

Topics for the doctoral examination in the basic discipline at IBCH PAS

General requirements

PhD students are expected to know fluently topics thematically related to areas of the doctoral dissertation and to have basic knowledge in other areas.

Topics for the doctoral examination in biological sciences

Nucleic acids – general topics

1. Types of nucleic acids and their functions.
2. Structures of DNA and RNA. Differences between DNA and RNA.
3. Methods for studies on nucleic acids used in diagnostics: e.g. PCR and qPCR, sequencing, NGS sequencing, karyotyping, SNP, microarrays, Southern and Northern blotting, etc.
4. Nucleic acids in therapeutic strategies.

RNA

5. RNA structural motifs.
6. The role of RNA structure in its biological function.
7. RNA maturation in the cell.
8. Formation and functions of short RNAs (miRNA, siRNA, snoRNA).
9. RNA interference.
10. Non-coding RNAs and their role.
11. tRNA and aminoacyl-tRNA-synthetase, ribosome structure.
12. Ribozymes.
13. Riboswitches.

DNA i genetics

14. Architecture of the human genome – coding and non-coding sequences, repetitive sequences.
15. Epigenetics – the epigenetic code.
16. Regulation of the expression of genetic information.
17. Mutations and their biological implications, examples of diseases, detection of mutations.
18. Gene expression inhibition.
19. Approaches to genome editing.
20. Methods of DNA recombination. Restriction enzymes, transformation, vectors, cloning.
21. DNazymes.
22. Genetic code, replication, transcription and translation in (i) eukaryotic and (ii) prokaryotic cells.
23. The central paradigm of molecular biology: the original and the present version.

Molecular evolution and bioinformatics

24. Duplications of genes and genomes – evolutionary pros and cons.
25. Mobile elements and their role in the evolution of genomes.
26. Methods and tools for comparing nucleotide and protein sequences.
27. Constructing phylogenetic trees.
28. Next-generation sequencing – technologies and basic steps in the assembly and analysis of genomes and transcriptomes.

29. Genome annotations.

Proteins

30. Proteins. Structure and types of amino acids. Primary, secondary, tertiary, and quaternary structures of proteins, protein functions.
31. Post-translational modifications of proteins and their significance.
32. Protein testing methods: electrophoresis, chromatography, immunodetection, mass spectrometry.
33. Methods of protein quantification.

Cell membranes

34. Structure of biological membranes.
35. Methods of transport through biological membranes. Passive and active transport, osmosis, transporter proteins.

Virology

36. Introduction to virology. Classification and structure of viruses.
37. The use of viruses in molecular biology.
38. The replication cycle of the virus studied in the dissertation.

Other topics

39. Basics of biocatalysis: enzymes: structure, division, kinetics, inhibition and regulation of enzymatic activity.
40. Model organisms and research models used in biological research – features of a good model organism, examples, application.
41. Methods of imaging biological systems.

Topics for the doctoral examination in chemical sciences

General and organic chemistry

1. Chemical bonds and intermolecular interactions.
2. Nucleophilic substitution reactions, including SN(P).
3. Electrophilic substitution reactions.
4. The phenomenon of isomerism of organic compounds. Configurational and conformational isomerism.
5. Stereochemistry: types of stereoisomers, stereochemistry of the reaction (inversion, retention, racemization), differences in the stereochemistry of carbon and phosphorus.
6. Methods of purification of chemical compounds.
7. Analytical methods used in organic and bioorganic chemistry (with knowledge of theoretical basis).
8. Protecting groups – strategies for functional group blocking; classification according to the unlocking conditions and applications.
9. Fundamentals of kinetics and thermodynamics of chemical reactions.
10. Knowledge of the most important classes of organic compounds – characteristics and reactivity.
11. Low molecular weight compounds – definition and application.

12. Application of fluorescent probes, labeling methods.
13. High-throughput methods and their applications.
14. Molecular probes – types, chemical structure and applications.

Nucleic acids

15. Types of nucleic acids and their functions.
16. Structure of nucleosides, nucleotides and nucleic acids. Differences between DNA and RNA.
17. Post-transcriptional RNA modifications.
18. Chemical and physical properties of nucleic acids.
19. Physicochemical methods for determining the structure of nucleic acids.
20. Formation of an internucleotide bond and chemical synthesis of oligonucleotides.
21. Methods of formation of an *N*-glycosidic bond.
22. Oligonucleotides for therapeutic applications – types, chemical structure and mode of action.
23. The use of nucleoside derivatives in antiviral therapies.
24. Modifications of oligonucleotides for applications in molecular biology, therapy and diagnostics.
25. DNA testing methods: PCR, sequencing, karyotype, SNP, microarray, Southern and Northern blotting.
26. Microarrays – types and application.
27. Types of cellular DNA damage – origins and repair.
28. Methods for the analysis of primary, secondary, and tertiary structure of RNA.
29. RNA structural motifs.
30. The role of RNA structure in their biological function.
31. Natural modifications of nucleotides and their role.
32. Thermodynamics of nucleic acids.
33. Influence of modification of nucleic acids on their thermodynamic properties.
34. Nucleic acids in the methods of molecular biology.
35. Delivery of nucleic acids to cells.

Sugars

36. Sugars – types, structure, properties.

Proteins

37. Amino acids and proteins. Structure and properties. Primary, secondary, tertiary, and quaternary structures of proteins.

Lipids

38. Lipids – structure and properties.
39. Surfactants, micelles, structure of biological membranes.