

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
D082 - «Biotechnology»

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.

Block	Points
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 D082 - «Biotechnology» 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 "Modern methods in biotechnology"

Methods used in recombinant DNA technology.

Nucleic acid metabolism enzymes used in genetic engineering. Characterization of restriction enzymes, their classification. Isoschizomers. Restriction maps and restriction fragments. Methods for constructing a recombinant DNA molecule, obtaining a cDNA gene, restriction, ligation and methods for transferring genes into cells of various organisms.

Methods of cloned genes isolation .

Selection of clones of bacteria that have received recombinant plasmids using genes that determine antibiotic resistance (inactivation by insertion). Southern and northern blotting. Screening of gene libraries using oligonucleotide probes. Enzymatic, immunological and enzyme-linked immunosorbent (ELISA) methods for identifying protein products of genes and nucleic acids proper (digoxigenin, triple helix of nucleic acids). Use of the polymerase chain reaction (PCR) method for identification, amplification and isolation of specific DNA regions.

Methods of transformation of plant protoplasts, cells and tissues. Tumor-inducing plasmids induced by some soil bacteria.

Genetic engineering of plants. Crown galls are plant tumors. Tumor-inducing plasmids (Ti-plasmids). Mutants of Ti-plasmids. Integration of T-DNA with the plant chromosome. Ti plasmid DNA as vector. Transformation of plant cells and protoplasts. Mobilization of T-DNA using the vir-segment of the Ti-plasmid. Attached T-DNA vectors enable whole plant regeneration from a single cell. T-DNA insertion can be used to isolate plant genes. Practical application of plant genetic engineering using Ti-plasmids.

Methods of membrane structures studying in biotechnology. Separation of subcellular components. Identification of cellular components and criteria for their purification. Methods used to isolate and study lipids of membrane structures. Separation and analysis of membrane lipid components. Identification of lipid components of membranes. Solubilization and reconstruction of membrane structures. Criteria for the selection of detergents, their characteristics. Methods for the isolation and modification of membrane proteins and peptides. Methods of isolation and identification of fatty acids. Chromatography types used for the quantitative determination of fatty acids. Their advantages and disadvantages.

Physical and biophysical methods used to study membrane systems. Spectral methods for studying stationary properties of biological systems. The method of electronic and paramagnetic resonance, nuclear magnetic resonance. Methods for studying the ionic permeability of biological membranes. Calorimetric methods for the study of proteins. Spectral methods for the study of proteins. Proteomic methods for studying proteins. Methods for the isolation and purification of proteins. Centrifugation, salt fractionation, gel filtration, dialysis. Types of membrane filtration for the isolation of proteins. Ultrafiltration methods, reverse phase chromatography, partition chromatography, gel chromatography. Principles and devices of microscopes.

Discipline "Chromosomal and genetic engineering"

Advantages of the eukaryotic cloning system for genetic research and for studying the regulation of eukaryotic gene expression using the example of yeast cells.

Yeast spheroplasts. Expression of yeast genes in *E. coli* bacteria. Shuttle vectors. Yeast plasmids. Improve transformation efficiency with additional replication origin points (offline replication elements, EAP). Stabilization of yeast plasmids by introducing centromeric (CEN) yeast DNA. The hairpins at the ends of yeast chromosomes are telomeres. Directed insertion of cloned DNA into yeast chromosomes. Organization and regulation of gene expression in yeast. Metabolic engineering.

Discipline "**Physiology of resistance of microorganisms**"

Biotechnology objects. Industrial microorganisms - bacteria, actinomycetes, yeasts, molds, microalgae.

Storage of industrial strains of microorganisms. Methods for long-term preservation and protection against phage damage to industrial strains of microorganisms.

Cultivation of microorganisms. Regularities of their growth and cultivation. Optimization of microorganism cultivation processes.

Features of the metabolism of microorganisms. Features of energy metabolism in prokaryotes. Ways of solving energy problems by chemoorganotrophs and chemolithotrophs. Features of bacterial photosynthesis.

Control of biotechnological and microbiological production. Microbes-pollutants of biotechnological industries and the fight against them. Production and sanitary-microbiological control of production facilities. Microorganisms in medicine, agriculture, food biotechnology

Probiotics production. Properties and selection criteria for strains of probiotic microorganisms. Classification of probiotic drugs. Biotechnology for obtaining probiotics.

Bioenergy. Phototrophic microorganisms. Biomethanogenesis. Getting alcohol. Getting hydrogen. Biofertilizers.

Discipline "**Regulation of the genome**"

Engineering enzymology. Immobilized enzymes. application of immobilized enzymes in biotechnology. Synthetic and functional genomics. Genetic modification of viruses. Function of the protein domain encoded by the R genes. The role of the specific allele of the R-gene. Extrachromosomal factors of heredity.

New antibacterial drugs using genomics and proteomics. Targeted delivery of drugs and therapeutic genes. Metagenomics in the study of pro- and eukaryotic genomes.

Discipline "**Genetic foundations of phytopathology**"

General concepts of phytopathology.

History of the Science of Plant Diseases. Plant disease and pathological process. Classification of plant diseases. Non-infectious and infectious plant diseases.

Types of parasitism in microorganisms.

The main groups of organisms are obligate saprophytes, facultative parasites, facultative self-profits and obligate parasites as a result of the evolution of parasitism. Mechanisms of action on the affected tissues, depending on the type of parasitism. Mechanisms of pathogenicity.

Pathological process.

Pathological process: the period before the penetration of the pathogen; penetration of a pathogen into a plant; the spread of the pathogen in the tissues of the host plant; manifestation of external signs of the disease.

Plant protection mechanisms.

Passive and active defense mechanisms of plants. Passive immunity factors: anatomical and morphological features; the chemical composition of plants; osmotic pressure of cells; phytoncides, etc. Factors of active immunity: hypersensitivity, phytoalexins, phagocytosis, etc.

Parasitic specialization.

Types of pathogen specialization: phylogenetic, histotropic, organotropic, ontogenetic. Pathogens are highly specialized (monophages) and highly specialized (polyphages). The concept of physiological races. Ways of the emergence of physiological races.

Variability of plant pathogens.

Variability of pathogens as the basis for the formation of new pathogenic forms. Mechanisms of variability in fungi, bacteria and viruses.

Genetics of relationships between host plants and their parasites.

The theory of conjugate evolution of the parasite and the host in their common inhabitat. Flora's theory "gene for gene". Types of plant resistance to pathogens. Monogenic and polygenic resistance. Convergent and multi-line grades.

The main directions in breeding for disease resistance.

Screening methods for immunity: assessment of the extent and intensity of the lesion; the role of infectious backgrounds in assessing disease resistance.

Plant immunity to insect pests.

Forms of food relations of phytophages with fodder plants. Plants as a habitat for harmful organisms. The phytophage-plant system and its evolution. Plant immunity factors: rejection or selection of plants by pests; antibiosis; plant resistance to damage. System of immunogenetic barriers: constitutional, induced.

Genetic bases of plant immunity to pests.

Polymorphism. Ecological and genetic structure of phytophage populations. Biological races (biotypes). Principles and methods for identifying plant resistance to phytophages

Genetically Modified Food Sources

Discipline "**Biotechnology of agricultural plants**"

Clonal micropropagation and plant health.

Methods of clonal micropropagation of plants, stages of microclonal reproduction, factors affecting the process of microclonal reproduction, improvement of planting material from viruses.

Overcoming *in vitro* progamous and postgamous incompatibility. Progamous and postgamous incompatibility with distant hybridization. In vitro fertilization. A culture of isolated charges. Endosperm culture.

Haploid technology. Anther culture. Using haploproducers and distant hybridization in obtaining haploid tissues. Obtaining haploid plants in the culture of female haploid. Possibilities of haploid technologies.

Cellular Engineering. Protoplast culture. Isolation and production of viable protoplasts. Cultivation of protoplasts. Plant regeneration in protoplast culture.

Somatic hybridization. The principles of somatic hybridization. Genetic bases of somatic hybridization. Somatic hybridization of distant plant species. Breeding methods for somatic hybrids. Methods for the analysis of hybrid plants. Practical application of somatic hybridization.

Cell selection. Cell selection methods. Selection of resistant cells. Stability of the trait of resistance. Induced mutagenesis. Features of mutagenesis and selection of mutants in vitro. Effect of mutagens on the survival of cells cultured in vitro. Methods for the selection of cell variants.

Somaclonal options. Somaclonal variability. Natural genetic diversity of plant cells. Genome variability during in vitro cultivation. Cytoplasm variability in somaclonal variants. The value of the genotype and the original explant. Influence of cultivation conditions on plant regeneration. Genetic analysis of somaclones. Practical use and prospects for the use of somaclonal variability.

Genetic engineering of plants. Transformation of plants with Ti-plasmid from *Agrobacterium tumefaciens*. Vector systems based on Si-plasmids. Methods for transferring genes into plant cells. The use of reporter genes in the transformation of plant cells. Isolation of various promoters and their use. Introduction of foreign genes into chloroplast DNA. Obtaining transgenic plants that do not contain marker genes.

Application of genetic engineering of plants. Breeding of plants resistant to insects - pests, viruses, herbicides, fungi and bacteria.

Obtaining plants that are resistant to various stress factors and aging. Oxidative stress, salt stress. Fruit ripening. Use of phytopathogen toxins in the selection of disease-resistant plant forms. Isolation of salt tolerant forms of plants by direct and indirect selection in tissue culture. Selection of cold-resistant forms.

Discipline "Biotechnology of the production of biotechnologically active substances"

Classification of products of biotechnological industries. Natural macromolecules - proteins, enzymes, hormones, vitamins, polysaccharides, polyesters, antibiotics, biogenic stimulants, pesticides isolated from the cells of microorganisms, tissues and organs of plants and animals.

Basic principles of obtaining proteins and methods of their purification. The use of microorganisms (yeast, bacteria, algae, fungi) for the production of protein. Protein purification methods. Extract preparation Cell disruption and extraction. Optimization and clarification of the extract. Methods used in the purification of particle-associated proteins and enzymes.

Methods for the isolation of biologically active substances from plant materials. Features of extraction from plant materials with a cellular structure. Extraction stages and their quantitative characteristics. The main factors affecting the completeness and rate of extraction. Requirements for extractants.

The main types of extraction (maceration, percolation, repercolation, accelerated fractional maceration by the counterflow method, circulating extraction, continuous countercurrent extraction with mixing of raw materials and extractant, extraction with liquefied gases). Intensification of extraction processes (extraction using a rotary-pulsating apparatus, using ultrasound, using electrical discharges, using electroporation and electro dialysis).

Industrial production of biologically active substances from plant cell culture. Preparation of the medium for the cultivation of the producer and inoculum. Biosynthesis of biologically active substances. Isolation, purification of biologically active substances and obtaining end products.

Biotechnology of enzymes production. Scope and sources of enzymes. Selection of strain and cultivation conditions. Technology of cultivation of microorganisms - producers of enzymes, isolation and stabilization of enzymes. The use of enzymes of microorganisms.

Amino acid production. Biotechnology for the synthesis of amino acids and their purification. Obtaining amino acids using immobilized cells and enzymes. Obtaining optical isomers of amino acids by using acylases of microorganisms.

Vitamin production. General characteristics of vitamins. Obtaining water-soluble (vitamin B1, B2, B6, Sun, PP, B3, B12, vitamin C) vitamins. Obtaining fat-soluble (ergosterol, vitamin D2) vitamins. Obtaining carotenoids.

Organic acid production. Obtaining organic acids (citric, lactic, acetic, propionic, itaconic, gluconic, fumaric acids) for use in the food and pharmaceutical industries, in technology and as chemical raw materials.

Principles of technical equipment for bio-production. Hardware design for microbiological production. Management of technological processes of biosynthesis of biologically active substances. Waste from biotechnological industries and their neutralization and disposal.

3. List of references.

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