AL-FARABI KAZAKH NATIONAL UNIVERSITY

Approved at a meeting of
the Academic Committee (SMB) of
al-Farabi KazNU
Vice Rector for academic affairs
_____ A.K. Khikmetov
Protocol No.____6_____
from «__22___»_June_____2020

PROGRAM
ENTRANCE EXAMINATION FOR SPECIALTIES FOR APPLICANT
PhD PROGRAM FOR SPECIALTIES
8D05104-GENETICS

ALMATY 2020

The program is compiled following the State educational standard in the specialty 8D05104-Genetics. The program was composed of: Doctor of Biological Sciences, Professor Aytasheva Z.G., Candidate of Biological Sciences Kalimagambetov A.M., Candidate of Biological Sciences Altybayeva N.A., Ph.D. Lovinskaya A.V.

The program was considered at a meeting of the Department of Molecular Biology and Genetics
Protocol No._____ from _____2020

Head of the Department _____ **Zh.K. Zhunusbayeva**

Approved at a meeting of the Faculty Methodical Bureau
Protocol No._____ from _____2020

Head of the Faculty Methodical Bureau_____ **O.Yu. Yurikova**

Approved at the meeting of the Scientific Council
Protocol No._____ from _____2020

Chairman of the Scientific Council
Dean of the Faculty _____ **B.K. Zayadan**

Scientific Secretary _____ **B.O. Bauenova**

CONTENT

1. Aims and objectives of the entrance exam in the specialty "8D05104 – Genetics"

The aim of the entrance exam for applicants to the Ph.D. program is to determine the level of general preparedness of applicants in various sections of general and molecular genetics; the ability to navigate the hierarchy of relationships of heredity and variability in prokaryotic and eukaryotic organisms; knowledge of the key, classical laws of genetics, as well as the principles, tasks, methods, and achievements of modern genetic research.

The objectives of the exam are to give an objective assessment of the degree of development of the program material received by Ph.D. students; the level of competencies formed during the period of study in Bachelor's and Master's degrees and a set of skills for the implementation of professional research, teaching and management activities; to assess the horizons, the level of critical thinking, the ability to pose, solve and analyze the scientific and practical problems of modern genetics and related fields of knowledge.

The exam form is in writing**.**

2. Requirements for the level of training of people entering Ph.D. programs in the specialty "8D05104 - Genetics"

The minimum threshold level of prior education for people who want to master the Ph.D. educational program is the Master's program. Applicants to the Ph.D. program must have general professional competencies corresponding to the level of training of masters, be able to formulate and study new problems from various areas of modern genetics; be able to organize on a scientific basis experimental, other search or management activities, use the knowledge gained in laboratory, biomedical and industrial conditions.

3. Prerequisites for the educational program

"Genetic analysis", "Methodology of systemic genetic research", "Evolutionary biology".

4. The Exam Topics

1. The subject and objectives of modern genetics. The methodology of modern genetics. The use of the laws of classical genetics in systems analysis

2. Model objects and their role in genetic research. Biological features of model objects and their role in genetic research. The main differences in the organization of cells of prokaryotes and eukaryotes. Application of knowledge about the life cycles of plants and animals in genetic experiments. The selection of a model object following the purpose and objectives of the study. Bioethics issues and risks.

3. The Hybridological method of studying heredity. Practical level and research procedures.

4. Cytogenetic research methods. Basic principles of cytogenetic analysis. Modern cytogenetic methods for testing the mutagenic activity of environmental factors and assessing its quality.

5. Karyotyping. Genetic maps of chromosomes and their practical application. Diagnostic problems of fetal karyotyping. Sex chromatin.

6. Hybridization. Monohybrid Crossing. Dihybrid Crossing. Unrelated Crossing. Prospects for the use of crossbreeding systems to obtain highly productive breeds of farm animals, varieties of cultivars and strains of microorganisms.

7. The genealogical method. The Twin method. The biological significance of the genealogical method.The twin method and its application to assess the role of the environment in the characters' manifestation and heritability. Comparison of the concordance of mono- and

dizygotic twins.

8. Molecular genetic methods of analysis in genetic research. The use of molecular genetic methods to study the mechanisms of genetic processes, the action of individual genes, and intergenic interactions, in particular genetic suppression.

9. The use of genetic methods to solve problems in the food industry, agriculture, medicine. Synthesis of methods in current conditions and the solution of problems of heredity and variability management to ensure food security, human health, and nature conservation. Solving the problems of the food industry, agriculture based on genetic methods. Genetic background of modern methods of artificial insemination in humans (IVF).

10. The genetic basis of the diversity of organisms and the importance of evolution and breeding. Genetic collections. Test forms and line analyzers. Banks of cell cultures. Gene banks

11. Modern achievements in the breeding of cereal crops. Methods of chromosome engineering of wheat. A brief history of chromosome engineering.

12. Problems of hetero-, poly- and aneuploidy of plants. Chromosomal abnormalities on the example of plants and, in particular, cereals. Development of the nomenclature of chromosomes. The discovery, study, and use of aneuploids.

13. Methods for creating a series of aneuploid lines of soft wheat. Schemes for producing aneuploids.

14. The structure and properties of chromosomes. Chromosomal rearrangements. Comparative analysis of prokaryotic and eukaryotic chromosomes and their properties.

15. Methods of localization of genes in chromosomes. Identification of localized genes.

16. Linkage analysis and gene mapping. Genetic mapping methods.

17. Methods for reconstructing the wheat genome. Inter-varietal chromosome substitution. Scheme of obtaining lines with inter- varietal chromosome substitution. Substitution of a chromosome involved in reciprocal translocation in wheat.

18. Chromosomal additions. Allohexaploids, wheat lines complemented by chromosomes of various other cereals (*Secale cereale* L., *Haynaldia villosa* (L.)Schur., *Aegilops umbellulata* Zhuk.).

19. Genomic analysis of soft wheat. Types of wheat and formulas of their genomes. Genetic structure of soft wheat and related cereals. The original numbering of chromosomes and their assignment to the corresponding genomes.

20. Chemical and radiation mutagenesis as a method of increasing the diversity of the starting material for hybridization.

21. The evolutionary views of de Lamarck and Darwin. Evolutionary views of Lamarck. Driving forces of progressive evolution (gradation) and speciation. The contradictory views of Lamarck. The main driving forces of evolution, according to Darwin. Fundamentals of Darwin's theory.

22. The synthesis of Darwinism and Genetics. The main provisions of the synthetic theory of evolution.

23. A population is an elementary unit of an evolutionary process. A population is an elementary unit of evolution. Genetic heterogeneity and population polymorphism. The genetic unity of the population. Hardy-Weinberg Law. The conditions under which the Hardy-Weinberg equilibrium holds.

24. The genetic basis of evolution. Variability: phenotypic, genotypic, paratypic, modification. Modifications Reaction rate. The concept of adaptive reaction rate.

25. Elementary evolutionary factors are causing changes in the genotypic structure of the population.

26. The biological and evolutionary significance of species. The general concept of the species, the characteristic of difficulty in its universal application. The reasons for the increase in the number of species

27. Speciation. Instant speciation. Gradual and sympatric speciation

28. The importance of geographical variability and its adaptive nature. Analysis of insulating mechanisms, their classification, and significance. Examples of violations of the action of insulating mechanisms.

29. Natural selection and the significance of probability and chance.

30. Double species and justification of the reasons for their prevalence. Examples of duplicate species and their meaning.

31. The evolution of ontogenesis. The concept of ontogenesis. Features of ontogenesis in different organisms and their duration. Ontogenetic differentiation. Duration of ontogenesis. Integrity and stability of ontogenesis. Embryonization of ontogenesis.

32. The evolution of phylogenetic groups. The primary forms of phylogenesis: phyletic evolution, divergence, parallelism, convergence. The main directions of evolution are arogenesis, allogenesis. Forms of allogenesis (telogenesis, hypergenesis, hypogenesis, etc.) The typical phase change of adaptation.

33. Directions and patterns of the evolutionary process. The ratio of micro- and macroevolution. The relationship between ontogenesis and phylogenesis. Müller-Haeckel Law. Severtsov's Theory. Biological and morphophysiological progress and regression in evolution. Recapitulation.

34. Anthropogenesis. The place of man in the system of the animal world. The ancestors of man. The main stages of the evolution of *Homo*. The main stages of the development of *Homo sapiens*. The role of labor and social lifestyle in human evolution. Influence on the human evolution of elementary evolutionary factors.

35. Genetic research methods in human genetics.

36. Genetic methods used to study the mechanisms of genetic processes.

37. Genetic methods for determining the gene localization

38. The importance of mobile genetic elements in genetic analysis.

39. The role of computer technology in genetic analysis

40. The use of mutations in genetic analysis.

41. General principles and methods of genetic engineering

42. Overview of enzymes used in genetic engineering. Enzymology methods in genetic engineering.

43. Genetic engineering of cultured mammalian cells. Methods of introducing DNA molecules into mammalian cells (hypertonic salt method, DEAE-dextran method, calcium phosphate method, etc.).

44. Site-directed *in vitro* mutagenesis.

45. General characteristics of vectors. DNA based vector systems. The introduction of DNA into cells

46. Methods for the construction of recombinant DNA molecules. Methods for determining the nucleotide sequence of DNA.

47. Methods for producing transgenic plants. Obtaining crops with higher yields and resistance to pests. Modern methods of plant transformation. Crowned galls, the use of Ti plasmids, and Ri plasmids to obtain transgenic plants, T-DNA.

48. Plant viruses as vectors for genetic engineering. The use of transgenic plants.

49. Polymerase chain reaction (PCR) method. The principle, steps, reaction components, varieties, and equipment for PCR.

50. Methods for selecting hybrid clones of bacterial cells. Selective media, competent cells. Enzyme-linked immunosorbent assay (ELISA).

51. Vector systems based on animal and plant cells. Shuttle vectors, selective marker genes, transformation frequency.

52. Methods for the reconstruction of transgenic animals. Expediency and stages of obtaining transgenic animals. Technologies for the use of embryonic stem cells. Gene transgenes with turned-off genes, gene targeting.

53. Prospects for gene therapy. Ways to eliminate hereditary and non-hereditary

diseases during the transformation of patient cells by "healthy" and regulatory genes.

54. The main directions of genetic analysis: the classical approach from phenotype to genotype and molecular genetic methods from genotype to phenotype.

55. Ecological and genetic variability of the population and methods for their analysis.

56. Methods of genetic analysis of animals. Methods and objects of animal behavior genetics.

57. Genetic bioinformatics. Genosystematics

5. References

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The criterion for assessing knowledge in the specialty 8D05104 -Genetics, Ph.D. program

Letter Grade	Grade Point Value	Percentage	Conventional Grade	Competency Scale
A	4,0	95-100	Excellent	This grade is given if the applicant: - owns deep theoretical and practical knowledge in the areas of genetics; - owns the knowledge of modern methods used in genetics; understanding of the essence and

				interconnection of the considered genetic mechanisms and processes; - owns the skills of data processing and analysis, their use in research and calculations; - owns the basics of management, has the skills to analyze the primary experimental data of the study of the structure and functions of genetic objects using basic methods; - presents the correct, logically consistent, complete, and specific answers to all questions of the exam ticket.
A-	3,67	90-94		This grade is given if the applicant: - owns excellent skills in using theoretical and practical knowledge in genetics; - owns the knowledge of modern methods used in genetics; - understands the essence and interconnections of the considered genetic processes; - provides consistent and specific answers to the questions posed with the free removal of comments on individual and particular aspects of the answers.
B+	3,33	85-89	Good	This grade is given if the applicant: - has sufficient knowledge of theoretical and practical knowledge in genetics; - owns the knowledge of modern methods used in genetics; - understands the essence and interconnections of the considered genetic processes; - gives correct, consistent, specific answers to the questions posed with the free removal of comments on an individual, private aspects of the answers.
B	3,0	80-84		This grade is given if the applicant: - Owns simple skills in using theoretical and practical knowledge in genetics; - knows modern methods of genetics; - gives the correct answers to the questions posed.
B-	2,67	75-79		This grade is given if the applicant: - has an incomplete knowledge of theoretical and practical knowledge in genetics and an understanding of the main issues of the program; - non-specific, without significant errors, answers to the questions posed when eliminating inaccuracies and errors in the course of answering clarifying questions of the members of the commission.
C+	2,33	70-74		This grade is given if the applicant: - has an incomplete knowledge of theoretical and practical knowledge in genetics; - lack of understanding of the main issues of the program; -specific, without significant errors, answers to the questions posed when eliminating

				inaccuracies and errors in the course of answering clarifying questions of examiners
C	2,0	65-69	Satisfactory	This grade is given if the applicant: - the wrong answer to at least one of the main questions: - system errors in the answer, misunderstanding of the essence of the problems posed; - uncertain and inaccurate answers to additional questions