Biology Masters Course – Closing examination topics

Molecular, Immune- and Microbiology specialization

2024

Molecular biology sub-specialization[1]

1. Thermodynamic and bioenergetics' basics. The role and characteristics of ATP and other "macroerg" compounds, the importance of energy coupling. The energy provision of life phenomena (functional symmetry of chloroplast and mitochondrion). (MB, PB)

2. The molecular machineries and energetics of replication, transcription and translation. The regulation of pro- and eukaryote gene expression: transcription and translation level, RNA interference, chromatin structure, epigenetics. (MB)

3. Molecular cloning, host-vector system. The PCR and its application. DNA sequencing, genome projects. Performing gene knockout and gene silencing. Generation of transgenic organisms and their use. The role of bioinformatics in gene technology. (GT, BI)

4. Methods of producing recombinant proteins (strength and weaknesses of different techniques), and their uses. Mutagenesis methods. Investigation of molecular interactions using gene technology tools. (GT, PS)

5. Role of bioinformatics in gene technology. Methods of structural bioinformatics. Sequence and structure predictions. Studying protein-protein interactions by biochemical, biophysical and bioinformatics methods. Protein evolution. (BI, PBI, PS)

6. Amino acids and peptides. Levels of protein structure. Structural biology techniques. Studying proteins. Isolation and analysis of proteins, chemical modifications. Spectroscopic techniques, reporter groups, fluorescence methods. (PS)

7. The thermodynamic and kinetic description of enzyme function, the essence of biocatalysis. Single molecule enzyme kinetic techniques. Pharmacobiochemistry, therapeutic use of proteins. (PS)

8. The architecture of metabolism, catabolic and anabolic processes, the regulation mechanisms in the metabolism and their systems biology characteristics. (SB)

9. Omics' sciences and system biology. High-throughput techniques in proteomics. The investigation of molecular interaction at network level. Logics of signal transduction networks. (PS, SB, CST)

10. Energy transformation in macromolecular machineries: the characteristics of the mechanochemistry of ATP-synthase, the catalytic steps in myosin and their relation to its structure, the role of actin. The comparison of the two systems. (MB, MP).

[1] Abbreviations: BI, Bioinformatics; CST, Molecular logic of cellular signaling; GT, Gene technology; MB, Molecular biology – selected topics; MP, Motor proteins; PB, Physical biochemistry; PBI, Protein bioinformatics; PS, Protein science; SB, Systems biology

Immunology sub-specialization[2]

11. The structure and function of antibodies, therapeutic use of monoclonal antibodies. (AI)

12. The general characterization of T-lymphocytes, their development, and role in the immune response. (AI)

13. The general characterization of B-lymphocytes, their development, and role in the immune response. (AI)

14. Characterisation of the immune response developed to extra- and intracellular bacteria. (II)

15. Characterisation of the immune response developed against unicellular and other parasites. (II)

16. Characterisation of the immune response developed against viruses (e.g. influenza, HIV). (II)

17. Development of immunological tolerance, autoimmunity, autoimmune diseases. (AI, IP)

18. Mechanisms of the IgE-mediated allergic reaction, characterization of the effector cells. (IP)

19. Relationship of tumours and the immune system, immune therapy. (IP)

20. Characterisation of the inherited and acquired immune deficiencies. (AI, IP)

[2] Learning material for the examination topics include the textbook Molecular and Cellular Immunology (ed.: A. Abbas et al.) and the compulsory lecture Immunology. In addition, the following elective subjects are indicated for the topics: AI – Adaptive immune response; II – Infectional immunology; IP – Immunopathology

Microbiology sub-specialization[3]

21. Co-evolution of prokaryotes and the biosphere, the three-domain system of life, systematics and taxonomy (species definition in the prokaryote domains, identification, and determination).

22. Methods in prokaryotic taxonomy. Phenotypic characterization (Biolog, API). Chemotaxonomy. Pattern-based identification: fatty acid profile (MIDI system), MALDI-TOF MS. Nucleic acid-based techniques in taxonomy: 16S rRNA gene-based identification, whole genome analysis. Polyphasic approaches.

23. Cultivation based methods to explore the microbial diversity. Light and electron microscopy techniques. In situ methods to determine microbial activity.

24. Nucleic acid-based techniques to explore microbial diversity: isolation, detection and amplification of nucleic acids, nucleic acid-based pattern analysis, sequencing technologies (amplicon sequencing and shotgun metagenomics). Basics of transcriptomics, proteomics, and metabolomics.

25. Interaction among microbial populations: neutralism, commensalism, proto-cooperation, mutualism, ammensalism, competition, predation, parasitism. Organisation and characteristics of biofilms.

26. Plant-microbe interactions: exo- and endophytic microbes, plant growth promoting microorganisms. Plant pathogenic microbes. Animal-microbe interactions. Biological pest control.

27. Microbial partners of the human body (microbial communities of the skin, eye, mouth, teeth, respiratory system, digestive tract, urinary system, and reproductive organs), the human microbiome. The role of microbes in maintaining human health.

28. Basics of clinical microbiology. Infectious diseases and principles of epidemiology: pathogenicity, virulence, infectivity, invasivity, toxigenity, endemicity, epidemic and pandemic. Use of antibiotics and control of epidemics. Indoor microbiology.

29. Microbiology of aquatic habitats. Microbiology of natural waters, drinking waters and ultra-pure water. Basics of microbial corrosion, risk assessment. Microbiology of wastewaters and wastewater treatment technologies. Basics of environmental virology.

30. Application of biotechnology in microbiology. Microbial processes in the food- and environmental industries and in agriculture. Microbiological treatment strategies for the elimination of different soil and water pollutions, biogeochemical cycles of potentially toxic elements. Bioremediation strategies (biostimulation, bioaugmentation, biotransformation, co-metabolism). The fate of genetically modified microbes in the nature.

[3] All the topics are covered in the course: Chapters from classical and molecular bacteriology. Additionally topics 21 and 22 are discussed in more details in course Bacterial taxonomy and virus diagnostic PR.