AL-FARABI KAZAKH NATIONAL UNIVERSITY
Faculty of Medicine and Healthcare
Higher School of Medicine
Department of Fundamental Medicine

PROGRAM
of final exam on discipline
Mechanisms of Defense and Health - 11 ECTS

Approved final exam form - written exam
Topics included in final exam:

BIOCHEMISTRY (7 ECTS)

1. The foundations of biochemistry
2. Biochemical Evolution. Protein Structure and Function
3. Enzymes: basic concepts and kinetics
4. Enzymes: catalytics strategies
5. Carbohydrates
6. Lipids & Cell membranes
7. Transducing & storing energy
8. Glycolysis & Gluconeogenesis
9. The Citric Acid Cycle. Oxidative phosphorylation.
10. The Pentose Phosphate Pathway: Glycogen metabolism
11. Fatty acid metabolism
12. Protein turnover and amino acid catabolism
13. The biosynthesis of amino acids
14. Nucleotide biosynthesis I
15. Nucleotide biosynthesis II
16. The Biosynthesis of Membrane Lipids and Steroids I
17. The Biosynthesis of Membrane Lipids and Steroids II
18. DNA Replication, Recombination, and Repair
19. Protein Synthesis I
20. Protein Synthesis II
21. The Integration of Metabolism I
22. The Integration of Metabolism II
23. Sensory Systems I
24. Sensory Systems II
25. Molecular Motors I
26. Molecular Motors II
27. DNA-based information technologies
28. Biochemistry of blood cells, kidneys and urine

IMMUNOLOGY (4 ECTS)

1. Introduction to Immunology
2. Innate immunity
3. Adaptive immunity
4. Major histocompatibility complex and its general organization
5. Antigens
6. Humoral factors of Immunity B-cell maturation
7. B cell development
8. Structure and functions of antibodies
9. The complement system

10. Cells of innate immunity
11. Cell-mediated immunity
12. Cell-mediated cytotoxic response
13. Cytokines
14. Immune response
15. Antiviral immune response
16. Antibacterial immune response

Expected outcomes. After completing this course students will be able to:

1. *Describe the main biochemical processes and metabolism at the molecular level with an understanding of the principles of maintaining the stability of the internal environment of the body.*
2. *Apply knowledge of normal metabolism and its regulation under different physiological conditions.*
3. *Apply knowledge of molecular genetic mechanisms to maintain homeostasis, gene expression and epigenetics.*
4. *Describe the components of the immune system, the mechanisms of immune defense are normal and the adaptive immune response, the development of the immune system; genes responsible for the functioning of the immune system and immunoregulation;*
5. *Apply knowledge of the normal immune response to various types of infections (viral, bacterial, fungal, parasitic)*

A typology of tasks for the exam

Ticket №1–

№	Questions	Max. points
	Block 1 - Immunology	
1.	Describe interferons, the general characteristics and mechanisms of biological effects in the immune response.	40
	Block 2 - Biochemistry	
2.	The clinical symptoms of the two forms of galactosemia, one of which is caused by galactokinase deficiency and the other by galactose-1-phosphate-uridyltransferase, differ sharply in severity. In both cases, milk causes intestinal disorders in patients, but if galactose-1-phosphate-uridyltransferase is insufficient, the functions of the liver, kidneys, spleen and brain are impaired, and then death occurs. Explain which products accumulate in the blood and tissues when each of the two enzymes is deficient and evaluate the comparative toxicity of these products based on the above data.	60

GUIDELINES FOR AN EXAM CONDUCTED OFFLINE IN THE CLASSROOM STANDART WRITTEN.

The process of taking a written exam by the student involves the automatic creation of an exam ticket for the student, to which you must form a written answer by direct handwriting.

Exam Technology Instruction

1. The duration of the exam is exactly 3 hours.
2. Written exams are administered according to the approved schedule.
3. Students may enter the auditorium where the written exam is administered only with an ID card (Passport or student ID card). The presence of persons not participating in the examination procedure is prohibited.
4. The proctor reconciles the identification document with the admission permission slip. A student who has a discipline clearance rating of less than 50% is not allowed to take the written exam.

5. The proctor (calls the names from the list and sits them down according to the list) starts them in the auditorium.
6. Late students are not allowed to take the exam.
7. Proctor gives each student an answer sheet (if necessary, the student may take an additional answer sheet) and gives the student the opportunity to choose a ticket for the discipline being passed (the text of the ticket should not be visible to the student).
8. Students present at the exam must sign the admission form.
9. The start and end times of the written exam are recorded on the blackboard.
10. During the written exam, students' questions on the content of the examination tickets are not considered.
11. If the student does not comply with the established requirements at the exam: uses crib notes, mobile and other devices, allows disciplinary violations, disturbs other students with their actions, the proctor has the right to remove student from the audience. In this case, an act of violation of the examination procedure is drawn up, the answer sheet is annulled by crossing out diagonally, the mark "Removed for violation" is made in the admission sheet, "0" points will be given in the sheet.
12. It is allowed for a student to visit the restroom no more than 1 time per hour, lasting no more than 5 minutes. If frequent visits to the restroom are required (for example, due to health conditions), the student must undergo a medical examination, and the exam is counted as the student's absence from the exam.
13. At the end of the exam, the student must turn in his/her ticket and answer sheet.

Block 1. FOUNDATION OF BIOCHEMISTRY

№	Topic	Exam questions
1	The foundations of biochemistry.	1. *Compare and contrast prokaryotic and eukaryotic cells, their organelles and properties.* 2. *Discuss the types of chemical bonds and name the functional groups and their function.* 3. *Explain stereoisomers and cis-trans configurations.* 4. *Evaluate the properties of thermodynamics and chemical kinetics.* 5. *Articulate on anabolism and catabolism.* 6. *Explain biochemical hierarchy from monomers to polymers and then to the cell.* 7. *Explain the evolution of cells by endosymbiosis, vertical and horizontal gene transfer.* 8. *Distinguish evolution of proteins: orthologs and paralogs.*
2	Biochemical evolution. Protein structure and function	1. *Understand how biochemical unity underlies biological diversity.* 2. *Explain the nature of key organic molecules are used by living systems.* 3. *Draw the chemical structure of each of the 20 natural amino acids.* 4. *Describe the three building blocks of protein structure (α-helix, β-sheet, loop).* 5. *Describe the forces and interactions that promote protein folding.* 6. *Evaluate, based on the knowledge o f protein structure, whether a given protein structure model is likely to represent a native physiological protein structure.* 7. *Make predictions about the effect of mutations on protein structure and folding.*

3	Enzymes: Basic Concepts and Kinetics	1. *Describe enzymes as powerful and highly specific catalysts* 2. *Explain free energy essence for understanding enzymes* 3. *Explain how the interaction between enzyme and substrate affect the velocity of a reaction* 4. *Apply the fundamental principles o f Michaelis-Menten enzyme kinetics* 5. *Predict the mode o f action and the impact of different classes o f inhibitors on enzyme kinetics* 6. *Understand the kinetics o f enzymes acting on several substrates* 7. *Design mutations hypothesized to affect different enzyme kinetic parameters* 8. *Describe vitamins as often precursors to coenzyme.*
4	Enzymes: Catalytic Strategies.	1. *Understand proteases: facilitating a difficult reaction.* 2. *Explain how carbonic anhydrases make a fast reaction faster.* 3. *Describe highly specific DNA-Cleavage reactions by restriction enzymes.* 4. *Understand the key functions o f nucleoside monophosphate kinases.* 5. *Explain how hemoglobin transports oxygen efficiently by binding oxygen cooperatively.* 6. *Understand the relationship between covalent modification and regulating enzyme activity.* 7. *Explain how enzymes are activated by specific proteolytic cleavage*
5	Carbohydrates	1. *Explain the structure of monosaccharides considering by aldehydes or ketones with multiple hydroxyl groups.* 2. *Understand how complex carbohydrates are formed by linkage of monosaccharides.* 3. *Describe how carbohydrates can attach to proteins to form glycoproteins.* 4. *Explain why lectins are specific carbohydrate-binding proteins.* 5. *Define carbohydrates as informational macromolecules: the Sugar Code* 6. *Explain how the structure of a glucose makes it soluble in water and highly reactive.*
6	Lipids & Cell Membranes.	1. *Understand how some common features are the significant bases o f the diversity o f biological membranes.* 2. *Describe fatty acids as key constituents o f lipids.* 3. *Learn the four main groups o f lipids.* 4. *Explain the role o f proteins carry out most membrane processes.* 5. *Explain how the fluid mosaic model allows lateral movement but not rotation through the membrane.* 6. *Understand the transport o f molecules across a membrane.* 7. *Explain how membrane proteins use ATP hydrolysis to pump ions across membranes.* 8. *Understand how multidrug resistance and cystic fibrosis highlight a family of membrane proteins with ATP-Binding cassette domains.*

		9. *Understand how specific channels can rapidly transport ions across membranes.*
7	Transducing & Storing Energy.	1. *Explain why metabolism is composed of many coupled, interconnecting reactions.* 2. *Explain the oxidation o f carbon fuels as an important source of cellular energy.* 3. *Understand the role o f recurring motifs in metabolic pathways.* 4. *Explain how seven-transmembrane-helix receptors change conformation in response to ligand binding and activate G proteins.* 5. *Explain defects in signaling pathways and leading disease.*
8	Glycolysis & Gluconeogenesis.	1. *Describe glycolysis as an energy-conversion pathway.* 2. *Explain the role of phosphofructokinase in the control of glycolysis.* 3. *Explain how glucose can be synthesized from noncarbohydrate precursors (Gluconeogenesis).* 4. *Describe gluconeogenesis and glycolysis how they are reciprocally regulated.*
9	The Citric Acid Cycle. Oxidative Phosphorylation	1. *Explain how the citric acid cycle oxidizes two-carbon units.* 2. *Describe the pyruvate dehydrogenase complex regulation by reversible phosphorylation.* 3. *Explain why the citric acid cycle is a source o f biosynthetic precursor.* 4. *Describe the oxidative phosphorylation and where does it occur.* 5. *Explain the dependence o f oxidative phosphorylation on electron transfer.* 6. *Describe the respiratory chain complexes: three proton pumps and a physical link to the Citric acid cycle Understand the regulation of oxidative phosphorylation by the need for ATP.*
10	The Pentose Phosphate Pathway. Glycogen Metabolism.	1. *Explain the calvin cycle synthesizes hexoses from carbon dioxide and water* 2. *Explain the generation of NADPH and synthesize of Five-Carbon Sugars by the pentose phosphate pathway* 3. *Explain how the metabolism of glucose 6-phosphate is coordinated with glycolysis by the pentose phosphate pathway* 4. *Understand how Glucose 6-phosphate Dehydrogenase plays a key role in protection against reactive oxygen species* 5. *Explain what kind o f enzymes are necessary in glycogen breakdown*
11	Fatty Acid Metabolism.	1. *Explain why triacylglycerols are highly concentrated energy stores.* 2. *Understand the utilization of fatty acids as fuel requires three stages of processing.* 3. *Explain degradation steps of Fatty Acids that Require Additional Steps.* 4. *Characterize fatty acids are synthesized and degraded by different pathways.* 5. *Determination of Acetyl Coenzyme A Carboxylase as a Key Role*

		in Controlling Fatty Acid Metabolism.
12	Protein Turnover and Amino Acid Catabolism.	1. *Explain degradation of proteins to amino acids.* 2. *Understand how protein turnover is tightly regulated.* 3. *Explain the first step in amino acid degradation is the removal of nitrogen.* 4. *Understand how ammonium ion is converted into urea in most terrestrial vertebrates.* 5. *Explain why carbon atoms of degraded amino acids emerge as major metabolic intermediates* 6. *Understand inborn errors of metabolism can disrupt amino acid degradation.*
13	The Biosynthesis of Amino Acids.	1. *Understand the biosynthesis of amino acids.* 2. *Recognize amino acids are made from intermediates of the citric acid cycle and other major pathways.* 3. *Explain how the iron-molybdenum cofactor of nitrogenase binds and reduces atmospheric nitrogen.* 4. *Understand amino acid biosynthesis is regulated by feedback inhibition.* 5. *Realize amino acids are precursors of many biomolecules.* 6. *Understand glutathione, a gamma-glutamyl peptide, serves as a sulthydryl buffer and an antioxidant.* 7. *Explain why nitric oxide is a short-lived signal molecule.* 8. *Describe how mammalian porphyrins are synthesized from glycine and succinyl coenzyme A.* 9. *Explain Some Inherited Disorders of Porphyrin Metabolism.*
14	Nucleotide Biosynthesis I-II.	1. *Understand how the pyrimidine ring is assembled from bicarbonate, aspartate, and glutamine.* 2. *Tolerate how bicarbonate and other oxygenated carbon compounds are activated by phosphorylation.* 3. *Understand how the side chain of glutamine can be hydrolyzed to generate ammonia.* 4. *Predict what intermediates can move between active sites by channeling.* 5. *Explain how orotate acquires a ribose ring from PRPP to form a pyrimidine nucleotide and is converted into uridylate* 6. *Understand why nucleotide mono-, di-, and triphosphates are interconvertible.* 7. *Realize how CTP is formed by animation of UTP* 8. *Explain purine bases can be synthesized de Novo or recycled by Salvage Pathways* 9. *Explain how deoxyribonucleotides synthesized by the reduction of ribonucleotides through a radical mechanism* 10. *Conceive that thymidylate is formed by the methylation of deoxyuridylate* 11. *Explain how dihydrofolate reductase catalyzes the regeneration of tetrahydrofolate* 12. *Know why several valuable anticancer drugs block the synthesis of thymidylate* 13. *Define key steps in nucleotide biosynthesis are regulated by*

		feedback inhibition 14. *Understand how NAD+, FAD, and Coenzyme A are formed from ATP* 15. *Explain why disruptions in nucleotide metabolism can cause pathological conditions.*
15	The Biosynthesis of Membrane Lipids and Steroids I-II	1. *Understand why phosphatidate is a common intermediate in the synthesis of phospholipids and triacylglyccrols.* 2. *Understand the synthesis of phospholipids requires an activated intermediate.* 3. *Explain how plasmalogens and other ether phospholipids are synthesized from dihydroxyacetone phosphate.* 4. *Understand how plasmalogens and other ether phospholipids are synthesized from dihydroxyacetone phosphate.* 5. *Summarize the difference between sphingosine and ceramide.* 6. *Describe gangliosides as carbohydrate-rich sphingolipids that contain acidic sugars.* 7. *Predict how sphingolipids confer diversity on lipid structure and function.* 8. *Estimate the disruption of lipid metabolism as the main reason of respiratory distress syndrome and tay-sachs disease.* 9. *Define three stages of cholesterol synthesis from acetyl coenzyme A.* 10. *Examine the synthesis of mevalonate, which is activated as isopentenyl pyrophosphate, initiates the synthesis of cholesterol.* 11. *Estimate the significance of six molecules of isopentenyl pyrophosphate in squalene synthesis.* 12. *Understand the complex regulation of cholesterol biosynthesis that takes place at several levels* 13. *Predict how lipoproteins transport cholesterol and triacylglycerols throughout the organism* 14. *Examine diagnostic purposes of the blood levels of certain lipoproteins* 15. *Identify a central role of low-density lipoproteins in cholesterol metabolism* 16. *Identify five different functional regions of the LDL receptor* 17. *Understand the absence of the LDL receptor which leads to hypercholesteremia and atherosclerosis* 18. *Identify bile salts and steroid hormones as important derivatives of cholesterol*
16	DNA Replication, Recombination, and Repair	1. *Compare different characteristics of A-DNA and B-DNA.* 2. *Understand what statement about the major and minor grooves is true.* 3. *Predict the results of studies of single crystals of DNA revealed local variations in DNA structure.* 4. *Understand primer requirement and template specificity of the DNA.* 5. *Understand how DNA replication of both strands proceeds rapidly from specific start sites.* 6. *Predict how double-stranded DNA molecules with similar sequences sometimes recombine.*

		7. *Estimate possible mutations that involve changes in the base sequence of DNA.* 8. *Understand transcription which is catalyzed by RNA polymerase.* 9. *Compare eukaryotic transcription and translation which are separated in space and time.* 10. *Understand the transcription products of all three eukaryotic polymerases.* 11. *Summarize the discovery of catalytic RNA.*
17	Protein Synthesis I-II	1. *Understand how accurate protein synthesis must be.* 2. *Predict a common design for transfer RNA molecules* 3. *Understand the structure of activated amino acid and the anticodon of tRNA which are at opposite ends of the L-shaped molecule.* 4. *Understand the precise recognition of tRNAs as important for high-fidelity protein synthesis.* 5. *Understand A Ribosome as a Ribonucleoprotein Particle (70S) Made of a Small (30S) and a Large (50S) Subunit* 6. *Understand key roles of protein factors in protein synthesis* 7. *Examine how elongation factors deliver aminoacyl-tRNA to the ribosome.* 8. *Describe the formation of a peptide bond which is followed by the GTP-driven translocation of tRNAs and mRNA* 9. *Explain how protein reads the stop codon and terminates translation* 10. *Predict how eukaryotic protein synthesis differs from prokaryotic protein synthesis.*
18	The Integration of Metabolism I-II	1. *Describe highly interconnected pathways which metabolism consists of.* 2. *Describe recurring motifs in metabolic regulation.* 3. *Describe major metabolic pathways and control sites.* 4. *Describe key junctions: glucose 6-phosphate, pyruvate, and acetyl CoA.* 5. *Explain unique metabolic profile of each organ.* 6. *Explain metabolic changes in food intake and starvation* 7. *Describe the relationship between metabolic adaptations in prolonged starvation and protein degradation* 8. *Explain what metabolic derangements in diabetes result from relative insulin insufficiency and glucagon excess* 9. *Describe regulating body weight by caloric homeostasis* 10. *Explain fuel choice during exercise which is determined by intensity and duration of activity* 11. *Describe how ethanol alters energy metabolism in the liver*
19	Sensory Systems I-II	1. *Explain how a wide variety of organic compounds are detected by olfaction.* 2. *Explain how olfaction is mediated by an enormous family of seven-transmembrane-helix receptors.* 3. *Describe the relationship between combinatorial mechanism and odorants.*

		4. *Describe how functional magnetic resonance imaging reveals regions of the brain processing sensory information.* 5. *Describe combination of senses that function by different mechanisms.* 6. *Summarize sequencing the human genome and the discovery of a large family of 7TM bitter receptors.* 7. *Explain how a family of 7TM receptors almost certainly respond to sweet compounds.* 8. *Explain a key role of the Passage of Sodium Ions Through Channels in salty tastes detection.* 9. *Explain the effects of hydrogen ions (acids) on channels and sour tastes arise.* 10. *Explain the significance of photoreceptor molecules in visible light detection.* 11. *Describe how rhodopsin, a specialized 7TM receptor, absorbs visible light.* 12. *Explain a specific isomerization of bound 11-cis-retinal caused by light absorption.* 13. *Explain how light-induced lowering of the calcium level coordinates recovery.* 14. *Identify three cone receptors that are homologs of rhodopsin and how they mediate color vision.* 15. *Establish relationship between hearing and the speedy detection of mechanical stimuli.* 16. *Explain how hair cells use a connected bundle of stereocilia to detect tiny motions.* 17. *Predict what other factors touch includes beside pressure and temperature.* 18. *Summarise studies of capsaicin as the active ingredient in «hot» pepper.*
20	Molecular Motors I-II	1. *List general characteristics of most molecular-motor proteins as members of the P-Loop NTPase superfamily.* 2. *Describe the two main building blocks of a motor protein.* 3. *List main reasons to induce changes in the conformation and binding affinity of motor proteins.* 4. *Explain how myosins move along actin filaments.* 5. *Describe a complex components of muscle.* 6. *Describe actin as a polar, self-assembling, dynamic polymer.* 7. *Explain how motions of single motor proteins can be observed.* 8. *Describe the factor that triggers the myosin power stroke.* 9. *Describe the key element that determines motor velocity.* 10. *Explain how kinesin and dynein move along microtubules.* 11. *Characterize the general structure of microtubules.* 12. *Explain why kinesin motion is highly processive.* 13. *Examine what structural changes can reverse motor polarity.* 14. *Identify the main reason how bacteria swim* 15. *Explain what drives bacterial flagellar rotation.*
21	DNA-based information technologies	1. *Explain steps of DNA amplification by PCR.* 2. *Explain recombinant DNA cloning using viruses.*

		3. *Explain recombinant DNA cloning using bacterial artificial chromosome.* 4. *Explain the strategy of DNA purification.*
22	Biochemistry of blood cells, kidneys and urine	1. ***List** the functions of blood.* 2. ***Describe** the chemical composition of blood plasma and indicate its difference from blood serum.* 3. ***Name** the main organic and inorganic components of blood plasma and indicate their normal content in blood plasma, the reasons for the deviation from the norm.* 4. ***Describe** the main types of violation of the content of protein fractions.* 5. *Interpret changes in the main indicators of organic and inorganic components in a biochemical blood test.* 6. ***Describe** the chemical composition of erythrocytes.* 7. ***Explain** the features of erythrocyte metabolism (glycolysis, pentose phosphate cycle)* 8. ***Describe** the causes and conditions for the formation of reactive oxygen species in erythrocytes.* 9. ***Describe** the antioxidant enzymes in erythrocytes.* 10. ***Describe** the structure and types of hemoglobin, terms of formation and normal content.* 11. ***Explain** the biochemical basis of gas transport (allosteric effects of hemoglobin: cooperative effect, Bohr effect, 2,3-diphosphoglycerate effect).* 12. *Describe the clinically significant dyshemoglobins: carboxyhemoglobin (COHb), methemoglobin (MetHb), glycated hemoglobin (HbA1C, Glycated Hemoglobin), nitrosohemoglobin (HbNO), the reasons for their formation.* 13. ***Describe** the enzymopathies that cause hemolysis of erythrocytes (impaired activity of glucose-6-phosphate dehydrogenase. Development of hemolytic anemia).* 14. ***Explain** the participation of blood buffer systems in maintaining the acid-base state, the mechanism of their action on the example of a bicarbonate buffer.* 15. ***Describe** the causes and compensatory mechanisms in the event of metabolic acidosis and alkalosis.* 16. ***Give** the concept of an anion gap.* 17. ***Describe** the concept of water-salt metabolism. **List** the importance of water for the human body, water exchange and explain the concept of electrolytes.* 18. ***Describe** the hormones that regulate water-salt metabolism: aldosterone, vasopressin, natriuretic.* 19. ***Specify** the features of metabolism in the kidneys* 20. ***Describe** the chemical composition of normal urine* 21. ***Explain** the reasons for the deviation of the main indicators in the urine* 22. ***Name** the pathological components of urine, indicating the qualitative reactions to them. Interpret urinalysis.*

Block 2. FOUNDATION OF IMMUNOLOGY

№	Topic	Exam questions
1	Introduction to Immunology. Historical background of Immunology	*1. List the main historical stages in the development of immunology* *2. Define the science of immunology* *3. Define the subject of study of immunology* *4. List the main areas of immunology: general immunology and private immunology* *5. Discuss the place of the discipline of immunology in individual specialties* *6. Describe the task of general immunology*
2	Innate Immunity.	*1. List and discuss components of innate immunity.* *2. Justify external barriers against infection* *3. Identify and classify cells of the immune system* *4. Classify the types of pattern recognition receptors.* *5. Explain initiation of an immune response* *6. Know how do the innate immune system instigates adaptive immunity* *7. Explain collaboration between innate and adaptive immune responses* *8. Draw and describe interaction between innate and adaptive immune responses*
3	Adaptive Immunity.	*1. List and describe the central and peripheral organs of the immune system.* *2. Explain the patterns of clonal selection.* *3. Explain the importance of antigen-independent differentiation of lymphocytes.* *4. Explain the importance of antigen-dependent differentiation of lymphocytes.* *5. List the main types of lymphatic tissue cells and indicate their functions.* *6. Name and explain types of immune response* *7. Discuss primary and secondary immune response* *8. Describe and explain the interaction of immune cells in the immune response.* *9. Describe the interaction between innate and adaptive immunity* *10. Explain the differences between innate and adaptive immunity.* *11. Compare the functional characteristics of cells of innate and adaptive immunity.*
4	Major histocompatibility complex and its general organization.	*1. Describe and explain the structure of the major histocompatibility complex.* *2. Describe the structure and function of the MHC I and MHC II molecules.* *3. Explain the principle of MHC inheritance* *4. Explain the role of major histocompatibility complex gene products in the immune response.* *5. Give examples of associations between HLA antigens and diseases.*
5	Antigens	*1. Define the terms: antigen, hapten, carrier.* *2. Describe the chemical properties of antigens;*

		3. *List the main features of antigens;* 4. *Explain role of antigenic determinants and carrier in the induction of immune response;* 5. *Describe the thymus-dependent and thymus-independent antigens.* 6. *Explain mechanisms of formation of the immune response to thymus-dependent and thymus-independent antigens.* 7. *Compare and contrast thymus-dependent and thymus-independent antigens.* 8. *Contrast primary and secondary self-antigens. Give examples of each.*
6	Humoral factors of Immunity B-cell maturation.	1. *Describe development of B-lymphocytes.* 2. *Explain the ability of B lymphocytes to the immune response in the process of differentiation. Explain how B cells recognize and respond to an antigen* 3. *List the markers of B-cells.* 4. *Describe B-cell receptor.* 5. *Summarize role of humoral immunity in immune reactions* 6. *Draw and describe antigen-dependent differentiation of B-lymphocytes.*
7	B cell development.	1. *Discuss the role bone marrow in development of B cells* 2. *Describe antigen-dependent differentiation of B-lymphocytes.* 3. *Define antigen-independent differentiation of B-lymphocytes* 4. *Compare differences between antigen-independent and antigen-dependent differentiation of B-lymphocytes.* 5. *List key components of humoral immune responce*
8	Structure and functions of antibodies.	1. *Describe the structure and five types of antibodies;* 2. *Describe the structure of an antibody monomer and state what part of it binds to antigens;* 3. *Name and explain the functions of the Fab and Fc fragments of immunoglobulins.* 4. *Complete test quiz "HUMORAL IMMUNITY" (mark true or false)* 5. *List and describe features of the structure and functions of the major classes of immunoglobulins* 6. *Describe ways in which an antibody acts against an antigen;* 7. *Provide examples of using monoclonal antibodies in therapy.*
9	The complement system.	1. *Describe the immune roles of the complement system;* 2. *Explain how do the complement system protect against disease* 3. *List general characteristics of the complement system and its role in immune reactions;* 4. *Draw and explain classical and alternative pathway activation of the complement system;* 5. *Compare and contrast classical and alternative pathway* 6. *Name and describe factors that contribute to the initiation of classical and alternative pathways* 7. *Draw the mechanism of activation of the complement system by the classical pathway* 8. *Draw the mechanism of activation of the complement system via*

		the alternative and lectin pathways. *9. Identify the biological role of intermediate fragments of the complement system* *10. Explain role of the complement system in immunopathological processes.*
10	Cells of innate immunity.	*1. Describe the defensive functions of various types of leukocytes and macrophages.* *2. List the main types of antigen presenting cells.* *3. Name the main functions of macrophages.* *4. Explain what macrophages are? Give examples and state where they are found* *5. Describe the process of antigen presentation and T cell activation.* *6. Explain what role does an antigen-presenting cell play in the activation of T cells.*
11	Cell-mediated immunity.	*1. Identify the three distinguishing characteristics of adaptive immunity.* *2. List contrast cellular and humoral immunity.* *3. Explain what role does the thymus play in the life history of a T cell* *4. List the types of lymphocytes involved in cellular immunity and describe the roles they play.* *5. Explain antigen-independent differentiation of T lymphocytes.* *6. Explain the processes of positive and negative selection in the thymus.* *7. Draw and explain polarization of T-helper cells.*
12	Cell-mediated cytotoxic response.	*1. Explain how is a cytotoxic T cell like a natural killer (NK) cell.* *2. List and discuss how CTL and NK-cells different.* *3. Describe mechanism of action of the CD8 + CTL.* *4. Explain what do NK, T, and B cells have in common? How do their functions differ?* *5. List specialized lymphocytes.*
13	Cytokines	*1. List main groups of cytokines.* *2. Outline the immune roles of interferons.* *3. Describe the process of inflammation and explain what accounts for its cardinal signs.* *4. Describe the general roles played by lymphocytes, antigen presenting cells, and interleukins in the immune response.*
14	Immune response	*1. Describe structure and features of the immune system.* *2. Explain the relationship in the immune response* *3. Identify some of the characteristics of the main components of the immune system.*
15	Antiviral immune response	*1. Characterize the role innate immune system against viruses* *2. Discuss the importance of adaptive immune response in antiviral immunity* *3. Define the mechanism of action of interferons against viruses* *4. Describe the role of immunological memory is an important mechanism that protects the organism from viruses*

		5. *Explain the collaboration of innate and adaptive immune systems against viruses*
16	Antibacterial immune response	1. *Explain the role innate immune system against bacterial infection* 2. *Define the protective mechanism of innate immunity components against bacteria.* 3. *Outline the importance of adaptive immune response in antibacterial immunity* 4. *Describe the role of immunological memory as an important mechanism that protects the organism from bacterial agents.* 5. *Explain the collaboration of innate and adaptive immune systems against bacterial pathogens.*

Response Quality Scale

Grade	Criteria	Scale, scores
excellent	1. all key aspects included and presented logically; 2. high accuracy (relevance, without redundancy) and consistent focus on question; 3. excellent integration of theoretical issues; 4. provision of relevant examples; 5. in-depth analysis and theoretical justification of given problem (if applicable), all key aspects identified and interpreted; 6. fluency in use of professional terminology	90 - 100
good	1. all key aspects included and presented logically; 2. consistent focus on question with satisfactory accuracy, and relevance, and/or some redundancy; 3. satisfactory integration of theoretical issues; 4. lack of examples; 5. satisfactory analysis and theoretical justification of given problem (if applicable), most key aspects identified and interpreted; 6. correct use of professional terminology	70 - 89
satisfactory	1. most key aspects included; 2. satisfactory focus on question - some lapses of relevance and/or noticeably redundancy; 3. theoretical issues presented without noticeably integration; 4. provision of unsuccessful examples or no examples; 5. some analysis and theoretical justification of given problem (if applicable), most key aspects identified and interpreted; 6. correct use of professional terminology	50 - 69
unsatisfactory (FX)	1. most key aspects missed; 2. lack of focus on question - no relevance and notable redundancy; 3. some theoretical issues presented in someway; 4. no or irrelevant examples; 5. some analysis and theoretical justification of a given problem (if applicable), most key aspects missed; 6. lapses in use of professional terminology	25 - 49

failed (F)	1. most or all key aspects missed; 2. no focus on question, irrelevant information; 3. theoretical issues missed or superficial; 4. no or irrelevant examples; 5. no analysis and no theoretical justification of a given problem (if applicable), most key aspects missed; 6. lapses in use of professional terminology	0-24

System of grades

Letter Grade	The digital equivalent of points	% content	Traditional system assessment
A	4,0	95-100	Excellent
A-	3,67	90-94	
B+	3,33	85-89	Good
B	3,0	80-84	
B-	2,67	75-79	
C+	2,33	70-74	
C	2,0	65-69	Satisfactory
C-	1,67	60-64	
D+	1,33	55-59	
D-	1,0	50-54	
FX	0	25-49	Unsatisfactory
F	0	0-24	
I (Incomplete)	-	-	"Discipline is not completed" *(not taken into account when calculating GPA*)

Basic literature

1. Warren Levinson. Review of Medical Microbiology and Immunology (13th Edition) 2014, - McGraw Hill, 2014. - 1950 p. - ISBN 978-0-07-181812-4.
2. David L. Nelson, Michael M. Cox. Lehninger Principles of Biochemistry 7th Edition, W. H. Freeman and Company, 2017. — 3270 p. - ISBN: 9781464126116.
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