

# **CONTENT OF THE END-OF-COURSE EXAMINATION FOR THE STUDENTS STUDYING GENERAL MEDICINE**

1. The nature of life, the role of proteins and nucleic acids in the organization of living systems.
2. Organization levels of living matter.
3. Human as a biological and social being. The role of biology in medical education.
4. Organization of hereditary material in viruses, prokaryotes and eukaryotes. Organization levels of genetic material in eukaryotes (gene, chromosome and genome levels).
5. Gene organization level of hereditary material.
6. The main functions of gene. Properties of genes.
7. Structure of deoxyribonucleic acid (DNA).
8. Watson and Crick postulates.
9. Evidence for the role of DNA in the transmission of hereditary information (transformation and transduction). Ribonucleic acid (RNA) and its types.
10. Chromosome organization level of hereditary material.
11. DNA condensation in eukaryotes. Chromatin remodeling. Euchromatin and heterochromatin.
12. Genome organization level of hereditary material. Nuclear genes and cytoplasmic genes. Cytoplasmic inheritance.
13. The nature of genetic information.
14. Genetic code and its properties.
15. Housekeeping and tissue-specific genes.
16. Human genome: protein-coding genes, RNA genes, non-coding sequences (repeats, introns, junk DNA).
17. DNA transposons and retrotransposons.
18. Lac and trp operons. Polycistronic RNA.
19. Regulation of transcription in eukaryotes: preinitiation complex. Enhancers, silencers.
20. Epigenetic mechanisms of controlling gene expression: histone modifications, cytosine methylation, CpG-islands, regulatory systems of non-coding RNA.
21. International human genome research projects: Human genome, ENCODE, Roadmap.
22. Analysis of genetic material.
23. Methods of DNA analysis: gel electrophoresis, restriction analysis, hybridization of nucleic acids, DNA microarrays.
24. Polymerase chain reaction (PCR), reaction components, stages of the method.

25. PCR variants: qPCR, RT-PCR (reverse transcription), nested PCR, multiplex PCR, methylation-sensitive PCR.
26. DNA sequencing: Sanger sequencing, next generation sequencing (NGS): pyrosequencing, nanopore sequencing, bisulfite sequencing.
27. The concept of bioinformatics. Phylogenetic analysis. Genome editing tools: CRISPR/Cas 9, TALEN.
28. Perspectives for medicine and bioethical problems of genomic editing. Internet databases and online services containing information about nucleotide sequences (Blast, NCBI).
29. Personalized medicine.
30. Pharmacogenetics. Gene therapy.
31. Molecular genetic markers for tumors. Cancer genetic diagnostics.
32. Aims, objectives and stages of genetic engineering. Methods allowing to obtain genes for transgenesis.
33. Recombinant DNA.
34. Construction of vectors, their types: plasmids, cosmids, viral and phage vectors, phasmids, shuttle vectors.
35. Introduction of recombinant DNA into a recipient cell.
36. Selection of transformed cells. Selective and reporter genes.
37. Medical applications of genetic engineering: production of protein products, monoclonal and polyclonal antibodies, recombinant antigens.
38. DNA probes. Biotechnology and its significance in medicine.
39. Genetically modified organisms (GMO). Food products containing GMOs.
40. Cytology.
41. Methods of cytology (light microscopy, fluorescence microscopy, electron microscopy and histochemistry and immunohistochemistry).
42. Differential centrifugation, autoradiography, morphometry.
43. The method of light microscopy. The structure of light microscope. The instructions for working with a microscope.
44. Cell as the least structural and functional unit of life. General characteristics of viruses prokaryotes and eukaryotes.
45. Models of plasma membrane.
46. The structure, properties and functions of plasma membrane. Transport across the membrane.
47. Passive transport (simple diffusion, facilitated diffusion, osmosis), active transport (ion channels, their functions), endocytosis, exocytosis.
48. Cytosol. Cytoskeleton: microtubules, intermediate filaments, microfilaments.
49. Vesicular transport. Nuclear localization signal.
50. Assimilation and dissimilation. Ribosomes.
51. Endomembrane system (nucleus, endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes, endosomes, vesicles).
52. Photosynthesis and chemosynthesis, fermentation and respiration. Stages of catabolism, mitochondria, enzymes of mitochondria.

53. Disorders caused by impairments of cellular activities (mitochondrial diseases, lysosomal storage diseases, peroxisomal disorders and prion diseases).
54. The structure and functions of nucleus.
55. Types of chromosomes.
56. Rules of chromosomes.
57. Karyotype and idiogram. Nomenclatures of human chromosomes.
58. The Central Dogma of Molecular Biology.
59. Semi-conservative mechanism of DNA replication. Replicon.
60. Transcription. Transcription factors.
61. Eukaryotic mRNA synthesis: primary transcript, pro-mRNA processing, splicing.
62. Alternative splicing. Transcriptome. Reverse transcription.
63. Aminoacyl-tRNA synthetases. Translation: initiation, elongation and termination. Proteome. Metabolome.
64. Posttranslational modifications of proteins. Protein folding. Chaperones. Utilization of proteins in cell. Proteasomes. Ubiquitin.
65. Types of cell division. Cell cycle regulators (cyclins and cyclin-dependent kinases). Cell proliferation and cell death. Necrosis and apoptosis. Caspases.
66. Genetics. The subject, methods and tasks of Genetics. Hybridological analysis.
67. Monohybrid crossing. Hypothesis of Purity of Gametes. Test cross. Backcrossing.
68. Polyhybrid cross. Limitations of Mendel's laws. Pleiotropy.
69. Intra-allelic interaction (complete and incomplete dominance, super-dominance, codominance and allelic exclusion).
70. Multiple alleles. Inheritance of blood groups (ABO, MN, Rh).
71. Inter-allelic interaction (complementary gene action, inhibitory gene action, polymeric gene interaction and position effect).
72. Bombay blood group.
73. T. Morgan's experiments.
74. Genetic linkage.
75. Complete and partial linkage. Crossing-over and genetic recombination. Linkage groups. Chromosomal Theory of inheritance. Genetic and cytological chromosome maps.
76. Variability. Types of variability. Phenotypic plasticity. Morphosis. Phenocopies. Medical aspects of phenotypic plasticity.
77. Genotypic variability.
78. Combinative variability and its mechanisms. Genetic variation caused by mutations.
79. Causes of mutations: Replication errors, unequal crossing over, mutagens. Mechanisms of mutagenesis. Genocopies. Physical, chemical and biological mutagens.
80. Supermutagens.
81. Genetic hazards of environmental pollution with mutagens.

82. Classification of mutations.
83. Genome stability and DNA repair.
84. Types of DNA repair: excision repair, double-strand break repair, direct reversal repair.
85. Antimutagens.
86. Medical aspects of DNA repair.
87. Carcinogenesis. Oncogenes and tumor suppressor genes.
88. Sex as a biological trait. Sex-limited, sex-influenced, sex-linked and holandric inheritance.
89. Determination and development of sex in ontogenesis.
90. Peculiarities of sex determination in humans: physical, intermediate and socio-psychological determinants. Genetic mechanisms of gonadogenesis in humans.
91. Barr body, Mary Lyon's hypothesis of X chromosome inactivation.
92. Hermaphroditism. Disruption of sex formation in humans. Ethical aspects associated with sex, disorders of sex development, sex change and transsexualism.
93. Current tasks of human genetics. Human being as a specific object of genetic analysis.
94. The main methods human genetics: pedigree analysis, twin study, cytogenetic techniques, the methods of population genetics.
95. Biochemical diagnostic techniques, the methods of molecular genetics.
96. Methods used for diagnosis of genetic disorders: direct sequencing, PCR, restriction fragment length polymorphism (RFLP) analysis, single-strand conformation polymorphism (SSCP) analysis, DNA-microarrays.
97. Methods used for diagnosis of numerical and structural chromosomal abnormalities: karyotyping, SKY, FISH and SNP array-based karyotyping.
98. Rapid diagnostic tests: Guthrie bacterial inhibition assay, detection of sex chromatin.
99. Neonatal screening of monogenic disorders. Screening programs in the Republic of Belarus.
100. Human disorders caused by numerical and structural chromosomal abnormalities. Partial monosomies and trisomies.
101. Uniparental disomy. Monogenic hereditary disorders.
102. Disorders of amino acid, carbohydrate, lipid and nucleic acid metabolism.
103. Coagulation system disorders.
104. Mineral metabolism disorders.
105. Hemoglobinopathies.
106. Multifactorial and polygenic (complex) genetic disorders.
107. Approaches to the treatment of human hereditary disorders.
108. Genetic counselling. Indications for direction to genetic counseling. Diagnosis, prognosis and calculation of genetic risk.
109. The Addition and Multiplication Rules of Probability, Bayes' theorem, calculation of prior and posterior probability.
110. Assessing the severity of medical and social consequences of hereditary pathology

111. Ethical and legal aspects of genetic counseling. Medical and family secrecy.
112. Prenatal methods for diagnosis of hereditary pathology - alpha-fetoprotein test, ultrasonography,
113. Chorionic villus sampling (CVS), amniocentesis, placentocentesis, cordocentesis and fetoscopy.
114. Prenatal screening in the Republic of Belarus. Ethical aspects of prenatal diagnosis. National policy on induced termination of pregnancy.
115. Reproduction of living things.
116. Sexual and asexual reproduction, their forms and biological roles. Hermaphroditism and dioeciousness.
117. Lateral gene transfer.
118. Oogenesis and spermatogenesis in humans.
119. Regulation of gametogenesis. Characteristics of human gametes. Insemination. Peculiarities of fertilization in humans.
120. Assisted reproductive technologies (ART) in overcoming infertility in humans: artificial insemination; in vitro fertilization (IVF) and its variations (intracytoplasmic sperm injection (ICSI), oocyte donation;
121. Surrogacy; assisted hatching; cytoplasmic transfer).
122. Preimplantation genetic diagnosis. Medical research using human embryos, and associated ethical problems.
123. Periodization of ontogenesis. Determination of phenotype by genetic and environmental factors in ontogenesis.
124. Prezygotic period of ontogenesis. Prenatal period of ontogenesis. Genetic control of prenatal development.
125. Significance of ooplasmic segregation, totipotency of zygote, selective gene expression. Interactions between parts of developing embryo.
126. Embryonic induction, positional information of embryonic cells.
127. Critical periods of human prenatal ontogenesis, teratogenic factors.
128. Genomic imprinting. Diseases of genomic imprinting.
129. Periodization of postnatal ontogenesis in humans.
130. Genetic control of postnatal ontogenesis.
131. The influence of external and internal factors on postnatal ontogenesis.
132. Growth and development of the organism and their regulation. Acceleration.
133. Human constitution and habitus.
134. Critical periods of postnatal ontogenesis.
135. Molecular and genetic basis of aging. Gerontology and Geriatrics. Clinical and biological death.
136. Resuscitation and its biological aspects. Moral and ethical problems of euthanasia.
137. Human organism as an open and self-regulating system. Regulation of homeostasis.
138. Cybernetic basis of homeostasis. Levels and mechanisms of homeostasis regulation.

139. Biorhythmology.
140. Medical significance of chronobiology. Chronoprophylaxis, chronodiagnostics and chronotherapy.
141. Regeneration. Physiological regeneration as a mechanism maintaining homeostasis.
142. Classification of cells according to their regenerative ability.
143. Reparative regeneration, its types and mechanisms.
144. Regulation of regeneration.
145. Importance of regeneration for biology and medicine. Regenerative medicine.
146. Transplantation.
147. Types of transplantation: autotransplantation, allotransplantation, homotransplantation and xenotransplantation.
148. Tissue incompatibility.
149. Immunological mechanisms of tissue incompatibility and ways to overcome it. HLA system.
150. Cultivation of cells and tissues outside human body, tissue preservation. Stem cells.
151. Cell lines in biological and medical experiments.
152. Artificial organs.
153. Cultivation of human organs in animals and decellularization, therapeutic cloning, 3D-bioprinting.
154. Ethical and legal aspects of transplantation: death certificate, concept of brain death, donation and its commercialization.
155. Population. Ecological and genetic characteristics of populations. Gene pool. Ideal population.
156. Hardy-Weinberg equilibrium.
157. Factors disturbing Hardy-Weinberg equilibrium.
158. Natural selection. Mutations. Migration.
159. Genetic drift, founder effect, bottleneck effect.
160. Non-random mating, inbreeding, assortative mating, inbreeding coefficient.
161. Population structure of humanity. Large populations, demes and isolates. Peculiarities of gene pool of isolates.
162. Effects of elementary evolutionary factors on human populations.
163. Human genetic polymorphism, its biological, medical and social aspects. Genetic burden, its biological essence and medical significance.
164. Parasitism as an antagonistic form of symbiosis.
165. Parasitocoenosis. Microbiome.
166. Medical parasitology, its goals and objectives.
167. Classification of parasitic diseases.
168. Classification of parasites. Classification of hosts.
169. Characteristics of the parasite-host system. Transmission routes of parasites. Pathogenic action and specificity of parasites.

170. Morphophysiological and biological adaptations of parasites. Responses of the host organism to the invasion of parasites. Parasitic system.
171. Phylum *Sarcomastigophora*. The most common parasites of the class *Zoomastigota* (*Giardia duodenalis*,  
 172. *Trichomonas vaginalis*, *Trypanosoma* spp., *Leishmania* spp.  
 173. The class Sarcodina (*Entamoeba coli*, *Entamoeba gingivalis*, *Entamoeba histolytica*).
174. Phylum *Apicomplexa*. Human parasites of the class *Sporozoa*: *Plasmodium* spp., *Toxoplasma gondii*, *Cryptosporidium* spp.)
175. Phylum *Infusoria*. Parasitic protists of the class *Ciliata*: *Balantidium coli*.
176. Laboratory diagnosis of the diseases caused by pathogenic protists. Prevention of protozoan diseases.
177. Phylum *Platyhelminthes*, class *Trematoda* – *Fasciola hepatica*, *Opisthorchis felineus*.
178. *Paragonimus westermani*, *Schistosoma* spp., schistosomatid dermatitis.
179. Class *Cestoda* - *Taenia solium*, *Taenia saginata*, *Hymenolepis nana*, *Echinococcus granulosus*, *Echinococcus multilocularis*, *Diphyllobothrium latum*.
180. Phylum *Nemathelminthes*, class *Nematoda*.
181. *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Necator americanus*, *Strongyloides stercoralis*, *Toxocara canis*.
182. *Enterobius vermicularis*, *Trichinella spiralis*, *Dirofilaria repens*, *Dracunculus medinensis*, *Onchocerca volvulus*, *Wuchereria bancrofti*, *Brugia malayi*, *Loa loa*.
183. Methods of diagnosis of intestinal and tissue helminth infections of humans. Prevention of helminth infections.
184. The concept of natural focal diseases.
185. Phylum *Arthropoda*.
186. Class *Arachnida*: morphology, biology and medical significance of the ticks and mites of the families *Ixodidae*, *Argasidae*, *Sarcoptidae*, *Acaridae* and *Demodecidae*, infraorder *Gamasina*.
187. Phylum *Arthropoda*. Class *Insecta*: morphology, biology and medical significance of cockroaches (*Blattoidea*), lice (*Anoplura*),  
 188. Fleas (*Aphaniptera*), bugs (*Heteroptera*), mosquitoes (*Culicidae*), sand flies (*Phlebotominae*),  
 189. Flies (*Muscidae*), black flies (*Simulidae*), botflies (*Oestridae*, *Gastrophilidae*, *Hypodermatidae*),  
 190. Horse-flies (*Tabanidae*), biting midges (*Ceratopogonidae*).
191. Control of parasitic arthropods. Prevention of parasitic and vector-borne diseases.
192. Poisonousness and venomousness is a universal phenomenon in living nature.
193. The concept of poisons, venoms and toxins.
194. Classification of poisonous and venomous animals.
195. Poisonous animals of the phylum: *Coelenterata*, *Arthropoda* and *Chordata* (*Chondrichthyes*, *Osteichthyes*, *Amphibia*, *Reptilia*).

196. Physiological characteristics of the toxins of invertebrates (jellyfishes, spiders, hymenopterans), their effect on humans; first aid and prevention of bites and stings.
197. Physiological characteristics of the toxins of vertebrates (fishes, amphibians, reptiles), their effect on humans.
198. First aid and prevention of bites and stings and poisonings.
199. Poisonous mushrooms and plants, their characteristics.
200. The value of poisonous and venomous organisms as a source of materials for pharmacy and medicine.
201. Ontogenesis and phylogenesis. Von Baer's Law. Recapitulation. Biogenetic law.
202. The concept of cenogenesis and palingenesis. The teaching of A. N. Severtsov on phyllembryogenesis.
203. Correlations in the course of individual development.
204. Evolution of integumentary, skeletal, nervous, circulatory, respiratory, digestive, urinary and reproductive systems of chordates.
205. Malformations of human organ systems which can be explained by the evolution of these systems.

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