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:	Developmental Biology/Биология развития
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: 7 (fall) - 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 12.07.2023

Annotation

The purpose of this discipline is to introduce students to the basic concepts, methods and objects of developmental biology. After completing the course, the student will understand the fundamental concepts and principles, methods and objects of developmental biology, the history of views on individual development, the processes of sex determination in different groups of animals, gametogenesis and fertilization, cleavage, gastrulation and early development; will learn about the main experimental approaches in the study of developmental mechanisms, the role of genetic factors in development; special attention will be paid to the importance of developmental biology for modern medicine and medical research.

1. Study objective

Purpose of the course

to introduce students to the basic concepts, methods and objects of developmental biology

Tasks of the course

- students' mastering of basic terms and concepts of developmental biology;
- acquisition by students of the ability to apply the acquired knowledge;
- providing advice and assistance to students during the study 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
Pro.C-3 Select the necessary devices, tools, and research methods for problem-solving in a selected subject area	Pro.C-3.1 Apply functional principles and operating ranges of scientific equipment
	Pro.C-3.2 Apply theory to evaluate the accuracy of analytical calculations
	Pro.C-3.3 Estimate the accuracy of numerical methods used on a computer, learn the computational complexity of the applied algorithms and the number of required computing resources

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 developmental biology;
- the history of studying the individual development of living organisms;
- directions of developmental biology;
- principles and modern methods of research and objects of developmental biology.
- patterns of reproduction and individual development of biological objects;
- sources of development and mechanism of tissue formation at a certain stage of embryogenesis;
- modern concepts of the development of the organism as a systemic process, molecular and physiological mechanisms of development, the influence of external and internal factors on the development of the organism and its life expectancy.

be able to:

- to use the acquired fundamental knowledge of developmental biology to the planning of scientific experiments;
- to use the acquired fundamental knowledge about developmental biology to solve practical problems, including in biotechnology and medicine.

master:

- skills of mastering a large amount of information;
- independent work skills;
- skills in using of 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

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Introduction to developmental biology.	2	2	4	8
2	A brief history of the study of the individual development of living organisms.	3	3	6	6
3	The life cycle.	3	3	6	6
4	Gametogenesis	3	3	6	6
5	Fertilization.	3	3	6	6
6	Cleavage.	2	2	4	6
7	Gastrulation and formation of germ layers	2	2	4	6
8	Organogenesis and histogenesis	2	2	4	8
9	Features of the development of the main groups of vertebrates	2	2	4	4
10	Experimental analysis of early development	2	2	4	6
11	Genetic foundations of development	2	2	4	6
12	Developmental biology and medical research.	2	2	4	3
13	Individual development and evolution	2	2	4	4
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: 7 (Fall)

1. Introduction to developmental biology.

What is developmental biology? The main tasks of developmental biology. Objects of developmental biology. Methods of developmental biology. Developmental biology and other sciences. Practical significance of developmental biology.

2. A brief history of the study of the individual development of living organisms.

Historical review of the ideas on individual development and ontogenesis. Ideas about the development of living organisms in ancient civilizations. The views of ancient thinkers on the processes of development. Hippocrates and Aristotle's ideas about the mechanisms of development. Preformation and epigenesis. Evolutionary embryology. The origin of experimental embryology The contribution of W. Roux and H. Driesch to the formation of modern embryology. Modern developmental biology.

3. The life cycle.

The concept of the life cycle. The life cycle on the example of vertebrates. The main stages of the life cycle: fertilization, cleavage, gastrulation, organogenesis. Life cycle and ontogenesis.

4. Gametogenesis

Sex determination. Genetic mechanisms of sex determination in different groups of animals. Environment and sex determination. Formation of the gonad. Primordial germ cells. Principles of gametogenesis. The egg. Classification of eggs by yolk quantity and distribution. Oogenesis. Stages of oogenesis. Storage of substances in the egg. Features of oogenesis in mammals. Spermatozoon. Distinctive features of the sperm. Stages of spermatogenesis. Comparison of oogenesis and spermatogenesis.

5. Fertilization.

External and internal fertilization. Distant interactions of gametes. Chemotaxis and rheotaxis. Sperm capacitation. Contact interactions of gametes. Recognition of the sperm by the egg. Acrosome reaction. The entry of the sperm into the egg. Short-term and long-term block of polyspermy. Pronuclei fusion.

6. Cleavage.

Types of cleavage of different types of eggs. Mosaic and regulatory cleavage. Cytological features of cleavage. Periods of synchronous and asynchronous cleavage. Features of cleavage in different groups of vertebrates. Blastulation. Types of blastula.

7. Gastrulation and formation of germ layers

Gastrulation. Mechanisms of gastrulation. Mechanisms of gastrulation in sea urchins. Mechanisms of gastrulation in amphibians. Germ layers and their derivatives.

8. Organogenesis and histogenesis

Neurulation. Mechanisms of neurulation in amphibians. Development of endoderm derivatives and related rudiments. Archenteron and its differentiation. Development of mesoderm derivatives. Axial mesoderm. Development of excretory organs. The development of the genital glands and genital ducts. Development of the circulatory system. Development of ectoderm derivatives. Development of the skin and its appendages. Development of the central nervous system and sensory organs. The neural crest and its derivatives. Determination of the rudiments of organs.

9. Features of the development of the main groups of vertebrates

Features of early development of fish. Ananias and amniotes. Features of the development of amniotes. Early development of reptiles and birds. Extra-embryonic organs in the development of amniotes. The main groups of mammals. Features of the development of placental mammals.

10. Experimental analysis of early development

Basic concepts and methods of experimental embryology. Embryonic regulations. Embryonic induction. H. Spemann's works on the study of primary embryonic induction. Modern ideas about embryonic induction. Morphological organization and differentiation of induced rudiments. Experimental approaches in modern developmental biology.

11. Genetic foundations of development

Developmental biology and genetics. Drosophila as an object of developmental genetics. Early stages of Drosophila development. Embryo body plan. Establishing the anterior-posterior polarity of the embryo. Division of the Drosophila embryo into segments. Regulation of gene expression during segmentation. Homeotic genes and positional information. Similarity of mechanisms of regional cellular determination in insects and vertebrates.

12. Developmental biology and medical research.

Regeneration. Types of regeneration processes. Regeneration and recapitulation of development. Regeneration and evolution. Regeneration mechanisms. Stem cells and induced pluripotent cells. Teratogenesis. Defects of embryonic development. Developmental biology and carcinogenesis.

13. Individual development and evolution

Mechanisms of evolutionary changes. Evolutionary constraints related to the development. The Haeckel's Biogenetic Law. Palingenesis and cenogenesis. Heterochronies, heterotopies, cenogenesis. Modes of progressive evolution. Evolution and integrality of ontogenesis.

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;
- microscopes;
- histological and w. m. preparations.

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

Main literature
Provided at the department:

1) Michael J.F. Barresi, Scott F. Gilbert. Developmental Biology. - 12th Edition. - Sinauer Associates is an imprint of Oxford University Press, 2020. - 888 p.

Additional literature
Provided at the department:
1) Jonathan M. W. Slack. Essential Developmental Biology. - 3rd Edition. - Wiley-Blackwell, 2013. - 496 pages.
2) Bruce Alberts. Molecular Biology of the Cell. - 6th Edition. - Garland Science, 2015. - 1464 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)

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term:	4
qualification:	Bachelor

Semester, form of interim assessment: 7 (fall) - 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
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Pro.C-3 Select the necessary devices, tools, and research methods for problem-solving in a selected subject area	Pro.C-3.1 Apply functional principles and operating ranges of scientific equipment
	Pro.C-3.2 Apply theory to evaluate the accuracy of analytical calculations
	Pro.C-3.3 Estimate the accuracy of numerical methods used on a computer, learn the computational complexity of the applied algorithms and the number of required computing resources

2. Competency assessment indicators

As a result of studying the course the student should:

know:

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be able to:

- to use the acquired fundamental knowledge of developmental biology to the planning of scientific experiments;
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master:

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

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

1. Fate maps.
2. Embryonic induction.
3. Features of Amniota development.
4. Early development of mammals.
5. Developmental biology and genetics.
6. Regeneration.
7. Stem cells.
8. Developmental biology and medicine.
9. Haeckel’s Biogenetic Law.
10. Evolution and integrality of ontogenesis.

4. Evaluation criteria

1. The concept of the life cycle.
2. Methods and objects of developmental biology.
3. The main problems considered by developmental biology.
4. The history of ideas about the mechanisms of individual development.
5. Differential gene expression.
6. Embryonic regulations.
7. Genetics of the establishment of axes in the early development of drosophila.
8. Preformation and its significance for modern biology
9. The dispute between preformation and epigenesis
10. Contribution of C. Wolf to the development of embryology
11. K. Baer's contribution to the development of embryology.
12. Contribution of W. Roux to the development of embryology.
13. G. Driesch's contribution to the development of embryology.
14. H. Spemann's contribution to the development of embryology.
15. Features of the structure of the egg.
16. Eggs: classification, morphology, physiology.
17. Oogenesis.
18. Features of mammalian oogenesis.
19. The structure of the sperm.
20. Spermatogenesis.
21. Differences between spermato- and oogenesis.
22. Fertilization and its biological significance.
23. Distant interactions of gametes.
24. Contact interactions of gametes.
25. Block of Polyspermy.
26. Types of cleavage and their dependence on the structure of the egg.
27. Mosaic and regulatory cleavage.
28. Cytological features of cleavage.
29. Types of blastula.
30. The structure of the amphibian blastula.
31. Gastrulation and formation of germ layers.
32. Ectoderm derivatives in vertebrates.
33. Derivatives of mesoderm in vertebrates.
34. Endoderm derivatives in vertebrates.
35. Development of the central nervous system and sensory organs.

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.
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.