

Board of Immunology

Topics for the exam:

A. Immunology

I. Basic components and principles of the immune system

1. Functions of T lymphocytes, non-classical T cells, ILC, functional methods of studying T lymphocytes
2. Function of B lymphocytes, functional methods of studying B lymphocytes
3. Development and functions of monocytes/macrophages
4. Development and functions of granulocytes and mast cells
5. Ontogenesis of immunity, immunological development of the child
6. Immunological memory
7. Mucosal immune system, proteins and peptides with antimicrobial activity
8. Mechanisms of elimination of autoreactive lymphocytes
9. Regulation of the immune response - general principles
10. Regulatory cells of the immune system, MDSCs
11. Regulation of immune responses by the nervous and endocrine systems, and microbiome
12. Phylogeny of immunity
13. Mechanisms of immunological tolerance
14. Relationship and cooperation of innate and adaptive immunity
15. Cellular components of innate immunity and their functions, recognition of microorganisms by innate immunity cells and molecules
16. Antigen-specific lymphocyte receptors: structure and function, structure and expression of genes encoding antigen-specific receptors
17. Development of T and B lymphocytes and selection of the repertoire of their specific receptors, molecular mechanisms
18. Antigen-presenting cells, molecular mechanisms of their function
19. Mechanisms of signal transduction by lymphocyte surface receptors; "positive" and "negative" signals; "activation" of T and B lymphocytes
20. Structure and function of secreted immunoglobulins, affinity and avidity
21. Structure and function of MHC glycoproteins, the biological significance of MHC glycoprotein polymorphism
22. Leukocyte adhesive molecules, role in lymphocyte activation and effector function, migration of T lymphocytes to lymphoid vs. non-lymphoid tissues
23. Costimulatory molecules; signaling, role in activation, expansion and effector functions of T and B lymphocytes
24. Effector mechanisms of cellular immunity
25. Effector mechanisms of humoral immunity
26. Structure and function of complement receptors, complement cascade, regulation of the complement system
27. Cytokines, chemokines and other soluble immunoregulatory molecules
28. Use of living organisms in immunological research, mutant, transgenic and knock-out model organisms

II. Physiological and pathophysiological aspects of immunity

29. Mechanisms of inflammation; inflammatory mediators
30. Immunological importance of breastfeeding, the relationship between the immune system of the mother and the fetus
31. Immunodeficiency - causes, types, principles of therapy
32. Primary immunodeficiencies
33. Acquired (secondary) immunodeficiencies
34. Immunopathological reactions accompanying physiological immune responses
35. Autoimmune diseases - causes, types, therapy
36. GIT immune disorders
37. Immune disorders of the respiratory system and skin
38. Immune disorders of the nervous system,
39. Immune disorders of endocrine system
40. Systemic immune-mediated diseases
41. Immunopathological reactions (hypersensitivity)-general principles, types, mechanisms, treatment options
42. Lymphoproliferative diseases
43. Mechanisms of anti-infective immunity (specifics for different types of pathogens)
44. Mechanisms of the evasion of immune responses by microorganisms
45. Mechanisms of tissue damage by pathogens and immunopathological reactions
46. Mechanisms of the antitumor immunity, tumor antigens
47. Mechanisms of the evasion of immune responses by tumor cell
48. Immunotherapy - basic principles and approaches (stimulation, suppression)
49. Antigen-specific immunotherapy (vaccines, passive immunization, specific immunosuppression), adjuvants and their mechanisms of action
50. Experimental models of immunopathological conditions
51. Transplant immunology, principles, xenotransplantation, graft-versus-host disease
52. Classical and non-classical HLA antigens, HLA typing methods, therapeutic approaches of transplant immunology
53. Immunologically privileged sites

B. Molecular and cell biology

Proteins

54. Protein structure (primary, secondary, tertiary, quaternary)
55. Metabolic turnover of proteins (proteosynthesis vs. degradation, proteasomes)
56. Posttranslational protein modifications (glycosylation, phosphorylation, acylation, prosthetic groups)
57. Membrane proteins (origin, types of association with the membrane, examples)

Cell structure and function

58. Membrane structure (bilayer, amphipathic properties, lateral diffusion, phospholipids, steroids, proteins), membrane function (semi-permeability, compartmentalization, asymmetry, transporters, receptors, nuclear-cytosol transport, nuclear pore, dynamics during mitosis, lamins)
59. Cell energy metabolism, mitochondria (DNA, electron transport chain, uncoupling proteins, proton gradient)

60. Endoplasmic reticulum (rough vs. smooth ER, posttranslational protein modifications, lipid synthesis)
61. Protein signal sequences (address labeling, SRP, membrane transport mechanism)
62. Golgi system (localization, function, glycosylation, sorting of molecules to different destinations)
63. Lysosomes (endocytosis, clathrin, acidic pH, hydrolases, mannose 6-phosphate receptor)
64. Endocytosis and exocytosis (principle, endosomes - early, clathrin, recycling, late endosomes, regulation of exocytosis)
65. MHC I and ER (mechanism of MHC I peptide loading, peptide transporters, transport to plasmid membrane)
66. MHC II and endosomes (mechanism of MHC II peptide loading, invariant chain, late endosomes)
67. Comparison of the types of the cytoskeleton (logic of structure, similarities and differences in structure and function)

Extracellular signaling

68. Types of extracellular signaling (autocrine, paracrine, endocrine, cell contact-dependent, synaptic)
69. Types of receptors (surface vs. intracellular, kinases, cyclases, ion channels, associated molecules)
70. Types of signaling molecules (nitric oxide, carbon monoxide, steroids, peptides, proteins, prostaglandins...)
71. Types of second messengers (cyclic GMP and AMP, Ca²⁺, diacylglycerol, inositol phosphates)
72. Types of signaling pathways (receptors associated with G-proteins, ion channels, kinase activity)
73. G-protein-coupled receptors (trimeric G-protein, receptor structure, cAMP, cGMP, PKA, diacylglycerol, phospholipase C-β, IP₃, Ca²⁺, PKC, calmodulin)
74. Receptors utilizing enzymatic activity (receptor tyrosine kinases, tyrosine kinase associated receptors, receptor tyrosine phosphatases, receptor serine/threonine kinases, receptor guanylyl cyclases)
75. Signal transduction by protein tyrosine kinases (receptor PTK, autophosphorylation, dimerization, SH2 domains, adapter proteins, Src family kinases, PLC-γ, Ras proteins, MAP kinase pathway, PI 3-kinase)

Cell cycle and programmed cell death

76. Cell cycle definition (G₁, G₂, M, S phase, interphase, modification, duration)
77. Cell cycle regulation (checkpoints, examples of sensors - Rb protein and p53, Cdk, cyclins)
78. Malignant transformation (mechanisms of tumor cell formation, key factors and molecules)
79. Apoptosis (definition, apoptosis vs. necrosis, caspases, role of mitochondria, Fas, Bcl-2, phosphatidylserine), apoptosis in the immune system
80. Autophagy

Methods

81. Reverse genetics (transgenes, knock-out, knock-in, Crispr-Cas9, RNA interference, ES cells).
82. Flow cytometry: principles, applications
83. Hybridoma technology (immunization, myeloma cell, selection)
84. Mass spectrometry (use, advantages, limitations)
85. DNA and RNA detection (fluorescent and radioactive probes, in situ hybridization, sequencing)
86. DNA cloning (restriction endonucleases, vectors, amplification)
87. PCR (principle, thermostable DNA polymerases, primers, PCR variants – real-time, nested etc., primer modifications)

88. Methods for determining the structure of proteins (X-ray crystallography, cryo-EM)
89. Methods based on antigen-antibody interaction (ELISA, Western blot, nephelometry)
90. Light microscopy (resolution, fluorescence microscopy, confocal microscopy, electron microscopy (resolution, scanning vs. transmission))
91. Use of fluorescent proteins (logic, in vivo studies, fusion proteins, FRAP, FRET)