

**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: Cell Technology/Клеточные технологии
major: Biotechnology
specialization: Medical Biotechnology/Медицинская биотехнология
Phystech School of Biological and Medical Physics
Center for educational programs in bioinformatics
term: 1
qualification: Master

Semester, form of interim assessment: 1 (fall) - Grading test

Academic hours: 90 AH in total, including:

lectures: 30 AH.

seminars: 0 AH.

laboratory practical: 60 AH.

Independent work: 90 AH.

In total: 180 AH, credits in total: 4

Author of the program: E.V. Petersen, candidate of medical sciences

The program was discussed at the Center for educational programs in bioinformatics 25.04.2024

Annotation

The course introduces the main directions of cell technologies, methods and devices used in working with cells, a variety of areas of cell biotechnologies and prospects for their development in the coming decades. In practical classes, students acquire skills in applying methods aimed at isolating individual types of cells from various sources, their cultivation (cultivation) in order to increase the number and subsequent use of the products of the vital activity of these cells or the cells themselves for scientific or scientific-practical purposes.

1. Study objective

Purpose of the course

introduction to the main directions of cell technologies, methods and devices used in working with cells, a variety of areas of cell biotechnologies and prospects for their development in the coming decades.

Tasks of the course

- acquisition of initial skills in the application of methods aimed at isolating individual cell types from various sources, their cultivation (cultivation) in order to increase the number and subsequent use of the products of the vital activity of these cells or the cells themselves for scientific or scientific-practical purposes.

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
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of biological, physical, mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of biological, physical, mathematical sciences
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.4 Able to plan, organise and carry out research work in biotechnology, correctly process the results of experiments and draw valid opinions and conclusions
Pro.C-3 Use research and testing equipment (devices and installations, specialized software) in a selected subject field	Pro.C-3.1 Understand the operating principles of the equipment and specialized software
	Pro.C-3.2 Conduct an experiment (simulation), using research equipment (software)
	Pro.C-3.5 Apply bioengineering and bioinformatics methods to create biological objects with altered properties

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

As a result of studying the course the student should:

know:

- basic information about cell technologies, imagine their significance for the development of biology and medicine, and the value and necessity of fundamental research in this area.

be able to:

- correlate the biotechnological task with the approaches and tools that are necessary for its solution;
- apply the obtained theoretical knowledge about experimental approaches in cell technology to solve specific experimental problems;
- use your knowledge to solve fundamental and applied problems;

master:

- skills of mastering a large amount of information;
- skills of independent work in the laboratory and on the Internet;
- culture of setting and modeling biological problems;
- skills for the proper processing of the results of the experiment 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	Subject and objectives of microbial biotechnology.	2		4	10
2	Methods for producing microorganisms-producers, methods of cultivation of microorganisms.	4		8	11
3	Applications of microbial biotechnology. Microbial bioenergetics.	3		6	12
4	Directions and tasks of eukaryotic biotechnology. Stem and tissue-specific cells. Methods of isolation and cultivation of eukaryotic cells.	6		12	12
5	Products of cellular technologies. Types of genetic editing of eukaryotic cells.	3		6	11
6	In silico treatment of genetic information sequences. Validation of genetic sequences treatment using the PCR method.	4		8	11
7	Use of cellular test systems in pharmacology and Biomedicine. Setting up an experiment. Methods of optical observation.	4		8	12
8	Fixation of biological material. Immunofluorescence and immunoenzyme assays. Optogenetics and patch-clamp.	4		8	11
AH in total		30		60	90
Exam preparation		0 AH.			
Total complexity		180 AH., credits in total 4			

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

Semester: 1 (Fall)

1. Subject and objectives of microbial biotechnology.

History of the use of microorganisms. The subject and tasks of biotechnology of microorganisms, the main directions. Introduction to the systematics of microorganisms, physiological groups of prokaryotes.

Legal and ethical aspects of cell technologies in medicine and biotechnology.

Prospects for the development of cellular technologies. Bioprinting.

2. Methods for producing microorganisms-producers, methods of cultivation of microorganisms.

Microbiological method for obtaining microorganisms-producers-search, isolation, evaluation of properties, introduction of the microorganism into the culture.

Genetic engineering methods for producing microbial producers, selection and screening of producers.

Methods of laboratory and industrial cultivation of microorganisms.

3. Applications of microbial biotechnology. Microbial bioenergetics.

Biotechnology of microorganisms in medicine. Antibiotics, probiotics, vaccines, vitamins, recombinant enzymes, and hormones.

Food biotechnology.

Biopesticides, the chemical fertilizers, bioherbicides and bio-fertilizer.

Bio-diagnostics and bioindication.

Biodegradation of waste.

Biohydrometallurgy.

Microbial bioenergetics.

Biotechnology of extremophiles.

Biotechnology of viral particles.

4. Directions and tasks of eukaryotic biotechnology. Stem and tissue-specific cells. Methods of isolation and cultivation of eukaryotic cells.

The history of the use of cell cultures. The main directions and tasks of biotechnology of eukaryotes. Stem (pluripotent, multipotent, polypotent unipotent) and tissue-specific cells, classification, physiological features. Biological weapon. Bioterrorism. Methods of cell isolation – biopsy, primary, and suspension cell cultures. Methods of laboratory and industrial cultivation of eukaryotic cells. Bioreactors, perfusion systems, automation of industrial cultivation.

5. Products of cellular technologies. Types of genetic editing of eukaryotic cells.

Products of cellular technologies.

Vaccines, antibodies, proteins, enzymes, and their applications. Genetic engineering methods for producing microbial producers, selection and screening of producers.

Types of genetic editing of eukaryotic cells (transformation, transfection, transduction). Advantages and disadvantages of the most commonly used methods: CRISPRcas9, TALEN, ZFN.

Biomedical technologies, application in medicine. Treatment of cancer with modified cells on the example of CAR-T, treatment of genetic pathologies.

6. In silico treatment of genetic information sequences. Validation of genetic sequences treatment using the PCR method.

In silico treatment of genetic information sequences (selection of primers, insertion sites), determination of SNP variants by PCR.

Verification of genetic sequences by PCR, sequencing (capillary Sanger sequencing, NGS, single-cell sequencing). Processing of the obtained readings, and working with libraries.

7. Use of cellular test systems in pharmacology and Biomedicine. Setting up an experiment. Methods of optical observation.

Use of cellular test systems in pharmacology and biomedicine. Two-dimensional and three-dimensional cell models (co-culture, spheroids, organoids, organotypic cultures). Screening (survival, MTT, LD50) and specific methods for assessing the effect of pharmacological substances (exposure kinetics, physiological activity, assessment of the activity of signal cascades).

Setting up an experiment. Types of experiments, experiment design, types of controls, work log, research report, standard experiment Protocol.

Methods of optical observation. Microscopy (types of microscopy, advanced microscopy, high-resolution microscopy), colorimetry, spectrometry.

8. Fixation of biological material. Immunofluorescence and immunoenzyme assays. Optogenetics and patch-clamp.

Fixation of biological material, filling, cutting, smear, immunofluorescence methods, immunoenzyme methods, radioautography, ELISA, vital cell staining.

Optogenetics and patch-clamp, electrophoresis, co-immunoprecipitation. In situ hybridization, hybridomas, FISH.

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

Classroom with a projector and computer. A training laboratory equipped for microbiological research with an optical unit and sterile rooms.

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

Main literature

Additional literature

Recommended literature for self-study

1. Molecular biology of the cell / B. Alberts, A. Johnson, J. Lewis [et al.] ; with problems by J. Wilson, T. Hunt. - 6th edition. - New York : Garland science, 2015. - 1342 p.

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

Not used

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

MS Office software package: MS Word, MS Power Point, MS Visio. Acrobat Reader, DJVU Reader.

9. Guidelines for students to master the course

Successful assimilation of the course material involves attending lectures, performing and passing laboratory work, thoughtful study of recommended literature, independent search in information databases on new methods and research on the use of cellular technologies in restorative and substitution medicine.

Assessment funds for course (training module)

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Center for educational programs in bioinformatics
term: 1
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Semester, form of interim assessment: 1 (fall) - Grading test

Author: E.V. Petersen, candidate of medical sciences

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of biological, physical, mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of biological, physical, mathematical sciences
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Pro.C-3 Use research and testing equipment (devices and installations, specialized software) in a selected subject field	Pro.C-3.1 Understand the operating principles of the equipment and specialized software
	Pro.C-3.2 Conduct an experiment (simulation), using research equipment (software)
	Pro.C-3.5 Apply bioengineering and bioinformatics methods to create biological objects with altered properties

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- basic information about cell technologies, imagine their significance for the development of biology and medicine, and the value and necessity of fundamental research in this area.

be able to:

- correlate the biotechnological task with the approaches and tools that are necessary for its solution;
- apply the obtained theoretical knowledge about experimental approaches in cell technology to solve specific experimental problems;
- use your knowledge to solve fundamental and applied problems;

master:

- skills of mastering a large amount of information;
- skills of independent work in the laboratory and on the Internet;
- culture of setting and modeling biological problems;
- skills for the proper processing of the results of the experiment 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

Current control consists of performing and passing laboratory work, answering control questions written and oral questions.

Stem (pluripotent, multipotent, polypotent unipotent) and tissue

-specific cells, classification, physiological features.

Methods of cell isolation – biopsy, primary, and suspension cell cultures.

Methods of laboratory and industrial cultivation of eukaryotic cells.

Bioreactors, perfusion systems, automation of industrial cultivation.

Products of cellular technologies.

Vaccines, antibodies, proteins, enzymes, and their applications. Genetic engineering

methods for producing microbial producers, selection and screening of producers.

Types of genetic editing of eukaryotic cells (transformation, transfection, transduction).

Advantages and disadvantages of the most commonly used methods: CRISPRcas9, TALEN, ZFN.

Biomedical technologies, application in medicine. Treatment of cancer with modified cells on the example of CAR-T, treatment of genetic pathologies.

Methods of working with genetic sequences in silica (selection of primers, insertion sites), determination of SNP variants by PCR

Verification of genetic sequences by PCR, sequencing (capillary Sanger sequencing, NGS, single-cell sequencing) Processing of received readings, working with libraries.

Use of cellular test systems in pharmacology and Biomedicine. Two-dimensional and three-dimensional cell models (co-culture, spheroids, organoids, organotypic cultures). Screening (survival, MTT, LD50) and specific methods for assessing the effect of pharmacological substances (exposure kinetics, physiological activity, assessment of the activity of signal cascades).

4. Evaluation criteria

Examples of questions for differentiated test:

1. Theoretical and methodological approaches to cell culture.
2. Use of cell lines in cell replacement therapy.
3. Mechanisms of cell differentiation, malignancy, carcinogenesis, and programmed cell death.
4. Stem cells of various nature and orientation in the body and during in vitro cultivation.
5. Cellular technologies in the treatment of various pathologies: skin therapy; therapy of the cardiovascular system; defects in bone and cartilage tissues; therapy of the endocrine glands.
6. Typical questions for current performance monitoring:
7. General characteristics and types of stem cells
8. The retrieval of stem cells
9. Application of cellular technologies in the XXI century
10. Cellular technologies in medicine
11. Development prospects and ethical problems of cell technologies in medicine
12. Biopesticides, the chemical fertilizers, bioherbicides and bio-fertilizer.
13. Microbial bioenergetics
14. Biotechnology of extremophiles.
15. Biotechnology of viral particles

Example:

1. General characteristics and types of stem cells
3. The retrieval of stem cells

Assessment excellent 10 points-exposed to the student who showed a comprehensive, systematic, in-depth knowledge of the curriculum discipline, showing interest in the subject area, demonstrated the ability to confidently and creatively apply them in practice in solving specific problems, free and correct justification of decisions.

Assessment excellent 9 points-exposed to the student, who showed a comprehensive, systematic, in-depth knowledge of the curriculum discipline and the ability to confidently apply them in practice in solving specific problems, free and correct justification of decisions.

Assessment is excellent 8 points-exposed to the student, who showed a comprehensive, systematic, in-depth knowledge of the curriculum discipline and the ability to confidently apply them in practice when solving specific problems, the correct justification of the decisions, with some shortcomings.

Score well 7 points is assigned to the student if he knows the material, competently, and essentially presents it, is able to apply the acquired knowledge in practice, but has not been properly justifies the results obtained.

Score well 6 points is assigned to the student if he knows the material, competently, and essentially presents it, is able to apply the acquired knowledge in practice, but admits in the answer or in the task some inaccuracies.

Score well 5 points is assigned to the student if he basically knows the material, competently, and essentially presents it, is able to apply the acquired knowledge in practice, but admits in the answer or in the task of quite a number of inaccuracies.

The satisfactory rating of 4 points is assigned to the student who showed the fragmented, piecemeal nature of the knowledge is not enough for the correct formulation of the basic concepts, disorders of logical sequence in the presentation of program material, but he mastered parts of the curriculum necessary for further learning, and can apply the knowledge modeled in the standard situation.

Rating satisfactory 3 points - is given for student, who showed the fragmented, piecemeal nature of knowledge makes a mistake in the formulation of the basic concepts of violation of logical sequence in the presentation of program material, has little major parts of the curriculum necessary for further studies and work applies the knowledge gained even in the standard situation.

Assessment unsatisfactory 2 points-exposed to the student who does not know most of the basic content of the curriculum discipline, makes blunders in the wording of the basic principles and does not know how to use the knowledge in solving typical problems.

Assessment unsatisfactory 1 point-exposed to the student who does not know the basic content of the curriculum discipline, makes gross errors in the wording of the basic concepts of discipline and 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 a differentiated test, the student is given 40 minutes to prepare. The student's ticket survey should not exceed one astronomical hour.