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:	Introduction to Molecular Biology and Genetics/Введение в молекулярную биологию и генетику
major:	Applied Mathematics and Physics
specialization:	Applied Bioinformatics/Прикладная биоинформатика
	Phystech School of Biological and Medical Physics
	Chair of Bioinformatics and Systems Biology
term:	1
qualification:	Master

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

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

Independent work: 75 AH.

Exam preparation: 30 AH.

In total: 135 AH, credits in total: 3

Author of the program: Y.A. Medvedeva, candidate of biological sciences

The program was discussed at the Chair of Bioinformatics and Systems Biology 04.06.2020

Annotation

The purpose of this discipline is give an idea of the main mechanisms of storage, flow and implementation of genetic information, genome organisation. Give an overview of the diversity of tools for molecular biology. After completing the course, the student will understand physical and chemical properties of nucleic acids and chromatin proteins, processes involving nucleic acids and proteins, the main mechanisms of DNA replication, transcription, modern molecular biological methods for studying cell processes.

1. Study objective

Purpose of the course

Give an idea of the main mechanisms of storage, flow and implementation of genetic information, genome organisation. Give an overview of the diversity of tools for molecular biology.

Tasks of the course

- Give knowledge of molecular biology of prokaryotic and eukaryotic cell;
- Give an overview of genetics and applied biotechnology;
- Train skills of information retrieval for research in the field of molecular biology, genetics, bioinformatics.

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-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
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-1.3 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results
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-3.3 Evaluate the accuracy of the experimental (numerical) results

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

As a result of studying the course the student should:

know:

- physical and chemical properties of nucleic acids and chromatin proteins;
- processes involving nucleic acids and proteins;
- the main mechanisms of DNA replication, transcription;
- modern molecular biological methods for studying cell processes;

be able to:

- understand the mechanisms underlying the research methods in genetics, genomics, molecular biology;
- understand the methods of modern molecular biology and the main features of experimental setup

master:

- categories and concepts used in cell biology;
- ideas about modern methods used in the study of cells.

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	Biology of the cell and modern taxonomy	2			8
2	The basics of prokaryotic and eukaryotic genome organization	4			8
3	Transcription, reverse transcription, translation. DNA replication and reparation	4			8
4	Genetics. Mendel's laws. Chromosome mapping	2			8
5	Non-Mendelian inheritance	2			8
6	Immunity. Innate immunity, acquired immunity. Mechanisms of antigen recognition. Inflammation.	4			8
7	Antibodies. Immune response, immune memory. Immune system and cancer.	4			6
8	Applications of antibodies and enzymes in biotechnology and research.	4			5
9	Genetic therapy	2			8
10	Biology of aging	2			8
AH in total		30			75
Exam preparation		30 AH.			
Total complexity		135 AH., credits in total 3			

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

Semester: 1 (Fall)

1. Biology of the cell and modern taxonomy

Structure of prokaryotic and eukaryotic cell. Structure of viral particles. Modern data on taxonomy and phylogenetic linkage of living organisms.

2. The basics of prokaryotic and eukaryotic genome organization

Chromosomes and extrachromosomal elements in prokaryotes. Chromosomes of eukaryotes.

3. Transcription, reverse transcription, translation. DNA replication and reparation

Transcription in prokaryotes and eukaryotes. Retroviruses and mobile genetic elements. RNA processing. Ribosome. Protein folding. DNA replication and reparation. SOS response.

4. Genetics. Mendel's laws. Chromosome mapping

Genes as elementary units of heredity. Mutations as the source of raw matter for evolution process. Chromosomal theory of inheritance. Mendel's laws. Genetic linkage and crossing-over. Chromosome mapping.

5. Non-Mendelian inheritance

The extrachromosomal inheritance: plastids, mitochondria. The cytoduction. The inheritance of episomes, prions, endosymbiotic organisms. Linkage disequilibrium.

6. Immunity. Innate immunity, acquired immunity. Mechanisms of antigen recognition. Inflammation.

Cellular and humoral components of innate immunity. Mechanisms of antigen recognition in innate immune response. Inflammation. The acquired immunity. The active and passive immunity.

7. Antibodies. Immune response, immune memory. Immune system and cancer.

Antigen presentation. Main histocompatibility complex. Immune response and immune memory. Immune system and cancer. Antiviral immune response. The ways by which pathogens override immune response or gain control over it.

8. Applications of antibodies and enzymes in biotechnology and research.

The applied use of organisms in biotechnology and research. Biomass production. Fabrication and conversion of organic compounds. The use of antibodies from different sources in therapy, diagnostics and research. Enzymes for use in research.

9. Genetic therapy

Genetic therapy of inherited diseases. Therapeutic approaches, delivery systems. Delivery to different organs and tissues.

10. Biology of aging

Free radical theory of aging. Mitochondrial theory of aging. DNA reparation efficiency and average lifespan. The role of chaperones and proteasomes in recycling and refolding of damaged proteins. The telomeres and their length

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

Equipment needed for lectures and seminars: whiteboard with markers, computer and multimedia equipment (projector, sound system)

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

Main literature

Provided at the department:

1. Molecular Biology of the Cell. 5th Edition. B.Alberts, et al. Ed. Garland Sc., USA (имеется электронная версия). 2008.
2. Alberts et al, Molecular biology of the cell. ISBN 978-0-8153-4111-6

Additional literature

Provided at the department:
1. Molecular Biology of the Gene. 5th Edition. J. D. Watson et al. Ed. CSHL Press. USA (имеется электронная версия). 2004.

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

Scientific bibliographic and patent databases in the field of physico-chemical biology, available on the Internet in free mode - Science Citation Index (Web of Science), Medline (PubMed), Scientific Electronic Library (NEB), Russian Patent DB of FGU FIPS and American USPAFULL patent database; email addresses of major scientific publishers who provide access to the full text of current and archival issues of these journals.

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

Internet access. For some of the lessons, you 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

A student who studies discipline must, on the one hand, master a 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 should know the basic definitions of the discipline, be able to apply this knowledge to solve various problems.

Successful learning requires:
- visits to all classes provided by the curriculum for the discipline;
- conducting the abstract of occupations;
- intense independent work of the student.

Independent work includes:
- reading recommended literature;
- study of educational material, preparation of answers to questions intended for self-study;
- solving problems offered to students in the classroom;
- preparation for performance of tasks of the current and intermediate certification.

An indicator of possession of the material is the ability to answer questions on discipline topics without an outline.

It is important to achieve an understanding of the material being studied, and not its mechanical memorization. If it is difficult to study individual
topics, questions, you should seek advice from the teacher.

Intermediate control of students' knowledge in the form of problem solving in accordance with the subject of classes is possible

SUPPLEMENT

Assessment funds for course (training module)

major:	Applied Mathematics and Physics
specialization:	Applied Bioinformatics/Прикладная биоинформатика Phystech School of Biological and Medical Physics Chair of Bioinformatics and Systems Biology
term:	1
qualification:	Master

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

Author: Y.A. Medvedeva, candidate of biological sciences

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
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
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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-3.3 Evaluate the accuracy of the experimental (numerical) results

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- physical and chemical properties of nucleic acids and chromatin proteins;
- processes involving nucleic acids and proteins;
- the main mechanisms of DNA replication, transcription;
- modern molecular biological methods for studying cell processes;

be able to:

- understand the mechanisms underlying the research methods in genetics, genomics, molecular biology;
- understand the methods of modern molecular biology and the main features of experimental setup

master:

- categories and concepts used in cell biology;
- ideas about modern methods used in the study of cells.

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. Structure of prokaryotic and eukaryotic cell. Compartments of the cell.
2. Structure of viral particles.
3. Organisation of prokaryotic genome.
4. Extrachromosomal genetic units in prokaryotes.
5. Eukaryotic genome organization.
6. Transcription of RNA. RNA polymerase, transcription unit in prokaryotes and eukaryotes.
7. Reverse transcription, its role in life cycle of viruses.
8. Translation. Ribosome structure.
9. The folding of proteins. Protein structure.
10. Retroviruses and mobile genetic elements.
11. DNA replication and reparation in prokaryotes.
12. DNA replication and reparation in eukaryotes.
13. Transport of biomolecules.

14. Gene structure in prokaryotes and eukaryotes.
15. Mutations, types of mutations.
16. Mendel’s laws. The genetic linkage and crossing-over.
17. Non-mendelian inheritance.
18. The innate immunity, its cellular and humoral components.
19. Antigen recognition and presentation.
20. The acquired immunity. Antibodies. Main histocompatibility complex.
21. The applied use of organisms in biotechnology and research.
22. Genetic therapy of inherited diseases.
23. Biology of aging.

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 completion of control slices of knowledge gives an advantage in the exam.

4. Evaluation criteria

Intermediate certification for the discipline "Molecular biology and genetics" is carried out in the form of an exam (test). Exam (test) is held in written (oral) form.

1. Structure of prokaryotic and eukaryotic cell. Compartments of the cell.
2. Structure of viral particles.
3. Organisation of prokaryotic genome.
4. Extrachromosomal genetic units in prokaryotes.
5. Eukaryotic genome organization.
6. Transcription of RNA. RNA polymerase, transcription unit in prokaryotes and eukaryotes.
7. Reverse transcription, its role in life cycle of viruses.
8. Translation. Ribosome structure.
9. The folding of proteins. Protein structure.
10. Retroviruses and mobile genetic elements.
11. DNA replication and reparation in prokaryotes.
12. DNA replication and reparation in eukaryotes.
13. Transport of biomolecules.
14. Gene structure in prokaryotes and eukaryotes.
15. Mutations, types of mutations.
16. Mendel’s laws. The genetic linkage and crossing-over.
17. Non-mendelian inheritance.
18. The innate immunity, its cellular and humoral components.
19. Antigen recognition and presentation.
20. The acquired immunity. Antibodies. Main histocompatibility complex.
21. The applied use of organisms in biotechnology and research.
22. Genetic therapy of inherited diseases.
23. Biology of aging.

The examples of exam questions:
1. DNA replication and reparation in prokaryotes.
2. DNA replication and reparation in eukaryotes.
3. Transport of biomolecules.
4. Gene structure in prokaryotes and eukaryotes.
5. Mutations, types of mutations.

The mark is excellent (10 points) - it is given to a student who has shown comprehensive, systematic, deep knowledge of the curriculum of the discipline, who has an interest in this subject area, has demonstrated the ability to confidently and creatively put them into practice in solving specific problems, and a free and proper substantiation of decisions.

The mark is excellent (9 points) - it is given to a student who has shown comprehensive, systematic, in-depth knowledge of the curriculum of the discipline and the ability to confidently put them into practice in solving specific problems, free and proper substantiation of the decisions made.

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

A mark is good (7 points) - it is put up for a student, if he knows the material firmly, sets it up competently and in essence, knows how to apply the knowledge gained in practice, but does not competently substantiate the results obtained.

Evaluation is good (6 points) - it is put up to a student, if he knows the material firmly, sets it up correctly and in essence, knows how to apply this knowledge in practice, but admits some inaccuracies in the answer or in solving problems.

A mark is good (5 points) - it is given to a student, if he basically knows the material, correctly and essentially sets it out, knows how to apply this knowledge in practice, but allows a sufficiently large number of inaccuracies to answer or solve problems.

Grade satisfactorily (4 points) is given to a student who has shown the fragmented, fragmented nature of knowledge, insufficiently correct formulations of basic concepts, violations of the logical sequence in the presentation of program material, but at the same time he has mastered the main sections of the curriculum necessary for further education and can apply knowledge is modeled in a standard situation.

Grade satisfactorily (3 points) - given to a student who showed the fragmented, scattered nature of knowledge, making mistakes in formulating basic concepts, disrupting the logical sequence in presenting program material, poorly masters the main sections of the curriculum required for further education and even applies the knowledge gained in a standard situation.

The rating is unsatisfactory (2 points) - is given to a student who does not know most of the main content of the curriculum of the discipline, makes gross mistakes in the wording of the basic principles and does not know how to use this knowledge when solving typical tasks.

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

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

During the oral exam, the student is given 30 minutes to prepare. The interview for a student in an oral exam must not exceed one astronomical hour.