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УЧРЕЖДЕНИЕ ОБРАЗОВАНИЯ
«ГРОДНЕНСКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ»

Кафедра биологической химии

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BIOCHEMISTRY

Guidelines for students of the Medical Faculty for International Students studying in the specialty 1-79 01 01 Medical Affair (in English)

Edited by professor V. V. Lelevich

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БИОХИМИЯ

Методические рекомендации для студентов факультета иностранных учащихся, обучающихся по специальности 1-79 01 01 Лечебное дело (на английском языке)

Под общей редакцией профессора В. В. Лелевича

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PREFACE

Nowadays biochemistry forms the basis of molecular biology, physiology, pharmacology, immunology, and other biological and medical disciplines. Together with other disciplines it contributes to developing of the intelligence and intuition of a future doctor.

These guidelines are designed for students to prepare to classes on biochemistry. It contains the description of 36 classes corresponding to the Working Program on Biochemistry. The list of theoretical questions and the list of training literature are provided for each class. The laboratory works to be performed during classes are also listed in corresponding themes.

The Appendix provides the list of normal concentrations of some laboratory tested substrates and enzymes, as well as lists of basic and additional literature for training.

The authors hope that these guidelines will be useful for studying biochemistry.

CLASS № 1

<u>THEME</u>: INTRODUCTION INTO BIOCHEMISTRY

THEORETICAL PART

1. History of biochemistry.
2. Major objectives, branches and research trends of biochemistry.
3. Objects and methods of biochemistry.
4. Role of biochemistry in medical education.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 1-5.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 1-5.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 1-5.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 1-5.
5. Basics of Biochemistry / Н. Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 6-9.
6. Lecture notes.

LABORATORY WORK

1. Safety rules.
2. Work with pipettes.
3. Colorimetry. Work with photoelectrocolorimeter.

CLASS № 2

<u>THEME</u>: PROPERTIES AND FUNCTIONS OF PROTEINS

THEORETICAL PART

1. History of protein studies.
2. Proteins as the major components of the body. Functions of proteins. Protein content in the tissues.

3. Structure of amino acids. Classification. Shape of proteins. Molecular mass of protein.
4. Physicochemical properties of proteins. Precipitation reactions of proteins.
5. Methods for separation and purification of protein: ultracentrifugation, electrophoresis, chromatography, dialysis.
6. Colour reactions of amino acids and proteins, practical use.
7. Methods for the quantitative measurement of proteins in a solution. Total serum protein.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 14-24.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 17-29.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 15-25.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 14-21.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 10-15, 251.
6. Lecture notes.

LABORATORY WORK

1. Colour reactions of amino acids and proteins.
2. Quantitative determination of total protein in blood serum.

CLASS № 3

<u>THEME</u>: STRUCTURES OF PROTEINS

THEORETICAL PART

1. Primary structure of proteins. Determination of primary structure. Properties of the peptide bond.
2. Secondary structure of proteins. Supersecondary structure.
3. Tertiary structure of proteins. Types of stabilizing bonds.

4. Relation between tertiary structure and function of proteins. Denaturation of proteins, factors, practical use.
5. Quaternary structure of proteins.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 25-40.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 25-47.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 25-48.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 23-44.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 15-20.
6. Lecture notes.

LABORATORY WORK

1. Denaturation of protein by nitric acid.
2. Separation of albumins and globulins of egg white by salting-out.

CLASS № 4

<u>THEME</u>: DIVERSITY AND CLASSIFICATION OF PROTEINS

THEORETICAL PART

1. Biologically important peptides; classification, representatives, biological functions. Glutathione.
2. Dynamic state of native proteins. Complementarity. Ligands and function of proteins.
3. A variety of proteins and their functions. Quantitative determination of protein for functional properties. Protein medicines (hormones, enzymes, etc.).
4. Changes of proteins in ontogenesis and disease.
5. Simple proteins; representatives, characteristics, biological functions.
6. Conjugated proteins: representatives, characteristics, biological functions.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 43-50.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 48-56.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 44-48, 51-59.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 41-44, 47-55.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 11-12, 20-22.
6. Lecture notes.

LABORATORY WORK

Acidic hydrolysis of proteins.

CLASS № 5

<u>THEME</u>: ENZYMES: PROPERTIES AND MECHANISM OF ACTION

THEORETICAL PART

1. History of enzymes study.
2. Properties of enzymes. Active and allosteric centers in enzymes.
3. Simple and conjugated enzymes. Cofactors of enzymes. Co-enzymatic functions of vitamins.
4. Mechanism of enzyme catalysis.
5. Specificity of enzymes.
6. Classification and nomenclature of enzymes.
7. Isoenzymes.
8. Units of enzyme activity.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 51-56.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 57-65.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 60-68.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 56-63.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 23-31.
6. Lecture notes.

LABORATORY WORK

1. Effect of temperature on amylase activity.
2. Effect of activator and inhibitor on amylase activity.
3. Determination of amylase activity in blood serum.

CLASS № 6

THEME: KINETICS OF ENZYMATIC REACTIONS

THEORETICAL PART

1. Enzyme kinetics (Michaelis-Menten and Lineweaver-Burk equations).
2. Factors affecting enzymatic reaction rate (temperature, pH, substrate and enzyme concentration).
3. Regulation of enzyme activity:
   3.1. Activation and inhibition of enzymes
   3.2. Allosteric regulation. Covalent modification of the structure of enzymes (phosphorylation – dephosphorylation, limited proteolysis).
4. Drugs as the inhibitors of enzymes.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 62-83.

2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 70-83.
3. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 73-86.
4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 68-81, 84-91.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 32-39.
6. Lecture notes.

LABORATORY WORK

Kinetics of lipase-catalyzed hydrolysis of triacylglycerols.

CLASS № 7

THEME: APPLIED ASPECTS OF ENZYMOLOGY

THEORETICAL PART

1. Tissue-specific enzymes.
2. Serum enzymes used in clinical diagnosis. Origin of serum enzymes.
3. Enzymes in genetic diseases.
4. Practical applications of enzymes in medicine. Immobilized enzymes.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 56-61.
2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 63-69.
3. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 68-70.
4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 63-65.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 39-43.

6. Maslovskaya, A.A. Biochemistry : test assignments for the Faculty of Foreign Students (in English Medium) / A.A. Maslovskaya, V.V.Lelevich. – Grodno, GrSMU, 2013. – P. 5-18.
7. Lecture notes.

MCQ «Proteins. Enzymes»

Students' individual work «Proteins, enzymes»

CLASS № 8

MINI-EXAM «PROTEINS & ENZYMES»

1. History of protein study.
2. Proteins as the major components of the body. A variety of proteins and their functions.
3. Structure of amino acids. Classification. Shape of proteins. Molecular mass of proteins, methods of determination.
4. Physicochemical properties of proteins. Precipitation reactions of proteins.
5. Methods for separation and purification of protein: ultracentrifugation, electrophoresis, chromatography, dialysis.
6. Colour reactions of amino acids and proteins.
7. Methods for the quantitative measurement of proteins in a solution. Total serum protein.
8. Primary structure of proteins. Determination of primary structure. Peptide bond formation.
9. Secondary structure of proteins. Supersecondary structure.
10. Tertiary structure of proteins. Types of stabilizing bonds.
11. Relation between tertiary structure and function of proteins. Denaturation of proteins, factors, practical use.
12. Quaternary structure of proteins.
13. Factors responsible for the stability of proteins in solution. Salting out.
14. Biologically important peptides; classification, representatives, biological functions. Glutathione.

15. Dynamic state of native proteins. Complementarity. Ligands and function of proteins. Quantitative determination of protein for functional properties.
16. Protein medicines (hormones, enzymes, etc.).
17. Changes of proteins in ontogenesis and disease.
18. Simple proteins; representatives, characteristics, biological functions.
19. Conjugated proteins; representatives, characteristics, biological functions.
20. History of enzymes study.
21. Properties of enzymes. Active and allosteric centers in enzymes.
22. Simple and conjugated enzymes. Cofactors of enzymes. Co-enzymatic functions of vitamins.
23. Mechanism of enzyme catalysis.
24. Specificity of enzymes.
25. Classification and nomenclature of enzymes.
26. Isoenzymes.
27. Definition of enzyme activity. Units of enzyme activity.
28. Enzyme kinetics (Michaelis-Menten and Lineweaver-Burk equations).
29. Factors affecting enzymatic reaction rate (temperature, pH, substrate, and enzyme concentration).
30. Regulation of enzyme activity.
31. Activation and inhibition of enzymes.
32. Drugs as the inhibitors of enzymes.
33. Tissue-specific enzymes.
34. Serum enzymes used in clinical diagnosis. Origin of serum enzymes.
35. Enzymes in genetic diseases.
36. Practical applications of enzymes in medicine. Immobilized enzymes.

CLASS № 9

<u>THEME</u>: GENERAL PATHWAYS OF AMINO ACID METABOLISM

THEORETICAL PART

1. Dynamic state of body proteins. Nitrogen balance.
2. Sources of amino acids in the body and ways of their use.
3. Digestion of proteins in the gastrointestinal tract. Absorption of amino acids.
4. Intestinal putrefaction of proteins (conversion of amino acids by intestinal bacteria).
5. General pathways of amino acid metabolism.
6. Transamination of amino acids, enzymes, biological role. Coenzyme function of vitamin B_6. Mechanism of transamination. Aminotransferases, their tissue specificity and diagnostic significance.
7. Types of deamination of amino acids. Oxidative deamination and reductive amination. Biological role.
8. Transdeamination. Biological role.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 234-236, 239-242, 462, 465.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 265-270, 519-521.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 282-283, 287-292, 539-541, 543-544.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 263-264, 269-274, 519-523, 525.
5. Basics of Biochemistry / Н.Э. Петушок [et al].– Гродно: ГрГМУ, 2021. – P. 237-251.
6. Lecture notes.

LABORATORY WORK

Determination of the alanine aminotransferase activity in the blood serum.

CLASS № 10

<u>THEME</u>: DETOXIFICATION OF AMMONIA. METABOLISM OF CERTAIN AMINO ACIDS

THEORETICAL PART

1. Decarboxylation of amino acids. Types of decarboxylation, biological role. Biogenic amines: synthesis, their functions. Oxidation of biogenic amines.
2. Ways for the formation and detoxification of ammonia.
3. Intracellular detoxification of ammonia: reductive amination, synthesis of glutamine and asparagine. Role of glutaminase in the maintenance of acid-base balance in the body.
4. Biosynthesis of urea. Disorders of the urea synthesis and excretion.
5. Catabolism of amino acids in the organism. Glucogenic and ketogenic amino acids.
6. Metabolism of methionine: formation of S-adenosylmethionine, its role in transmethylation reactions. Synthesis of creatine.
7. Metabolism of phenylalanine and tyrosine. Disorders of phenylalanine and tyrosine metabolism (phenylketonuria, alkaptonuria, albinism).

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 146, 243-247, 248,254, 257-258, 268-269, 435-436.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 271-290, 303, 304.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 291-296, 299, 304-306, 315-316.

4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 264-265, 273-278, 286-288, 290.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 251-267.
6. Lecture notes.

LABORATORY WORK

Determination of urea in the blood serum.

Students’ individual work «Metabolism of amino acids»

CLASS № 11

<u>THEME:</u> STRUCTURE OF NUCLEOTIDES AND NUCLEIC ACIDS

THEORETICAL PART

1. History of nucleic acids study.
2. Chemical composition of nucleic acids. Differences between DNA and RNA.
3. DNA: composition, structure, cell localization, biological role.
4. RNA: types, composition, structures, cell localization, biological role.
5. Nucleoproteins: structure of ribosomes of eukaryotes and chromatin.
6. Biosynthesis of purine nucleotides: synthesis of phosphoribosylamine, origin of atoms in the purine ring.
7. Inosinic acid as a precursor for synthesis of adenylic and guanylic acids. Regulation of biosynthesis of purine nucleotides.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 285-291, 292-295, 302-311, 312-317.

2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 323-342, 343-359, 741-743.
3. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 340-342, 347-348, 359-377.
4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 320-322, 325, 327-331, 338-355.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 44-54.
6. Lecture notes.

LABORATORY WORK

Hydrolysis of nucleoproteins. Reactions on nucleoproteins components in hydrolysate:

a. Biuret reaction on peptides.
b. Silver test on purine bases.
c. Trommer test on ribose and deoxyribose.
d. Molybdenum test on phosphoric acid.

CLASS № 12

<u>THEME:</u> METABOLISM OF NUCLEOTIDES AND NUCLEIC ACIDS

THEOREICAL PART

1. Biosynthesis of pyrimidine nucleotides. Regulation of biosynthesis of pyrimidine nucleotides.
2. Synthesis of deoxyribonucleotides. Synthesis of thymidylic acid.
3. Digestion of nucleic acids in the gastrointestinal tract. Degradation of nucleic acids in tissues. Re-utilization of nucleosides and nitrogenous bases for synthesis of nucleotides.
4. Degradation of purine and pyrimidine nucleotides.
5. Disorders of metabolism of nucleotides: xanthinuria, orotaciduria, gout.

6. Biosynthesis of DNA in eukaryotic cells: substrates, enzymes, scheme.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 295-301, 311, 322-330.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 323-342, 365-394, 741-743.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 352-357, 381-389.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 332-337, 361-369.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 54-68.
6. Lecture notes.

LABORATORY WORK

Determination of uric acid concentration in the blood serum.

CLASS № 13

THEME: *BIOSYNTHESIS OF NUCLEIC ACIDS AND PROTEIN*

THEORETICAL PART

1. Biosynthesis of RNA in eukaryotic cells: substrates, enzymes, steps, scheme.
2. RNA processing.
3. Reverse transcription: scheme, biological role.
4. The genetic code: its characteristic features.
5. Stages of protein synthesis. Activation of amino acids.
6. Eukaryotic translation: initiation, elongation, termination.
7. Posttranslational processing of proteins.
8. Regulation of gene expression.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P.335-351, 353-368, 369-387.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P.395-410, 411-432, 434-446.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 394-411, 413-426.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 374-392, 393-406, 428-450.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 68-82.
6. Maslovskaya, A.A. Biochemistry : test assignments for the Faculty of Foreign Students (in English Medium) / A.A. Maslovskaya, V.V.Lelevich. – Grodno, GrSMU, 2013. – P. 18-23.
7. Lecture notes.

MCQ «Metabolism of nucleotides and nucleic acids».

Students' individual work «Metabolism of nucleotides and nucleic acids».

CLASS № 14

<u>THEME:</u> PRINCIPLES OF MOLECULAR BIOLOGY

THEORETICAL PART

1. Antibiotics as inhibitors of protein synthesis.
2. Enzymes and techniques used in molecular biology.
3. The blot-analysis of DNA and RNA. Methods for protein identifying: Western blot analysis.
4. Polymerase chain reaction: stages and practical applications.

5. Restriction fragment length polymorphism. DNA fingerprint.
6. Sequencing of nucleic acids.
7. Genetic engineering, recombinant DNA technology.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 367-368, 388-405.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P.395-410, 411-432, 434-446.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 426-427, 451-467.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 432-449, 406-407.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 83-91.
6. Lecture notes.

Students' individual work «Principles of molecular biology».

CLASS № 15

MINI-EXAM «METABOLISM OF NUCLEIC ACIDS AND NUCLEOTIDES. PRINCIPLES OF MOLECULAR BIOLOGY»

1. History of nucleic acids study.
2. Chemical composition of nucleic acids. Differences between DNA and RNA.
3. DNA: composition, structure, cell localization, biological role.
4. RNA: types, composition, structures, cell localization, biological role.
5. Nucleoproteins: structure of ribosomes of eucaryotes and chromatin.

6. Biosynthesis of purine nucleotides: synthesis of phosphoribosyl amine, origin of atoms in the purine ring.
7. Inosinic acid as a precursor for synthesis of adenylic and guanylic acids. Regulation of biosynthesis of purine nucleotides.
8. Biosynthesis of pyrimidine nucleotides. Regulation of biosynthesis of pyrimidine nucleotides.
9. Synthesis of deoxyribonucleotides. Synthesis of thymidylic acid.
10. Digestion of nucleic acids in the gastrointestinal tract. Degradation of nucleic acids in tissues. Re-utilization of nucleosides and nitrogenous bases for synthesis of nucleotides.
11. Degradation of purine and pyrimidine nucleotides.
12. Disorders of metabolism of nucleotides: xanthinuria, orotaciduria, gout.
13. Biosynthesis of DNA in eukaryotic cells: substrates, enzymes, scheme.
14. Biosynthesis of RNA in eukaryotic cells: substrates, enzymes, steps, scheme.
15. RNA processing.
16. Reverse transcription: scheme, biological role.
17. The genetic code: its characteristic features.
18. Stages of protein synthesis. Activation of amino acids.
19. Eukaryotic translation: initiation, elongation, termination.
20. Posttranslational processing of proteins.
21. Regulation of gene expression.
22. Antibiotics as inhibitors of protein synthesis.
23. Enzymes and techniques used in molecular biology.
24. The blot-analysis of DNA and RNA. Methods for protein identifying: Western blot analysis.
25. Polymerase chain reaction: stages and practical applications.
26. Restriction fragment length polymorphism. DNA fingerprint.
27. Sequencing of nucleic acids.
28. Genetic engineering, recombinant DNA technology.

CLASS № 16

<u>THEME:</u> BASICS OF BIOENERGETICS

THEORETICAL PART

1. Bioenergetics of the cell.
2. High-energy compounds: structure, biological role (ATP and other nucleoside triphosphates, 1,3-bisphosphoglycerate, phosphoenolpyruvate, creatine phosphate, acetyl CoA, succinyl CoA).
3. Electron transport chain (ETC), its structural organization and functioning. Electron transport chain complexes.
4. NAD^+($NADP^+$)-dependent dehydrogenases, structure of coenzyme, biological role.
5. FAD(FMN)-dependent dehydrogenases, structure of coenzyme, biological role.
6. Coenzyme Q, structure, biological role.
7. Cytochromes, structure, biological role.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 92-97, 99-100, 103-106.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 109-114, 121-131.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 113-117, 119-122, 126-132.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 105-109, 111-121.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 107-116.
6. Lecture notes.

LABORATORY WORK

Quantitative determination of high-energy compounds in the muscular tissue.

CLASS № 17

<u>THEME:</u> THE CENTRAL PATHWAY OF METABOLISM. BIOCHEMISTRY OF MEMBRANES

THEORETICAL PART

1. ATP: structure, biological role; the ways of its formation (oxidative and substrate-level phosphorylation) and use.
2. Oxidative phosphorylation, mechanisms. The chemiosmotic theory of oxidative phosphorylation. The P/O ratio.
3. Regulation of ETC. Activators and inhibitors of the electron transport chain. Uncoupling agents.
4. The citric acid cycle: reactions, regulation and biological role.
5. Relation of the citric acid cycle with the electron transport chain, energy yield of the citric acid cycle.
6. Chemical composition and structure of biological membranes. Lipids and proteins of biological membranes.
7. General properties and functions of biological membranes.
8. Types of transport mechanisms across membranes.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 94-95, 106-112, 143-148, 406-424.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 115-120, 147-150, 163-169, 664-665.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 115-118, 132-134, 161-167, 477-495.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 108-110, 121-125, 150-155, 459-477.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 98-106, 108-109, 116-123.
6. Lecture notes.

LABORATORY WORK

1. Detection of the succinate dehydrogenase activity
2. Detection of the cytochrome oxidase activity

Students' individual work "Energy metabolism"

CLASS № 18

THEME: ***OXIDATIVE PROCESSES IN THE CELL. INTRODUCTION INTO METABOLISM***

THEORETICAL PART

1. General characteristics of oxidation processes. Oxidase and peroxidase types of oxidation: schemes, enzymes, biological role.
2. Dioxygenase and monooxygenase types of oxidation: schemes, enzymes, biological role. Microsomal oxidation: scheme, cytochrome P_{450}, biological role.
3. Reactive oxygen species: their tissue-damaging effects.
4. Antioxidant systems, role of enzymes and non-enzymatic antioxidants.
5. Metabolism and metabolic pathways. Interrelations between anabolism and catabolism.
6. Experimental study of metabolism, the use of radioisotope tracers.
7. The specific and common pathways of catabolism.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 98-102, 131-134, 596-597.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 115-120, 151-154.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 120-125, 139-141, 758-760.

4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 111-116, 129-131, 709-710.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 92-97, 124-132.
6. Lecture notes.

CREDIT SESSION

CLASS № 19

THEME: CARBOHYDRATES OF PHYSIOLOGICAL SIGNIFICANCE

THEORETICAL PART

1. Carbohydrates: general characteristics and classification, biological functions, contents in human tissues.
2. Dietary carbohydrates, their characteristics.
3. Digestion and absorption of carbohydrates in the gastrointestinal tract. Lactose intolerance.
4. The general scheme of pathways of glucose metabolism and their estimation.
5. Reactions of glucose phosphorylation and dephosphorylation of glucose 6-phosphate. Regulation.
6. Galactose metabolism. Galactosemia.
7. Fructose metabolism. Essential fructosuria, hereditary fructose intolerance.
8. Lactose metabolism, regulation of synthesis.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 113-120, 149-151, 178-182, 459-460.
2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 132-139, 170-172, 201-203, 205-206, 518.

3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 152-160, 168-170, 202-205, 538.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 141-149, 157-159, 187-191, 520.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 176-181, 182-183.
6. Lecture notes.

LABORATORY WORK

Quantitative determination of glucose in serum by Glucose Oxidase Kit.

CLASS № 20

THEME: WAYS FOR GLUCOSE UTILIZATION – I

THEORETICAL PART

1. Aerobic glycolysis: reactions.
   1.1. Pyruvate dehydrogenase complex: components, mechanism of the reaction, regulation, biological role.
   1.2. Energy yield and biological role of aerobic glycolysis.
2. Anaerobic glycolysis: reactions.
   2.1. Reactions of substrate-level phosphorylation and oxidation-reduction reactions in anaerobic glycolysis.
   2.2. Energy yield, biological role and regulation of anaerobic glycolysis.
3. Formation of ethanol during fermentation.
4. Glucuronic acid pathway, scheme, biological role.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 149-156, 177-178.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 170-177, 201-202.

3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.168-175, 200-201.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 157-165, 186-187.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 183-187, 191-192.
6. Lecture notes.

LABORATORY WORK

Glucose tolerance test.

CLASS № 21

THEME: WAYS FOR GLUCOSE UTILIZATION – II

THEORETICAL PART

1. Scheme of pyruvate metabolism.
2. Metabolism of lactate. Cori's cycle.
3. Gluconeogenesis: metabolic precursors of glucose, scheme, biological role, regulation.
4. Key reactions of gluconeogenesis. Role of biotin.
5. Pentose phosphate pathway: oxidative and non-oxidative reactions, biological role.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 165-170, 174-177.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 187-193, 197-200.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.185-191, 196-200.

4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P.172-177, 178, 182-186.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 188-191.
6. Lecture notes.

LABORATORY WORK

Determination of pyruvate in the urine.

CLASS № 22

THEME: METABOLISM OF GLYCOGEN. REGULATUION OF CARBOHYDRATE METABOLISM

THEORETICAL PART

1. Physiological role of glycogen. Synthesis of glycogen, regulation.
2. Degradation of glycogen, regulation.
3. Disorders of glycogen metabolism: glycogenoses, aglycogenoses.
4. Glycemia, regulation of glycemia.
5. Hyperglycemia and hypoglycemia, their causes.
6. Disorders of carbohydrate metabolism in diabetes mellitus.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 157-164, 167-173.
2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 178-186, 192-195.
3. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.176-184, 191-194.
4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P.164-171, 177-181.

5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 193-198.
6. Maslovskaya, A.A. Biochemistry : test assignments for the Faculty of Foreign Students (in English Medium) / A.A. Maslovskaya, V.V.Lelevich. – Grodno, GrSMU, 2013. – P. 52-66.
7. Lecture notes.

Students' individual work "Metabolism of carbohydrates"

MCQ "Metabolism of carbohydrates"

CLASS № 23

MINI-EXAM «METABOLISM OF CARBOHYDRATES»

1. Carbohydrates: general characteristics and classification, biological functions, contents in human tissues.
2. Dietary carbohydrates, their characteristics.
3. Digestion and absorption of carbohydrates in the gastrointestinal tract. Lactose intolerance.
4. The general scheme of pathways of glucose metabolism and their estimation.
5. Reactions of glucose phosphorylation and dephosphorylation of glucose 6-phosphate. Regulation.
6. Galactose metabolism. Galactosemia.
7. Fructose metabolism. Essential fructosuria, hereditary fructose intolerance.
8. Lactose metabolism, regulation of synthesis.
9. Aerobic glycolysis: reactions.
10. Pyruvate dehydrogenase complex: components, mechanism of the reaction, regulation, biological role.
11. Energy yield and biological role of aerobic glycolysis.
12. Anaerobic glycolysis: reactions.
    - 12.1. Reactions of substrate-level phosphorylation and oxidation-reduction reactions in anaerobic glycolysis.
    - 12.2. Energy yield, biological role and regulation of anaerobic glycolysis.

13. Formation of ethanol during fermentation: reactions.
14. Scheme of pyruvate metabolism. Diagnostic value of pyruvate determination in the blood and urine.
15. Metabolism of lactate, Cori's cycle.
16. Gluconeogenesis: metabolic precursors of glucose, scheme, biological role, regulation.
17. Key reactions of gluconeogenesis. Role of biotin.
18. Pentose phosphate pathway: oxidative and non-oxidative reactions, biological role.
19. Glucuronic acid pathway, major reactions, biological role.
20. Physiological role of glycogen, synthesis of glycogen, regulation.
21. Degradation of glycogen, regulation.
22. Disorders of glycogen metabolism: glycogenoses, aglycogenoses.
23. Glycemia, regulation of glycemia.
24. Hyperglycemia and hypoglycemia, their causes.
25. Disorders of carbohydrate metabolism in diabetes mellitus.
26. Methods for determination of glucose in the blood serum. Diagnostic value.
27. Glucose tolerance test.

CLASS № 24

THEME: LIPIDS OF PHYSIOLOGICAL SIGNIFICANCE

THEORETICAL PART

1. Classification of lipids. Lipids of human tissues. Biological functions of lipids.
2. Dietary lipids, polyunsaturated fatty acids – essential nutrients. Digestion and absorption of lipids in the gastrointestinal tract (emulsification, enzymatic hydrolysis, formation of micelles). Role of bile acids.
3. Re-synthesis of triacylglycerols in the intestinal wall. Formation of chylomicrons. Composition and metabolism of chylomicrons.
4. Intracellular lipolysis. Hormonal regulation of triacylglycerols mobilization (lipolysis) in adipose tissue.

5. Fatty acids of human tissues: classification, representatives. Activation of fatty acids, transport of acyl CoA into mitochondrion. Role of carnitine.
6. β-Oxidation of fatty acids: reactions, energy production of β-oxidation, biological role.
7. Oxidation of odd-chain fatty acids.
8. Lipid peroxidation.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 121-129, 167 (figure 20-2), 184-187, 205, 214-215, 220-223, 460-461.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P.140-150, 189 (figure 20-2), 207-210, 240-242, 247-248, 518-520.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 187 (figure 19-2), 211-221, 223-226, 255-258, 261-263, 538-540.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 174 (figure 19-2), 195-206, 207-210, 238-241, 244-247, 520-522.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 129-131, 199-206, 209-212, 213-218.
6. Lecture notes.

LABORATORY WORK

Determination of triacylglycerols in the blood serum.

CLASS № 25

THEME: METABOLISM OF FATTY ACIDS. KETONE BODIES

THEORETICAL PART

1. Reactions of synthesis and utilization of ketone bodies. Their biological role.
2. Mechanism of ketosis in diabetes mellitus and starvation. Ketoacidosis.
3. Biosynthesis of fatty acids:

3.1. Sources of acetyl CoA and NADPH in the cytoplasm;
3.2. Synthesis of malonyl CoA;
3.3. Fatty acid synthase: structure;
3.4. Biosynthesis of palmitic acid: reactions.

4. Biosynthesis of triacylglycerols.
5. Biosynthesis of phospholipids.
6. Fatty infiltration of the liver. Lipotropic agents.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 187-192, 193-198, 205-208, 218-220.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P.210-220, 229-233, 244-246.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.226-231, 232-237, 246-250, 260-261.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 210-215, 216-222, 230-233, 243-244.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 219-224, 225-226.
6. Lecture notes.

LABORATORY WORK

Determination of total cholesterol in blood serum by enzymatic method.

CLASS № 26

METABOLISM OF CHOLESTEROL AND COMPLEX LIPIDS

THEORETICAL PART

1. Metabolism of cholesterol in the body.
2. Biosynthesis of cholesterol: main steps, scheme. Regulation of cholesterol synthesis.

3. Initial reactions of cholesterol biosynthesis.
4. Bile acids: representatives, structure, metabolism, biological functions.
5. Metabolism of sphingolipids. Disorders of sphingolipid metabolism.
6. Transport of lipids and fatty acids in the blood. Role of albumins. General characteristics of lipoproteins.
7. Metabolism of lipoproteins: formation and utilization. Lipoprotein lipase. Role of apoproteins.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 208-211, 212-218, 224-233.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P.233-236, 237-244, 250-258.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.249-252, 253-260, 267-274.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 233-235, 236-243, 249-256.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 203-206, 226-228, 229-234.
6. Lecture notes.

LABORATORY WORK

Determination of low density lipoproteins (LDL) in the blood serum.

CLASS № 27

THEME: DISTURBANCES OF LIPID METABOLISM

THEORETICAL PART

1. Disorders in digestion and absorption of lipids in the gastrointestinal tract.
2. Dislipoproteinemias: hyper- and hypolipoproteinemias.

3. Hypercholesterolemia and atherosclerosis. Biochemical principles of treatment.
4. Cholelithiasis. Formation of cholesterol gall stones.
5. Obesity: disturbances of lipid metabolism.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P.230-233.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P.258-260.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.274-276.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 256-259.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 206-208, 233-236.
6. Maslovskaya, A.A. Biochemistry : test assignments for the Faculty of Foreign Students (in English Medium) / A.A. Maslovskaya, V.V.Lelevich. – Grodno, GrSMU, 2013. – P. 66-81.
7. Lecture notes.

MCQ "Metabolism of lipids".

Students' individual work "Metabolism of lipids"

CLASS № 28

MINI-EXAM «METABOLISM OF LIPIDS»

1. Classification of lipids. Lipids of human tissues. Biological functions of lipids.
2. Dietary lipids, polyunsaturated fatty acids – essential nutrients. Digestion and absorption of lipids in the gastrointestinal tract (emulsification, enzymatic hydrolysis, formation of micelles). Role of bile acids.
3. Resynthesis of triacylglycerols in the intestinal wall. Formation of chylomicrons. Composition and metabolism of chylomicrons.

4. Intracellular lipolysis. Hormonal regulation of triacylglycerols mobilization (lipolysis) in adipose tissue.
5. Fatty acids of human tissues: classification, representatives. Activation of fatty acids, transport of acyl CoA into mitochondrion. Role of carnitine.
6. β-Oxidation of fatty acids: reactions, energy production of β-oxidation, biological role.
7. Oxidation of odd-chain fatty acids.
8. Reactions of synthesis and utilization of ketone bodies. Their biological role.
9. Mechanism of ketosis in diabetes mellitus and starvation. Ketoacidosis.
10. Sources of acetyl CoA and NADPH for fatty acids biosynthesis. Synthesis of malonyl CoA.
11. Biosynthesis of palmitic acid: reactions. Fatty acid synthase.
12. Biosynthesis of triacylglycerols.
13. Biosynthesis of phospholipids.
14. Fatty infiltration of the liver. Lipotropic agents.
15. Metabolism of cholesterol in the body.
16. Biosynthesis of cholesterol: main steps, scheme. Regulation of cholesterol synthesis.
17. Initial reactions of cholesterol biosynthesis.
18. Bile acids: representatives, structure, metabolism, biological functions.
19. Metabolism of sphingolipids. Disorders of sphingolipid metabolism.
20. Transport of lipids and fatty acids in the blood. Role of albumins. General characteristics of lipoproteins.
21. Metabolism of lipoproteins: formation and utilization. Lipoprotein lipase. Role of apoproteins.
22. Disorders in digestion and absorption of lipids in the gastrointestinal tract.
23. Dislipoproteinemias: hyper- and hypolipoproteinemias.
24. Hypercholesterolemia and atherosclerosis. Biochemical principles of treatment.
25. Cholelithiasis. Formation of cholesterol gall stones.
26. Obesity: disturbances of lipid metabolism.
27. Major lipid components of the blood serum. Diagnostic value.

CLASS № 29

THEME*: *HORMONE ACTION MECHANISM

THEORETICAL PART

1. General characteristics of hormones: properties, types of biological action. Classification of hormones on the chemical structure, site of formation, mechanism of action. Target tissues and the cell receptors of hormones.
2. Mechanisms of action of hormones binding with the membrane receptors. Second messengers: cyclic purine nucleotides, calcium ions, products of hydrolysis of phosphatidylinositol. Diversity of protein kinases and their role in transmission of hormonal signal.
3. Mechanism of action of hormones binding with the intracellular receptors.
4. Thyroid hormones: structure, target tissues, biological effects. Hyper- and hypoproduction of the hormones.
5. Parathyroid hormone, calcitonin: target tissues, biological effects. Hyper- and hypofunction of parathyroid hormone.
6. Pancreatic hormones: insulin, glucagon. Target tissues, biological effects. Hyper- and hypoproduction of the hormones.
7. Adrenaline and noradrenaline: structure, target tissues, biological effects. Hyperproduction of adrenaline.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 425-429, 435-442, 444-458, 634-635.
2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 478-482, 487-497, 498-513.
3. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.498-503, 509-513, 515-517, 518-536.
4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 480-485, 491-499, 500-518.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 133-139, 143-151.

6. Lecture notes.

LABORATORY WORK

Qualitative reaction on adrenaline.

CLASS № 30

THEME: BIOLOGICAL ACTION OF HORMONES

THEORETICAL PART

1. Glucocorticoids: structure of cortisol, target tissues, effects on metabolism and functions. Hyper- and hypoproduction of the hormones.
2. Mineralocorticoids: structure of aldosterone, target tissues, biological effects. Hyper- and hypoproduction of the hormones.
3. Female sex hormones: structure of estradiol and progesterone, target tissues, effects on metabolism and functions. Hyper- and hypoproduction of the hormones.
4. Male sex hormones: structure of testosterone, target tissues, effects on metabolism and functions**.** Hyper- and hypoproduction of the hormones.
5. Hormones of hypothalamus and hypophysis, their biological action. Growth hormone, adrenocorticotropic hormone: target tissues, effects on metabolism. Hyper- and hypoproduction of growth hormone.
6. Eicosanoids (prostaglandins, thromboxanes, leukotrienes) and their role in the regulation of metabolism and functions.
7. Disorders of functions of endocrine glands: hyper- and hypoproduction of hormones.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 200-201, 202-204, 442-443.
2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 483-487, 142-143, 224-228.

3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.218-219, 239-241, 502-509.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 224-227, 485-491.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 140-142, 152-162.
6. Lecture notes.

Students' individual work "Characteristics of the major hormones"

CLASS № 31

THEME: BIOCHEMISTRY OF NUTRITION. VITAMINS

THEORETICAL PART

1. Components of human food. The significance of nutrition for the vital activity. Essential food components. Causes and biochemical characteristics of malnutrition syndrome
2. Pathological states related to nutrition disorders: protein-energy malnutrition – kwashiorkor, marasmus; causes and disturbance of metabolism.
3. Vitamins, general characteristics, classification, biological functions. Vitamin-like substances.
4. Sources of vitamins for a human. Causes of hypo- and hypervitaminoses. Role of microflora of large intestine in synthesis of some vitamins.
5. Fat-soluble vitamins: A, D, E, and K, biological role, daily requirements, dietary sources, symptoms of deficiency. Hypervitaminosis of some vitamins.
6. Water-soluble vitamins: B_1, B_2, B_6, B_{12}, PP, C, pantothenic acid, biotin, folic acid, biological role, daily requirements, dietary sources, symptoms of deficiency.
7. The use of vitamins in clinical practice. Polyvitamin medications.
8. Anti-vitamins, mechanism of action, representatives, their application in medical practice and scientific investigations.

Formulas for memorizing: structure of **vitamins A, D, B_1, B_2, B_6, PP, C,** and **pantothenic acid.**

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 198-200, 463-466, 467-481, 485, 635-637.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 517-524, 525-542.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 537-545, 546-563.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 519-526, 527-540.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 163-166, 167-175.
6. Lecture notes.

LABORATORY WORK

Quantitative determination of the vitamin C in the urine.

CLASS № 32

THEME*: *BIOCHEMISTRY OF THE BLOOD

THEORETICAL PART

1. Blood, general characteristics and functions.
2. Specific features of chemical composition, structure and metabolism of blood cells.
3. Hemoglobin, structure, derivatives. Variants of hemoglobin in ontogenesis. Hemoglobinopathies.
4. Transport of oxygen and carbon dioxide in blood.
5. Metabolism of iron. Transferrin and ferritin. Iron deficiency anemia.
6. Plasma proteins: their classification and characteristics.

7. Hemostasis. Blood coagulation factors. Intrinsic and extrinsic pathways of blood coagulation. Scheme of blood coagulation. Role of vitamin K in blood coagulation.
8. Anticoagulant and fibrinolytic system. Disorders of coagulation and anticoagulation systems. Thrombosis and hemophilia.
9. Biochemical analysis of blood, major laboratory results, use for diagnosis.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 141 (*table 16-3*), 463, 566-608.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 161 (*table 16-3*), 521-522, 629-649, 650-675.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 150 (*table 14-3*), 541, 668-688, 689-721.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 139 (*table 14-3*), 523-524, 627-680.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 300-323.
6. Lecture notes.

LABORATORY WORK

1. Determination of hemoglobin concentration in the blood.
2. Determination of calcium concentration in the blood serum.

CLASS № 33

THEME: BIOCHEMISTRY OF THE LIVER

THEORETICAL PART

1. Role of the liver in carbohydrate, lipid, amino acid and protein metabolism.
2. Detoxification functions of the liver.
3. Heme synthesis, reactions.

4. Degradation of heme. Bilirubin metabolism, scheme.
5. Disorders in bilirubin metabolism: jaundice, its types.
6. Biochemical mechanisms of hepatic failure and hepatic coma. Biochemical tests for diagnosis of liver disorders.

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 141 (*table 16-3*), 272-283, 609-615.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 161 (*table 16-3*), 308-320, 676-682.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.150 (*table 14-3*), 323-335, 583-588.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 139 (*table 14-3*), 305-316, 556-559.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 272-286.
6. Lecture notes.

LABORATORY WORK

Quantitative determination of the bilirubin in the blood serum

CLASS № 34

THEME*: *BIOCHEMISTRY OF KIDNEY AND URINE

THEORETICAL PART

1. The kidney, biochemical functions, metabolism of the kidney.
2. Role of the kidney in regulation of pH balance.
3. Synthesis of biologically active compounds in kidney. Role of renin, erythropoietin, calcitriol.
4. Electrolytes composition of body fluids.
5. Regulation of sodium, water balance and pH in body fluids.

6. Water and electrolyte imbalance, acid-base imbalance. Dehydration, oedema, acidosis, alkalosis.
7. Mineral components of tissues: classification, representatives, biological role.
8. Sodium, potassium; their biological role, metabolism, regulation of balance.
9. Calcium, phosphorus; their biological role, metabolism, regulation of balance.
10. Trace elements, biological role (Fe, Cu, Co, I, Zn, Mn, Se).

LITERATURE FOR TRAINING:

1. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 141 (*table 16-3*), 480.
2. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 161 (*table 16-3*), 541.
3. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 150 (*table 14-3*), 562-563.
4. Harper's Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 139 (*table 14-3*), 540.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 287-299, 324-339.
6. Lecture notes.

LABORATORY WORK

Biochemical analysis of the urine:

1. Qualitative reaction on protein;
2. Quantitative determination of protein in the urine;
3. Qualitative determination of glucose in the urine;
4. Qualitative reaction on blood pigments;
5. Urine dipstick express tests.

CLASS № 35

THEME*: *BIOCHEMISTRY OF NERVOUS, MUSCULAR AND CONNECTIVE TISSUE

THEORETICAL PART

1. Morphochemical composition of nervous tissue. Myelin membrane: composition and structure.
2. Specific features of carbohydrate, lipid and amino acid metabolism in nervous tissue. Energy metabolism in the brain.
3. Molecular mechanisms of synaptic transmission.
4. Mediators, biogenic amines and neuropeptides
5. Structure and composition of muscle tissue. Muscle proteins, their functions.
6. Biochemical mechanisms of muscle contraction and relaxation. Role of ions in regulation of muscle contraction.
7. Muscle energy metabolism. Sources of ATP for muscle contraction, role of creatine phosphate, creatine kinase.
8. Chemical composition and metabolism of extracellular matrix. Collagen, elastin; specific features of their structure and metabolism.
9. Proteoglycans, glycosaminoglycans and glycoproteins of the connective tissue; specific features of their synthesis and degradation, biological role.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 141 (*table 16-3*), 506-565.
2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P. 161 (*table 16-3*), 568-628.
3. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P. 150 (*table 14-3*), 569-582, 627-667.
4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P. 139 (*table 14-3*), 546-555, 592-626.
5. Basics of Biochemistry / Н.Э. Петушок, [et al]. – Гродно: ГрГМУ, 2021. – P. 340-389.

6. Lecture notes.

LABORATORY WORK

Quantitative measurement of protein in the liquor.

CLASS № 36

THEME: INTEGRATION AND REGULATION OF METABOLISM. PRINCINPLES OF CLINICAL BIOCHEMISTRY. FINAL COMPUTER TESTING

THEORETICAL PART

1. The role of regulation of metabolism in functioning of organs and systems. Intracellular location of major metabolic pathways.
2. Regulation of metabolism: major mechanisms.
3. The levels of metabolism integration. The substrate-level interrelationships in metabolism. The role of TCA substrates in integration of metabolism.
4. Energy interrelations among catabolic and anabolic pathways.
5. Substrate-level relations among metabolism of carbohydrates and amino acids. Biosynthesis of lipids from carbohydrates and amino acids. Integration of metabolism by coenzymes.
6. The role of clinical biochemistry in diagnostics and treatment of metabolic pathology.
7. Basic and special biochemical tests.
8. Laboratory values of clinical importance.

LITERATURE FOR TRAINING:

1. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – P. 131-142, 616, 647.
2. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – P.151-162, 718-727.
3. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – P.139-1514, 589-600.

4. Harper’s Illustrated Biochemistry / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – P.129-140, 560-567.
5. Basics of Biochemistry / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – P. 268-271, 390-398.
6. Maslovskaya, A.A. Biochemistry : test assignments for the Faculty of Foreign Students (in English Medium) / A.A. Maslovskaya, V.V.Lelevich. – Grodno, GrSMU, 2013. – P. 5-105.
7. Lecture notes.

FINAL COMPUTER TESTING

Appendix

NORMAL CONCENTRATIONS OF SOME LABORATORY TESTED SUBSTRATES AND ENZYMES

BLOOD	
Alanine aminotransferase (AlAT)	5-42 IU/L
Albumins	33-53 g/L
Amylase	up to 90 U/L
Aspartate aminotransferase (AsAT)	5-37 IU/L
Bilirubin total	5,0-20,5 μmol/L
Bilirubin conjugated (direct)	1,0-7,5 μmol/L
Calcium	2,25-2,75 mmol/L
Ceruloplasmin	150-600 mg/L
Chlorides	95-110 mmol/L
Copper	4,4-12,6 mmol/L (female); 11-24 mmol/L (male)
C-reactive protein	0-10 mg/L
Creatinine	53-115 μmol/L
Creatine kinase	25-200 U/L
Fibrinogen	2-4 g/L
Gamma-glutamyltranspeptidase	11-50 U/L
Globulins	20-30 g/L
Glucose (serum)	3,3-6,4 mmol/L
Glucose (capillary blood)	3,3-5,55 mmol/L
Hemoglobin	115-145 g/L (female); 130-160 g/L (male)
Hemoglobin glycosylated	up to 6.5%
Iron	8,8-31,0 μmol/L
Lactate dehydrogenase	174-516 U/L
LDL	2-4 g/L
Magnesium	0,8-1,0 mmol/L
Phosphatase alkaline	18/306 U/L
Phosphorus	0,8-1,6 mmol//L
Potassium	3,2-5,6 mmol/L
Sodium	130-155 mmol/L

Transferrin	1,74-3,82 g/L
Total serum protein	65-85 g/L
Triacylglycerols	0,4-1,54 mmol/L (female); 0,45-1,82 mmol/L (male)
Urea	2,50-8,3 mmol/L
Uric acid	140-340 μmol/L (female); 200-415 μmol/L (male)
Cholesterol	3,6-5,2 mmol/L
URINE	
Amylase	28-160 g/h·L
Urea	333-583 mmol/day
Uric acid	1,6-6,4 mmol/day
CEREBROSPINAL FLUID	
Chlorides	120-130 mmol/L
Glucose	2,5-3,89 mmol/L
Protein	0,22-0,33 g/L

BASIC LITERATURE FOR TRAINING

1. **Harper's Illustrated Biochemistry** / Robert K. Murray [et. al.]. – 28th ed. – New York [etc]: McGraw-Hill, Medical, 2009. – 694 p.
2. **Harper's Illustrated Biochemistry** / Robert K. Murray [et. al.]. – 29th ed. – New York [etc]: McGraw-Hill, Medical, 2012. – 812 p..
3. **Harper's Illustrated Biochemistry** / Robert K. Murray [et. al.]. – 30th ed. – New York [etc]: McGraw-Hill, Medical, 2015. – 817p.
4. **Harper's Illustrated Biochemistry** / Robert K. Murray [et. al.]. – 31th ed. – New York [etc]: McGraw-Hill, Medical, 2018. – 786p.
5. **Basics of Biochemistry** / Н.Э. Петушок [et al]. – Гродно: ГрГМУ, 2021. – 400p.
6. Maslovskaya, A. A. **Biochemistry: test assignments for the faculty of foreign students (in English Medium)** / A. A. Maslovskaya, V. V. Lelevich ; under the general editorship of V. V. Lelevich ; ГрГМУ, Grodno : GrSMU, 2013. – 114 p.

ADDITIONAL LITERATURE FOR TRAINING

1. **Marks, Dawn. Biochemistry** / D. B. Marks. - 2nd ed. - Baltimore : Williams & Wilkins. A Waverly Company, 1994. - 338 p.
2. **McKee, Trudy. Biochemistry** / Trudy McKee, James R. McKee. - Dubuque, I A. Bogota; Boston: Wm. C. Brown Publishers, 1996. – 638p.
3. **Lehninger Principles of Biochemistry** / D. L. Nelson, M. M. Cox. – 5th ed. – New York, 2008. - 1158 p.
4. **Chatterjea, M.N. Textbook of Medical Biochemistry** / M. N. Chatterjea, M. - 8th ed. – New Delhi, 2012. – 743 p.
5. **Koolman, J. Color Atlas of Biochemistry** / J. Koolman - 2nd ed – Stuttgart, 2005. – 467 p.
6. **Baynes, J.W., Dominiczak, M.N. Medical Biochemistry** / J.W. Baynes, M.N. Dominiczak - 2nd ed. Elsevier, 2007. – 607 p.
7. **Spencer L. Seager, Michael R. Slabaugh** Organic and Biochemistry for Today. - Cengage Learning, 2013. - 464 p.