ITMO UNIVERSITY

LIST OF ENTRANCE EXAM QUESTIONS

FOR THE INTERNATIONAL MASTER'S DEGREE PROGRAM

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Please note: For an exam there are **two questions**: one from 1-3 section and another from 4-5 section).

1 Molecular biology

1. The central dogma of molecular biology. The history of genes discovery.The modern concept of the gene. The concept of gene expression.
2. Evidence for DNA as the genetic material. Avery, Hershey and Chase experiments.
3. Nucleosides, nucleotides and their examples. Purines and pyrimidines nitrogenous bases.
4. Chemical structure of oligonucleotides (ribo- and deoxyribo- nucleotides), polynucleotides, 5'- and 3'-ends.
5. The secondary structure of DNA (Watson-Crick model). Antiparallel polynucleotide chains. Chargaff's rules and the principle of complementarity.
6. DNA conformation: A, B and Z forms.
7. The principles of DNA packaging in eukaryotic and prokaryotic cells. The structure of nucleosomes.
8. The main types of RNA: structure and functions.
9. Genetic code. The essence of genetic coding. Basic properties and universality of the genetic code.
10. The structure of prokaryotic genes: coding sequence and promoter.
11. The mosaic structure of eukaryotic genes (introns and exons), organization of promoters.

2 Processes of central dogma

12. Semi-conservative DNA replication. Replication stages in pro- and eukaryotes: initiation, elongation and termination.
13. Replication enzymes of prokaryotes: types and functions.
14. Replication enzymes of eukaryotes: types and functions.
15. Replication in prokaryotic genome (theta-replicating and principle of rolling circle).
16. Classification of DNA repair mechanisms. Direct repair of thymine dimers and methylated guanine. Cutting of nitrogenous bases. Glycosylase.
17. Transcription as an intermediate stage of gene expression. Stages of transcription (initiation, elongation and termination).
18. The products of transcription in pro- and eukaryotes.
19. Post-transcriptional RNA processing in eukaryotic cells and its biological significance: capping, polyadenylation and splicing.
20. The principles of gene expression regulation in prokaryotes. Biological feasibility of regulating expression.
21. Protein as a product of gene expression.
22. The chemical composition of proteins. Classification of amino acids.

3 Genetic engineering

23. Genetic engineering. Bacteria as vectors for amplifying foreign DNA.
24. Operon organization of the genes. Positive and negative regulation. Induction and repression.
25. Lactose operon. Functioning mechanism.
26. Attenuation of transcription. Mechanisms for transcription termination.
27. Regulation of gene expression in the tryptophan operon.
28. Recombinant DNA Technology: cloning vectors. Restriction enzymes and ligases.
29. Bacterial plasmids as vectors. Production of recombinant proteins.
30. Methods of nucleic acids analyzing: identification of unique nucleotide sequences. Polymerase chain reaction, blotting (Southern, Northern), DNA chips.
31. The practical application of DNA and RNA analysis.
32. Mobile genetic elements in eukaryotes (types of mobile elements, displacement mechanisms, examples).

3 Microbiology

33. Taxonomy of bacteria. Principles of taxonomy: genetic, phenotypic, serological criteria.
34. The structure of bacteriophages. Virulent and moderate phages.
35. Growth of bacterial population. Bacterial growth curve.
36. Genetic exchange in bacteria: transformation, transduction, conjugation. State of competency.
37. Prokaryotic genome: nucleoid, plasmid, mobile genetic elements.
38. Major carbohydrate-containing polymers of the bacterial surface: CPS, LPS, EPS.
39. Social behavior in bacteria. Quorum sensing, swarming, biofilms.
40. Phenotypic heterogeneity of bacterial populations. Uncultivated forms of bacteria, persister cells, L-forms.

4 Cytology

41. Morphology and structural organization of bacterial cell.
42. Cytoplasmic membrane: structure and functions. The cell wall of bacteria.
43. Flagella and fimbriae of bacteria. Bacterial motility.
44. Differences in the structure of pro- and eukaryotic cells.
45. The structure of the eukaryotic cell nucleus.
46. Cell theory: tenets and proofs.
47. Passive and active transport: examples and mechanisms.
48. Membrane cell organoids: types, structure, functions.
49. Concept and stages of mitosis and meiosis.

EXAM PREPARATION MATERIALS

Molecular Biology and Biotechnology

1. Microbiology: https://drive.google.com/file/d/1uWf2EVzhjzuUygl-ML3hUTDLQU9qI4PB/view?usp=sharing
2. Basic Methods in Microbiology:
   https://drive.google.com/file/d/1rvhXkS8eLeki3ohBynZDyz-8g1klv0-T/view?usp=sharing

   Voet, Donald, Judith G. Voet, and Charlotte W. Pratt. Fundamentals of biochemistry: life at the molecular level. John Wiley & Sons, 2016

   Nina Parker, Mark Schneegurt, Anh-Hue Thi TUDonald, Brian M. Forster, Philip Lister. Microbiology. OpenStax, 2018

Coursera courses

1. Biofilms: https://www.coursera.org/learn/bacterial-infections
2. Antibiotic resistance: https://www.coursera.org/learn/antimicrobial-resistance
3. Examples of infections (pathogens): https://www.coursera.org/learn/stories-of-infection#syllabus

Edx courses

1. Human microbiome
   https://www.edx.org/course/nutrition-and-health-human-microbiome?index=product&queryID=42414229407b37c0c7a4adf44a15b1db&position=3
2. https://www.edx.org/course/quantitative-methods-for-biology?index=product&queryID=b754ea26b1003a9245b2254252357845&position=4
3. https://www.edx.org/course/molecular-foundations-of-medicine?index=product&queryID=aef4041f16b50eab4a0cbcb226bf8d03&position=5

MIT courses

1. Biochemistry
   https://www.edx.org/course/biochemistry-biomolecules-methods-and-mechanisms
2. Molecular biology (3 parts)
   https://www.edx.org/course/molecular-biology-part-1-dna-replication-and-repair
   https://www.edx.org/course/molecular-biology-part-2-transcription-and-transposition
   https://www.edx.org/course/molecular-biology-part-3-rna-processing-and-transl