

**APPROVED**  
**at a meeting of the**  
**Scientific Council**  
**NJSC «Al-Farabi KazNU».**  
**Minutes No.10 dated**  
**May 13, 2023.**

**The program of the entrance exam for applicants to the PhD**  
**for the group of educational programs**  
**D081 – «Genetics»**

**1. General provisions.**

1. The program was drawn up in accordance with the Order of the Minister of Education and Science of the Republic of Kazakhstan dated October 31, 2018 No. 600 “On Approval of the Model Rules for Admission to Education in Educational Organizations Implementing Educational Programs of Higher and Postgraduate Education” (hereinafter referred to as the Model Rules).

2. The entrance exam for doctoral studies consists of writing an essay, passing a test for readiness for doctoral studies (hereinafter referred to as TRDS), an exam in the profile of a group of educational programs and an interview.

<b>Block</b>	<b>Points</b>
1. Essay	10
2. Test for readiness for doctoral studies	30
3. Exam according to the profile of the group of the educational program	40
4. Interview	20
Total admission score	100/75

3. The duration of the entrance exam is 4 hours, during which the applicant writes an essay, passes a test for readiness for doctoral studies, and answers an electronic examination. The interview is conducted on the basis of the university before the entrance exam.

**2. Procedure for the entrance examination.**

1. Applicants for doctoral studies in the group of educational programs D081 – «Genetics» write a problematic / thematic essay. The volume of the essay is at least 250-300 words.

2. The electronic examination card consists of 3 questions.

## **Topics for exam preparation according to the profile of the group of the educational program.**

### **Discipline "Methodology of systemic genetic research"**

#### **The subject and objectives of modern genetics**

Methodology of modern genetics. Using the laws of classical genetics in systems analysis. Empirical levels and procedures of scientific inquiry. Subjects, objectives, prospects, and methods of different genetics (pharmacogenetics, environmental genetics, radiation genetics, medical genetics, oncogenetics, immunogenetics, etc.). Heredity, inheritance, heritability.

#### **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. The problem of extrapolating to humans the results of testing mutagens obtained using various model objects.

#### **Cytogenetic research methods.**

Basic principles of cytogenetic analysis. Modern cytogenetic methods for testing the mutagenic activity of environmental factors and assessing its quality. Differential chromosome staining methods.

#### **Karyotyping.**

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

#### **Genetic research methods in human genetics.**

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. Molecular diagnostics.

#### **Molecular genetic methods of analysis in genetic research.**

The use of molecular genetic methods to study the mechanisms of genetic processes (gene expression, translation, transcription, DNA repair, methylation, and genomic imprinting, etc.), the action of individual genes, and intergenic interactions. Methods for identifying factors in the development of carcinogenesis. Methods for molecular genetic assessment of oncological diseases. The main stages of DNA isolation and purification. DNA sequencing. Methods for the molecular genetic study of gametogenesis.

#### **The use of genetic methods to solve problems in the food industry, agriculture, medicine.**

Solving the problems of the food industry, agriculture based on genetic methods. Genetic background of modern methods of artificial insemination in humans (IVF). Polymerase chain reaction (PCR) method: principle, steps, reaction components, varieties, and equipment for PCR. Prospects and problems of using stem cells.

#### **General principles and methods of genetic engineering.**

An overview of enzymes used in genetic engineering. Enzymological methods in genetic engineering. Genetic engineering of cultured mammalian cells. Methods of introducing DNA molecules into mammalian cells (hypertonic salt method, DEAE-dextran method, calcium phosphate method, etc.). Site-directed *in vitro* mutagenesis. Gene cloning. Methods for selecting

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

### **General characteristics of vectors.**

DNA based vector systems. The introduction of DNA into cells. Methods for the construction of recombinant DNA molecules. Methods for determining the nucleotide sequence of DNA. Vector systems based on animal and plant cells. Shuttle vectors, selective marker genes, transformation frequency.

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

### **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.

### **Prospects for gene therapy.**

Ways to eliminate hereditary and non-hereditary diseases during the transformation of patient cells by "healthy" and regulatory genes. Bioethical Issues of Gene Therapy

### **Radiation genetics.**

Hereditary disorders in radiation injury. Routes of entry of radionuclides into the body. Radiation genetics methods. Nuclear medicine. "Peaceful" atom. Biodosimetry

### **Mitosis, meiosis and the cell cycle**

Features of the course of mitosis of polyploidy and polyteny. Spermatogenesis and Oogenesis. Mechanisms of chromatin condensation and decondensation at different periods of the cell cycle. Fission spindle formation.

### **Biostatistics in genetics**

Statistical methods for data interpretation in genetic research. Application packages for statistical processing of genetic data

## **Discipline "Genetic analysis"**

### **The main directions of genetic analysis**

The classical approach from phenotype to genotype and molecular genetic methods from genotype to phenotype. Mendel's laws. Chromosomal theory of heredity of the Morgan school.

### **Hybridization.**

Monohybrid crossing. Dihybrid crossing. Unrelated crossing. Hybridological method for studying heredity. Prospects for using crossing systems for obtaining highly productive breeds of farm animals, varieties of cultivated plants, and strains of microorganisms. Chemical and radiation mutagenesis as a method of increasing the diversity of the starting material for hybridization.

### **Modern achievements in the breeding of cereals.**

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

### **The structure and properties of chromosomes.**

Chromosomal rearrangements. Comparative analysis of prokaryotic and eukaryotic chromosomes and their properties. Euchromatin and heterochromatic regions of chromosomes. Chromosomal additions. Interphase cytogenetics methods.

### **The use of mutations in genetic analysis.**

Endogenous and exogenous sources of mutations. Gene, chromosomal and genomic mutations, their classification, and examples of diseases associated with the occurrence of mutations. Mobile elements as a source of mutations. Induced and spontaneous mutagenesis.

### **Methods for localizing genes in chromosomes.**

Identification of localized genes. Linkage analysis and gene mapping. Genetic mapping methods.

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. Genomic analysis of soft wheat.

### **Methods used in genetic analysis of bacteria and bacteriophages**

Clonal analysis. Selective media method. Fingerprint method

### **Genetic bioinformatics. Genosystematics. Genetic collections.**

The relationship between molecular genetics and bioinformatics. Conservation of biodiversity in situ and ex situ. Test forms and line analyzers. Banks of cell cultures. Gene banks. 3D bioprinting. DNA markers in taxonomic research. DNA barcoding methodology

## Discipline "Evolutionary biology"

### **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. The main provisions of the synthetic theory of evolution.

### **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. Ecological and genetic variability of the population and methods of their analysis. DNA markers in population genetic studies.

### **Genetic foundations of evolution.**

Variability: phenotypic, genotypic, paratypic, modification. Modifications. Reaction rate. The concept of the adaptive rate.

### **Elementary factors of evolution.**

Evolutionary factors are causing changes in the genotypic structure of the population. Natural selection and the significance of probability and chance.

### **Biological and evolutionary significance of species.**

The general concept of the species, characteristic of the difficulty in its universal application. The reasons for the increase in the number of species. Speciation. Instant speciation. Gradual and sympatric speciation.

### **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.

### **Evolution of ontogeny.**

The concept of ontogeny. Features of ontogenesis in different organisms and its duration. Ontogenetic differentiation. Duration of ontogenesis. Integrity and stability of ontogeny. Autonomy and embryonization of ontogenesis.

### **Evolution of phylogenetic groups.**

The primary forms of phylogenesis: phyletic evolution, divergence, parallelism, convergence. The main directions of evolution are arogenesis, allogeneses. Forms of allogeneses (telogenesis, hypergenesis, hypogenesis, etc.) Typical change of phases of adaptationogenesis.

### **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. Molecular evolution of genes.

### **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.

## **3. List of references.**

### **Main:**

1. Макрушин Н. М., Плугатарь Ю. В., Макрушина Е. М., Гончарова Ю. К., Гончаров С. В., Шабанов Р. Ю. Генетика: учебник для ВУЗов: 2-е изд. – СПб.: Изд-во «Лань». – 404 с.
2. Инге-Вечтомов, С. Г. Генетика с основами селекции: учебник для студ. высш. учеб. заведений / С. Г. Инге-Вечтомов. - 3-е изд. – Санкт-Петербург : Изд-во Н-Л, 2015. - 718 с.
3. Жимулёв И.Ф. Общая и молекулярная генетика : учебное пособие для вузов — Новосибирск : Сибирское университетское издательство, 2017. — 480 с.
4. Нахаева В.И. Практический курс общей генетики. Учебное пособие 2-е изд., стереотип. - М.: Флинта, 2011. - 210 с
5. Биотехнология: учебник и практикум для вузов / под редакцией Н.В.Загоскиной, Л.В. Назаренко. - 3-е изд., испр. и доп. – М.: Издательство Юрайт, 2021. – 381 с.
6. Бочков Н.П. Клиническая генетика: учеб. / Н. П. Бочков, В. П. Пузырев, С. А. Смирнихина; под. ред. Н.П. Бочкова. - 4-е изд., доп. и перераб. - М.: Изд. группа "ГЭОТАР-Медиа", 2013. - 582 с.
7. Северцов А.С. Теории эволюции: учебник для вузов/ А.С. Северцов. — 2-е изд., испр. и доп. — М.: Издательство Юрайт, 2020. — 384 с.
8. Черенков В. Г. Онкология: учебник / В.Г. Черенков. — 4-е изд., испр. и доп. — М.: ГЭОТАР-Медиа, 2020. — 512 с.
9. Медицинская генетика : учебник / под ред. Н. П. Бочкова. - М.: ГЭОТАР-Медиа, 2014. - 224 с.
10. Генетические основы селекции растений. В 4 т. Т. 4. Биотехнология в селекции растений. Геномика и генетическая инженерия. – Минск: Издательский дом "Белорусская наука", 2014. – 653 с.

11. А.С.Спирин. Молекулярная биология. Рибосомы и биосинтез белка. "Академия", 2011.
12. Моссэ, И.Б. Радиационная генетика: курс лекций / И.Б. Моссэ. – Электронный учебник, 2013 г.
13. Абилов С.К., Глазер В.М. Мутагенез с основами генотоксикологии. – СПб.: Нестор-История, 2015. – 304 с.
14. Молекулярная биология клетки: в 3-х томах / Б. Альбертс, А. Джонсон, Д. Льюис и др. — М.-Ижевск: НИЦ «Регулярная и хаотическая динамика», Институт компьютерных исследований, 2013.
15. Актуальные вопросы радиоэкологии Казахстана: сборник / М-во индустрии и новых технологий. - Павлодар : ТОО "Дом печати", 2015
16. Бекман, И. Н. Ядерная медицина: физические и химические основы : учебник для бакалавриата и магистратуры / И. Н. Бекман. — 2-е изд., испр. и доп. — Москва : Издательство Юрайт, 2019. — 400 с.
17. Биоразнообразие и охрана природы: учебник и практикум для вузов / Е.С.Иванов, А.С. Чердакова, В.А. Марков, Е.А. Лупанов. — 2-е изд., испр. и доп. — М.: Издательство Юрайт, 2019. — 247 с.
18. Цитогенетические методы в генетическом мониторинге: учеб.-метод. пособие / С.Ж. Колумбаева, А.В. Ловинская, А.М. Калимагамбетов; КазНУ им. аль-Фараби. - Алматы : Қазақ ун-ті, 2018. - 161 с.
19. Введение в молекулярную диагностику. В 2 томах / под редакцией Пальцева М., Залетаева Д. – М.: Медицина, 2011.
20. Бияшева З.М., Ловинская А.В., Даулетбаева С.Б., Калимагамбетов А.М. Статистические методы в биологии с программным обеспечением //Учебное пособие для биол. специальностей: Алматы – Казак университет, 2019. – 108 с.
21. Фаллер, Д.М. Молекулярная биология клетки: руководство для врачей / Джеральд М. Фаллер, Деннис Шилдс ; пер. с англ. под общ. ред. акад. И. Б. Збарского .— Москва : Бином-Пресс, 2012 .— 256 с.
22. Бактериофаги. Биология и практическое применение // под ред. Э.Каттер и А. Сулаквелидзе. – М.: «Научный мир», 2012. – 640 с.
23. Ozbolat I.T. 3D Bioprinting: Fundamentals, Principles and Applications. – 2016. – 342 p.
24. Огурцов А.Н. Основы биоинформатики: учебное пособие. – Х.: НТУ «ХПИ», 2013. – 400 с.
25. Ястребов А.П., Гребнев Д.Ю., Маклакова И.Ю. Стволовые клетки, их свойства, источники получения и роль в регенеративной медицине. – Екатеринбург 2016. - 282с.

#### **Additional:**

1. Горбунова В.Н., Имянитов Е.Н. Генетика и Канцерогенез. Методическое пособие. – Санкт-Петербург, 2007. – 24 с.
2. Коряков Д. Е., Жимулев И. Ф. Хромосомы. Структура и функции. — Новосибирск: Изд-во СО РАН, 2009. — 258 с..
3. Льюин Б. Гены. – М.: Бином. Лаборатория знаний. 2012. – 896 с.
4. Пухальский В.А., Соловьев А.А., Бадаева Е.Д. Практикум по цитологии и цитогенетике растений. - М.: КолосС, 2007. - С.62-67.
5. Рыбчин В.Н. Основы генетической инженерии. – Учебное пособие. С- Пб, 2002.- 522 с.
6. Хедрик Ф. Генетика популяций.М.: Техносфера, 2003.
7. Щелкунов С.Н. Генетическая инженерия, СУИ, Новосибирск – 2004.
8. Шмидт Р. Наглядная биотехнология и генетическая инженерия. – М.: Бином.. 2014. – 325 с.
9. Шулембаева К.К. Хромосомная инженерия, 2005 г.

10. Яблоков А.В., Юсуфов А.Г. Эволюционное учение. М.: Высш. шк., 2004.
11. Генетика. Под ред. Иванова В.И. М., 2006. - С. 557-568.
12. Гинтер. Современная генетика. М., 2003. -448 с.
13. Медицинская биология и генетика. Учебное пособие под ред. проф. Куандыкова Е.У. Алматы, 2004.
14. Муминов Т.А., Куандыков Е.У. Основы молекулярной биологии (курс лекций). Алматы, 2007.
15. Мушкамбаров Н.Н., Кузнецов С.Л. Молекулярная биология. М., 2003.
16. Эпигенетика /Отв. ред. С.М.Закиян, В.В.Власов, Е.В.Деменьтьева – Н.: Изд-во СО РАН, 2012. – 592с.