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Ф-рабочая программа по дисциплине		

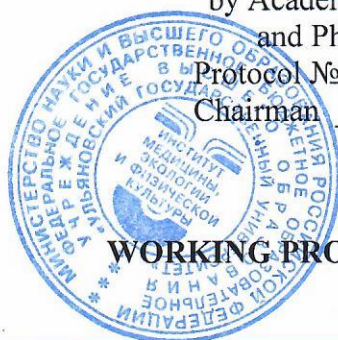
APPROVED

by Academic Council of Institute of Medicine, Ecology
and Physical Culture of Ulyanovsk State University

Protocol № 9/239 from «18» 05 2022.

Chairman /V.I. Midlenko/

(signature)



WORKING PROGRAM

Subject:	<u>Biological Chemistry</u>
Department:	<u>General and Biological Chemistry</u>

Speciality: 31.05.01 "General Medicine"
(код специальности (направления), полное наименование)

Qualification – specialist, term of training-6 years, form of training-full-time.

The date of implementation of the program:

«1» 09 2022 yr.



The program updated at the meeting of the department: protocol № _____ from _____ 20____ yr.


The program updated at the meeting of the department: protocol № _____ from _____ 20____ yr.

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Information about the developers:

Name	Department	Academic degree, academic title
Edward Sh. Yenikejev	General and Biological Chemistry	Cand.Biol.Sci., Associate professor

APPROVED	APPROVED
Head of the Department, realizing discipline	Head of the graduating department
 /Shroll O.Y./	 /Vise-Khripunova M.A./
Signature Name	Signature Name
« » 2022	« » 2022

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1. AIMS AND OBJECTIVES OF THE DISCIPLINE.

The purpose of mastering the discipline "Biological chemistry" is the formation of systemic knowledge of the chemical composition and molecular processes of the human body as the characteristics of its normal and pathological state. It is necessary for the study of subsequent disciplines and in the professional activities of future medics. The main objective of the discipline is to form a biochemical approach in assessing the parameters of all body systems in normal and pathological conditions, as well as their interaction with the environment.

2. PLACE OF DISCIPLINE IN MAIN PROFESSIONAL EDUCATION PROGRAM.


The discipline "Biological Chemistry" refers to the basic part of main professional education program of speciality.

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

- readiness to use basic physico-chemical, mathematical and other natural-scientific concepts and methods in solving professional problems (GPC-7);
- ability to assess morphofunctional, physiological States and pathological processes in the human body in solving professional problems (GPC-9).

3. LIST OF EXPECTED RESULTS OF TRAINING OF THE SUBJECT (MODULES), CORRELATED WITH THE EXPECTED RESULTS OF THE PROGRAM

Code and name of the implemented competence	The list of planned learning outcomes of subjects (modules), correlated with indicators of achievement of competencies
GPC – 7 Readiness to use basic physical, chemical, mathematical and other natural science concepts and methods in solving professional problems	To know: <ul style="list-style-type: none"> -basic concepts, laws, and modern scientific theories of biological chemistry; -structure and functions of biologically active substances in living systems; -metabolism at the level of metabolism of the main substrates and biosynthesis of compounds necessary for the body; - To be able to:

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	<ul style="list-style-type: none"> -use the acquired knowledge to solve situational problems; -evaluate the course of biochemical processes in living systems, based on theoretical provisions; <p>- To possess:</p> <ul style="list-style-type: none"> - the ability to work independently with educational, scientific and reference literature on the subject; - the ability to search for the necessary information and make generalizing conclusions;
<p>GPS – 9</p> <p>The ability to assess morphofunctional, physiological States and pathological processes in the human body for solving professional tasks.</p>	<p>To know:</p> <ul style="list-style-type: none"> - features of the course of biochemical processes in the body; -principles of metabolism regulation in living systems; -ways of exchanging matter and energy with the environment; - methods of biochemical analysis; <p>To be able to:</p> <ul style="list-style-type: none"> - conduct biochemical studies to resolve the issue of the normal or pathological state of metabolism; - present experimental data in the form of graphs and tables; <p>To possess:</p> <ul style="list-style-type: none"> - skills of safe work in the biochemical laboratory and handling of chemical utensils, reagents, working with gas burners and necessary electrical devices and analytical systems.

Volume of the discipline is 7 credit units (252 hours.)

4.VOLUME OF THE DISCIPLINE.

4.1. Volume of the discipline and types of educational work:

Type of educational work	Number of hours (form of training-full-time)		
	Total	By semester	
		2	3
Classroom lessons:	126	63	63
Lectures	36	18	18


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Practical works	90	36	54
Self - study	90	36	54
Type of certification (exam)			36
Total volume of the discipline	252	90	162


4.2. Distribution of hours by topics and types of educational work:

Form of training-full-time

Title of sections and topics	Total	Types of educational work			
		Classroom lessons			Self - study
		Lectures	Classes	Practical work	
Section 1. Static biochemistry					
1. Proteins (part 1).	5	1	1	1	2
2. Proteins (part 2).	5	1	1	1	2
3. Enzymes (part 1).	6	1	2	1	2
4. Enzymes (part 2).	6	1	2	1	2
5. Structure and functions of nucleic acids (part 1).	4	1	1		2
6. Structure and functions of nucleic acids (part 2).	5	1	1	1	2
7. Replication of DNA.	7	2	2	1	2
8. Transcription of DNA.	6	2	2		2
9. Translation: protein biosynthesis.	7	2	2	1	2
10. Mutations and DNA repair system.	5	1	1	1	2
11. Structure and functions of biological membrane.	5	1	1	1	2
12. Membrane	3	1			2

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transport.					
13. Respiration chain and ATP synthesis.	4	2			2
Section 2. Dynamic biochemistry.					
1. Introduction to metabolism.	7	1	1	1	4
2. Metabolism of carbohydrates (part 1).	9	1	1	1	5
3. Metabolism of carbohydrates (part 2).	9	1	2	1	5
4. Lipid metabolism.	10	2	2	1	5
5. Metabolism of proteins.	9	2	1	1	5
6. Metabolism of nucleotides (part 1).	8	1	2	1	4
7. Metabolism of nucleotides (part 2).	8	1	2	1	4
Section 3. Functional biochemistry.					
1. Hormones.	9	2	1	1	4
2. Hormonal regulation of metabolism of proteins, carbohydrates and fats.	9	1	2	1	5
3. Endocrine regulation of calcium and phosphate homeostasis.	9	2	2	1	5
4. Thyroid hormones, prostaglandins and steroid hormones.	9	1	2	1	5
5. Biochemistry of blood and liver.	9	2	2	1	5
6. Biochemistry of muscle and nervous system.	9	2	2	1	4
7. Biochemistry of extracellular matrix.	9	2	2	1	4
Total	216	36	58	32	90

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5. THE CONTENT OF THE DISCIPLINE.

1. **Proteins: molecular structure, functions.**

Biomedical significance of amino acids and peptides. Classification and nomenclature of peptides. Biomedical significance of proteins. Classification of proteins. The orders of protein structure. Forces stabilizing protein structures: weak and strong bonds. Properties of proteins. Isoelectric point of protein. Methods of protein separation. Protein functions in the body.

2. **Enzymes – general properties, kinetics.**

Biomedical importance of enzymes. Classification and nomenclature of enzymes. Coenzymes and prosthetic groups. Biochemical catalysis. The concept of transition state. Specificity of enzymes. Isoenzymes: properties and clinical significance. Functional and nonfunctional plasma enzymes. The rate of enzymatic reaction. The kinetics of enzymatic catalysis. Active site and allosteric site: structure and significance. Inhibition of enzymatic reaction: competitive and noncompetitive inhibitors. Enzyme poisons.

3. **Enzymes – mechanism of action, regulation of activities.**


Significance of metal ions in substrate binding and in catalysis. Metalloenzymes and metal-activated enzymes. Regulation of enzyme quantity. Compartmentation of enzymes. Constitutive and induced enzymes. Allosteric effectors. Feedback inhibition and feedback regulation. Covalent modifications of enzymatic activity.

4. **Nucleic acids and protein biosynthesis.**

Structure, function and replication of informational macromolecules. Significance of phosphorylated nucleosides. Metabolism of purine and pyrimidine nucleotides. Organization and replication of DNA. Classes of RNA. Synthesis, processing and modification of RNA. Features of the genetic code. Genetic mutations and their consequences. Protein biosynthesis: initiation, elongation and termination. Posttranslational modifications.

5. **Biologic oxidation. The citric acid cycle. The respiratory chain.**

Biomedical importance of the energy production and storage in the cell. Reactions of the citric acid cycle. Regulation and energy balance of the citric acid cycle. Characterization of oxidoreductases. Free radical reactions. Reactive oxygen species. The respiratory chain members. Inhibitors of the respiratory chain. Uncouplers. Oxidative phosphorylation.

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6. Overview of glucose metabolism.

Absorptive and postabsorptive state. Transport of glucose to the cell. Insulin-independent and insulin-independent tissues. Role of the liver, adipose tissue, erythrocytes, muscle and kidney in glucose metabolism. Hyperglycemia, hypoglycemia and glucosuria. Biochemical symptoms of diabetes mellitus.

7. Metabolism of glucose.

Synthesis of glucose: gluconeogenesis. Gluconeogenic substrates. The Cori cycle. The alanine-glucose cycle. Metabolic and hormonal regulation of gluconeogenesis. Control of blood glucose in well-fed state and in starvation. Glucose oxidation: glycolysis. Metabolic and hormonal regulation of glycolysis. Significance of glycolysis in aerobic and anaerobic conditions. Decarboxylation of pyruvate and its regulation.

8. Carbohydrates of physiologic significance. Metabolism of glycogen.

Classification of dietary carbohydrates. Glucose as the most important monosaccharide. Digestion of dietary saccharides. Absorption of monosaccharides. Synthesis of glycogen: glycogenesis. Degradation of glycogen: glycogenolysis.

9. The pentose phosphate pathway. Other pathways of hexose metabolism.

Physiologic significance of the pentose phosphate pathway. Reactions of the pentose phosphate pathway and their regulation. NADPH generation in the pentose phosphate pathway. The uronic acid pathway and its significance. Metabolism of fructose. Metabolism of galactose.

10. Lipids of physiologic significance. Lipid digestion and absorption.


Classification of lipids. Dietary lipids and their physiologic significance. Lipid digestion. Pancreatic lipase and other lipases. Emulsification and formation of mixed micelles. Role of bile salts in lipid digestion and absorption. Monoacylglycerol pathway.

11. Lipid transport and storage. Lipoproteins.

Classification and structure of lipoproteins. Metabolism of chylomicrons and VLDLs. Role of the liver and the adipose tissue in lipoprotein metabolism. Intravascular and intracellular lipolysis. Hepatic conversion of glucose to lipids. Down-regulation of LDL-receptor. Reverse cholesterol transport.

12. Metabolism of fatty acids.

Synthesis of fatty acids: lipogenesis. Regulation of lipogenesis. Oxidation of fatty acids: β -oxidation and its regulation. Ketogenesis. Ketonemia and ketonuria. Ketoacidosis.

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13. Overview of fatty acid metabolism.

Role of the adipose tissue in lipid metabolism. The synthesis of triacylglycerols and its regulation. Metabolism of fatty acids in the well-fed state and in starvation. Metabolism of acylglycerols and phospholipids.

14. Metabolism of cholesterol and bile acids.

Dietary sources of cholesterol. Regulation of cholesterol absorption. Biosynthesis of cholesterol and its regulation. Role of the liver in cholesterol metabolism. Catabolism of cholesterol. Primary and secondary bile acids. Enterohepatic circulation of bile acids.

15. Dietary proteins. Protein digestion and absorption.

Biological value of protein. Nitrogen balance. Digestion of dietary proteins. Production and secretion of HCl. Proteolytic enzymes: endopeptidases and exopeptidases. Zymogens – mechanism of activation. Absorption of amino acids.

16. Catabolism of the carbon skeletons of amino acids.

Biochemical pathways of catabolism of particular amino acids. Conversion of amino acids to substrates of carbohydrate and lipid metabolism. Metabolic disorders of amino acid catabolism.

17. Catabolism of amino acid nitrogen.

Deaminations, deamidations and transaminations. Formation of ammonia in the body: reactions and tissue localization. Cellular mechanisms of ammonia detoxification. The urea cycle. Metabolic disorders of the urea cycle. The alanine-glucose cycle.

18. Biosynthesis of the nutritionally nonessential amino acids. Conversion of amino acids to specialized products.


Nutritionally essential and nonessential amino acids. Biomedical importance of nonessential amino acids. Biosynthetic pathways of nonessential amino acids. Specialized products of amino acid metabolism.

19. Hormonal regulation of carbohydrate, protein and lipid metabolism. Insulin and glucagon.

Insulin: molecular structure, synthesis, secretion and biodegradation. Metabolic and hormonal regulation of insulin secretion. Glucagon: structure, synthesis and secretion. Physiologic activity of insulin and glucagon.

20. Acid – base balance.

Buffers of physiologic significance. Partial pressure of carbon dioxide. Respiratory regulation of acid-base balance. Renal regulation of acid-base balance. Recovery

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of filtered bicarbonate. Generation of new bicarbonate. Ammoniogenesis in the kidney. Quantitation of acid excretion. Plasma potassium concentration. Acid-base disturbances.

21. **Steroid hormones.**

Cholesterol as a precursor of steroid hormones. Classification of steroid hormones. Synthesis of steroid hormones in adrenal cortex and in gonads. Metabolic activity of steroid hormones.

22. **Plasma proteins. Immunoglobulins.**

Biomedical importance of plasma proteins. Classification and functions of plasma proteins. Specific and nonspecific transporters. Oncotic pressure in physiology and pathology. Acute phase proteins. Immunoglobulins: classification, structure, properties and functions.

23. **Porphyryns and bile pigments. Metabolism of iron.**

Biosynthesis of porphyrins. Hemoproteins. Synthesis of heme. Degradation of heme –bilirubin. Hepatic and intestinal metabolism of bilirubin. Stercobilinogen and urobilinogen. Hyperbilirubinemias. Dietary sources of iron. Iron absorption and its transport in plasma. Transferrin, ferritin and total iron binding capacity.

24. **Biochemistry of the liver.**

Central role of the liver in protein, carbohydrate and lipid metabolism. Hepatic detoxifications. Metabolism of xenobiotics in the liver.


25. **The vitamins.**

Classification of vitamins. Water-soluble and lipid-soluble vitamins. Metabolism of vitamins. Metabolic disorders caused by vitamin deficiency. Toxic effects of vitamins.

6. THEMES AND QUESTIONS FOR PREPARING TO CLASSES.

PROTEINS.

1. Amino acids as monomers of proteins.
2. Peptide bond: formation and features.
3. Proteins as biologically active molecules: functions and classification.
4. Primary structure of proteins.
5. Secondary structure of proteins (types and stabilizing factors).
6. Tertiary structure of proteins: principle of formation and stabilizing factors.

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7. Quaternary structure of proteins.
8. Denaturation and renaturation of proteins.
9. Methods of isolation, separation and purification of proteins.

ENZYMES.

1. Classification of enzymes.
2. Principles of action of enzymes.
3. Coenzymes and cofactors.
4. Specificity of enzymes.
5. The influence of temperature and pH on enzyme activity.
6. The influence of substrate concentration on the rate of enzymic reaction.
Michaelis – Menten equation.
7. Nonspecific inhibition of enzyme activity.
8. Specific inhibition: competitive, uncompetitive and noncompetitive.
9. Allosteric enzymes: mechanism of action.

STRUCTURE AND FUNCTIONS OF NUCLEIC ACIDS.


1. Components and classification of nucleic acids.
2. Primary structure of nucleic acids.
3. Secondary structure of DNA.
4. Tertiary and quaternary structure of DNA.
5. Secondary and tertiary structure of RNA.
6. Denaturation and renaturation of nucleic acids.
7. Hybridization of nucleic acids.

REPLICATION OF DNA.

1. General principles of replication.
2. Enzymes of replication.
3. Initiation of replication.
4. Elongation of replication.
5. Termination of replication.
6. Replication of plasmid DNA and genetic information of viruses.

TRANSCRIPTION OF DNA.

1. General principles of transcription (enzymes, matrix, substrates).
2. Initiation of transcription.

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3. Elongation of transcription.
4. Termination of transcription.
5. Post – transcriptional modification.

TRANSLATION (PROTEIN SYNTHESIS).

1. Genetic code and its features.
2. Initiation of translation.
3. Elongation of translation.
4. Termination of translation.
5. Post – translational modification.

OPERON STRUCTURE.

1. General structure of operon.
2. Structure and functions of promoter.
3. Structure and functions of operator.
4. Negative inducible and negative repressible operons.
5. Positive inducible and positive repressible operons.

MUTATIONS & DNA REPAIR SYSTEM.


1. Classification of mutations.
2. Mutagenic factors.
3. Enzymes of DNA repair system.
4. Mechanisms of DNA repair.
5. Spontaneous mutations.

STRUCTURE & FUNCTIONS OF CELL MEMBRANE.

1. Components of cell membrane.
2. Functions of cell membrane.
3. Model of elementary membrane.
4. Model of globular subunits.
5. Model of Sanger and Nicolson.
6. Features of cell membranes.

MEMBRANE TRANSPORT.

1. Classification of membrane transport processes.
2. Passive transport: kinds of transporters, kinds of transport systems.
3. Active transport.

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4. Endocytosis and exocytosis.

RESPIRATION CHAIN AND SYNTHESIS OF ATP.

1. Methods of obtaining and storing energy in cells.
2. Energy transporters.
3. Methods of synthesis of ATP.
4. Respiration chain and its components.
5. Coupling of respiration and synthesis of ATP: Mitchell hypothesis.
6. Uncoupling of respiration and synthesis of ATP.

METABOLISM OF CARBOHYDRATES. PART 1.

1. Digestion and absorption of carbohydrates in gastrointestinal tract.
2. Mechanisms of blood glucose uptake, kinds of porters (GLUT1, GLUT2, etc).
3. Pathways of glucose metabolism in cells.
4. Glycolysis: the sequence of reactions, enzymes, regulation.
5. Energy balance of glycolysis in aerobic and anaerobic conditions.

METABOLISM OF CARBOHYDRATES. PART 2.


1. Gluconeogenesis: reactions, enzymes, regulation, significance.
2. Metabolism of glycogen: glycogenesis and glycogenolysis.
3. Pentose phosphate pathway: metabolic reactions, metabolic significance.
4. Disorders of carbohydrates metabolism (diabetes, glycogen storage diseases, etc.).

TRICARBOXYLIC ACID CYCLE.

1. Oxydative decarboxylation of pyruvate. Pyruvate dehydrogenase complex, reactions, coenzymes.
2. Tricarboxylic acid cycle: reactions, regulation.
3. Energetics of TCA cycle.
4. Anaplerotic pathways of TCA cycle.

METABOLISM OF PROTEINS.

1. Digestion of proteins and absorption of amino acids in gastrointestinal tract.
2. General principles of catabolism of amino acids in cells.
3. Urea cycle in liver cells: reactions, enzymes, significance.

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4. General principles of biosynthesis of amino acids.
5. Disorders of metabolism of proteins and amino acids: disturbances of utilization, absorption and renal reabsorption.

LIPID METABOLISM.

1. Digestion and absorption of lipids in gastrointestinal tract. Lipoproteins.
2. B-oxidation of fatty acids (saturated and unsaturated, with an even and odd numbers of carbon atoms).
3. Synthesis of ketone bodies in liver.
4. Biosynthesis of fatty acids: enzyme complex, sequence of reactions.
5. Disorders of lipid metabolism: hypo- and hyperlipoproteinemia, atherosclerosis.

METABOLISM OF NUCLEOTIDES. PART 1.

1. Digestion and absorption of nucleotides in gastrointestinal tract.
2. Catabolism of purine nucleotides.
3. Catabolism of pyrimidine nucleotides.

METABOLISM OF NUCLEOTIDES. PART 2.


1. Biosynthesis of purine nucleotides.
2. Biosynthesis of pyrimidine nucleotides.
3. Disorders of metabolism of nucleotides.

HORMONES.

1. Classification of hormones.
2. Action of hormones with intracellular receptors.
3. Action of hormones with membrane receptors via adenylyl cyclase system.
4. Action of hormones with membrane receptors via guanylyl cyclase system.
5. Action of hormones via phosphatidylinositol system.
6. Calcium as a mediator of hormone action.

HORMONAL REGULATION OF METABOLISM OF PROTEINS, CARBOHYDRATES AND FATS.

1. Mechanism of action of insulin.

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2. Hormonal regulation of metabolism of carbohydrates.
3. Hormonal regulation of metabolism of proteins and amino acids.
4. Hormonal regulation of β -oxidation and biosynthesis of fatty acids.

HORMONAL REGULATION OF WATER – SALT BALANCE.

1. General principles of osmoregulation. Salt balance and water balance.
2. The role of kidneys in regulation of water-salt balance in the human body.
3. The renin – angiotensin – aldosterone system of long – term regulation of blood pressure and extracellular volume in the body.
4. Disturbances of water – salt balance. Urinary tract stone disease.

ENDOCRINE REGULATION OF CALCIUM AND PHOSPHATE HOMEOSTASIS.


1. Homeostatic pathways of calcium and phosphorus.
2. Hormonal and nonhormonal mechanisms of regulation of plasma calcium and phosphate concentrations.
3. Disturbances of homeostasis of calcium and phosphate in the human body.

THYROID HORMONES, PROSTAGLANDINS AND STEROID HORMONES.

1. Biosynthesis, secretion and transport of thyroid hormones.
2. Mechanism of action and biochemical effects of thyroid hormones.
3. Hypo- and hyperfunction of thyroid gland.
4. Synthesis and regulation of synthesis of prostaglandins.
5. Biosynthesis and function of steroids and steroid hormones.

BIOCHEMISTRY OF BLOOD AND LIVER.

1. Functions of blood. Components of normal blood.
2. Plasma proteins and its functions.
3. Blood clotting.
4. Metabolism of iron in human body.
5. Disorders of blood clotting.

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6. Steps of detoxication: chemical modification and conjugation.
7. Microsomal oxidation of xenobiotics: the role of cytochrome P₄₅₀.

BIOCHEMISTRY OF MUSCLE AND NERVOUS TISSUE.


1. Muscle structure. General characteristics of muscle proteins.
2. Energy sources and molecular event in muscle contraction.
3. Structure and biochemical features of a Neurone.
4. Action potential.
5. Transmission of Nerve Impulse for one neuron to other.
6. Transmission of an Impulse from the nerves to a skeletal muscle.
7. Disorders of metabolism of the nerve tissue.

BIOCHEMISTRY OF EXTRACELLULAR MATRIX.

1. Collagen: structure, types and functions.
2. Structure and functions of elastin.
3. Glycoproteins, proteoglycans, glycosaminoglycans.
4. Deceases of connective tissue.

7. PRACTICAL PART (LABORATORY WORKS).

№	Topic and content of laboratory classes
1	Quantitative assay of proteins by the biuret method.
2	Color reactions for amino acids and proteins. Properties of proteins
3	Assay of termolability of salivary amylase
4	Assay of influence of pH on activity of amylase.
5	Assay of influence of activators and inhibitors of amylase activity in saliva
6	Determination of lactate dehydrogenase activity in different tissues.
7	Determination of alpha-amylase activity in blood serum and urine by Caraway's method.
8	Qualitative assay of hydrolysis products of baker's yeast.
9	Qualitative reactions on vitamins.
10	Quantitative determination of ascorbic acid in urine.
11	Quantitative determination of ascorbic acid in various foodstuffs.
12	Quantitative determination of vitamin P in the different sorts of tea.

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13	Quantitative determination of glucose concentration in blood serum by o-toluidine method.
14	Quantitative determination of pyruvate (pyruvic acid) in biological fluids.
15	Detection of sialic acids in blood serum.
16	Qualitative assay of lactose in milk (reaction of Fehling).
17	Qualitative assay of uric acid.
18	Quantitative definition of chlorides in blood serum by Rushnyak's method.
19	Determination of alpha-amylase activity in blood serum by Caraway's method.
20	Determination of calcium in blood serum.
21	Assay of insulin and adrenalin (epinephrine).
22	Qualitative assay of bile acids.
23	Estimation of total serum bilirubin.
24	Estimation of total serum lipids.

8. SUBJECTS OF COURSE PAPERS, CONTROL WORKS, ABSTRACTS


This type of work does not provide by the program.

9. QUESTIONS TO THE EXAM OF BIOCHEMISTRY.


1. Amino acids as monomers of proteins.
2. Peptide bond: formation and features.
3. Proteins as biologically active molecules: functions and classification.
4. Primary structure of proteins.
5. Secondary structure of proteins (types and stabilizing factors).
6. Tertiary structure of proteins: principle of formation and stabilizing factors.
7. Quaternary structure of proteins.
8. Denaturation and renaturation of proteins.
9. Methods of isolation, separation and purification of proteins.
10. Classification of enzymes.
11. Principles of action of enzymes.
12. Coenzymes and cofactors.
13. Specificity of enzymes.

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14. The influence of temperature and pH on enzyme activity.
15. The influence of substrate concentration on the rate of enzymic reaction.
Michaelis – Menten equation.
16. Nonspecific inhibition of enzyme activity.
17. Specific inhibition: competitive, uncompetitive and noncompetitive.
18. Allosteric enzymes: mechanism of action.
19. Components and classification of nucleic acids.
20. Primary structure of nucleic acids.
21. Secondary structure of DNA.
22. Tertiary and quaternary structure of DNA.
23. Secondary and tertiary structure of RNA.
24. Denaturation and renativation of nucleic acids.
25. Hybridization of nucleic acids.
26. General principles of replication.
27. Enzymes of replication.
28. Initiation of replication.
29. Elongation of replication.
30. Termination of replication.
31. Replication of plasmid DNA and genetic information of viruses.
32. General principles of transcription (enzymes, matrix, substrates).
33. Initiation of transcription.
34. Elongation of transcription.
35. Termination of transcription.
36. Post – transcriptional modification.
37. Genetic code and its features.
38. Initiation of transcription.
39. Elongation of translation.
40. Termination of translation.

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41. Post – translational modification.
42. General structure of operon.
43. Structure and functions of promoter.
44. Structure and function of operator.
45. Negative inducible and negative repressible operons.
46. Positive inducible and positive repressible operons.
47. Classification of mutations.
48. Mutagenic factors.
49. Enzymes of DNA repair system.
50. Mechanisms of DNA repair.
51. Spontaneous mutations.
52. Components of cell membrane.
53. Functions of cell membrane.
54. Model of elementary membrane.
55. Model of globular subunits.
56. Model of Sanger and Nicolson.
57. Features of cell membranes.
58. Classification of membrane transport processes.
59. Passive transport: kinds of transporters, kinds of transport systems.
60. Active transport.
61. Endocytosis and exocytosis.
62. Methods of obtaining and storing energy in cells.
63. Energy transporters.
64. Methods of synthesis of ATP.
65. Respiration chain and its components.
66. Coupling of respiration and synthesis of ATP: Mitchell hypothesis.
67. Uncoupling of respiration and synthesis of ATP.
68. Digestion and absorption of carbohydrates in gastrointestinal tract.

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69. Mechanisms of blood glucose uptake, kinds of porters (GLUT1, GLUT2, etc).
70. Pathways of glucose metabolism in cells.
71. Glycolysis: the sequence of reactions, enzymes, regulation.
72. Energy balance of glycolysis in aerobic and anaerobic conditions.
73. Gluconeogenesis: reactions, enzymes, regulation, significance.
74. Metabolism of glycogen: glycogenesis and glycogenolysis.
75. Pentose phosphate pathway: metabolic reactions, metabolic significance.
76. Disorders of carbohydrates metabolism (diabetes, glycogen storage diseases, etc.).
77. Oxidative decarboxylation of pyruvate. Pyruvate dehydrogenase complex, reactions, coenzymes.
78. Tricarboxylic acid cycle: reactions, regulation.
79. Energetics of TCA cycle.
80. Anaplerotic pathways of TCA cycle.
81. Digestion of proteins and absorption of amino acids in gastrointestinal tract.
82. General principles of catabolism of amino acids in cells.
83. Urea cycle in liver cells: reactions, enzymes, significance.
84. General principles of biosynthesis of amino acids.
85. Disorders of metabolism of proteins and amino acids: disturbances of utilization, absorption and renal reabsorption.
86. Digestion and absorption of lipids in gastrointestinal tract. Lipoproteins.
87. β – oxidation of fatty acids (saturated and unsaturated, with an even and odd numbers of carbon atoms).
88. Synthesis of ketone bodies in liver.
89. Biosynthesis of fatty acids: enzyme complex, sequence of reactions.
90. Disorders of lipid metabolism: hypo- and hyperlipoproteinemia, atherosclerosis.

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91. Digestion and absorption of nucleotides in gastrointestinal tract.
92. Catabolism of purine nucleotides.
93. Catabolism of pyrimidine nucleotides.
94. Biosynthesis of purine nucleotides.
95. Biosynthesis of pyrimidine nucleotides.
96. Disorders of metabolism of nucleotides.
97. Classification of hormones.
98. Action of hormones with intracellular receptors.
99. Action of hormones with membrane receptors via adenylyl cyclase system.
100. Action of hormones with membrane receptors via guanylyl cyclase system.
101. Action of hormones via phosphatidylinositol system.
102. Calcium as a mediator of hormone action.
103. Mechanism of action of insulin.
104. Hormonal regulation of metabolism of carbohydrates.
105. Hormonal regulation of metabolism of proteins and amino acids.
106. Hormonal regulation of β – oxidation and biosynthesis of fatty acids.
107. General principles of osmoregulation. Salt balance and water balance.
108. The role of kidneys in regulation of water – salt balance in the human body.
109. The renin – angiotensin – aldosterone system of long – term regulation of blood pressure and extracellular volume in the body.
110. Disturbances of water – salt balance. Urinary tract stone disease.
111. Homeostatic pathways of calcium and phosphorus.
112. Hormonal and nonhormonal mechanisms of regulation of plasma calcium and phosphate concentrations.
113. Disturbances of homeostasis of calcium and phosphate in the human body.

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114. Biosynthesis, secretion and transport of thyroid hormones.
115. Mechanism of action and biochemical effects of thyroid hormones.
116. Hypo – and hyperfunction of thyroid gland.
117. Synthesis and regulation of synthesis of prostaglandins.
118. Biosynthesis and function of steroids and steroid hormones.
119. Functions of blood. Components of normal blood.
120. Plasma proteins and its functions.
121. Blood clotting.
122. Metabolism of iron in human body.
123. Disorders of blood clotting.
124. Steps of detoxication: chemical modification and conjugation.
125. Microsomal oxidation of xenobiotics: the role of cytochrome P450.
126. Muscle structure. General characteristics of muscle proteins.
127. Energy sources and molecular event in muscle contraction.
128. Structure and biochemical features of a Neurone.
129. Action potential.
130. Transmission of Nerve Impulse for one neuron to other.
131. Transmission of an Impulse from the nerves to a skeletal muscle.
132. Disorders of metabolism of the nerve tissue.
133. Collagen: structure, types and functions.
134. Structure and functions of elastin.
135. Glycoproteins, proteoglycans, glycosaminoglycans.
136. Diseases of connective tissue.

10. SELF-STUDY WORK OF STUDENTS:


№	The name of the section	Content of self – study work	Number of hours	Type of checking

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1	The subject, objectives and history of development of biochemistry. Structure, properties and functions of proteins (part 1).	Theoretical training for practical work	1	Additional questions on the exam
2	Structure, properties and functions of proteins (part 2).	Theoretical training for practical work	1	Additional questions on the exam
3	Enzymes, classification, structure, properties, functions and mechanism of action, specificity (part 1).	Theoretical training for practical work	1	Additional questions on the exam
4	Enzymes: coenzymes and cofactors, action of temperature and pH, inhibition (part 2).	Theoretical training for practical work	2	Additional questions on the exam
5	The structure of nucleic acids (part 1).	Theoretical training for practical work	1	Additional questions on the exam
6	Structure of nucleic acids (part 2).	Theoretical training for practical work	1	Additional questions on the exam
7	DNA replication.	Theoretical training for practical work	2	Additional questions on the exam
8	Transcription: RNA synthesis	Theoretical training for practical work	2	Additional questions on the exam
9	Protein biosynthesis (translation)	Theoretical training for practical work	1	Additional questions on the exam
10	Regulation of protein biosynthesis and gene expression. The operon hypothesis.	Theoretical training for practical work	2	Additional questions on the exam
11	Mutations and repair system.	Theoretical training for practical work	1	Additional questions on the exam
12	Immunity and antibodies. Blood groups, blood transfusion rules.	Theoretical training for practical work	1	Additional questions on the exam

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13	Structure and functions of biological membranes. Transport of substances through the membrane.	Theoretical training for practical work	1	Additional questions on the exam
14	Energy metabolism.	Theoretical training for practical work	1	Additional questions on the exam
15	Introduction to metabolism	Theoretical training for practical work	4	Additional questions on the exam
16	Common pathway of catabolism	Theoretical training for practical work	4	Additional questions on the exam
17	Carbohydrate metabolism and function. Glycolysis.	Theoretical training for practical work	4	Additional questions on the exam
18	Gluconeogenesis. Biosynthesis and breakdown of glycogen.	Theoretical training for practical work	5	Additional questions on the exam
19	The pentose phosphate pathway. Cori cycle, glucose-lactate pathway. The path of uronic acids. Disorders of carbohydrate metabolism.	Theoretical training for practical work	5	Additional questions on the exam
20	Oxidative decarboxylation of pyruvate. Tricarboxylic acid cycle.	Theoretical training for practical work	4	Additional questions on the exam
21	Lipid metabolism and functions (part 1).	Theoretical training for practical work	4	Additional questions on the exam
22	Lipid metabolism and functions (part 2). Disorders of lipid metabolism.	Theoretical training for practical work	4	Additional questions on the exam
23	Metabolism and functions of amino acids (part 1).	Theoretical training for practical work	4	Additional questions on the exam
24	Metabolism and functions of amino acids (part 2). Disorders of amino acid and protein metabolism.	Theoretical training for practical work	4	Additional questions on the exam

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25	The metabolism of purine nucleotides.	Theoretical training for practical work	4	Additional questions on the exam
26	The metabolism of pyrimidine nucleotides. Disorders of nucleotide metabolism.	Theoretical training for practical work	4	Additional questions on the exam
27	Hormones: General characteristics and mechanism of action.	Theoretical training for practical work	4	Additional questions on the exam
28	Regulation of carbohydrate, protein, and fat metabolism. Hormones of the pancreas. Corticoids as hormones of the adrenal cortex.	Theoretical training for practical work	4	Additional questions on the exam
29	Regulation of Ca ²⁺ and phosphate metabolism. Parathyroid hormone, calcitonin, and calcitriol. Regulation of water-salt metabolism	Theoretical training for practical work	4	Additional questions on the exam
30	Sex hormones. Thyroid hormone. Hormones of local action	Theoretical training for practical work	4	Additional questions on the exam
31	Blood biochemistry. Proteins of blood plasma. Coagulation and anticoagulation system. Iron metabolism.	Theoretical training for practical work	4	Additional questions on the exam
32	Biochemistry of the liver. Neutralization of toxic substances and xenobiotics in the liver.	Theoretical training for practical work	4	Additional questions on the exam
33	Muscle biochemistry. Mechanism and energy of muscle contraction. Features of metabolism in muscle tissue.	Theoretical training for practical work	4	Additional questions on the exam
34	Biochemical aspects of the origin and transmission of a nerve impulse. Features of	Theoretical training for practical work	4	Additional questions on the exam

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	metabolism in the nervous tissue.			
35	Biochemistry of the intercellular matrix.	Theoretical training for practical work	4	Additional questions on the exam

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10. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE SUBJECT

Main references:

1. Glukhov, A. I. Biochemistry with exercises and tasks / ed. by Glukhov A. I. , Garin V. V. - Москва : ГЭОТАР-Медиа, 2020. - 296 с. - ISBN 978-5-9704-5317-9. - Текст : электронный // ЭБС "Консультант студента" : [сайт]. - URL : <https://www.studentlibrary.ru/book/ISBN9785970453179.html>
2. Glukhov, A. I. Essential Biochemistry for Medical Students with Problem-Solving Exercises / ed. by Glukhov A. I. , Gubareva A. E. - Москва : ГЭОТАР-Медиа, 2020. - 584 с. - ISBN 978-5-9704-5650-7. - Текст : электронный // ЭБС "Консультант студента" : [сайт]. - URL : <https://www.studentlibrary.ru/book/ISBN9785970456507.html>

Additional references:

- 1) Glukhov, A. I. Biochemistry of the connective tissue. Biochemistry of mixed saliva / Glukhov A. I. , Babchenko E. V. - Москва : ГЭОТАР-Медиа, 2019. - 128 с. - ISBN 978-5-9704-4972-1. - Текст : электронный // ЭБС "Консультант студента" : [сайт]. - URL : <https://www.studentlibrary.ru/book/ISBN9785970449721.html>
- 2) Baigildina, A. A. Laboratory Manual on Biological Chemistry : for foreign students of Medical Department of Higher Education Institutions : tutorial / Baigildina A. A. , Davydov V. V. - Москва : ГЭОТАР-Медиа, 2019. - 304 с. - ISBN 978-5-9704-4971-4. - Текст : электронный // ЭБС "Консультант студента" : [сайт]. - URL : <https://www.studentlibrary.ru/book/ISBN9785970449714.html>
- 3 **Yenikeyev E. Sh.**
Laboratory Manual of Biochemistry for foreign medical students = Лабораторный практикум по биохимии для студентов-иностранцев медицинского факультета. Ч. 1 / **Yenikeyev E. Sh.**, N. V. Terekhina; Ulyanovsk State University, Insitute of Medicine, Ecology and Physical culture. - Ulyanovsk : Ulyanovsk State University, 2015. - Загл. с экрана; На англ. яз.; Имеется печ. аналог. - Электрон. текстовые дан. (1 файл : 797 Кб). - Текст : электронный. <http://lib.ulsu.ru/MegaPro/Download/MObject/341>
- 4 **Yenikeyev E. Sh.**
Laboratory manual of biochemistry for foreign medical students. P. 2 / **Yenikeyev E. Sh.**, L. F. Yenikeyeva, N. V. Terekhina; Ulyanovsk State University, Insitute of Medicine, Ecology and Physical culture. - Ulyanovsk : ULSU, 2017. - Текст на англ. яз.; Загл. с экрана. - Электрон. текстовые дан. (1 файл : 1,88 Мб). - Текст : электронный. <http://lib.ulsu.ru/MegaPro/Download/MObject/1029>

Educational- methodical:


1 Yenikeyev E. Sh.

Biochemistry: guidelines for self – study work of students of speciality 31.05.01

“General Medicine» / Yenikeyev E. Sh. - Ulyanovsk : ULSU, 2021. - 28 p. -

Неопубликованный ресурс. - URL:

<http://lib.ulsu.ru/MegaPro/Download/MObject/11111>. - Режим доступа: ЭБС УлГУ. -

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Профессиональные базы данных, информационно-справочные системы

1. Электронно-библиотечные системы:

1.1. Цифровой образовательный ресурс IPRsmart : электронно-библиотечная система : сайт / ООО Компания «Ай Пи Ар Медиа». - Саратов, [2022]. – URL: <http://www.iprbookshop.ru>. – Режим доступа: для зарегистрир. пользователей. - Текст : электронный.

1.2. Образовательная платформа ЮРАЙТ : образовательный ресурс, электронная библиотека : сайт / ООО Электронное издательство ЮРАЙТ. – Москва, [2022]. - URL: <https://urait.ru>. – Режим доступа: для зарегистрир. пользователей. - Текст : электронный.

1.3. Консультант врача. Электронная медицинская библиотека : база данных : сайт / ООО Высшая школа организации и управления здравоохранением-Комплексный медицинский консалтинг. – Москва, [2022]. – URL: <https://www.rosmedlib.ru>. – Режим доступа: для зарегистрир. пользователей. – Текст : электронный.

1.4. Большая медицинская библиотека : электронно-библиотечная система : сайт / ООО Букап. – Томск, [2022]. – URL: <https://www.books-up.ru/ru/library/>. – Режим доступа: для зарегистрир. пользователей. – Текст : электронный.

1.5. ЭБС Лань : электронно-библиотечная система : сайт / ООО ЭБС Лань. – Санкт-Петербург, [2022]. – URL: <https://e.lanbook.com>. – Режим доступа: для зарегистрир. пользователей. – Текст : электронный.

1.6. ЭБС Znanium.com : электронно-библиотечная система : сайт / ООО Знаниум. - Москва, [2022]. - URL: <http://znanium.com> . – Режим доступа : для зарегистрир. пользователей. - Текст : электронный.

1.7. Clinical Collection : научно-информационная база данных EBSCO // EBSCOhost : [портал]. – URL: <http://web.b.ebscohost.com/ehost/search/advanced?vid=1&sid=9f57a3e1-1191-414b-8763-e97828f9f7e1%40sessionmgr102> . – Режим доступа : для авториз. пользователей. – Текст : электронный.

1.8. База данных «Русский как иностранный» : электронно-образовательный ресурс для иностранных студентов : сайт / ООО Компания «Ай Пи Ар Медиа». – Саратов, [2022]. – URL: <https://ros-edu.ru>. – Режим доступа: для зарегистрир. пользователей. – Текст : электронный.

2. КонсультантПлюс [Электронный ресурс]: справочная правовая система. /ООО «Консультант Плюс» - Электрон. дан. - Москва : КонсультантПлюс, [2022].

3. Базы данных периодических изданий:


3.1. База данных периодических изданий EastView : электронные журналы / ООО ИВИС. - Москва, [2022]. – URL: <https://dlib.eastview.com/browse/udb/12>. – Режим доступа : для авториз. пользователей. – Текст : электронный.

3.2. eLIBRARY.RU: научная электронная библиотека : сайт / ООО Научная Электронная Библиотека. – Москва, [2022]. – URL: <http://elibrary.ru>. – Режим доступа : для авториз. пользователей. – Текст : электронный

3.3. Электронная библиотека «Издательского дома «Гребенников» (Grebinnikon) : электронная библиотека / ООО ИД Гребенников. – Москва, [2022]. – URL: <https://id2.action-media.ru/Personal/Products>. – Режим доступа : для авториз. пользователей. – Текст : электронный.

4. Федеральная государственная информационная система «Национальная электронная библиотека» : электронная библиотека : сайт / ФГБУ РГБ. – Москва, [2022]. – URL: <https://нэб.рф>. – Режим доступа : для пользователей научной библиотеки. – Текст : электронный.

5. SMART Imagebase : научно-информационная база данных EBSCO // EBSCOhost : [портал]. – URL: <https://ebSCO.smartimagebase.com/?TOKEN=EBSCO->

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6. Федеральные информационно-образовательные порталы:

6.1. Единое окно доступа к образовательным ресурсам : федеральный портал . – URL: <http://window.edu.ru/> . – Текст : электронный.

6.2. Российское образование : федеральный портал / учредитель ФГАУ «ФИЦТО». – URL: <http://www.edu.ru>. – Текст : электронный.

7. Образовательные ресурсы УлГУ:

7.1. Электронная библиотечная система УлГУ : модуль «Электронная библиотека» АБИС Мега-ПРО / ООО «Дата Экспресс». – URL: <http://lib.ulsu.ru/MegaPro/Web>. – Режим доступа : для пользователей научной библиотеки. – Текст : электронный.

Согласовано:

З.М. Кар
Должность сотрудника УИТИГ

Ключкова
ФИО

[Signature]
подпись

19.04.22
дата

Министерство науки и высшего образования РФ ФГБОУ ВО «Ульяновский государственный университет»	Форма
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11. SPECIAL CONDITIONS FOR STUDENTS WITH DISABILITIES

If necessary, students from among persons with disabilities (at the request of the student) may be offered one of the following information perception options, taking into account their individual psychophysical peculiarities:

- for persons with visual impairments: in printed form in enlarged font; in the form of an electronic document; in the form of an audio file (translation of educational materials into audio format); in printed form in Braille; individual consultations with the involvement of a typhoid translator; individual assignments and consultations;
- for persons with hearing impairments: in printed form; in the form of an electronic document; video materials with subtitles; individual consultations with the involvement of a sign language interpreter; individual tasks and consultations;
- for persons with disorders of the musculoskeletal system: in printed form; in the form of an electronic document; in the form of an audio file; individual assignments and consultations.

If it is necessary to use partially distance educational technologies in the educational process, the organization of work with students with disabilities and disabilities is provided in an electronic information and educational environment, taking into account their individual psychophysical characteristics.