Ministry of Agriculture of the Russian Federation
Federal State Budgetary Educational Institution
of Higher Education
«St. Petersburg State University of Veterinary Medicine»

APPROVED BY
Vice-Rector for Educational
Work and Youth Policy
Sukhinin A.A.
April 10, 2026

Department of Genetic and Reproductive Biotechnologies

EDUCATIONAL WORK PROGRAM

for the discipline

«VETERINARY GENETICS»

The level of higher education
SPECIALIST COURSE

Specialty 36.05.01 Veterinary Medicine
Profile: «General clinical veterinary medicine»
Full-time education
Education starts in 2026

Reviewed and adopted
at the meeting of the department
on March 2, 2026
Protocol No. 9

Head of the Department of Genetic and Reproductive Biotechnologies
Professor, Doctor of Veterinary Sciences,
Korochkina E.A.

Saint Petersburg
2026

1. AIMS AND OBJECTIVES OF THE DISCIPLINE

The purpose of the discipline is to study fundamental issues of general and veterinary genetics, to obtain scientific, theoretical and practical knowledge on genetic diagnosis and prevention of hereditary anomalies and diseases in animals. Familiarization with modern ideas about gene structure, regulation of gene activity, genome editing methods, model objects of genetics. Study of the basics of genomic selection, genetic markers of productivity and resistance of productive animals for use in the practice of veterinary selection.

To achieve this goal, it is necessary to solve the following objectives:

1) the general educational task is to study the genome of various types of farm animals, hereditary anomalies, mutational variability and diseases with hereditary predisposition, mastering modern methods for diagnosing latent carriers of genetic defects;

2) the applied task covers the influence of various factors on heredity and variability, animal resistance to diseases and climate change, the search for markers of resistance and susceptibility, the creation of disease-resistant lines, types, and breeds of animals with a low genetic load.

2. THE LIST OF THE PLANNED RESULTS OF THE DISCIPLINE (MODULE), CORRELATED WITH THE PLANNED RESULTS OF THE REALISED EDUCATIONAL PROGRAM

As a result of mastering the discipline, the student prepares for the following types of activities, in accordance with the educational standard of the FSE on 36.05.01 «Veterinary Medicine».

The field of professional activity:

13 Agriculture.

The student's competencies formed (acquired) as a result of mastering the discipline

The education of the discipline should form the following competencies:

a) General professional competencies (GPC)

GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.

GPC-2 ID-1 To know: ecology factors of the environment, its classification and the nature of relationships with living organisms; basic ecological concepts; interspecific relations of animals and plants, terms and bio ecology laws, parasites and hosts; ecological features of some types of pathogenic microorganisms; mechanisms of influence of anthropogenic and economic factors on the animal body.

GPC-2 ID-3 To possess skills of: the knowledge of the origin of living organisms, the levels of organization of living matter, favorable and unfavorable factors affecting the body; the basis for studying environmental knowledge of the environment, the laws of the development of nature and society; skills of observation, comparative analysis, historical and experimental modeling of the impact of anthropogenic and economic factors on living objects, with the use of digital technologies as well.

3. THE PLACE OF DISCIPLINE IN THE STRUCTURE OF THE MPEP

The discipline B1.O.18 «Veterinary genetics» is discipline of the Block 1 basic part of Federal State Educational Standard Of Higher Education in specialty 36.05.01 «Veterinary medicine» (level of higher education – specialist).

The course is mastered during first semester for full-time mode of study.

When studying «Veterinary genetics» course, the students use knowledge and skills acquired in such disciplines as biology, histology and embryology, biochemistry, physiology.

The discipline «Veterinary genetics» is the basis for such disciplines as:

1. Physiology and ethology of animals.
2. Embryology.
3. Clinical diagnosis.
4. Internal non-communicable diseases.
5. Pathological anatomy and forensic veterinary examination.
6. Veterinary and sanitary examination.
7. Obstetrics and gynecology.
8. Immunology and virology.
9. Diseases of laboratory, small and exotic animals.
10. Diseases of productive animals.

4. THE SCOPE OF DISCIPLINE AND TYPES OF ACADEMIC WORK

4.1. The scope of the discipline for full-time education

Type of educational work	Hours	Semesters
		1
Classroom classes (total)	**68**	**68**
Including:	-	-
Lectures, including interactive forms	34	34
Practical lesson (PL), including interactive forms, among which are:	34	34
- practical training (PT)	6	6
Self-study	**13**	**13**
Essay	+	+
Type of intermediate and final certification (exam)	**Exam**	**Exam**
Control	**27**	**27**
Total labor intensity hours/credits	**108/3**	**108/3**

5. THE CONTENT OF THE DISCIPLINE AND TYPES OF CLASSES

5.1. The content of the discipline (full-time education)

№	The title	Achieved competences	Semester	Types of academic work, including students' self-study and labor intensity (in hours)			
				Lectures	Practical lessons	Practical training	Self-study
1	Subject, methods and significance of genetics. Variation and heredity. methods of its study. Mutational variability.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
2	Cytological and molecular bases of heredity.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2		2	2
3	Mitosis, meiosis, gametogenesis.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
4	Basic laws of heredity. Chromosomal theory of heredity. Gene structure.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
5	The structure of eukaryotic genes. The concept of exons and introns. Alternative splicing.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
6	Genetics of the reproductive system. Disorders in sex development.	GPC-2 GPC-2 ID-1	1	2	2		2

7	Genetics of bacteria.	GPC-2 ID-3				
8	Genetics of viruses.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
9	Genetic basis of ontogenesis. Population genetics.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2			2
10	Gynogenesis, androgenesis, parthenogenesis.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
11	Genetic disorders in livestock and methods for preventing their spread.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
12	Model objects in genetics. Research directions and ethical considerations.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		2
13	Modern genetic engineering techniques.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		3
14	Genome editing systems.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		3
		GPC-2	1	2	2		3

		GPC-2 ID-1 GPC-2 ID-3					
15	Gene fingerprinting. Knockout and knockdown of genes. Gene therapy and gene diagnostics techniques.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2		3
16	Genomic selection in livestock breeding.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2	2	2	3
17	Animal genetic resources. Criteria for assessing the state of genetic resources.	GPC-2 GPC-2 ID-1 GPC-2 ID-3	1	2		2	3
	Total:			**34**	**28**	**6**	**40**

7

6. THE LIST OF EDUCATIONAL AND METHODOLOGICAL SUPPORT FOR STUDENTS' SELF-WORK

6.1. Guidelines for self -work

1. Methodological instructions for completing test assignments for students of the correspondence veterinary faculty in the discipline "Veterinary Genetics" / compiled by: P. I. Ukolov, O. G. Sharaskina; Ministry of Agriculture of the Russian Federation, SPbGAVM. - St. Petersburg: Publishing house SPbGAVM, 2013. - 19 p.

6.2. Literature for self-work

1. Nicholas F. W. Introduction to Veterinary Genetics / F. W. Nicholas - Oxford University Press, 1996 – 330 P. - ISBN 9780198542933.
2. Temple G. Genetics and the Behavior of Domestic Animals / G. Temple - Elsevier Science, 2022 – 586 P. – ISBN 9780323857529.

7. THE LIST OF BASIC AND ADDITIONAL LITERATURE NECESSARY FOR THE EDUCATION OF THE DISCIPLINE

a) Basic literature:

1. Krebs J. E., Goldstein E. S., Kilpatrick Lewin`s Genes XII / J. E. Krebs, E. S. Goldstein, Kilpatrick - Jones & Bartlett, 2017 – 838 P. - ISBN 9781284104493

b) Additional literature:

1. Passarge E. Color Atlas of Genetics, 5 ed. / E. Passarge - Thieme Verlagsgruppe, 2017 – 474 P. - ISBN: 9783132414402
2. Samuel E. A., Huaijun Z., Michèle T., Douglas D. R. Advances in Poultry Genetics and Genomics / E. A. Samuel, Z. Huaijun, T. Michèle, D. R. Douglas - Burleigh Dodds Science Publishing, 2020 – 580 P. – ISBN 9781003047735

8. THE LIST OF RESOURCES OF THE INFORMATION AND TELECOMMUNICATION NETWORK "INTERNET" NECESSARY FOR EDUCATION OF THE DISCIPLINE

Electronic library systems:

1. ELS «SPBGUVM» (date of request March 2, 2026)
2. Legal reference system «ConsultantPlus» (date of request March 2, 2026)
3. University information system «RUSSIA» (date of request March 2, 2026)
4. Scientific electronic Library ELIBRARY.RU (date of request March 2, 2026)
5. Russian Scientific Network (date of request March 2, 2026)
6. Full-text interdisciplinary database on agricultural and environmental sciences ProQuest AGRICULTURAL AND ENVIRONMENTAL SCIENCE DATABASE (date of request March 2, 2026)

To prepare for seminar classes and perform self study, students can use the following Internet resources:

1. http://omia.angis.org.au/home/ (date of request March 2, 2026)
2. www.vet.ohio-state.edu - Ohio State College of Veterinary Medicine (date of request March 2, 2026)

3. www.zoology.wisc.edu-сайт - Zoology department of Wisconsin-Madison (date of request March 2, 2026)

9. METHODOLOGICAL GUIDELINES FOR STUDENTS ON EDUCATION OF THE DISCIPLINE

Methodological recommendations for students are a set of recommendations and explanations that allow them organize the process of studying this discipline optimally.
The content of methodological recommendations, as a rule, may include:

- Tips on planning and organizing the time needed to study the discipline. Description of the sequence of actions of the student, or the «scenario of studying the discipline».

Morning time is the most effective for academic work (from 8-14 hours), followed by afternoon time (from 16-19 hours) and evening time (from 20-24 hours). The most difficult material is recommended to be studied at the beginning of each time interval after rest. After 1.5 hours of work, a break is required (10-15 minutes), after 4 hours of work, the break should be 1 hour. Part of the scientific organization of labor is the master of the technique of mental labor. Normally, a student should devote about 10 hours a day to studying (6 hours at university, 4 hours at home).

- Recommendations for working on lecture material

When preparing for a lecture, the student is advised to:

1) review the recordings of the previous lecture and recall previously studied material;

2) it is useful to browse the material of the upcoming lecture;

3) if independent study of certain fragments of the previous lecture is assigned, then it must be completed without delay;

4) get yourself mentally prepared for the lecture.

This work includes two main stages: taking notes of lectures and subsequent work on lecture material.

The methodology of work when taking notes of oral presentations differs significantly from the methodology of work when taking notes of written sources.

By taking notes of written sources, the student has the opportunity to read again the desired passage of the text, reflect on it, highlight the main thoughts of the author, briefly formulate them, and then write them down. If necessary, he can also note his attitude to this point of view. Listening to the lecture, the student should transist most of the complexity of the above–mentioned works for another time, trying to use every minute to record the lecture, and not to comprehend it - there is no time left for this. Therefore, when taking notes of a lecture, it is recommended, to leave separate fields on each page for subsequent entries in addition to the summary.

After recording a lecture or making a summary of it, you should not leave work on the lecture material before preparing for the test. It is necessary to do as early as possible the work that accompanies takimg notes of written sources, the last could not be done during the recording of the lecture - read your notes, deciphering individual abbreviations, analyze the text, establish logical connections between its elements, in some cases show them graphically, highlight the main thoughts, mark issues, requiring additional processing, in particular, the teacher's consultations.

When working on the text of the lecture, the student should pay special attention to the problematic issues, raised by the teacher, during the lecture, as well as to his assignments and recommendations.

For each lecture, practical lesson and laboratory work, classification cod, topic, list of issues under consideration, volume in hours and links to recommended literature are provided. For classes conducted in interactive forms, its organizational form should be indicated: computer simulation, business or role-playing game, analysis of a specific situation, etc.

Recommendations for preparing for practical classes

Practical (seminar) classes are an important part of the professional training of students. The main purpose of conducting practical (seminar) classes is to form students' analytical, creative thinking through the acquisition of practical skills. Practical classes are also conducted in order to deepen and consolidate the knowledge gained in lectures and in the process of independent work on normative documents, educational and scientific literature. For student, it is necessary, to study or repeat theoretical material on a given topic when preparing for a practical lesson for students.

When preparing for a practical lesson, the student is recommended to follow the following algorithm;

1) get acquainted with the plan of the upcoming lesson;

2) study the literature sources that have been recommended and familiarize yourself with the introductory notes to the relevant sections.

Methodological guidelines for practical (seminar) classes in the discipline, along with the work program and schedule of the educational process, refer to methodological documents that determine the level of organization and quality of the educational process.

The content of practical (seminar) classes is recorded in the working curricula of the disciplines in the sections "List of topics of practical (seminar) classes".

The most important component of any form of practical training are tasks. The basis of the task is an example that is understood from the standpoint of the theory developed in the lecture. As a rule, the main attention is paid to the formation of specific skills, which determines the content of students' activities - problem solving, laboratory work, clarification of categories and concepts of science, which are a prerequisite for correct thinking and speech.

Practical (seminar) classes perform the following tasks:

- stimulate regular study of recommended literature, as well as attentive attitude to the lecture course;
- consolidate the knowledge gained in the process of lecture training and independent work on literature;
- expand the scope of professionally significant knowledge, skills, and abilities;
- allow you to verify the correctness of previously acquired knowledge;
- initiate skills of independent self-thinking, oral presentation;
- contribute to the free use of terminology;
- provide the teacher with the opportunity to systematically monitor the level of independent work of students.

Methodological guidelines for practical (seminar) classes on the discipline should be focused on modern business conditions, current regulatory documents, advanced technologies, the latest achievements of science, technology and practice, modern ideas about certain phenomena, the studied reality.

• Recommendations for working with literature.

Working with literature is an important stage of the student's self-work on mastering the subject, contributing not only to the consolidation of knowledge, but also to the expansion of horizons, mental abilities, memory, the ability to think, express and confirm personal hypotheses and ideas. In addition, the skills of research work necessary for further professional activityare developed.

When starting to study the literature on the topic, it is necessary to make notes, extracts, notes. It is mandatory to take notes of the works of theorists, which allow us to comprehend the theoretical basis of the study. For the rest, you can limit yourself to summary from the studied sources. All summaries and quotations must have the exact "return address" (author, title of the work, year of publication, page, etc.). It is advisable to write an abbreviated title of the question to which the extract or quotation refers. In addition, it is necessary to learn how to immediately compile a file of special literature and publications of sources, both proposed by the teacher and identified independently, as well as refer to bibliographic reference books, chronicles of journal articles, book chronicles, abstract journals. At the same time, publications of sources (articles,

book titles, etc.) should be written on separate cards, which must be filled in according to the rules of bibliographic description (surname, initials of the author, title of the work. Place of publication, publisher, year of publication, number of pages, and for journal articles – the name of the journal, year of publication, page numbers). On each card, it is advisable to record the thought of the author of the book or a fact from this book on only one specific issue. If the work, even in the same paragraph or phrase, contains more judgments or facts on another issue, then they should be written out on a separate card. The presentation should be concise, accurate, without subjective assessments. On the back of the card, you can make your own notes about this book or article, its content, structure, on which sources it is written, etc.• Explanations about working with control and test materials for the course, recommendations for completing homework.

Testing allows one to determine whether the actual behavior of the program corresponds to the expected one by performing a specially selected set of tests. A test is the fulfillment of certain conditions and actions necessary to verify the operation of the function under test or part of it. Each question in the discipline must be answered correctly by choosing one option..

10. EDUCATIONAL WORK

As part of the implementation of the discipline, educational work is carried out to form a modern scientific worldview and a system of basic values, the formation and development of spiritual and moral, civil and patriotic values, a system of aesthetic and ethical knowledge and values, attitudes of tolerant consciousness in society, the formation of students' need for work as the first vital necessity, the highest value and the main way to achieve success in life, to realize the social significance of your future profession.

11. THE LIST OF INFORMATION TECHNOLOGIES USED IN THE IMPLEMENTATION OF THE EDUCATIONAL PROCESS

11.1 Information technologies

For the educational process of the discipline is previewed the use of information technologies:

Educational process involves the following information technologies::

- ✓ use of multimedia when conducting seminars;
- ✓ interactive technologies (dialogue and collective discussion of various approaches to solving a particular educational and professional problem);
- ✓ interaction via email;
- ✓ collaboration in the Electronic educational environment (EIOS SPbGUVM): https://spbguvm.ru/academy/eios/ (accessed: 06/27/2025)

11.2. Software

The list of licensed and free- distributed software, including national programs

№	Technical and computer programs recommended by sections and topics of the program	License
1	MS PowerPoint	67580828
2	LibreOffice	free software
3	OS ALT Education 8	AAO.0022.00
4	MARC-SQL Library Management Systems Line	02102014155
5	MS Windows 10	67580828

6	Consultant Plus System	503/КЛ
7	Android OC	free software

11. THE MATERIAL AND TECHNICAL BASE NECESSARY FOR THE IMPLEMENTATION OF THE DISCIPLINE EDUCATIONAL PROCESS.

The title of the discipline (module), practice in accordance with the curriculum	**The title of special rooms and rooms for self-work**	**Equipment of special rooms and rooms for self-work**
Veterinary genetics	335 (Saint Petersburg, st. Chernigovskaya, 5, 196084) Classroom for conducting seminars, consultations and course assessment	*Specialized furniture:* tables, chairs multimedia screen.
	214 (Saint Petersburg, st. Chernigovskaya, 5, 196084) Classroom for conducting seminars, consultations and course assessment	*Specialized furniture:* tables, chairs табуреты, multimedia screen.
	221 (Saint Petersburg, st. Chernigovskaya, 5, 196084) Classroom for conducting seminars, consultations and course assessment	*Specialized furniture:* tables, chairs *Technical means of education:* multimedia screen.
	206 Big reading room (Saint Petersburg, st. Chernigovskaya, 5, 196084) Room for independent work	*Specialized furniture:* tables, chairs *Technical teaching aids:* computers with an Internet connection and access to the electronic information and electronic educational environment
	214 Small reading room (Saint Petersburg, st. Chernigovskaya, 5, 196084) Room for independent work	*Specialized furniture:* tables, chairs *Technical means of education:* computers with an Internet connection and access to the electronic information and electronic educational environment
	324 Information technology department (Saint Petersburg, st. Chernigovskaya, 5, 196084) Room for storage and preventive maintenance of educational equipment	*Specialized furniture:* tables, chairs, special equipment, materials and spare parts for preventive maintenance of educational equipment

	Box №3 Carpentry workshop (Saint Petersburg, st. Chernigovskaya, 5, 196084) Room for storage and preventive maintenance of educational equipment	*Specialized furniture:* tables, chairs, special equipment, materials and spare parts for preventive maintenance of educational equipment.
	Molecular genetics laboratory (Saint Petersburg, st. Chernigovskaya, 5, 196084) Room for storage and \maintenance of molecular genetic equipment	*Specialized equipment for molecular genetic research and furniture:* tables, chairs, special equipment

Developers:

Professor,
Doctor of Veterinary Sciences — Korochkina E.A.

Associate Professor, Candidate of Biological Sciences — Kuznetsova T.Sh.

Assistant — Belikova A.O.

Annex 1

Ministry of Agriculture of the Russian Federation
Federal State Budgetary Educational Institution
of higher education
«Saint Petersburg State University of Veterinary Medicine»

Department of Genetic and Reproductive Biotechnologies

FUND OF ASSESMENT TOOLS
for the discipline
«Veterinary genetics»

Level of higher education
SPECIALIST COURSE

Specialty 36.05.01 Veterinary medicine
Profile: «General clinical veterinary medicine»
Full-time education

Education starts in 2026

Saint Petersburg
2026

1. PASSPORT OF THE FUND OF ASSESMENT TOOLS

Table 1

№	Acquired competence	Assessed modules of a discipline	Assesment tool
1	GPC-2 GPC-2 ID-1 GPC-2 ID-3	Section 2. The chromosomal basis of inheritance	Seminar, test
2		Section 3. Patterns of inheritance	Seminar, test
3		Section 4. Gene structure in eukaryotes and prokaryotes.	Seminar, test
4		Section 5. Methods of genetic engineering	Seminar, test
5		Section 8. Genetic disorders in livestock and its prevention.	Essay

2.List of assessment tools

Table 2

№	Name of the assessment tool	Brief description of the assesment tool	Presentation of the assessment tool in the fund
1.	Essay	Product of student's independent work. A brief written summary of specific scientific (educational and research) topic theoretical analysis result, where the author reveals the essence of the problem, gives various points of view, as well as his own interpretation.	List of essay topics
2.	Seminar	A mean of control is organized as a conversation between the teacher and the student on topics related to the discipline	Questions on topics/modules of the discipline
3.	Test	A system of standardized tasks, which allows to automate the assessment of students' knowledge and skills	A fund of test assignments

1. INDICATORS AND CRITERIA FOR ASSESSING COMPETENCIES AT VARIOUS STAGES OF ITS FORMATION, DESCRIPTION OF ASSESSMENT SCALES

Table 3

Planned results of competency acquaired	The level of development				Assesment tool
	Unsatisfactory	Satisfactory	Good	Excellent	
GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.)					
GPC-2 ID-1 To know: ecology factors of the environment, its classification and the nature of relationships with living organisms; basic ecological concepts; interspecific relations of animals and plants, terms and bio ecology laws, parasites and hosts; ecological features of some types of pathogenic microorganisms; mechanisms of influence of anthropogenic and economic factors on the animal body.	The level of knowledge is below the minimum requirements, gross errors have occurred	The minimum acceptable level of knowledge, many minor errors have been made	The level of knowledge corresponds to the training program, several minor errors have been made	The level of knowledge corresponds to the training program, no errors have been made	Seminar, test, essay
GPC-2 ID-3 To possess skills of: the knowledge of the origin of living organisms, the levels of organization of living matter, favorable and unfavorable factors affecting the body; the basis for studying environmental knowledge of the environment, the laws of the	The level of knowledge is below the minimum requirements, gross errors have occurred	The minimum acceptable level of knowledge, many minor errors have been made	The level of knowledge corresponds to the training program, several minor errors have been made	The level of knowledge corresponds to the training program, no errors have been made	Seminar, test, essay

development of nature and society; skills of observation, comparative analysis, historical and experimental modeling of the impact of anthropogenic and economic factors on living objects, with the use of digital technologies as well.					

3. A LIST OF CONTROL TASKS AND OTHER MATERIALS, NECESSARY FOR THE ASSESSMENT OF KNOWLEDGE, SKILLS AND WORK EXPERIENCE

3.1. Typical tasks for the current control of academic progress

3.1.1. Seminar questions

Questions to assess competency:
GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.
Questions for the seminar №1
Indicator GPC-2 ID-1
1. Chromosomes: structure, morphology, and composition. Classification of chromosomes based on the position of the centromere.
2. Structure and function of telomeres. The Hayflick limit.
3. Telomere structure. Histone protein structure.
4. Levels of chromatin compaction.
5. Chromatin remodeling in eukaryotes.
6. Difference between euchromatin and heterochromatin. Types of heterochromatin. Composition of heterochromatin.
7. Mobile genetic elements in eukaryotes.
8. Definition of karyotyping. Karyogram definition. Metaphase plate definition.
9. Standard karyotype of cattle.
10. Standard karyotypes of small ruminants.
11. Standard karyotype of the domestic horse.
12. Standard karyotype of the domestic pig.
13. Main features of avian karyotypes. Standard karyotype of the domestic chicken.
14. Definition, procedure and applications of karyotyping.
15. Chromosome banding techniques.
16. Systems of chromosome classification and nomenclature.
17. Метод FISH и его роль в изучении кариотипов продуктивных животных.
18. Cell division. Mitosis. Biological significance of mitosis.
19.Meiosis. Biological significance of meiosis.
20.Gametogenesis. Stages. Differences between spermatogenesis and oogenesis.
21.RNA: structure, types, function.
22.Non-coding RNAs.
23.Structural and functional differences between DNA and RNA.
24.Transfer RNA (t-RNA): structure and functions
25.DNA replication.
26.DNA replication enzymes.
27. DNA damage types.
28. Direct reversal repair in eukaryotes.
29. Base excision repair and its main steps.
30.Stages of protein synthesis.
31.Transcription, pre-mRNA processing.
32. RNA processing and its stages.
33. Post-translational modification of proteins.
34.Cell types in relation to proliferative potential.
35.Types of cell division.
36.Atypical mitosis.

37.Endoreduplication.

Indicator GPC-2 ID-3
38.Mendel's principles of inheritance.
39.Types of genetic crosses.
40.Modes of inheritance.
41.Classification of mutations.
42.Types of chromosomal abnormalities.
43.Watson-Crick Structure of DNA.
44.DNA polymorphism.
45.Definition of chromosomal territories..
46.Kinetochore: definition and function
47.Types of dominance.
48.The role of microtubules in chromosome segregation during mitosis/meiosis.
49.Variations in sex characteristics.
50.Types of variation.
51.Gene, genome and chromosome mutations.
52.Mutagens and antimutagens.
53.Chromosomal theory of inheritance.
54.Modern concept of gene structure.
55.The structure of eukaryotic genes.
56. Chromosomal territories.
57. Non-coding RNAs.
58. Alternative splicing.
59. Function of the kinetochore.
60. Types of kinetochore–microtubule attachments.

Questions for the seminar №2
Indicator GPC-2 ID-1
1. Non-allelic gene interactions.
2. Epistasis and complementation.
3. Pleiotropy and polygenic inheritance.
4. Modifier genes.
5. Intersexuality definition.
6. Freemartinism in cattle.
7. Hermaphroditism: definition, types and examples.
8. Genomic imprinting.
9. Klinefelter syndrome.
10. Turner syndrome.
11. Jacobs syndrome.
12. Triple X syndrome.
13. Gynandromorphism: definition and examples.
14. Definition of chimerism and mosaicism.
15. Viral genome organization.
16. Viral life cycle.
17. Bacterial genome structure.
18. Plasmid classifications and their biological significance.
19. Antibiotic resistance in bacteria.

20. Operon: definition, function and examples.
21. Gene expression during ontogenesis.
22. The driving forces of evolution.
23. Definition of population. Characteristics of popualtions.
24. Modes of speciation.
25. Definition of macroevolution.
26. Evolutionary dynamics of group formation.
27. Paths of evolution.
28. The Hardy-Weinberg equilibrium and its assumptions.
29. Parthenogenesis: definition, examples and usage.
30. Types parthenogenesis.
31. Definition of gynogenesis and androgenesis.
32. Sex inversion in fish. Sex control and manipulation in fish.
33. Polymerase chain reaction (PCR) and its use.
34. Components required for PCR. PCR basic protocols.
35. PCR primer design.
36. Types of PCR.

Indicator GPC-2 ID-3
37. Gene mutations.
38. Genetic disorders in cattle.
39. Genetic disorders in domestic pig.
40. Genetic disorders in small ruminant.
41. Avian genetic disorders.
42. Genetic disorders in domestic horse.
43. Genetic Disorders in arabian horses
44. Causes of congenital anomalies:
45. Definition of transformation in bacteria.
46. Definition of bacterial conjugation.
47. Definition of transduction in bacteria.
48. Model organisms in genetics.
49. Genetic engineering, its techniques and applications.
50. Strategies for gene delivery (at least three).
51. Cloning and genetic engineering.
52. Genome-editing and its application.
53. Genome-editing technologies.
54. DNA Fingerprinting.
55. Gene therapy and genomic-based diagnostic.
56. Genomic selection.
57. Genome-wide SNP detection. DNA microarray.
58. Genomic selection for livestock breeding.
59. Gene mapping.
60. Animal genome databases.

3.1.2. Tests

Formed competence:
GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.
GPC-2 ID-1 To know: ecology factors of the environment, its classification and the nature of relationships with living organisms; basic ecological concepts; interspecific relations of animals and plants, terms and bio ecology laws, parasites and hosts; ecological features of some types of pathogenic microorganisms; mechanisms of influence of anthropogenic and economic factors on the animal body.
GPC-2 ID-3 To possess skills of: the knowledge of the origin of living organisms, the levels of organization of living matter, favorable and unfavorable factors affecting the body; the basis for studying environmental knowledge of the environment, the laws of the development of nature and society; skills of observation, comparative analysis, historical and experimental modeling of the impact of anthropogenic and economic factors on living objects, with the use of digital technologies as well.

GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.)

FORCED-CHOICE QUESTIONS

Matching Tasks

GPC-2 ID-1 To know: ecology factors of the environment, its classification and the nature of relationships with living organisms; basic ecological concepts; interspecific relations of animals and plants, terms and bio ecology laws, parasites and hosts; ecological features of some types of pathogenic microorganisms; mechanisms of influence of anthropogenic and economic factors on the animal body.

Task 1.

Read the text and match.

Genetics is the science that studies heredity and variability. The objectives of genetic analysis are: studying the nature of the inheritance of individual traits (nuclear or non-nuclear inheritance), studying the interaction of genes with other genes, determining their localization on a specific chromosome, as well as their location within a linkage group, studying the genotype of a given organism, clarifying the structure and function of a gene, its molecular organization.

Heredity is the ability of organisms to pass on their traits and developmental features to their offspring. Thanks to this ability, all living beings retain the characteristic features of the species in their descendants. Such continuity of hereditary properties is ensured by the transfer of genetic information.

Species variability is the diversity of traits among representatives of a given species, as well as the ability of offspring to acquire differences from parental forms.

Match the wording of basic concepts of genetics with the corresponding definitions: for each position in the first column, select the corresponding position from the second column.

	Basic concepts of genetics		**Definition**
A	Heredity is	1	heredity and variability
B	Genetics is the science that studies	2	the diversity of traits among representatives of a given species, as well as the ability of offspring to acquire differences from parental forms.
C	Nuclear inheritance	3	the ability of organisms to pass on their traits

			and developmental characteristics to offspring
D	Gene is	4	this is a type of inheritance associated with the transmission of hereditary properties located on the chromosomes of the nucleus
E	Variability of species is	5	a fragment of deoxyribonucleic acid (DNA) that contains information about one or more products in the form of protein or RNA

Write the selected numbers in the table under the corresponding letters.

A	B	C	D	E

Answer: A3B1C4D5E2.

Task 2.

Read the text and match.

Chromosomes play a key role in heredity and the functioning of living organisms. They are structural units made up of DNA and proteins that store genetic information. Chromosomes contain genes responsible for various characteristics and functions of the body. Chromosomes not only determine physical traits, such as eye color or height, but also affect more complex processes, including the development of organs and the immune system. Changes in the structure or number of chromosomes can lead to various genetic diseases. Thus, chromosomes are the fundamental basis for the inheritance and diversity of life on Earth. Match the concepts and characteristics related to these definitions (concepts): for each position in the first column, select the corresponding position from the second column.

Concepts		**Definition**	
A	Chromosome	1	the area of a chromosome that connects two chromatids and is responsible for the proper distribution of chromosomes during cell division.
B	Chromatin	2	the structure made up of DNA and proteins that forms chromosomes in the cell nucleus.
C	Centromere	3	The terminal regions of a chromosome that play an important role in preventing chromosome fusion.
D	Telomeres	4	DNA sequences that contain information about one or more protein or RNA products.
E	Genes	5	the structure formed by the condensation of chromatin during cell division, visible under a microscope.

Write the selected numbers in the table under the corresponding letters.

A	B	C	D	E

Answer: A5B2C1D3E4.

Task 3.

Read the text and match.

Meiosis is a type of cell division that plays a key role in the formation of gametes in sexually reproducing organisms.

During meiosis, the number of chromosomes is halved, which ensures genetic diversity and stability of the chromosome number across generations. Crossing over creates unique combinations of genes, which contributes to the evolution of species and increases their genetic diversity.

Match concepts and processes: for each position in the first column, select the corresponding position from the second column.

Concepts		**Processes**	
A	Meiosis	1	The stage in which genetic material is exchanged between homologous chromosomes
B	Crossover	2	The division that results in the formation of four haploid cells
C	Cytokinesis	3	The stage of meiosis in which conjugation of homologous chromosomes and crossing over occurs.
D	Prophase I	4	The process that completes cell division, resulting in the formation of two daughter cells.
E	Anaphase II	5	The stage of meiosis in which sister chromatids separate and move toward the poles of the cell.

Write the selected numbers in the table under the corresponding letters.

A	B	C	D	E

Answer: A2B1C4D3E5.

Task 4.

Read the text and match.

Nucleic acids such as deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) play a key role in heredity and protein biosynthesis.

DNA stores the genetic information of all living organisms, ensuring the transmission of information from one generation to the next. It consists of two helical chains formed by nucleotides that contain adenine, thymine, guanine and cytosine. RNA is responsible for the transfer of information from DNA and the synthesis of proteins.

There are several types of RNA, which can be divided into coding and non-coding. Coding RNA is translated into protein and includes messenger RNA (mRNA). Non-coding RNAs are not translated into protein, examples include transfer RNA (tRNA), ribosomal RNA (rRNA), small nuclear RNAs, small nucleolar RNAs, etc. Thus, nucleic acids are fundamental molecules of life, providing not only the transmission of hereditary information, but also the implementation of this information in the form of proteins and RNAs necessary for the functioning of cells and organs.

Match the types of nucleic acids and the functions they perform. For each position in the first column, select the corresponding position from the second column.

Type		**Function**	
A	Messenger RNA (mRNA)	1	Participates in the process of protein synthesis, creates the basis of ribosomes with proteins.
B	Transfer RNA (tRNA)	2	Transports amino acids to ribosomes, where they are used to assemble polypeptide chains.
C	Ribosomal RNA (rRNA)	3	Contains information about the amino acid sequence in a protein and serves as a template for peptides synthesis.
D	Non-coding RNA (ncRNA)	4	Includes many types of RNA that do not encode peptides, but can perform various regulatory functions.
E	DNA	5	Stores, implements and transmits genetic information. Is part of chromosomes.

Write the selected numbers in the table under the corresponding letters.

A	B	C	D	E

Answer: A3B2C1D4E5.

Task 5.

Read the text and match.

Genetic mutations play a key role in the evolution and adaptation of species, contributing to their diversity and survival. Gene mutations are changes in the number and/or sequence of nucleotides in the DNA structure that can affect the functionality of genes. Gene mutations underlie gene diseases. There are several types of gene mutations. One of the most common is a point mutation, in which one nucleotide is replaced by another. This can lead to the replacement of an amino acid in a protein, which often affects its structure and function.

Match the type of mutation with the mechanism by which it occurs. For each position in the first column, select the corresponding position from the second column.

Mutation types		**Mechanism**	
A	Insertion	1	Substitution of a purine base for a pyrimidine base or vice versa in one of the codons.
B	Deletion	2	Removal of one or more nucleotide pairs from a DNA sequence, which can cause a frameshift.
C	Transversion	3	Increasing the number of copies of a particular DNA segment.
D	Inversion	4	Rotating by 180° a DNA segment ranging in size from two nucleotides to a fragment including several genes.
E	Duplication	5	Insertion of DNA fragments ranging in size from one nucleotide to an entire gene.

Write the selected numbers in the table under the corresponding letters.

A	B	C	D	E

Answer: A5B2C1D4E3.

Ordered-response questions

Task 6.

Read the text and determine the sequence.

The ability to synthesize its own unique proteins is inherited from one cell to another and is maintained throughout life. Protein biosynthesis occurs most intensively during the period of active cell growth and development. If protein biosynthesis is disrupted, the cell dies sooner or

later. DNA plays the main role in determining the structure of the synthesized protein; it is in its molecule that information about the primary structure of the protein molecule is stored.

At the final stage, the synthesized protein acquires its spatial structure, and only after all processes are completed does the protein molecule become fully functionally active. The importance of protein synthesis in the cell is that it provides the cells of living organisms with "building material", biological catalysts (enzymes), regulators and "body defenses".

Establish the sequence of stages in the implementation of genetic information from DNA to protein. Write down the numbers that indicate the events occurring in the cell during protein synthesis in the correct sequence.

1. Transcription
2. Translation
3. DNA replication
4. RNA synthesis

Answer: 3412.

Task 7.

Read the text and determine the sequence.

Meiosis is the process of cell division resulting in halved number of chromosomes in the daughter cells. In the process four haploid cells are formed. The biological significance of meiosis is the formation of cells with a single set of chromosomes. The gametes that develop from them then merge during sexual reproduction and the double set of chromosomes is restored as a result. In addition, crossing over leads to new combinations of genes in the chromosomes of cells, which serves as the basis for the combinatorial variability of organisms. Establish the sequence of stages of meiosis in a cell. Write down the numbers that designate the events that occur in the cell during division in the correct sequence.

1. Metaphase I
2. Crossover
3. Conjugation of chromosomes
4. Metaphase II
5. Anaphase II

Answer: 32145.

Task 8.

Read the text and determine the sequence.

Mutations play an important role in the evolution of fish, especially carp, salmon and sturgeon. They can lead to changes in the number of chromosomes, chromosome structure and even the emergence of new species with an increased number of chromosome sets. In fish farming, mutations are used to obtain gynogenetic offspring and to study the influence of the environment and external factors on the manifestation of traits. However, harmful mutations also reduce the viability and reproductive qualities of aquaculture, which can lead to mass death of fish. Establish the sequence of evolutionary processes during mutagenesis and the emergence of adaptation to environmental conditions. Write down the numbers that designate the events occurring in the population in the correct sequence.

1. Survival of mutant individuals during the struggle for existence
2. Crossbreeding of individuals - carriers of the mutation

3. The emergence of a recessive mutation in the gene pool of the population
4. The emergence of individuals with a phenotypic manifestation of the mutation
5. Fixation of the mutation in the gene pool of the population as a result of natural selection

Answer: 32415.

Task 9.

Read the text and determine the sequence.

There are many different types of genetic research methods, such as molecular genetic analysis. It includes DNA, RNA and protein analysis. In animal husbandry, it is used to determine the purity of breeding lines, identify hybrid individuals, and assess the genetic diversity of populations. The choice of a specific method depends on the objectives and levels of research.

Genetic research is of great importance for animal husbandry, as it allows solving various problems: clarifying the origin of animals; creating disease-resistant individuals; evaluating producers by the quality of offspring; studying the effect of various substances on the hereditary apparatus; studying anomalies and identifying their causes; detecting carriers of recessive genes; studying animal immunity; developing methods for increasing resistance to diseases. Genetic research helps to improve biotechnology methods, increase animal productivity, combat hereditary diseases and create new breeds resistant to various environmental factors.

Write down the numbers that designate the stages of molecular genetic research in the correct sequence.

1. DNA amplification
2. sampling
3. data analysis
4. DNA sequencing
5. electrophoresis

Answer: 21543.

Task 10.

Read the text and determine the sequence.

Fish karyotyping is the process of studying fish chromosomes to determine their structure and number. This method is used in genetic research and breeding to identify interspecific hybrids, conduct distant hybridization, and develop genetic selection methods. Karyotyping allows us to classify and identify chromosomes, as well as determine their basic characteristics, such as length and centromeric index. Fish karyotyping is performed on various fish species, including about 2000 species. Research has shown significant variability in the number of chromosomes in fish, which allows us to study evolutionary processes and adaptive mechanisms.

Write the numbers that designate the stages of fish karyotyping in the correct order.

1. Collecting fish tissue samples (e.g. bone marrow, testicular walls, or tumor cells)
2. Identifying chromosomes and compiling a karyogram (idiogram).
3. Blocking cell division in metaphase with colchicine or colcemid.
4. Fixation of cells to stop vital activity and preserve the structure of chromosomes
5. Staining of the chromosome preparation using the Giemsa method or another

Answer: 13452

GPC-2 ID-3 To possess skills of: the knowledge of the origin of living organisms, the levels of organization of living matter, favorable and unfavorable factors affecting the body; the basis for studying environmental knowledge of the environment, the laws of the development of nature and society; skills of observation, comparative analysis, historical and experimental modeling of the impact of anthropogenic and economic factors on living objects, with the use of digital technologies as well.

Tasks of a combined type with the choice of one/several correct answers from the proposed options

Task 11.

Read the text and choose the correct answer.

Fish chromosomes are structural elements of the cell that contain hereditary information. They are carriers of genes that control various traits and properties of fish. Chromosomes have their own characteristics associated with their structure and quantity.

The number of chromosomes may vary depending on the species. Chromosomes can contain both euchromatin (active genome) and heterochromatin (inactive genome). The study of animal chromosomes is important for understanding the processes of evolution, genetic diversity, and adaptation to various environmental conditions.

Using the passage and knowledge of genetics, select the correct statement from the list below and provide arguments.

1. Most animals have autosomes and sex chromosomes
2. All animal chromosomes are identical in structure to each other
3. In the cells of adult animals, there is only a diploid set of chromosomes
4. Chromosomes are contained only in sex cells.

Answer: 1.

Task 12.

Read the text and choose the correct answer.

Sometimes in nature there is a process of change in the nucleotide sequence of DNA, which leads to changes in the genetic material of living organisms. These changes can be natural or artificial. Most often, this process occurs under the influence of environmental factors such as ultraviolet radiation, radiation and chemicals. What process are we talking about?

1. Crossing over
2. Evolution
3. Mutagenesis
4. Cytokinesis

Answer: 3.

Task 13.

Read the text and choose the correct answer.

Chromosomes are thread-like nucleoprotein structures in the nucleus of a eukaryotic cell, which contain most of the hereditary information and are designed to store, implement and transmit it. Each chromosome has certain "components", each of which performs its own role.

For example, "components A" consist of the same sequence of nitrogenous bases (in humans - TTAGGG), which is repeated about 3 thousand times. Their main function is to protect the terminal sections of chromosomes from damage, which can lead, among other things, to cancer. As the cell divides, they shorten, and by the end of the cell's life cycle, they almost disappear. When they become too short, the chromosome can no longer create a copy of itself, then the process of cell destruction begins. What is "components A"?

1. Centromeres
2. Telomeres
3. Kinetochores
4. Chromatids

Answer: 2.

Combined type tasks with multiple correct answers from the proposed options

Task 14.

Read the text and choose the correct answers.

Crossbreeding of animals on farms is used to obtain hybrids with improved characteristics, such as fast growth, high viability and adaptability to various conditions. Hybrids can be sterile, which helps to maintain a high growth rate for a long time.

Heterosis is an increase in the power and viability of first-generation hybrids compared to parental forms in various crosses of animals or plants.

Using the passage and knowledge of genetics, select the correct judgments from the list provided. Write down the numbers under which they are indicated.

1. Using inbreeding offspring are always born healthy
2. Inbreeding depression is often encountered with inbreeding
3. Heterosis is not transmitted to subsequent generations
4. Hybridization is one of the promising areas in modern animal husbandry

Answer: 234.

Task 15.

Read the text and choose the correct answers.

A chromosome is a nucleoprotein structure in the nucleus of a eukaryotic cell that contains most of the genetic information and is designed to store, implement, and transmit it. Chromosomes become clearly visible under a light microscope during mitotic or meiotic cell division. The set of all chromosomes in a cell is called a karyotype and is a species-specific feature with a low level of individual variability. The chemical structure of chromosomes includes a complex of deoxyribonucleic acid (DNA) and associated proteins, as well as substances such as lipids, ions, and RNA molecules. Each chromosome consists of one long DNA molecule that contains nucleotide sequences that determine genetic information. Chromosomes, depending on the location of the centromere, can be metacentric, submetacentric, acrocentric, and telocentric. The external structure of chromosomes depends on their state: in interphase, chromosomes are presented in the form of chromatin (consisting of one chromatid) and are invisible to a light microscope, and during cell division (mitosis and meiosis), chromosomes become visible to a light microscope and consist of two chromatids. Also in the

structure of chromosomes, such structures as telomeres, centromeres, secondary constrictions, arms, and kinetochores are distinguished.

Using the passage and knowledge of genetics, select the correct judgments from the list provided. Write down the numbers under which they are indicated.

1. Chromosomes contain Ca^{2+} and Mg^{2+} ions
2. Centromeres may have differences in localization in non-homologous chromosomes
3. Telomeres contain coding sequences
4. All chromosomes in a cell of an organism have the same size and shape
5. Kinetochore ensures the attachment of the spindle threads to the chromosome

Answer: 125.

OPEN-RESPONSE TASK

Task 16.

Read the text and write down a detailed answer..

Genes are sections of DNA that contain information about the structure of proteins and RNA. Gene interaction is the combined action of several genes, resulting in the appearance of a trait that the parents do not have, or an increased expression of an existing trait. Gene interaction occurs at the level of biochemical processes, where proteins and enzymes interact with each other, determining the formation of traits. Allelic genes are genes located in the same loci (places) of homologous chromosomes and responsible for the development of the same trait. Examples of allelic genes include the eye color gene (brown and blue), scale type (shape and size).

List and define all types of allelic gene interaction.

Answer: Complete dominance - the dominant allele completely suppresses the effect of the recessive allele, and only the dominant trait is manifested in the phenotype. Incomplete dominance - the dominant allele does not completely suppress the recessive allele, and an intermediate trait is expressed in the phenotype.

Overdominance - the heterozygous state of alleles leads to a better manifestation of the trait than in the homozygous state.

Codominance - both alleles are expressed simultaneously, and the phenotype shows a combination of traits characteristic of each allele.

Task 17.

Read the text and write down a detailed answer..

Chromosomes are structures that carry genetic information and determine the hereditary properties of cells and organisms. Each chromosome is a group of linked genes capable of self-reproduction and gene expression. Chromosomes consist of two strands - chromatids, linked by a centromere. The ends of the chromosomes are called telomeres. Chromosomes have different lengths and diameters depending on the type of organism. During the development of multicellular organisms, chromosomes can acquire various forms. The chromosome set of each cell of the organism contains a characteristic and constant set of chromosomes, fixed in the evolution of the species.

Describe the chemical structure of the chromosome.

Answer: The composition of the chromosome includes:
-Deoxyribonucleic acid (DNA)
-Proteins: histone and non-histone.
- RNA.
-Ca2+ and Mg2+ ions.

-Lipids: neutral and polar.

Task 18.

Read the text and write down a detailed answer..

There are four main types of cell division: direct binary fission, amitosis, mitosis, and meiosis. Direct binary fission is typical for prokaryotes (bacteria and cyanobacteria), amitosis occurs in highly specialized cells with low activity, mitosis is an indirect division of somatic cells of eukaryotes, and meiosis is the division of eukaryotic cells that leads to the formation of haploid cells.

Write the biological significance of mitosis.

Answer: The biological significance of mitosis is as follows:

1. Accurate transmission of genetic information in a series of cell generations.
2. Maintenance of a constant number of chromosomes.
3. Increase in the number of cells. This is the basis for the growth and development of all multicellular organisms.
4. Regeneration - restoration of damaged tissues and organs.
5. Asexual reproduction of many organisms.

Task 19.

Read the text and write down a detailed answer.

Mutagenesis is the process of altering DNA, resulting in mutations. Mutations can occur randomly or as a result of natural factors, such as natural ionising radiation. Mutagenesis is an important element of the evolutionary process, as organisms acquire new useful properties as a result of natural selection of small useful mutations and their combinations. However, mutations associated with man-made pollution can lead to outbreaks of large chromosomal and genomic changes, including changes in germ cells. This can lead to the death of organisms at early stages of development or the appearance of deformities.

Name the three main groups of mutagens and give examples.

Answer: Mutagens can be divided into three main groups: physical, chemical, and biological.

Physical mutagens include ionizing radiation (X-rays and gamma rays), electromagnetic radiation (ultraviolet and visible light), charged particles, and neutron radiation. Chemical mutagens are various chemical compounds, such as alkaloids, oxidizing agents, and reducing agents, that cause mutations. Biological mutagens include specific DNA sequences (transposons), some viruses (measles, rubella, and influenza viruses), and metabolic products (lipid oxidation products, antigens of some microorganisms).

Task 20.

Read the text and write down a detailed answer.

Nucleic acids are polymer molecules consisting of nucleotides. Nucleotides consist of residues of: nitrogenous bases (pyrimidine or purine); monosaccharide; phosphoric acid.

Depending on the monosaccharide contained, there are two types of nucleic acids: deoxyribonucleic acid (DNA) - contains deoxyribose; ribonucleic acid (RNA) - contains ribose. Nucleotides differ in nitrogenous bases, of which there are only five: adenine, guanine, thymine, cytosine and uracil. RNA contains the nucleotides adenine, guanine, cytosine and uracil, and in DNA uracil is replaced by thymine.

RNA can be divided into coding and non-coding. Give examples and name their functions.

Answer:

Coding RNAs and functions:

messenger RNAs (mRNAs) — transmit information about DNA to the site of protein assembly on ribosomes.

Non-coding RNAs:

- ribosomal RNAs (rRNAs) — form the basis of ribosomes and participate in protein biosynthesis;
- transfer RNAs (tRNAs) — transport amino acids to the site of protein synthesis on the ribosome;
- micro RNAs — participate in transcriptional and post-transcriptional regulation of gene expression;
- small nuclear RNAs (snRNAs) — participate in important processes such as splicing, regulation of transcription factors, and maintenance of telomere integrity;
- piRNAs (pi RNAs) — found in complexes with proteins of the Piwi family, have the ability to silence mobile elements and provide genome protection.

3.1.3. 1.2.4. List of essay topics on GPC-2 competency:

GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.

GPC-2 ID-1 To know: ecology factors of the environment, its classification and the nature of relationships with living organisms; basic ecological concepts; interspecific relations of animals and plants, terms and bio ecology laws, parasites and hosts; ecological features of some types of pathogenic microorganisms; mechanisms of influence of anthropogenic and economic factors on the animal body.

GPC-2 ID-3 To possess skills of: the knowledge of the origin of living organisms, the levels of organization of living matter, favorable and unfavorable factors affecting the body; the basis for studying environmental knowledge of the environment, the laws of the development of nature and society; skills of observation, comparative analysis, historical and experimental modeling of the impact of anthropogenic and economic factors on living objects, with the use of digital technologies as well.

1. Application of molecular genetic technologies in animal husbandry.
2. Application of molecular genetic technologies in veterinary medicine.
3. Modern methods of genetic research in animal husbandry.
4. Modern methods of genetic research in veterinary medicine.
5. Diagnosis of a genetic disease.
6. Genetic diseases modern diagnostics for hereditary disorders in animals.
7. Application of veterinary cytogenetics in animal husbandry and veterinary medicine.
8. Application of genealogical analysis in animal husbandry and veterinary medicine.
9. Applications of CRISPR/Cas9 genome editing technology in animal husbandry and veterinary medicine.
10. Biotechnology for the livestock industry.
11. Biotechnology for the veterinary medicine.
12. Genetic engineering application in animal breeding.
13. Genetic engineering application in veterinary medicine.
14. Genetic disorders in cattle.

15. Genetic disorders in domestic pig.
16. Genetic disorders in small ruminant.
17. Genetic disorders in domestic horse.
18. Genetic disorders in pets.
19. Avian genetic disorders.
20. Multifactorial diseases in cattle.
21. Multifactorial diseases in small ruminant.
22. Multifactorial diseases in domestic pig.
23. Multifactorial diseases in domestic horse.
24. Multifactorial diseases in pets.
25. Genetic therapy in veterinary medicine.
26. Congenital disorders in cattle.
27. Congenital disorders in small ruminant.
28. Congenital disorders in domestic pig.
29. Congenital disorders in domestic horse.
30. Avian congenital disorders.
31. Congenital disorders in pets.
32. Monogenic disorders of cattle and their diagnosis.
33. Monogenic disorders of small ruminant and their diagnosis.
34. Monogenic disorders of domestic horse and their diagnosis.
35. Avian monogenic disorders and their diagnosis.
36. Моногенные заболевания с/х птицы и методы их диагностики.
37. Monogenic disorders of pets and their diagnosis.
38. Elective topic.

3.2. Standard tasks for intermediate certification

3.2.1. Exam questions

Formed competence:

GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.

GPC-2 ID-1 To know: ecology factors of the environment, its classification and the nature of relationships with living organisms; basic ecological concepts; interspecific relations of animals and plants, terms and bio ecology laws, parasites and hosts; ecological features of some types of pathogenic microorganisms; mechanisms of influence of anthropogenic and economic factors on the animal body.

GPC-2 ID-3 To possess skills of: the knowledge of the origin of living organisms, the levels of organization of living matter, favorable and unfavorable factors affecting the body; the basis for studying environmental knowledge of the environment, the laws of the development of nature and society; skills of observation, comparative analysis, historical and experimental modeling of the impact of anthropogenic and economic factors on living objects, with the use of digital technologies as well.

1. Chromosomes: structure, morphology, and composition. Classification of chromosomes based on the position of the centromere.
2. Structure and function of telomeres. The Hayflick limit.
3. Telomere structure. Histone protein structure.
4. Levels of chromatin compaction.

5. Chromatin remodeling in eukaryotes.
6. Difference between euchromatin and heterochromatin. Types of heterochromatin. Composition of heterochromatin.
7. Mobile genetic elements in eukaryotes
8. Definition of karyotyping. Karyogram definition. Metaphase plate definition.
9. Standard karyotype of cattle.
10. Standard karyotypes of small ruminants.
11. Standard karyotype of the domestic horse.
12. Standard karyotype of the domestic pig.
13. Main features of avian karyotypes. Standard karyotype of the domestic chicken.
14. Definition, procedure and applications of karyotyping.
15. Chromosome banding techniques.
16. Systems of chromosome classification and nomenclature.
17. The FISH technique and its application in livestock genetics.
18. Cell division. Mitosis. Biological significance of mitosis.
19. Meiosis. Biological significance of meiosis.
20. Gametogenesis. Stages. Differences between spermatogenesis and oogenesis.
21. RNA: structure, types, function.
22. Non-coding RNAs.
23. Structural and functional differences between DNA and RNA.
24. Transfer RNA (t-RNA): structure and functions
25. DNA replication.
26. DNA replication enzymes.
27. DNA repair mechanisms.
28. DNA damage types.
29. Direct reversal repair in eukaryotes.
30. Base excision repair and its main steps.
31. Stages of protein Synthesis.
32. Transcription, pre-mRNA processing, alternative splicing.
33. RNA processing and its stages.
34. Post-translational modification of proteins.
35. Cell types in relation to proliferative potential.
36. Types of cell division.
37. Atypical mitosis.
38. Endoreduplication.
39. Mendel's principles of inheritance.
40. Types of genetic crosses.
41. Modes of inheritance.

42. Classification of mutations.
43. Types of chromosomal abnormalities.
44. Watson-Crick Structure of DNA.
45. DNA polymorphism.
46. Definition of chromosomal territories..
47. Kinetochore: definition and function
48. Types of dominance.
49. The role of microtubules in chromosome segregation during mitosis/meiosis.
50. Variations in sex characteristics.
51. Types of variation.
52. Gene, genome and chromosome mutations.
53. Mutagens and antimutagens.
54. Chromosomal theory of inheritance.
55. Modern concept of gene structure.
56. The structure of eukaryotic genes.
57. Non-allelic gene interactions.
58. Epistasis and complementation.
59. Pleiotropy and polygenic inheritance.
60. Modifier genes.
61. Intersexuality definition.
62. Freemartinism in cattle.
63. Hermaphroditism: definition, types and examples.
64. Genomic imprinting.
65. Klinefelter syndrome.
66. Turner syndrome.
67. Jacobs syndrome.
68. Triple X syndrome.
69. Gynandromorphism: definition and examples.
70. Definition of chimerism and mosaicism.
71. Viral genome organization.
72. Viral life cycle.
73. Bacterial genome structure.
74. Plasmid classifications and their biological significance.
75. Antibiotic resistance in bacteria.
76. Operon: definition, function and examples.
77. Gene expression during ontogenesis.
78. The driving forces of evolution.
79. Definition of population. Characteristics of popualtions.
80. Modes of speciation.
81. Definition of macroevolution.

82. Evolutionary dynamics of group formation.
83. Paths of evolution.
84. The Hardy-Weinberg equilibrium and its assumptions.
85. Parthenogenesis: definition, examples and usage.
86. Types parthenogenesis.
87. Definition of gynogenesis and androgenesis.
88. Sex inversion in fish. Sex control and manipulation in fish.
89. Polymerase chain reaction (PCR) and its use.
90. Components required for PCR. PCR basic protocols.
91. PCR primer design.
92. Types of PCR.
93. Gene mutations.
94. Genetic disorders in cattle.
95. Genetic disorders in domestic pig.
96. Genetic disorders in small ruminant.
97. Avian genetic disorders.
98. Genetic disorders in domestic horse.
99. Genetic Disorders in arabian horses
100. Causes of congenital anomalies:
101. Definition of transformation in bacteria.
102. Definition of bacterial conjugation.
103. Definition of transduction in bacteria.
104. The lytic and lysogenic cycles of bacteriophages.
105. Model organisms in genetics.
106. Genetic engineering, its techniques and applications.
107. Vectors for gene transfer.
108. Strategies for gene delivery (at least three).
109. Cloning and genetic engineering.
110. Application of cell culture technology in genetic engineering.
111. Genome-editing and its application.
112. Genome-editing technologies.
113. DNA Fingerprinting.
114. Gene therapy and genomic-based diagnostic.
115. Genomic selection.
116. Genome-wide SNP detection. DNA microarray.
117. Genomic selection for livestock breeding.
118. Gene mapping.
119. Animal genome databases.
120. Animal genetic resources.

4. METHODOLOGICAL MATERIALS DEFINING THE PROCEDURES FOR ASSESSING KNOWLEDGE, SKILLS AND ABILITIES AND WORK EXPERIENCE CHARACTERIZING THE STAGES OF COMPETENCE FORMATION

Criteria for evaluating students` knowledge during seminar:

- **Mark «excellent»** - the student clearly expresses his point of view on the issues under consideration, giving appropriate examples.
- **Mark «good»** - the student have some errors in the answer.
- **Mark «satisfactory»** - the student have gaps in knowledge of the basic educational and normative material.
- **Mark «unsatisfactory»** - the student have significant gaps in knowledge of the basic provisions of the discipline, the inability to obtain the correct solution to a specific practical problem with the help of a teacher.

Criteria for evaluating students' knowledge during the test:

Mark «excellent» the grade is given if the student answers no less than 90% of the test tasks correctly;

Mark «good» the grade is given if the student answers no less than 80% of the test tasks correctly;

Mark «satisfactory» the grade is given if the student answers no less than 70% of the test tasks correctly;

Mark «unsatisfactory» the grade is given if the student answers less than 70% of the test tasks correctly.

Criteria for evaluating students` knowledge while writing an essay.

Mark «excellent» - the problem is identified and its relevance is justified; an analysis of various points of view on the problem was made and one's own position was logically stated; conclusions are formulated, the topic is fully disclosed, the volume is maintained; formatting requirements have been met, the basic requirements for the abstract have been met.

Mark «good» - shortcomings were made. In particular, there are inaccuracies in the presentation of the material; there is no logical consistency in judgments; the volume of the essay is not maintained; there are omissions in the design, there are significant deviations from the requirements.

Mark «satisfactory» - the topic is only partially covered; there were factual errors in the content of the essay; there are no conclusions, the topic of the essay is not disclosed.

Mark «unsatisfactory» - there is a significant misunderstanding of the problem or the essay is not presented at all.

Criteria for evaluating students` knowledge during the examination:

- **Mark «excellent»** – all types of educational work provided for in the curriculum have been completed. The student demonstrates the compliance of knowledge, skills, and abilities with the indicators given in the tables, operates with acquired knowledge, skills, and applies them in various situations of increased complexity. At the same time, inaccuracies, difficulties in analytical operations, transfer of knowledge and skills to new, non-standard situations may be allowed.
- **Mark «good»** – all types of educational work provided for in the curriculum have been completed. The student demonstrates the compliance of knowledge, skills, and abilities with the indicators given in the tables, operates with acquired knowledge, skills, and applies them in standard situations. At the same time, minor errors, inaccuracies, difficulties in analytical operations, transfer of knowledge and skills to new, non-standard situations could be made.

• **Mark «satisfactory»** – one or more types of educational work provided for in the curriculum have not been completed. The student demonstrates incomplete compliance of knowledge, skills, and abilities with the indicators given in the tables, significant errors are made, a partial lack of knowledge, skills, and skills are manifested in a number of indicators, the student experiences significant difficulties in operating with knowledge and skills when transferring them to new situations. –

• **Mark «unsatisfactory»** – the types of educational work provided for in the curriculum have not been completed. demonstrate incomplete compliance of knowledge, skills, and abilities given in the tables of indicators, significant errors are made, a lack of knowledge, skills, and skills are manifested for a large number of indicators, the student experiences significant difficulties in operating with knowledge and skills when transferring them to new situations.

6. ACCESSIBILITY AND QUALITY OF EDUCATION FOR DISABLED PEOPLE

If necessary, persons with disabilities and persons with disabilities are given additional, time to prepare an answer for the test.

When conducting the procedure for evaluating the learning outcomes of disabled people and persons with disabilities, their own technical means could be used.

The procedure for evaluating the learning outcomes of disabled people and persons with disabilities in the discipline provides for the provision of information in forms adapted to the limitations of their health and perception of information:

For people with visual impairments:	– in printed form in enlarged font; – in the form of an electronic document.
For people with hearing impairments:	– in printed form; – in the form of an electronic document.
For people with disorders of the musculoskeletal system:	– in printed form, the device; – in the form of an electronic document.

When conducting the procedure for evaluating the learning outcomes of disabled people and persons with disabilities in the discipline, it ensures that the following additional requirements are met, depending on the individual characteristics of the students:

a) instructions on the procedure for conducting the assessment procedure are provided in an accessible form (orally, in writing);

b) an accessible form of assignment of assessment tools (in printed form, in printed form in enlarged font, in the form of an electronic document, assignments are read out by the teacher);

c) an accessible form of providing answers to tasks (written on paper, a set of answers on a computer, orally).

If necessary, for students with disabilities and the disabled, the procedure for evaluating the results of training in the discipline could be carried out in several stages.

The procedure for evaluating the learning outcomes of disabled people and persons with disabilities is allowed using distant learning technologies.

Program abstract of the discipline B1.O.18
"Veterinary genetics"
specialty 36.05.01 Veterinary Medicine
Profile: «General clinical veterinary medicine»

The purpose of the discipline is for students to study fundamental issues of general and veterinary genetics, to obtain scientific, theoretical and practical knowledge on genetic diagnosis and prevention of hereditary anomalies and diseases in animals. Familiarization with modern ideas about gene structure, regulation of gene activity, genome editing methods, model objects of genetics. Study of the basics of genomic selection, genetic markers of productivity and resistance of productive animals for use in the practice of veterinary selection.

Position of the discipline in the curriculum: The discipline B1.O.18 «Veterinary genetics» is discipline of the Block 1 basic part of Federal State Educational Standard Of Higher Education in specialty 36.05.01 «Veterinary medicine», is mastered during first semester for full-time mode of study.

Requirements for the results of mastering the discipline: The graduate of the discipline should form the following competencies:

GPC-2. Is able to interpret and evaluate in professional activity the influence of natural, socio-economic, genetic and economic factors on the physiological status of the animal body.

GPC-2 $_{ID-1}$ To know: ecology factors of the environment, its classification and the nature of relationships with living organisms; basic ecological concepts; interspecific relations of animals and plants, terms and bio ecology laws, parasites and hosts; ecological features of some types of pathogenic microorganisms; mechanisms of influence of anthropogenic and economic factors on the animal body.

GPC-2 $_{ID-3}$ To possess skills of: the knowledge of the origin of living organisms, the levels of organization of living matter, favorable and unfavorable factors affecting the body; the basis for studying environmental knowledge of the environment, the laws of the development of nature and society; skills of observation, comparative analysis, historical and experimental modeling of the impact of anthropogenic and economic factors on living objects, with the use of digital technologies as well.

To achieve such goal, it is necessary to solve the following objectives:

1) The general educational task is to study the genome of various types of farm animals, hereditary anomalies, mutational variability and diseases with hereditary predisposition, mastering modern methods for diagnosing latent carriers of genetic defects;

2) The applied task covers the influence of various factors on heredity and variability, animal resistance to diseases and climate change, the search for markers of resistance and susceptibility, the creation of disease-resistant lines, types, and breeds of animals with a low genetic load.

As a result of mastering the discipline, the student must:

Know: the mode of inheritance and manifestations of the main inherit disorders of livestock, molecular and cytological basis of inheritance, modern methods of molecular genetics.

Be able to: determine the mode of inheritance of a congenital disorder.

The complexity of the discipline is: 108 academic hours (3 credits).

Final control of the discipline: exam.