ENTRANCE EXAMINATION IN SPECIALTY FOR APPLICANTS ENTERING MASTER'S PROGRAMS OF LANDAU PHYSTECH SCHOOL OF PHYSICS AND RESEARCH

The question list includes 2 questions. 1 hour is given for preparation, while it is allowed to use literature except electronic media. The use of communications and Internet access is not permitted. The applicant answers the ticket in the form of an oral interview, during which additional questions may be asked on the relevant section of the program.

Introduction

1. Who wrote the book "What is life from the point of view of physics" and when?

General biology

1. Cell theory. Homology of cells, versatility of storage and transmission of hereditary information. The origin of prokaryotes, eukaryotes, multicellular organisms.
2. Plasma membrane.
3. Cell compartmentalization. Cellular organelles. Membrane and non-membrane organelles. Prokaryotes, eukaryotes: similarities and differences.
4. Ribosomes - structure and function.
5. Mitochondria - structure and function. Cellular respiration. ATP synthase.
6. Chloroplasts - structure and function.

Bioorganic chemistry

1. Chemical bond. Types of chemical bonds. The mechanism of formation of a covalent bond (exchanging and donor-acceptor). Ionic bond. Types of intermolecular interactions.
2. Nucleic acids. Structure and function.
3. Proteins and peptides. Structure and function.
4. Lipids. Structure and function.
5. Carbohydrates. Structure and function.

Biochemistry and molecular biology

1. Types of cellular membranes and their lipid composition. Membrane ultrastructure.
2. Membrane proteins and their modifications.
3. The structure of the bacterial cell wall.
4. Glycoproteins and their biological functions.
5. Glycoproteins as molecules of biological specificity. Blood groups.
6. Integral and surface membrane proteins. The mechanisms of association of proteins with membranes. Covalent and non-covalent interactions of proteins and modifiers. Basic structures of membrane proteins.
7. Lipoproteins. Post-translational modifications of proteins.
8. Physics of biological membranes. Asymmetry of lipid composition and its biological meaning. Association of membrane structures, membrane rafts.
9. Interaction of membranes and cytoskeleton.
10. Facilitated diffusion and active transport across membranes.
11. Ionic channels, their structure and functions.
12. The main mechanisms of transport through membranes: symport, antiport, uniport.
13. Sodium-potassium pump: structure and biological meaning: classification, synthesis, mechanisms of action.
14. Peptide and steroid hormones.
15. Membrane receptors. Basic structures and mechanisms of action.
16. Phosphorylation and dephosphorylation of proteins as a method of metabolism regulation. Signal protein kinases and protein phosphatases.

17. The mechanism of transmission and amplification of the signal through the coupling of the receptor with the G-protein. Cyclic nucleotides as secondary messengers
18. Enzymes, classification of enzymes (examples for main Enzyme Commission groups).
19. Kinetics of enzymatic catalysis. Michaelis constant, Michaelis-Menten equation.
20. Lipid bilayer - the basis of the cellular membrane. Mosaic model of cellular membranes. Membrane proteins and their types.
21. Active transport. Loiger's model for Na + / K + -ATPase.
22. The Nernst-Planck equation. Diffusion potential - Planck's approximation for the case of "thick" membranes. Goldman's equation for "thin" membranes.

Methods of Physics in Biology

1. Absorption spectroscopy in the ultraviolet and visible regions. Bouguer-Lambert-Beer law.
2. Fluorescence spectroscopy. The physical basis of fluorescence. Resonant energy transfer. Requirements for fluorophores.
3. Fluorescence microscopy.
4. Optical activity. Circular dichroism and dispersion of optical rotation.
5. Study of the secondary structure of proteins and peptides by circular dichroism methods.
6. Theory of small-angle scattering on particles in solution. Scattering curve at small values of Q. Asymptotic behavior of the scattering curve at large values of Q. Porod ratio.
7. Contrast variation in X-ray and neutron scattering. Change of contrast by solvent. Change of contrast due to the scattering properties of the particle. Synthetic and biosynthetic deuteration.
8. X-ray crystallography. Determination of the spatial structure of biomolecules.
9. Free Electron Lasers (XFEL). Biomolecular research.
10. Basic principles of NMR, solvent, chemical shift, multiplicity, integral.
11. Fourier NMR, 2D NMR spectroscopy. Methods for determining the structure of low molecular weight compounds, NMR / mass spectrometry.
12. Peculiarities of NMR spectroscopy of proteins, isotope labeling, limitations of the method.
13. Mass spectrometry. Physical basis of the method. The main methods of ionization used in mass spectrometry.
14. Main features of MALDI and ESI ionization.
15. Tandem mass spectrometry (MS / MS) for obtaining the structure of proteins and peptides.

Literature

1. Serdyuk I., Zakkai N., Zakkai J. Methods in molecular biophysics.
2. Kantor Ch., Shimmel P. - Biophysical chemistry, V. 1, 2, 3. -M .: Mir, 1984-1985.
3. Basics of Biochemistry Lehninger. In 3 volumes. Nelson D., Cox M.
4. Molecular Biology Of The Cell, 2014 https://drive.google.com/open?id=0B9LVWn9N829pRWh6Z2RsRE5uTGc
5. Ovchinnikov Yu.A. Bioorganic chemistry.