**Questions to prepare for the exam:**

1. Biotechnology as a science and a sphere of production. A brief history of the development of biotechnology. The relationship of biotechnology to fundamental disciplines.

2. Recombinant producers of biologically active substances. Transgenic plants and animals.

3. Bioconversion (biotransformation) as a method of obtaining biologically active substances. Enzyme preparations as biocatalysts in the pharmaceutical industry.

4. Definition of the concept of "biomedical technologies". Biotechnology and understanding of the foundations of the pathology of infectious, oncological, hereditary diseases. Bioprosthetics. Reproduction of tissues. Tissue and organ transplantation. In vitro fertilization (IVF) method. Gene therapy.

5. Preparatory stages for use in the production of micro-level biological objects.

6. Classification and properties of enzymes as biological catalysts.

7. Biotechnology and new methods of analysis and control. Biosensors. Biodetectors.

8. Biological objects as a means of production of medicinal, prophylactic and diagnostic products. Donor and donator concept. Classification of biological objects.

9. Protoplasty and fusion of protoplasts of microorganisms as a method of cell engineering. Possibility of interspecies and intergeneric fusion. Fusion of protoplasts and production of new hybrid molecules as target products.

10. Microbial objects of animal origin. A person as an object of immunization and a donor. Mammals, birds, reptiles, fish, insects, active substances.

11. Culture of isolated tissues and cells of plants and animals as a method of cell engineering. Technology of isolation and cultivation of isolated cells and tissues. Features of the process as applied to animal cells.

12. Genetic markers. Methods for the identification and isolation of clones with recombinant DNA.

13. Biological objects of plant origin. Wild-growing, plantation plants, algae. Plant tissue cultures. The main groups of biologically active substances obtained.

14. Mechanisms of intracellular regulation and biosynthesis of target biotechnological products. Induction and repression of enzyme synthesis. Operon concept. Retroinhibition and its mechanism. Allosteric enzymes.

15. Complex and synthetic nutrient media. Components of the nutrient medium and the speed of reproduction of a biological object in a technogenic niche. Monod equation.

16. Bioobjects - microorganisms. Eukaryotes (protozoa, fungi, yeast). Prokaryotes (actinomycetes, eubacteria). Viruses. The main groups of biologically active substances obtained.

17. Methods of selection. Induced mutagenesis and selection. Physical and chemical mutagens, their mechanism of action. Classification of mutations. Problems of the genetic stability of mutants.

18. The use of plant cells for the transformation of medicinal substances. Immobilization of plant cells. Immobilization methods.

19. Bioobjects - macromolecules with fermentation activity. Industrial biocatalysts based on individual enzymes and multienzyme complexes.

20 Methods of cell engineering applied to animal cells. Hybridoma technology. Monoclonal antibodies.

21. Medicines and other target products obtained from plant cell cultures.

22. Problems of stabilization of industrial strains. The reasons for the instability of superproducers and ways to maintain their activity.

23. Genetic engineering and creation of methods for producers of new medicinal substances. Basic principles and stages of recombinant DNA technology.

24. Hierarchical structure of biotechnological production. Subsystems of the type: biological object - bioreactors, biomass - separators, extractors.

25. Classification of microorganisms by the mechanism of nutrition. Ways to maintain the viability of microorganisms during long-term storage.

26. Cultures of plant tissues. The concept of totipotency of plant cells. Callus and suspension cultures. Culture media. Phytohormones. Features of the metabolism of plant cells in vitro. Bioreactors for the cultivation of plant cell cultures.

27. Genomics. Complete genome sequencing. The value of the international project "Human Genome" in the biomedical aspect.

28. Genetic engineering and creation of methods for producers of new medicinal substances. Basic principles and stages of recombinant DNA technology.

*29. Hierarchical structure of biotechnological production. Subsystems of the type: biological object - bioreactors, biomass - separators, extractors.*

*30. Classification of microorganisms by the mechanism of nutrition. Ways to maintain the viability of microorganisms during long-term storage.*

31. The concept of a vector in genetic engineering. Vector molecules based on plasmid and phage DNA: plasmids, cosmids, viruses, bacteriophages. (25b)

32. Preparation and sterilization of culture media. Deindorfer-Humphrey test. Preservation of biological usefulness of media during sterilization. The predecessors of the target product and the time of their introduction into the nutrient medium.

33. Methods of isolation and purification of the target product: precipitation, extraction, adsorption, chromatography, electrophoresis, recrystallization.

34.Stages of seed preparation. Recovery of producers from the condition of anabiosis. Inoculators.

35. Sorption and ion exchange chromatography. Affinity chromatography in relation to the isolation of peptides. Monoclonal antibodies as ligands for affinity chromatography.

36. Classification and properties of enzymes as biological catalysts.

*37. Stages of seed preparation. Recovery of producers from condition of anabiosis. Inoculators.*

*38. Sorption and ion exchange chromatography. Affinity chromatography in relation to the isolation of peptides. Monoclonal antibodies as ligands for affinity chromatography.*

*39. Classification and properties of enzymes as biological catalysts.*

40. Methods of DNA sequencing. Chemical-enzymatic gene synthesis.

41. Sterilization of fermentation equipment. "Weak points" inside the sterilized containers. The problems of pressurization of equipment and communications.

42. Methods for dehydration of the target product. Drying. Types of dryers used in the biotechnological process.

43. Bioreactor as a technogenic niche for the growth of microorganisms in monoculture. Basic bioreactor systems. Selection criteria for bioreactors.

44. Methods for concentrating the target product: evaporation, reverse osmosis, ultrafiltration. Membrane technology. Classification and characterization of membrane separation methods.

45. Engineering enzymology and increasing the efficiency of biological objects in production conditions. Immobilization carriers. Carriers classification. Basic requirements for carriers for immobilization.

46. ​​The biological role of vitamins. Traditional production methods (isolation from natural sources and chemical synthesis). Microbiological synthesis of vitamins and construction of producer strains by methods of genetic engineering.

47. Actinomycetes-producers of antibiotics. Cell structure. Antibiotics produced by bacteria.

48. Carriers for immobilization. Carriers classification. Basic requirements for carriers for immobilization.

*49. The biological role of vitamins. Traditional production methods (isolation from natural sources and chemical synthesis). Microbiological synthesis of vitamins and construction of producer strains by methods of genetic engineering.*

*50. Actinomycetes-producers of antibiotics. Cell structure. Antibiotics produced by bacteria.*

51. Purification and sterilization of process air. Diagram of the preparation of the air flow supplied to the fermenter. Preliminary purification of the gas stream. Coarse purification of the gas stream. Sterilizing filtration. Effectiveness of the filters. Air sterilization problems.

52. Principles of organization of material flows: periodic, semi-periodic, volumetric, continuous. Deep fermentation. Mass transfer. Surface fermentation.

53. Standardization of medicines obtained by biotechnology methods. Packing of medicinal substances.

54. Insoluble carriers of organic nature. Purposes of use, advantages and disadvantages. The main representatives. Microstructure of carriers. (25b)

55. Vitamin B2. Main producers. Scheme of biosynthesis and ways of intensifying the process.

56. Methods for screening antibiotic producers. Possibility of screening for low molecular weight bioregulators when selecting for antibiotic function. Ways to create highly active producers of antibiotics

*57. Insoluble carriers of organic nature. Purposes of use, advantages and disadvantages. The main representatives. Microstructure of carriers.*

*58. Vitamin B2. Main producers. Scheme of biosynthesis and ways of intensifying the process.*

*59. Methods for screening antibiotic producers. Possibility of screening for low molecular weight bioregulators when selecting for antibiotic function. Ways to create highly active producers of antibiotics*

60. Immobilization of biological objects-biocatalysts. Benefits of using immobilized enzymes and whole cells.

61. Microorganisms of prokaryotes-producers of vitamin B12. Schemes and features of biosynthesis using various producers. Methods for determining the content of cyanocobalamin in the target product.

62. Bacterias (eubacterias) – producers of antibiotics. Cell structure. Antibiotics produced by bacteria.

63. Insoluble carriers of inorganic nature. Microstructure of carriers. Purposes of use, advantages and disadvantages. The main carriers.

64. Microbiological synthesis of pantothenic acid, vitamin PP. Combination of biosynthesis and organic synthesis in multistage production of ascorbic acid. Microorganisms-biocatalysts.

65. Modern technologies for screening antibiotic agents. Identification of housekeeping genes and ivi genes in pathogenic microorganisms. IVET method. Targeted screening as a method for finding new targets based on ivi gene products for antimicrobial substances and producing new drugs.

66. Isolation, concentration, purification of biotechnological products. Specific features of the first stages. The generality of the methods of purification of products of biosynthesis, organic synthesis and traditional technologies at the final stages of their production of medicinal substances.

67. Methods of immobilization. Chemical and physical immobilization. Advantages and disadvantages of chemical and physical immobilization.

68. Ergosterol and vitamins of group D. Producers and ergosterol biosynthesis scheme. Media and ways of intensification of biosynthesis. Obtaining vitamin D2 from ergosterol.

69. Immobilization due to the formation of covalent bonds between the enzyme and the carrier. Chemical immobilization variants. Functions of crosslinking agents. Carrier’s pre-activation. Goals and activation mechanisms. Activation with cyanogen bromide. Bifunctional connections.

70. Preprocesing of the culture suspension for a more complete phase separation. Acid coagulation. Thermal coagulation. Adding electrolytes.

71. Carotenoids and their classification. Scheme of biosynthesis. Media for producing microorganisms and regulation of biosynthesis. Stimulants of carotene-formation-beta-carotene. Formation from beta-carotene-vitamin A

72. Influence of enzyme immobilization on their substrate spectrum and kinetic characteristics. Michaelis-Menten equation.

73. Antibiotics as biotechnological products. Definition. General features of antibiotics. The biological role of antibiotics as secondary metabolites. The origin of antibiotics and the evolution of their functions.

74. Probiotics in the fight against dysbiosis. Probiotic classifications. Medicines and dietary supplements of probiotics. Eubiotics.

75. Extrachromosomal genetic elements - plasmids and their functions in microorganisms used in biotechnological processes. The main physical and chemical characteristics of plasmids. Interaction of plasmids with the host genome.

76. Methods for separating biomass and culture liquid: flotation, centrifugation, filtration, sedimentation of biomass. Sedimentation rate equation. Coagulants. Flocculants. Peculiarities of isolation of cells of higher plants and microorganisms from the culture suspension.

77. Microecology of a macroorganism. Types of relationships between a macroorganism and microorganisms. Resident and transient microflora of the gastrointestinal tract. Dysbiosis problem. Dysbacteriosis is a syndrome that accompanies most diseases.

78. Requirements for the fermentation process depending on the physiological significance of the target products for the producer - primary metabolites, secondary metabolites, high molecular weight substances. Biomass as a target product. Requirements for the fermentation process when using recombinant strains that form target products foreign to the biological object.

79. Methods of physical immobilization. Absorption of enzymes on inert carriers and ion exchangers. The main variants of the method. Reasons for partial restrictions on the use of this immobilization method.

80. Transient microflora drugs. Producers. Enterol. Flonivin. Bactisubtil.

81. Features of GMP requirements for biotechnological production. GMP rules for the production of beta-lactam antibiotics. Reasons for validation when replacing producer strains and changing the composition of fermentation media.

82. Methods for the isolation of intracellular products. Destruction of the cell wall (cell disintegration) of biological objects and extraction of target products from biomass. Auger extractor.

83. Bioreactors for processes using immobilized biocatalysts.

84. Immobilization of enzymes by inclusion in the structure of the gel as a method of physical immobilization. Organic and inorganic gels. Methods of incorporation into alginate and polyacrylamide gel.

85. Molds are producers of antibiotics. Features of the structure of the cell and cycle of the development. Antibiotics and other compounds produced by molds.

86. Rules for the transportation and storage of immunobiological preparations. ‘Cold chain’ concept.

87. Immobilized cells in the biotransformation of steroids. Traditional sources of steroid structures. Advantages of the biotransformation of the steroids before chemical transformation. Examples of steroid bioconversion.

88. Biosynthesis of antibiotics. The reasons for the late accumulation of antibiotics in the fermentation medium compared to the accumulation of biomass. The role of phenylacetic acid in the biosynthesis of penicillins.

89. Modern classification of immunotropic drugs. Immunomodulators. Immunosuppressants.

90. Insulin, sources of production. Recombinant human insulin. Species specificity. Immunogenic impurities.

92. Modern principles of vaccine construction. Vaccines based on recombinant protective antigens or alive hybrid carriers, genetically engineered vaccines, ribosomal vaccines, DNA vaccines, etc.

93. Methods of analysis based on the use of monoclonal (polyclonal) antibodies.

94. Human growth hormone. The process of construction of somatotropin producers. Microbiological synthesis of growth hormone. Somatotoropin drugs.

95. Monoclonal antibodies in medical diagnostics. Early diagnosis of oncological diseases.

96. Immunobiotechnology as one of the sections of biotechnology. Immunoprophylaxis and immunotherapy.

97. Interferons. Classification. Interferons for viral and oncological diseases. Species specificity. Synthesis of various classes of human interferon in genetically engineered cells of microorganisms. Problems of the expression of beta and gamma interferons and ways of their solutions. Interferon drugs.

98. Mechanisms of bacterial resistance to antibiotics. Chromosomal and plasmid resistance. Factors contributing to the spread of resistant strains of microorganisms.

99. Normoflora. Bifidobacteria, lactic acid bacteria; non-pathogenic strains of Escherichia coli, which form bacteriocins as the basis of normal flora. The mechanism of antagonistic action on putrefactive bacteria. Biotechnological production of biomass and medicinal products containing microorganisms of normal microflora

100. Enzymes: directions and problems of production and use. Biotechnological production of enzyme drugs. Proteolytic enzymes. Amylolytic, lipolytic enzymes. Asparaginase. Standardization.

101. Semi-synthetic antibiotics. Purposes of the development. Combination of biosynthesis and organic synthesis in the production of semi-synthetic antibiotics.

102. Methods for obtaining amino acids. Medicines containing amino acids.

103. Nutrient media. Features of nutrient media for growing microorganisms. Characteristics of the main components.

104. Microbiological synthesis of amino acids. Amino acid producers. General principles for the design of amino acid producers. Auxotrophic mutants.

105. Vaccines, components of which vaccines consist of. Substantiate the need for each component.

106. Methods for sterilization of culture media. Periodic and uninterrupted sterilization. Sterilization of thermolabile components.

107. Genetic engineering. Introduction of a gene into a vector. Vector concept in genetic engineering. Vector molecules based on plasmids and phage DNA.

108. Production of the penicillin. Extraction and purification of penicillin.

109. Typical scheme for converting raw material into a biotechnological product.

110. Problems of the expression of foreign genes in the cells of microorganisms. Introns and exons.

111. Conditions of cultivation of the producer of glutamic acid, providing over-synthesis of the target product.

112. Extraction of a biotechnological product from a solid phase (biomass).

113. Genetic engineering. The essence of technology. The main stages of creating bioobjects containing recombinant DNA.

114. Periodic fermentation of a benzylpenicillin producer. The essence of the process. Realisation of targeted synthesis of benzylpenicillin. Features of adding a predecessor – phenylacetic acid.

115. Fermentation is the main stage of any biotechnological production. Deep and surface fermentation.

116. Genetic engineering. Enzymatic gene synthesis based on isolated matrix RNA.

117. Problems of resistance of microorganisms to antibiotics. The need to search for and produce new antibiotics. Semi-synthetic antibiotics.

118. Nutrient media for obtaining biotechnological products. Main requirements for culture media.

119. Callus culture. Composition of nutrient media and conditions for growing a culture of plant tissue in the form of callus.

120.Biosynthesis of glutamic acid. Regulation mechanisms. Disturbances in the regulatory mechanisms of the producer of glutamic acid.

121. Preparation of the inoculum of the biological object. Pure culture of the microorganism. Inoculators.

122. Genetic engineering. Transfer of genes into the cells of the recipient organism. Microorganisms used as recipients for genetically engineered modifications. Disadvantages of E. coli as a recipient. Competent cells.

123. Obtaining vitamin B12 by microbiological synthesis. Producers. Biogenesis of structural units and assembly of the vitamin B12 molecule.

124. Providing the fermentation process with sterile air. Sterile air preparation.

125. The two-phase nature of the development of antibiotic producers. Characteristics of the tropo- and idiophase.

126. Technological parameters ensuring the maximum synthesis of a biotechnological product.

127. Mutations are spontaneous and induced. Mutagenic factors, their mechanism of action.

128.Biogenesis of the penicillin molecule. Connection of the synthesis of structural units of the molecule with carbohydrate metabolism of the cell.

129. The main stages of development of biotechnology.

130. Fermenter - apparatus for cultivating a biological object, its design features.

131. Genetic engineering. Chemical-enzymatic gene synthesis.

132. Nutrient media. Features of nutrient media for the cultivation of plant cells and animal cells. Characteristics of the main components.

133. Cultivation of the producer of vitamin B12. Conditions necessary for the synthesis of true vitamin B12. The role of 5,6-dimethyl-benzimidazolyl and aeration.

134. Methods for obtaining amino acids. Advantages and disadvantages of each method.

135. Extraction of a biotechnological product from a liquid phase (from a native solution).

136. Anatoxins, definition. Methods for neutralization of toxins. Biosynthesis of lysine via diaminopimelic acid. Regulation mechanisms. Disturbances of regulatory mechanisms of the lysine producer.

137. Features of the stage of fermentation when growing microorganisms, plant and animal cells.

138. Genetic engineering. Isolation of genes from DNA. Enzymes used to break down DNA, their specificity. Disadvantages of the method.

 139. Production of enzyme preparations by deep cultivation of producers. Obtaining technical and purified enzyme drugs.

140. Composition of nutrient media for surface cultivation. Preparation and sterilization of culture media.

141. Insulin. Sources of obtaining. Specificity of porcine, bovine and human insulin. Problems of using insulin of animal origin in medicine.

142. A basic scheme for obtaining inactivated vaccines. Methods of inactivation of the pathogen for obtaining vaccines.

143. The main stages of development of biotechnology. Characteristics of the era of controlled biosynthesis.

144. Development of the method of culture of cells, tissues and organs of plants. Features of cultivation.

145. Obtaining of hybridomas that synthesize monoclonal antibodies. Ribosomal vaccines. Isolation and purification of ribosomes. Benefits of ribosomal vaccines.

146. Construction of human interferon-producing strains

147.Bioobjects as a means of producing various biologically active substances. Bioobjects-immobilized enzymes.

148. The main stages of development of biotechnology. Characterization of the era of antibiotics.

149. Large-scale production of monoclonal antibodies.

150. Obtaining molecular antigens biosynthetically. The main stages of the process, their purposes and objectives.

151. Obtaining monoclonal antibodies. Cloning of hybridoma cells.

152. Bioobjects as a means of production of medicinal, prophylactic and diagnostic agents. Bioobject-plant cell cultures.

153. Interferons, their characteristics. Getting interferon gamma

154. Bioobjects as a means of production of medicinal, prophylactic, diagnostic means. Bioobjects - animal organs, immunocompetent cells, cultured animal cells.

155. Use of immobilized enzymes in the production of biologically active substances.

156. Subunit viral vaccines. Technological scheme of obtaining.

157. Subject and tasks of biotechnology, its connection with biological, chemical and pharmaceutical sciences.

158. Production of enzyme preparations by surface cultivation of producers. Obtaining technical and purified preparations.

159.Biotechnological process. Characteristics of the stages of the biotechnological process.

160. Ways of solving problems of ecology and environmental protection by methods of biotechnology.

161. Identification of recipient cells containing recombinant DNA. Genetic marker.

162. Producers of antibiotics, distribution and methods of detection. Screening for antibiotics.

163. Bioobjects as a means of production of medicinal, prophylactic and diagnostic agents. Bioobject microbial cell.

164. Anatoxins. Definition. Methods for neutralizing toxins.

165. Definition of the term biotechnology. Varieties of biotechnology, characteristics. The main biologically active substances obtained using various types of biotechnology.

166. Genetic engineering. Transfer of genes into the cells of the recipient organism. Microorganisms used as recipients for genetically engineered modifications. Disadvantages of E. coli as a recipient. Competent cells.

167. Culture media. Classification. Features of nutrient media for growing, depending on the object. Characteristics of the main components.

168. Periodic fermentation of the producer of benzylpenicillin. The essence of the process. Justification of the need for the simultaneous presence of lactose and glucose in the medium

169. Methods for producing amino acids. Advantages and disadvantages of each method.

170. Types of cultivation. Characteristics.

171. Molecular vaccines. Methods for obtaining molecular antigens. Advantages and disadvantages of molecular vaccines compared to live ones.

172. Processing and utilization of industrial waste using biotechnology methods.

**ALGORITHM FOR CARRYING OUT AND PASSING EXAM FOR THE DISCIPLINE "BIOTECHNOLOGY", specialty "Pharmacy"**

The exam in the discipline "Biotechnology" is conducted in writing.

For writing written responses, 3 astronomical hours of time are provided. The answers should be detailed within the designated questions.

After the allotted time, work is handed over to the teacher.

The structure of the ticket includes 4 questions, of which 3 are theoretical and 1 question in the form of a situational task. Each question is estimated at 25 points with the full presentation of the answers to the questions posed, which is equivalent to 100%.

<17 points - unsatisfactory (less than 70%)

18-19 points - satisfactory (70%)

20-22 points - good (80%)

23-25 ​​points - excellent (90-100%)

**Sample ticket**

Kazan State Medical University of the MINISTRY OF HEALTH OF THE RUSSIAN FEDERATION

Institute of Pharmacy

Specialty 33.05.01 Pharmacy

Biotechnology

**Examination ticket number 1**

1. Biotechnology as a science and a sphere of production. A brief history of the development of biotechnology. The relationship of biotechnology to fundamental disciplines. (25p.)

2. Recombinant producers of biologically active substances. Transgenic plants and animals. (25p.)

3. Bioconversion (biotransformation) as a method of obtaining biologically active substances. Enzyme preparations as biocatalysts in the pharmaceutical industry. (25p.)

4. Name the equipment, purpose, principle of operation (25p.)

**Response (answer) algorithm**

**1. Biotechnology as a science and a sphere of production. A brief history of the development of biotechnology. The relationship of biotechnology to fundamental disciplines. (25p.)**

Biotechnology is a discipline that studies the possibilities of using living organisms, their systems or products of their vital activity to solve technological problems, as well as the possibility of creating living organisms with the necessary properties by methods of genetic and cellular engineering.

Sciences with which biotechnology is closely related: genetics, molecular biology, chemistry, biochemistry, microbiology, embryology, cell biology, physiology, virology, etc.

Currently, biotechnology is an interdisciplinary science and it is subdivided into:

- green biotechnology - plants;

- blue biotechnology - marine and freshwater microorganisms;

- red biotechnology - humans and animals;

- gray biotechnology - microorganisms;

- white biotechnology - industrial use of enzymes.

The main scientific discoveries that ensure the development of biotechnology:

1. proof of the role of nucleic acids in the storage and transmission of hereditary information;

2. decoding of the genetic code universal for all living organisms;

3. improvement of existing and development of new technologies for the cultivation of microorganisms, plant and animal cells;

4.discovery of various classes of enzymes;

5. development of DNA technologies.

Components of biotechnology: It can be conventionally assumed that biotechnology includes two parts:

1. molecular biotechnology, including cellular and genetic engineering, designed to create new highly productive forms of organisms suitable for use in industrial conditions and to develop effective methods for the cultivation of microorganisms, fungi, cells and tissues of plants and animals;

2. industrial biotechnology is the use of biotechnology in various sectors of the economy.

Historical periods of biotechnology development:

The pre-Pasteur period (up to 1865) - the use of alcoholic and lactic acid fermentation for the production of beer and wine, the production of bread and cheese.

Post-Pasteur period (1866-1940) - production of ethanol, butanol, acetone, glycerol, organic acids, vaccines, feed yeast. Aerobic sewage treatment.

Antibiotic period (1941-1960) - production of penicillin and other antibiotics by deep fermentation, cultivation of plant cells, obtaining viral vaccines.

The period of controlled synthesis (1961-1975) - the production of amino acids using microbial mutants, the production of pure enzymes, the use of immobilized enzymes and cells, anaerobic wastewater treatment, the production of bacterial polysaccharides.

The period of new biotechnology (after 1975) - the use of genetic and cellular engineering in order to obtain biosynthetic agents, obtaining monoclonal antibodies.

**2. Recombinant producers of biologically active substances. Transgenic plants and animals. (25p.)**

Genetic engineering concept:

Technology for *in vitro* joining of DNA fragments with subsequent introduction of recombinant (new) structures into a living cell. This method is used to obtain overproducers of recombinant compounds in the biotechnology of drugs, create transgenic plants and transgenic animals, and also develop methods of gene therapy for hereditary diseases.

Recombinant DNA technology stages:

1. Obtaining a cloned gene: native DNA (cloned DNA, embedded DNA, target DNA, foreign DNA) is extracted from the donor organism of the desired genes and subjected to enzymatic hydrolysis (cleaved, cut);

2. Introduction of the cloned vector into the vector: the cloned DNA is combined (ligated, stitched) with another DNA (cloning vector) to form a recombinant (chimeric) DNA;

3. Transfer of the recombinant DNA into the recipient cell: the recombinant DNA is introduced into competent prokaryotic or eukaryotic cells (host cell or recipient cell), where it is replicated and transmitted to offspring;

4. Identification of recipient cells containing recombinant DNA. Using methods, clones of cells carrying recombinant DNA (transformed cells) are identified and selected;

5. Obtaining the cloned protein: a specific protein product synthesized by the transformed cells is obtained, which serves as confirmation of the cloning of the desired gene.

Transgenic plants and transgenic animals are organisms, which genome contains foreign genetic material that has been passed down over generations.

Signs of transgenic plants: resistance to adverse environmental conditions, the ability to synthesize insecticides, resistance to viral infections, changes in fruit ripening conditions, changes in flower color, altered fruit taste, increased nutritional value of seeds, the ability to synthesize antibodies.

Transgenesis in animals is based on the introduction of a cloned gene into the nucleus of a fertilized ovum with subsequent implantation into a recipient female. Genetic modifications of animals make it possible to obtain model systems for studying the mechanism of cancer, cystic fibrosis, Alzheimer's disease and other hereditary human diseases.

**3. Bioconversion (biotransformation) as a method of obtaining biologically active substances. Enzyme preparations as biocatalysts in the pharmaceutical industry. (25p.)**

Biotransformation is the process of converting substances with the help of microorganisms into certain products with valuable practical properties.

The method uses enzymes localized in the cell and capable of changing the functional groups of chemical compounds added from outside.

An example is the use of a method for converting digitoxin to digoxin by Digitalis lanata cells. When extracting from the mass of plantation-grown plants, digitoxinis mainly released. Undifferentiated cultures of Digitalis lanata cells, due to a change in the nature of nutrition from photoautotrophic to chemoheterotrophic, do not form cardiac glycosides, but they can carry out certain reactions of biotransformation of substrates added to the nutrient medium. Biotransformation of digitoxin into digoxin occurs as a result of a 12-hydroxylation reaction catalyzed by the enzyme Digitalis lanata cells.

In the reactions of biotransformation and biocatalysis, the biological object is enzymes and multienzyme complexes isolated from the composition of biological systems or located inside cells that are artificially deprived of the ability to grow.

Properties of enzymes as catalysts of biological origin:

* High activity
* Specificity (selectivity) of action
* Adjustable activity depending on environmental conditions
* Catalysis of reactions under "mild" conditions
* Dependence of the reaction rate on the amount of enzyme

**4. Name the equipment, purpose, principle of operation (25p.)**



The diagram shows an installation for continuous sterilization of the culture medium, consisting of 1 - receiver of the culture medium concentrate, 2 -filter for separating lumps of the medium, 3 - pump, 4 - steam injector, 5 - tubular holding, rolled in the form of a flat spiral, 6 - heat exchanger.

In industrial conditions, culture media are usually prepared in separate manufactures of an enterprise in containers equipped with mechanical stirrers, adding components in a certain sequence. If necessary, individual components are subjected to additional processing: grinding, sieving, boiling, extraction. The medium is heated to a temperature of 70-80 °C with live steam. For reliable sterilization, solid particles of insoluble components must be small enough, since large particles slowly warm up and the likelihood of retaining foreign microflora in them increases, especially during continuous sterilization. The prepared culture medium is sterilized in continuous sterilization installations. The cycle of intermittent sterilization consists of three stages: heating, holding at a temperature of 121 ° C, cooling.

Continuous operation uses a direct ultrapure steam injection system, indirect heat exchanger systems and both systems operate at a pressure above atmospheric.