

MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS
Educational Institution
BELARUSIAN STATE MEDICAL UNIVERSITY

Контрольный
экземпляр



APPROVED

by First Vice-Rector, Professor

I.N.Moroz

04.07.2022

Reg. # UD-L.728/2223/edu.

BIOLOGICAL CHEMISTRY

**Curriculum of higher educational institution
in the academic discipline for the specialty:**

1-79 01 01 «General Medicine»

Curriculum is based on the educational program «Biological Chemistry», approved 01.07.2022, registration # УД-Л.728/2223/уч.; on the educational plan in the specialty 1-79 01 01 «General Medicine», approved 18.05.2022, registration # L 79-1-1/2223/mf

COMPILERS:

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RECOMMENDED FOR APPROVAL:

by the Department of Biological Chemistry of the educational institution «Belarusian State Medical University»
(protocol # 9 of 20.05.2022);

by the Scientific and Methodological Council of the educational institution «Belarusian State Medical University»
(protocol # 6 of 29.06.2022)

EXPLANATORY NOTE

«Biological chemistry» – the educational discipline of the module «Medical and Biological Module 1», which contains systematized scientific knowledge and techniques in the field of medical biochemistry, studying the molecular basis of normal life processes in human and the possible causes and effects of metabolic disturbances.

The aim of the discipline «Biological Chemistry» is the formation of basic professional competencies about the molecular basis of normal physiological functions in human in terms of ontogenesis; molecular basis of the pathological processes, their prevention and treatment; biochemical methods of diagnosing and monitoring of human health status.

The objectives of the discipline «Biological Chemistry» are to form students' scientific knowledge about:

- basic principles of the molecular organization of the cell, tissue, organism;
- basic laws of metabolic processes, metabolic regulation and its interaction with the functional activity in a living system;
- pathogenetic mechanisms of pathological processes, subject to the main types of heritable metabolic defects;
- research techniques;
- basic principles of clinical, laboratory and knowledge-based sanitary and hygienic technologies.

The tasks of the discipline include the formation of skills and abilities necessary for:

- using the results of biochemical analyses for the health assessment;
- interpretation of the results of laboratory and instrumental methods of analysis;
- diagnosing.

The knowledge, skills, and abilities acquired during the study of the academic discipline «Biological Chemistry» are necessary for successful mastering of the following academic disciplines or modules: «Pharmacology», «Pathologic Physiology».

Studying the educational discipline «Biological Chemistry» should ensure the formation of students' basic professional.

BPC. Use knowledge about the molecular basis of the vital activity processes in the human body in normal and pathological conditions, apply the basic methods of biochemical investigation for disease diagnosis.

As a result of studying the discipline «Biological Chemistry» the student should

know:

- the molecular composition of living systems; structure, physical and chemical properties of the main classes of compounds: proteins, nucleic acids, carbohydrates, lipids; metabolism of these compounds, mechanisms of metabolism regulation;
- structure of enzymes; mechanisms of the enzyme-catalyzed reactions (in terms of proteins, nucleic acids, carbohydrates and lipids conversions); molecular

mechanisms regulating the action of enzymes (types of regulation); hierarchy of the regulation; types of catalysis in enzymatic reactions;

mechanisms of oxidative phosphorylation, molecular mechanisms of the energy coupling;

protein synthesis, the sequence of the reactions and their mechanisms, regulation and energy supply of the process; mechanisms of the protein spatial structure formation;

chain reaction of oxidation and its role in biological systems under physiological and pathological conditions;

biochemical basis of a healthy diet and the effects of malnutrition on physical condition;

be able to:

carry out the chemical testing according specified scheme;

analyze and document the obtained results of biochemical research;

master:

operating skills to work with instruments and equipment used in biochemical laboratories (spectrophotometer, photoelectric colorimeter, centrifuge, automatic pipettes);

methods of qualitative and quantitative analysis of nucleic acids, proteins, lipids, carbohydrates, vitamins and hormones in biological material.

Total number of hours for the study of the discipline is 228 academic hours. Classroom hours according to the types of studies: lectures - 32 hours (including 16 hours of supervised student independent work), laboratory classes – 105 hours), student independent work (self-study) - 75 hours.

Intermediate assessment is carried out according to the syllabus of the specialty in the form of a credit (3 semester) and examination (4 semester).

Form of higher education – full-time.

**ALLOCATION OF ACADEMIC TIME
ACCORDING TO SEMESTERS OF STUDY**

Code, name of the specialty	semester	Number of academic hours						Form of intermediate assessment
		total	in-class	including			out-of-class self-studies	
				lectures (including supervised independent work)	supervised student independent work	laboratory studies (practical classes and seminars)		
1-79 01 01 «General Medicine»	3	114	78	24	8	54	36	credit
	4	114	75	24	8	51	39	examination

THEMATIC PLAN

Section (topic) name	Number of class hours	
	lectures	practicals
1. Introduction to the discipline «Biological Chemistry». The structure and functions of proteins	2	9
1.1. The subject and significance of biochemistry. Proteins: properties and functions		3
1.2. Structure of protein molecule	2	3
1.3. Methods of protein isolation and purification		3
2. Enzymes	4	9
2.1. Enzymes: properties and mechanism of action	2	3
2.2. Regulation of enzyme action	2	6
3. Introduction to metabolism. Biological oxidation. Central metabolic pathways	4	6
3.1. Introduction to metabolism and energy exchange. Central pathways of metabolism	2	3
3.2. Biological oxidation	2	3
4. Carbohydrates metabolism and functions	4	12
4.1. Carbohydrates. Anaerobic pathways of glucose utilization in the cell. Glycogen metabolism	2	3
4.2. Aerobic glucose degradation. Pathways of pyruvate metabolism. Gluconeogenesis	1.3	3
4.3. Secondary pathways of glucose metabolism. Fructose and galactose metabolism. Hereditary disorders of carbohydrate metabolism. Hormones influence on blood glucose level	0.7	6
5. Lipids metabolism and functions	6	18
5.1. Lipid classification. Lipids digestion and absorption. Transport of exogenous lipids	2	3
5.2. Lipid transport forms in blood. Cholesterol metabolism	2	3
5.3. Intracellular metabolism of fatty acids. Ketone bodies. Regulation of lipid metabolism. Disorders of lipid metabolism	2	12
6. Simple protein and amino acid metabolism	4	6
6.1. Protein digestion. Pathways of amino acid utilization in cells	2	3
6.2. Ammonia detoxification. Fates of the amino acids carbon skeletons. Characteristics of nitrogen metabolism	2	3

Section (topic) name	Number of class hours	
	lectures	practicals
7. Nucleoproteins metabolism. Structure and synthesis of nucleic acids. Protein biosynthesis. Methods of molecular biology	6	9
7.1. Structure and metabolism of nucleoproteins	2	3
7.2. Biosynthesis of nucleic acids and proteins. Modern methods of molecular biology and their medical application	4	6
8. Regulation of metabolism. Biochemistry of hormones	6	6
8.1. Principal mechanisms of metabolism regulation. Mechanism of hormone action	2	3
8.2. Influence of major hormones on metabolism	4	3
9. Biochemistry of organs and tissues	5.33	15
9.1. Biochemistry of the blood	2	6
9.2. Biochemistry of the liver	1.34	3
9.3. Biochemistry of the muscles	0.67	-
9.4. Biochemistry of the connective tissues	0.66	-
9.5. Biochemistry of the nervous tissue	0.66	-
9.6. Biochemistry of kidney and urine	-	6
10. Biochemistry of nutrition	5.33	9
10.1. Essential nutritive factors. Vitamins. Causes and biochemical characteristics of protein-energy malnutrition	3.33	3
10.2. Water and mineral salts. Calcium and phosphorus metabolism. Microelements	2	6
11. Integration of metabolism	1.33	6
Total hours	48	105

CONTENT OF THE EDUCATIONAL MATERIAL

1. Introduction to the discipline «Biological Chemistry». The structure and functions of proteins

1.1. The subject and significance of biochemistry. Proteins: properties and functions

The development of biochemistry, major stages. Position of biochemistry in medical education. Major categories and areas in biochemistry. Objects in biochemical research. Medical biochemistry. Role of biochemistry in understanding of human and environment interrelations.

Brief historical essay on the development of protein chemistry: discovery of amino acids, peptide theory of structure. Protein classification according to their functions, molecular shape, constitution complexity.

Physical and chemical properties of proteins and protein solutions.

1.2. Structure of protein molecule

Primary protein structure, types of bonds, properties of the peptide bond. Methods of primary structure analysis. Amino acid composition of proteins in different organs and tissues, importance of this fact in biochemistry of nutrition. Protein composition of tissues, its changes in ontogenesis and pathology.

Conformation of the polypeptide chain. Secondary protein structure, types; role of hydrogen bonds in its stabilization. Supersecondary structure, its types. Protein tertiary structure. Role of weak intramolecular interactions in stabilization of protein 3-D structure and conformational changes. Dependence of protein biological activity on conformational changes. Protein denaturation, its reversibility.

Quaternary protein structure. Functional features of proteins with quaternary structure.

Conjugated proteins. General notion of conjugated proteins composition, structure of prosthetic groups, types of bonds between apoprotein and prosthetic group.

Capability to specific interactions – the base of protein biological functions. The concept of complementarity. Ligands and protein function. Reversibility of ligand binding.

1.3. Methods of protein isolation and purification

Separation and purification methods for proteins: ultracentrifugation, ultrafiltration, electrophoresis, isoelectrofocusing, chromatography. Dialysis and its medical application. Means for production of protein preparations. Methods of protein identification, Western-blot.

Quantitative determination of total and individual proteins on base of their biological properties.

2. Enzymes

2.1. Enzymes: properties and mechanism of action

History of enzymes discovery and investigation. Enzyme classification and nomenclature. Properties of enzymes. Dependence of the velocity of enzyme-catalyzed on temperature, pH, substrate and enzyme concentrations. Single- and two-component enzymes. Coenzymes, classification. Coenzyme function of water-soluble

vitamins.

Units of enzyme activity.

2.2. Regulation of enzyme action

Mechanisms of enzyme activity regulation: competitive inhibition, allosteric enzymes, regulation of enzyme structure by covalent modification. Role of enzyme cooperative conformational changes in mechanisms of reaction catalysis. Natural and artificial inhibitors of enzyme activity. Medical application of inhibitors.

Cellular organization of enzymes. Enzyme composition in different cells, organs and tissues. Organo-specific enzymes. Determination of enzyme activity in blood for diagnosis; plasma enzymes origin. Isoenzymes. Enzymes as medicinal preparations. Enzymes as analytical reagents in laboratory research, immobilized enzymes.

3. Introduction to metabolism. Biological oxidation. Central metabolic pathways

3.1. Introduction to metabolism and energy exchange. Central metabolic pathways

The concept of metabolism, metabolic pathways. Forms of metabolic pathways. Methods of metabolism study at the level of the whole organism, organs, tissue sections, cell cultures. Tissue homogenates, fractionation of homogenates, subcellular structures. Isolation of metabolites and enzymes, determination of substrate transformation sequence. Isotopic methods. Methods of modelling and synthesis.

The diagram of the main substances (carbohydrates, lipids, proteins) catabolism. The concept of specific and central metabolic pathways. The concept of metabolon. Interrelations between anabolism and catabolism.

Oxidative decarboxylation of pyruvate, sequence of reactions, characteristics of enzymes and coenzymes. The concept of multienzyme complex. Connection of the process with the electron transport chain. Mechanisms of regulation.

Citric acid cycle: sequence of reactions, characteristics of enzymes. Connection of the process with the electron transport chain. Mechanisms of regulation. Functions of the citric acid cycle.

3.2. Biological oxidation

Endergonic and exergonic reactions in the living cell. The concept of high-energy compound. Oxidation as the main energy producing pathway in the living cell. Mechanisms of oxidation – electron transfer, addition of oxygen to substrate, dehydrogenation. Dehydrogenases, structure and role of coenzymes. Oxidative reaction chains.

Mitochondria structure, structural organization of electron and proton transport chain. Mitochondrial multienzyme complexes, their composition.

Mechanisms of adenosine triphosphate (ATP) production in the cell. Substrate-level phosphorylation, oxidative phosphorylation. Mechanism of oxidative phosphorylation. Inhibitors of tissue respiration and oxidative phosphorylation. Uncoupling of oxidative phosphorylation, properties of uncouplers.

Role of oxygen in oxidation processes of a cell. Oxidase and oxygenase pathways of oxygen utilization by cells.

4. Carbohydrates metabolism and functions

4.1. Carbohydrates. Anaerobic pathways of glucose utilization in the cell.

Glycogen metabolism

Carbohydrates classification. Major carbohydrates in animals, their biological role. Dietary carbohydrates, daily requirement.

Central reaction of carbohydrate metabolism. Anaerobic glucose degradation (anaerobic dichotomy, glycolysis). Glycolytic oxidoreduction; pyruvate as hydrogen acceptor. Substrate-level phosphorylation. Other hydrogen acceptors under anaerobic conditions, alcoholic and lactic fermentation, their biological role. Cellular localization of glycolysis, regulation of anaerobic dichotomy. Energy yield of anaerobic glucose oxidation.

Glycogen properties and its distribution as reserve polysaccharide. Glycogen biosynthesis and mobilization. Role of hormones in regulation of glycogen storage and mobilization. Glycogenoses and aglycogenesis.

4.2. Aerobic glucose degradation. Pyruvate metabolism pathways.

Gluconeogenesis

Aerobic glucose degradation: common reactions with glycolysis. Oxidative decarboxylation of pyruvate, tricarboxylic acid cycle as stages of aerobic glucose degradation. Energy yield of glucose oxidation under aerobic conditions.

Pyruvate as a central metabolite. Gluconeogenesis, major substrates for glucose biosynthesis in a cell. Key enzymes of gluconeogenesis. Regulation of gluconeogenesis.

4.3. Secondary pathways of glucose metabolism. Fructose and galactose metabolism. Hereditary disorders of carbohydrate metabolism. Hormones influence on blood glucose level

Pentose phosphate pathway of glucose oxidation (apotomy). Enzymes of oxidative phase. Role of the oxidative phase. Non-oxidative phase of pentose phosphate pathway, major enzymes. Connection with glycolysis. Cellular distribution and biological role. Regulation of the pathway.

Uronic acid pathway. The main reactions. Biological role of the pathway. Connection with pentose phosphate pathway and glycolysis.

Sucrose, lactose and maltose metabolism. Fructose and galactose metabolism. Hereditary disorders of monosaccharide and disaccharide metabolism: galactosemia, fructosuria, fructose and disaccharide intolerance.

Hormonal regulation of blood glucose level. Role of insulin, epinephrine, glucagon, glucocorticosteroids.

Quantitative methods of blood glucose determination.

5. Lipid metabolism and functions

5.1. Lipid classification. Lipids digestion and absorption. Transport of exogenous lipids

The concept of lipids. Saponifiable and unsaponifiable lipids. Simple and complex lipids. Dietary lipids. Requirements for lipid composition of food products. Lipid digestion: emulsification, enzymatic hydrolysis, micelle formation. Role of bile acids. Disorders of digestion and absorption.

Lipids re-synthesis in enterocytes. Lipid transport forms in the blood,

chylomicron as a transport form of exogenous lipids.

5.2. Lipid transport forms in blood. Cholesterol metabolism

Lipid transport forms in blood. Lipids re-synthesis in the liver, formation of very-low density lipoproteins (VLDL). Lipoprotein lipase and its role in blood lipoprotein metabolism.

Synthesis of hydroxy-methylglutaryl-CoA. Its reduction to mevalonic acid. Cholesterol biosynthesis. Regulation of cholesterol biosynthesis. Cholesterol transport in the blood, role of VLDL, low density lipoproteins (LDL), high density lipoproteins (HDL). Cholesterol conversion to bile acids. Cholesterol excretion from the body. Quantitative determination of cholesterol and major lipoprotein fractions content in the blood.

Hypercholesterolemia and its causes. Gallstones. Biochemistry of atherosclerosis, risk factors. Biochemical basis for treatment and prophylaxis of hypercholesterolemia and atherosclerosis.

5.3. Intracellular metabolism of fatty acids. Ketone bodies. Regulation of lipid metabolism. Disorders of lipid metabolism

Mechanisms of fatty acid activation. Fatty acid transport to mitochondria. Role of carnitine. β -oxidation of fatty acids – specific fatty acid catabolic pathway. Enzymes of β -oxidation. Oxidation of «odd-chain» fatty acids. Connection of β -oxidation with tissue respiration enzymes, energy yield of fatty acid oxidation.

Other pathways of fatty acid oxidation, their significance. Ways of active acetic acid utilization.

Fatty acid biosynthesis. Structure of fatty acid synthase complex. Role of glucose metabolic pathways in fatty acid synthesis. Polyunsaturated fatty acids – essential nutritive factors.

Lipid storage and mobilization in the adipose tissue; hormonal regulation of the processes. Fatty acid transport in the blood. Role of lipid storage and mobilization, their disturbances in obesity.

Mechanisms of ketone bodies synthesis and utilization. Their biological role.

Phospholipids and glycolipids. General concept of mechanisms of their synthesis and degradation. Phospholipases. Phospholipids and glycolipids – functions, congenital disorders of metabolism.

6. Simple protein and amino acid metabolism

6.1. Protein digestion. Pathways of amino acid utilization in cells

Food proteins as a source of amino acids. Requirements for protein nutrition. Protein digestion. Endo- and exopeptidases of the gastro-intestinal tract. Amino acid absorption. Protein putrefaction in the gut. General concept of nitrogen balance: positive, negative nitrogen balance, nitrogen equilibrium.

Amino acid pool of a cell: sources and ways of utilization of amino acid pool. Mechanisms of amino acid catabolism. Transamination, aminotransferases. Tissue and intracellular specificity of aminotransferases, their significance. Direct and indirect amino acid deamination. Biological role of deamination. Central role of glutamic acid in amino acid metabolism. Decarboxylation of amino acids. Biogenic amines, formation, functions. Oxidation of biogenic amines. Aminooxidases.

Role of individual amino acids. Methionine and S-adenosylmethionine,

synthesis of creatine, epinephrine, phosphatides, DNA methylation, source of single-carbon groups. Lipotropic factors. Metabolism of tyrosine and phenylalanine, its disorders: phenylketonuria, alkaptonuria, albinism. Synthesis of hormones - tyrosine derivatives.

6.2. Ammonia detoxification. Fates of the amino acids carbon skeletons. Characteristics of nitrogen metabolism

Ammonia major sources in the body. The ways of ammonia utilization and detoxification: reductive amination, synthesis of dicarboxylic acid amides, formation of carbamoyl phosphate. Kidney and liver glutaminase. Ammonia salts production and excretion. Activation of kidney glutaminase in acidosis. Urea synthesis, sources of urea nitrogen. Abnormalities of urea synthesis and excretion. Other non-protein nitrogen-containing plasma components, significance of their determination in medical practice.

The ways of amino acid carbon skeletons utilization: synthesis of new amino acids, glucose production (glucogenic amino acids), ketone bodies production (ketogenic amino acids), direct oxidation, conversion into lipids in the abnormal protein nutrition.

7. Nucleoproteins metabolism. Structure and synthesis of nucleic acids. Protein biosynthesis. Methods of molecular biology

7.1. Structure and metabolism of nucleoproteins

History of nucleoprotein discovery. Nucleic acids.

Features of nucleic acids primary structure. Bond between nucleotides. Secondary structure of nucleic acids: features of DNA and RNA secondary structure, types of bonds stabilizing secondary structure. Tertiary structure, role of proteins in organization of nucleic acid spatial structure. Ribosome structure. Polyribosomes. Informosome and messenger RNA, transfer RNA, structure and functions. Chromosome structure.

Denaturation of nucleic acids. DNA-DNA, DNA-RNA hybridization. Methods of nucleic acid structure investigation.

Nucleic acid degradation. Nucleases in gastro-intestinal tract. Degradation of purine nucleotides, uric acid formation. Synthesis of purine nucleotides. Substrates, key enzymes and regulation of purine nucleotide synthesis.

Degradation of pyrimidine nucleotides, end products. The concept of pyrimidines synthesis: substrates and enzymes.

Cellular proteins and nucleic acids degradation. Proteins and nucleic acids biological half-life. Enzymes catalyzing the processes of protein and nucleic acid degradation. Reutilization of nucleosides and nitrogen bases for nucleotide synthesis. Disorders of nucleotide metabolism.

7.2. Biosynthesis of nucleic acids and proteins. Modern methods of molecular biology and their medical application

Synthesis of DNA, substrates, enzymes, conditions of synthesis. Replication as a way of the information transfer from matrix to the reaction product. Reverse transcription, its biological role.

Biosynthesis of RNA (transcription): substrates, enzymes, conditions of transcription. Transcription as a way of the information transfer from DNA to RNA.

Biosynthesis of ribosomal, transfer and messenger RNA. Mechanisms of transcription regulation.

Protein biosynthesis. Genetic (amino acid, nucleotide) code and its properties. Adaptor role of transfer RNA. Recognition. Biosynthesis of aminoacyl-tRNA: substrate specificity of aminoacyl-tRNA-synthetases. Mechanisms and stages of translation. Regulation of translation. Universality of genetic code and protein biosynthesis mechanism. Antibiotics – inhibitors of protein and nucleic acid synthesis.

Processing of nucleic acids and proteins. Pattern of changes in nucleic acid and protein structure after the initial synthesis.

Polymerase chain reaction, steps and application. Blot-analysis of DNA and RNA. Genomic fingerprinting.

DNA nucleotide sequence determination by Sanger.

Cloning, genetic engineering.

8. Regulation of metabolism. Biochemistry of hormones

8.1. Principal mechanisms of metabolism regulation. Mechanism of hormone action

Regulation of metabolic processes by changing of enzymes' activity (activation, inhibition), changing enzymes' amount (induction and repression of synthesis, enzyme degradation rate), changing plasma membrane permeability.

Hormonal regulation as a way of intercellular and inter-organ coordination of metabolism.

Hormones classification by the chemical structure, place of synthesis, mechanism of action. Target cells and cellular hormonal receptors.

Action of hormones binding to plasma membrane receptors, special features. Messengers of hormonal action on a cell: cyclic purine nucleotides, calcium ions, products of phosphatidylinositol hydrolysis. Protein kinases, role in mechanisms of enzyme activity modulation.

Mechanism of action of hormones binding to intracellular receptors. Influence on protein biosynthesis.

8.2. Influence of major hormones on metabolism

Structure, mechanism of action and influence on metabolism of hypothalamic, pituitary, thyroid, pancreatic, sex and adrenal hormones. Procedure and diagnostic value of glucose tolerance test. Hormonal regulation of calcium and phosphorus metabolism.

Abnormalities of endocrine glands function: hyper- and hypoproduction of hormones. General approaches to treatment of such states.

Eicosanoids (prostaglandins, thromboxanes, leucotriens) and their role in metabolism and physiological functions regulation.

9. Biochemistry of organs and tissues

9.1. Biochemistry of the blood

Blood cells. Peculiarities of erythrocytes chemical composition and structure. Kinds and derivatives of hemoglobin. Oxygen and carbon dioxide transport in blood. Peculiarities of hemoglobin saturation with oxygen and carbon monoxide. Hemoglobinopathies. Hypoxias. Leucocytes, peculiarities of chemical composition

and structure. Role of leucocytes.

Blood plasma and serum. Plasma proteins. Classification of blood proteins according to their functions: transfer proteins, proteins of complement system, kinin system, blood clotting, system of fibrinolysis, immunoglobulins, protein-inhibitors of proteolysis. Plasma proteins – a source of amino acids in starvation. Methods of plasma proteins separation.

Biochemical blood analysis, its significance in description of human health state. Methods of acid-base state examination.

Blood clotting. Primary and secondary hemostasis (coagulation). Role of platelets in hemostasis. Intrinsic and extrinsic systems of coagulation. Phases. Enzymes, involved in coagulation, cascade mechanism of activation. Role of vitamin K in blood clotting. Anticoagulative systems (anticoagulant, fibrinolytic). Concept of haemophilias and thromboses.

9.2. Biochemistry of the liver

Role of the liver in carbohydrate, lipid, amino acid metabolism. Synthesis of plasma proteins in the liver.

Reactions of substances detoxification in the liver. Role of microsomal oxidation in detoxification processes. Active glucuronic and sulfuric acids in detoxification processes. Detoxification of putrefaction products coming from the intestines.

Role of the liver in pigment metabolism. Reactions of heme synthesis, substrates, enzymes. Reactions of heme degradation, direct and indirect bilirubin. Disorders of bilirubin metabolism. Jaundices: hemolytic, obstructive, parenchymatous. Jaundice of newborns. Bile pigments in blood, intestines, urine.

Biochemical mechanisms of hepatocellular failure and hepatic coma development. Biochemical tests for diagnosis of liver function disturbances.

9.3. Biochemistry of the muscles

Proteins of myofibrils. Peculiarities of amino acid composition. Myofibril molecular structure. Sarcoplasmic proteins, individual representatives, their structure and functions. Non-protein muscle compounds.

Biochemical mechanisms of muscle contraction and relaxation. Role of ions in regulation of muscle contraction. Special features of energy exchange in muscles. Creatine phosphokinase and its isoenzymes.

9.4. Biochemistry of the connective tissues

Cells of the connective tissue, characteristics of metabolism. Chemical composition of intercellular substance. Collagen, peculiarities of synthesis and degradation. Elastin, peculiarities of metabolism.

Protein-carbohydrate complexes. Classification. Proteoglycans, glycosaminoglycans, glycoproteins. Peculiarities of synthesis and degradation. Role in the body. Connective tissue changes in ageing. Role of nutrition in the connective tissue metabolism.

9.5. Biochemistry of the nervous system

Chemical composition of the nervous tissue. Myelin membranes: features of composition and structure.

Features of energy exchange in the nervous tissue, the role of aerobic glucose

oxidation.

Molecular mechanisms of synaptic transfer. Neurotransmitters, mechanisms of synthesis and breakdown. The role of biogenic amines. Active brain peptides.

9.6. Biochemistry of kidneys and urine

The main parameters of urinalysis under physiological conditions – volume, density, color, transparency, pH, mineral and organic urine components (urea, uric acid, creatinine, amino acids, nitrogen-free organic components, hormones and their metabolites).

Diagnostic value of pathological urine components determination: proteinuria, glucosuria, hematuria, ketonuria, bile pigments, enzymes.

Characteristics of metabolism in the renal tissue. Role of kidneys in maintenance of the acid-base balance. Production of the biologically active substances in kidneys.

10. Biochemistry of nutrition

10.1. Essential nutritive factors. Vitamins. Causes and biochemical characteristics of protein-energy malnutrition

Vitamins, history of discovery and study. Classification of vitamins. Causes of vitamin deficiency: exogenous and endogenous hypo- and avitaminoses. Hypervitaminoses (vitamin toxicity), their causes.

Water-soluble vitamins (B₁, B₂, PP, B₆, B₉, B₁₂, biotin, pantothenic acid, C). Chemical structure, active forms, role of water-soluble vitamins in metabolism, mechanisms of absorption and excretion from the body.

Fat-soluble vitamins. Vitamins A, E, K, D, special features of structure and mechanism of action. Influence on metabolism and organism development. Antioxidant function of fat-soluble vitamins. Use as medicinal preparations.

Vitamin daily requirements. Vitamin content in foods. Gut microflora – important source of vitamins in human. Antivitamins. Evaluation of body saturation with vitamins.

Other essential nutritive factors and their role (polyunsaturated fatty acids, amino acids). Vitamin-like substances.

Nutrition disturbances. Clinical forms of protein-energy malnutrition – kwashiorkor and marasmus. Causes of development, principal biochemical disorders.

10.2. Water and mineral salts. Calcium and phosphorus metabolism. Microelements

Minerals as essential nutritional factors. Classification. Body entering routes for minerals, mechanisms of absorption. Functions of minerals.

Electrolyte composition of biological fluids. Mechanisms of regulation of body fluids volume, electrolyte composition and pH. Role of kidneys, gastro-intestinal tract, skin, lungs in regulation of water and mineral metabolism. Conditions and development mechanisms of acidosis, alkalosis, exsiccation and edema.

Sodium and potassium metabolism. Peculiarities of distribution in the body. Regulation of metabolism.

Calcium and phosphorus requirement. Mechanisms of absorption. Distribution in the body. Regulation of their metabolism.

Microelements (trace elements). Biological role of iron, copper, cobalt, iodine,

zinc, manganese, fluorine, selenium. Microelement exchange in the body. Iron metabolism. Transferrin, ferritin. Iron-deficient anemias, diagnosis.

11. Integration of metabolism

Intracellular localization of the major metabolic pathways. Metabolic specialization of the organs.

Inter-organ metabolism in the well fed state, between meals and in starvation. The major energy sources. Role of hormones.

Examples of metabolic disorders. Metabolic syndrome, diabetes mellitus: causative agents, major biochemical derangements. Diabetic and hypoglycemic coma. Mechanism of development of diabetes mellitus complications (angiopathies, neuropathies, cataract).

ACADEMIC DISCIPLINE CURRICULAR CHART

Section, topic #	Section (topic) name	number of hours			Self-studies	Form of control
		lectures	supervised student work	laboratory		
3 semester						
1.	Introduction to the discipline «Biological Chemistry». The structure and functions of proteins	1.33	0.66	9	3	
<i>1.1.</i>	<i>The subject and significance of biochemistry. Proteins: properties and functions</i> Introduction to practical work. Introduction to biochemistry. The structure of amino acids and peptides. Lab. work: Determination of the protein content in biological fluids	-	-	3	1	interviews, written accounts of laboratory work, electronic testing
<i>1.2.</i>	<i>Structure of protein molecule</i> Introduction to biochemistry. Structure and functions of proteins	1.33	0.66	3	1	
	Levels of organization of a protein molecule. Physical and chemical properties of proteins Lab. work: Reactions of protein sedimentation	-	-	3	1	interviews, written accounts of laboratory work, electronic testing
<i>1.3.</i>	<i>Methods of protein isolation and purification</i> Methods of separation, isolation and purification of proteins Lab. work: Gel-filtration	-	-	3	1	interviews, written accounts of laboratory work, electronic testing
2.	Enzymes	2.66	1.32	9	5	
<i>2.1.</i>	<i>Enzymes: properties and mechanism of action</i> Introduction to enzymology. Classification and general properties of enzymes.	1.33	0.66	3	1	
		1.33	0.66	-	-	

	Enzymes. Classification, structure, properties. Lab. work: Effect of various factors on enzyme activity	-	-	3	1	interviews, written accounts of laboratory work, electronic testing
2.2.	<i>Regulation of enzyme action</i>	1.33	0.66	6	4	
	Enzymology. Regulation of enzyme activity.	1.33	0.66	-	-	
	Regulation of enzyme action Lab. work: Determination of enzyme activity	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
	Colloquium «The chemistry of proteins, enzymes» Identification and assessment of students' knowledge on topics	-	-	3	2	written colloquium, control questioning
3.	Introduction to metabolism. Biological oxidation. Central metabolic pathways	2.66	1.32	6	4	
3.1.	<i>Introduction to metabolism and energy exchange. Central pathways of metabolism</i>	1.33	0.66	3	2	
	Introduction to metabolism and energy exchange. Central pathways of metabolism: oxidative decarboxylation of pyruvate	1.33	0.66	-	-	
	Introduction to metabolism. Central metabolic pathways (oxidative decarboxylation of pyruvate, citric acid cycle). Lab. work: Evaluation of TCA cycle functioning	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
3.2.	<i>Biological oxidation</i>	1.33	0.66	3	2	
	Central pathways of metabolism: TCA cycle. Tissue respiration. Oxidative phosphorylation	1.33	0.66	-	-	
	Biological oxidation. Oxidative phosphorylation. Pathways of oxygen utilization by cells. Lab. work: Studying of oxidative phosphorylation	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
4.	Carbohydrates metabolism and functions	2.66	1.32	12	8	
4.1.	<i>Carbohydrates. Anaerobic pathways of glucose utilization in the cell. Glycogen metabolism</i>	1.33	0.66	3	1	
	Carbohydrate metabolism. Glycogen metabolism. Anaerobic glucose oxidation	1.33	0.66	-	-	
	Digestion of carbohydrates. Glycogenesis and glycogenolysis. Glycolysis and alcoholic fermentation.	-	-	3	1	interviews, written accounts of laboratory work, electronic testing

	Lab. work: Detection of alcoholic fermentation products						
4.2.	<i>Aerobic glucose degradation. Pyruvate metabolism pathways. Gluconeogenesis</i>	1.33	-	3	2		
	Carbohydrate metabolism. Aerobic glucose oxidation Gluconeogenesis	1.33	-	-	-		
	Metabolic pathways of pyruvate. Gluconeogenesis. Aerobic oxidation of glucose (CO ₂ and H ₂ O). Lab. work: Determination of pyruvate in the urine	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
4.3.	<i>Secondary pathways of glucose metabolism. Fructose and galactose metabolism. Hereditary disorders of carbohydrate metabolism. Hormones influence on blood glucose level</i>	-	0.66	6	5		
	Carbohydrate metabolism. Fructose and galactose metabolism	-	0.66	-	-		
	Secondary pathways of glucose metabolism. Metabolism of fructose and galactose Lab. work: Determination of blood glucose	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
	Colloquium «Introduction to metabolism. Central metabolic pathways. Biological oxidation. Carbohydrate metabolism» Identification and assessment of students' knowledge on topics	-	-	3	3		written colloquium, control questioning
5.	Lipids metabolism and functions	3.99	1.98	18	11		
5.1.	<i>Lipids classification. Lipids digestion and absorption. Transport of exogenous lipids</i>	1.33	0.66	3	2		
	Lipid metabolism. Digestion and absorption. Transport of exogenous lipids. Lipid re-synthesis	1.33	0.66	-	-		
	Lipid metabolism: digestion, absorption, re-synthesis. Transport of exogenous lipids. Lab. work: Evaluation of lipase activity	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
5.2.	<i>Lipid transport forms in blood. Cholesterol metabolism</i>	1.33	0.66	3	2		
	Transport of endogenous lipids. Mechanisms of atherosclerosis development	1.33	0.66	-	-		
	Lipid transport in blood. Cholesterol metabolism. Storage	-	-	3	2		interviews, written accounts of

	and mobilization of lipids. Lab. work: Determination of plasma β -lipoproteins						laboratory work, electronic testing
5.3.	<i>Intracellular metabolism of fatty acids. Ketone bodies. Regulation of lipid metabolism. Disorders of lipid metabolism.</i>	1.33	0.66	12	7		
	Intracellular metabolism of fatty acids. Ketosis.	1.33	0.66	-	-		
	Intracellular metabolism of fatty acids. Ketone bodies. Lab. work: Determination of cholesterol in serum	-	-	3	-		interviews, written accounts of laboratory work, electronic testing
	Colloquium «Lipid metabolism».	-	-	3	3		written colloquium, control questioning
	Control over practical skills of biochemical analysis: Color reactions for protein and amino acids, determination of total protein in serum by biuret method	-	-	3	1		written accounts of laboratory work with oral defense
	Final lesson «The chemistry of proteins, enzymes. Biological oxidation. Carbohydrate metabolism and functions. Lipid metabolism and functions»	-	-	3	3		Credit, electronic testing
6.	Simple protein and amino acid metabolism	2.66	1.32	-	5		
6.1.	<i>Protein digestion. Pathways of amino acid utilization in cells</i>	1.33	0.66	-	3		
	Protein metabolism. Intracellular amino acid metabolism	1.33	0.66	-	3		
6.2.	<i>Ammonia detoxification. Fates of the amino acids carbon skeletons. Characteristics of nitrogen metabolism</i>	1.33	0.66	-	2		
	Protein metabolism. Detoxification of ammonia	1.33	0.66	-	2		
4 semester							
6.	Simple protein and amino acid metabolism	-	-	6	4		
6.1.	<i>Protein digestion. Pathways of amino acid utilization in cells</i>	-	-	3	2		
	Digestion and absorption of proteins. Lab. work: Analysis of gastric juice	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
6.2.	<i>Ammonia detoxification. Fates of the amino acids carbon skeletons. Characteristics of nitrogen metabolism</i>	-	-	3	2		
	Intracellular amino acid metabolism. Detoxification of ammonia. Abnormalities of amino acid metabolism Lab. work: Determination of non-protein nitrogen in blood	-	-	3	2		interviews, written accounts of laboratory work, electronic testing

	and urea in urine						
7.	Nucleoproteins metabolism. Structure and synthesis of nucleic acids. Protein biosynthesis. Methods of molecular biology	3.99	1.98	9	7		
7.1.	<i>Structure and metabolism of nucleoproteins</i>	1.33	0.66	3	2		
	Metabolism of nucleic acids	1.33	0.66	-	-		
	Nucleoproteins chemistry and metabolism Lab. work: Determination of uric acid in urine	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
7.2.	<i>Biosynthesis of nucleic acids and proteins. Modern techniques of molecular biology and their medical application</i>	2.66	1.32	6	5		
	Matrix biosyntheses	1.33	0.66	-	-		
	Modern techniques of molecular biology	1.33	0.66	-	-		
	Matrix biosyntheses (synthesis of DNA, RNA, proteins). Lab. work: Analysis of yeast nucleoprotein hydrolysis products	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
	Colloquium «Simple proteins and nucleoproteins metabolism», «Synthesis of DNA, RNA and proteins» Identification and assessment of students' knowledge on topics	-	-	3	3		written colloquium, control questioning
8.	Regulation of metabolism. Biochemistry of hormones	3.99	1.98	6	4		
8.1.	<i>Principal mechanisms of metabolism regulation. Mechanism of hormone action</i>	1.33	0.66	3	2		
	Introduction to endocrinology	1.33	0.66	-	-		
	Hormones. General characteristic and peculiarities of biological action. Lab. work: Qualitative reactions for hormones	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
8.2.	<i>Influence of major hormones on metabolism</i>	2.66	1.32	3	2		
	Biochemistry of hormones	2.66	1.32	-	-		
	Biochemistry of hormones. Lab. work: Glucose tolerance test	-	-	3	2		interviews, written accounts of laboratory work, electronic testing
9.	Biochemistry of organs and tissues	1.33	-	3	2		

9.2.	<i>Biochemistry of the liver</i>	1.33	-	3	2	
	Biochemistry of the liver	1.33	-	-	-	
	Biochemistry of the liver Lab. work: Determination of total bilirubin in serum	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
11.	Integration of metabolism	1.33	-	6	5	
	Integration of metabolism	1.33	-	-	-	
	Integration of metabolism Lab. work: Effects of hormones on blood glucose level	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
	Colloquium «Hormones. Biochemistry of the liver. Integration of metabolism»	-	-	3	3	written colloquium, control questioning
9.	Biochemistry of organs and tissues	1.33	0.66	6	4	
9.1.	<i>Biochemistry of the blood</i>	1.33	0.66	6	4	
	Biochemistry of the blood. System of hemostasis	1.33	0.66	-	-	
	Biochemistry of the blood. Physical and chemical properties of the blood. Hemoglobinoses Lab. work: Studying of serum buffer properties. Determination of chlorides in serum	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
	Blood plasma proteins. System of hemostasis. Lab. work: Separation of serum proteins by electrophoresis on acetylcellulose. Determination of calcium in plasma	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
10.	Biochemistry of nutrition	3.99	1.32	9	7	
10.1.	<i>Essential nutritive factors. Vitamins. Causes and biochemical characteristics of protein-energy malnutrition</i>	2.66	0.66	3	2	
	Biochemistry of nutrition	1.33	0.66	-	-	
	Biochemistry of nutrition. Vitamins	1.33	-	-	-	
	Biochemistry of nutrition. Role of proteins, fats, carbohydrates, vitamins Lab. work: Qualitative reactions for vitamins. Determination of vitamin C in urine	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
10.2	<i>Water and mineral salts. Calcium and phosphorus metabolism. Microelements</i>	1.33	0.66	6	5	

	Biochemistry of nutrition. Water and mineral metabolism	1.33	0.66	-	-	-
	Biochemistry of nutrition. Mineral substances. Regulation of water and mineral balance. Lab. work: Determination of sodium and potassium in serum	-	-	3	2	interviews, written accounts of laboratory work, electronic testing
	Colloquium «Biochemistry of nutrition. Biochemistry of the blood. Water and mineral metabolism»	-	-	3	3	written colloquium, control questioning
9.	Biochemistry of organs and tissues	-	1.98	6	6	
9.3.	<i>Biochemistry of the muscles</i>	-	<i>0.66</i>	-	<i>1</i>	<i>electronic testing</i>
9.4.	<i>Biochemistry of the connective tissues</i>	-	<i>0.66</i>	-	<i>1</i>	<i>electronic testing</i>
9.5.	<i>Biochemistry of the nervous tissue</i>	-	<i>0.66</i>	-	<i>1</i>	<i>electronic testing</i>
9.6.	<i>Biochemistry of kidney and urine</i>	-	-	6	3	
	Biochemistry of the urine Lab. work: Determination of the urine physiological and pathological components	-	-	3	1	interviews, written accounts of laboratory work, electronic testing
	Control over practical skills of biochemical analysis. Analysis of gastric juice and urine Identification and assessment of students' knowledge on the discipline «Biological Chemistry»	-	-	3	2	written accounts of laboratory work with oral defense Examination, electronic testing
	Total hours	32	16	105	75	

INFORMATION AND INSTRUCTIONAL UNIT**LITERATURE****Basic:**

1. Textbook Biological Chemistry. Lecture notes/ A. D. Taganovich, I. L. Kotovich, A. V. Kolb, N. N. Kovganko, T. Yu. Prinkova – Minsk, BSMU, 2017. – 162 p.
2. Gubsky, Yu. Biological Chemistry: textbook/ ed. Yu. Gubsky. – Vinnitsia : Nova Knyha, 2017. – 488 p.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

The time allowed for independent work can be used by students for:
preparation for lectures and laboratory classes;
preparation for colloquia, tests and exam in the academic discipline;
research practice and creative tasks;
preparation of thematic reports, abstracts, presentations;
taking notes of original sources.

The main methods of organizing independent work:
preparation and presentation of abstracts;
presentation of reports;
computer testing.

Control of independent student work can be carried out in the form of:
final class, colloquium in the form of written work, testing;
discussion of abstracts;
defense of educational assignments;
assessment of an oral reply to a question, presentation, report or problem solving;
checking up abstracts, written reports;
individual interview.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF SUPERVISED STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

Main forms of supervised student independent work:
studying topics and problems that have not been discussed at the lectures.

Control of supervised student independent work is carried out in the form of:

final class, colloquium in the form of written work, testing;
individual interview.

LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms are used for competences assessment:

Oral form:

colloquiums;
interviews;
examination.

Written form:

control questioning;
written accounts of laboratory work.

Oral-written form:

accounts of laboratory work with oral defense;
credit.

Technical form:

electronic testing.

LIST OF AVAILABLE TEACHING METHODS

Traditional method (lecture, laboratory practicals);

Active (interactive) methods:

- Problem-Based Learning (PBL);
- Case-Based Learning (CBL).

LIST OF PRACTICAL SKILLS

1. Quantitative determination of protein, glucose, cholesterol, bilirubin, calcium, sodium and potassium ions in blood serum.
2. Analysis of gastric juice.
3. Qualitative determination of pathological components in urine: ketone bodies, glucose, protein, blood pigments.
4. Quantitative determination of pathological components in urine: glucose, protein.

LIST OF EQUIPMENT USED

Centrifuge, thermostat, photoelectric colorimeter, fume hood, laboratory ware, automatic pipettes, pipette-holders.

LIST OF LECTURES**3 semester**

1. Introduction to biochemistry. Structure and functions of proteins.
2. Introduction to enzymology.
3. Enzymology (continuation).
4. Introduction to metabolism and energy exchange. The central metabolic pathways. Oxidative decarboxylation of pyruvate.
5. The central metabolic pathways: citric acid cycle. Tissue respiration. Oxidative phosphorylation.
6. Carbohydrate metabolism. Glycogen metabolism. Anaerobic glucose oxidation.
7. Carbohydrate metabolism. Aerobic glucose oxidation. Gluconeogenesis.
8. Lipid metabolism. Lipids digestion and absorption. Transport of exogenous lipids. Lipid re-synthesis.
9. Transport of endogenous lipids. Mechanisms of atherosclerosis development.
10. Intracellular metabolism of fatty acids. Ketosis.
11. Protein metabolism. Intracellular amino acid metabolism.
12. Protein metabolism. Detoxification of ammonia.

4 semester

1. Metabolism of nucleic acids.
2. Matrix biosynthesis.
3. Modern techniques of molecular biology.
4. Introduction to endocrinology.
5. Biochemistry of hormones.
6. Biochemistry of hormones (continuation).
7. Biochemistry of the liver.
8. Integration of metabolism.
9. Biochemistry of the blood. System of hemostasis.
10. Biochemistry of nutrition.
11. Biochemistry of nutrition. Vitamins.
12. Biochemistry of nutrition. Water and mineral metabolism.

LIST OF LABORATORY (PRACTICAL) STUDIES**3 semester**

Lesson 1. Introduction to practical work. Introduction to biochemistry. The structure of amino acids and peptides. Determination of the protein content in biological fluids.

Lesson 2. Levels of organization of a protein molecule. Physical and chemical properties of proteins. Reactions of protein sedimentation.

Lesson 3. Methods of separation, isolation and purification of proteins. Gel-filtration.

Lesson 4. Enzymes. Classification, structure, properties. Effect of various factors on enzyme activity.

Lesson 5. Regulation of enzyme action. Determination of enzyme activity.

Lesson 6. Colloquium «The chemistry of proteins, enzymes».

Lesson 7. Introduction to metabolism. Central metabolic pathways (oxidative decarboxylation of pyruvate, citric acid cycle). Evaluation of TCA cycle functioning.

Lesson 8. Biological oxidation. Oxidative phosphorylation. Pathways of oxygen utilization by cells. Studying of oxidative phosphorylation.

Lesson 9. Digestion of carbohydrates. Glycogenesis and glycogenolysis. Glycolysis and alcoholic fermentation. Detection of alcoholic fermentation products.

Lesson 10. Metabolic pathways of pyruvate. Gluconeogenesis. Aerobic oxidation of glucose (CO_2 and H_2O). Determination of pyruvate in the urine.

Lesson 11. Secondary pathways of glucose metabolism. Metabolism of fructose and galactose. Determination of blood glucose.

Lesson 12. Colloquium «Introduction to metabolism. Central metabolic pathways. Biological oxidation. Carbohydrate metabolism».

Lesson 13. Lipid metabolism: digestion, absorption, re-synthesis. Transport of exogenous lipids. Evaluation of lipase activity.

Lesson 14. Lipid transport in blood. Cholesterol metabolism. Storage and mobilization of lipids. Determination of plasma β -lipoproteins.

Lesson 15. Intracellular metabolism of fatty acids. Ketone bodies. Determination of cholesterol in serum.

Lesson 16. Colloquium «Lipid metabolism».

Lesson 17. Control over practical skills of biochemical analysis: Color reactions for protein and amino acids, determination of total protein in serum by biuret method.

Lesson 18. Final lesson «The chemistry of proteins, enzymes. Biological oxidation. Carbohydrate metabolism and functions. Lipid metabolism and functions».

4 semester

Lesson 1. Digestion and absorption of proteins. Analysis of gastric juice.

Lesson 2. Intracellular amino acid metabolism. Detoxification of ammonia. Abnormalities of amino acid metabolism. Determination of non-protein nitrogen in blood and urea in urine.

Lesson 3. Nucleoproteins chemistry and metabolism. Determination of uric acid in urine.

Lesson 4. Matrix biosyntheses (synthesis of DNA, RNA, proteins). Analysis of yeast nucleoprotein hydrolysis products.

Lesson 5. Colloquium «Simple proteins and nucleoproteins metabolism. Synthesis of DNA, RNA and proteins».

Lesson 6. Hormones. General characteristic and peculiarities of biological action. Qualitative reactions for hormones.

Lesson 7. Biochemistry of hormones. Glucose tolerance test.

Lesson 8. Biochemistry of the liver. Determination of total bilirubin in serum.

Lesson 9. Integration of metabolism. Effects of hormones on blood glucose level.

Lesson 10. Colloquium «Hormones. Biochemistry of the liver. Integration of metabolism».

Lesson 11. Biochemistry of the blood. Physical and chemical properties of the blood. Hemoglobinoses. Studying of serum buffer properties. Determination of chlorides in serum.

Lesson 12. Blood plasma proteins. System of hemostasis. Separation of serum proteins by electrophoresis on acetylcellulose. Determination of calcium in plasma.

Lesson 13. Biochemistry of nutrition. Role of proteins, fats, carbohydrates, vitamins. Qualitative reactions for vitamins. Determination of vitamin C in urine.

Lesson 14. Biochemistry of nutrition. Mineral substances. Regulation of water and mineral balance. Determination of sodium and potassium.

Lesson 15. Colloquium «Biochemistry of nutrition. Biochemistry of the blood. Water and mineral metabolism».

Lesson 16. Biochemistry of the urine. Determination of the urine physiological and pathological components.

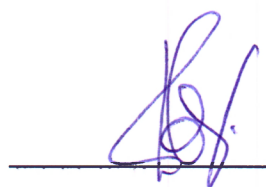
Lesson 17. Control over practical skills of biochemical analysis. Analysis of gastric juice and urine.

**PROTOCOL OF THE CURRICULUM APPROVAL
BY OTHER DEPARTMENTS**

Title of the discipline requiring approval	Department	Amendments to the curriculum in the academic discipline	Decision of the department, which designed the curriculum (date, protocol #)
1. Pharmacology	Pharmacology	No proposals and remarks	20.05.2022, protocol # 9
2. Pathological Physiology	Pathological Physiology	No proposals and remarks	20.05.2022, protocol # 9

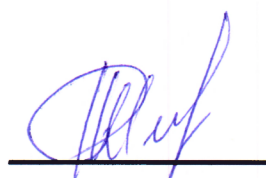
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Curriculum content, composition and the accompanying documents comply with the established requirements.

Dean of the Medical Faculty for International Students of the educational institution «Belarusian State Medical University»

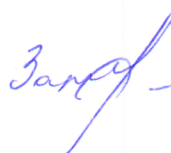
28.06. 2022



O.S. Ishutin




Methodologist of the educational institution «Belarusian State Medical University»

28.06. 2022



S.V. Zaturanova

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LIST OF LECTURES**3 semester**

1. Introduction to biochemistry. Structure and functions of proteins.
2. Introduction to enzymology.
3. Enzymology (continuation).
4. Introduction to metabolism and energy exchange. The central metabolic pathways. Oxidative decarboxylation of pyruvate.
5. The central metabolic pathways: citric acid cycle. Tissue respiration. Oxidative phosphorylation.
6. Carbohydrate metabolism. Glycogen metabolism. Anaerobic glucose oxidation.
7. Carbohydrate metabolism. Aerobic glucose oxidation. Gluconeogenesis.
8. Lipid metabolism. Lipids digestion and absorption. Transport of exogenous lipids. Lipid re-synthesis.
9. Transport of endogenous lipids. Mechanisms of atherosclerosis development.
10. Intracellular metabolism of fatty acids. Ketosis.
11. Protein metabolism. Intracellular amino acid metabolism.
12. Protein metabolism. Detoxification of ammonia.

4 semester

1. Metabolism of nucleic acids.
2. Matrix biosynthesis.
3. Modern techniques of molecular biology.
4. Introduction to endocrinology.
5. Biochemistry of hormones.
6. Biochemistry of hormones (continuation).
7. Biochemistry of the liver.
8. Integration of metabolism.
9. Biochemistry of the blood. System of hemostasis.
10. Biochemistry of nutrition.
11. Biochemistry of nutrition. Vitamins.
12. Biochemistry of nutrition. Water and mineral metabolism.