**Al-Farabi Kazakh National University**

***Higher School of Medicine***

*Department of Fundamental Medicine*

**SYLLABUS**

Autumn semester, academic year 2019-2020

**Academic course information**

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| **Discipline’s code** | **Discipline’s title** | **Type** | **No. of hours per week** | **Number of credits** | **ECTS** |
| Lect. | Pract. | Lab. |
| **MBOH1202** | Molecular Biology and Bioorganic Chemistry | CDUC | 0 | 5 | 0 | 5 | 5 |
| **Lecturers** | - | **Office hours** | - |
| **e-mail** | - |
| **Phone number** | - | **Auditorium** | - |
| **Assistants** | Bates Kudaibergenova, PhDIlya Pinskiy, PhD | **Office hours** | According to schedule |
| **e-mail** | ilya.pinskyi@mail.ru  |
| **Phone number** | *+7747-243-1895*  | **Auditorium** | Faculty of Chemistry, auditoria 508 and 512. |

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| **Academic presentation of the course** | **Course type:** core discipline of university component of the module “Biomedicine essentials”.**Course goal.** During the study of the discipline students will learn following aspects:-Explain the structure, isomerism and nomenclature of biologically active compounds-Describe the physico-chemical properties, the biological role of compounds involved in the processes of vital activity-Demonstrate knowledge of gene biology and mechanisms for implementing genetic information, protein biosynthesis;-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-Understand the mechanisms of hereditary variability and their role in the formation of human hereditary pathology and congenital malformations-Understand the molecular-genetic and cellular mechanisms of the body's response to drugs and biologically active compounds.-Demonstrate the ability to apply the language and knowledge of each discipline to discuss and solve fundamental scientific and clinical problems.-Integrate knowledge of the structural and functional characteristics of the genome to solve clinical problems.- Independently find, analyze and summarize educational and scientific information about situations related to the course content;-Work in a team, defend your point of view reasonably, consider the opinions of others, provide and receive feedback correctly using interpersonal and group communication skills.During the study of course, students should be competent in: to form an understanding of the molecular basis of the functioning of the cell and the organism as a whole, 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. |
| **Prerequisites** | - |
| **Post requisites** | “Mechanisms of Defense and Health” |
| **Information resources**  | **Basic literature**:1. Lodish H. et al. Molecular cell biology. 8th ed. 2016. WH Freeman.
2. Alberts B. et al. Molecular biology of the cell. 6th ed. 2015. Garland Science.
3. Watson J. et al. Molecular Biology of the gene. 7th ed. 2013. CSH Press.
4. John McMurry, et al. Fundamentals of General, Organic, and Biological Chemistry, 8th Edition. 2018. Pearson Education Limited.
5. Kenneth W. Raymond. General Organic and Biological Chemistry. An Integrated Approach. 8th Edition. 2013. Wiley.

 **Additional literature:**1.Soderberg T. Organic Chemistry with a Biological Emphasis. 2016. Chemistry Publications. 2. Jenis, J. Study Guide and Practice Tests for Organic Chemistry (Organic Compounds of Aliphatic Series) / Al-Farabi KazNU. Almaty : Qazaq university, 2017.3. Russell P.J. iGenetics. A molecular approach. 3rd ed. 2009. Pearson.4. Karp G. Cell and molecular biology. Concepts and experiments. 7th ed. 2013. Wiley.5. Hartwell L. et al. Genetics. From genes to genomes. 4th ed. 2011. McGraw Hill.6. Zhussupova A.I. Molecular Biology (Interdisciplinary Approaches in Teaching and Research) / Al-Farabi KazNU. Almaty : Qazaq university, 2016.**Internet resources:**1. “Human Genome” Project <https://web.ornl.gov/sci/techresources/Human_Genome/project/info.shtml>2. NCBI - The National Center for Biotechnology Information, USA <https://www.ncbi.nlm.nih.gov/>3. NDB - a portal for three-dimensional structural information about nucleic acids <http://ndbserver.rutgers.edu/>4. OMIM - compendium of human genes and genetic phenotypes <https://www.ncbi.nlm.nih.gov/omim?db=OMIM>5. Ensembl - Genome browser for vertebrate genomes <http://asia.ensembl.org/index.html>6. EMBL-EBI - European Bioinformatics Institute <https://www.ebi.ac.uk/> |
| **Academic policy of the course in the context of university moral and ethical values** | **Academic behavior rules.** *Attendance policy*Attendance for lectures and workshops is mandatory. Attendance for anadditional extracurricular research activity is highly recommended forincreasing the course assessment. No less than 50% attendance isrequired for the lectures and workshops. Additional research activities arenot required, but highly beneficial for the course better comprehension.*Class participation*All students are expected to participate in class activities and discussions.*Classroom decorum*All unrelated activities are prohibited during a lecture and workshop time.Cell phones, computer games and unrelated Internet and computeractivities are strictly prohibited. *Missed exams*Students can retake midterm exams with an official document for the days ofabsence. Other excuses are not accepted and the exam will be annulated. Missing of the final exam is registered according the rules of Academic Policy of the University.*Late assignments*Late assignments, projects, reports and etc. are not accepted with no excuses.*Appeals policy*Students may appeal instructor decisions by speaking directly with him. If a solution is not found students can consult with Head of the Department.*Electronic resources*You are expected to regularly check your emails for updates and announcementsabout the course. *Plagiarism and Cheating* As a student, you are expected to adhere tothe norms of academic integrity. Academic dishonesty includesplagiarism, cheating, fabrication, unauthorized collaboration, use ofnotes during exams and quizzes, and other forms. These studentswill be given 0 with no further retake activities.**Academic values.** *Academic honesty*There will be no tolerance for lapses of academic integrity. Astudent found to be guilty of falsifying, plagiarism and cheating orany other form of academic dishonesty will be given a failinggrade.*Tolerance and non-discrimination*There is zero tolerance for unsafe activity in laboratory duringworkshops and additional research activities. There will be nodiscrimination per nationality, gender and anything else. |
| **Evaluation and attestation policy** | **Criteria-based evaluation:** evaluation of study results in accordance with the descriptors, test of formed competences (the results of study that are indicated in goal of the course) at border control and examinations.**Summative evaluation:** 1. 30 lessons will be held during the course. The maximum score that can be obtained in one lesson for right answers by case-study questions equals to 7 points. Points for the classwork will constitute 42% of the final course grade. For implementation of Self Work of Student (SWS) students can get maximum 10 points additionally to the final course grade.2. Control examinations will be held in test and written form on the 5th, 10th and 15th week. Score for each control examination is 30 points and equals to 18% of the final course grade. Exam questions will be based on the course material.3. Final examination will be held in test form and constitute 40% of the final course grade. Final course grade is calculated in accordance with Academic policy of the University by the following formula:(BC1+МТ+BC2/3)х0,6+(FEх0,4),where BC1 is Border Control 1,MT is MidTerm, BC2 is Border Control 2,FE is Final Examination.Students who take less than 50% of the final course grade by the results of current control (BC1+МТ+BC2/3) will not be admitted to final examination. |

**Calendar (schedule) of the implementation of the course content**

*Coursework calendar*

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| **Molecular biology** |
| **Week** | **Topic title** | **Number of hours** | **Max. grade** |
| 1 | 2 | 3 | 4 |
| 1 | **Introduction to molecular biology.**History and scope of molecular biology. Informational macromolecules: proteins, nucleic acids. DNA as a carrier of genetic information: key experiments. Central dogma of molecular biology. The role of molecular biology in medicine. **Learning outcomes:** *describe the Chargaff, Griffith, Avery-MacLeod-McCarty, Hershey-Chase experiments and explain their significance; explain informational properties of macromolecules; explain the central dogma of molecular biology; briefly discuss the role of molecular biology in medicine.* | 2 | 7 |
| 1 | **Nucleotides and nucleic acids.** Composition and structure of components of nucleic acids: nitrogen bases, monosaccharides. Nucleosides and nucleotides, products of incomplete hydrolysis of nucleic acids. Structure of nucleotides. Structure and biochemical functions of DNA. Types of RNA, their structural organization and their biological role. Differences in structure, location and functions of DNA and RNA.**Learning outcomes:** *describe, identify, and draw the components of nucleosides and nucleotides; describe and identify nucleic acid chains in DNA and RNA.* | 3 | 7 |
| 2 | **DNA replication.**Hypothetical mechanisms of DNA replication: conservative, semi-conservative, dispersive. Replication enzymology. Molecular underpinnings of DNA synthesis.**Learning outcomes:** *describe the three hypotheses of DNA replication; describe the Meselson-Stahl experiment and explain its significance; explain the molecular mechanism of semiconservative DNA replication; explain the role of main enzymes implicated in the replication process; explain proofreading mechanisms and error correction during DNA replication.* | 2 | 7 |
| 2 | **DNA repair.**Sources of DNA damage in cells. DNA repair enzymology. Single-strand damage repair: nucleotide excision repair, base excision repair, mismatch repair. Double-strand damage repair: homologous recombination, non-homologous end joining.**Learning outcomes:** *explain what a mutation is and its importance for evolution of life; explain the importance of DNA repair; explain the mechanisms of base excision, nucleotide excision, homologous recombination, non-homologous end joining modes of repair.*  | 3 | 7 7 |
| 3 | **Transcription of genetic information.**Gene structure: promoter, exons, introns, terminator. Transcription enzymology. The mechanism of gene transcription: initiation, elongation, termination.**Learning outcomes:** *define the terms: transcription, promoter, enhancer, terminator; describe prokaryotic and eukaryotic RNA-polymerases' structure and functions; describe phases of transcription, explain the processes happening at each phase and their importance; explain the process, importance and difference of rho-independent and rho-dependent termination.* | 2 | 7 |
| 3 | **Post-transcriptional RNA modifications.**Post-transcriptional maturation of mRNA: 3' polyadenylation, 5' capping, exon excision.**Learning outcomes:** *explain mechanisms of polyadenylation, its importance; describe the cap structure, its synthesis and functions; describe the mechanism of splicing and its importance; explain the effect of splicing on gene expression.* | 3 | 7 |
| 3 | **Consultation by preparation for the plenary conference** | 2 |  |
| 4 | **Translation of genetic information.**Ribosome structure: rRNA and ribosomal proteins. Genetic code: properties and key experiments. tRNAs, aminoacyl-tRNA synthetases. The mechanism of translation: initiation, elongation, termination.**Learning outcomes:** *explain the ribosome cycle and fidelity of translation; define the genetic code, tRNA, mRNA, codon, anticodon; describe the structure of tRNA and the mechanism of its charging; explain the scanning model of translation; explain the mechanism of translation and its phases; describe the structure of ribosomes and polysomes.* | 2 | 7 |
| 4 | **Post-translational protein modifications and folding.**Protein post-translational modifications. Protein folding: chaperones.**Learning outcomes:** *draw a functional connection between primary structure and higher-order spatial organization of polypeptides; explain the auxiliary role of chaperones in protein folding; give detailed examples of human disorders linked with protein misfolding.* | 3 |  7 |
| 4 | **Consultation by preparation for the plenary conference** | 2 |  |
| 5 | **Regulation of gene expression in prokaryotes.**Gene structure in prokaryotes. Bacterial operons: lac, ara, trp, gal.**Learning outcomes:** *define the terms: operon, cistron, promoter; explain the functioning and regulation of the following operons: lac, ara, trp, gal; explain positive and negative controls of operons; differentiate between constitutive and inducible promoters.* | 2 | 7 |
| 5 | **Regulation of gene expression in eukaryotes.** Gene structure in eukaryotes. Regulation of transcription: transcription factors. Regulation of translation: translation factors.**Learning outcomes:** *explain the mechanism of transcriptional regulation in eukaryotes; describe promoter structure: TATA-,GC-boxes; explain functions of enhancers and silencers; describe the roles of transcription factors and transcription activators in transcription regulation; describe structure and significance of DNA-binding domains and transcription activation domains; explain translational regulation.* | 2 | 7 |
| 5 | **Сurrent Control 1** | 1 | 30 25 |
| 5 | **Plenary conference “GMOs: pros and cons”** | 2 | 5 |
| 6 | **Epigenetics** Significance of epigenetic regulation of gene expression. Mechanisms of epigenetic regulation: DNA methylation, RNA interference. Mechanisms of epigenetic regulation: histone modifications, histone variants.**Learning outcomes:** *explain the importance of epigenetic regulation and its role in heritability of cellular traits; explain the role of DNA methylation in regulation of gene expression; explain the mechanism of RNAi; describe chromatin structure at the levels of organization: nucleosome, 30-nm fiber, chromosome; explain the effects of histones on transcription; explain how transcription is affected by: nucleosome positioning, histone acetylation and methylation, chromatin remodeling; describe the mechanisms and major players of above mentioned processes.* | 2 | 7 |
| 6 | **Mobile genetic elements.**Transposable elements: transposons, retrotransposons.**Learning outcomes:** *describe DNA transposons, retrotransposons, retroviral integration; provide examples of human diseases triggered by transposable elements; discuss the usage of transposable elements in medicine.* | 3 | 7 |
| 7 | **Modern techniques in medicine PART I**Recombinant DNA technology: gene engineering, GMOs. Advanced genome editing techniques: CRISPR-Cas9. Application of genomic technologies in medicine: gene therapy.**Learning outcomes:***describe recombinant DNA technology; discuss about perspectives and dangers of creating the genetically modified organisms; explain the principles of CRISPR-Cas9 technology; discuss the perspectives of genomic technologies in medicine.* | 2 | 7 |
| 7 | **Modern techniques in medicine PART II**Genome sequencing: Sanger method, Next Generation sequencing. Genomic data as a gateway to personalized medicine: SNPs, 23andMe. Human Genome Project. Databases: EMBL-EBI, DDJB, NCBI, PIR, MIPS, NBRF, SwissProt, UniProt, etc.**Learning outcomes:***explain the Sanger, Maxam-Gilbert, NGS and other methods of genome sequencing; discuss Human Genome Project and the application of genomic data in personalized medicine; describe EMBL-EBI, DDJB, NCBI, PIR, MIPS, NBRF, SwissProt, UniProt and other bioinformatical databases; discuss about future perspectives and applications of genomics and bioinformatics.* | 3 |  7 |
| 7 | **Plenary conference “Gene therapy: myths and reality”.** | 3 | 7 5 |
| 8 | **Recap lesson** | 2 | 77 7 |
| **Bioorganic chemistry** |
| 8 | **Introduction to bioorganic chemistry.**The Nature of organic molecules. Families of organic molecules: functional groups. Chemical structure and bonding. The structural theory of organic compounds. The structure of atoms. The nature of chemical bonding. Bonding in carbon compounds (hybridization). Classification of organic compounds. Nomenclature of organic compounds. Isomerism. IUPAC nomenclature.**Learning outcomes:***identify the general structural characteristics of organic molecules, in particular, the tetravalent nature of carbon and the different ways in which it can be expressed; define functional group - identify the functional groups in organic molecules; recognize structural (constitutional) isomers and functional group isomers; write structures of organic molecules in various ways; classify the organic compounds; name the compounds according to IUPAC system of nomenclature and also derive their structures from the given names; draw structural, condensed, and line formulas for simple chemical compounds; convert any given structural, condensed, or line formula into its corresponding alternative.* | 3 | 7 |
| 9 | **Safety rules in organic chemistry laboratory.**Introduction to Lab Safety. Labware introduction.**Learning outcomes:***plan and organize laboratory work in a correct and safe manner and carry out simpler risk and security assessments.* | 2 | 7 |
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| 9 | **Hydrocarbons.**Classification (saturated and unsaturated hydrocarbons). Configurations and shapes of molecules. Alkanes, cycloalkanes. Properties of alkanes; reactions of alkanes, alkenes, alkynes. Naming alkenes and alkynes. The structure of alkenes: cis–trans isomerism. Properties of alkenes and alkynes. Addition reactions of alkenes. Alkene polymers.**Learning outcomes:** *name hydrocarbons according to IUPAC system of nomenclature; recognise and write structures of isomers of alkanes, alkenes, and alkynes; distinguish between alkanes, alkenes, alkynes and aromatic hydrocarbons on the basis of physical and chemical properties; identify the physical properties of alkanes; determine the basic reactions of alkanes; draw the isomeric products formed during the halogenation of simple alkanes; identify a cycloalkane from its structure; name a cycloalkane given its structure and draw a cycloalkane given its name; identify the functional groups present in alkenes and alkynes; differentiate between saturated and unsaturated molecules; name a simple alkene or alkyne given its condensed or line structure; draw the condensed or line structure of an alkene or alkyne given its name; identify cis–trans isomers of alkenes; predict the addition products obtained when alkenes react with H2, Cl2, HCl, or H2O; identify “unsymmetrically substituted” and “symmetrically substituted” alkenes; utilize Markovnikov’s rule when addition reactions to unsymmetrically substituted alkenes occur; predict what polymer forms given an alkene monomer; explain the preliminary laboratory techniques of organic chemistry; being able to perform practical chemical techniques; develop experimental skill and research potential.* | 3 | 7 |
| 9 | **Consultation by preparation for the plenary conference** | 2 |  |
| 10 | **Types of organic reactions.**Types of organic reactions. Organic halogen compounds. Nucleophilic substitution. Reaction rates and activation energy. SN2 reactions, E2 reactions, SN1 reactions and E1 reactions. α-Eliminations. Alcohol dehydration. Alkyl halides from alcohols.**Learning outcomes:** *describe the reactions and properties of halogen compounds; identify an alkyl or aryl halide, identify the different types of organic reactions.* | 2 | 7 |
| 10 | **Alcohols, phenols, and ethers. Properties of hydroxy compounds.** Alcohols, phenols, ethers. Properties of alcohols, phenols, ethers. Reactions of alcohols, phenols, ethers.**Learning outcomes:** *describe the structural differences between alcohols, phenols, and ethers; explain why alcohols have higher boiling points than compounds of similar molecular mass; write systematic names for simple alcohols; draw the structure of an alcohol given its name, in both condensed and line structure format; classify an alcohol as primary, secondary, or tertiary; define and identify a glycol; describe the properties of alcohols; describe hydrophobic and hydrophilic alcohols; predict the products obtained upon dehydration of an alcohol; predict the oxidation products of a primary, secondary, and tertiary alcohol; explain why alcohols and phenols are weak acids; identify an ether; distinguish between an ether and an alcohol.* | 2 | 7 |
| 10 | **MidTerm (Current Control 2)** | 1 | 25 |
| 10 | **Consultation by preparation for the plenary conference** | 2 |  |
| 11 | **Aldehydes and ketones.**The carbonyl group. Naming 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: hemiacetals and acetals.**Learning outcomes:** *identify a carbonyl group and describe its polarity and shape; name and draw simple aldehydes and ketones given a structure or a name; describe the polarity, hydrogen bonding, and water solubility of aldehydes and ketones; identify the products of the reduction of aldehydes and ketones; identify the differences between hemiacetals, hemiketals, acetals, and ketals; predict the products of hemiacetal, hemiketal, acetal, and ketal formation and their hydrolysis.* | 2 | 7 |
| 11 | **Carboxylic acids and their derivatives. Properties of carbonyl-containing compounds.**Carboxylic acids and their derivatives: properties and names. Acidity of carboxylic acids. Reactions of carboxylic acids: ester and amide formation. Hydrolysis of esters and amides. Polyamides and polyesters. Phosphoric acid derivatives.**Learning outcomes:** *compare and contrast the structures, reactions, hydrogen bonding, water solubility, boiling points, and acidity or basicity of carboxylic acids, esters, and amides; name simple carboxylic acids, esters, and amides given a structure and write a structure given a name; describe the acidity of different carboxylic acids and predict the products obtained when they react with strong bases; describe how esters and amides are formed from carboxylic acids.* | 3 | 7 |
| 11 | **Consultation by preparation for the plenary conference** | 2 |  |
| 12 | **Aromatic and aromatic heterocyclic compounds.**Aromatic compounds. Aromatic compounds and the structure of benzene. Naming aromatic compounds. Reactions of aromatic compounds. Aromatic hydrocarbons. Preparation and properties of nitrogen containing compounds. Properties, nomenclature, chemical reactions and the role of heterocyclic compounds.**Learning outcomes:** *identify the structures of aromatic compounds; explain the importance and function of resonance in aromatic compounds; name simple monosubstituted or disubstituted aromatic compounds; predict the products obtained when aromatic compounds react with concentrated HNO3, CL2, Br2, or concentrated H2SO4; define and recognize aromatic compounds and the importance of resonance and aromaticity; explain Huckel’s Rule; name the chemical properties of heterocyclic compounds; formulate conclusions about the possible products of chemical reactions of heterocyclic compounds; describe the nomenclature, structure and properties of heterocyclic compounds.* | 1 | 7 |
| 12 | **Stereochemistry and chirality.**Enantiomers and chirality. Asymmetric carbon and stereocenters. Chirality and symmetry. R,S Nomenclature. Optical activity, diastereoisomers, and meso-compounds. Enantiomer resolution. The importance of being asymmetric.**Learning outcomes:** *identify a chiral carbon; differentiate chiral and achiral molecules; identify the stereocenters in a molecule and assign the configuration as R or S; explain the relationships between enantiomers and their specific rotations.* | 3 | 7 |
| 12 | **Plenary conference (case-based discussion)** | 3 | 5 |
| 13 | **Introduction to spectral methods.** FTIR, UV-Vis, NMR, Mass Spectrometry.**Learning outcomes:** *to describe the principles of structure determination for organic molecules using the tools of ultraviolet-visible spectroscopy, infrared spectroscopy, nuclear magnetic resonance spectroscopy, and mass spectrometry; explain the basis of IR, NMR, UV and mass spectra methods of determination the structures of aromatic compounds.* | 2 | 7 |
| 13 | **Amines and amino acids.**Classifying amines. Naming and drawing amines. Properties of amines. Heterocyclic nitrogen compounds. Basicity of amines. Amine salts. Acid-base properties of amino acids.**Learning outcomes:** *describe and recognize the 20 alpha amino acid structures and their side chains; identify and classify an amine as primary, secondary, or tertiary; name a simple amine given its structure or draw an amine given its name; describe amine properties such as hydrogen bonding, solubility, boiling point, and basicity; identify a quaternary ammonium ion and describe its properties; define what is meant by alpha-amino acids, isoelectric point for amino acids, L-configuration for natural amino acids and the "zwitterion" nature of amino acids.* | 3 | 7 |
| 13 | **Consultation by preparation for the plenary conference** | 2 |  |
| 14 | **Peptides and proteins.**Amino acids and proteins. Classification of proteins, simple and complex proteins. Protein and its structures. Chemical properties of proteins. The peptide bond and primary structure of proteins. Secondary structure of protein, α-helix, β-pleated sheet, turns and loops of polypeptide chains. Tertiary structure of the protein, principles, structural and functional units, and quaternary structure, their functions.**Learning outcomes:** *describe the different functions of proteins and give an example for each function; identify a peptide bond, and explain how it is formed; draw and name a simple protein structure given its amino acid sequence; identify the amino-terminal end and the carboxyl-terminal end of a simple protein (peptide) structure given its amino acid sequence; define primary protein structure and explain how primary structures are represented; describe the planar sections of the primary sequence, their influence on the shape of the protein backbone, and identify these sections given a drawing of the primary sequence; give an example of how the change in primary sequence can change the function of a protein; identify the a-helix and b-sheet structures and give an example of a protein that contains primarily helix and one that contains primarily sheet secondary structure; describe the specific hydrogen bonding responsible for secondary structures; distinguish between fibrous and globular proteins.* | 2 | 7 |
| 14 | **Carbohydrates.**An Introduction to carbohydrates. Handedness of carbohydrates and Fischer projections. Structure of glucose and other monosaccharides. Some important monosaccharides, reactions of monosaccharides. Test for carbohydrates / Qualitative analysis of carbohydrates.Common disaccharides. Some important polysaccharides based on glucose. Qualitative analysis of carbohydrates.**Learning outcomes:** *classify carbohydrates by functional group and number of carbon atoms and label them accordingly; identify D and L enantiomers and any diastereomers of a monosaccharide from the Fischer projection; draw the Fischer projection for a monosaccharide; convert five- and six-carbon monosaccharides from the Fischer projection to the Haworth projection; identify the anomeric carbon and the alpha (a) or beta (b) form of the monosaccharide and describe the role of mutarotation in cyclic structure; identify by name and structure the common monosaccharides, their sources and uses; predict the products of oxidation and reduction reactions on monosaccharides; predict the products of reactions between monosaccharides and alcohols; recognize and predict the products of hydrolysis reactions of polysaccharides and phosphorylation reactions of monosaccharides; predict the results of some common reactions of simple carbohydrates such as oxidation, reduction, osazone formation, etc.; describe glycosidic bond formation as a type of dehydration reaction; identify by name and structure the common disaccharides, the subunits and the bond between them, their sources and uses; recognize common polysaccharides and identify where each polysaccharide is found in nature and its function; identify the monomers and type of bond present in each polysaccharide; identify the modified monosaccharides found in naturally occurring polysaccharides and identify the functions of these polysaccharides.* | 3 | 7 |
| 14 | **Consultation by preparation for the plenary conference** | 2 |  |
| 15 | **Lipids.**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.**Learning outcomes:** *describe the chemical structures and general properties of fatty acids, waxes, sterols, fats, and oils; describe the characteristics of fatty acids and fatty acid esters; list the physical properties of fats and oils and explain why they are different; describe hydrogenation and hydrolysis reactions of triacylglycerols, and, given the reactants, predict the products; recognize phospholipids and glycolipids and describe their functions; identify sterols and their derivatives and describe their structures and roles.* | 2 | 7 |
| 15 | **Recap lesson** | 2 | 7 |
| 15 | **Current Control 3** | 1 | 20 |
| 15 | **Plenary conference (case-based discussion)** | 3 | 5 |

Teacher by Bioorganic Chemistry \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Kudaibergenova B.M.

Teacher by Molecular Biology \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Pinsky I.V.

Head of the Department \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Sarsenova L.K.

Chairman of the Faculty Methodical Bureau \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_