**The principles of Final Master Thesis Exam**

1. During the exam, student should answered the two questions overlapping the scope of dissertation.

2. The next questions will check the knowledge of the student obtained during the master thesis studies i.e. during the four trimesters of the second level studies. These questions are mentioned bellow as “A list of the exam questions”.

3. Additionally, members of the examination committee might create the questions for the student based on the content of syllabuses prepared for the subjects chosen by the student during the second level of the studies.

**A list of exam questions**

1. What are the law regulating the use of animals for scientific purposes?
2. Which administrative authority can authorize an experiment involving animals?
3. What characteristics should "good" animal models display?
4. What is the 3R rule?
5. Principles of the functioning of the respiratory chain.
6. Basis of the Michaelis-Menten model.
7. Principles of protein separation using ion exchange chromatography, hydrophobic interaction chromatography, affinity chromatography and gel filtration.
8. Classification of enzymes based on the type of catalysed reaction and their structure.
9. How do factors such as substrate concentration, temperature and pH affect the rate of enzymatic reactions?
10. Levels of protein structures.
11. The role of the length and degree of saturation of hydrophobic chains of phospholipids and cholesterol in regulating the fluidity of the biological membrane.
12. Explain what is an SNV (SNP).
13. What information does the NCBI GEO database contain? What analyzes can be performed using the on-line tools of this database?
14. List the elements of the functional analysis of the genome.
15. Discuss the types of transport across the cell membrane.
16. What hetero- and euchromatin mean?
17. The stem cells; their characteristics and division.
18. What are liposomes and what are they used for?
19. Discuss the processes taking place in the mitochondria.
20. Characterize mitochondrial DNA.
21. Discuss the process of mitosis.
22. List the main components of the cell cytoskeleton and discuss their functions.
23. What is the principle of real time PCR? What makes it different from the classic PCR reaction?
24. The function of tumor suppressor genes and oncogenes in the cell.
25. What is gene imprinting? What is its molecular mechanism.
26. List the post-translational modifications of proteins. Discuss their functions.
27. What is miRNA and what is its role in the cell?
28. What post-transcriptional modifications does mRNA undergo and what is its significance.
29. What is DNA methylation (what enzymes are involved, in what places on DNA)? What is the function of this process?
30. The process of initiation of DNA transcription and its mechanism.
31. Difference between conformation and configuration of a molecule.
32. What is isomerism and what two types of it can be distinguished? Give examples of each type of isomerism.
33. What does it mean that a molecule is chiral?
34. What are the differences in the structure and properties of fats and oils?
35. Discuss the classification of hormones in terms of their mechanism of action, give examples.
36. Discuss the importance of hormone binding proteins, give examples.
37. Discuss the genomic effects of hormones.
38. Discuss the extragenomic effects of hormones.
39. Discuss the mechanisms of hormone secretion control.
40. List three classical models/theories of substrate and enzyme matching and explain the main principle of one of them.
41. Discuss what competitive inhibition is and what kinetic parameters of the enzyme it can affect.
42. Describe the concept of apoenzyme and the conditions for the formation of catalytic activity typical for enzymes.
43. Give the definition of a coenzyme and examples of coenzymes (minimum 3).
44. Discuss the physical factors that have a direct impact on the rate of an enzymatic reaction.
45. List three processess for which the sympathetic nervous system is responsible.
46. List the elements necessary in synaptic transmission.
47. Explain the role of iron and folic acid in the production of red blood cells.
48. Explain the physiological role of fibrinolysis.
49. Discuss the advantages of Danio Rerio as a model organism.
50. Discuss the 4 most important advantages of the mouse as an animal model in in-vivo research.
51. List the mechanisms of horizontal gene transfer in bacteria.
52. What is the difference between type I and type II restrictive enzymes.
53. What is the importance of the CRISPR system for bacteria.
54. Give the name of the process whose product is pre-mRNA, and specify the location of this process in the human cell.
55. Describe the process of DNA replication and characterize the enzymes involved in it.
56. Indicate and briefly characterize the stages of protein biosynthesis.
57. What is the function of poly(A) fragments in the RNA molecule?
58. List and discuss types of inheritance incompatible with Mendel's laws.
59. List and discuss the types of DNA mutations and their effects.
60. List and discuss the types of chromosomal aberrations and their effects.
61. What role do tRNA and mRNA play in the translation process?
62. What are the mobile elements of the genome? Give examples.
63. What is the difference between serum and plasma?
64. What role does trypsin play during passaging of cells? Why do we have to remove the serum before adding it?
65. List four possible applications of immunocytochemistry and immunohistochemistry in medicine and medical diagnostics.
66. What is the difference between cytochemical, cytoenzymatic and immunocytochemical methods?
67. Please describe the relationship between desmosomes/hemidesmosomes and the use of EDTA for iPSc passage.
68. Why do we add FBS to culture media?
69. What is the passage procedure and what is its purpose?
70. What is cellular viability and how can it be measured?
71. List the most common causes of cell culture contamination.
72. What are the standard cell culture conditions?
73. What are the types of MHC molecules and what are their functions?
74. What is an antigen and what are its properties?
75. How is an antibody made and what are the classes of antibodies?
76. What is APC and what cells can play this role?
77. What is complement, what is its role and activation pathways?
78. Discuss the properties of DAPI for in vitro analyses
79. Discuss the principle of the comet test. For what kind of research can the comet test be used?
80. List the types of comet test. What DNA damage can be analyzed with each type of comet test?
81. Describe and give examples of genetic syndromes predisposing to cancer.
82. What is the staging of the carcinogenesis process? Describe the stages of the carcinogenesis process (initiation, promotion, progression).
83. Small molecules and monoclonal antibodies in therapy - show similarities and differences.
84. Give examples of the use of sequencing in the selection of therapy for an oncological patient.
85. Characterize the selected type of DNA repair (by base excision (BER), nucleotide excision (NER), base mismatch (MMR), homologous recombination (HR) or non-homologous end joining (NHEJ)) and indicate the key proteins involved in it.
86. Indicate physical, chemical and biological factors type of DNA damage that may be caused by them.
87. List and briefly describe the characteristics of stem cells.
88. List the main differences between naive and primed induced pluripotent stem cells.
89. Suggest techniques/methods to assess the stemness of the obtained iPS cells at the protein level.
90. Suggest techniques/methods to assess the stemness of the obtained iPS cells at the mRNA level.
91. List and describe biological drug delivery systems in the treatment of cancer and other diseases.
92. What factors should mainly determine the method of obtaining iPS cells and derivatives?
93. What are non-protein amino acids? What are they characterized by? Give examples.
94. What are the differences and similarities between a motif and a protein domain? Give an example of a domain and motif in a protein.
95. List and discuss the phases of drug trials.
96. List in silico drug design methods.
97. List the methods that allow you to analyze the structure of a protein.
98. Spatial organization of chromatin.
99. Characteristic features of the RNA structure.
100. Methods of testing nucleic acids (ultraviolet (UV) and infrared (IR) spectrophotometry, circular dichroism spectra (CD), electrophoretic separation).
101. A therapeutic strategy based on the phenomenon of RNA interference.
102. Ribozymes and deoxyribozymes - molecular structure, mechanism of action and application in gene therapy.
103. Explain what the research problem is?
104. What is a research sample? Define the terms "open-label, single-blind, double-blind"
105. How a selection of the research sample should me made?
106. Define the term medical experiment, discuss types.
107. List and briefly discuss the types of scientific papers.
108. What is ethics in animal research?
109. List alternative methods of scientific research conducted on animals.
110. What is and what is the role of randomization?
111. What is the placebo/nocebo effect?
112. How can the effectiveness of a molecule with anticancer potential be assessed?
113. What are biological drugs? Give 3 examples.
114. What are the types of vaccines and what are their characteristics?
115. Name 3 components of the CRISPR system. Why is the PAM sequence important and what are the limitations of CRISPR?
116. How are CAR-T cells made and what is their mechanism of action?
117. When and for what purpose is the Gateway technique used?
118. What technique would you choose to check protein expression in the test cells? Briefly describe this method.
119. Will changing the codon to a codon encoding the same amino acid affect the conformation of the resulting protein? Justify your answer.
120. What methods of protein purification do you know? Briefly describe them.
121. How are monoclonal antibodies made?
122. List two in vitro cytotoxicity assays to assess the structure and integrity of biological membranes and characterize one of them.
123. Define the concept of genotoxicity of chemical substances and show how it can be assessed in vitro.
124. List at least two in vitro tests for cytogenetic assessment of damage to the genetic material of cells and characterize one of them.
125. What is the difference between transfection and transduction.
126. What are probiotics, prebiotic and symbiotic.
127. What is the difference between substrate phosphorylation and oxidative phosphorylation.
128. List the aspects that should be taken into consideration when selecting the appropriate cellular model to conduct a scientific study.
129. What are the advantages and disadvantages of using cellular models in research?
130. Why are 3D models and co-cultures considered a better model than 2D cell cultures?
131. What is IC50?
132. What information can be found in the cell line characteristic card (data sheet)?
133. List the factors that can cause anaphylactic reactions
134. Give two Th2-type inflammatory cytokines.
135. How are allergen vaccines produced?
136. The use of pathogenic factors (toxins) of bacteria in therapies.
137. Give and describe examples of pathogenicity factors of gram-negative and gram-positive bacteria (for example, LPS, envelopes, protein A, hemolysins).
138. What are pathogenic islands, give their molecular characteristics.
139. Give a definition of a carcinogen. Give examples that belong to the group of biological carcinogens.
140. What is an acute phase reaction? Name 3 acute phase proteins.
141. List 3 characteristics of a "good" tumor marker.
142. Discuss the molecular basis of type 1 diabetes (T1DM)
143. Discuss the mechanisms of genetic adaptation of the influenza virus
144. Discuss the mechanism of formation of thick sticky mucus in the respiratory tract in the course of cystic fibrosis
145. Compare the molecular basis of alpha thalassemia and beta thalassemia
146. Discuss the etiology of primary and secondary hypercholesterolemia
147. Explain what is the difference between a genetically modified microorganism and an organism? Give one example of each.
148. To which group, GMO or GMM, do cells grown in vitro belong? Justify your answer.
149. What is a plasmid and what is it characterized by? What is its significance in the natural environment and in laboratory conditions?
150. How to genetically modify plants?
151. List the techniques for obtaining genetically modified organisms and briefly characterize one of them.
152. What is stem cell reprogramming technology in biotechnology?
153. Explain the terms related to the construction of a plasmid: restriction map, MCS (multicloning site), CMV, reporter gene, promoter, antibiotic resistance gene.
154. What is a reporter gene and why do we use such genes in genetic engineering? List and characterize one selected reporter gene used in genetic engineering.
155. Explain the principle of Sanger DNA sequencing.
156. Give an example of a molecular biology technique that will be optimal for the evaluation of a molecularly or phenotypically heterogeneous material and briefly characterize it.
157. Give an example of a molecular biology technique that uses antibodies as research tools and briefly characterize it.
158. Indicate the techniques that allow the analysis of the material at the level of DNA/protein/mRNA and briefly characterize it.
159. Explain how the FISH technique works and what is its application.
160. Discuss the steps of Western blotting.
161. What is the advantage of Western blotting (WB) over immunocytochemistry (ICH) and what is the advantage of immunocytochemistry over Western blotting? In which situations is it better to use the WB test and in which IHC?
162. Explain how gene expression levels are calculated using delta delta CT method in real-time PCR.
163. Compare the possibilities of real-time PCR and FISH for detecting genomic amplification of a gene and for detecting translocations.
164. Explain the principle of RFLP-PCR method.
165. Give the differences between PCR and qPCR (taking into account the composition of the reaction mixture, reaction conditions, application).
166. What are the differences between bacterial strains depending on whether they are to be used for protein production or only to multiply the plasmid?
167. What is the difference between subcloning with the so-called sticky and blunt ends
168. How to determine if the orientation of the insert after subcloning with restriction enzymes is correct?
169. What are the differences between protein production in eukaryotic and prokaryotic cells in biotechnological procedures
170. What is the role of the so-called tags in genetic engineering?
171. What are the main stages of biotech drug development?
172. In which branches of medicine is medical biotechnology used in practice?
173. What is the use and importance of the analysis of the patient's genomic DNA in personalized medicine?
174. What are the benefits of stem cell treatment?
175. What is gene therapy?
176. Which drugs are called "generic" and which are biosimilars? What are the similarities and differences between them?
177. Characterize the cell banking system used in the production of a biotechnological drug
178. What characterizes a stable cell line as a starting material for the production of a biotechnological drug, how is it created?
179. Explain the terms "biosimilar" and "reference drug".
180. Describe the relationship between the null hypothesis and the alternative hypothesis of a statistical test. Provide example of both in the t-test.
181. The researcher wants to present the relationship between CRP level and gender. She found that CRP has a non-normal distribution. What chart should she create (type of chart, central tendency measures and dispersion)?
182. The researcher is creating a classifier (decision tree) to distinguish between individuals who are sick and healthy based on measurement of various laboratory parameters. The database contains significantly more cases of healthy individuals than sick individuals. How can he try to balance the sensitivity and specificity of the created test?
183. In what situations (to describe the results of which studies) do we use OR (odds ratio), and when do we use RR (relative risk)?
184. On what basis should we decide to perform a meta-analysis with a fixed or a random effect? How can one assess publication bias in metaanalyses – what is the cause of that phenomenon?