

**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:** Cancer Cell Biology/Биология опухолевой клетки  
**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) - Grading test

Academic hours: 30 AH in total, including:

lectures: 30 AH.

seminars: 0 AH.

laboratory practical: 0 AH.

Independent work: 15 AH.

In total: 45 AH, credits in total: 1

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

This course will examine the biophysical and biochemical basis of the functioning of cancer cells. Modern approaches to selective suppression of their growth, combined methods of cancer treatment.

### 1. Study objective

#### Purpose of the course

The purpose of the course is to familiarize students with modern knowledge and the latest scientific achievements in biology and medicine related to the causes, development mechanisms and clinical manifestations of tumors (neoplasms), as well as the development of methods for their diagnosis, treatment and prevention.

#### Tasks of the course

- 1) Acquaintance of students with the chemical structure of living matter
- 2) Acquaintance of students with the basic patterns of development and life of the body based on the structural organization of cells
- 3) Acquaintance of students with the molecular basis of the formation of tumor cells
- 4) Acquaintance of students with the basics of the development of carcinogenesis

### 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-2 Able to manage the project through all stages of implementation	UC-2.4 Publicly present the project results (or results of its stages) via reports, articles, presentations at scientific conferences, seminars, and similar events
UC-3 Organize and manage a team, and develop the team strategy to achieve the objectives	UC-3.2 Consider the interests, specific behavior, and diversity of opinions of team members/colleagues/counterparties
UC-4 Use modern communication tools in the academic and professional fields, including those in a foreign language	UC-4.1 Exchange business information in oral and written forms in Russian and at least one foreign language
	UC-4.2 Use the acquired skills to write, translate, and edit various academic texts (abstracts, essays, reviews, articles, etc.)
UC-6 Determine priorities and ways to improve performance through self-assessment	UC-6.1 Achieve personal growth and professional development, determine priorities and ways to improve performance
Gen.Pro.C-1 Gain 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-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings
	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form within professional communication
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-4 Successfully perform a task, analyze the results, and present conclusions,	Gen.Pro.C-4.1 Apply ICT knowledge and skills to find and study scientific literature and use software products

apply knowledge and skills in the field of physical and mathematical sciences and ICTs	Gen.Pro.C-4.3 Justify the chosen method of scientific research
Gen.Pro.C-5 Undertake professional training, achieve professional growth, and become a team leader in a professional sphere, tolerant of social, ethnic, religious, and cultural differences	Gen.Pro.C-5.3 Apply new knowledge and achieve personal and professional growth
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-1.1 Locate, analyze, and summarize information on current research findings within the subject area
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 and methodological foundations of biochemistry;
- 2) the chemical structure of living matter: the structure and functions of proteins and nucleic acids, the principles and mechanisms of reproduction and preservation of deoxyribonucleic acid (DNA) in a number of generations (replication and repair), decoding of genetic information by ribonucleic acid (RNA) molecules, mechanisms of processing of primary transcripts, stages and mechanisms of protein biosynthesis (translation), post-translational modification of proteins;
- 3) the main patterns of development and life of the body based on the structural organization of cells, the functioning of the cell cycle;
- 4) general issues of development of the structure and function of tumor cells;
- 5) factors that shape human health. Etiology and pathogenesis of the tumor;
- 6) the main patterns of development of pathological processes and conditions. tumor growth;
- 7) physical and chemical mechanisms of pathology: the role of damage to various cell structures in its pathology; phospholipase membrane damage; lipid peroxidation; osmotic violation of the structure and function of cells;
- 8) biochemistry of pathological processes: metabolism of tumor growth, enzymatic system, biochemistry of immunity during tumor growth.

be able to:

- 1) formulate and plan research tasks in biochemistry, molecular biology and immunology;
- 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) methods for isolating and separating macromolecules; skills in working with automatic dispensers, basic chromatography techniques;
- 4) spectrophotometric analysis of various biological systems;
- 5) methods of fluorescent, chemiluminescent analysis.

### 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			1
2	Basic mechanisms of tumor formation	2			1
3	"Oncogene" and "tumor" suppressor	2			1
4	Mechanisms of replicative aging	2			1
5	Mechanisms of programmed cell death	2			1
6	Genetic instability	2			1
7	Violation of adhesion and cytoskeleton	2			1
8	Impact of tumor cells on the microenvironment	2			1
9	The role of microenvironmental modifications in invasive tumor growth	2			1
10	Impaired function of Ras oncoproteins and p53 tumor suppressor	2			1
11	The role of chemical carcinogens	2			1
12	Human oncogenic viruses	2			1
13	New methods of prevention, diagnosis and treatment of malignant tumors based on the elucidation of the molecular mechanisms of carcinogenesis.	2			1
14	The main targets of action of anticancer drugs. Analysis of genomic and biomedical databases by subject.	2			1
15	Virogenetic concept of cancer L.A. Zilber. The concept of an oncogenic virus. The main groups of oncogenic human and animal viruses (adenoviruses, herpesviruses, papoviruses, retroviruses, etc.).	2			1
AH in total		30			15
Exam preparation		0 AH.			
Total complexity		45 AH., credits in total 1			

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

Semester: 2 (Spring)

##### 1. Introduction

The concepts of “tumor”, “benign and malignant neoplasms”, “tumor progression (invasion and metastasis)”. Classification of neoplasms, incidence of the world population and animals with various forms of tumors.

##### 2. Basic mechanisms of tumor formation

Basic mechanisms of tumor formation. Excessive reproduction of cells due to violations of the positive and negative regulation of the cell cycle.

### 3. "Oncogene" and "tumor" suppressor

Concepts "oncogene" and "tumor" suppressor. Disturbances in the function of oncogenes and tumor suppressors that regulate the cell cycle in cells of various human neoplasms.

### 4. Mechanisms of replicative aging

Mechanisms of replicative cell aging and their disturbances in carcinogenesis. The role of telomerase in the immortalization of neoplastic cells.

### 5. Mechanisms of programmed cell death

Methods and mechanisms of programmed cell death (apoptosis, autophagy, etc.). Dysregulation of apoptosis and autophagy in tumor cells.

### 6. Genetic instability

Genetic instability of neoplastic cells: pathways of occurrence and role in tumor progression.

### 7. Violation of adhesion and cytoskeleton

Violation of adhesion and cytoskeleton of tumor cells and the acquisition of a "locomotor" phenotype associated with them. Epithelial-mesenchymal transition in the invasive growth of cancerous tumors.

### 8. Impact of tumor cells on the microenvironment

Impact of tumor cells on the microenvironment: destruction of the extracellular matrix, stimulation of angiogenesis, modification of the stroma.

### 9. The role of microenvironmental modifications in invasive tumor growth

The role of microenvironmental modifications in invasive tumor growth. Mechanisms of cancer metastasis. Features of the progression of leukemia.

### 10. Impaired function of Ras oncoproteins and p53 tumor suppressor

Disturbances in the function of Ras oncoproteins and the tumor suppressor p53 are the most universal molecular changes in the cells of various neoplasms in humans and animals. Mechanisms of oncogenic action of Ras and p53 mutations.

### 11. The role of chemical carcinogens

The role of chemical carcinogens, radiation and infectious agents in the development of tumors.

### 12. Human oncogenic viruses

Oncogenic human viruses: mechanisms of oncogenic action and types of emerging tumors.

### 13. New methods of prevention, diagnosis and treatment of malignant tumors based on the elucidation of the molecular mechanisms of carcinogenesis.

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### 14. The main targets of action of anticancer drugs. Analysis of genomic and biomedical databases by subject.

The main targets of action of anticancer drugs. Analysis of genomic and biomedical databases by subject.

15. Virogenetic concept of cancer L.A. Zilber. The concept of an oncogenic virus. The main groups of oncogenic human and animal viruses (adenoviruses, herpesviruses, papoviruses, retroviruses, etc.).

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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)**

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:

1. Патология. В 2 т. Т. 1 [Электронный ресурс] : учебник / П.Ф. Литвицкий. - 5-е изд., перераб. и доп. - М. : ГЭОТАР-Медиа, 2016. - <http://www.studmedlib.ru/book/ISBN9785970438374.html>
2. Клиническая онкология. Избранные лекции [Электронный ресурс] / Л.З. Вельшер, Б.И. Поляков, С.Б. Петерсон - М. : ГЭОТАР-Медиа, 2014. - <http://www.studmedlib.ru/book/ISBN9785970428672.html>
3. Онкология [Электронный ресурс] / под общей ред. С. Б. Петерсона - М. : ГЭОТАР-Медиа, 2014. - <http://www.studmedlib.ru/book/ISBN9785970425329.html>

### Additional literature

Фонд базовой кафедры:

Патология. Задачи и тестовые задания [Электронный ресурс] : учебно-методическое пособие / П.Ф. Литвицкий, В.А. Войнов, С.В. Пирожков, С.Б. Болевич, В.В. Падалко, А.А. Новиков, А.С. Сизых; под ред. П.Ф. Литвицкого. - М. : ГЭОТАР-Медиа, 2013.' - <http://www.studmedlib.ru/book/ISBN9785970424834.html>

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

RosOncoWeb - <http://www.rosoncoweb.ru/> Канцерогенез - <http://surgeryzone.net/patient/onkologiya/kancerogenez.html> Медицинская онлайн-библиотека - <http://doctor-i.ru/onkologiya/obshee-ponyatie-opuholei-onkologii.-dobrokachestvennie-opuholi.html> Онкологический портал - <http://onco.ucoz.net>  
Эволюционный взгляд на опухоль сулит революцию в онкологии - [https://www.gazeta.ru/science/2011/04/04\\_a\\_3573945.shtml](https://www.gazeta.ru/science/2011/04/04_a_3573945.shtml)

## **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.

**Assessment funds for course (training module)**

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Chair of Biophysics  
**term:** 1  
**qualification:** Master

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

**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-4 Successfully perform a task, analyze the results, and present conclusions, apply knowledge and skills in the field of physical and mathematical sciences and ICTs	Gen.Pro.C-4.1 Apply ICT knowledge and skills to find and study scientific literature and use software products
	Gen.Pro.C-4.3 Justify the chosen method of scientific research
Gen.Pro.C-5 Undertake professional training, achieve professional growth, and become a team leader in a professional sphere, tolerant of social, ethnic, religious, and cultural differences	Gen.Pro.C-5.3 Apply new knowledge and achieve personal and professional growth
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## 2. Competency assessment indicators

As a result of studying the course the student should:

**know:**

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- 3) the main patterns of development and life of the body based on the structural organization of cells, the functioning of the cell cycle;
- 4) general issues of development of the structure and function of tumor cells;
- 5) factors that shape human health. Etiology and pathogenesis of the tumor;
- 6) the main patterns of development of pathological processes and conditions. tumor growth;
- 7) physical and chemical mechanisms of pathology: the role of damage to various cell structures in its pathology; phospholipase membrane damage; lipid peroxidation; osmotic violation of the structure and function of cells;
- 8) biochemistry of pathological processes: metabolism of tumor growth, enzymatic system, biochemistry of immunity during tumor growth.

**be able to:**

- 1) formulate and plan research tasks in biochemistry, molecular biology and immunology;
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- 8) critically evaluate any incoming information, regardless of the source;
- 9) generate new ideas and methodological solutions;
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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) methods for isolating and separating macromolecules; skills in working with automatic dispensers, basic chromatography techniques;
- 4) spectrophotometric analysis of various biological systems;
- 5) methods of fluorescent, chemiluminescent analysis.

**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. The concept of tumor growth.
2. Main biological features of tumor tissue: autonomy of tumor growth, tumor atypism (morphological, functional, biochemical, antigenic), invasive growth, metastasis, recurrence.
3. The concept of the progression of tumors.
4. Clonal nature of tumors. Classification and nomenclature of tumors. Principles of classification of tumors: histological, histogenetic, clinical and morphological, etc.
5. Basic models used in experimental oncology; induced and transplanted tumors, spontaneous, cell and organ cultures
6. Characteristic features in the metabolism of tumor cells.
7. Telomeres of animal cells - their nature and significance for the cell.
8. Telomerase: organization of this enzyme, function in the cell and connection with the process of cancerous transformation of cells.

9. Biochemistry of metastasis.

10. Tumor influence on metabolism and homeostasis

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 a credit. 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.