1. Pharmacology.
2. Pharmacognosy.
3. Pharmaceutical chemistry.
4. Pharmaco-therapy.

**3. Deliverables of mastering the academic discipline and metrics of competence acquisition**

Mastering the discipline aims at acquiring the following universal (UC) or/and general professional (GPC) or/and professional (PC) competencies

| № | Compe-tence code | The content of the competence (or its part) | Code and name of the competence acquisition metric | As a result of mastering the discipline, the students should: | | |
|---|---|---|---|---|---|---|
| | | | | know | be able to | possess |
| 1. | GPC-1 | Able to use basic biological, physical-chemical, chemical, mathematical methods for the development, research and examination of medicines, the manufacture of | GPC-1.2. Applies basic physical-chemical and chemical analysis methods for the development, research and examination of medicinal products and medicinal plant raw materials | Rules of work and safety precautions in chemical laboratories, with reagents, instruments; structure and biochemical properties of the main classes of biologically important compounds. Principles of | Use knowledge to analyze the essence of general pathological processes and the mechanism of action of drugs; independently work with educational, scientific, popular science | Techniques for working with basic technologies for converting information: text, spreadsheet editors, techniques for working on the Internet for |

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|---|---|---|---|---|---|---|
| | | medicinal products | | biochemical analysis; application of biochemistry methods in the production and analysis of drugs. | literature, the Internet for professional activities. | professional activities. |
| 2. | GPC-2 | Able to apply knowledge about morphofunctional features, physiological conditions and pathological processes in the human body to solve professional tasks | GPC-2.1. Analyzes the pharmacokinetics and pharmacodynamics of medicines based on knowledge about morphofunctional features, physiological conditions and pathological processes in the human body GPC-2.2. Explains the main and side effects of drugs, the effects of their combined use and interaction with food, taking into account morphofunctional features, physiological conditions and pathological processes in the human body | The main metabolic pathways of bio-transformation of drugs, their transformation and regulation; the role of cell membranes and their transport systems in the body's metabolism; the chemical and biological essence of the processes occurring at the molecular and cellular levels in the body in normal and pathological conditions. | Interpret the data of physical-chemical, bio-chemical examinations in the professional activity of a pharmacist. Use both structural formulas and a schematic representation of the sequence of reactions of the main metabolic pathways and biochemical processes, use reference material | The skills of independent work on drawing up a plan for the use of biochemical methods in the work of a pharmacist and the formation of generalizing conclusions. |

**4. Sections of the academic discipline and competencies that are formed when mastering them**

| № | Competence code | Section name of the discipline | The content of the section in teaching units |
|---|---|---|---|
| 1 | GPC-1 GPC-2 | Structure and function of proteins and amino acids | Subject and tasks of biochemistry. The connection of biochemistry with pharmacy, its role in the preparation of pharmacists. Molecular organization of living cells. Proteins as the basis of life processes. The chemical composition of proteins. Amino acids. Types of chemical bonds in protein molecules. Levels of structural organization of proteins. Physico-chemical properties of proteins. Classification of proteins. Simple and complex proteins, their structure and functions. Protein folding, participation of chaperones. The role of proteomics in the assessment of pathological conditions. |
| 2 | GPC-1 GPC-2 | Enzymes | The concept of enzymes as biological catalysts. Enzymes, structural organization and functions. Vitamins and their coenzyme function. The concept of the active and allosteric center of enzymes. Properties of enzymes. Classification and nomenclature of enzymes. Kinetics of |

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|---|---|---|---|
| | | | enzymatic reactions. Michaelis-Menten equation and graph. Lineweaver-Burk transformation. The mechanism of action of enzymes and the regulation of their activity. The use of enzymes and vitamins in pharmacy. Enzymodiagnostics and enzyme therapy. Isoenzymes. organ-specific enzymes. Hereditary enzymopathies. |
| 3 | GPC-1<br>GPC-2 | Introduction to the metabolism. Biological oxidation. Oxidative phosphorylation. Cycle of di- and tricarboxylic acids. | General concepts of metabolism. Energy exchange of substances. External and intermediate metabolism. Digestion as the initial stage of metabolism. Catabolic, anabolic and amphibolic metabolic pathways. Biological oxidation. Redox systems. Stages of oxidation in the cell. Oxidative decarboxylation of pyruvic acid. Biological oxidation. Citric acid cycle. Respiratory chain of enzymes. Oxidative phosphorylation, other types of phosphorylation. |
| 4 | GPC-1<br>GPC-2 | Hormones | Hormonal regulation as a mechanism to coordinate metabolism. Hierarchy of hormonal regulation. Classification of hormones. Steroid hormones. Hormones are derivatives of amino acids. Peptide hormones. Hormones are derivatives of fatty acids. Signal transmission to the cell. Characteristics of receptors. Properties of hormones and their mechanism of action. Application of hormones and their synthetic analogues in medicine. |
| 5 | GPC-1<br>GPC-2 | Metabolism of proteins and amino acids | Digestion of proteins in the gastrointestinal tract. The concept of nitrogen balance. Common pathways of amino acid metabolism. Direct and indirect deamination of amino acids. Decarboxylation of amino acids. Deactivation of biogenic amines. Pathways for the transformation of nitrogen-free amino acid residues. Reactions on the radical of amino acids. The fate of ammonia and methods of its neutralization. Ornithine cycle. Amino acids as drugs. |
| 6 | GPC-1<br>GPC-2 | Nucleoprotein metabolism. Protein synthesis. | Synthesis and degradation of purine and pyrimidine nucleoproteins. The use of allopurinol in hyperuricemia. Biosynthesis of deoxyribonucleoproteins. Drugs inhibiting nucleotide synthesis, matrix biosyntheses. Antibiotics as inhibitors of protein biosynthesis. |
| 7 | GPC-1<br>GPC-2 | Metabolism of carbohydrates. | Digestion of carbohydrates. Interstitial transformations of carbohydrates. Glycogenolysis, glycolysis. The concept of the pentose phosphate pathway of carbohydrate catabolism. Biosynthesis of carbohydrates. Gluconeogenesis. Biosynthesis of glycogen. Neuro-humoral regulation of carbohydrate metabolism. Sources of blood glucose. Regulation of blood glucose levels. The role of the liver in carbohydrate metabolism. Disorders of carbohydrate metabolism. |
| 8 | GPC-1<br>GPC-2 | Metabolism of lipids. | Digestion of lipids in the gastrointestinal tract. Resynthesis of lipids in the intestinal epithelium. Transport of lipids, blood plasma lipoproteins: structure, functions, metabolism. Oxidation of glycerol and fatty acids. Synthesis and oxidation of ketone bodies. Synthesis of fatty acids and lipids in tissues. Sterol and cholesterol metabolism. Neurohumoral regulation of lipid metabolism. Lipid metabolism disorders. Biological membranes: structure, properties, functions. Free radical oxidation. Antioxidant system of the cell. Antioxidants as drugs. Liposomes as a model of biological membranes and a transport form of drugs. |
| 9 | GPC-1<br>GPC-2 | Biochemistry of blood. | Blood is a part of the body's internal environment. The main functions of blood. Protein spectrum of plasma. Albumins, their transport function and contribution to plasma oncotic pressure. Globulins, their characteristics. Plasma enzymes: "own" and coming in case of cell damage. Diagnostic value of plasma enzyme analysis. Respiratory function of the blood. Hemoglobin, structure. Molecular mechanisms of gas exchange in lungs and tissues. Kinetics of oxygenation of myoglobin and hemoglobin. hemoglobin polymorphism. Buffer systems of the blood. |
| 10 | GPC-1 | Biochemistry of | The role of the liver in metabolism. The role of the liver in the formation |

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| | GPC-2 | the liver. | of bile pigments. Synthesis and degradation of heme. Direct and indirect bilirubin. Jaundice. |
| 11 | GPC-1<br>GPC-2 | Pharmaceutical biochemistry | Application of biochemical knowledge and methods in drug technology, pharmaceutical chemistry, pharmacology. Medicines as foreign compounds. The main stages of the metabolism of biogenic toxins and foreign drugs. The main stages of the biotransformation of drugs and their significance. The role of microsomal enzymes and conjugation reactions. in drug metabolism. Factors affecting drug metabolism. |
| 12 | GPC-1<br>GPC-2 | Biochemistry of connective and muscle tissue | Biochemistry of the intercellular matrix. Organization of the intercellular matrix. General information about the structure of collagen proteins. Synthesis of collagen. Violations of the synthesis of collagen proteins in humans. Non-collagen proteins of the extracellular matrix. Elastin. Synthesis and breakdown of elastin. Proteoglycans and glycosaminoglycans. Catabolism of proteins of the intercellular matrix. Myofibril proteins, molecular structure. Bio-chemical mechanisms of muscle contraction and relaxation. Features of energy metabolism in muscles. Biochemical changes in muscular dystrophies. Creatinuria. Features of myocardial metabolism. |
| 13 | GPC-1<br>GPC-2 | Biochemistry of the nervous system | Features of the chemical composition of the nervous tissue and its metabolism. Energy metabolism in the nervous tissue. Violation of the metabolism of biogenic amines in nervous system and mental diseases. |

**5. Volume of the academic discipline and types of academic work**

| Type of educational work | Labor intensity | | Labor intensity (AH) in semesters | |
|---|---|---|---|---|
| | volume in credit units (CU) | volume in academic hours (AH) | 4 | 5 |
| Classroom work, including | | | | |
| Lectures (L) | 1 | 38 | 26 | 12 |
| Laboratory practicum (LP)* | 2.6 | 92 | 60 | 32 |
| Practicals (P) | | | - | - |
| Seminars (S) | | | - | - |
| Student's individual work (SIW) | 2.4 | 86 | 58 | 28 |
| Mid-term assessment | | | | |
| exam | 1 | 36 | | |
| TOTAL LABOR INTENSITY | 7 | 252 | 144 | 72 |

**6. Content of the academic discipline**

**6.1. Sections of the discipline and types of academic work**

| № | Name of the section of the academic discipline | Types of academic work* (in AH) | | | | | |
|---|---|---|---|---|---|---|---|
| | | L | LP | P | S | SIW | total |
| 1 | Structure and function of proteins and amino acids | 2 | 3 | - | - | 4 | 9 |
| 2 | Enzymes | 4 | 12 | - | - | 10 | 26 |
| 3 | Introduction to the metabolism. Biological oxidation. Oxidative phosphorylation. Cycle of di- and tricarboxylic acids. | 4 | 9 | - | - | 8 | 21 |
| 4 | Hormones | 2 | 3 | - | - | 4 | 9 |
| 5 | Metabolism of proteins and amino acids | 6 | 12 | - | - | 9 | 27 |
| 6 | Nucleoprotein metabolism. Protein synthesis. | 2 | 6 | - | - | 5 | 13 |
| 7 | Biochemistry of blood | - | - | - | - | 6 | 6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | Metabolism of carbohydrates. | 6 | 12 | - | - | 10 | 28 |
| | Final test | - | 3 | - | - | 2 | 5 |
| 9 | Metabolism of lipids. | 8 | 15 | - | - | 12 | 35 |
| 10 | Biochemistry of the liver. | 2 | 3 | - | - | 3 | 8 |
| 11 | Pharmaceutical biochemistry | 2 | 6 | - | - | 4 | 12 |
| 12 | Biochemistry of connective and muscle tissue | - | 3 | - | - | 2 | 5 |
| 13 | Biochemistry of the nervous system | - | 3 | - | - | 3 | 6 |
| 14 | Final test | | 2 | - | - | 4 | 6 |
| | TOTAL | 38 | 92 | - | - | 86 | 216 |

* - L – lectures; LP – laboratory practicum; P – practicals; S – seminars; SIW – student's individual work.

**6.2. Thematic schedule of educational work types:**

**6.2.1 Thematic schedule of lectures**

| № | Name of lecture topics | Volume in AH | |
|---|---|---|---|
| | | 4 semester | 5 semester |
| 1 | INTRODUCTION TO THE SUBJECT OF BIOCHEMISTRY, ITS ROLE IN PHARMACY. AMINO ACIDS AND THEIR DRUGS. CLASSIFICATION AND FUNCTIONS OF PROTEINS, THEIR STRUCTURAL ORGANIZATION, PROTEIN FOLDING. PROTEIN-LIGAND INTERACTIONS. PROTEIN-PEPTIDE MEDICINES. | 2 | |
| 2 | STRUCTURE OF ENZYMES. ENZYME COFACTORS. COENZYME FUNCTION OF VITAMINS. SPECIFICITY OF ENZYMES. ENVIRONMENT INFLUENCE ON ENZYME ACTIVITY. | 2 | |
| 3 | KINETICS OF ENZYMATIVE REACTIONS. REGULATION OF ENZYME ACTIVITY. TYPES OF INHIBITION: COMPETITIVE AND NON-COMPETITIVE, REVERSIBLE AND IRREVERSIBLE. INFLUENCE OF PHARMACEUTICALS ON ENZYME ACTIVITY. | 2 | |
| 4 | THE CONCEPT OF METABOLISM. BIOENERGY OF THE CELL. THE CYCLE OF THRICARBOXIC ACIDS, ITS REGULATION. MEDICINES - ACTIVATORS OF THE KREBS CYCLE. | 2 | |
| 5 | BIOLOGICAL OXIDATION. STRUCTURAL ORGANIZATION OF THE RESPIRATORY CHAIN, ITS FUNCTIONS. OXIDATED PHOSPHORYLATION. ENERGY METABOLISM DISTURBANCES. THE ROLE OF UNCOUPLERS IN THERMOREGULATION. EFFECT OF MEDICINES ON OXIDATIVE PHOSPHORYLATION. | 2 | |
| 6 | BIOCHEMISTRY OF HORMONES. CENTRAL REGULATION OF THE ENDOCRINE SYSTEM. CLASSIFICATION OF HORMONES. MECHANISMS OF SIGNAL TRANSMISSION INTO THE CELL: MEMBRANE AND INTRA-CELLULAR. MEDICINAL FORMS OF HORMONES. | 2 | |
| 7 | PROTEIN AND AMINO ACID METABOLISM. BIOLOGICAL VALUE OF PROTEINS. NITROGEN BALANCE. PROTEIN DIGESTION. CHARACTERISTICS OF PROTEOLITIC ENZYMES. MODERN MEDICINES USED FOR CORRECTION OF PROTEIN DIGESTION DISORDERS. | 2 | |
| 8 | INTRACELLULAR CATABOLISM OF AMINO ACIDS. DEAMINATION AND DECARBOXYLATION OF AMINO ACIDS. BIOGENIC AMINES. MAO INHIBITORS AS MEDICINAL SUBSTANCES. EXCHANGE OF PHE-NYLALANINE AND TYROSINE AND ENZYMOPATHIES OF THIS EXCHANGE. PHARMACEUTICAL PRODUCTS FOR CORRECTION OF | 2 | |

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|---|---|---|---|
| | ENZYMOPATHIES. | | |
| 9 | FORMATION AND NEUTRALIZATION OF AMMONIA. SYNTHESIS OF UREA. HYPERAMMONIEMIA. SYNTHESIS OF CREATIN, CREATIN PHOSPHATE, CREATININE. RESIDUAL BLOOD NITROGEN. AZOTHEMIA. NITRIC OXIDE, ITS PHYSIOLOGICAL ROLE, MEDICINES. | 2 | |
| 10 | METABOLISM OF NUCLEOPROTEINS. PROTEIN SYNTHESIS. SYNTHESIS AND CATABOLISM OF PURINE AND PYRIMIDINE NUCLEOTIDES. USE OF ALLOPURINOL IN HYPERURICEMIA. BIOSYNTHESIS OF DEOXYRIBONUCLEOTIDES. MEDICINES OF INHIBITION OF NUCLEOTIDE SYNTHESIS. MATRIX BIOSYNTHESIS. ANTIBIOTICS AS INHIBITORS OF PROTEIN BIOSYNTHESIS. | 2 | |
| 11 | CARBOHYDRATE METABOLISM. BASIC CARBOHYDRATES OF FOOD AND BODY. CARBOHYDRATE DIGESTION. DISORDERS OF DIGESTION AND ABSORPTION OF CARBOHYDRATES. ROLE OF DIETARY FIBERS. MEDICINES TO CORRECT OF CARBOHYDRATE DIGESTION. GLYCOGEN AS A RESERVE POLYSACCHARIDE: BIOSYNTHESIS AND MOBILIZATION OF GLYCOGEN. REGULATION OF PROCESSES. GLYCOGENOSIS AND AGLICOGENOSIS. | 2 | |
| 12 | CARBOHYDRATE METABOLISM. GLUCOSE CATABOLISM: GLYCOLIS, PENTOSOPHOSPHATE PATHWAY OF GLUCOSE OXIDATION. ITS SIGNIFICANCE IN THE BIOTRANSFORMATION OF DRUGS. | 2 | |
| 13 | GLUCONEOGENESIS AND ITS RELATIONSHIP WITH GLYCOLYSIS. COREY CYCLE. REGULATION OF CARBOHYDRATE METABOLISM. HYPO AND HYPERGLYCEMIA. DIABETES. MEDICINES FOR CORRECTION. | 2 | |
| 14 | BASIC LIPIDS OF THE BODY, STRUCTURE AND PROPERTIES. DIGESTION AND ABSORPTION OF LIPIDS, THE ROLE OF MEDICINAL CHOLOGICAL AND ENZYME DRUGS IN DIGESTIVE DIGESTION. TRANSPORT OF LIPIDS - LIPOPROTEINS, THEIR CHARACTERISTICS. ATHEROGENIC AND ANTI-ATHEROGENIC LIPOPROTEINS | | 2 |
| 15 | LIPID CATABOLISM: MOBILIZATION OF FATS, BETA-OXIDATION OF HIGHER FATTY ACIDS, REGULATION. CATABOLISM OF GLYCEROL. SYNTHESIS OF KETONE BODIES, THEIR PHYSIOLOGICAL SIGNIFICANCE. | | 2 |
| 16 | LIPID ANABOLISM: SYNTHESIS OF FATTY ACIDS, CHOLESTEROL, NEUTRAL FATS AND PHOSPHOLIPIDS, REGULATION OF PROCESSES. LIPOTROPIC FACTORS IN MODERN MEDICINES. RELATIONSHIP BETWEEN LIPID AND CARBOHYDRATE METABOLISM. | | 2 |
| 17 | MEMBRANE STRUCTURE, ITS METABOLISM. ROLE OF LIPOSOM IN POINT DELIVERY OF DRUGS. LIPID PEROXIDATION, ITS STAGES AND PHYSIOLOGICAL SIGNIFICANCE. ROLE OF ANTIOXIDANS, IT'S MEDICINES. | | 2 |
| 18 | BIOCHEMISTRY OF THE LIVER. THE ROLE OF THE LIVER IN THE METABOLISM. SYNTHESIS AND CATABOLISM OF HEME. DIRECT AND INDIRECT BILIRUBIN. BILIRUBIN METABOLIC DISTURBANCES. | | 2 |
| 19 | PHARMACEUTICAL BIOCHEMISTRY. ANTITOXIC FUNCTION OF THE LIVER. ENDOGENOUS AND EXOGENOUS XENOBIOTS. THE MECHANISM OF THEIR TOXIC ACTION. THE ROLE OF MICROSOMAL OXIDATION IN THE NEUTRALIZATION OF XENOBIOTS. WIDE AND NARROW SPECTRUM INDUCERS. INFLUENCE OF EXTERNAL FACTORS ON THE BIOTRANSFORMATION OF DRUGS. | | 2 |

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|---|---|---|---|
| | TOTAL (total - AH) | 26 | 12 |

**6.2.2. The thematic plan of laboratory practicums (*if this type of classes is stipulated in the curriculum*)**

| № | Name of laboratory practicums | Volume in AH | |
|---|---|---|---|
| | | 4 semester | 5 semester |
| 1 | Structure and properties of proteins. Protein folding. Proteins and amino acids as medicines. | 3 | |
| 2 | The structure of enzymes. The specificity of the action of enzymes. | 3 | |
| 3 | Enzymes. Vitamins as participants in enzymatic reactions. Vitamins and antivitamins as medicines. | 3 | |
| 4 | Properties of enzymes. Nonspecific regulation of enzymes. Specific regulation of enzyme activity. Enzyme inhibitors as medicines. | 3 | |
| 5 | Control on the topic "Structure, properties, functions of proteins and enzymes" | 3 | |
| 6 | Energy exchange. Tricarboxylic acid cycle. Violation of energy metabolism. Hypoxic and hypoenergetic state. | 3 | |
| 7 | Biological oxidation. Oxidative phosphorylation. Inhibitors and uncouplers as drugs. | 3 | |
| 8 | Control on the topic “Biological oxidation. Krebs cycle. Oxidative phosphorylation” | 3 | |
| 9 | Biochemistry of hormones. Hormones as drugs. | 3 | |
| 10 | Digestion of proteins. Diagnostic value of biochemical analysis of gastric contents. Drugs to correct of protein digestion processes. | 3 | |
| 11 | Transformations of amino acids in the body. Hereditary disorders of amino acid metabolism. Medications. | 3 | |
| 12 | End products of protein metabolism. Neutralization of ammonia. Violation of the synthesis and excretion of urea. | 3 | |
| 13 | Control on the topic "Protein and amino acid metabolism" | 3 | |
| 14 | Nucleic acids. Nucleotide metebolism and its disorders. Protein biosynthesis. Antibiotics as inhibitors of matrix biosynthesis. | 3 | |
| 15 | Control on the topic “Nucleic acid metebolism. Protein biosynthesis”. | 3 | |
| 16 | Digestion of carbohydrates. The main carbohydrates of the body. Glycogen: synthesis and breakdown. | 3 | |
| 17 | Glucose catabolism is glycolysis. Gluconeogenesis. | 3 | |
| 18 | Pentose phosphate pathway as an alternative pathway for glucose oxidation. Regulation of carbohydrate metabolism. | 3 | |
| 19 | Control on the topic "Carbohydrate metabolism". | 3 | |
| 20 | Final test | 3 | |
| 21 | The most important lipids in the body. Lipid digestion. Mobilization of triacylglycerols. | | 3 |
| 22 | Lipid transport. Atherogenic lipoproteins. Lipid anabolism. | | 3 |
| 23 | Lipid transformations in the body. Ketone bodies. | | 3 |
| 24 | Membrane metabolism. Lipid peroxidation. | | 3 |
| 25 | Control on the topic "Lipid metabolism" | | 3 |

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|---|---|---|---|
| 26 | Biochemistry of the liver. | | 3 |
| 27 | Antitoxic function of the liver. Pharmaceutical biochemistry. | | 3 |
| 28 | The role of the liver in the biotransformation of drugs. | | 3 |
| 29 | Biochemistry of connective and muscle tissue. | | 3 |
| 30 | Biochemistry of nervous tissue. | | 3 |
| 31 | Final test | | 2 |
| | TOTAL (total - AH) | 60 | 32 |

**6.2.3. Thematic plan of practicals** is not stipulated in the curriculum.

**6.2.4. Thematic plan of seminars** is not stipulated in the curriculum.

**6.2.5. Types and topics of student's individual work (SIW)**

| № | Types and topics of SIW | Volume in AH | |
|---|---|---|---|
| | | 4 semester | 5 semester |
| 1 | **The structure and function of proteins and amino acids.**<br>Preparations for practical exercises, current control and tests. To make abstracts on topics:<br>- Methods for isolation and purification of proteins.<br>- Amino acids and peptides as medicines. | 4 | |
| 2 | **Enzymes.**<br>Preparations for practical exercises, current control and tests.<br>To make abstracts on topics:<br>- Protein enzyme inhibitors. Enzyme inhibitors as drugs,<br>- Enzymes as drugs. | 10 | |
| 3 | **Introduction to metabolism. Biological oxidation. oxidative phosphorylation. Cycle of di- and tricarboxylic acids (Krebs cycle).**<br>Preparationd for practical exercises, current control and tests. To make abstracts on topics:<br>- Alimentary, non-alimentary and anti-alimentary food substances,<br>- Chemiosmotic theory of oxidative phosphorylation. Formation and use of electrochemical potential ($\Delta\mu H+$),<br>- Uncouplers of oxidative phosphorylation as drugs. | 8 | |
| 4 | **Hormones.**<br>Preparation for practical exercises, current control and tests. To make abstracts on topics:<br>- Target cells and cellular hormone receptors.<br>- Insulin, insulin receptor, insulin resistance.<br>- Eicosanoids as regulators of cellular functions. | 4 | |
| 5 | **Metabolism of proteins and amino acids.**<br>Preparation for practical exercises, current control and tests. To make abstracts on topics:<br>- The biological value of protein nutrition. Essential and non-essential amino acids. | 9 | |

| | | | |
|---|---|---|---|
| | - Protein nutrition and nitrogen balance.<br>- Exchange of sulfur-containing amino acids,<br>- Enzymopathies of amino acid metabolism. | | |
| 6 | **Nucleoprotein exchange.**<br>Protein synthesis. Preparation for practical exercises, current control and tests. To make abstracts on topics:<br>- Features of the exchange of purine nucleotides. Drugs used in the treatment of gout.<br>- The role of antibiotics in the regulation of protein synthesis in prokaryotes and eukaryotes/ | 5 | |
| 7 | **Biochemistry of blood.**<br>To make abstracts on topics:<br>- The role of albumin in the transport of drugs and the regulation of blood osmotic pressure.<br>- Proteins of the "acute phase" of inflammation. Metal ion transport proteins (transferrin, ceruloplasmin)<br>- Modern drugs derived from human plasma.<br>- Manufacture of blood products, biotechnology and use in medicine. | 6 | |
| 8 | **The exchange of carbohydrates.**<br>Preparation for practical exercises, current control and tests. To make abstracts on topics:<br>- The role of enzyme therapy in carbohydrate digestion disorders, modern drugs.<br>- Indigestible carbohydrates (dietary fiber) and sugar substitutes, their dosage forms.<br>- Principles of drug therapy in the treatment of type 1 and type 2 diabetes mellitus.<br>- Enzymopathies of carbohydrate metabolism and their correction with drugs. | 10 | |
| | **Final test** | 2 | |
| 9 | **Lipid metabolism.**<br>Preparation for practical exercises, current control and tests. To make | | 12 |

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APPROVED
Vice-Rector for Academic and
Educational Affairs
_____ E.S. Bogomolova
_____ 20___

**WORKING PROGRAM**

Name of the academic discipline: **BIOLOGICAL CHEMISTRY**

Specialty: **33.05.01 PHARMACY**

Qualification: **PHARMACIST**

Department: **BIOCHEMISTRY named after G.Ya. GORODISSKAYA**

Mode of study: **FULL-TIME**

Labor intensity of the academic discipline: **252 academic hours**

Nizhny Novgorod
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| | | | |
|---|---|---|---|
| | abstracts on topics: - Cholesterol derivatives as biologically active substances, - Use of statins in medicine, mechanism of action, side effects. -Pro- and antioxidants, their role in the regulation of free-radical processes occurring in body tissues. - Antioxidant drugs and requirements for their use. - The role of cardiac glycosides in the regulation of K +, Na + - ATPase. -β-oxidation of saturated and unsaturated fatty acids. Carnitine preparations in the regulation of this process. - Enzymopathies of lipid metabolism, the use of modern drugs in their correction. - Biochemical mechanism of action of steroid and non-steroidal anti-inflammatory drugs. | | |
| 10 | **Biochemistry of the liver**.<br>Preparation for practical exercises and programmed control. To make abstracts on topics:<br>- Exchange of iron. Hemoglobinopathies. Iron deficiency anemia. Modern drugs for the treatment of anemia.<br>- Importance of the liver in drug metabolism. | | 3 |
| 11 | **Pharmaceutical biochemistry.**<br>Preparation for practical exercises and programmed control.<br>To make abstracts on topics:<br>- Barbiturates as broad-spectrum inducers.<br>- Bioactivation of drugs in the human body. The concept of a prodrug.<br>- Cytochrome P450 family.<br>- Factors affecting the biotransformation of drugs. | | 4 |
| 12 | **Biochemistry of connective and muscle tissue.**<br>Preparation for practical exercises and programmed control.<br>To make abstracts on topics:<br>- Changes in the structure of collagen and elastin during pathological processes,<br>- Proteoglycans and glycosaminoglycans. Large pro-theoglycans. Small proteoglycans. Proteoglycans rich in leucine.<br>- Modern drugs-chondroprotectors.<br>- Drugs for the treatment of myopathies and pathologies of the heart. | | 2 |
| 13 | **Biochemistry of the nervous system.**<br>To make abstracts on topics:<br>- Brain peptides as drugs.<br>- Metabolism of biogenic amines in the brain. MAO inhibitors and their use as medicines. | | 3 |
| | **Final test** | | 4 |
| | TOTAL (total – 86 AH) | 58 | 28 |

**7. Types of assessment formats for ongoing monitoring and mid-term assessment**

| № | Semester No. | Types of control | Name of section of academic discipline | Competence codes | Assessment formats | | |
|---|---|---|---|---|---|---|---|
| | | | | | types | number of test questions | number of test task options |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | Monitoring the student's individual work | | | | | |
| 1. | 4 | Current monitoring | Control of mastering the topic | Structure and function of proteins and amino acids | GPC-1 GPC-2 | Test | 10 | 6 |
| 2. | 4 | Current monitoring | Control of mastering the topic | Enzymes | GPC-1 GPC-2 | Test | 10 | 6 |
| 3 | 4 | Current monitoring | Control of mastering the topic | Introduction to the metabolism. Biological oxidation. Oxidative phosphorylation. Cycle of di- and tricarboxylic acids. | GPC-1 GPC-2 | Program control | 2 | 6 |
| 4 | 4 | Current monitoring | Control of mastering the topic | Hormones | GPC-1 GPC-2 | Program control | 2 | 6 |
| 5 | 4 | Current monitoring | Control of mastering the topic | Metabolism of proteins and amino acids | GPC-1 GPC-2 | Program control | 2 | 6 |
| 6 | 4 | Current monitoring | Control of mastering the topic | Nucleoprotein metabolism. Protein synthesis. | GPC-1 GPC-2 | Program control | 2 | 6 |
| 7 | 4 | Current monitoring | Monitoring the student's individual work | Biochemistry of blood | GPC-1 GPC-2 | Questions on the exam | | |
| 8 | 4 | Current monitoring | Control of mastering the topic | Metabolism of carbohydrates. | GPC-1 GPC-2 | Program control | 2 | 6 |
| 9 | 4 | Final test | Control of mastering the semester | | GPC-1 GPC-2 | Test | 20 | Unlimited (when conducting computer testing) |
| 10 | 5 | Current monitoring | Control of mastering the topic | Metabolism of lipids. | GPC-1 GPC-2 | Program control | 2 | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | 5 | Current monitoring | Control of mastering the topic | Biochemistry of the liver. | GPC-1 GPC-2 | Program control | 3 | 5 |
| 12 | 5 | Current monitoring | Control of mastering the topic | Pharmaceutical biochemistry | GPC-1 GPC-2 | Test | 5 | 6 |
| 13 | 5 | Current monitoring | Control of mastering the topic | Biochemistry of connective and muscle tissue | GPC-1 GPC-2 | Test | 10 | 6 |
| 14 | 5 | Current monitoring | Control of mastering the topic | Biochemistry of the nervous system | GPC-1 GPC-2 | Test | 1 | 6 |
| 15 | 5 | Final test | Control of mastering the semester | | GPC-1 GPC-2 | Test | 20 | Unlimited (when conducting computer testing) |
| | 5 | Mid-term assessment | Exam | | GPC-1 GPC-2 | Questions | 2 | - |
| | | | | | | Case | 1 | - |

## 8. Educational, methodological and informational support for mastering the academic discipline (printed, electronic publications, the Internet and other network resources)

### 8.1. Key literature references

| № | Name according to bibliographic requirements | Number of copies | |
|---|---|---|---|
| | | at the department | in the library |
| 1 | Lippincott Illustrated Reviews: Biochemistry / E. E. Abali, S. D. Cline, D. S. Franklin, S. M. Viselli. – 8th ed. – Philadelphia : Wolters Kluwer, 2022. – XI, 625 p. | Electronic resource | 60 |
| 2 | Biochemistry with exercises and tasks : монография / b. ed, V. V. ; ed. by A. I. Glukhov ; V. V. Garin. – Москва : ГЭОТАР-Медиа, 2022. – 296 с. | Electronic resource | Electronic resource |
| 3 | Essential Biochemistry for Medical Students with Problem-Solving Exercises : учебник / A. I. Glukhov, A. E. Gubareva ; Glukhov A. I. ; Gubareva A. E. – Москва : ГЭОТАР-Медиа, 2020. – 584 p. | Electronic resource | Electronic resource |

### 8.2. Further reading

| № | Name according to bibliographic requirements | Number of copies | |
|---|---|---|---|
| | | at the department | in the library |
| 1 | Manual on **biochemistry**. Part 1 / compilers E. I. Erlykina, P. P. Zagoskin, L. M. Obukhova, E. I. Kuzmina, I. K. Lyalina, L. M. Anashkina, O. V. | Electronic resource | Electronic resource |

| | | | |
|---|---|---|---|
| | Barinova, A. B. Yazykova, V. P. Frantsuzova. – N. Novgorod : Изд-во ПИМУ, 2020. – 92 p. | | |
| 2 | Training material in biochemestry : Training material / E. Erlykina, A. A. Anashkina, O. V. Barinova [et al.] ; Erlykina, E. ; Zagoskin, P. P. ; Obukhova, L. ; Kuzmina, E. ; Lyalina, I. K. ; Barinova, O. V. ; Anashkina, A. A. ; Yazykova, A. B. ; Konovalova, E. V. ; Frantsuzova, V. P. – N. Novgorod : Publishing House of Privolzhskiy Research Medical University, 2019. | Electronic resource | Electronic resource |
| 3 | Kopytova, T. V. Biotransformation of xenobiotics and drugs : course book / T. V. Kopytova, E. I. **Erlykina**, V. I. Borisov ; FSBEI HE PRMU MOH Russia ; ed. by E. I. **Erlykina**. – N. Novgorod : Publishing House of Privolzhskiy Research Medical University, 2022. | Electronic resource | Electronic resource |

**8.3. Electronic educational resources for teaching academic subjects**

**8.3.1. Internal Electronic Library System of the University (IELSU)**

| № | *Name of the electronic resource* | *Brief description (content)* | *Access conditions* | *Number of users* |
|---|---|---|---|---|
| | Internal Electronic Library System of the University (IELSU) http://nbk.pimunn.net/MegaPro/Web | Proceedings of PIMU staff (textbooks, teaching aids, collections of tasks, methodological manuals, laboratory work, monographs, scientific articles, dissertations, abstracts of dissertations, patents, etc.) | Access by individual login and password from any computer and mobile device (on the platform of the PIMU Digital Library) | Unlimited |

**8.3.2. Electronic educational resources acquired by the University**

| № | *Name of the electronic resource* | *Brief description (content)* | *Access conditions* | *Number of users* |
|---|---|---|---|---|
| 1 | Database “Medicine. Healthcare and “Medicine. Healthcare" as part of the database "Electronic library of a technical university (ELS "Student Consultant"): https://www.studentlibrary.ru/ | Textbooks and teaching aids for higher medical and pharmaceutical education | from any computer and mobile device on the Internet, by password and login | Unlimited |
| 2 | DB “Doctor's Consultant. Electronic Medical Library» http://www.rosmedlib.ru/ | Scientific medical publications (national guidelines, clinical guidelines, monographs, etc.) | from any computer and mobile device on the Internet, by password and login | Unlimited |
| 3 | Electronic library system "BookUp" https://www.books-up.ru/ | Scientific and educational medical literature of Russian publishing houses, incl. translations of foreign publications | from any computer and mobile device on the Internet, by password and | Unlimited |

| | | | | |
|---|---|---|---|---|
| | | | login | |
| 4 | Integrated Information Library System (IBS) of the Scientific and Educational Medical Cluster of the Volga Federal District "Srednevolzhsky" https://pimunn.ru/lib#rec64131355 | Electronic copies of publications from the collections of libraries participating in the cluster (Medical Universities of Kazan, Perm, Izhevsk, Kirov; Ulyanovsk State University). | from any computer and mobile device on the Internet, by password and login | Unlimited |
| 5 | Electronic periodicals 1. on the eLIBRARY.RU platform: https://elibrary.ru/projects/subscription/rus_titles_open.asp 2. on the East View platform: https://dlib.eastview.com/browse | Domestic electronic periodicals on medicine and biology | 1. from any computer and mobile device located in the university network 2. from any computer and mobile device located on the Internet, using a password and login | Unlimited |

**8.3.3 Open access resources**

| № | *Name of the electronic resource* | *Brief description (content)* | *Access conditions* |
|---|---|---|---|
| 1 | Federal Electronic Medical Library (FEMB) http://feml.scsml.rssi.ru/feml | Full-text electronic copies of printed publications, and independent original electronic publications in medicine and biology | from any computer and mobile device located on the Internet |
| 2 | Scientific electronic library eLIBRARY.RU https://elibrary.ru/defaultx.asp | Russian information portal in the field of science, technology, medicine and education, containing abstracts and full texts of scientific publications, including electronic versions of Russian scientific journals. | from any computer and mobile device located on the Internet |
| 3 | Scientific electronic library of open access CyberLeninka https://cyberleninka.ru/about | Full texts of scientific articles with annotations published in scientific journals in Russia and neighboring countries | from any computer and mobile device located on the Internet |
| 4 | National Electronic Library https://neb.rf/ | Full-text electronic copies of works on a wide range of knowledge. | from any computer and mobile device located on the Internet |

## 9. Material and technical support for mastering an academic discipline

### 9.1. List of premises for classroom activities for the discipline

*1.* 7 equipped classrooms for conducting practical classes and seminars in the study of the discipline.

*2.* 2 specialized laboratories.

### 9.2. List of equipment for classroom activities for the discipline

Multimedia complex (laptop, projector, screen), TVs, printers, scanners, teaching boards, water baths, photoelectric colorimeters, laboratory centrifuges, thermostats, ionometers, spectrophotometers, urine analyzers, laboratory glassware, tripods, sets of appropriate reagents, weights, scales , tweezers, Petri dishes, flasks, test tubes, reagent bottles.

**9.3. A set of licensed and freely distributed software, including domestic production**

| Item no. | Software | number of licenses | Type of software | Manufacturer | Number in the unified register of Russian software | Contract No. and date |
|---|---|---|---|---|---|---|
| 1 | Wtware | 100 | Thin Client Operating System | Kovalev Andrey Alexandrovich | 1960 | 2471/05-18 from 28.05.2018 |
| 2 | MyOffice is Standard. A corporate user license for educational organizations, with no expiration date, with the right to receive updates for 1 year. | 220 | Office Application | LLC "NEW CLOUD TECHNOLOGIES" | 283 | without limitation, with the right to receive updates for 1 year. |
| 3 | LibreOffice | | Office Application | The Document Foundation | Freely distributed software | |
| 4 | Windows 10 Education | 700 | Operating systems | Microsoft | Azure Dev Tools for Teaching Subscription | |
| 5 | Yandex. Browser | | Browser | «Yandex» | 3722 | |
| 6 | Subscription to MS Office Pro for 170 PCs for FGBOU VO "PIMU" of the Ministry of Health of Russia | 170 | Office Application | Microsoft | | 23618/HN10030 LLC "Softline Trade" from 04.12.2020 |

**10. List of changes to the working program (to be filled out by the template)**

Federal State Budgetary Educational Institution of Higher Education
"Privolzhsky Research Medical University"
Ministry of Health of the Russian Federation
(FSBEI HE "PRMU" of the Ministry of Health of Russia)

Department of
*Name of the department*

**CHANGE REGISTRATION SHEET**

working program for the academic discipline
***NAME OF THE ACADEMIC DISCIPLINE***

Field of study / specialty / scientific specialty: _____
*(code, name)*

Training profile: _____
(*name) - for master's degree programs*

Mode of study: _____
*full-time/mixed attendance mode/extramural*

| Position | Number and name of the program section | Contents of the changes made | Effective date of the changes | Contributor's signature |
|---|---|---|---|---|
| 1 | | | | |

Approved at the department meeting
Protocol No. _____of _____20__

Head of the Department
_____ _____/_____
department name, academic title signature print name