LIST OF ENTRANCE EXAM QUESTIONS

FOR THE INTERNATIONAL MASTER'S DEGREE PROGRAM

ITMO

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Part 1. Molecular Biology

1. The central dogma of molecular biology. Semi-conservative DNA replication. Experi-ments that confirmed semi-conservative DNA replication.
2. Nucleosides, nucleotides and their examples. Purines and pyrimidines nitrogenous bases. Biological roles of nucleotides in cells.
3. The principles of DNA packaging in eukaryotic and prokaryotic cells. The structure of nucleosomes.
4. The main types of RNA: structure and functions.
5. Genetic code. The essence of genetic coding. Basic properties and universality of the genetic code.
6. The structure of prokaryotic genes: coding sequence and promoter.
7. The mosaic structure of eukaryotic genes (introns and exons), organization of pro-moters.
8. Replication stages in prokaryotes: initiation, elongation and termination. Replication enzymes of prokaryotes.
9. Replication stages in eukaryotes: initiation, elongation and termination. Replication enzymes of eukaryotes: types and functions.
10. Transcription as an intermediate stage of gene expression. Stages of transcription (initiation, elongation and termination).
11. Translation of proteins. Protein as a product of gene expression.
12. DNA repair mechanisms.
13. Recombinant DNA Technology: cloning vectors. Restriction enzymes and ligases.
14. Polymerase chain reaction. Principle, variants, applications.
15. The chemical composition of proteins. Classification and properties of amino acids.

Part 2. Microbiology

1. Bacterial taxonomy and nomenclature. Non-taxonomic groups: strains, serotypes. Taxonomy and non-taxonomic groups (if possible) for Escherichia coli O157:H7 and Lactobacillus sp. ATCC 15578.
2. Main ecological groups of bacteria depending on oxygen presence. Techniques that can be used for cultivation of anaerobes. Techniques that can be used to increase oxygenation for aerobes. Examples of aerobic and anaerobic organisms.
3. Main ecological groups of bacteria depending on temperature and pH. Adaptations to temperature: sigma factors, membrane fluidity, chaperones.
4. Isolate, pure culture, strain. Purpose of use for following growth media: general nutri-ent media, minimal media, enrichment media, selective media, differential media. Steps of Gram staining and how it can be used for microorganism identification.
5. Bacterial cell wall. Scheme and structure of Gram positive and Gram negative cell walls. Examples of organisms for each group (different genera). Features of Myco-plasma and Mycobacteria cell envelope.
6. Biofilms. Stages of biofilm formation. Components of the biofilm matrix. Biofilm sub-populations: fast growing, slow growing, persisters, mutants.
7. Fed-batch culture, repeated fed-batch culture, batch culture, continuous culture. Standard bacterial growth curve. Level of protein synthesis and number of live and dead cells on each stage. Quorum sensing and how it affects culture growth.
8. Bacterial cell division. Z ring. Difference between binary fission and budding. Exam-ples of bacteria which have binary and budding types of division. Generation time.
9. Bacteriophages. Lytic and lysogenic life cycle. Prophage. Examples of dsDNA and ssDNA bacteriophages. Bacteriophages P1 and T7 in genetic engineering?
10. 3 main types of horizontal gene transfer in prokaryotes. Conditions of chemical trans-formation and electroporation. Features of competent cells in comparison to other strains.

11. Regulation of gene expression in bacteria. DNA folding, examples of histone-like pro-teins. Sigma factors. Regulator operons: lac operon, tryptophan operon.
12. Antibiotics targets. Mechanisms of antibiotics resistance (at least 3). Multidrug anti-biotics resistance. R plasmids.
13. Examples of antibiotics and their targets (at least 5). Bacteriocins: source, function. Antimicrobial peptides: source, function. Quorum quenchers: source, function.
14. Bacterial antigens (O-, H-, Vi-antigen). Pathogenicity, virulence, attenuation. Virulence factors, pathogenicity islands. Colonization and invasion.
15. Definition and difference between microbiota and microbiome. Dysbiosis. Probiotics and prebiotics. Commensal and conditionally pathogenic bacteria. Mechanisms of regulation of intestinal microbiota composition (at least 3).

Part 3. Cell Biology

1. Structure of a eukaryotic cell. Non-membrane, single-membrane and double layered organelles. Their main functions.
2. Structure of a eukaryotic nucleus and its membrane.
3. Scheme of human cell cycle. Main phases and regulators of the cell cycle.
4. Stages of mitotic cell division of a eukaryotic cell. Main phases and their characteristics.
5. Anaerobic glucose oxidation process. Glucose transportation to the cell. Steps and products of glycolysis.
6. Scheme of tricarboxylic acid cycle with its stages and compounds. Main functions of the cycle in the cell.
7. Oxidative phosphorylation and its main stages. Complexes of the electron transport chain and their functions.
8. Names and structures of non-essential and conditionally essential amino acids. Their biosynthesis inside the cell.
9. Types and mechanisms of membrane transport. Examples of compounds transport-ed by each type.
10. Scheme of a typical optical microscope. Principle of image production in brightfield, darkfield and phase-contrast microscopes.
11. Principle of enzymatic reaction. Michaelis–Menten equation.
12. Signal transduction in human cells. Primary transducers, receptors and secondary transducers.
13. Main principle of optical absorbance and fluorescence in terms of applications in mo-lecular biology.
14. B vitamins and their role in human cellular metabolism.