PLAN OF LECTURES AND PRACTICAL EXERCISES
IN MOLECULAR BIOLOGY

Section 1. The cell as an integrated, dynamic system

Topic 1. Supramolecular systems are the bridge between inanimate and living matter.
Lecture 1. The subject of molecular biology.
Question 1. The main stages of development. Major discoveries.
Summary of 1 question. Definition of the subject of molecular biology. Formation of molecular biology as a science. Examples.
Question 2. The concept of supramolecular systems. Intermolecular interaction.
Summary 2 questions. Supramolecular systems are the bridge between inanimate and living matter. The concept of the main types of non-covalent interactions: guest-host, induced correspondence, dispersion, van der Waals, Coulomb, hydrophobic interaction. Examples.
Question 3. The role of the environment in intermolecular interactions. Structure of water.
Summary of 3 questions. Three-dimensional grid of hydrogen bonds in water as an example of cooperative interaction. Examples.
Laboratory lesson 1. Supramolecular systems are the bridge between inanimate and living matter.
Summary of the practical lesson. Lesson 1. The concept of the main types of non-covalent interactions: guest-host, induced correspondence, dispersion, van der Waals, Coulomb, hydrophobic interaction.
Structure of water. Three-dimensional grid of hydrogen bonds in water as an example of cooperative interaction. The Grothus mechanism.
Three-dimensional organization of organic polymers in the cell depending on the near environment. The true and the apparent volume of the molecules. The concept of the excluded volume and its role in the organization of cellular processes and three-dimensional structure of organic polymers and cells. Excluded volume effects. Self-organization of molecular groups. The concept of supramolecular systems. Intermolecular interaction. The role of the environment in intermolecular interactions.

Topic 2. The cell as a holistic, dynamic system. System analysis of the organization of living matter. The cell is the basic unit of structure and development of all living organisms. Cell cycle.
Lecture 2. Structure and functions of biological membranes.
Question 1. Excluded volume effects and their role in the organization of three-dimensional structure of biomolecules, biochemical and regulatory processes.
Summary of 1 question. Cell membrane as a structure providing chemical unity and constancy of composition. The role of cell membranes in information interaction. Effects of excluded volume in the organization of compartments, regulation of cellular chemical interactions and three-dimensional organization of proteins and nucleic acids. Examples.
Question 2. Three-dimensional structure of the cell.
Summary 2 questions. The role of cytoskeleton and electrostatic gradients in the organization of directed transport within the cell. The relationship between the three-dimensional structure of the cell and its function. Examples.

Laboratory lesson 2. The cell as a holistic, dynamic system. System analysis of the organization of living matter. The cell is the basic unit of structure and development of all living organisms. Cell cycle.
Summary of the practical lesson. The cell as a whole living system. The structure of the biological membrane as the main building block of the cell. The mechanism of action of the biological membrane. Types of biological membranes. Three-dimensional organization of the cell membrane system-compartments. The role of cytoskeleton. Interaction of organic molecules in the cell

membrane. The complete Nernst equation. Interaction of cell membranes with water, effects of epitaxy and excluded volume. The concept of the cell cycle.
Independent work: development of multimedia presentations on the topic of the lesson.

Topic 3. Features of the phylogeny of prokaryotes and eukaryotes. Metabolism. Structure of biological membranes. Three-dimensional structure of the cell.
Laboratory lesson 3. Features of the phylogeny of prokaryotes and eukaryotes. Metabolism, the role of the cell membrane in this process. Structure of biological membranes. Three-dimensional structure of the cell.
Summary of the practical lesson. The origin of eukaryotes is the theory of symbiogenesis. General characteristics of membranes. Structure and composition of membrane membranes and their role in metabolism and energy. Transport of substances through membranes. Transmembrane signal transmission. The role of membranes in the regulation of metabolism, transport of substances into the cell and removal of metabolites. Molecular mechanisms of action of hormones and other signaling molecules on target organs. The main methods of transfer of substances through membranes. The main components and stages of transmembrane signal transmission of hormones, mediators, cytokines, eicosanoids. Three-dimensional structure of the cell skeleton and its role in the functional specialization of the cell.
Independent work: development of multimedia presentations on the topic of the lesson.

Topic 4. Universality of building and functional blocks at the molecular level of biological systems organization
Laboratory lesson 4. Universality of building and functional blocks at the molecular level of biological systems organization
Summary of the practical lesson. Characteristics of proteins. Species-specific proteins. Functions of proteins. Amino acid composition of proteins. Structural organization of proteins: primary, secondary, tertiary and Quaternary structures. the α Helix and β structure of a protein. Protein biosynthesis. Stages of biosynthesis. The process of formation of the spatial structure of protein-folding. Molecular chaperones. Degradation of proteins in the cell.
Independent work: methods of molecular genetics (Abstract – methods used in molecular genetics: RNA expression matrices, nucleic acid hybridization, gene and DNA cloning, production of proteins using recombinant DNA molecules, primers corresponding to known genes, recombinant DNA molecules, detection of mutations with obligatory sequencing, segments occupied by them, analysis of images of fluorescent labeled nucleotides, RNA isolation, detection of mutations, genome correction, DNA sequencing).

Topic 5. Colloquium " Cell as an integral, dynamic system»
Laboratory lesson 5. Written test control of knowledge on the basis of test items containing theoretical questions and problems in molecular biology.

Section 2. Molecular biology of nucleic acids

Topic 6. Nucleic acids: the structural organization of DNA. Chemical structure and spatial organization of DNA, stabilizing interactions in structures. dna polymorphism. Nuclear, extragerii, transposome DNA.
Viral DNA. Heterocomplexes with DNA.
Lecture 3. Three-dimensional structure of nucleic acids.
Question 1. DNA replication, the concept of replication. The types of DNA.
Summary of 1 question. Methods used in molecular biology. Nucleic acids - history of discovery, evidence of the genetic role of nucleic acids. Macromolecular structure of DNA. Polymorphism of the double helix. Structure and functions of RNA. The types of RNA. The types of DNA. DNA replication. Proteins and enzymes involved in DNA replication (DNA polymerase, DNA primase,

DNA ligase, DNA helicase), the SSB proteins. Replication steps. Replication of telomeric chromosome regions. Examples.
Question 2. DNA repair.
Summary 2 questions. Types of DNA damage. Methods of DNA repair. Examples.
Question 3. RNA world, RNA types, RNA interference.
Summary of 3 questions. The concept of the RNA world as the pre-biological phase of the formation of life. Classification of RNA. RNA interference as a way to regulate transcription activity. Examples.
Laboratory lesson 6. Nucleic acids: the structural organization of DNA. Chemical structure and spatial organization of DNA, stabilizing interactions in structures. dna polymorphism. Nuclear, extragerii, transposome DNA.
Summary of the practical lesson. Nucleic acids - history of discovery, evidence of the genetic role of nucleic acids. Macromolecular structure of DNA. Polymorphism of the double helix. Structure and functions of RNA. The types of RNA. Matrix syntheses. DNA replication. Proteins and enzymes involved in DNA replication (DNA polymerase, DNA primase, DNA ligase, DNA helicase), the SSB proteins. Replication steps. Replication of telomeric chromosome regions. Transcription. Transcription regulation. Transcript processing.
Independent work: preparation of multimedia presentations on the topic of the lesson.

Topic 7. Organization of chromosomes and biological functions of DNA
Lecture 4. Three-dimensional functional organization of DNA in a cell.
Question 1. The regulation of processes of the expression of DNA.
Summary of 1 question. The structure of the genome of eukaryotes. Unique sequences. Genes encoding proteins, regulatory elements of genes. Tandem repeats. Mini and microsatellites.
Question 2. The concept of epigenome.
Summary 2 questions. Mobile genetic elements of eukaryotes. The program "human Genome". DNA methylation. Genomic imprinting.
Laboratory lesson 7. Organization of chromosomes and biological functions of DNA
Summary of the practical lesson. Coding, storage and transmission of hereditary information. Differences between the genomes of the nucleus and mitochondria. Three-dimensional organization of the genome. The definition of a gene. Differences in gene structure in Pro-and eukaryotes. Replication processes. The concept of replication machines and translation machines.
Independent work: preparation of multimedia presentations on the topic of the lesson.

Topic 8. Solving problems in molecular biology

Topic 9. DNA repair. Mechanisms of mutations. Molecular basis of genetic recombination. Splicing, its types, role in the immune response.
Summary of the practical lesson. The causes and mechanisms of DNA damage. DNA repair processes, their molecular support. MRNA splicing and its types. Alternative splicing on the example of selection of antibodies to antigen.

Topic 10. Structural organization of RNA. Functions and variety of RNA. RNA structures and their stabilization. MRNA transcription and processing. Genetic code. Transcription and processing of tRNA. The structure and functions of rRNA.
Lecture 5. Transcription, the concept of transcriptome and replication.
Question 1. DNA polymerase, DNA revertase. Proteins are transcription assistants. Organization of replication. Three-dimensional cooperative interaction of active and inactive genome regions.
Summary of 1 question. Classification and three-dimensional structure of polymerases. SSB proteins are their role in transcription. Three-dimensional structure of the genome. Replication and transcription machines.

Laboratory lesson 10. Structural organization of RNA. Functions and variety of RNA. RNA structures and their stabilization. MRNA transcription and processing. Genetic code. Transcription and processing of tRNA. The structure and functions of rRNA.
Summary of the practical lesson. RNA world. Cage, as the environment of existence of RNA. Classification of RNA, the concept of RNA and PH ohms. Three-dimensional RNA structure, single- and double-stranded RNA. The stability of the RNA. Functions of different types of RNA. RNA interference. The epigenome.
Independent work: preparation of multimedia presentations on the topic of the lesson.

Topic 11. Main directions of applied molecular biology: genetic engineering. Methods of genetic engineering. DNA restriction, nucleic acid hybridization, cloning. Chemical synthesis of the gene. Genetic transformation. Construction of microbial cells.
Laboratory lesson 11. Main directions of applied molecular biology: genetic engineering. Methods of genetic engineering. DNA restriction, nucleic acid hybridization, cloning. Chemical synthesis of the gene. Genetic transformation. Construction of microbial cells. Obtaining transgenic organisms.
Summary of the practical lesson. Genetic engineering is the sum of techniques that allow genes to be transferred from one organism to another. Construction of new biological objects. Preparation of transgenic organisms (GMO) for pharmacy and diagnostics in medicine. Artificial insemination and multiple conception. The problem of introducing the desired gene into the desired group of eukaryotic cells.
Independent work. Preparation of multimedia presentations.

Topic 12. Colloquium " structure and functions of nucleic acids»
Laboratory lesson 12. Written test control of knowledge on the basis of test items containing theoretical questions and problems in molecular biology.

Section 3. Molecular biology of proteins

Topic 13. Translation. Differences of translational mechanisms in Pro-and eukaryotes.
Lecture 6. Translation. The concept of proteome.
Question 1. Ribosomal genes, tRNA genes, histone genes.
Summary of 1 question. Three-dimensional structure of ribosomes. The evolution of the mechanisms of translation and ribosomes. Conservative and nonconservative genes and proteins. Classification of histone proteins.
Question 2. Splicing and its types. The role of alternative splicing in lymphocyte training. The concept of "pathological" protein markers.
Summary 2 questions. Differences in the formation of information RNA in Pro-and eukaryotes. Maturation of RNA information in prokaryotes. Mechanisms of classical and alternative splicing. Recombinant genome reading. The crisis of the concept of the gene.
Question 3. Proteome Pro-and eukaryote.
Summary of 3 questions. Genetic and protein markers of pathological processes. The concept of the proteome and the metabolome. Predictive medicine.
Laboratory lesson 13. Translation. Differences of translational mechanisms in Pro-and eukaryotes.
Summary of the practical lesson. The structure of the genome of eukaryotes. Unique sequences. Genes encoding proteins, regulatory elements of genes. Ribosomal genes, tRNA genes, histone genes. Tandem repeats. Mini - and microsatellites. Stages of transcription (initiation, elongation, termination), the differences in the process of transcription in Pro - and eukaryotes.
Independent work: preparation of multimedia presentations on the topic of the lesson.

Topic 14. Posttranslational protein modification and folding. Mechanisms of storage and removal of proteins that have lost their functionality. Prions and amyloids

Lecture 7. Posttranslational protein modification and folding. Mechanisms of storage and removal of proteins that have lost their functionality. Prions and amyloids.
Question 1 Classification of posttranslational modification of proteins. Splicing of the protein.
Short content 1voprosa. Enzymatic and non-enzymatic posttranslational modification of proteins. Protein splicing as an example of protein autocatalysis in the formation of native structure.
Question 2. Folding and pathological folding of protein.
Summary 2 questions. Spontaneous and adjustable protein folding. Heat shock proteins-chaperones and chaperonins. Molten globule. Enzymes of protein folding.
Question 3. Ubiquitarian and smallerone proteins. Prions and amyloids.
Summary of 3 questions. Tagging proteins that have lost their functionality. The role of proteasomes in the mechanisms of protein removal from cells. Prioritaria proteins and formation of amyloid as an example of supramolecular interaction with the formation of nanostructures with pathological features.
Laboratory lesson 14. Posttranslational modification of proteins, the processes of storing and removal of proteins. Prions. Amyloids.
Summary of the practical lesson. The concept of post-translational protein modification of its species. Bioregulatory functions and pathogenetic role of Ubiquitin proteolysis - proteasome pathway of protein breakdown. The role of chaperones in proteolysis. Proteasomes. ATP-dependent proteolysis. Misfolding on the example of amyloid and prions. Biological functions of amyloids.
Independent work. Preparation of multimedia presentations.

Topic 15. Apoptosis and oncogenesis processes.
Lecture 8. Apoptosis and oncogenesis.
Question 1. Apoptosis.
Short content 1voprosa. The role of apoptosis in the formation of tissues, organs and body. The ratio of apoptosis and proliferation as a cause of pathology and aging. Physiological and activated apoptosis, its differences from cell necrosis. Supramolecular processes of formation of supramolecular structures of apoptosis, the role of caspases and protein p53.
Question 2. Oncogenes.
Summary 2 questions. Genetic and protein markers of oncogenesis. Types of oncogenes and their classification. The role of heat shock proteins in the mechanisms of oncogenesis.
Laboratory lesson 15. Apoptosis and oncogenesis processes.
Summary of the practical lesson. Apoptosis as a process of programmed cell death, its role in pathological processes and aging. Balance of proliferative and apoptotic processes. Violation of apoptosis, as the cause of the formation of clones of cancer cells. Oncogenes and anti-oncogenes. P53 protein as a target of oncogenes action. Tumor markers. Mobile genetic elements of eukaryotes. The program "human Genome".
Independent work. Preparation of multimedia presentations.
Topic 16. Colloquium "Molecular biology of proteins»
Laboratory lesson 16. Written final test control of knowledge on the basis of test items containing theoretical questions and problems in molecular biology.