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

APPROVED
Head of Landau Phystech-School of Physics & Research
A.V. Rogachev

Work program of the course (training module)

course:	Experimental Oncology/Экспериментальная онкология
major:	Applied Mathematics and Physics
specialization:	General and Applied Physics/Общая и прикладная физика
	Landau Phystech-School of Physics & Research
	Chair of Biophysics
term:	1
qualification:	Master

Semester, form of interim assessment: 2 (spring) - Exam

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

Independent work: 30 AH.

Exam preparation: 30 AH.

In total: 90 AH, credits in total: 2

Number of course papers, tasks: 2

Author of the program: I.V. Manukhov, doctor of biological sciences

The program was discussed at the Chair of Biophysics 19.06.2023

Annotation

The discipline covers the issues of application of physical research methods for solving applied medical and biological problems.

1. Study objective

Purpose of the course

The purpose of the course is to form a holistic understanding of the theoretical foundations and basic methods of molecular biophysics, the biophysics of membrane processes, the structure and functioning of biological membranes, the main methods for studying membrane processes, the theoretical foundations and main methods for studying photobiological processes, the theoretical foundations and basic methods of radiation biophysics, about the main biophysical methods of recording functional activity indicators, the application of acquired knowledge and skills in solving professional problems.

Tasks of the course

1) Acquaintance of students with the theoretical foundations and basic methods of molecular biophysics

2) Acquaintance of students with the biophysics of membrane processes, the structure and functioning of biological membranes

3) Acquaintance of students with the theoretical foundations and basic methods of radiation biophysics

4) Acquaintance of students with the main biophysical methods for recording indicators of functional activity, applying the acquired knowledge and skills in solving professional problems

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 Use a systematic approach to critically analyze a problem,and develop an action plan	UC-1.1 Systematically analyze the problem situation, identify its components and the relations between them
	UC-1.2 Search for solutions by using available sources
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of physical and mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional settings
Gen.Pro.C-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
Gen.Pro.C-3 Select and/or develop approaches to professional problem-solving with consideration to the limitations and specifics of different solution methods	Gen.Pro.C-3.1 Analyze problems, plan research strategy to achieve solution(s), propose, and combine solution approaches
	Gen.Pro.C-3.2 Employ research methods to solve new problems and apply knowledge from various fields of science (technology)
	Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations of the implementation of the obtained solutions in practice
Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems and obtain new scientific results	Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model

Pro.C-2 Organize and conduct scientific research and testing independently or as a member (leader) of a small research team	Pro.C-2.1 Plan and conduct scientific research independently or as part of a research team

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

As a result of studying the course the student should:

know:

1) Theoretical foundations and basic methods of molecular biophysics
2) Theoretical foundations of the biophysics of membrane processes, the structure and functioning of biological membranes
3) Theoretical foundations and basic methods of radiation biophysics
4) Basic biophysical methods for recording functional activity indicators, applying the acquired knowledge and skills in solving professional problems

be able to:

1) formulate and plan research tasks in medical biophysics;
2) using a personal computer to find bibliographic information on a given topic;
3) reproduce modern research methods and develop new methodological approaches for solving the problems of biomedical research;
4) use theoretical and methodological approaches to study the nature and mechanisms of development of pathological processes;
5) determine and evaluate the possibilities of modeling pathological processes;
6) use software systems for processing experimental and clinical data, studying biochemical processes in the body.
7) identify and systematize the main ideas in scientific texts;
8) critically evaluate any incoming information, regardless of the source;
9) generate new ideas and methodological solutions;
10) carry out the design of their scientific activities;
11) present their scientific results in oral presentations.

master:

1) methods of planning and developing a scheme of biomedical experiments;
2) the main methods of laboratory, biochemical and instrumental diagnostics;
3) spectrophotometric analysis of various biological systems;
4) theoretical and methodological approaches for studying the nature and mechanisms of development of pathological processes.

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	Introduction	2			2
2	Electrical conductivity of organs and tissues.	4			4
3	General laws of the sense organs	6			6
4	Mechanical properties of tissues	6			6
5	The role of voltage-gated and ligand-operated ion channels	4			4
6	Membrane pump - transport ATPase	4			4
7	Free radical processes in pathology.	4			4
AH in total		30			30
Exam preparation		30 AH.			

Total complexity	90 AH., credits in total 2

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

Semester: 2 (Spring)

1. Introduction

Goals and objectives of the course. Repetition of the basics of biochemistry and molecular biology

2. Electrical conductivity of organs and tissues.

Methods for measuring the electrical conductivity of organs and tissues.

3. General laws of the sense organs

Biophysical bases of vision, hearing, smell.

4. Mechanical properties of tissues

Biomechanical processes in nature. Biomechanical processes in biochemistry. Biomechanical tissue models. Model of the collagen-elastin fiber. Mechanical properties of muscles

5. The role of voltage-gated and ligand-operated ion channels

The role of voltage-dependent and ligand-operated ion channels in the formation of cell excitation, the generation of action potentials in normal and pathological conditions. Analysis of ionic currents, channel activity and membrane state during a series of pulses carried out by an excitable cell. The role of trace potentials. Activation of pacemakers in neurons during thermo-, chemo- and mechanostimulation.

6. Membrane pump - transport ATPase

Classification of membrane ATPases (ATPase P-type, V(F)-type, ABC-type), their localization and functions.

7. Free radical processes in pathology.

The role of reactive oxygen species. Chain reactions. Antioxidant status: enzymes and major antioxidants.

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 media projector and screen, Internet access.

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

Main literature

Фонд базовой кафедры:
Антонов В.Ф., Физика и биофизика [Электронный ресурс] : учебник / В. Ф. Антонов, Е. К. Козлова, А. М. Черныш. - 2-е изд., испр. и доп. - М. : ГЭОТАР-Медиа, 2015. - 472 с. - ISBN 978-5-9704-3526-7 - Режим доступа: http://www.studmedlib.ru/book/ISBN9785970435267.html Антонов В.Ф., Физика и биофизика. Руководство к практическим занятиям [Электронный ресурс] : учебное пособие / Антонов В.Ф., Черныш А.М., Козлова Е.К., Коржуев А.В. - М. : ГЭОТАР-Медиа, 2013. - 336 с. - ISBN 978-5-9704-2677-7 - Режим доступа: http://www.studmedlib.ru/book/ISBN9785970426777.html Ремизов А.Н., Медицинская и биологическая физика [Электронный ресурс] : учебник

Additional literature
Фонд базовой кафедры:
Эйдельман Е.Д., Физика с элементами биофизики [Электронный ресурс] : учебник / Е.Д. Эйдельман - М. : ГЭОТАР-Медиа, 2013. - 512 с. - ISBN 978-5-9704-2524-4 - Режим доступа: http://www.studmedlib.ru/book/ISBN9785970425244.html Камкин А.Г.,
Атлас по физиологии. В двух томах. Том 1 [Электронный ресурс] : учебное пособие / Камкин А.Г., Киселева И.С. - М. : ГЭОТАР-Медиа, 2013. - 408 с. - ISBN 978-5-9704-2418-6 - Режим доступа: http://www.studmedlib.ru/book/ISBN9785970424186.html Камкин А.Г., Атлас по физиологии. В двух томах. Том 2 [Электронный ресурс] : учебное пособие / Камкин А.Г., Киселева И.С. - М. : ГЭОТАР-Медиа, 2013. - 448 с. - ISBN 978-5-9704-2419-3 - Режим доступа: http://www.studmedlib.ru/book/ISBN9785970424193.html

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)

Not used

9. Guidelines for students to master the course

A student studying the discipline must, on the one hand, master the general conceptual apparatus, and on the other hand, must learn to apply theoretical knowledge in practice.
As a result of studying the discipline, the student must know the basic definitions and concepts, be able to apply the knowledge gained to solve various problems.
Successful completion of the course requires:
- attendance of all classes provided for by the curriculum for the discipline;
- keeping a synopsis of classes;
- student's intense independent work.
Independent work includes:
- reading recommended literature;
- study of educational material, preparation of answers to questions intended for independent study;
- solving problems offered to students in the classroom;
- preparation for the performance of tasks of the current and intermediate certification.
An indicator of mastery of the material is the ability to answer questions on the topics of the discipline without a synopsis.
It is important to achieve an understanding of the material being studied, not its mechanical memorization. If a student finds it difficult to study certain topics, questions, he/she should seek advice from a teacher.
Intermediate control of students' knowledge is possible in the form of solving problems in accordance with the topic of classes.

SUPPLEMENT

Assessment funds for course (training module)

major:	Applied Mathematics and Physics
specialization:	General and Applied Physics/Общая и прикладная физика Landau Phystech-School of Physics & Research Chair of Biophysics
term:	1
qualification:	Master

Semester, form of interim assessment: 2 (spring) - Exam

Author: I.V. Manukhov, doctor of biological sciences

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
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	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional settings
Gen.Pro.C-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
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	Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations of the implementation of the obtained solutions in practice
Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems and obtain new scientific results	Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model
Pro.C-2 Organize and conduct scientific research and testing independently or as a member (leader) of a small research team	Pro.C-2.1 Plan and conduct scientific research independently or as part of a research team

2. Competency assessment indicators

As a result of studying the course the student should:

know:

1) Theoretical foundations and basic methods of molecular biophysics
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4) Basic biophysical methods for recording functional activity indicators, applying the acquired knowledge and skills in solving professional problems

be able to:

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4) use theoretical and methodological approaches to study the nature and mechanisms of development of pathological processes;
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11) present their scientific results in oral presentations.

master:

1) methods of planning and developing a scheme of biomedical experiments;
2) the main methods of laboratory, biochemical and instrumental diagnostics;
3) spectrophotometric analysis of various biological systems;
4) theoretical and methodological approaches for studying the nature and mechanisms of development of pathological processes.

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

In order to control the students' mastery of the training material, an oral questioning is conducted at the beginning of the lesson on the topic of the last session.

4. Evaluation criteria

Checking questions:

1. Subject and tasks of biophysics.
2. The main requirements for biophysical methods: the need to comply with the integrity of the system under study: the requirement for high resolution.
3. Basic concepts of communication theory and information theory, characteristic properties of signals and messages.
4. Calculation of information, units of measurement of information, transmission of information.
5. Coding of hereditary information. Transmission and processing of information in the nerve centers.
6. The main physical and chemical reasons for the violation of the barrier properties of membranes: lipid peroxidation, enzymatic cleavage of lipids and proteins, changes in the charge and conformation of proteins, adsorption of foreign proteins, osmotic stretching of membranes.
7. The role of phospholipases activation in cell damage during tissue hypoxia, transformation of the physical structure and membrane permeability as a result of the action of phospholipases.
8. Lipid peroxidation as a fundamental mechanism of membrane pathology.
9. Methods for studying lipid peroxidation: analysis of oxygen consumption and accumulation of various peroxidation products, measurement of chemiluminescence.
10. Generation of free radicals in electron transfer chains, the role of iron ions in the generation of free radicals. Superoxide and hydroxyl radicals

Examples of exam question papers:

Question paper 1.

1. Subject and tasks of biophysics
2. The main physical and chemical reasons for the violation of the barrier properties of membranes: lipid peroxidation, enzymatic cleavage of lipids and proteins, changes in the charge and conformation of proteins, adsorption of foreign proteins, osmotic stretching of membranes.

Question paper 2.

1. The main requirements for biophysical methods: the need to comply with the integrity of the system under study: the requirement for high resolution
2. The role of phospholipases activation in cell damage during tissue hypoxia, transformation of the physical structure and membrane permeability as a result of the action of phospholipases.

Question paper 3.

1. Basic concepts of communication theory and information theory, characteristic properties of signals and messages

2. Lipid peroxidation as a fundamental mechanism of membrane pathology.

Question paper 4.

1. Calculation of information, units of measurement of information, transmission of information

2. Methods for studying lipid peroxidation: analysis of oxygen consumption and accumulation of various peroxidation products, measurement of chemiluminescence.

Question paper 5.

1. Coding of hereditary information. Transmission and processing of information in the nerve centers.

2. Generation of free radicals in electron transfer chains, the role of iron ions in the generation of free radicals. Superoxide and hydroxyl radicals

Assessment “excellent (10)” is given to a student who has displayed comprehensive, systematic and deep knowledge of the educational program material, has independently performed all the tasks stipulated by the program, has deeply studied the basic and additional literature recommended by the program, has been actively working in the classroom, and understands the basic scientific concepts on studied discipline, who showed creativity and scientific approach in understanding and presenting educational program material, whose answer is characterized by using rich and adequate terms, and by the consistent and logical presentation of the material;

Assessment “excellent (9)” is given to a student who has displayed comprehensive, systematic knowledge of the educational program material, has independently performed all the tasks provided by the program, has deeply mastered the basic literature and is familiar with the additional literature recommended by the program, has been actively working in the classroom, has shown the systematic nature of knowledge on discipline sufficient for further study, as well as the ability to amplify it on one’s own, whose answer is distinguished by the accuracy of the terms used, and the presentation of the material in it is consistent and logical;

Assessment “excellent (8)” is given to a student who has displayed complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently performed all the tasks stipulated by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (7)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in the answer, has independently performed all the tasks provided by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (6)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently carried out the main tasks stipulated by the program, studied the basic literature recommended by the program, showed systematic character of his knowledge of the discipline, which is sufficient for further study;

Assessment “good (5)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, mastered the basic literature recommended by the program, made some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors by himself;

Assessment “satisfactory (4)” is given to a student who has discovered knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, learned the main literature but allowed some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors under the guidance of a teacher;

Assessment “satisfactory (3)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, not showed activity in the classroom, independently fulfilled the main tasks envisaged by the program, but allowed errors in their implementation and in the answer during the test, but possessing necessary knowledge for elimination under the guidance of the teacher of the most essential errors;

Assessment “unsatisfactory (2)” is given to a student who showed gaps in knowledge or lack of knowledge on a significant part of the basic educational program material, who has not performed independently the main tasks demanded by the program, made fundamental errors in the fulfillment of the tasks stipulated by the program, who is not able to continue his studies or start professional activities without additional training in the discipline in question;

Assessment “unsatisfactory (1)” is given to a student when there is no answer (refusal to answer), or when the submitted answer does not correspond at all to the essence of the questions contained in the task.

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

The course is graded at an exam. The questioning starts with a random task assigned to each student and time given for completion of the task. No aids are allowed. The student then proceeds to a chat with the examiner, at which he/she presents his/her solution to the assigned task. The examiner then asks the student several questions that evenly cover the course content. A final grade is assigned based on the quality of answers and demonstrated level of understanding.