SCOPE OF THE QUALIFICATION EXAMINATION - BIOLOGICAL SCIENCES

Doctoral School of Exact and Natural Sciences

The scope of the qualification examination will be related to the subject of the candidate's master thesis and future Ph.D. project. The candidate obtains 3 questions and answers 2 of them.

SYSTEMATICS AND EVOLUTION

1. Endosymbiosis in evolution (hypotheses, proofs, role in evolution).
2. Characteristics of Prokaryotes.
3. Characteristics of Eukaryotic microorganisms.
4. Horizontal gene transfer and its role in evolution.
5. The main steps in Plant evolution.
6. The main steps in Animal Evolution (Transition from unicellular to multicellular life forms among animals, the changes in body plan, the diversity and adaptations to the environment).
7. Fungi and their ecological roles.
8. Analogous and homologous features – definition and examples.
9. Coevolution. The meaning and examples.
10. Great extinctions during the history of the Earth - their causes and effects.
11. Systematic position of Homo sapiens and the main steps of anthropogenesis.
12. Theory of evolution. Mendelian and non-mendelian inheritance, adaptive radiation, and its examples.
13. The types of natural selection.
14. Mechanisms of evolution: mutations, non-random mating, gene flow, genetic drift, and natural selection.
15. Speciation and species concepts.

ECOLOGY OF ORGANISMS

1. Biosphere and ecosystems.
2. Comparison of natural and disturbed ecosystems.
3. Cycle of water, carbon, and nitrogen in an ecosystem.
4. Changes in population density over time and factors affecting these changes.
5. Limiting factors in the environment and the concept of ecological niche.
6. Flow of energy and matter in the ecosystem (food chain).
7. Natural cycles - examples and effects on the biocenosis.
8. Distribution of organisms on Earth.
9. Characteristics of biomes.
10. Human impacts on the environment.
11. Concept of sustainable development.
12. Interactions of organisms in the environment.
13. Parasitism and Mutualism – comparison and examples.
14. Predation and Competition – comparison and examples.
15. Basic issues in population genetics.

CELL BIOLOGY

1. Nucleus: chromatin and envelope structure, transport through nuclear pores.
2. Mitochondria: structural molecular and functional level of their organization.
3. Protein intra- and extracellular transport.
4. Plastids: structural molecular and functional level of their organization.
5. Cell mechanics.
6. Cell cycle (phases and regulation).
7. Meiosis, gametes, and embryonal cells.
8. Determination of cell lines.
9. Embryonal and induced stem cells: obtaining and application.
10. Transcriptomics and proteomics as a tool of cell biology.
11. Mitosis, phases, and their regulation.
12. Programmed cell death.
13. Cytokinesis in different cell types.
14. Embryonic and post-embryonic development in plants and animals.
15. Prokaryotic and eukaryotic flagella.
16. Types and functions of cells in the brain.
17. The basic function and structure of synapses.

BIOCHEMISTRY AND BASIC TECHNICS

1. Biological membranes: structure, functions, and molecules transport.
2. Oxidative and photo-phosphorylation.
3. Proteins (four levels of protein structure, function, and stability).
4. Enzymes - classification, structure, and function.
5. Structure and functions of nucleic acids: DNA and RNA.
6. Genetic mapping.
7. Genetic analysis of metabolic pathways.
8. Lipids and their role in the cell.
9. Liquid chromatography and collision fragmentation mass spectrometry (LC-MS-MS/MS)
10. Methods for protein and peptide identification and proteomic differential analyses.
11. Cellular respiration: aerobic, anaerobic, and fermentation.
12. Metabolism - connections between individual pathways and metabolic cycles in cells.
13. Structure of the cell wall of gram-positive and gram-negative bacteria.
14. The primary and secondary metabolism.
15. The biochemistry and types of viruses.

GENETICS AND BASIC TECHNICS

1. Principles of Mendelian Inheritance (Mendel's Laws).
2. Epigenetic modifications.
3. Complementation in diploid (D. melanogaster) and haploid (S. cerevisiae) organisms.
4. Human genetics: Mendelian inheritance, genetic diseases, analysis of pedigrees.
5. Prokaryotic and eukaryotic gene structure.
6. Mutations as causes of genetic variability.
7. Ames test as a tool for the study of mutagens.
8. Genetic code and the principles of codon-anticodon interaction.
9. Mechanisms of mutation repair.
10. Suppression and reversion of mutations.
11. Horizontal gene transfer.
12. Regulation of gene expression in bacteria on the example of lactose and tryptophan operons in E. coli.
13. Replication, transcription, and translation - from DNA to protein.
14. Techniques for molecular RNA analysis (e.g. primer extension, RNase H cutting of RNA-oligonucleotide duplexes).
15. Methods for determining the biochemical activity of RNA-degrading enzymes, methods for the analysis of 3' ends.

BASIC METHODS USED IN BIOLOGY

1. Principles of nucleic acid sequencing techniques (Sanger method), including NGS methods (Illumina, PacBio, nanopore sequencing).
2. Basic reporter genes.
3. Coning of genes into a plasmid vector using ligation methods and alternative methods (e.g.: SLIC, GATEWAY).
4. PCR and quantitative PCR (qPCR) reactions and their use in molecular biology.
5. Reverse transcription.
6. Cytogenetic methods and molecular diagnosis of human genetic diseases.
7. Methods of transformation of yeast and bacteria.
8. Southern and Northern blot.
9. Immunocytochemistry, and hybridization in situ (FISH) analyses.
10. Western blot technique.
11. Methods of genome modification using CRISPR/Cas.
12. Methods of DNA delivery into cells (e.g. biolistic bombardment, electroporation, PEG, Silicon carbide whiskers, lipofection, Agrobacterium, microinjection, glass beads, etc).
13. Principles of light microscopy (including fluorescence microscopy).
14. Principles of electron microscopy.
15. Methods of 3D reconstruction and visualization applied in biology.
16. Plasmids in molecular biology/biotechnology- structure, applications.
17. Cultivation of cell lines and organisms in laboratory – methods, purpose, media ingredients.
18. Cloning of genes in Bacteria. Plasmids and vectors structure.
19. Nucleic acid modifying enzymes and their applications.
20. Restriction enzymes and their applications.
21. Development of vaccines.
22. Biological methods of wastewater treatment.
23. Methods for heterologous gene expression and purification of recombinant proteins (affinity chromatography, immunoprecipitation).
24. Methods for investigation of protein-protein interactions.
25. Phylogenetic reconstruction methods.
26. Modern methods in ecological research (eg., Geographic Information Systém (GIS), telemetry).
27. Methods for biodiversity assessment.
28. Methods for biodiversity conservation.
29. Sci-com – current methods of communication in science.
30. Biodiversity monitoring methods in in-situ studies.
31. Methods of statistical analysis of biological data.
32. Principles of design of experimental systems in environmental research, with special emphasis on long-term experiments.