**AL-FARABI KAZAKH NATIONAL UNIVERSITY**

**Medicine and Health Care Faculty**

**Higher School of Medicine**

**Department of Fundamental Medicine**

**METHODOLOGICAL INSTRUCTIONS FOR PRACTICAL LESSONS**

**by discipline** **«Molecular Biology and Bioorganic Chemistry»**

**(5 credits)**

**Practical lesson 1.**

**Topic: Introduction to molecular biology. Part I**

**Content:** History and subject of molecular biology. Nucleotides and nucleic acids

*Maximal point: 3*

**Learning outcomes:**

1. Describe the Chargaff, Griffith, Avery-MacLeod-McCarty, Hershey-Chase experiments and explain their significance.

2. Explain informational properties of macromolecules.

3. Explain the central dogma of molecular biology.

4. Briefly discuss the role of molecular biology in medicine.

5. Describe, identify and draw the components of nucleosides and nucleotides.

6. Characterize and describe the chains of nucleic acids in DNA and RNA.

**Practical lesson 2.**

**Topic: Introduction to bioorganic chemistry.**

**Content:** The nature of organic molecules. Families of organic molecules: functional groups. Chemical structure and bonding. Structural theory of organic compounds. The structure of atoms. The nature of the chemical bond. Bonds in carbon compounds (hybridization). Classification of organic compounds. Nomenclature of organic compounds. Isomerism. The IUPAC nomenclature.

*Maximal point: 2*

**Learning outcomes:**

1. Describe the general structural characteristics of organic molecules, in particular, the tetravalent nature of carbon and the various ways in which it manifests.

2. Define the functional groups of atoms in organic molecules and give examples.

3. Describe the differences between structural (constitutional) isomers and isomers of functional groups.

4. Write the structures of organic molecules in various ways.

5. Classify organic compounds.

6. Name the organic compounds in accordance with the IUPAC nomenclature system, and also derive their structures from the given names.

7. Make structural, condensed, and linear formulas for simple organic compounds.

8. Convert any structural, condensed, or linear formula into its corresponding alternative.

**Practical lesson 3.**

**Topic: Introduction to molecular biology. Part II**

**Content:** Replication of DNA. Hypothetical DNA replication mechanisms: conservative, semi-conservative, dispersive. Enzymology of replication. Molecular bases of DNA biosynthesis.

*Maximal point: 3*

**Learning outcomes:**

1. Describe the three hypotheses of DNA replication.

2. Describe the Meselson-Stahl experiment and explain its significance.

3. Explain the molecular mechanism of semiconservative DNA replication.

4. Explain the role of main enzymes implicated in the replication process.

5. Explain proofreading mechanisms and error correction during DNA replication.

**Practical lesson 4.**

**Topic: Safety in the chemical laboratory.**

Introduction to safety procedures in the laboratory. Familiarization with basic chemical dishes and equipment.

*Maximal point: 2*

**Learning outcomes:**

Be able to properly and safely plan and conduct laboratory work, it is easier to assess risks and safety.

**Practical lesson 5.**

**Topic: Transcription of genetic information**

**Content:** Structure of gene: promoter, exons, introns, terminator. Enzymology of transcription. Mechanism of gene transcription: initiation, elongation, termination. Post-transcriptional maturation of mRNA: 3 'polyadenylation, 5 'capping, cutting out introns.

*Maximal point: 3*

**Learning outcomes:**

1. Define the terms: transcription, promoter, enhancer, terminator.

2. Describe prokaryotic and eukaryotic RNA-polymerases' structure and functions.

3. Describe phases of transcription, explain the processes happening at each phase and their importance.

4. Explain the process, importance and difference of Rho-independent and Rho-dependent termination of transcription.

5. Explain the mechanism of polyadenylation, its importance.

6. Describe the structure of the cap fragment, its synthesis and functions.

7. Describe the splicing mechanism and its meaning.

8. Explain the effect of splicing on gene expression.

**Practical lesson 6.**

**Topic: Hydrocarbons (Alkane, Cycloalkane, Alkene).**

**Content:** Classification (saturated, unsaturated). Configurations and shapes of molecules. Alkanes, cycloalkanes. Properties of alkanes; reactions of alkanes, alkenes and alkynes. Names of alkenes and alkynes. Structure of alkenes: cis-trans-isomerism. Properties of alkenes and alkynes. Reactions of addition of alkenes. Alkene polymers.

*Maximal point: 2*

**Learning outcomes:**

1. Name the hydrocarbons according to the IUPAC nomenclature system.

2. Name and write the structural isomers of alkanes, alkenes, and alkynes.

3. Describe the differences in the physical and chemical properties of alkanes, alkenes, alkynes and aromatic hydrocarbons.

4. Describe the physical properties and basic reactions of alkanes.

5. Draw the isomeric products formed by the halogenation of simple alkanes.

6. Name the cycloalkane by its structure and draw the cycloalkane by its name.

8. Name the functional groups present in the alkenes and alkynes.

9. Explain the differences between saturated and unsaturated molecules.

10. Name a simple alkene or alkyne, given its condensed or linear structure.

11. Draw a condensed or linear structure of an alkene or alkyne by name.

12. Draw and name the cis-trans isomers of alkenes.

13. Predict the products of addition to the alkenes H2, Cl2, HCl and H2O.

14. Define "unsymmetrically substituted" and "symmetrically substituted" alkenes.

15. Apply the Markovnikov rule, describing the addition reactions to unsymmetrically substituted alkenes.

16. Predict what polymer forms the alkene monomer gives.

17. Explain the preliminary laboratory techniques of organic chemistry.

18. Be able to apply practical chemical methods.

19. Develop experimental skills and research potential.

20. Give the name according to the IUPAC system and the rational nomenclature of alkanes.

**Practical lesson 7.**

**Topic: Translation of genetic information**

**Content:** Structure of ribosome: rRNA and ribosomal proteins. Genetic code: properties and key experiments. tRNA, aminoacyl-tRNA synthetase. Mechanism of translation: initiation, elongation, termination.

*Maximal point: 3*

**Learning outcomes:**

1. Explain the ribosome cycle and fidelity of translation.

2. Define the genetic code, tRNA, mRNA, codon, anticodon.

3. Describe the structure of tRNA and the mechanism of its charging.

4. Explain the scanning model of translation.

5. Explain the mechanism of translation and its phases.

6. Describe the structure of ribosomes and polysomes.

**Practical lesson 8.**

**Topic: Hydrocarbons. Alkadiene. Alkyne.**

**Content:** Alkynes, alkadiene. Properties of alkynes and alkadienes. Names. Structure: cis-trans-isomerism. Properties and Reactions.

*Maximal point: 2*

**Learning outcomes:**

1. Name the hydrocarbons according to the IUPAC nomenclature system.

2. Name and write the structural isomers of alkynes, alkadienes.

3. Describe the differences in the physical and chemical properties of alkynes, alkadienes.

4. Describe the physical properties and basic reactions of alkynes, alkadienes.

5. Draw the isomeric products formed by the halogenation of simple alkynes, alkadienes.

6. Name the functional groups present in the alkenes and alkynes.

7. Explain the differences between saturated and unsaturated molecules.

8. Draw a condensed or linear structure of an alkene or alkyne by name.

9. Draw and name the cis-trans isomers of alkadienes.

10. Predict the products of addition to the alkadienes H2, Cl2, HCl and H2O.

11. Explain the preliminary laboratory techniques of organic chemistry.

12. Be able to apply practical chemical methods.

13. Develop experimental skills and research potential

**Practical lesson 9.**

**Topic: Post-translational protein modifications and folding.**

**Content:** Posttranslational modification of protein. Folding of protein: chaperones

*Maximal point: 3*

**Learning outcomes:**

1. Draw a functional connection between primary structure and higher-order spatial organization of polypeptides.

2. Explain the auxiliary role of chaperones in protein folding.

3. Give detailed examples of human disorders linked with protein misfolding.

**Practical lesson 10.**

**Topic: Halogenated hydrocarbons.**

*Maximal point: 2*

**Learning outcomes:**

1. Describe the structural differences of halogenated hydrocarbons.

2. Write systematic names for simple halogenated hydrocarbons.

3. Classify halogenated hydrocarbons as primary, secondary, and tertiary.

4. Describe the chemical properties of halogenated hydrocarbons.

5. Predict the obtained products

6. Describe the physical properties of halogenated hydrocarbons.

**Practical lesson 11.**

**Topic: Regulation of gene expression in prokaryotes and eukaryotes**

**Content:** Gene structure in prokaryotes. Bacterial operons: lac, ara, trp, gal. Gene structure in eukaryotes. Regulation of transcription: transcription factors.

*Maximal point: 3*

**Learning outcomes:**

1. Define the terms: operon, cistron, promoter.

2. Explain the functioning and regulation of the following operons: lac, ara, trp, gal.

3. Explain positive and negative controls of operons.

4. Differentiate between constitutive and inducible promoters.

5. Explain the mechanism of transcription regulation in eukaryotes.

6. Describe the structure of the promoter: TATA-box, GC-box.

7. Explain the functions of enhancers and silencers.

8. Describe the role of transcription factors and activators in the regulation of transcription

9. Describe the structure and significance of DNA-binding domains and transcription activation domains.

10. Compare translation regulation in pro- and eukaryotes.

**Practical lesson 12.**

**Topic: Aromatic compounds.**

**Content:** Aromatic compounds. Aromatic compounds and structure of benzene. The name of the aromatic compounds. Reactions of aromatic compounds. Properties, nomenclature, chemical reactions.

*Maximal point: 2*

**Learning outcomes:**

1. Name and write the structures of the aromatic compounds.

2. Explain the importance and function of resonance in aromatic compounds.

3. Name simple monosubstituted or disubstituted aromatic compounds.

4. Predict the products of the interaction of aromatic compounds with concentrated acids and halogens: HNO3, Cl2, Br2 and H2SO4.

5. Define and name the aromatic compounds by their structure, explain the value of resonance and aromaticity.

6. Explain the Hückel rule.

**Practical lesson 13.**

**Topic: Mutations**

**Content:** Mutations: gene, chromosomal, genomic. Hereditary diseases. The value of mutations for the evolution of living nature. Colloquium 1

*Maximal point: 34*

**Learning outcomes:**

1. Explain what a mutation is and its importance for the evolution of life.

2. Classify and characterize the main types of mutations.

3. Define the terms: deletion, insertion, inversion, duplication, translocation, and explain what type of mutation each term belongs to and why.

4. Give specific examples of hereditary diseases.

**Practical lesson 14.**

**Topic: Alcohols, phenols, and esters. Properties of hydroxy compounds.**

**Content:** Alcohols, phenols, esters. Properties of alcohols, phenols, and esters. Reactions of alcohols, phenols, and esters. Colloquium 1

*Maximal point: 29*

**Learning outcomes:**

1. Describe the structural differences between alcohols, phenols, and esters.

2. Explain why alcohols have higher boiling points than compounds of similar molecular weight.

3. Write systematic names for simple alcohols.

4. Draw the alcohol structure by name in condensed and linear format.

5. Classify alcohols as primary, secondary, and tertiary.

6. Define and give examples of glycols.

7. Describe the chemical properties of alcohols.

8. Describe the hydrophobic and hydrophilic alcohols.

9. Predict the products obtained by dehydration of alcohol.

10. Predict the oxidation products of primary, secondary and tertiary alcohol.

11. Explain why alcohols and phenols are weak acids.

12. Define and explain the differences between esters and alcohols.

**Practical lesson 15.**

**Topic: DNA repair.**

**Content:** Sources of DNA damage in the cell. Enzymology of DNA repair. Repair of single-strand damage: excisional repair of nucleotides, excisional repair of bases, repair of mismatched bases. Repair of double-stranded damage: homologous recombination, non-homologous end joining.

*Maximal point: 3*

**Learning outcomes:**

1. List and describe the sources of DNA damage in the cell.

2. Explain the significance of DNA repair.

3. Explain the mechanisms of base excision, nucleotide excision, homologous recombination, non-homologous end joining modes of repair.

**Practical lesson 16.**

**Topic: Aldehydes and ketones.**

**Content:** Carbonyl group. Names of simple aldehydes and ketones. Properties of aldehydes and ketones. Some common aldehydes and ketones. Oxidation of aldehydes. Reduction of aldehydes and ketones. Addition of alcohols: semi-acetal and acetal.

*Maximal point: 2*

**Learning outcomes:**

1. Describe the carbonyl group, its polarity, shape, and chemical properties.

2. Name and draw simple aldehydes and ketones.

3. Describe the polarity, hydrogen bonds, and water solubility of aldehydes and ketones.

4. Describe the reactions and reduction products of aldehydes and ketones.

5. Explain the differences between hemiacetals and hemiketals, acetals and ketals.

6. Name and draw hemiacetals, hemiketals, acetals, and ketals and predict their hydrolysis products.

**Practical lesson 17.**

**Topic: Epigenetics.**

**Content:** Significance of epigenetic regulation of gene expression. Mechanisms of epigenetic regulation: DNA methylation, RNA interference. Mechanisms of epigenetic regulation: histone modifications, histone variants.

*Maximal point: 3*

**Learning outcomes:**

1. Explain the importance of epigenetic regulation and its role in heritability of cellular traits.

2. Explain the role of DNA methylation in regulation of gene expression.

3. Explain the mechanism of RNAi.

4. Describe chromatin structure at the levels of organization: nucleosome, 30-nm fiber, chromosome.

5. Explain the effects of histones on transcription.

6. Explain how transcription is affected by: nucleosome positioning, histone acetylation and methylation, chromatin remodeling.

7. Describe the mechanisms and major players of above-mentioned processes.

**Practical lesson 18.**

**Topic: Carboxylic acids and their derivatives. Properties of carbonyl containing compounds.**

**Content:** Carboxylic acids and their derivatives: properties and names. The acidity of carboxylic acids. Reactions of carboxylic acids: formation of esters and amides. Hydrolysis of esters and amides. Polyamides and polyesters. Phosphoric acid derivatives.

*Maximal point: 2*

**Learning outcomes:**

1. Compare and contrast the structures, reactions, hydrogen bonds, water solubility, boiling points, and acidity or basicity of carboxylic acids, esters, and amides.

2. Name simple carboxylic acids, esters, and amides by their structure, and vice versa, write the structure by the name of these substances.

3. Describe the acidity of various carboxylic acids and predict the products of their reactions with strong bases.

4. Describe how esters and amides are formed from carboxylic acids.

**Practical lesson 19.**

**Topic: Intracellular signaling.**

**Content:** Intracellular signaling pathways. Membrane receptors. Secondary intermediaries. Cytoplasmic and nuclear receptors.

*Maximal point: 3*

**Learning outcomes:**

1. Give the definition of intracellular signaling (signal transduction).

2. Classify and characterize membrane cell receptors, give specific examples.

3. Describe and provide examples of secondary intermediaries.

4. Predict the signaling pathways when the cell is exposed to insulin and thyroid hormone, steroid hormones.

5. Characterize the cytoplasmic and nuclear receptors.

6. Give examples of signaling pathways when a cell is exposed to steroid hormones.

**Practical lesson 20.**

**Topic: Heterocyclic compounds.**

**Content:** Heterocyclic compounds. Structure. The name of the heterocyclic compounds. Properties, nomenclature, chemical reactions, and the role of heterocyclic compounds.

*Maximal point: 2*

**Learning outcomes:**

1. Name and write the structures of the heterocyclic compounds.

2. Explain the importance and function of heterocyclic compounds.

3. Name simple heterocyclic compounds.

4. Describe the chemical properties of heterocyclic compounds.

5. Predict the possible products of chemical reactions of heterocyclic compounds.

6. Describe the nomenclature, structure, and properties of heterocyclic compounds.

**Practical lesson 21.**

**Topic: Cell differentiation and development of a multicellular organism.**

**Content:** Differentiation. Morphogenesis. Ontogenesis. Stem cells. Totipotency. Pluripotency. Aging mechanisms of the body.

*Maximal point: 3*

**Learning outcomes:**

1. Give the definitions to the following terms: cell differentiation, morphogenesis, embryogenesis, ontogenesis, stem cells, totipotency, pluripotency.

2.Explain how the level of expression of various genes changes during cell differentiation and at different stages of development of a multicellular organism.

3. Describe the use of stem cells in medicine and cosmetology, analyze the advantages and disadvantages of these methods.

4. Analyze the various theories of aging in the body and the possible relationship of the aging process with stem cells and molecular biological processes.

**Practical lesson 22.**

**Topic: Amines and amino acids.**

**Content:** Classification of amines. Name and structure of amines. Properties of amines. Heterocyclic nitrogen compounds. Basicity of amines. The amine salt. Acid-base properties of amino acids.

*Maximal point: 2*

**Learning outcomes:**

1. Draw the structures of twenty protein α-amino acids and their side chains.

2. Define and classify amines as primary, secondary, or tertiary.

3. Name simple amines by their structure or draw amines by their name.

4. Describe the properties of amines, such as hydrogen bonding, solubility, boiling point, and basicity.

5. Define the quaternary ammonium ion and describe its physical and chemical properties.

6. Explain what is meant by α-amino acids, isoelectric point for amino acids, L-configuration for natural amino acids, and the "zwitter-ionic" nature of amino acids.

**Practical lesson 23.**

**Topic: Molecular and genetic basis of immunity.**

**Content:** Major histocompatibility complex. Humoral and cellular immunity. Antibodies. Cytokines, interferons and the complement system.

*Maximal point: 3*

**Learning outcomes:**

1. Describe the main histocompatibility complex and its role in human immunity.

2. Explain what humoral and cellular immunity is.

3. Classify and characterize proteins involved in humoral and cellular immunity.

4. Describe congenital and acquired disorders of human immunity.

**Practical lesson 24.**

**Topic: Peptides and proteins.**

**Content:** Classification of proteins, simple and complex proteins. Protein and its structures. Chemical properties of proteins. The peptide bond and the primary structure of proteins. The secondary structure of the protein, the α-helix, the folded β-structure, the coils and loops of the polypeptide chains. Tertiary structure of protein, principles, structural and functional units and quaternary structure, functions of proteins.

*Maximal point: 2*

**Learning outcomes:**

1. Describe the different functions of proteins and give an example for each function.

2. Define the peptide bond and explain how it is formed.

3. Draw and name the oligopeptide by its amino acid sequence.

4. Find the amide and carboxyl end of the amino acid sequence by its chemical structure.

5. Define the primary structure of the protein and explain how the primary structures are written and depicted.

6. Describe the flat sections of the primary sequence, their effect on the shape of the protein backbone, and find these sections using the drawing of the primary sequence.

7. Give an example of how changing the primary sequence can change the function of a protein.

8. Define the secondary structure, the α-helix and β-sheet, give an example of a protein that consists of α-helices, and a protein that contains β-sheets.

9. Describe the specific hydrogen bond responsible for the formation of the secondary structure of the protein.

10. Explain the differences and functions of fibrous and globular proteins.

**Practical lesson 25.**

**Topic: The human genome. Part I**

**Content:** History of the Human Genome Project. The structure of the human genome: protein-coding genes and non-coding DNA. Satellite DNA. Tandem repeats. Single nucleotide polymorphisms (SNP). Transposed elements of the genome: transposons, retrotransposons.

*Maximal point: 3*

**Learning outcomes:**

1. Describe the structure of the human genome: protein-coding genes, intergenic regions (spacers), satellites, tandem repeats, single nucleotide polymorphisms (SNPs).

2. Explain the role of non-coding DNA in the human genome.

3. Discuss the prospects for applying knowledge about the human genome in medicine and pharmaceuticals.

4. Describe DNA transposons, retrotransposons, retroviral integration.

5. Provide examples of human diseases triggered by transposable elements.

6. Discuss the usage of transposable elements in medicine.

**Practical lesson 26.**

**Topic: Carbohydrates.**

**Content:** Introduction to carbohydrates. The value of carbohydrates and the Fischer projection. The structure of glucose and other monosaccharides. Some important monosaccharides, monosaccharide reactions. Common disaccharides. Some important glucose-based polysaccharides. Qualitative analysis of carbohydrates.

*Maximal point: 2*

**Learning outcomes:**

1. Classify carbohydrates by functional group and number of carbon atoms, give examples.

2. Draw the D-and L-enantiomers and any diastereomers of the monosaccharides in the Fischer projection.

3. Draw the Fischer projection for the given monosaccharide.

4. Convert the five-and six-carbon monosaccharides from the Fischer projection to the Haworth projection.

5. Find the anomeric carbon atom and the α-or β-form of the monosaccharide and describe the role of mutarotation in the cyclic structure.

6. Give the names and structures of the most common monosaccharides, describe their sources and use.

7. Predict the products of the oxidation and reduction reactions of monosaccharides.

8. Predict the reaction products between monosaccharides and alcohols.

9. Predict the products of polysaccharide hydrolysis reactions and monosaccharide phosphorylation reactions.

10. Predict the results of some common reactions of simple carbohydrates, such as oxidation, reduction, osazone formation, etc.

11. Describe the formation of a glycosidic bond as a type of dehydration reaction.

12. Give the names and structures of the most common disaccharides, their components, and the relationship between them, describe the sources of these disaccharides and their use.

13. Name and describe common polysaccharides, their natural sources, and functions.

14. Describe the monomers of these polysaccharides and the type of chemical bond between them in each polysaccharide.

15. Name and describe the modified monosaccharides found in natural polysaccharides and determine the functions of these polysaccharides.

**Practical lesson 25.**

**Topic: The human genome. Part II**

**Content:** Methods for the study of nucleic acids and proteins. Proteomic methods of analysis. Bioinformation databases. DNA diagnostics: polymerase chain reaction, restriction analysis, FISH hybridization. Linked immunosorbent assay. Bioethics of genetic experiments with humans.

*Maximal point: 3*

**Learning outcomes:**

1. Give the definitions of genomics, proteomics, and bioinformatics, describe their research methods.

2. Explain the Sanger, Maxam-Gilbert, NGS (New Generation Sequencing) and other methods of genome sequencing.

3. Characterize and analyze the main methods of protein research: two-dimensional gel electrophoresis, mass spectrometry, chromatography, X-ray structural analysis, nuclear magnetic resonance.

4. Describe EMBL-EBI, DDJB, NCBI, PIR, MIPS, NBRF, SwissProt, UniProt and other bioinformatical databases.

5. Give the definition of molecular diagnostics and describe its various methods.

6. Explain the reasons for choosing different methods of molecular diagnostics to detect different types of hereditary diseases (gene, chromosomal and genomic), infectious diseases and metabolic diseases, give specific examples.

7. Discuss the ethics of conducting genetic and molecular biological experiments on humans.

**Practical lesson 28.**

**Topic: Lipids.**

**Content:** Structure and classification of lipids, their biological function. Fatty acids and their esters. Properties of fats and oils. Chemical reactions of triacylglycerols. Phospholipids, glycolipids, and sterols.

*Maximal point: 2*

**Learning outcomes:**

1. Describe the chemical structure and general properties of fatty acids, waxes, sterols, fats, and oils.

2. Describe the characteristics of fatty acids and fatty acid esters.

3. List the physical properties of fats and oils and explain how they differ.

4. Describe the reactions of hydrogenation and hydrolysis of triacylglycerols, give the reagents and reaction products.

5. Define phospholipids and glycolipids, describe their chemical structure and functions.

6. Define sterols and their derivatives and describe their structure and functions.

**Practical lesson 29.**

**Topic: Molecular biomedicine. Colloquium 2.**

**Content:** The use of genetic engineering in the production of vaccines and drugs. Genome Editing Technologies (CRISPR-Cas9). *Ex vivo* and *in vivo* gene therapy. Technologies for targeted delivery of drugs and gene therapy vectors: liposomes, dendrimers, aptamers, nanoparticles, genetically modified viruses, etc. Quantum dots. Prospects for the use of nanorobots in medicine. Pharmacogenomics. Pharmacogenetics.

*Maximal point: 31*

**Learning outcomes:**

1. Describe recombinant DNA technology.

2. Discuss about perspectives and dangers of creating the genetically modified organisms.

3. Describe the use of genetic engineering in the production of vaccines and drugs.

4. Explain the principles of CRISPR-Cas9 technology.

*5.* Explain what gene therapy is ex vivo and in vivo, analyze the problems and prospects of genomic technologies in medicine.

6. Give definitions of nanotechnology and bionanotechnology.

7. Describe and provide examples of various bionanotechnologies for targeted delivery of drugs and gene therapy vectors into the cells of the human body.

8. Analyze bionanotechnological methods for the diagnosis and treatment of cancer: quantum dots, magnetic and radioactive nanoparticles, etc.

9. Analyze the prospects for the use of nanorobots in biomedicine.

10. Give definitions and explain the difference between the term’s "pharmacogenomics", "pharmacogenetics", "personalized medicine".

11. Explain how a hereditary predisposition can affect the individual reactions of the human body to drugs and dietary supplements, give specific examples.

**Practical lesson 30.**

**Topic: Recap lesson by bioorganic chemistry. Colloquium 2.**

*Maximal point: 27*

**Learning outcomes:**

1. Explain the principles of classification and nomenclature of organic compounds.

2. Describe the safety rules in the organic chemistry laboratory.

3. Name, classify and write the structure of the main hydrocarbons and their physical and chemical properties and reactions.

4. Describe the main types of reactions of organic substances.

5. Name, classify and write the structure of alcohols, phenols, esters and other hydroxy compounds and their physical and chemical properties and reactions.

6. Name, classify and write the structure of the main aldehydes and ketones and their physical and chemical properties and reactions.

7. Name, classify and write the structure of the main carboxylic acids and their derivatives, as well as their physical and chemical properties and reactions.

8. Name, classify and write the structure of the main aromatic and heterocyclic compounds and their physical and chemical properties and reactions.

9. Explain the stereochemistry and chirality, give examples.

10. Describe, explain, and illustrate the spectral methods of organic chemistry.

11. Name, classify and write the structure of the main amines and 20 α-amino acids and their physical and chemical properties and reactions.

12. Describe and explain the chemical structure and functions of peptides and proteins.

13. Name, classify and write the structure of the main carbohydrates and their physical and chemical properties and reactions.

14. Name, classify and write the structure of the main lipids and their physical and chemical properties and reactions.

**METHODICAL INSTRUCTIONS FOR THE PRACTICAL LESSONS**

**The goal:** to form an understanding of the molecular basis of the functioning of the cell and the organism, regulation of gene expression, the chemical structure, properties, and functions of biologically active compounds in living organisms, which are necessary for further understanding of both normal processes of life activity and their disruption, diseases, including hereditary.

**Learning outcomes:**

1. Explain the structure, isomerism, and nomenclature of biologically active compounds.
2. Describe the physico-chemical properties, the biological role of compounds involved in the processes of vital activity.
3. Demonstrate knowledge of gene biology and mechanisms for implementing genetic information, protein biosynthesis.
4. Apply knowledge of the causes and mechanisms of development of certain changes in the structure and functioning of nucleic acids, especially the expression of genes.
5. Understand the mechanisms of hereditary variability and their role in the formation of human hereditary pathology and congenital malformations.
6. Understand the molecular-genetic and cellular mechanisms of the body's response to drugs and biologically active compounds.
7. Demonstrate the ability to apply the language and knowledge of each discipline to discuss and solve fundamental scientific and clinical problems.
8. Integrate knowledge of the structural and functional characteristics of the genome to solve clinical problems.
9. Demonstrate the ability to identify learning gaps and create strategies to enhance one’s own knowledge and skills.
10. Effectively communicate with other students and teachers regarding medical and scientific information, articulate their opinions clearly when discussing and work effectively as a member of the team.

**Plan of preparation work for each Practical lesson**

1. Familiarize yourself with the basic and additional literature, use textbooks, the syllabus and present directions, Internet resources to prepare for Practical lessons.

2. Be prepared for class and participate actively on case-discussion and problem-solving group activities.

3. Use the examples (in this number cases and your own experience studied before) for illustration of theoretic material.

4. Use different tools for studying, discussion and visualisation of thoughts - drawing,

5. Use the group work with cases for the development of teamwork skills, communication, and problem solving and self-studying.

**Response quality scale (written / oral response)**

|  |  |  |
| --- | --- | --- |
| **Mark** | **Criteria** | **Scale, points** |
| Excellent | 1. all key aspects are included and presented logically;  2. high accuracy (relevance, without redundancy) and constant attention to the issue;  3. excellent integration of theoretical questions;  4. providing relevant examples;  5. in-depth analysis and theoretical justification of the problem (if applicable), all key aspects identified and interpreted;  6. fluency in professional terminology | 90 - 100 |
| Good | 1. all key aspects are included and presented logically;  2. constant focus on the issue with satisfactory accuracy, relevance, and / or some redundancy;  3. satisfactory integration of theoretical questions;  4. the lack of examples;  5. satisfactory analysis and theoretical justification of the problem (if applicable), most of the key aspects identified and interpreted;  6. correct use of professional terminology | 70 - 89 |
| Satisfactory | 1. most of the key aspects are included;  2. satisfactory focus on the question - some errors and / or noticeable redundancy;  3. theoretical problems presented without noticeable integration;  4. Providing failed examples or no examples;  5. some analysis and theoretical justification of this problem (if applicable), most of the key aspects are defined and interpreted;  6. correct use of professional terminology | 50 - 69 |
| Unsatisfactory (FX) | 1. most of the key aspects are omitted;  2. lack of attention to the issue-irrelevant and significant redundancy;  3. some theoretical problems presented without integration and understanding;  4. missing or outdated examples;  5. some analysis and theoretical justification of this problem (if applicable), most of the key aspects are omitted;  6. problems in using professional terminology | 25 - 49 |
| Unsatisfactory (F) | 1. most or all of the key aspects are omitted;  2. no focus on the question, not much related to the issue of information;  3. significant gaps in theoretical questions, or their superficial consideration;  4. the lack of examples or irrelevant examples;  5. there is no analysis and no theoretical justification for the given problem (if applicable), most of the key aspects are omitted;  6. problems in using professional terminology | 0-24 |

**METHODICAL INSTRUCTIONS FOR THE TEAMWORK**

The medical profession involves working in multidisciplinary teams, so these skills are identified as key in the competence of the doctor and other health professionals in all countries.

Therefore, group work is included as an essential component in the practical exercises of our course. In addition, it aims to provide a safe environment in which you can try out new ideas and practices and acquire relevant group skills. These can be tasks for performance in pairs, triples, or small groups of 4-6 people (work with cases, tasks of the ISW, etc.).

When you are working on a project or task in a team, you could use the various strengths of the group members to create a wider and better project or task than if you were working independently.

Group training means you need to share your knowledge and ideas with other students. There are two benefits to this: you need to think carefully about your own ideas to explain them to others, and you expand your own understanding, taking into account the knowledge and ideas of others.

**Interpersonal Communication and Discussion**

Take some time to chat and get to know each of your group mates. The better you know each other and the more convenient you communicate, the more effective you can work together.

Create a culture of mutual respect in your group. You probably had little choice or no choice at all when forming training groups and small teams in the classroom. Therefore, you will have to learn to overcome the differences between people. In addition, you will not have the opportunity to choose employees in the workplace, and at work, you will experience much greater pressure to be a productive member of the team.

For effective communication and discussion in a team: you should not be shy to express your opinion and it is important to feel that these opinions will be heard; it is necessary to feel that all members of the group make a feasible contribution to solving problems, observing agreed rules and plans, performing work efficiently and on time; it is important to know that everyone’s feelings are taken into account by team members, but the goals and objectives of the group are not compromised, in favor of the whims or desires of individual members;

Try to express your opinion and listen to others. There is nothing wrong with disagreeing with your classmates, no matter how confident they are. When you disagree, be constructive and focus on the problem, not the person. Similarly, when someone disagrees with you, respect what he says and the risk that he takes upon himself to express his opinion. Try to find a way that everyone can agree with, and this is not necessarily the opinion of the loudest or smartest member of the team.

Below we provide some examples of constructive and destructive group behavior[[1]](#footnote-1)

Constructive group behavior - a person who:

***Unites*** - interest in the views and opinions of others and willingness to adapt to interest

***Clarifies*** - clearly defines the problems for the group by listening, summarizing, focusing the discussion

***Inspires***- encourages the group, stimulates participation and progress

***Harmonizes*** - stimulates group unity and teamwork. For example, uses humor as a relaxation after difficult situations.

***Take the risk*** - willingness to take risks at the expense of oneself for the success of the group or project

***Manages the process*** - organizes a group on the issues of the process: for example, plan, schedule, timeline, topic, solution methods, and use of information

Destructive group behavior:

*Domination* - takes a lot of time expressing your opinion and views. Trying to take control by capturing energy, time, etc.

*Fussiness* - hastens the group to move quickly before the task is completed. Impatient in listening to other opinions and working together.

*Suspension* - removes itself from a discussion or decision. Opt out

*Ignoring* - does not respect or belittle the ideas and suggestions of the team or individuals. An extreme manifestation of ignoring is an insult in the form of ridicule.

*Distraction* - excessive talkativeness, tells stories and leads groups away from the goal

*Blocking* - prevents group progress by denying all ideas and suggestions. “It will not work because ...”

Effective group work does not arise by itself. A conscious and planned effort is needed, and since many people participate in it, one cannot rely on memory; need to make notes. The following steps will help you and your team work together effectively.

*1. Define clear objectives.* At each stage, you should try to coordinate the tasks. They include a timeline for the project, as well as more specific tasks (such as “agree on an approach to the task before Friday”). Each meeting or discussion should also begin with a specific goal (for example, make a list of tasks that need to be completed). Tasks should be broken down into smaller parts and planned. Sometimes one part cannot be started until the other part is finished, so you may need to draw a simple temporary map.

· Discuss the resources that you have and those that you will need to find.

· Formulate the desired result.

· Consider how you know when you did it well enough?

· Split tasks between the team and

· Set deadlines for subtasks and time for future meetings.

*2. Set the basic rules.* Discussions can become erratic and can prevent more modest group members from participating if you do not have rules to stimulate discussion, resolve disagreements, and make decisions without repetition. Set the rules from the start and change them as needed. For example: an interesting rule that was developed by one group - anyone who missed a meeting would buy the rest of the group coffee in a coffee shop. No one ever missed a meeting after that.

*3. Communicate effectively.* Make sure you regularly communicate with group members. Try to be clear and positive in what you say without repeating.

*4. Find consensus.* People work together most effectively when they work towards a goal with which they have agreed. Make sure everyone has their own opinion, even if you need time to get more participants to say something. Make sure you listen to everyone’s ideas and then try to come to an agreement that everyone shares, and everyone has contributed.

*5. Define the roles.* Divide the work that needs to be done into separate tasks, for which you can use the strengths of individual team members. Define roles for both fulfilling your tasks and for meetings / discussions (for example, Arani is responsible for summarizing the discussions, Joseph is for everyone to express their opinions and make decisions, etc.).

Examples of roles and functions:

*Facilitator* or *leader* (depending on context) - to clarify the goals of the meeting and to summarize the discussions and decisions; ensures that the meeting takes place, continues and the basic rules are respected.

*Secretary* - keep a record of the ideas discussed and decisions made and who does what.

*Time Manager* - to make sure that you discuss everything that you need in the time allotted for the meeting.

*Controller* - to ensure that work is completed by an agreed time, and to solve problems if they are not being performed.

*A process observer* is someone who monitors the process, not the content, and can bring problems to the attention of the team. In this role, it is important to be positive, not condemning.

*Editor* - bring all materials together, identify gaps or matches and ensure consistency in the final presentation.

*6. Make it clear.* When a decision is made, it should be explained in such a way that it is clear to everyone that it was decided, including the time frame.

*7. Keep good notes.* Always summarize the discussions and document the decisions and publish them (for example in WhatsApp or Kaizala chat) so you can always get back to them. This includes lists of those who agreed what to do.

*8. Stick to the plan.* If you agreed to do something as part of the plan, do it. Your group relies on you to do what you agreed to do, and exactly in this way, not in the way you would like. If you think the plan should be reviewed, discuss it.

*9. Keep track of progress and keep up to date*. Discuss progress together regarding your schedule and deadlines. Make sure you meet deadlines personally, so you do not let your group down.

**Co-writing a document / report**

Joint writing is one of the most difficult parts of group work. There are many ways to do this, and your group must decide how to separate the work of writing, comparing, editing, and finalizing your work. Writing in a group (six people crowd around the keyboard) is a recipe for conflict and lack of progress. The other extreme - when one person assumes all responsibility and ultimately does most of the work - is also unproductive and contributes to conflict.

Three approaches are possible when working on a common document:

1 - One person writes the most part - this means that a narrow circle of ideas is used, and the rest of the team does not learn (and will not learn) to write reports and documents.

2 - Each person writes one section - then it is difficult to make a single consistent report, and you will not know about the rest, except for your own section.

3- Co-writing. This is the most productive way to solve group problems and provides the greatest benefit from collaboration. For example: in each section, there is a writer and at least one reviewer, and each team member is the author of a section and a reviewer of another one.

All team members before finalization by **the editor** must review the final product. Alternatively, you can have one author with others, editors, add and review, and someone tidies the finished report.

Try to divide the writing of source documents into tasks and solve them individually or in pairs. After the first draft of the sections are written, send out all the components and read them. You will probably need to come together to discuss how to combine them so that they fit together. Any participants who were not involved in preparing the drafts can do part of this work. Then edit, improve and polish the draft. It’s convenient to collaborate on documents in Google documents.

When preparing a report / final document, regularly check the following:

- Is the purpose of the project clear from the report?

- Are the conclusions or recommendations clear?

- Do conclusions follow from the main part of the report?

- Do sections fit well?

- Does the report achieve goals (and evaluation criteria)?

- Are the necessary components sufficiently covered?

Whatever method you use, all group members must agree on the process and how they are going to maximize the collaborative approach to writing the final document.

**Monitoring team performance and coping**

Below is a checklist that includes a list of common problems that arise in a group work. Use it regularly to identify problems before they get out of hand. If serious problems and tensions arise, use it to determine where something might go wrong. First answer each question about yourself, and then give answer to this **question** about the group. Then gather a group and discuss where, in your opinion, problems may arise, and think about how you can overcome these problems.

Each participant must complete this checklist. You should do this exercise regularly to track and improve your team’s performance.

1. Answer each question regarding your teamwork.

2. Answer each question regarding the rest of the team.

3. Get together with your entire team and discuss where, in your opinion, any problems arise.

4. Discuss what you are going to do to overcome these problems.

**Checklist for self-assessment of team effectiveness.**

|  |  |  |  |
| --- | --- | --- | --- |
| You | I personally | Group as a whole | Comments |
| Effectively clarify your tasks and tasks at each stage? |  |  |  |
| Evaluate the progress of work? |  |  |  |
| We clarify and document everything that the group decided? |  |  |  |
| We clarify who will do what and how? |  |  |  |
| We clarify by what date each task should be done? |  |  |  |
| Setting meeting management rules? |  |  |  |
| Adhere to agreed rules? |  |  |  |
| Listening to each other? |  |  |  |
| Allow some team members to dominate? |  |  |  |
| Allow some team members to refuse / withdraw? |  |  |  |
| We sacrifice personal desires for the success of the team? |  |  |  |
| Recognize the feelings of other team members? |  |  |  |
| Making equal contributions to team progress? |  |  |  |
| Adhere to agreed rules for writing and naming files? |  |  |  |

**Points and Grade**

Group tasks and assignments mean that grades are given to the whole group based on the results of the work of the whole group. Everyone should be interested in ensuring the effective contribution of all members of the group and ensuring the high quality of the assignment. Sometimes, to assess the relative contribution of each to the group process, a form of peer-to-peer or peer review and a team assessment form will be used. This can be used to moderate assignment grades, or simply as a way to give feedback on your work in a group. The following are examples of student assessment criteria for team training.

|  |  |
| --- | --- |
| **№** | **Student assessment criteria in practical classes** |
| 1 | *Preparation for classes:*  He studies information focused on the case and problematic issues, uses various sources, and supports the statements with relevant links. |
| 2 | *Group skills and professional attitude:*  Demonstrates excellent attendance, reliability, responsibility Takes the initiative, takes an active part in the discussion, helps the teammates, willingly takes on tasks |
| 3 | *Communication skills:*  Actively listens, shows emotions according to the situation, is susceptible to non-verbal and emotional signals, shows respect and correctness in relation to others, helps to resolve misunderstandings and conflicts |
| 4 | *Feedback Skills:*  Demonstrates a high level of introspection, critically evaluates oneself and colleagues, provides constructive and objective feedback in a friendly manner, accepts feedback without opposition |
| 5 | *Skills of critical thinking and effective learning:*  Effectively participates in generating hypotheses and formulating problematic questions, gives relevant examples from life, skillfully applies knowledge to the problem / case under consideration, critically evaluates information, draws conclusions, explains and substantiates statements, draws diagrams and drawings, demonstrates a constant interest in the material being studied |
| 6 | *Theoretical knowledge and skills on the topic of the lesson:*  All key aspects are presented logically; accuracy, relevance of answers to the questions posed without redundancy; integration of theoretical issues; Use of relevant examples proper use of professional terminology |

**Basic literature:**

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2. Lodish H. et al. Molecular cell biology. 8th ed. 2016. WH Freeman.
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**Additional literature:**

1. Jenis, J. Study Guide and Practice Tests for Organic Chemistry (Organic Compounds of Aliphatic Series) / Al-Farabi KazNU. Almaty: Qazaq university, 2017.
2. Russell P.J. iGenetics. A molecular approach. 3rd ed. 2009. Pearson.
3. Karp G. Cell and molecular biology. Concepts and experiments. 7th ed. 2013. Wiley.
4. Hartwell L. et al. Genetics. From genes to genomes. 4th ed. 2011. McGraw Hill.
5. Zhussupova A.I. Molecular Biology (Interdisciplinary Approaches in Teaching and Research) / Al-Farabi KazNU. Almaty: Qazaq university, 2016.
6. Kroschwitz J.I. Chemistry: general, organic, biological. New York, 1990.
7. Rastogi V.B. Zubay's principles of biochemistry. New Dehli, 2017.
8. Alagarsamy, V. Textbook of Medicinal Chemistry. New Dehli, 2016.
9. Zhussupova A.I. Modern issues in molecular diagnostics / Al-Farabi. Kazakh National University - Almaty: Qazaq university, 2015.
10. Nazarbekova S.P. Chemistry. - Almaty: Association of Higher Educational Institutions of Kazakhstan, 2016.
11. Jenis J. Chemistry of Natural Compounds / Al-Farabi Kazakh National University. - Almaty: Qazaq university, 2016.

**Internet resources:**

1. Lecturio.com

https://www.lecturio.com

2. “Human Genome” Project https://web.ornl.gov/sci/techresources/Human\_Genome/project/info.shtml

3. NCBI - The National Center for Biotechnology Information, USA https://www.ncbi.nlm.nih.gov/

4. NDB - a portal for three-dimensional structural information about nucleic acids http://ndbserver.rutgers.edu/

5. OMIM - compendium of human genes and genetic phenotypes https://www.ncbi.nlm.nih.gov/omim?db=OMIM

6. Ensembl - Genome browser for vertebrate genomes http://asia.ensembl.org/index.html

7. EMBL-EBI - European Bioinformatics Institute

https://www.ebi.ac.uk/

8. Video lectures by Molecular Biology:

https://www.khanacademy.org/

1. adapted from Brunt (1993): <https://tle.wisc.edu/solutions/engagement/constructive-and-destructive-groupbehaviors> [↑](#footnote-ref-1)