Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Head of the Phystech School of Biological and Medical Physics
D.V. Kuzmin

Work program of the course (training module)

course:	Immunology/Иммунология
major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия
	Phystech School of Biological and Medical Physics
	Center for educational programs in bioinformatics
term:	3
qualification:	Bachelor

Semester, form of interim assessment: 6 (spring) - Grading test

Academic hours: 30 AH in total, including:
lectures: 30 AH.
seminars: 0 AH.
laboratory practical: 0 AH.

Independent work: 60 AH.

In total: 90 AH, credits in total: 2

Author of the program: D.V. Kuprash, doctor of biological sciences, full professor

The program was discussed at the Center for educational programs in bioinformatics 24.02.2020

Annotation

The aim of this discipline is to provide students with the foundations of fundamental knowledge in the field of molecular immunology. After completing the course, the student will understand the fundamental basics of the functioning of the immune system; modern level of knowledge and problems of immunology; the possibilities of applying the acquired knowledge in medicine, pharmacology, biotechnology and other related fields.

1. Study objective

Purpose of the course

- creation of students' foundations of fundamental knowledge in the field of molecular immunology.

Tasks of the course

- getting an idea of the anatomical structure, cellular composition and patterns of functioning of the immune system in humans and other mammals; - study of modern concepts of the molecular and cellular mechanisms of immune recognition of pathogens;
- getting an idea of the genetic and biochemical mechanisms of immune reactions;
- consideration of the role of the immune system in the development of socially significant diseases;
- familiarization with the mechanisms of action of the main classes of drugs that affect immunity;
- understanding of the evolution of molecular mechanisms of immunity in various species;
- study of examples of the use of knowledge about the immune system in biotechnology and genetic engineering;
- getting an idea of modern approaches to the study of immunity in humans and experimental animals;
- the formation of the fundamental foundations necessary to increase the creative and research potential of students.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
UC-1 Search and identify, critically assess, and synthesize information, apply a systematic approach to problem-solving	UC-1.1 Analyze problems, highlight the stages of their solution, plan the actions required to solve them
	UC-1.2 Find, critically assess, and select information required for the task in hand
	UC-1.3 Consider various options for solving a problem, assess the advantages and disadvantages of each option
	UC-1.4 Make competent judgments and estimates supported by logic and reasoning
	UC-1.5 Identify and evaluate practical consequences of possible solutions to a problem
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
	Gen.Pro.C-1.2 Build mathematical models, make quantitative measurements and estimates
	Gen.Pro.C-1.3 Determine the applicability limits of the obtained results
Gen.Pro.C-3 Write scientific and/or technical (technological, innovative) reports (publications, projects)	Gen.Pro.C-3.1 Adopt the general criteria for submission of manuscripts, scientific and technical documentation, using relevant software applications
	Gen.Pro.C-3.2 Employ practical methodologies for preparing scientific and technical reports (projects)
	Gen.Pro.C-3.3 Visually and graphically present scientific (scientific and technical, innovative technological) outcomes in the form of reports, scientific publications
Gen.Pro.C-5 Participate in fundamental and applied research and development activities; independently develop new theoretical research	Gen.Pro.C-5.1 Perform tasks in the field of theoretical and experimental research and development activities

independently develop new theoretical research methods (including mathematical research methods)	Gen.Pro.C-5.2 Apply new knowledge through the study of literature, scientific articles, and other sources

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- fundamental foundations of the functioning of the immune system;
- modern level of knowledge and problems of immunology;
- the possibilities of applying the acquired knowledge in medicine, pharmacology, biotechnology and other related fields.

be able to:

- formulate and set the research task and its stage-by-stage implementation;
- master the technique of searching and analyzing information found on the Internet;
- present the results of research in oral and visual form;
- draw correct conclusions from the comparison of the results of theory and experiment;
- use your knowledge to solve fundamental and applied problems and technological problems.

master:

- skills of mastering a large amount of information;
- skills of independent work in the laboratory and the Internet;
- skills of competent processing of experience results and comparison with theoretical data;
- practice of research and solving theoretical and applied problems.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	History of immunology, humoral and cellular theory of immunity. Principles of immunological recognition. The main stages of the immune response, features of the immune response to various types of pathogens. Effector mechanisms of innate immunity.	3			4
2	Classification of cells of the immune system. Hematopoiesis scheme. Dendritic cells. Human lymphatic system. The structure of the secondary lymphoid organs. Patterns of migration of myeloid cells and lymphocytes.	3			6
3	Innate immunity receptors: major families, localization, ligand recognition and signaling. Complement system.	3			6
4	Cytokines, classification by receptor type. Chemokines. The TNF superfamily.	3			5
5	Development of lymphocytes in mice and humans. Receptors of lymphocytes and the formation of their diversity. Proteins involved in V (D) J recombination. Somatic hypermutation and isotype switching.	3			5

6	Formation of ligands for the T-cell receptor. Lymphocyte activation. Activation motifs and kinases associated with receptors. Signaling cascades and transcription factors.	3			6
7	Molecular basis of costimulation. Differentiation of T-helpers and the choice of the type of immune response. Regulation of the immune response. Regulatory T cells. Immunological memory and secondary immune response.	3			6
8	Pathological processes directly related to immunity: immunodeficiencies, autoimmune diseases, allergic reactions.	3			6
9	Oncoimmunology, concept of immunological surveillance. Antitumor immunity and approaches to its stimulation. Use of mouse models in cancer immunology.	3			6
10	Mechanisms used by pathogenic viruses and bacteria to suppress host immune responses. The role of commensal microflora in maintaining immune homeostasis.	1			4
11	Pharmaceuticals that activate immunity and immunosuppressants. Clinical use of monoclonal antibodies, cytokines and their blockers.	1			4
12	Phylogenesis of the immune system, features of antibodies in cartilaginous fish, the structure of antibodies in cyclostomes. Cas / CRISPR system in bacteria and its application in genetic engineering.	1			2
AH in total		30			60
Exam preparation		0 AH.			
Total complexity		90 AH., credits in total 2			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 6 (Spring)

1. History of immunology, humoral and cellular theory of immunity. Principles of immunological recognition. The main stages of the immune response, features of the immune response to various types of pathogens. Effector mechanisms of innate immunity.

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4. Cytokines, classification by receptor type. Chemokines. The TNF superfamily.

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5. Development of lymphocytes in mice and humans. Receptors of lymphocytes and the formation of their diversity. Proteins involved in V (D) J recombination. Somatic hypermutation and isotype switching.

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6. Formation of ligands for the T-cell receptor. Lymphocyte activation. Activation motifs and kinases associated with receptors. Signaling cascades and transcription factors.

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7. Molecular basis of costimulation. Differentiation of T-helpers and the choice of the type of immune response. Regulation of the immune response. Regulatory T cells. Immunological memory and secondary immune response.

Molecular basis of costimulation. Differentiation of T-helpers and the choice of the type of immune response. Regulation of the immune response. Regulatory T cells. Immunological memory and secondary immune response.

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9. Oncoimmunology, concept of immunological surveillance. Antitumor immunity and approaches to its stimulation. Use of mouse models in cancer immunology.

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10. Mechanisms used by pathogenic viruses and bacteria to suppress host immune responses. The role of commensal microflora in maintaining immune homeostasis.

Mechanisms used by pathogenic viruses and bacteria to suppress host immune responses. The role of commensal microflora in maintaining immune homeostasis.

11. Pharmaceuticals that activate immunity and immunosuppressants. Clinical use of monoclonal antibodies, cytokines and their blockers.

Pharmaceuticals that activate immunity and immunosuppressants. Clinical use of monoclonal antibodies, cytokines and their blockers.

12. Phylogenesis of the immune system, features of antibodies in cartilaginous fish, the structure of antibodies in cyclostomes. Cas / CRISPR system in bacteria and its application in genetic engineering.

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5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

- classrooms for lecture-type lessons;
- auditoriums equipped with computer equipment with connection to the Internet;
- computer and multimedia equipment (projector, sound system),
- individual computing facilities of students (personal computers) for doing homework.

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

This literature is provided by the base department

Janeway's Immunobiology, 9-е издание, 2013 г.

Additional literature

This literature is provided by the base department

Molecular Biology of The Cell 6th Edition Alberts Textbook

Immunobiology, 5th edition (NCBI bookshelf). http://www.ncbi.nlm.nih.gov/books/NBK10757/

Англоязычная Википедия. http://en.wikipedia.org/

7. List of web resources that are necessary for the course (training module) mastering

Immunobiology, 5th edition (NCBI bookshelf). http://www.ncbi.nlm.nih.gov/books/NBK10757/

Англоязычная Википедия. http://en.wikipedia.org/

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

For some of the lessons, you will need Zoom. Google Drive to access course materials. The presence of smartphones / laptops during classes is encouraged to participate in interactive exercises.

9. Guidelines for students to master the course

The section provides instructions on organizing the student's activities in mastering the discipline: preparing for lecture and seminar classroom classes, independent work, recommendations on the optimal organization of the process of studying the educational material of the discipline, links to the methodological sections of the department's website, a list of guidelines used in the educational process on this discipline.

SUPPLEMENT

Assessment funds for course (training module)

major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия Phystech School of Biological and Medical Physics Center for educational programs in bioinformatics
term:	3
qualification:	Bachelor

Semester, form of interim assessment: 6 (spring) - Grading test

Author: D.V. Kuprash, doctor of biological sciences, full professor

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
UC-1 Search and identify, critically assess, and synthesize information, apply a systematic approach to problem-solving	UC-1.1 Analyze problems, highlight the stages of their solution, plan the actions required to solve them
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Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
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Gen.Pro.C-3 Write scientific and/or technical (technological, innovative) reports (publications, projects)	Gen.Pro.C-3.1 Adopt the general criteria for submission of manuscripts, scientific and technical documentation, using relevant software applications
	Gen.Pro.C-3.2 Employ practical methodologies for preparing scientific and technical reports (projects)
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Gen.Pro.C-5 Participate in fundamental and applied research and development activities; independently develop new theoretical research methods (including mathematical research methods)	Gen.Pro.C-5.1 Perform tasks in the field of theoretical and experimental research and development activities
	Gen.Pro.C-5.2 Apply new knowledge through the study of literature, scientific articles, and other sources

2. Competency assessment indicators

As a result of studying the course the student should:

know:

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- modern level of knowledge and problems of immunology;
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be able to:

- formulate and set the research task and its stage-by-stage implementation;
- master the technique of searching and analyzing information found on the Internet;
- present the results of research in oral and visual form;
- draw correct conclusions from the comparison of the results of theory and experiment;
- use your knowledge to solve fundamental and applied problems and technological problems.

master:

- skills of mastering a large amount of information;
- skills of independent work in the laboratory and the Internet;
- skills of competent processing of experience results and comparison with theoretical data;
- practice of research and solving theoretical and applied problems.

3. List of typical control tasks used to evaluate knowledge and skills

During the current control, the student should be able to answer the following questions:

1. Jenner's smallpox vaccine.
2. Theories of immunity by Mechnikov and Ehrlich.
3. Yellow fever vaccine.
4. Promising vaccines against COVID-19.
5. Classification of pathogens.
6. Phases of the immune response and their characteristic duration.
7. Components of the local inflammatory response.
8. Protective role of inflammation.
9. Cytokines and their classification.
10. Properties of acquired immunity.
11. The concept of "trained immunity".
12. Clonal selection of lymphocytes.
13. Involvement of antibodies in immune defense.
14. Main physiological consequences of TCR activation.
15. Primary and secondary immune response.
16. The main subpopulations of T-helpers.
17. Mechanisms for maintaining tolerance in the periphery.
18. Features of the immune system of newborns.
19. Chronic inflammation and cancer.
20. Autoimmune diseases and infections.

During the class, interactive discussions can take place in the course chats, which will be homework. It is possible to perform patent search as an independent task. Successful completion of all tasks in the course and the implementation of control slices of knowledge gives an advantage on differential credit.

4. Evaluation criteria

1. Factors of protection against pathogens on the skin.
2. Factors of protection against pathogens in the intestine.
3. Factors of protection against pathogens in the lungs.
4. Features of C3 as a key factor of the complement system.
5. Three ways of activation and protective functions of complement.
6. Small complement proteins and their functions.
7. Composition and structure of the lytic complement complex.
8. The role of the liver in the systemic response to local inflammation.
9. Recognition of pathogens and their own cells by macrophages.
10. Examples of ligands of Toll-like receptors on the outer membrane.
11. Endosomal Toll-like receptors and their ligands.
12. The role of inflammasome in inflammation.
13. Anti-inflammatory cytokine blockers.
14. What is tocilizumab and why it helps with COVID-19.
15. Relationship between the families of Toll receptors and IL1 / 18 receptors.
16. The main directions of differentiation of hematopoietic cells.
17. Primary and secondary mammalian lymphoid organs.
18. Interaction of dendritic cells with T-helpers.
19. Interaction of B-cells with T-helpers.
20. Follicular dendritic cells.
21. Immune effector module involving macrophages.
22. Immune effector module involving neutrophils.
23. Immune effector module involving granulocytes.
24. Activation of natural killer cells.
25. B-cell response to protein M of streptococci.

26. The structure of the B-cell receptor.
27. BCR coreceptors and B-cell costimulatory receptors.
28. Classes and isotypes of human antibodies.
29. Properties and functions of IgM.
30. Properties and functions of IgG.
31. Properties and functions of IgA and IgE.
32. Neonatal Fc receptor.
33. Proteins A and G, their use in research.
34. Plasma cells.
35. The structure of the T-cell receptor.
36. TCR coreceptors and T cell co-stimulatory receptors.
37. Features of the structure and functioning of the MHCI.
38. Features of the structure and functioning of MHCII.
39. Genetics of V (D) J recombination.
40. Mechanism of V (D) J recombination.
41. Somatic hypermutagenesis and switching of antibody isotypes.
42. ITAM and ITIM motives.
43. Immunological synapse.
44. Positive selection of T cells in the thymus.
45. Negative selection of T cells in the thymus.
46. Origin of T-regulatory cells.
47. Mechanisms of action of T-regulatory cells.
48. T-killer effector molecules.
49. Features of gamma-delta T cells.
50. Immunological tolerance in the intestine.
51. Immune privileged organs.
52. AB0 blood groups and central tolerance.
53. Immunological tolerance during pregnancy.
54. Hemolytic disease of the newborn.
55. Use of activation of innate immunity in cancer immunotherapy.
56. Tumors of viral origin and immunosuppression.
57. HPV and cervical cancer.
58. Dendritic cell-based cancer vaccines.
59. Paraneoplastic autoimmune syndromes.
60. CAR-T technology.
61. Mechanisms of anti-tumor action of antibodies.
62. Immunological checkpoints and cancer.
63. Autoimmune diseases and gender imbalance.
64. Mechanism of anaphylactic type hypersensitivity.
65. Allergic diseases and microbiota.
66. Ways to suppress allergic reactions.
67. The main types of immunosuppressants and their mechanisms of action.
68. Rejection of grafts between allogeneic strains of mice.
69. Direct and indirect allogeneic recognition.
70. Primary and secondary immunodeficiencies.
71. Examples of mutations leading to SCID.
72. Examples of mutations leading to X-SCID.

The mark is excellent (10 points) - given to a student who has shown comprehensive, systematized, deep knowledge of the curriculum of the discipline, who is interested in this subject area, who has demonstrated the ability to confidently and creatively apply them in practice in solving specific problems, free and correct justification of the decisions made.

The mark is excellent (9 points) - given to a student who has shown comprehensive, systematized, in-depth knowledge of the curriculum of the discipline and the ability to confidently apply them in practice when solving specific problems, free and correct justification of decisions made.

The mark is excellent (8 points) - given to a student who has shown comprehensive, systematized, deep knowledge of the curriculum of the discipline and the ability to confidently apply them in practice when solving specific problems, the correct justification of the decisions made, with some drawbacks.

The mark is good (7 points) - given to a student if he firmly knows the material, expresses it competently and in essence, knows how to apply the knowledge gained in practice, but does not correctly justify the results obtained.

The mark is good (6 points) - given to the student if he knows the material well, expresses it competently and in essence, knows how to apply the knowledge gained in practice, but makes some inaccuracies in the answer or in solving problems.

A good mark (5 points) is given to a student if he basically knows the material, expresses it competently and in essence, knows how to apply the knowledge gained in practice, but makes a sufficiently large number of inaccuracies in the answer or in solving problems.

The mark is satisfactory (4 points) - given to a student who has shown a fragmentary, scattered nature of knowledge, insufficiently correct formulations of basic concepts, violation of the logical sequence in the presentation of the program material, but at the same time he has mastered the main sections of the curriculum necessary for further education, and can apply the obtained knowledge modeled on a standard situation.

The mark is satisfactory (3 points) - given to a student who has shown a fragmentary, scattered nature of knowledge, makes mistakes in the formulation of basic concepts, breaks the logical consistency in the presentation of program material, has poor command of the main sections of the curriculum necessary for further education and hardly applies the knowledge gained even in a standard situation.

The mark is unsatisfactory (2 points) - given to a student who does not know most of the main content of the curriculum of the discipline, makes gross errors in the formulation of basic principles and does not know how to use the knowledge gained in solving typical problems.

The mark is unsatisfactory (1 point) - given to a student who does not know the main content of the curriculum of the discipline, makes gross errors in the formulation of the basic concepts of the discipline, and generally does not have the skills to solve typical practical problems.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

When conducting an oral differential test, the student is given 60 minutes to prepare. Interrogation of a student on a ticket on an oral differential test should not exceed one astronomical hour.