MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Technical University of Ukraine
“Igor Sikorsky Kyiv Polytechnic Institute”

Head of the Admission Commission
Rector
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Faculty of Biotechnology and Biotechnics

PROGRAM
of professional test
for admission to the educational program of master's training "Biotechnologies"
specialty: 162 Biotechnologies and Bioengineering

The program has been approved:
Academic Council of the Faculty of Biotechnology and Biotechnology
Protocol № 8 from 23/03/2024.
Chairman of the
Academic Council Tetiana TODOSIICHUK

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INTRODUCTION

The professional test is conducted with entrants to study under the educational program of master's training "Biotechnologies" in specialty 162 Biotechnologies and bioengineering. The purpose of the program is to acquaint applicants who have a bachelor's degree and want to continue their studies at a master's degree with the conditions and features of conducting a professional test. The task of the program is to provide a list of educational and informational material for the test, which will help the entrant prepare for the competitive selection.

The professional test allows to assess the level of preparation of applicants for master's degree studies and the formation of the ability to integrate the acquired knowledge within the framework of the main professional disciplines of bachelor's training.

The program of the professional examination provides for checking the entrant's acquisition of competencies and learning outcomes determined by the standard of higher education in specialty 162 Biotechnologies and bioengineering for the first (bachelor) level of higher education. Chosen for tasks, questions are presented in the main part of the program. Also, the program provides an example of an exam ticket, which consists of three theoretical questions from various listed earlier disciplines, the answer to which the applicant gives in writing.

The complex professional test is conducted face-to-face or remotely using distance learning technologies and video phone communication services (Zoom, Google Meet, etc.) with a mandatory video recording of the test process.

I THE MAIN PART

1.1 List of topics included in the program

The professional exam program contains topics that are designed to test acquisition the entrant's competencies and learning outcomes defined by the standard of higher education in specialty 162 Biotechnologies and bioengineering for the first (bachelor) level of higher education education/ The professional exam program includes theoretical questions on the following topics: general microbiology, virology, biochemistry, genetics, general biotechnology, processes and devices biotechnological industries.

1.2 Program content

1. Formation and development of microbiology. Morphological period of development of microbiology. Ecological and physiological period of development of microbiology. Louis Pasteur's discovery (participation of microbes in the biochemical transformation of substances; fermentation; anaerobiosis; the problem of spontaneous generation of life; microorganisms are the causative agents of diseases; attenuation of microorganisms). Discovery of Robert Koch. Development of research methods. Contribution of domestic scientists to the development of microbiology (phagocytic theory of immunity; chemosynthesis, accumulation cultures; discovery of viruses, etc.). Development of microbiology in the 20th century.

2. Position of microorganisms in nature. Characteristic features of eukaryotes and prokaryotes. Structural, genetic, functional and chemical differences of prokaryotes and eukaryotes (summary data). Characteristic features of gram-positive and gram-negative bacteria (summary data). Classification of living organisms. Akaryotes, prokaryotes and eukaryotes. General properties of microorganisms (size of an individual and ratio between surface and volume; plasticity of metabolism; distribution of microorganisms).

Morphology of microorganisms. Bacteria (spherical bacteria, or cocci; cylindrical form of bacteria; spiral-shaped bacteria; winding, unusual-shaped bacteria; filamentous forms of bacteria). Microscopic mycelial fungi (vegetative body; growth and reproduction of fungi). Yeast.

3. Chemical composition of a bacterial cell. Cellular water; elemental composition; organic compounds: proteins, nucleic acids, carbohydrates, lipids, pigments.

4. Structure of a microbial cell. Cell walls of microorganisms. Surface structures of the bacterial cell wall (flagella and motility; fimbriae and pili; taxis; capsule and mucous layer). Structure and chemical composition of cell walls of prokaryotes (Gram staining; peptidoglycans; cell wall of gram-positive and gram-negative bacteria; action of lysozyme and penicillin; outer membrane).

Membranes of microbial cells. General ideas about the chemical composition and structure of membranes. Cytoplasmic membrane (membrane proteins; membrane carbohydrates; membrane lipids). Structural and functional features of the membranes of prokaryotes and eukaryotes (membrane formations of gram-negative and gram-positive bacteria). Intracellular structures. Ribosomes. Vacuoles. Carboxysomes. Magnetosomes. Reserve substances (polysaccharides, fatty substances, polyphosphates, sulfur). Nucleoid. Extrachromosomal genetic elements.

Forms of rest in bacteria. Endospores (thermoresistance of spores; characteristics of spore-forming bacteria; identification of endospores; sporulation; properties of mature spores; germination of spores; lifespan of spores). Other forms of dormancy (cysts, exospores, myxospores).

5. Growth and nutrition of microorganisms. Effect on microorganisms of external factors. Physical factors (temperature; humidity and osmotic pressure; hydrostatic pressure; radiant energy; electricity; ultrasound). Chemical factors (concentration of hydrogen ions; oxygen and aeration, redox potential of the environment; chemical compounds). Death and destruction of microorganisms. Sterilization methods (moist heat; dry heat; filtration; irradiation; chemicals). Preservation methods (physical and chemical methods).

Adaptive reactions of microorganisms to stressful actions. Changes in the lipid composition of membranes. Formation of protective compounds (osmoprotectors; pigments; carbohydrates; protective proteins). Anti-radical protection. The role of intercellular chemical communications in the adaptation of microorganisms to stress. Regulatory systems of response to stressful actions.

Nutrition of microorganisms. Major and minor bioelements. Types of nutrition (nutrients as energy sources; nutrients as carbon sources and electron donors). Needs of microorganisms in growth factors. Types of nutrient media for growing microorganisms. Elective methods of cultivation (accumulating and pure cultures). Mechanisms of transport of nutrients into the bacterial cell.

Physiology of growth. Definition of growth (the concept of "growth"). Reproduction of bacteria. Growth of bacteria in a bacterial population. Methods for determining the concentration of bacteria and biomass. Exponential growth and generation duration. Growth of bacteria in batch culture. Growth curve parameters. Growth in continuous culture. Fundamental differences between periodic and continuous crops. Synchronous cultures.

6. Systematics of prokaryotes. Introduction to the taxonomy of bacteria. Principles of classification of bacteria; terminology used in taxonomy (classification; nomenclature; taxon, identification). The species concept in bacteriology. Historical aspects of bacterial taxonomy. Splitting Bergey's 9th edition into a Manual of Systematics and a Manual of Bacterial Identification.

Characterization of higher-ranking taxa (Category) according to the 9th edition of Bergey's Manual of Bacterial Taxonomy.

Modern trends in the taxonomy of bacteria. Disadvantages of phenotypic systematics. Genosystematics of bacteria (GC content in DNA; DNA–DNA and DNA–RNA hybridization; amino acid sequence of proteins; nucleotide sequence of genes: polymerase chain reaction method and 16S rRNA analysis). Phylogenetic systematics - 11 main groups of bacteria; class Proteobacteria; ed. “Prokaryotes”, second edition (10th general edition) of Bergey's Manual of Bacterial Taxonomy.

7. Viruses. Discovery of viruses. Stages of development of virology. Chronology of the discovery of viruses. Forms of existence and general organization of viruses. The structure of viruses. The nature and origin of viruses. Classification of viruses (criteria of virus taxonomy, characteristics of DNA- and RNA-containing viruses). Cultivation and reproduction of viruses (methods of cultivation of viruses, stages and phases of virus reproduction). Mechanisms of interaction between viruses and macroorganism cells. Viruses of bacteria (classification, form and structure of bacteriophages, properties of phages, reproduction of virulent phage: lytic cycle; development of temperate phages: lysogeny, production and practical use of phages in biology and medicine). Forms and types of viral infections in humans and animals. The relationship of viruses and plasmids to the formation of tumors (oncogenesis).

8. General concepts about metabolism. Ways of catabolism of glucose and other carbohydrates. Constructive metabolism. Energy metabolism (macroergic compounds; ATP as a coenzyme for the activation of metabolites; reducing equivalents). The principle of "biochemical unity". The role of enzymes in metabolism. Enzymes of microorganisms.

Fructose-1,6-diphosphate pathway (glycolysis, Embden-Meyerhof-Parnas pathway). Entner-Dudorov path (KDFG-path). Pentose phosphate cycle (phosphogluconate pathway, hexose phosphate shunt). The concept of "key enzymes". Cycle of tricarboxylic acids. Anaplerotic reactions during the growth of microorganisms on carbohydrates (carboxylation of pyruvate and phosphoenolpyruvate).

9. Respiratory chain and phosphorylation (ATP synthesis) during electron transfer. Components of the respiratory chain (flavoproteins, iron-sulfur proteins, quinones and cytochromes). Redox potential. Placement and functions of redox systems in the respiratory chain. R/O ratio and energy balance. Mechanism of ATP synthesis during electron transfer. Mitchell's hypothesis and the transmembrane electrochemical gradient of protons (proton motive force, proton potential). Toxic effect of molecular oxygen on aerobic and anaerobic microorganisms. Electron transport processes in anaerobic bacteria. Respiratory chain inhibitors.

10. Transfer of electrons in anaerobic conditions (anaerobic respiration). Denitrification and reduction of nitrate (denitrifying bacteria). Formation of hydrogen sulfide during sulfate reduction (sulfate-reducing bacteria). Formation of methane during carbonate reduction (methanogenic bacteria). Acetate formation during carbonate reduction (acetogenic bacteria). The formation of succinate during the reduction of fumarate. Reduction of Fe (III) ions to Fe (II).

11. Use of inorganic hydrogen donors: aerobic chemolithotrophic bacteria. Oxidation of ammonia and nitrite. Nitrifying bacteria (bacteria that oxidize ammonia; bacteria that oxidize nitrite; the role of nitrification processes in the soil). Oxidation of reduced sulfur compounds. Bacteria that oxidize sulfur and its compounds. Oxidation of ferrous iron. Reverse transfer of electrons due to ATP energy in aerobic chemolithoautotrophs. Isolation of metals from ores. Oxidation of molecular hydrogen. Hydrogen and carboxybacteria. CO2 fixation (Calvin-Bassam cycle; anaerobic acetyl-CoA pathway; reducing cycle of tricarboxylic acids).

12. Fixation of molecular nitrogen. Nitrogen fixation by symbiotic (bubble) bacteria. Nitrogen fixation by free-living bacteria. Biochemistry of nitrogen fixation.

13. Phototrophic bacteria and photosynthesis. Characteristics and peculiarities of the metabolism of purple and green phototrophic bacteria. Distribution of phototrophic bacteria. Cyanobacteria. Processes of photosynthesis (oxygenic and anoxygenic photosynthesis). Use of light energy by halobacteria.

14. Microorganisms and the environment. Participation of microorganisms in the cycle of substances in nature (cycle of carbon, nitrogen, phosphorus, sulfur).

Microorganisms as symbiotic partners (symbiosis, neutralism, mutualism, commensalism, antagonism). Mutualistic symbiosis (associations between microorganisms; microorganisms and plants; microorganisms and animals). Antagonistic symbiosis.

Microorganisms and geological history of the Earth (iron deposits; calcium carbonate deposits; sulfur deposits). Evolution of microorganisms (primary atmosphere of the Earth; chemical evolution; biological evolution; evolution of prokaryotes; transition from the primary atmosphere to an atmosphere that contains oxygen; evolution of eukaryotes).

15. Introduction to biochemistry. The history of biological chemistry development. Subject, main achievements and tasks of biochemistry. The main differences between living organisms and the processes that take place in them from inanimate matter. Cells: prokaryotes and eukaryotes, biochemical role of organelles.

Chemical composition of living matter: organogens, macro- and microelements; main classes of biomolecules and their functional groups. Stereochemistry of biomolecules.

16. Proteins and Amino acids

Amino acids. The structure of amino acids. Stereoisomerism. Classification of amino acids based on the chemical structure of R-groups and their polarity. Characteristics of amino acids that are part of proteins. Characteristic reactions to amino acids. Acid-base and electrochemical properties of amino acids. Analytical methods for amino acid: chromatography, electrophoresis.

Peptides. Peptides: structure, classification and chemical properties. Biological activity of peptides. Natural peptides.

Proteins. Classification of proteins and their biological functions. Structural organization of protein molecules: primary, secondary, undersecondary, supersecondary, tertiary and quaternary structures. Physicochemical and electrochemical properties of proteins. Methods of isolation and purification of proteins. Identification and quantitative determination of proteins. Amino acid sequence determination methods in protein chains. Protein denaturation.

General characteristics of globular proteins. The relationship between the structure of a protein

molecule and its biological function on the example of myoglobin and hemoglobin. Characteristics of fibrillar proteins. α-, β- keratins, collagen, elastin, etc. Complex proteins: structure and biological properties.

17. Enzymes. Structure and classification of enzymes. Classification and nomenclature of enzymes. Structure of enzyme molecules and their general properties (specificity, catalytic efficiency, lability, ability to regulate). Cofactors and coenzymes. Allosteric enzymes, isoenzymes, enzyme complexes. The structure and functions of individual coenzymes and prosthetic groups.

Kinetics of enzymatic catalysis. Mechanisms of enzymatic catalysis: from the point of chemical reactions energetics, from the point of processes occurring in the active center, molecular mechanisms of enzymatic catalysis. Kinetics of enzymatic reactions: enzyme activity, dependence of an enzymatic reaction speed on physical and chemical factors. Equations of L. Michaelis – M. Menten, G. Lineuiver – D. Burke, Hill.

Enzyme activity and factors determining it. Activation and inhibition of enzymes. Inhibitors: reversible and irreversible. Types of enzyme inhibition: competitive, non-competitive and retroinhibition.

Regulation of cellular enzymatic apparatus. Regulation of enzyme activity: change in the number of enzyme molecules, availability of substrate and coenzyme molecules, allosteric regulation, regulation by protein-protein interaction, regulation by phosphorylation-dephosphorylation, regulation by limited proteolysis. Organ specificity, intracellular localization of enzymes.

18. Vitamins. Vitamins and microelements: their role in the enzymes functioning. Classification of vitamins and general characteristics. Fat-soluble vitamins (groups A, E, K, D, F, ubiquinones): chemical nature, biological role and prevalence in nature.

Water-soluble vitamins (PP, P, C, H and group B): chemical nature, biological role and prevalence in nature. Methods of vitamins determination.

Microelements: Iron, Cuprum, Zinc, Manganese, Cobalt, Selenium, etc. and their role in the functioning of enzymes.

19. Nucleic acids. Structure and properties of nucleic acids. Purine and pyrimidine nitrogen bases. Nucleosides and nucleotides. Oligonucleotides and polynucleotides. DNA: biological function, structure (primary, secondary and tertiary structures), rules of E. Chargaff, physical and chemical properties. Comparative characteristics of viral, prokaryotic and eukaryotic DNA. DNA of mitochondria and chloroplasts. Gene, palindrome and intron.

Types of RNA: structure, properties and biological function.

Nucleic acid metabolism. Catabolism and anabolism of purine and pyrimidine nucleotides. Regulation of nucleotide biosynthesis. DNA biosynthesis: replication enzymes, mechanisms of DNA replication in bacterial and eukaryotic cells, energy balance of the process.

RNA biosynthesis: structure and properties of RNA polymerases, mechanisms of transcription in prokaryotic and eukaryotic cells (binding of the enzyme to the matrix, initiation and elongation, termination and release of the enzyme, maturation of RNA transcripts).

20. Protein metabolism. General pathways of amino acid metabolism. Common pathways of amino acid metabolism: transamination, deamination, decarboxylation. End products of nitrogen metabolism. Urea biosynthesis. Energy balance of the process. Peculiarities of individual amino acids metabolism.

Protein biosynthesis. Activation of amino acids and formation of aminoacyl-tRNA. Structure and functions of ribosomes. Transport and matrix RNAs. Coding problems and characteristic features of the genetic code. Mechanism of translation: initiation of translation, polypeptide chain elongation, termination of translation. Processing. Energy balance of the process. Regulation of protein biosynthesis. Inhibition of protein biosynthesis by antibiotics.

21. Carbohydrates. Structure and properties of carbohydrates. Biological role of carbohydrates. Structure and classification of carbohydrates. Stereoisomerism and tautomerism of monosaccharides. Chemical properties of carbohydrates: reactions of hemiacetal hydroxyl, hydroxyl groups, oxidation and reduction. Individual representatives of mono-, oligo- and polysaccharides.

Metabolism of carbohydrates. Anaerobic conversion of carbohydrates. Alcoholic fermentation. Aerobic transformation of carbohydrates. Cycle of tri- and dicarboxylic acids (Krebs cycle). Apotomic (pentose) cycle of carbohydrate oxidation. Energy balance of processes.

Biosynthesis of carbohydrates. Gluconeogenesis. The formation of carbohydrates in the photosynthesis processes. Regulation of carbohydrate metabolism.

22. Lipids. Structural components of lipids. Lipids (higher fatty acids, wax, neutral lipids (triacylglycerols, cholesterol ethers, glycolipids), phospholipids, sphingolipids): structure, classification, physicochemical properties and biological role.

Lipid metabolism. Catabolism of fatty acids: activation of fatty acids, β-oxidation of fatty acids. Energy balance of fatty acid oxidation. Catabolism of phospholipids

Biosynthesis of saturated and unsaturated fatty acids: mechanisms of acetyl-CoA transfer through the mitochondrial membrane, biosynthesis of fatty acids. Biosynthesis of triacylglycerols. Biosynthesis of phospholipids. Biosynthesis of ketone compounds. Cholesterol biosynthesis. Regulation of lipid metabolism.

Basic principles of biomembrane organization. Composition and structure of biological membranes. Structural components of biomembranes. Phase state of membrane lipids. The role of lipids in the regulation of membrane-bound enzymes activity. Asymmetry of biomembrane components. Functions of biological membranes. Biomembranes role in metabolism and energy conversion.

23. Oxidative phosphorylation. Biological types of energy. Mitochondrial respiratory chain complexes. Transfer of electrons along the mitochondrial respiratory chain. Structure and properties of mitochondrial respiratory chain components. Electron transport chains in prokaryotes (aerobic and anaerobic conditions) and plant mitochondria. Chemiosmotic theory of the combination of oxidation and phosphorylation in mitochondria. Mechanisms of the electrochemical hydrogen ions potential gradient generators in animal mitochondria.

24. Photosynthesis. Basic ideas about photosynthesis. Photosynthesis in eukaryotic photosynthetic cells. Photosystems of chloroplasts. Features of photosynthesis in prokaryotes (cyanobacteria, purple bacteria, green bacteria - anaerobes, halo bacteria). Participation of sodium ions in the process of energy conversion.

25. Regularities of inheritance and principles of heredity.

The subject, methods and history of genetics. The subject and tasks of genetics. The main stages of the development of genetics. Methods of modern genetic research. The value of genetics to solve the problems of biotechnology, breeding, environmental protection and medicine.

Monohybrid and polyhybrid crosses. Patterns of inheritance in monohybrid crossing, discovered by Mendel. Alleles as structural variants of a gene. Types of interaction of allelic genes. Multiple alleles. Mendel′s factorial hypothesis of heredity and the rule of gamete purity law formulated by U. Batson. Homozygosity and heterozygosity. The concept of genotype and phenotype. Statistical causes for deviations from Mendel’s law ratios (chi-square test and standard rejection).

Patterns of inheritance in di- and polyhybrid crossings. The importance of meiosis in the implementation of the rule of gamete purity law and the law of independent inheritance.

Conditions to ensure of Mendel's laws.

Nonallelic genes interaction. Monogenic and polygenic inheritance. Pleiotropic and polymeric genes interaction. Types of nonallelic genes interaction. Modifier genes. Peculiarities of inheritance of quantitative traits.

Concept of genotype as a complex system of allelic and non-allelic interactions. Penetrance and expressivity.

26. Material bases of heredity. The structure and functions of chromosomes. The cell as the basis of heredity and reproduction. Evidence of the role of the nucleus and cytoplasm in heredity. Karyotype. Specificity of morphology and number of chromosomes. Structure of chromosomes. Cell cycle and phases of mitosis. Meiosis and the formation of gametes. The genetic role of mitosis and meiosis. Changes in the organization and morphology of chromosomes during mitosis and meiosis. Polytene chromosomes and "lamp brush" chromosomes type, artificial chromosomes of eukaryotes. Reproduction of organisms. Sexual reproduction. Asexual reproduction. Concept of life cycle. The alternation of haploid and diploid phases and their importance in the life cycle of eukaryotes. Irregular types of sexual reproduction and their role in inheritance and the features of inheritance under these conditions.

Chromosomal determination of sex and inheritance of sex-linked traits. Sex chromosomes, homo- and heterogametic sex, types of chromosomal sex determination. Inheritance of sex-linked traits. Peculiarities of inheritance for the primary and secondary sex chromosome non-disjunction. Dose compensation of X-chromosome genes. Features inheritance sex-limited and sex-influenced traits.

Types, mechanisms and meaning of crossing over. T. Morgan's chromosomal theory of heredity. Crossing over. Types of crossing over. Mitotic crossing over. Genetic maps, principles of their structure in eukaryotes. Interference and coefficient of coincidence. Molecular mechanism of crossing over. Gene conversion. Cytological maps. Comparison characteristics of genetic and cytology maps. Factors affecting the crossing-over. Significance of crossover as one of the mechanisms of occurrence of combinative variability.

Patterns of non-chromosomal inheritance. Maternal effect of cytoplasm. Plastid inheritance. Mitochondrial inheritance. Cytoplasmic male sterility in plants. Infectious factors of extranuclear inheritance. Predetermination of cytoplasm. Interaction of nuclear and extranuclear genes. The importance of studying non-chromosomal inheritance.

27. Variability. Variabilities classification and their characteristics, the relationship between them. Hereditary variability. The concept of hereditary and non-hereditary variability. Modification variability. Combinatorial variability, mechanisms of its occurrence, role in evolution and selection. Mutational variability. The concept of mutation, H. de Vries mutation theory of and its importance in genetics. Classification of mutations. Spontaneous and induced mutation process. Mechanisms of spontaneous mutagenesis, mutator and antimutator genes.

Genome mutations. Genomic changes: polyploidy, haploidy, aneuploidy. Mechanisms of occurrence, features of meiosis, and inheritance in different types of genomic mutations. Autopolyploids, allopolyploids. The use of mono-, poly - and aneuploids in breeding.

Gene and chromosomal mutations. Classification of chromosomal rearrangements and mechanisms of their occurrence. Peculiarities of meiosis with different types of chromosomal rearrangements. Effect of gene position. The influence of different types of rearrangements on the viability of organisms and their significance for the evolution of genomes. Classification of gene mutations. General characteristics of the molecular nature of the occurrence of gene mutations. The mechanism of action of analogues of nitrogenous bases, nitrous acid, acridine dyes, heavy metals and other chemical mutagens.

Genetic processes at the level of organism and population. Population and evolutionary genetics. Concept of frequencies of genes and genotypes in the population. Hardy-Weinberg law, possibilities of its use. Genetic heterogeneity of populations. Factors of the dynamics of the genetic composition of the population. Concept of genetic polymorphism. The value of population genetics for medical genetics, selection, solving the problems of preserving the gene pool and the biosphere.

28. Molecular organization of genetic processes. Nucleic acids as carriers of genetic information. Evidence of the genetic role of nucleic acids. Structure of DNA and RNA. Watson and Crick DNA model. Functions of nucleic acids in the implementation of genetic information. Molecular and supramolecular organization of chromosomes of eukaryotes and prokaryotes.

Molecular organization of genomes. General principles of genetic material organization.

Parameters that characterize the organization of the genome. The viruses genome. Bacterial genomes. Genomes of eukaryotes. Nucleosome and its structure. Peculiarities of prokaryotic and eukaryotic genomes compactization.

Redundancy of eukaryotes genome. Types of nucleotide sequences that are found in the genome of eukaryotes. Tandem repeats of DNA sequences. Palindromes. Telomerase. Satellite DNA. Gene clusters, pseudogenes. Regulatory sequences. Spacers. Intron-exon organization of eukaryotic genes.

Gene structure and functions. Development of ideas about the complex structure of the gene. Functional and recombination criteria of allelism. Multiple allelism.

Gene as a unit of function, mutation, and recombination. Subtle structure of genes and molecular genetic approaches in its research. Genetic block and stepwise metabolism under the genes control.

Extrachromosomal factors of heredity. The size and structure of DNA plasmid. Replication of plasmids and their regulation. Classification of plasmids. The role of plasmids in the evolution of bacteria.

Mobile genetic elements (MGE) of bacteria, their nomenclature, distribution, and structure of MGE. IS-elements. Effect of MGE on gene expression. Transposons of eukaryotes, their structural and functional features. Retrotransposons of eukaryotes. Use of MGE in genetic analysis and construction of eukaryotes. The origin and evolutionary significance of MGE.

Genetic recombination in prokaryotes. Conjugation in bacteria. F-factor in Escherichia coli, its role. Genetic recombination during transformation. Transduction in bacteria. The use of conjugation, transformation, and transduction in strains genetic construction and genetic mapping.

Mechanisms of control and regulation of molecular genetic processes. Genetic control and molecular mechanisms of replication. The General scheme of the replication on

an example of E. coli. Concept of the replicon. Peculiarities of the organization and replication of eukaryotes chromosomes.

Restriction and modification systems in bacteria. Problems of stability of genetic material. Types of repair processes. Mechanisms of excisional and post-replication repair. Photoreactivation and reparative DNA synthesis. The role of repair systems in ensuring genetic processes.

Mechanisms of genetic information expression. Transcription. Promoters and terminators. Transcription. Cycle of DNA-dependent transcription. Processing of primary transcripts. Mechanisms of splicing, alternative splicing, transsplicing. Translation. Molecular organization of ribosomes. Mechanisms of translation.

A variety of molecular mechanisms regulating the activity of genes. The levels of gene regulation activity in prokaryotes. Transcription regulation in prokaryotes. The concept of operon. Comparison of the principles gene regulation in prokaryotes and eukaryotes. Transcriptionally active chromatin. Regulatory role of histones, non-histone proteins, hormones. Peculiarities of the organization of regulatory regions of the genome in eukaryotes.

Post-transcriptional levels of protein synthesis regulation.

29. Genetics as a theoretical basis of selection and biotechnology. Genetic bases of selection. Breeding as a science. Subject and research methods. Genetics as a theoretical basis of selection. The doctrine of source material in breeding. The concept of variety, breed, strain. Peculiarities of selection of microorganisms. Crossbreeding systems in the selection of plants and animals. Selection methods. Genetic markers and their use in breeding. Achievements of world breeding and successes of domestic breeders in creating new highly productive strains of microorganisms, varieties of plants and breeds of animals.

Genetic engineering of microorganisms, plants, and animals. Purpose and methodology of genetic engineering. DNA technologies. Main areas of genetic engineering of microorganisms, plants and animals. The value of genetic engineering to solving the problems of medicine, agriculture and biotechnology. Social and ethical aspects of genetic engineering.

30. The subject and significance of the biotechnology industry. The emergence and main stages of the development of biotechnology. Features and differences of biotechnologies in comparison

with other technological processes (technologies). Basic terminology. Principles of classification and examples of classifications of biotechnological industries**.**

Microbiological industry as a basic component of modern biotechnology. Areas of use of the biosynthetic potential of microorganisms. Fields of application of products of biotechnological industries.

Principles of creation of biotechnology. Modern and new trends in the development of biotechnology and the biotechnological industry.

Main scientific centres and industrial enterprises of the sector.

31. Biological agents of biotechnology. Cells of microorganisms, plants and tissues as industrial producers of biologically active substances (BAS). Specificity of callus tissues. Selection of explants, preparation and cultivation conditions of isolated cells, tissues and organelles. Factors affecting the synthesis and accumulation of metabolites in the culture of isolated cells and tissues.

Dependence of the metabolic activity of microorganisms on the influence of environmental factors: temperature, aeration, pH, composition and concentration of environmental components.

Basic requirements for industrial and industrially promising producers of BAS, selection criteria. Principles and basics of methods of selection of industrial strains.

32. Nutrient medium in biotechnology. Classification of nutrient media used in biotechnology.

Selection of the composition of the nutrient medium, development of technological stages of cultivation depending on the mechanisms of regulation of metabolic pathways and physiological features of the cells of the industrial strain.

Raw material base of biotechnology. Main sources of major and minor elements. Growth factors. Precursors of the synthesis of the target product.

Features of nutrient medium for the cultivation of plant cells and tissues.

Principles of nutrient medium creation, requirements for components.

33. Aseptic in the biotechnological industry. Concepts of "aseptic", "sterility", "contamination". Influence of outside microflora on the efficiency of biosynthesis processes. Methods of maintaining aseptic conditions.

Methods of inactivation of contaminating microflora. Methods of sterilization of equipment, nutrient medium and air. Inactivation of microorganisms and destruction of chemical compounds under the influence of physical and chemical factors.

Kinetics of sterilization. Calculation of efficiency of thermal sterilization of liquids. Humphrey's model of activated spores, Richards' method, Deindorfer's and Humphrey's theory. Periodic method of sterilization. Continuous method of sterilization.

Selection of optimal technological parameters of thermal sterilization.

34. The main types of stages of the biotechnological process. Typical technological solutions in biotechnology. Stages of biotechnological production. Preparatory (pre-fermentation) processes, cultivation of biological agents, selection and standardization of biologically active substances. Generalized scheme of biotechnological productions.

Technological principles of sanitary preparation of production. Preparation, washing and sterilization of equipment and communications.

Preparation of nutrient medium for industrial biosynthesis: storage and dosing of nutrient medium components, methods of sterilization of nutrient media. Control of quality indicators of nutrient medium.

Seed material. Obtaining seed material for surface and deep cultivation. Museum cultures, working batches of BAS producer strains.

Air preparation for the technological process. Calculation of the needs of the BAS producer's culture in dissolved oxygen. Methods of cleaning and sterilizing air for biosynthesis and industrial premises. Typical technological methods of air sterilization. Air filters. Principles of selection of filter

materials for air filters. Evaluation of the efficiency of air cleaning and sterilization. Control of the efficiency of air cleaning and sterilization.

Technological scheme of obtaining sterile air.

35. Cultivation of microorganisms. Surface and deep methods of cultivation. Periodic and continuous processes of biosynthesis. Features, advantages, disadvantages of obtaining BAR.

Fermenters. Classification of fermenters. Principles of selection of typical fermentation equipment.

Features of technologies using native and immobilized cells of microorganisms. Features of equipment for cultivation of microbial cultures.

Foam formation and its regulation in the processes of deep cultivation. Causes of foaming and its effect on the efficiency of biosynthesis. Foam regulation methods: chemical, physical, mechanical and combined. Characteristics of defoamers used in industry.

Periodic cultivation and its graphic interpretation. Deep cultivation in an ideal batch bioreactor. Logistic curve as an example of a one-parameter model of population development. Basic kinetic indicators of periodic cultivation. Kinetics of substrate utilization and metabolite formation in a periodic mode of cultivation. Specific growth rate, economic coefficients, biomass yield, degree of substrate utilization, biosynthesis productivity, physiological value of the substrate. Mathematical modeling of growth processes. Exponential growth model. Kinetic equations of Monod, Verhulst-Pearl-Reed, Andrews, etc.

Kinetics of balanced growth. Basic kinetic indicators and mathematical models of semi-continuous and continuous modes of cultivation. Classification of continuous systems and methods of their management, material balance by biomass and substrate. Self-regulation of continuous systems. Hemostatic, turbidostatic and other control systems for continuous processes of biosynthesis. Cultivation in a system of several ideal bioreactors. Biomass and substrate balance in a battery of continuous chemostats.

Technological implementation of typical methods of continuous cultivation.

36. Cultivation of tissue cells and plant cells. Features of biotechnological processes based on the cultivation of plant and animal cells. Suspension cultures, conditions of their obtaining and cultivation. Cultivation of callus and suspension cultures in order to obtain products of secondary synthesis (alkaloids, glycosides, essential oil, sterols).

Specificity of callus tissues. Selection of explants, preparation and cultivation conditions of isolated cells, tissues and organelles. Factors affecting the synthesis and accumulation of metabolites in the culture of isolated cells and tissues.

Features of equipment for laboratory and industrial cultivation of isolated cells and tissues.

37. Technological processes of separation, purification and drying of biosynthesis products. Principles and typical technological solutions for the separation of target products of biosynthesis. Justification and selection of allocation methods depending on the characteristics of the product and its location.

Methods of biomass concentration: settling, flotation, sedimentation in the field of artificially created gravitational forces.

Methods of separation of solid and liquid phases of culture liquid: filtering, centrifugation, separation. Pretreatment of cell suspensions. Extraction of the target product.

Membrane methods: dialysis, electrodialysis. Baromembrane methods: microfiltration, ultrafiltration, reverse osmosis.

Methods of precipitation of proteins: organic solvents, salts, selective pH- and T-denaturation, at the isoelectric point.

Separation and purification of the product by adsorption methods.

Obtaining the final form of products of microbial synthesis.

Stabilization of the product. Fillers and stabilizers of BAS activity.

Thermostability of biosynthesis products. Methods of drying products. Vacuum drying, spray

and sublimation drying. The choice of method depends on the characteristics of the substance to be dried and the requirements for the finished product.

Ready forms of products of biosynthesis. Packing, packaging, storage.

Control in the production of biosynthesis products. Types of control, control points, product quality.

38. Application of microorganisms in industrial waste treatment processes. Principles of choosing a biological treatment system for liquid industrial waste.

Typical industrial wastewater treatment schemes (aerobic and anaerobic methods of wastewater treatment).

39. Traditional biotechnologies. General characteristics of the technology of protein-vitamin concentrates (PVC). Main producers, features of production and selection of the product.

Features of the technology for obtaining organic acids. Technological principles, types of commodity forms.

Microbiological method of obtaining amino acids. Features of producers and technological regimes.

Microbiological production of enzyme preparations. Methods of cultivating producers. Nomenclature, activity of target products.

Features of the technology of obtaining antibiotics by microbial synthesis.

Dependence of the technological scheme on the purpose of the target product.

40. Processes and equipment of biotechnological industry. Classification of biotechnological processes by technological features, methods of their implementation. General methods of biotechnology and equipment for biosynthesis processes.

41. **Implementation of biosynthesis processes**. Statics of biosynthesis processes. Calculation of material balances of biosynthesis processes. Integral stoichiometric equations of processes.

Mathematical models of biomass growth and synthesis of target products.

Calculation of the volumes of fermentation equipment according to the Malthus, Mono-Yerusalimskyi, Ferhulst models in periodic processes, as well as continuous processes (one- and multi-stage homogeneous cultivation, negative-topping-up method, cultivation with biomass recirculation).

Calculation of the thermal effect of biosynthesis. Calculation of thermal power arising during biomass synthesis (determination of heat emissions arising during biomass synthesis, in statics and dynamics).

42. The thermal effect of mixing the culture liquid and the calculation of the required heat exchange area. Experimental methods of determining thermal power. Calculation method for determining the thermal power transferred to the culture liquid from the stirring device based on its calculation, depending on the oxygen demand. Pneumatic mixing. Calculation of the energy transferred to mixing with the gas phase. Scaling of mixing processes.

Types and calculation of heat exchange devices of fermenters. The procedure for calculating the heat exchange device of the fermenter.

43. Features of oxygen mass transfer during biosynthesis. Scheme of oxygen transport from the air into the cell. The equation of the material balance of the fermenter for oxygen and its solution. The effect of oxygen concentration on the growth rate of microorganisms. Concept of critical concentration of oxygen. Ways of intensification of the oxygen biosorption process. Methods of measuring dissolved oxygen concentration. Volumetric mass transfer coefficient for oxygen during the cultivation of microorganisms, experimental methods of its determination (dynamic, integral, balance, degassing, sulfite). Homogenization time. Micro and macro transfer. The influence of the specific contact surface of phases (gas-liquid, liquid-cell) on the rate of oxygen sorption. Peculiarities of mass transfer during bubble aeration and pneumomechanical mixing. Criteria for scaling fermenters.

44. Pre-fermentation procedures. Typical equipment for the preparation of nutrient media. Typical equipment for transporting and dosing loose materials. Equipment for transportation and dosing of liquid materials.

Sterilization procedures. Theoretical foundations of the death of microorganisms in the process of heat treatment of nutrient medium. Periodic and continuous sterilization.

Engineering implementation of equipment and communication sterilization methods. Selection of the equipment for continue sterilization line and technological calculations of the line. Apparatus for sterilization of nutrient medium used for surface fermentation.

Methods of air sterilization during cultivation of microorganisms. Calculation of the needs of the BAS producer culture in dissolved air. Particle settling mechanisms that provide fine air purification: inertial, diffusion, capture, sedimentation, electrodeposition. Calculation of deposition coefficients for various deposition mechanisms. Types of filter materials for air sterilization, their selection. Calculation of the height of the packed filter for air sterilization depending on the selected sterilization criterion, the filter material and the speed of air movement in the filter. Equipment for sterilization of aeration air.

Cultivation of seed material. Apparatus for growing inoculum.

45. Basic construction schemes of fermentation equipment. Fermentation equipment. Types of fermenters according to the feature of the biosynthesis process. Classification of fermenters by construction, method of energy input and mixing. Ideal mixing and extrusion reactors. Designs of container-type fermenters with electric stirring devices. Fermenters with pneumatic stirring. Other designs of fermenters for deep cultivation of producers. A typical rigging of a fermenter for deep fermentation. Schemes of fermenters for surface fermentation. The problem of creating devices of large unit capacity for aerobic cultivation of microorganisms.

46. Foaming and defoaming, adjusting the foam level. Physico-chemical methods of defoaming. Mechanical methods of defoaming.

47. Concentration and separation of target products of biosynthesis. Separation of biomass from the native solution. Advocacy Normal filtering. Optimization of the filtering process. Typical designs of capacitive filtering devices of cyclic action. Filter presses with manual sediment discharge. Automatic filter presses FPAKM. Drum vacuum filters. Tape vacuum filters. Other designs of filters. Installations for dehydration of biomeal. Sedimentation. Centrifugation, ordinary centrifuges. Separation: tubular separators, plate separators. Flotation

48. Concentration of native solutions. Evaporation: technological calculation of a tubular vacuum evaporator with a rising film, rotary vacuum evaporators, periodic glass evaporators for concentrating target products of microbiological synthesis.

Membrane processes of concentration and separation: microfiltration, ultrafiltration, nanofiltration, reverse osmosis. The concept of selectivity and permeability of membranes. Donnan's theory of equilibrium. Classification of membranes. Existing and prospective designs of devices for baromembrane processes of purification and concentration of products of microbiological synthesis.

Diffusion and electrodiffusion processes of purification of solutions containing enzymes.

49. Sorption methods of extraction of target products. The concept of liquid chromatography. Ion exchange resins and equipment for ion static and dynamic ion exchange. Affinity chromatography for protein extraction.

50. Treatment of native solutions by methods of liquid extraction and precipitation. Apparatus for liquid extraction (capacitive extractors with stirring, "injector-separator" systems, "Luvesta" type extraction machine, Podbilniak differential-contact extractor).

Isolation of target products from native solutions by precipitation.

51. Biomass processing and solid phase extraction. Disintegration of biomass and further processing of disintegrated biomass. Solid-phase extraction: equipment (capacity extractors with a stirring device, percolators, etc.) and technological calculations.

52. Drying of products of microbiological synthesis. Pneumatic, air-fountain dryers and dryers in a fluidized state. Spray dryers, cyclones. Sublimation drying. Vacuum drying cabinets. Roller dryers. Other types of dryers used in the microbiological industry. Technological calculations of drying equipment.

53. Conditioning and packaging of commercial products of microbiological synthesis, auxiliary processes and devices. Special grinding, granulation, mixing of powders. Filling and packing machines. Brief information about air compression machines. Refrigerating machines. Tubular fittings in a sterile design.

II FINAL POSITIONS

2.1 Evaluation criteria of the professional test

At the professional test the entrants perform written examination work according to individual options.

The entrant's total score for the complex professional test is defined as the sum of the points received by the entrant for answering each of the questions on the examination ticket.

The examination ticket consists of 3 questions, the first question is valued at 34 points, the second and third at 33 points.

The maximum number of points for answering a ticket is 100 points.

Points	Percentages	Answer evaluation criteria
31-34 30-33	91-100	a complete answer with explanations, does not contain unnecessary information, knowledge of other topics and academic disciplines is demonstrated
28-30 27-29	81-90	complete answer with unprincipled inaccuracies, does not contain unnecessary information
24-27 23-26	71-80	fundamentally correct answer with unprincipled inaccuracies, there is redundant information
20-23 20-22	60-70	basically a complete answer with inaccuracies

For the purpose of calculating the competitive score of the entrant, the total score received by the entrant for the exam (60...100 points) must be converted to points on the 200-point scale (100...200 points) according to the Correspondence Table:

60...100 points	100...200 points	60...100 points	100...200 points	60...100 points	100...200 points	60...100 points	100...200 points
60	100	70	140	80	160	90	180
61	105	71	142	81	162	91	182
62	110	72	144	82	164	92	184
63	115	73	146	83	166	93	186
64	120	74	148	84	168	94	188
65	125	75	150	85	170	95	190
66	128	76	152	86	172	96	192
67	131	77	154	87	174	97	194
68	134	78	156	88	176	98	196
69	137	79	158	89	178	99	198
						100	200

2.2 An example of a typical task of the professional test

National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Specialty: 162 Biotechnologies and Bioengineering
Complex professional test
for admission to the educational program of master's training "Biotechnologies"

EXAMINATION TICKET № 1

1. Analyze the main mechanisms of the entry of nutrients into a bacterial cell.
2. Justify the principles and necessary calculations of the modes of thermal sterilization of liquid media and their implementation in technological equipment for periodic and continuous sterilization.
3. Analyze the microbiological method of obtaining amino acids. Features of producers, nutrient environments, stages of biosynthesis.

Approve Academic Council of the Faculty of Biotechnology and Biotechnology
Protocol № ___ from _____

Head of the certification subcommittee
under the master's training program
specialty 162 Biotechnologies and Bioengineering _____

2.3 The procedure for conducting a complex professional test

The professional test is conducted face-to-face or remotely using distance learning technologies and video phone communication services (Zoom, Google Meet, etc.) with a mandatory video recording of the exam process.

The professional test is completed by entrants according to the approved schedule.

If the test is conducted remotely, a link to a video conference for conducting a complex professional test is created the day before and sent to all participants (examiners and entrants) through the appropriate information channels - e-mail, Viber, Telegram, etc. networks.

The examination commission is obliged to ensure reliable identification (identification) of the entrant. Otherwise, the entrant is considered not to have appeared for the professional test. Identification of the entrant can be carried out, for example, by showing the examiner via video communication his passport or another identity document.

At the professional test the entrants perform a written test. Individual exam ticket numbers are distributed among entrants through a random number server and announced to the list of entrants via video communication.

The total time allotted for the handwritten tasks of the examination ticket is 150 minutes, without a break. The start time and end time of the test are announced by the examiner. During the entire time of preparation of answers to the questions of the examination ticket, the applicant must have the camera of the device, which is used for video communication with the examiner, constantly turned on.

3 to 5 minutes before the end of the test, the entrant must sign each sheet of his examination paper, make a photocopy of it and send it to the e-mail of the examination board or another method established by the examination board (Viber, Telegram networks) by the set time.

After receiving all the photocopies of the written papers, the examination committee starts checking them. Evaluation of works is carried out in accordance with clause 2.1.

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The Program of complex professional test for admission to the educational program of master's training "Biotechnologies", specialty 162 Biotechnologies and Bioengineering was recommended:
Department of Industrial Biotechnology and Biopharmacy
(protocol №11 from 20/03/24),
Department of Bioenergy, Bioinformatics and Environmental Biotechnology
(protocol № 11 from 27/03/24),
Department of Biotechnics and Engineering
(protocol № 9 from 13/03/24)