Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Institution of Higher Education
"National Research Nuclear University "MEPhI"

INSTITUTE OF ENGINEERING PHYSICS FOR BIOMEDICINE

DEPARTMENT OF FUNDAMENTAL MEDICINE

APPROVED НТС ИФИБ

Protocol No. 3.1

dated 30.08.2024

ACADEMIC COURSE OUTLINE

БИОХИМИЯ / BIOCHEMISTRY

Educational program track (speciality) [1] 31.05.01 General Medicine

Semester	**Labour input, credits**	**Total course academic, hours**	**Lectures, hrs.**	**Practical sessions, hrs.**	**Laboratory sessions, hrs.**	**In the form of practical studies, hrs.**	**Independent studies, hrs.**	**Independent studies monitoring, hrs.**	**Course progress, Exam/Pass-fail exam/Term**
3	3	108	34	0	56		18	0	PFE
4	5	180	14	0	50		62	0	Ex
Total	8	288	48	0	106	0	80	0	

ABSTRACT

The discipline is a fundamental medical and biological course that studies the processes of the human body at the molecular level. Biochemistry lies at the intersection of organic chemistry and biology and represents a dynamic field of chemistry dedicated to metabolism and its regulation. Biochemistry also encompasses many aspects of cell biology, genetics, and epigenetic regulation.

The knowledge acquired through the study of this discipline is essential for developing the ability of a future physician to assess the morphofunctional and physiological states, as well as pathological processes in the human body, in order to solve professional tasks.

1. ACADEMIC COURSE GOALS AND OBJECTIVES

The goal of studying the discipline: to develop systematized knowledge in the field of biological chemistry regarding the fundamental principles of the molecular organization of the cell, tissues, and the organism as a whole.

Objectives of studying the discipline:

• to develop a system of knowledge about the fundamental patterns of metabolic processes, the regulation of metabolism, and its relationship with the functional activity of living systems;

• to develop a system of knowledge about methods of biochemical research and the ability to use their results to assess human health;

• to develop the ability to understand the pathogenetic mechanisms of pathological process development, taking into account the main types of inherited metabolic defects;

• to develop the ability to apply the acquired knowledge, skills, and competencies while studying subsequent fundamental medical and clinical disciplines, as well as to assess morphofunctional and physiological states and pathological processes in the human body for solving professional tasks;

• to develop knowledge and skills related to the principles of clinical and laboratory technologies and practical skills for working with them.

2. PLACE OF THE ACADEMIC COURSE IN THE MAIN HIGHER EDUCATION CURRICULUM

The study of this discipline is based on the knowledge, skills, and competencies acquired through such courses as medical and biological physics, chemistry (organic), biology, anatomy, and histology.

The knowledge, skills, and competencies gained as a result of studying this discipline are essential for the subsequent successful mastery of pharmacological disciplines, as well as for the study of clinical medicine.

3. DEVELOPED COMPETENCIES AND INTENDED LEARNING OUTCOMES

Universal and/or general professional competencies:

Competency code and title	**Code and title of competency-based rubrics**
ОПК-5 [1] – Capable of assessing	З-ОПК-5 [1] – Know: - basic medical, pharmaceutical, and

morphofunctional and physiological states, as well as pathological processes in the human body to solve professional tasks.	morphofunctional terminology, including Latin terms; - structure and functions of the human body, age-related, gender-specific, and individual characteristics of the structure and development of a healthy organism; - physical and chemical nature of processes occurring in a living organism; - patterns of vital activity of the organism, mechanisms of self-regulation and regulation; - features of regulation of the functioning of human body systems in pathological conditions; - patterns of occurrence, development, and outcome of typical pathological processes, the concept of sanogenesis; - etiology and pathogenesis of the most common diseases; - the concept of nosology, principles of disease classification; - principles of microorganism classification, their morphology, physiology, and impact on human health; - structure and functions of the human immune system. У-ОПК-5 [1] – Be able to: - analyze mechanisms of disease development and manifestation; - recognize morphological and functional changes in cells, tissues, organs, and systems of the human body; - use basic physical-chemical and other natural science concepts and methods in solving professional tasks; - determine the cause of death and formulate a pathological diagnosis. В-ОПК-5 [1] – Possess skills in: - conducting microscopy and analyzing microscopic specimens; - correlating morphological and clinical manifestations of diseases; - assessing morphofunctional, physiological states, and pathological processes in humans; - clinical-anatomical analysis of autopsy results.

4. PEDAGOGIC POTENTIAL OF THE COURSE

Pedagogic tracks/objectives	**Pedagogic goals (code)**
Intellectual education	Establishing conditions for: formation of culture of intellectual work (B11)
Vocational and labor education	Establishing conditions for: formation of a deep understanding of the profession's social role, a positive and active commitment to the values of the chosen specialty, and a responsible attitude towards professional activity and work (B14)

5. ACADEMIC COURSE STRUCTURE AND CONTENT

Academic course sections, their scope, terms of study and assessment:

No.	Academic course section name	Weeks	Lectures/ Practical (seminars)/ Laboratory sessions, hrs.	Compulsory current assessment (form*, week)	Maximum grade per section**	Section assessment (form*, week)	Competency-based rubrics
	3 Semester						
1	The First Section	1-5	10/0/18	Cq-5 (15)	15	Cq-5	З-ОПК-5, У-ОПК-5, В-ОПК-5
2	The Second Section	6-10	12/0/18	Cq-10 (15)	15	Cq-10	З-ОПК-5, У-ОПК-5, В-ОПК-5
3	The Third Section	11-16	12/0/20	Cq-15 (20)	20	Cq-16	З-ОПК-5, У-ОПК-5, В-ОПК-5
	Totals for 3 Semester		34/0/56		50		
	Assessment events for 3 Semester				50	PFE	З-ОПК-5, У-ОПК-5, В-ОПК-5
	4 Semester						
1	The First Section	1-5	4/0/15	Cq-4 (15)	15	Cq-5	З-ОПК-5, У-ОПК-5, В-ОПК-5
2	The Second Section	6-10	4/0/15	Cq-10 (15)	15	Cq-10	З-ОПК-5, У-ОПК-5, В-ОПК-5
3	The Third Section	11-15	6/0/20	Cq-15 (20)	20	Cq-15	З-ОПК-5, У-ОПК-5, В-ОПК-5
	Totals for 4 Semester		14/0/50		50		
	Assessment events for 4 Semester				50	Ex	З-ОПК-5, У-ОПК-5, В-ОПК-5

* – abbreviated name of assessment

** – 100 maximum points per semester including a pass/fail exam and (or) an exam

Abbreviated current assessment forms and section assessment

Abbreviation	Full name
Cq	Colloquium
PFE	Pass/fail examination
Ex	Exam

SYLLABUS

Weeks	Topics / Content	Lect., hrs.	Pr./sem., hrs.	Lab., hrs.

	3 Semester	34	0	56
1-5	**The First Section**	10	0	18
1 - 5	**Amino Acids. Proteins. Enzymes. Nucleic Acids.** Amino Acids. Proteins. Enzymes. Nucleic Acids. Structure, classification, and significance of amino acids. Functions of peptides and proteins in the human body. Levels of organization of the protein molecule and the chemical bonds involved in their formation. Complex proteins: hemoglobin and myoglobin. Characteristics of enzymes: structure, active site, cofactors and coenzymes. Classification and nomenclature of enzymes. Mechanism of enzyme–substrate interaction. Stages of the enzymatic reaction. Enzyme kinetics, the Michaelis–Menten equation. Influence of substrate and enzyme concentration, pH, and temperature on the rate of the enzymatic reaction. Regulation of enzymatic activity: allosteric site and effector, feedback regulation, regulatory proteins. Inhibition of enzymatic activity: competitive, noncompetitive, irreversible. The concept of isoenzymes and abzymes, and the use of enzymes in medicine. The Central Dogma in biochemistry. Purine and pyrimidine nucleotides: structure, functions, and role in the organism. Cyclic nucleotides and their isomers. Oligonucleotides and polynucleotides: structure, bonds, DNA and RNA. Chromosomes: levels of DNA organization, nucleosomes, chromatosomes, and histones. DNA replication: replication fork, Okazaki fragments, enzyme complex. DNA polymerase: active sites, cofactors, mechanism of action. Replication error correction, exonuclease activity of DNA polymerase.	All 10 Online 0	 0 0	 18 0
6-10	**The Second Section**	12	0	18
6 - 10	**Membranes. Transport. Carbohydrates. Hormones. Diabetes.** Membranes. Transport. Carbohydrates. Hormones. Diabetes. Structure of biological membranes: membrane lipids, carbohydrates, and proteins. Properties of membranes: microviscosity, asymmetry, fluidity. Membrane transport. Ion channels and transporters. Primary active transport. Structure of the Na^+,K^+-ATPase. Secondary active transport. Endocytosis and exocytosis. Significance of carbohydrates. Structure and functions of carbohydrates: monosaccharides, disaccharides, polysaccharides. Derivatives of monosaccharides – acetylhexosamine, glucuronic acid. Disorders of carbohydrate metabolism. Blood lipoproteins: classification, structure, stages of biosynthesis. Apolipoproteins: classification, functions. Transport of dietary triacylglycerols in the body. Chylomicrons: lipid composition, structure, functions. The role of lipoprotein lipase in chylomicron metabolism. Hormones. Hierarchy of regulatory systems. Classification of hormones by chemical structure. Cellular signaling. Plasma membrane and intracellular receptors. Secondary messengers. Adenylate cyclase mechanism of hormone action. G-protein–coupled receptors. Tyrosine kinase and guanylyl cyclase receptors,	All 12 Online 0	 0 0	 18 0

	ligand-gated ion channels, adhesion and nuclear receptors. Receptors associated with tyrosine kinase activity. Cytosolic mechanism of hormonal signaling: hormones, features of intracellular receptors, stages. Hypothalamic–pituitary–adrenal axis. Glucocorticoids. Hypo- and hyperproduction of glucocorticoids (metabolic disorders, biochemical aspects, principles of treatment). Insulin: biological role, main stages of synthesis, regulation of secretion, mechanism of action, molecular effects (metabolic and mitogenic pathways). Insulin: very rapid, rapid, slow, and very slow effects. Enzymatic cascade associated with Ras-protein activation: its scheme, sequence of events, key participants, role in cellular metabolism. Enzymatic cascade associated with activation of phosphoinositide-3-kinase and protein kinase B. Insulin-dependent glucose transporter. Effects of insulin on carbohydrate, lipid, and protein metabolism. Type I and Type II diabetes mellitus. Causes of absolute and relative insulin deficiency. Similarities and differences in metabolic disturbances in Type I and Type II diabetes. Biochemical mechanisms of clinical manifestations. Causes of insulin resistance. Complications of diabetes mellitus. Biochemical tests in the diagnosis of diabetes. Vitamin A: sources, structure, active forms, functions, clinical manifestations of hypo- and hypervitaminosis. Retinoic acid, its receptors, and its role in cell differentiation.			
11-16	**The Third Section**	12	0	20
11 - 16	**Carbohydrate Metabolism: Catabolism, Biosynthesis, Gluconeogenesis, Regulation. ATP Synthesis** Carbohydrate Metabolism: Catabolism, Biosynthesis, Gluconeogenesis, Regulation. ATP Synthesis Transport of monosaccharides across membranes. Glucose transporters: types, structures, functions. Pathways of glucose metabolism. Phosphorylation of glucose. The role of glucose-6-phosphate. Glucose metabolism in the liver: the role of glucokinase and glucose-6-phosphatase in maintaining blood glucose levels. Biosynthesis and catabolism of glycogen. Features of glycogen metabolism in the liver and muscles under specific physiological conditions. Hormonal regulation of these processes. Glycogen storage diseases: causes, classification, clinical manifestations. Pathways of glucose catabolism. The key role of glucose-6-phosphate. Glycolysis: localization, stages and their characteristics, irreversible reactions of glycolysis, end products. Substrate-level phosphorylation in glycolysis. Anaerobic glycolysis. Glucose breakdown under aerobic conditions, energy yield. Gluconeogenesis: tissue localization, substrates, bypass of irreversible glycolysis reactions, energy requirements, overall equation. The role of gluconeogenesis during fasting and physical exercise. Reciprocal regulation of glycolysis and gluconeogenesis (hormonal and allosteric) and its significance. The glucose–lactate cycle (Cori cycle). The glucose–alanine cycle. The pentose phosphate pathway of glucose oxidation: tissue	All 12 Online 0	0 0	20 0

	localization and role. Stages of the pentose phosphate pathway. Interaction with glycolysis. The role of the pentose phosphate pathway in adipocytes, erythrocytes, and dividing cells. Inherited glucose-6-phosphate dehydrogenase deficiency: causes, clinical manifestations. Features of glucose metabolism in the liver, brain, skeletal muscles, adipose tissue, and erythrocytes. Hormonal regulation of carbohydrate metabolism. Characteristics of physiological and pathological hyperglycemia and hypoglycemia. Oxidative decarboxylation of pyruvate: stages, regulation, vitamins as cofactors. Structure of the pyruvate dehydrogenase complex. The tricarboxylic acid cycle: reactions, substrate-level phosphorylation and oxidative decarboxylation, role and regulation of the cycle. High-energy compounds: classification, ATP as the universal "energy currency." Pathways of ATP synthesis: substrate-level and oxidative phosphorylation. Oxidative phosphorylation of ADP. Mechanism of coupling between oxidation and phosphorylation. Structure of the electron transport chain: components, complexes, arrangement in the inner mitochondrial membrane. Structure of ATP synthase and the mechanism of ATP synthesis. Regulation of oxidative phosphorylation. Uncoupling of oxidation and phosphorylation. Physiological significance. UCP proteins. Molecular-biological aspects of mitochondrial function and dysfunction.			
	4 Semester	14	0	50
1-5	**The First Section**	4	0	15
1 - 5	**Lipids. Fatty Acids. Bile Acids. Cholesterol. Ketone Bodies. Ketoacidosis. High- and Low-Density Lipoproteins** Resynthesis of triacylglycerols, cholesterol esters, and phospholipids. Synthesis of fatty acids from glucose: glucose as a precursor of acetyl-CoA, the role of citrate and biotin, synthesis of malonyl-CoA. Structure of fatty acid synthase, mechanism of palmitate synthesis, regulation of the process. Synthesis of phosphatidic acid from glycerol-3-phosphate and fatty acids: intracellular localization, sources of glycerol-3-phosphate and energy, sequence of reactions, interaction with carbohydrate metabolism, metabolic pathways of phosphatidic acid. Reactions of triacylglycerol synthesis (lipogenesis). Lipolysis: localization, mechanism, end products and their fate, hormonal regulation. Reactions of fatty acid oxidation to carbon dioxide and water: the role of carnitine, localization, reactions of β-oxidation, the role of vitamins and cofactors. Calculation of the energy yield from β-oxidation of palmitic acid. Synthesis of ketone bodies: tissue localization, biological role, and regulation. The role of oxaloacetate deficiency in activating ketogenesis. Catabolism of ketone bodies and its significance. Ketoacidosis during fasting and diabetes mellitus. Chemical structure and biological role of cholesterol. Biosynthesis of cholesterol. Synthesis of mevalonate. Interaction with carbohydrate metabolism. Regulation of cholesterol synthesis. Bile acids: classification, structure, and physiological role. Stages of their synthesis, the role of	All 4 Online 0	0 0	15 0

	vitamins. Primary, secondary, and conjugated bile acids. Enterohepatic circulation. Sources of triacylglycerol in the liver. Very-low-density lipoproteins (VLDL): lipid composition, structure, functions, apolipoproteins. The role of lipoprotein lipase in VLDL metabolism. Localization and role of the apoB-100 receptor. The role of receptor-mediated endocytosis of low-density lipoproteins (LDL). Acyl-CoA: cholesterol acyltransferase and its role. Transport of cholesterol and cholesterol esters in the blood. The role of HDL and LDL. Lecithin–cholesterol acyltransferases and their role. ω-3 polyunsaturated fatty acids: examples, structure, properties, biological role. Eicosanoids: prostaglandins, thromboxanes, leukotrienes. Biological role and synthesis scheme. The role of phospholipase A_2, cyclooxygenase, and lipoxygenase. Regulation of eicosanoid synthesis.			
6-10	**The Second Section**	4	0	15
6 - 10	**Nitrogen Balance. Transamination Reactions. Amino Acid Transport. Sources of Ammonia in Tissues. Purine and Pyrimidine Nucleotides. Liver. Bile. Xenobiotics** Nitrogen Balance. Transamination Reactions. Amino Acid Transport. Sources of Ammonia in Tissues. Purine and Pyrimidine Nucleotides. Liver. Bile. Xenobiotics Nitrogen balance. Negative and positive nitrogen balance. Nitrogen equilibrium. Physiological and pathological conditions associated with different nitrogen balance states. Nitrogen balance in children. Protein digestion in the stomach and intestine. Mechanism of gastric acid synthesis and its biological role. Disorders of HCl production. Enzymes of gastric juice, pancreatic juice, and intestinal juice involved in protein digestion. Protein putrefaction. Sources and pathways of amino acid utilization in tissues. Glucogenic and ketogenic amino acids. Fate of α-keto acids (pyruvate, oxaloacetate, α-ketoglutarate). Calculation of the energy yield from amino acid catabolism leading to final metabolic products. Deamination of amino acids: direct and indirect oxidative deamination, reductive amination. Transamination reactions. Synthesis of biogenic amines (γ-aminobutyric acid, histamine, serotonin, dopamine) and their roles. Catabolism of biogenic amines: deamination by monoamine oxidase and methylation reactions. Ammonia toxicity. Transport forms of ammonia in the blood; reactions of their formation. Glucose–alanine cycle. Role of the liver, kidneys, and intestine in ammonia binding and excretion. Urea cycle. Interaction with the tricarboxylic acid cycle. Diagnostic significance of blood and urinary urea levels. Hyperammonemias, their causes and consequences. Physiological blood ammonia concentration. Causes of ammonia poisoning. Purine and pyrimidine nucleotides. Sources of nitrogen and carbon atoms in the purine ring. Scheme of purine nucleotide synthesis and its regulation. Synthesis of 2'-deoxyribonucleotides: enzymes, role of NADPH and thioredoxin. Mechanism of dTMP synthesis. Role of folic acid	All 4 Online 0	0 0	15 0

	and tetrahydrofolate. Megaloblastic anemia and folic acid deficiency. Mechanism of antibacterial activity of sulfonamides. Inhibitors of thymidylate synthesis. Catabolism of purine nucleotides: degradation of AMP and GMP; salvage pathways for hypoxanthine and guanine; synthesis of uric acid from hypoxanthine and xanthine; role of xanthine oxidase. Primary and secondary hyperuricemias. Pathways of glycine and serine metabolism. Interaction of glycine, serine, methionine, and cysteine metabolism. Role of vitamins B_6, B_9, and B_{12}. Mechanism of serine–glycine interconversion. Synthesis of methylene- and methyl-tetrahydrofolate, S-adenosylmethionine, homocysteine. Role of S-adenosylmethionine in transmethylation reactions. Mechanism of homocysteine conversion into cysteine. Metabolism of phenylalanine and tyrosine. Anabolic and catabolic pathways of tyrosine. Conversion of phenylalanine to tyrosine. Pathways of tyrosine conversion into catecholamines. Metabolism of arginine. Arginine as a precursor of urea, creatine, nitric oxide (NO). Synthesis of polyamines. Synthesis of creatine and creatine phosphate in various tissues. Biological role of creatine phosphate. Role of the liver in the metabolism of proteins and other nitrogen-containing compounds. Diagnostic tests (urea, creatinine, plasma proteins), physiological ranges, and clinical significance. Plasma proteins: albumins, α_1- and α_2-globulins, β-globulins, γ-globulins. Acute-phase proteins. Role of the liver in carbohydrate metabolism: maintenance of blood glucose homeostasis, hormonal and metabolic regulation. Role of the liver in lipid metabolism: main stages of triacylglycerol, cholesterol, and phospholipid synthesis; their hormonal and metabolic regulation; lipoproteins synthesized in the liver. Fatty liver disease and its causes. Role of the liver in digestion. Composition of bile and its function. Structure and types of bile acids and reactions of their synthesis. Causes and consequences of impaired bile synthesis and secretion. Biotransformation of xenobiotics and endogenous toxins in the liver. Role of the liver in the overall pathway of xenobiotic metabolism; interaction with other organs. Microsomal oxidation. NADPH-dependent and NADH-dependent pathways. Sources of NADH and NADPH; components of the electron transport chain of the microsomal system. Role of cytochrome P450. Substrates of microsomal oxidation; inducers and inhibitors. Conjugation reactions in detoxification. Structure of UDP-glucuronic acid and phosphoadenosine-phosphosulfate. Reactions of conjugated bilirubin and indican formation. Glycine conjugation and its role. Ethanol metabolism. Heme synthesis. Formation of porphobilinogen, scheme of protoporphyrin IX synthesis and its conversion into heme. Role of ferrochelatase. Hemoglobin degradation and bilirubin formation in the reticuloendothelial system. Transport of bilirubin to the liver and stages of its			

	metabolism. Iron metabolism: daily requirements, dietary sources, absorption mechanisms, transport in the blood, transmembrane transport mechanism, storage forms. Iron-containing proteins. Regulation of iron metabolism. Role of hepcidin and cytokines.			
11-15	**The Third Section**	6	0	20
11 - 15	**Iron. Bilirubin. Blood. Kidneys. Muscles. White and Brown Adipose Tissue. Connective Tissue — Section Title** Iron. Bilirubin. Blood. Kidneys. Muscles. White and Brown Adipose Tissue. Connective Tissue — Section Title Renal metabolism: metabolic processes in the renal cortex and medulla, aerobic and anaerobic oxidation. Gluconeogenesis. Role of the kidneys in the synthesis of biologically active substances. Process of urine formation. Water balance: role of organs in water elimination, factors determining water balance in the body. Regulation of water reabsorption. Role of antidiuretic hormone. Hypoproduction of antidiuretic hormone and its clinical manifestations. Renin–angiotensin–aldosterone system and its role in sodium reabsorption. Role of the kidneys in maintaining acid–base balance — bicarbonate reabsorption, secretion of H^+ and ammonium, excretion of organic acids. General properties of urine. Organic, inorganic, and pathological components of urine. Muscle proteins: structure of myofibrils and myofibrillar proteins; structure and properties of myosin. Enzymatic activity of myosin. Thin (actin) filaments: structure and composition. Structure of the thick filament. Features, stages, and chemistry of muscle contraction. Functions of troponin subunits. Regulation of muscle contraction and relaxation. Tetanus and rigor mortis. Biochemical characteristics of smooth muscle; regulation of contractility and relaxation. Structural and metabolic features of the myocardium. Role of oxygen in the myocardium and metabolic disturbances in ischemic heart disease. Influence of reactive oxygen species and lipid peroxidation on the myocardium. Markers of acute myocardial infarction and heart failure. White adipose tissue: functions. Features of carbohydrate and lipid metabolism in white adipocytes. Endocrine function of white adipose tissue. Brown and beige adipose tissue: functions. Metabolic characteristics of brown and beige adipocytes. Connective tissue proteins: classification, functions. Structure and function of collagen, elastin, and fibronectin. Stages of collagen fiber formation. Matrix metalloproteinases. Role of vitamins and minerals. Scurvy. Glycosaminoglycans of connective tissue. Biochemical markers of connective tissue damage. Iron deficiency and iron overload: causes, biochemical effects, and clinical manifestations. Hemochromatosis. Iron deficiency states. Carbon dioxide transport. Role of carbonic anhydrase. Influence of erythrocyte processes on plasma bicarbonate	All 6 Online 0	0 0	20 0

	concentration. Mechanism of hemoglobin–heme binding with oxygen and its role in acid–base regulation. Acid–base balance of blood. Importance of constant H^+ concentration. Sources of H^+ ions in cells. Main indicators of acid–base balance and their normal ranges. Influence of the liver, stomach, pancreas, and intestines on the acid–base state of the body. Blood buffer systems. Major types of acid–base disorders and their causes. Hemostasis system: role and components. Anticoagulant properties of intact endothelium. Procoagulant properties of damaged endothelium and the subendothelial layer. Role of platelets in blood coagulation. Platelet receptors, their ligands, and functions. Vascular–platelet hemostasis and its stages. Mechanism of platelet activation. General characteristics of secondary hemostasis. Plasma coagulation proteins. Cell-based model of coagulation. Anticoagulants: characteristics, functions, and role. Main components of the fibrinolytic system, physiological mechanism of activation. Fibrin degradation by plasmin and resulting degradation products.			

Abbreviated names of online options:

Abbreviation	**Full name**
EC	E-course
FtM	Full-text material
FtL	Full-text lectures
VM	Video materials
AM	Audio materials
Prs	Presentations
T	Tests
ERM	E-reference materials
IS	Interactive site

LABORATORY (LAB) SESSIONS TOPICS

Weeks	**Topics / Content**
	3 Semester
1 - 5	**Amino acids. Proteins. Enzymes. Vitamins.** Amino acids. Proteins. Enzymes. Vitamins. 1. Structure, functions, and properties of complex proteins. Hemoproteins. Study of complex protein molecules, their structural features, and the role of hemoproteins in biological processes. 2. Enzymes: Structure, Mechanisms of Action, Kinetics. Coenzymes A review of enzyme structure, their operating principles, reaction kinetics, and the role of coenzymes. 3. Regulation of enzyme activity. Isoenzymes. Enzyme diagnostics and enzyme therapy. Analysis of enzyme regulation mechanisms, their variations (isoenzymes), and applications in medicine. 4. Vitamins. Basic properties, functions, and importance of vitamins in the body
6 - 10	**Metabolism.** 1. General catabolic pathways. Description of the main stages of molecule breakdown for energy production. 2. ATP synthesis: substrate-level and oxidative phosphorylation. Mechanisms of energy

	production at the cellular level. 3. Oxidative stress. Cellular antioxidant systems. The influence of reactive oxygen species and cellular defense mechanisms. 4. Biological oxidation. Testing knowledge on biological oxidation. 5. Proteins and enzymes. Testing knowledge on proteins and enzymes.
11 - 16	**Carbohydrate Metabolism** Carbohydrate Metabolism 1. Carbohydrate Digestion. Glycogen Metabolism. The Processes of Carbohydrate Breakdown and Energy Storage as Glycogen 2. Glycolysis. Gluconeogenesis. The Main Pathways of Carbohydrate Energy Metabolism 3. Pentose Phosphate Pathway. Fructose and Galactose Metabolism. Alternative Carbohydrate Metabolic Pathways and Their Importance 4. Regulation of Blood Glucose Concentrations. Mechanisms for Maintaining Normal Glucose Levels 5. Carbohydrate Metabolism. Carbohydrate Metabolism Knowledge Test
	4 Semester
1 - 5	**Lipids** 1. Digestion and absorption of lipids. Fatty acid synthesis. Lipogenesis. 2. Metabolism of phospholipids and sphingolipids. Study of lipid processing and synthesis pathways. 3. Tissue lipolysis. Fatty acid oxidation. Ketone body metabolism. 4. Fat mobilization and energy utilization processes. 5. Cholesterol metabolism. Blood lipid transport. Serum lipoproteins. 6. Cholesterol metabolism and its transport involving lipoproteins 7. Dyslipoproteinemia. Atherosclerosis. Lipid metabolism disorders and their relationship with vascular diseases 8. Lipid metabolism. Lipid metabolism knowledge test
6 - 10	**Catecholamines. Liver Metabolism.** Catecholamines. Liver Metabolism. 1. Catecholamines. Non-classical endocrine organs and tissues. The role of the liver in carbohydrate, lipid, and protein metabolism. Endocrine functions and the metabolic role of the liver. 2. The role of the liver in pigment metabolism. Hemoglobin biosynthesis and breakdown. Porphyrias and thalassemias. Jaundice. Markers of cytolysis syndromes, cholestasis, and liver failure. 3. Review of pigment metabolism in the liver, hemoglobin synthesis and breakdown processes, and associated pathologies. 4. Blood biochemistry: oxygen transport, iron metabolism, anemia, acid-base balance 5. Blood functions and associated metabolic processes
11 - 16	**Hormones. Tissue Biochemistry.** Hormones. Tissue Biochemistry. 1. Hormones: Hierarchy of Regulatory Systems, Classification 2. Fundamentals of Hormonal Regulation and Mechanisms of Their Action 3. Tissue Biochemistry: Nervous, Muscular, Adipose, and Connective 4. Metabolic characteristics in different tissues of the body. 5. Biochemistry of the liver and blood. 6. Tissue biochemistry. Testing knowledge of tissue biochemistry.

6. EDUCATIONAL TECHNOLOGIES

Mastery of the subject is achieved through educational technologies such as lectures, seminars, and practical classes. The learning process incorporates elements of dialogue and discussion, as well as multimedia tools to enhance material comprehension. Students prepare and present reports on assigned topics, including visual materials such as drawings, photographs, tables, graphs, diagrams, charts, audio and video materials. The educational process emphasizes discussion of current topics, analysis of scientific articles, and the search for solutions to medical problems.

7. ASSESSMENT TOOLKIT

The assessment toolkit ensures verification of the intended learning outcomes achievement (competency-based rubrics) using current, midterm and interim assessment of the course.

The link between developed competencies and their assessment is presented in the following table:

Competency	**Achievement rubrics**	**Assessment activity (Syl 1)**	**Assessment activity (Syl 2)**
ОПК-5	З-ОПК-5	PFE, Cq-5, Cq-10, Cq-16, Кл-5, Кл-10, Кл-15	Ex, Cq-5, Cq-10, Cq-15, Кл-4, Кл-10, Кл-15
	У-ОПК-5	PFE, Cq-5, Cq-10, Cq-16, Кл-5	Ex, Cq-5, Cq-10, Cq-15, Кл-4
	В-ОПК-5	PFE, Cq-5, Cq-10, Cq-16, Кл-10, Кл-15	Ex, Cq-5, Cq-10, Cq-15, Кл-10, Кл-15

Educational achievement rubrics scales

The scale of each assessment activity varies from 0 to the maximum established point, inclusive. The final assessment of the course is performed on a 100-point scale and represents the sum of the points earned by the student in the section assessments, framework of current and interim assessment.

Sections and interim assessments are considered passed when the student achieves a minimum score equal to 60% of the maximum. The final grade is assigned only upon passing all sections and the interim assessment.

The final grade is assigned in accordance with the following scale:

Total score	**Rating on a 4-point scale**	**Pass/fail examination**	**ECTS assessment**
90-100	5 – *«excellent»*	*«pass»*	A
85-89	4 – «*good*»		B
75-84			C
70-74			D
65-69	3 – «*satisfactory*»		
60-64			E
below 60	2 – «*fail*»	*«fail»*	F

An “excellent” grade indicates a deep and solid mastery of the program material by a student who presents their answers consistently, clearly, and logically, is able to closely link theory with practice, and uses materials from monographic literature in their answers.

A “good” grade corresponds to a student’s solid knowledge of the material, who presents their answers competently and to the point, without any significant inaccuracies.

A “satisfactory” grade corresponds to the basic level of mastery of the material by the student, in which the main material has been mastered, but its details have not been assimilated, the answers contain inaccuracies, insufficiently correct wording and logical inconsistencies.

A grade “pass” corresponds to at least a basic level of mastery of the program material, in which the student possesses the necessary knowledge, skills, and abilities, and is able to apply theoretical principles to solve typical practical problems.

A grade “fail” is given to a student who lacks a significant understanding of the curriculum material, makes significant errors in their answers, or fails all required assignments. These students are generally unable to continue their studies without additional classes.

8. ACADEMIC COURSE EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT

CORE READING:

1. ЭИ С51 Chemistry: Medical aspects : tutorial guide : , Ponomareva N.I. , Ilinova T.N. , Poprygina T.D. , Москва: ГЭОТАР-Медиа, 2022

2. ЭИ Е80 Essential Biochemistry for Medical Students with Problem-Solving Exercises : учебник, , Москва: ГЭОТАР-Медиа, 2020

FURTHER READING:

1. ЭИ Е21 Biochemistry with exercises and tasks : , ed. by , V. V. , Москва: ГЭОТАР-Медиа, 2022

2. ЭИ Б63 Биологическая химия и биохимия полости рта. Ситуационные задачи и задания : учебное пособие, Глухов А.И., Москва: ГЭОТАР-Медиа, 2019

3. ЭИ Б63 Биохимия : учебник, Авдеева Л.В., Андрианова Л.Е., Алейникова Т.Л., Москва: ГЭОТАР-Медиа, 2020

4. ЭИ В12 Биохимия тканей и жидкостей полости рта : учебное пособие, Вавилова Т.П., Москва: ГЭОТАР-Медиа, 2019

5. ЭИ Ф 76 Органическая химия и основы биохимии. Практикум : учебное пособие для вузов, Тарасенко Е. В., Фоминых В. Л., Денисова О. Н., Москва: Юрайт, 2022

SOFTWARE:

No special softwares is required

LMS AND ONLINE RESOURCES

https://online.mephi.ru/

http://library.mephi.ru/

9. LOGISTICAL SUPPORT

1. Бинокулярные микроскопы "Микромед 2" (64-305)

2. Тринокулярный микроскоп "Микромед 3" (64-305)

3. Видеоокуляр ToupCam 10,0 MP (64-305)

4. Интерактивная доска SMART SBM 685 (64-405)

5. Мебель лабораторная, стулья, шкафы для хранения (64-405)

6. Мышь, клавиатура (64-405)

7. Персональный компьютер: Моноблок Lenovo V540-24IWL All-In-One 23,8" i3-8145U 8Gb 256GB_SSD_M.2 Intel (64-405)

8. Шкаф лабораторный вытяжной "Лабтех" ШВ202 (64-405)

9. Лабораторная посуда, приборы, реактивы (64-405)

10. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR STUDENTS

Lecture:

Taking lecture notes: briefly, schematically, and consistently record the main points, conclusions, definitions, and generalizations; mark important ideas and highlight key words and terms. Verify terminology and concepts using encyclopedias, dictionaries, and reference books, writing down definitions in a notebook. Identify questions, terms, or material that cause difficulties, mark them, and try to find answers in the recommended literature. If independent study does not help to clarify the material, it is necessary to formulate a question and ask the instructor during a consultation or in a practical class.

Independent Work:

Each student must individually prepare for the topics of the discipline by reading lecture notes and the recommended literature. Independent work allows the student to think calmly, analyze the information on the topic, and refer to reference sources when necessary. Careful reading and review of the material help fully absorb the topic and structure knowledge.

To ensure long-term retention of the material, it is advisable to study it step-by-step — by topics and in strict sequence, since subsequent topics usually rely on previous ones. For this reason, a large portion of independent work involves preparation for seminars, completion of assigned problem sets, preparation for colloquia, completion and defense of individual homework assignments, as well as preparation for laboratory work. To successfully complete these tasks, each student may use the methodological materials developed by the department.

Students are advised to plan their independent study time for the entire semester, ensuring regular review of previously covered material. Lecture notes should be regularly supplemented with information from the literature listed in the course syllabus. For each topic designated for independent study, the recommended literature should be read first, and, if necessary, a brief outline of the key points, terms, and essential information should be prepared — these are fundamental for mastering this topic and subsequent sections of the course. To expand knowledge, the use of online resources is encouraged.

While working independently, students are advised to take notes on the material. The notes may be concise, containing only key points yet sufficient for a complete answer, or detailed. The volume of notes is determined by the student.

When working with academic or scientific literature, students are encouraged to make notes during reading in the form of simple or extended outlines, compose theses, and prepare annotations of the material. Such notes may provide additional points for active participation.

Laboratory Classes:

Reviewing the course syllabus, with special attention to goals, objectives, structure, and content. Taking notes from sources. Working with lecture notes, preparing answers to control questions, reviewing recommended literature, and working with textbook texts. Listening to audio and video materials on the assigned topic, completing calculation and graphic assignments, solving problems according to algorithms, etc.

Written Assignment:

Becoming familiar with primary and additional literature, including reference sources and international publications; taking notes on key concepts, terms, and essential information required for memorization and fundamental to the topic. Preparing annotations to the reviewed literature sources, etc.

Term Paper (Essay):

Searching for literature and compiling a bibliography, using 3 to 5 scholarly works, presenting authors' viewpoints and one's own judgment on the chosen issue; covering the main aspects of the problem. Becoming familiar with the structure and formatting of an academic essay.

Preparation for Exam/Assessment:

When preparing for an exam (or assessment), students should rely on lecture notes, recommended literature, and other provided materials.

11. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR TEACHERS

During practical classes, students' mastery of lecture material is assessed; supervision of pregnant women is conducted in maternity hospitals and antenatal clinics; and practical skills are evaluated in examination rooms, procedure rooms, and operating theaters. Visual aids, surgical instruments, and an obstetric simulator are used to demonstrate and practice obstetric skills. To assess clinical thinking, students are offered situational tasks, clinical birth case histories, test assignments, clinical case discussions, attendance at medical conferences, consultations, and scientific symposia.

Active and interactive teaching methods are widely used in the educational process (small-group work, enhancement of creative activity, use of computer-based learning programs, class conferences).

The instructor monitors students' independent work, preparation of reports and research projects, work with patients under supervision, interpretation of additional diagnostic methods, and completion of medical documentation.

Students' initial level of knowledge is assessed through testing. Ongoing assessment of subject mastery is conducted through oral questioning during classes, clinical discussions, solving standard situational tasks, and responding to test questions.

At the end of the course, intermediate and final assessments are conducted using test-based evaluation, verification of practical skills, and solving situational tasks.

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