

**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 General and Molecular Genetics/Введение в общую и молекулярную генетику

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) - 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: A.S. Ermakov, candidate of biological sciences

The program was discussed at the Center for educational programs in bioinformatics 16.05.2024

Annotation

This discipline introduces students to the history of the study of biological heredity, modern ideas about the storage, transmission and realization of hereditary information. Information of the basic methods of classical and modern molecular genetics is given..

1. Study objective

Purpose of the course

To familiarize students with the history of the study of biological heredity and variability, modern ideas about the mechanisms of storage and transmission of genetic information. An overview of the methods of classical and molecular genetics will be given.

Tasks of the course

- formation of the knowledge about the history of studying the mechanisms of biological heredity and variability;
- mastering concepts used in classical and molecular genetics;
- formation of students' basic data retrieval skills for conducting scientific research in the field of classical and molecular genetics.

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 a selected subject area
	Pro.C-1.2 Apply fundamental knowledge of mathematics, physics, chemistry, and biology in professional settings
	Pro.C-1.4 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results
	Pro.C-1.5 Has the ability to create software tools and databases used in bioengineering and bioinformatics
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 experimental (numerical) results
	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:

- the history of the study of biological heredity and variability;
- fundamental concepts and principles of genetics;
- principles, research methods and objects of classical and molecular genetics;
- patterns of reproduction of biological objects;
- modern ideas about the mechanisms of biological heredity and variability.

be able to:

- to understand the processes underlying research methods in genetics;
- to search for data for scientific research in the field of classical and molecular genetics

master:

- categories and concepts used in classical and molecular genetics;
- ideas about the methods used in genetics.

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	Genetics as a science	2			8
2	The history of the study of biological heredity.	4			8
3	The discovery of the laws of inheritance	4			8
4	The formation of classical genetics	2			8
5	The interaction of genes	2			8
6	Genotype and Phenotype	4			8
7	The Chromosomal Theory of Inheritance	4			6
8	Sex and Inheritance	4			5
9	Linked inheritance. Genetic maps	2			8
10	Basics of evolutionary genetics	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. Genetics as a science

What is genetics? Heredity and variability. Types of variability. The main directions of genetics. Classical and molecular genetics. Genetics and other biological sciences. Methods, tasks and objects of genetics.

2. The history of the study of biological heredity.

The history of ideas about biological heredity. The Theory of Pangenesis by Ch. Darwin. The theory of Germ Plasm by A. Weismann. The discovery of the laws of inheritance by G. Mendel. The birth of genetics. The Chromosome Theory of Inheritance. The DNA Double Helix Model. Molecular genetics and molecular biology. Modern ideas about biological heredity. The history of genetics in Russia and in the USSR.

3. The discovery of the laws of inheritance

The predecessors of G. Mendel. The methodology of G. Mendel. Specific features of the research object of G. Mendel's research. The main results of G. Mendel's research. Laws of inheritance

4. The formation of classical genetics

The rediscovery of the laws of inheritance by Correns, Tschermak and Hugo de Vries in 1900. The Mutation Theory. Patterns of inheritance in animals. The formation of the basic concepts and terms of classical genetics

5. The interaction of genes

Allelic and non-allelic interaction of genes. Multiple allelism. Dominance, co-dominance and intermediate dominance. Complementarity, epistasis, additive interaction. Pleiotropic effect of genes. The modifying effect of genes. Qualitative and quantitative traits.

6. Genotype and Phenotype

Genes as elementary units of heredity. The concepts of genotype and phenotype. Types of variability. The Reaction Norm. Penetrance and expressivity. Phenocopy

7. The Chromosomal Theory of Inheritance

The cell nucleus and heredity. The Chromosomal Theory of Inheritance by Sutton and Boveri. Theoretical evidence for the Chromosome Theory of Inheritance. The scientific research school of T. H. Morgan and experimental evidence of the Chromosome Theory of Inheritance

8. Sex and Inheritance

Genetic sex determination. Sex determination of the fruit fly. Sex determination in mammals. The concept of homo- and heterogamous sex. Sex determination in birds. Sex determination in social hymenoptera insects. Sex determination due to the external environment.

9. Linked inheritance. Genetic maps

Non-divergence of chromosomes in *Drosophila*. Sex-linked Inheritance. Linked genes. Chromosomal crossover. The location of genes on a chromosome. Genetic maps.

10. Basics of evolutionary genetics

Fundamentals of Charles Darwin's Theory of Evolution. Population as an elementary unit of evolution. Mutations as a source for evolution. The Hardy-Weinberg principle. The conditions for the relevance of the Hardy-Weinberg principle.

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. William Klug, Michael Cummings, Charlotte Spencer, Michael Palladino, Darrell Killian. Concepts of Genetics (Mastering genetics), 12th Edition. 2019. Pearson. – 864 pages.
2. Michael Goldberg, Janice Fischer, Leroy Hood, Leland Hartwell, Charles (Chip) Aquadro, Lee Silver and Ann E. Reynold. Genetics: From Genes to Genomes, 7th Edition. 2021. NY: McGraw Hill LLC. 2021. – 878 pages.
3. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, and Darrell J. Killian. Essentials of Genetics. 10th Edition. UK: Pearson Education Limited. 2021. – 608 pages.

Additional literature

Provided at the department:

1. Bernard Dujon, Georges Pelletier. Trajectories of Genetics (Biology) 1st Edition. Wiley-ISTE. 2020. 266 pages.
2. P. Meneely, R Dawes Hoang, I N Okeke, K Heston. Genetics. Genes, Genomes and Evolution. UK. Oxford University Press, 2017. 740 pages.
3. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's GENES XII 12th Edition. Jones & Bartlett Learning. 2017. – 838 pages.
4. Alberts et al, Molecular biology of the cell. ISBN 978-0-8153-4111-6

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

Assessment funds for course (training module)

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qualification: Master

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

Author: A.S. Ermakov, 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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2. Competency assessment indicators

As a result of studying the course the student should:

know:

- the history of the study of biological heredity and variability;
- fundamental concepts and principles of genetics;
- principles, research methods and objects of classical and molecular genetics;
- patterns of reproduction of biological objects;
- modern ideas about the mechanisms of biological heredity and variability.

be able to:

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- to search for data for scientific research in the field of classical and molecular genetics

master:

- categories and concepts used in classical and molecular genetics;
- ideas about the methods used in genetics.

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

1. Genetic engineering.
2. The Hardy-Weinberg principle.
3. Expressivity and penetrance.
4. The Reaction Norm.
5. Hereditary human diseases.
6. Genetics and medicine.
7. Genetic engineering.
8. An application of genetics in agriculture.
9. Transgenic animals.

10. Transgenic plants.

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

1. What does genetics study?
2. Heredity and variability.
3. Types of variability.
4. The history of the study of biological heredity.
5. Genetics and other biological sciences.
6. The main directions of genetics.
7. The theory of pangenesis.
8. The theory of Germ plasm.
9. G. Mendel and the discovery of the laws of inheritance.
10. Methodology and main scientific results of G. Mendel.
11. The birth of scientific genetics
12. The concept of a gene in classical genetics and modern biology.
13. Nuclear Theory of Inheritance.
14. Chromosome theory of inheritance
15. Incomplete dominance.
16. Gene interactions.
17. Sex determination.
18. Sex-linked inheritance.
19. Linked inheritance.
20. Chromosomal CrossingOver. Genetic maps.
21. Methods of chromosome staining.
22. Chromosome abnormalities.
23. The structure of eukaryotic chromosomes.
24. The works of E. Chargaff.
25. Prerequisites for the formulation of DNA Double Helix Model.
26. The DNA Double Helix Model. DNA as a substance of biological inheritance
27. The Hershey and Chase experiment.
28. The Avery, McLeod and McCarthy experiment.
29. The mechanism of DNA replication.
30. Storage and realization of genetic information.
31. The genetic code.
32. Genetic material of prokaryotes.
33. Genetic material of eukaryotes.
34. The structure of eukaryotic chromosomes.
35. Methods of molecular biology.

Примеры билетов:

Билет 1.

Вопрос 1. What does genetics study?

Вопрос 2. Gene interactions.

Вопрос 3. The genetic code.

Билет 2.

Вопрос 1. Heredity and variability.

Вопрос 2. Sex determination.

Вопрос 3. The genetic material of prokaryotes.

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 oral exam, the student is given 40 minutes to prepare. Interview with a student on oral exam should not exceed one astronomical hour.

During the exam, students can use the discipline program.