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: General Genetics/Общая генетика
major: Biotechnology
specialization: Biomedical Engineering/Биомедицинская инженерия
Phystech School of Biological and Medical Physics
Center for educational programs in bioinformatics
term: 4
qualification: Bachelor

Semester, form of interim assessment: 8 (spring) - Exam

Academic hours: 120 AH in total, including:
lectures: 30 AH.
seminars: 30 AH.
laboratory practical: 60 AH.

Independent work: 75 AH.

Exam preparation: 30 AH.

In total: 225 AH, credits in total: 5

Author of the program: A.S. Ermakov, candidate of biological sciences, teacher

The program was discussed at the Center for educational programs in bioinformatics 10.07.2023

Annotation

The study of the discipline is aimed at obtaining fundamental basic knowledge about the nature of hereditary material, patterns of inheritance of genetic traits, patterns variability at all levels of organization of living matter. Students receive modern ideas about the structure and functions of genes, mechanisms and methods of regulation of their action, replication, recombination and DNA repair.

1. Study objective

Purpose of the course

To introduce students to the basic concepts, methods and objects of genetics.

Tasks of the course

- students' mastering of basic terms and concepts of genetics;
- acquisition by students of the ability to apply the acquired knowledge;
- providing advice and assistance to students during the development of the material.

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
Pro.C-2 Analyze research data and make scientific conclusions	Pro.C-2.1 Adopt methods of statistical process and scientific data analysis
	Pro.C-2.2 Define key parameters of the studied phenomenon and make relevant numerical estimates
	Pro.C-2.3 Make scientific claims with supporting evidence for a professional audience in verbal and written form, state scientific problems and propose solutions

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

As a result of studying the course the student should:

know:

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

be able to:

- to apply the acquired fundamental knowledge about the mechanisms of biological heredity and variability for planning scientific experiments;
- to apply the acquired fundamental knowledge about the mechanisms of biological heredity and variability to solve practical problems, particularly, in biotechnology and medicine.

master:

- to acquire skills of mastering a large amount of information;
- to acquire independent work skills;
- to know terminology, including special terms in sufficient volume.

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

		Types of training sessions, including independent work

№	Topic (section) of the course	Lectures	Seminars	Laboratory practical	Independent work
1	Introduction to genetics.	2	2	4	8
2	The works of G. Mendel and the birth of genetics	3	3	6	6
3	The interaction of genes	3	3	6	6
4	Chromosomal Theory of Inheritance.	3	3	6	6
5	Genetics and sex	3	3	6	6
6	Molecular bases of inheritance.	2	2	4	6
7	The structure of chromosomes and the basics of cytogenetics	2	2	4	6
8	Realization of genetic information.	2	2	4	8
9	Genetics and evolution	2	2	4	8
10	Genetic engineering and transgenic organisms	2	2	4	6
11	Genomics, transcriptomics and bioinformatics	3	3	6	6
12	The importance of genetics for practical activity and economics.	3	3	6	3
AH in total		30	30	60	75
Exam preparation		30 AH.			
Total complexity		225 AH., credits in total 5			

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

Semester: 8 (Spring)

1. Introduction to genetics.

What is genetics? Heredity and variability. Types of variability. Genetics and other biological sciences. Methods, tasks and objects of genetics. The history of ideas about biological heredity and variability. The idea of direct and indirect inheritance. The theory of Pangenesis of Ch. Darwin. The theory of Germ Plasm by A. Weisman. The discovery of the laws of heredity by G. Mendel. Cell nucleus and inheritance. The birth of genetics. Chromosomal Theory of Inheritance. Modern ideas about biological heredity. The history of genetics in Russia and the USSR.

2. The works of G. Mendel and the birth of genetics

Methodology of G. Mendel's experiments. Inheritance of traits in monohybrid crossing. Mendel's laws. The results of the dihybrid crossing. Independent combination. The results of the trihybrid crossing. The rediscovery of Mendel's laws and the birth of genetics.

3. The interaction of genes

Variability. Mutation Theory. Types of mutation. Genetic symbols. Incomplete dominance. Codominance. Epistasis. Complementary gene interaction. Pleiotropy. The influence of the genetic background and environment on the manifestation of the gene.

4. Chromosomal Theory of Inheritance.

Sex-linked inheritance. Genetic linkage. Determination of the distance between genes. Determination of the sequence of genes in groups. Construction of chromosome maps. Modern mapping methods. Specificity of genetic analysis and mapping of bacteria and viruses.

5. Genetics and sex

Genetic sex determination in different groups of organisms. Sex determination in humans. Diseases associated with the abnormalities of genetically-related sex determination in humans. Sex determination in Drosophila. Temperature-dependent sex determination.

6. Molecular bases of inheritance.

The discovery of DNA. The Griffith's experiment. The Avery, MacLeod, and McCarthy experiment. Works of E. Chargaff. The Hershey and Chase experiment. Prerequisites of the DNA Double Helix Model. The DNA Double Helix Model and the birth of molecular biology. DNA as a molecule of biological heredity. The Meselson-Stahl experiment. The mechanism of DNA replication.

7. The structure of chromosomes and the basics of cytogenetics

The organization of DNA in chromosomes. Levels of DNA compactification. The structure of eukaryotic chromosomes. Methods of chromosome staining. Euchromatin and heterochromatin. Terminology of cytogenetics. Normal human karyotype. Chromosomal abnormalities.

8. Realization of genetic information.

The genome of prokaryotes. The genome of eukaryotes. Chromosomal and cytoplasmic heredity. DNA replication in prokaryotes. DNA replication in eukaryotes. The genetic code. Gene expression and stages of realization of genetic information. Transcription. The structure of proteins. Translation. Mechanisms of regulation of gene expression in prokaryotes and eukaryotes. Epigenetics. Genetics of development.

9. Genetics and evolution

Fundamentals of The Theory of Evolution of Ch. Darwin. Population. Genetic variations in populations. The Hardy-Weinberg principle. In which conditions Hardy-Weinberg principle works? Migrations. Genetic drift. Natural selection. Types of natural selection.

10. Genetic engineering and transgenic organisms

The birth of genetic engineering. Fundamentals of recombinant nucleic acids technology. Principal scheme of molecular cloning. Genetic vectors. Work with microorganisms. Plant cell cultures. Animal cell cultures. Transgenic plants. Transgenic animals.

11. Genomics, transcriptomics and bioinformatics

Methods of molecular biology and genetics. PCR. DNA sequencing methods. DNA libraries. Genomics. Coding and non-coding regions. Areas of genomics. Decoding the genomes of different organisms. The Human Genome Project. Transcriptomics. Bioinformatics.

12. The importance of genetics for practical activity and economics.

Genetics of farm animals and agricultural plants. Genetics and selection. Genetic engineering and biotechnology. Genetics and medicine. Hereditary human diseases. Genetic diagnostics. Gene therapy. Ethical aspects of genetics.

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

– classrooms for conducting lecture/ seminar-type classes;
– computer and multimedia equipment (projector, sound system);
– individual computing facilities of students (personal computers) for homework
- basic laboratory equipment,
- reagents for DNA isolation,
- medium for bacterial cultivation;
- an amplifier and reagents for PCR.

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. - Pearson. 2019 – 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. - NY: McGraw Hill LLC, 2021. – 878 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. 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.
4. Jocelyn E. Krebs , Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's GENES XII. - 12th Edition. - Jones & Bartlett Learning, 2017. – 838 pages.

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)

For part of the classes, we will need Zoom. Google Drive to access course materials.
Smartphones/laptops are welcome during classes to participate in interactive exercises.

9. Guidelines for students to master the course

A student studying the discipline should, on the one hand, master the general conceptual apparatus, and on the other hand, should learn to use theoretical knowledge in practice.
As a result of studying the discipline, the student should know the basic concepts of the discipline, be able to apply the knowledge gained to solve various tasks.

Successful completion of the course requires:
- attendance of all classes provided for in the discipline curriculum;
– keeping a summary;
– intense independent work of the student.
- fulfilling the requirements of practical classes.

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 the tasks of the current and intermediate certification.

An indicator of material proficiency is the ability to answer questions on discipline topics without a text.

It is important to gain an understanding of the material being studied, and not to memorize it mechanically. If it is difficult to study certain topics, questions, you should seek advice from a teacher.

Intermediate control of students' knowledge is possible in the form of solving problems in accordance with the subject of classes, conducting colloquiums and written control papers.

SUPPLEMENT

Assessment funds for course (training module)

major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия Phystech School of Biological and Medical Physics Center for educational programs in bioinformatics
term:	4
qualification:	Bachelor

Semester, form of interim assessment: 8 (spring) - Exam

Author: A.S. Ermakov, candidate of biological sciences, teacher

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Pro.C-2 Analyze research data and make scientific conclusions	Pro.C-2.1 Adopt methods of statistical process and scientific data analysis
	Pro.C-2.2 Define key parameters of the studied phenomenon and make relevant numerical estimates
	Pro.C-2.3 Make scientific claims with supporting evidence for a professional audience in verbal and written form, state scientific problems and propose solutions

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- fundamental concepts and principles of genetics;
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be able to:

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master:

- to acquire skills of mastering a large amount of information;
- to acquire independent work skills;
- to know terminology, including special terms in sufficient volume.

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

1. DNA replication.
2. Transcription.
3. Translation.
4. Genetic material of prokaryotes.
5. Genetic material of eukaryotes.
6. The structure of eukaryotic chromosomes.
7. Methods of molecular biology.
8. Genetic engineering.
9. The Hardy-Weinberg principle.
10. The main directions of genomics.

4. Evaluation criteria

1. Genetics as a science.
2. Heredity and variability.
3. Types of variability.
4. The history of ideas about heredity.
5. The connection of genetics with other biological sciences.
6. The theory of pangenesis of Ch. Darwin.
7. The theory of germ plasm.
8. The discovery of the laws of heredity.

9. G. Mendel's methodology.
10. The main scientific results of G. Mendel.
11. The origin and development of scientific genetics.
12. The concept of a gene in classical genetics and modern biology.
13. The origin of the chromosomal theory of heredity.
14. Chromosomal Theory of Inheritance.
15. Experimental evidences of the Chromosomal Theory of Inheritance.
16. Incomplete dominance.
17. Mendel's laws.
18. Interactions of genes.
19. Sex determination.
20. Sex-linked inheritance.
21. Homogametic and heterogametic sex.
22. Genetic linkage.
23. Chromosomal crossing over.
24. Genetic maps.
25. Methods of chromosome staining.
26. The structure of eukaryotic chromosomes.
27. E. Chargaff's works.
28. Prerequisites for the emergence of the DNA Double Helix Model.
29. The DNA Double Helix Model.
30. DNA as a chemical substance of heredity.
31. The Hershey and Chase experiment.
32. The Avery, McLeod and McCarty experiment.
33. The mechanism of DNA replication.
34. Storage and realization of genetic information.
35. The genetic code.

Ticket number 1
1.Genetic linkage.
2. The discovery of the laws of heredity.

Ticket number 2
1. The origin and development of scientific genetics.
2. The concept of a gene in classical genetics and modern biology.

The mark is excellent (10 points) - 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) - 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) – is 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) - is given 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) - is given 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) - 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) - is 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.