

**SYLLABUS OF THE EDUCATIONAL COMPONENT
BIOLOGICAL CHEMISTRY**

Speciality: **222" Medicine "**
Educational and professional program: "**Medicine "**
Component code in the educational program: **MC 16**
Higher education level: the **second (master's degree)**
Form of education: **full-time**
Year of study: **2**
Semester(s): **III (autumn) and IV (spring)**
Type of educational component: **mandatory**
Academic year: **2025-2026**

Volume: **6,0 credits ECTS (180 hours)**
Training sessions: **lectures, practical classes**
Final control: **exam**
Prerequisites: **courses in medical biology, medical and biological physics; medical informational technologies, medical and bioorganic chemistry.**

Department/Unit: **Department of Biological Chemistry**, Nauky Ave., 4, main building, 5th floor
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Page of the educational component in the Distance Learning System of KhNMU (Moodle):
<https://distance.knmu.edu.ua/course/view.php?id=6211>

DESCRIPTION OF THE EDUCATIONAL COMPONENT

Biological chemistry, as an educational component, aims to train future doctors who must possess sufficient theoretical and practical knowledge regarding the biochemical foundations of the functioning of various organs and systems of the human body, the nature of metabolic processes that occur normally and in pathology, and the mechanisms of their regulation. The educational component "Biological Chemistry" is taught to second-year higher education students over two semesters.

PURPOSE OF THE COURSE: formation of theoretical knowledge about the chemical composition, structural organization and properties of bioorganic compounds - the constituent components of cells, tissues and organs of the human body; regularities of the metabolism of energy and substances (proteins, amino acids, carbohydrates, lipids, nucleotides, porphyrins, etc.) in normal and pathological conditions; hormonal regulation of metabolism and biological functions of cells; biochemistry of special physiological functions, as well as practical skills for evaluating the results of biochemical studies.

LEARNING OUTCOMES:

- explain the structure, functions and metabolism of the main classes of biomolecules of the human body; methods of storing and transmitting hereditary information; mechanisms of energy transformation and regulation of metabolism; patterns of metabolism in various organs and tissues;
- interpret the significance of biochemical processes of metabolism and its regulation in ensuring the functioning of organs, systems and the entire human organism; carry out quantitative and qualitative determination of substances in accordance with biochemical research methods with an indication of their clinical and diagnostic significance; interpret biochemical mechanisms of the occurrence of pathological processes in the human body and the principles of their correction; explain the biochemical and molecular foundations of the physiological functions of cells, organs and systems of the human body; solve situational problems (assessment of clinical and biochemical indicators characterizing the functions and parameters of homeostasis, as well as establishing mechanisms for regulating metabolic processes) that have an experimental or clinical and biochemical direction.

CONTENT OF THE EDUCATIONAL COMPONENT**List of lecture topics (30 hours):**

1. Introduction to biochemistry. Biochemistry of enzymes.
2. General characteristics of vitamins. Fat- and water-soluble vitamins. Vitamin-like substances. Antivitamins.

3. Bioenergetic processes: biological oxidation, mitochondrial respiratory chain, oxidative phosphorylation. Basic patterns of metabolism. General pathways of catabolism: oxidative decarboxylation of pyruvate, tricarboxylic acid cycle.
4. Biochemistry of hormones.
5. Digestion and absorption of carbohydrates in the gastrointestinal tract. Glycogen metabolism. Anaerobic and aerobic oxidation of glucose. Gluconeogenesis.
6. Pentose phosphate pathway of glucose oxidation. Fructose and galactose metabolism. Metabolism of glycosaminoglycans. Regulation and disorders of carbohydrate metabolism.
7. Digestion and absorption of lipids in the gastrointestinal tract. Transport forms of lipids. Exchange of triacylglycerols and phospholipids.
8. Exchange of higher fatty acids and ketone bodies. Exchange of glycerol. Exchange of cholesterol. Regulation and disorders of lipid metabolism.
9. Digestion and absorption of proteins in the gastrointestinal tract. Putrefaction in the intestine. Amino acid pool of tissues. General pathways of amino acid conversion. Decarboxylation of amino acids.
10. Deamination and transamination of amino acids. Exchange of ammonia. Specific exchange of amino acids.
11. Functions and exchange of nucleotides, its possible disorders. Analysis of the end products of nitrogen metabolism.
12. Biosynthesis of nucleic acids and proteins. Transfer of genetic information. Fundamentals of molecular genetics.
13. Blood biochemistry: functions, physicochemical properties, biochemical composition in normal and pathological conditions.
14. Erythrocyte biochemistry. Biochemistry and pathochemistry of hemoglobin.
15. Water and electrolyte metabolism. Biochemistry of the kidneys and urine.

List of topics of practical classes (92 hours):

1. Control of the initial level of knowledge. Introduction to biochemistry. Development of biochemistry as a science. Chemical composition of the human body. General characteristics of biochemical research.
2. Fundamentals of biocatalysis. Structure and physicochemical properties of enzymes. Classification and nomenclature of enzymes.
3. Mechanism of action of enzymes. Determination of enzyme activity. Kinetics of enzymatic catalysis.
4. Mechanisms of regulation of enzymatic processes. Inhibitors and activators of enzymes. Medical enzymology.
5. General characteristics of vitamins. Fat-soluble vitamins.
6. Water-soluble vitamins. Vitamin-like substances. Antivitamins.
7. Bioenergetic processes: biological oxidation, mitochondrial respiratory chain, oxidative phosphorylation.
8. Basic laws of metabolism. General pathways of catabolism: oxidative decarboxylation of pyruvate, tricarboxylic acid cycle (G. Krebs cycle).
9. Final test for section 1.
10. General characteristics of hormones. Hormones of the hypothalamic-pituitary system.
11. Protein-peptide hormones and amino acid derivatives.
12. Steroid hormones. Eicosanoids.
13. Digestion and absorption of carbohydrates in the gastrointestinal tract. Glycogen metabolism. Blood glucose level and its regulation.
14. Anaerobic and aerobic oxidation of glucose. Gluconeogenesis.
15. Pentose phosphate pathway of glucose oxidation. Polyol and glucuronate pathways of glucose metabolism. Fructose and galactose metabolism. Glycosaminoglycan metabolism. Regulation and disorders of carbohydrate metabolism.

16. Digestion and absorption of lipids in the gastrointestinal tract. Resynthesis of triacylglycerols in the intestine. Transport forms of lipids.
17. Exchange of triacylglycerols and phospholipids. Biochemistry of surfactant.
18. Exchange of higher fatty acids and ketone bodies. Exchange of glycerol.
19. Exchange of cholesterol. Regulation and disorders of lipid metabolism.
20. Final test for section 2.
21. Digestion and absorption of proteins in the gastrointestinal tract. Putrefaction in the intestine.
22. Tissue proteolysis. Amino acid pool of tissues. General pathways of amino acid conversion. Decarboxylation of amino acids.
23. Deamination and transamination of amino acids.
24. Ammonia metabolism: sources, mechanisms of neutralization, transport forms. Ornithine cycle of ureagenesis; role and disorders. Formation of ammonium salts in the kidneys.
25. Specific amino acid metabolism. Pathways of metabolism of nitrogen-free amino acids; connection with the Krebs cycle. Glycogenic and ketogenic amino acids. Metabolism of phenylalanine, tyrosine and tryptophan.
26. Metabolism of glycine and serine, arginine, methionine and cysteine, dicarboxylic amino acids and branched-chain amino acids. Glutathione as a product of metabolism of glycine, glutamate and cysteine. Nitric oxide as a product of arginine metabolism. Creatine as a product of arginine, glycine and methionine metabolism.
27. Functions and metabolism of nucleotides, its possible disorders. Analysis of the end products of nitrogen metabolism.
28. Biosynthesis of nucleic acids and proteins (matrix biosynthesis). Transfer of genetic information. Fundamentals of molecular genetics.
29. Final test for section 3.
30. Functions, physicochemical properties and chemical composition of blood. Buffer systems, mechanisms of action and role in maintaining the acid-base state of the body. Blood plasma proteins, their role. Alpha-1-antitrypsin deficiency (emphysema).
31. Biochemical composition of blood in normal and pathological conditions. Blood plasma enzymes. Non-protein organic substances of blood plasma - nitrogen-containing and nitrogen-free. Inorganic components of blood plasma. Kallikrein-kinin system.
32. Biochemistry of erythrocytes. Structure, properties and role of hemoglobin.
33. Hemoglobin metabolism. Iron metabolism, its role in the formation of heme. Porphyrias and hemoglobinoses (hemoglobinopathies, thalassemias). Jaundice.
34. Water and electrolyte metabolism. Regulation. Disorders.
35. Biochemistry of the kidneys and urine. Physicochemical properties and chemical composition of normal urine. Pathological components of urine. Biochemical examination of urine.
36. Biochemistry of tissues (liver, muscle, connective tissue). Biotransformation of xenobiotics and endogenous toxins.
37. Final test for section 4.

List of topics of independent work of the student (58 hours)

1. Purpose, objects, stages of biochemical research. General characteristics of biochemical research methods.
2. Oligomeric enzymes, multienzyme complexes, membrane-associated enzymes. Isoenzymes (on the example of isoforms of lactate dehydrogenase, creatine phosphokinase), role in the diagnosis of diseases.
3. Kinetics of enzymatic reactions: the influence of substrate and enzyme concentrations on the reaction rate (graphical dependencies). Michaelis-Menten equation. Michaelis constant, its definition and meaning.
4. Main aspects of modern enzyme diagnostics, enzymopathy and enzymotherapy.



5. History of the discovery of vitamins, the role of scientists in the development of vitaminology. Exogenous and endogenous hypo- and avitaminosis. Hypervitaminosis states. Vitamin F: structure of components, biological role, sources, daily requirement, symptoms of deficiency.
6. General characteristics of vitamin-like substances. Antivitamins; use in medicine.
7. Features of energy processes in the body. Exergonic and endergonic reactions. Macroergic compounds. The leading role of ATP in bioenergetics. Ways of using ATP energy. Mitochondrial ATP synthase, structure, principles of functioning. Chemiosmotic theory of oxidative phosphorylation. The role of oxygen in biooxidation; ways of its use. Ways of ATP synthesis in cells. Hypoenergetic states (hypoergosis). Respiratory control as a mechanism for regulating tissue respiration.
8. Stages of catabolism for exogenous and endogenous biomolecules in the body. General and specific pathways of catabolism. End products of catabolic pathways.
9. Methods of studying hormones. Guanylate cyclase messenger system. Proopiomelanocortin family - adrenocorticotropin, lipotropins, endorphins.
10. Hormones of the digestive tract: gastrin, secretin, cholecystokinin. General characteristics of thymus hormones; their structure and role.
11. Clinical use of analogues and antagonists of sex hormone. Biological and pharmacological properties of eicosanoids, their clinical use; acetylsalicylic acid and other nonsteroidal anti-inflammatory drugs as inhibitors of prostaglandin synthesis.
12. The role of carbohydrates in the body's vital activity; the most important representatives; energy value; daily requirement. Blood glucose; regulation of blood levels. Methods for determining glucose content in blood and urine, their significance.
13. The relationship between anaerobic and aerobic pathways of glucose oxidation in the cell. Pasteur effect. The relationship and reciprocal regulation of glycolysis and gluconeogenesis in the body. Glucose-lactate and glucose-alanine cycles.
14. Glycosaminoglycans: structure, role; general ideas about metabolism. Effects and mechanisms of glucagon, adrenaline, glucocorticoids, somatotropin and insulin on blood glucose levels. Changes in carbohydrate metabolism in hypoxic conditions. Disorders of carbohydrate metabolism associated with disaccharide deficiency (lactase, maltase, sucrase). Hereditary disorders of glycogen metabolism (glycogenoses and aglycogenoses).
15. Lipids: biological role, classification, structure and functions of simple lipids, structure and functions of complex lipids (phospholipids and glycolipids). Resynthesis of fat in intestinal epithelial cells; its significance; the role of \square -MAG in this process.
16. Metabolism of phosphoglycerols and sphingolipids. Sphingolipidoses. "Lysosomal diseases": Niemann-Pick disease, Tay-Sachs disease, Gaucher disease.
17. Biosynthesis of monounsaturated higher fatty acids in the human body. Glycerol metabolism.
18. Regulation of lipid metabolism. Pathologies of lipid metabolism: steatorrhea, obesity, atherosclerosis, hyperlipoproteinemia. Disorders of lipid metabolism in obesity, diabetes.
19. Clinical and diagnostic value of gastric juice analysis. Diagnostic value of qualitative determination of lactate in gastric juice.
20. Amino acid pool; main classes of organic compounds formed from amino acids.
21. Deamination of amino acids serine, threonine, cysteine and histidine.
22. The role of alanine in ammonia transport. Formation of ammonium salts in the kidneys.
23. Gluconeogenesis from amino acids: physiological significance and regulation of processes. Ketogenic and glyco-ketogenic amino acids.
24. Arginine metabolism pathways; nitric oxide as a product of arginine metabolism, its role in the body. Dicarboxylic amino acid metabolism pathways.
25. Nucleotides, their structure and role in the body. Digestion and absorption of nucleoproteins. Synthesis of deoxyribonucleotides. The relationship between protein and nucleic acid metabolism. End products of catabolism of simple and complex proteins (nucleoproteins). Nitrogen balance, its types.
26. Regulation of gene expression in prokaryotes. Features of the molecular organization of DNA and expression of the eukaryotic genome. Genetic recombination in prokaryotes. Biological significance and mechanisms of DNA repair. Repair of UV-induced gene mutations; pigmentary xeroderma.

Genetic engineering or recombinant DNA technology: general concepts, biomedical significance. Technology of gene transplantation and obtaining hybrid DNA molecules. Cloning of genes for the purpose of obtaining biotechnological medicinal substances. Mutations; role in the occurrence of enzymopathies.

Independent work is aimed at deepening and consolidating theoretical knowledge obtained during classroom training and contributes to the formation of professional competencies. The results of independent work are subject to control and are included in the current knowledge control.

Consultations: online, by pre-registration on the course page in the course's Distance Learning System.

Teaching methods: verbal (lecture, story-explanation, conversation, discussion), visual (illustration, presentation, videos, video films), practical (independent work, case method, brainstorming, test tasks).

EVALUATION

Current Learning Activities (CLA). The assessment of the success of education seekers is carried out in accordance with the Instructions for assessing the educational activities of higher education seekers at KhNMU (<https://knmu.edu.ua/documents/normatyvni-dokumenty-navchalnogo-proczesu/>). The practical grade is from 2 to 5 points. Submitting assignments late for unwarranted reasons entails a reduction in the grade according to the percentage of delay in time from the time of completing the assignment. Assignments are checked within 24 hours. Grades are posted in the electronic journal. Unsatisfactory grades are worked out in accordance with the Regulations on the procedure for working out academic classes by KhNMU students (https://knmu.edu.ua/wp-content/uploads/2021/05/polog_vidprac_zaniat.pdf).

At the end of the study of the educational component, the average score is converted into a multi-point score (70-120 points) in accordance with Table 1 of the Assessment Instructions (see above), which constitutes the total learning activity (TLA).

Individual tasks (IT) are evaluated up to 10 points.

Final control. The condition for admission to the exam is to score 70 points on the CIS. The exam score ranges from 50 to 80 points.

Grade in subject (GS). $GS = TLA + IT + exam$

Appealing the results of the final control is carried out in accordance with the procedure established in KhNMU (https://knmu.edu.ua/wp-content/uploads/2021/05/polog_apel_kontrol.pdf).

POLICIES OF THE EDUCATIONAL COMPONENT

Recommendations for working on the course: actively participate in all forms of work in classes, devote 1-2 hours daily to independent work and preparation for classes, ask questions during classes, attend consultations, submit assignments on time, and perform all forms of control.

Attending classes. Attendance at practical classes is mandatory. The uniform for offline classes is a white medical gown. If you are more than 5 minutes late, you may not be allowed to attend the class. Missed classes are made up in accordance with the Regulations on the Procedure for Students of KNMU to Complete Academic Classes (https://knmu.edu.ua/wp-content/uploads/2021/05/polog_vidprac_zaniat.pdf).

Academic integrity. KhNMU stands on the positions of zero tolerance to manifestations of academic dishonesty. Any violations of the principles of academic integrity entail responsibility in accordance with the procedure established by KhNMU (https://knmu.edu.ua/wp-content/uploads/2021/05/polog_ad-1.pdf).

Use of electronic gadgets and artificial intelligence tools is allowed only with the permission of the teacher.

Policy on persons with special educational needs. Applicants with special educational needs should contact a teacher to develop an individual educational trajectory.

Teacher Response Time: 24 hours.

Technical requirements for the course:

- access to a computer, laptop, tablet or smartphone
- Corporate Google account with your own photo
- skills in working with Google Workspace (Google Meet, Docs, Sheets, Slides, Forms) and Moodle

Technical support: ASM (ev.shevtsov@knu.edu.ua), Google (tehotdelknu@gmail.com), Moodle (al.korol@knu.edu.ua)

RECOMMENDED SOURCES

1. Biological chemistry: textbook / Yu.I. Gubsky, I.V. Nizhenkovska, M.M. Ko-rda [and others]; ed. I. V. Nizhenkovska. – Vinnytsia: Nova Knyga, 2021. – 648 p.
2. Lehninger Principles of Biochemistry / Nelson D.L., Cox M.M. - 8th edition. W.H. Freeman and Company, New -York, 2021. - 1328 p.
3. Ferrier. D.R. Lippincott Illustrated Reviews: Biochemistry. – South Asian Edition. - Wolters Kluwer, 2020. - 950 p.
4. MCQs in biochemistry 2nd edition / A. Ya. Sklyarov et al. - Lviv: Danylo Ha-lytsky Lviv National Medical University Press, 2020. - 319 p.
5. Biological chemistry: teaching and methodical manual, part 1 / [O.Ya. Sklyarov, T.M. Makarenko, L.P. Biletska and others]; edited by Sklyarova O.Ya. - Publishing House of LNMU, 2021. – 185 p.
6. Clinical biochemistry / M. Murphy, R. Shrivastava, K. Dins. – K.: Medicine, 7th edition, 2024. – 191 p.
7. Clinical Chemistry / W. Marshall, M. Lapsley, A. Day, K. Shipman. – Elsevier, 2020. - 432 p.
8. William Marshall, Martha Lapsley, Andrew Day, Kate Shipman. Clinical Chemistry. – Elsevier, 2020. – 432.

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