

PRIVATE HIGHER EDUCATIONAL ESTABLISHMENT
«INTERNATIONAL ACADEMY OF ECOLOGY AND MEDICINE»

Department of fundamental disciplines with a course of pharmacology

SYLLABUS OF THE EDUCATIONAL
DISCIPLINE

" Biological and bioorganic chemistry "

LEVEL OF HIGHER EDUCATION The second (master's) level

DEGREE OF HIGHER EDUCATION Master

AREA OF KNOWLEDGE 22 "Health care"

SPECIALTY 221 "Dentistry"

Reviewed and approved
at the meeting of the Department of fundamental
disciplines with a course of pharmacology

Protocol № 1 of « 01 » 09 2020

Head of the department Doctor of Biological
Sciences, associate professor


M.R. Vergolyas

Kiev 2020

| 1. General information | |
|---|---|
| Subject | Biological and bioorganic chemistry |
| Lector | <i>Shimanovsky I.O.</i> |
| Teacher's contact phone number | |
| Teacher's e-mail | <i>Koffund@ukr.net</i> |
| Discipline format | Normative discipline. |
| The volume of the discipline | 240 hours |
| Link to the distance learning site | maem.kiev.ua |
| Consultations | |
| 2. Annotation to the course | |
| The subject of study of the discipline are: <ul style="list-style-type: none"> - molecular structure of organic compounds; - physical and chemical properties of bioorganic compounds; - biological activity of organic compounds; - the relationship between the structure and properties of organic compounds, including metabolites and drugs. | Interdisciplinary links: - general and inorganic chemistry; biophysics; biology; biological chemistry; normal physiology; pathological physiology; pharmacology; histology. |
| 3. Purpose and objectives of the course | |
| The purpose of teaching the discipline "Biological and Bioorganic Chemistry" is: mastering by students of theoretical laws concerning chemical properties of bioorganic compounds in interrelation with their structure and on this basis understanding of biochemical processes which take place in biological systems; acquaintance with the basic methods of identification of bioorganic compounds as the main prerequisites for further mastering of laboratory methods of diagnosis and understanding of many pathological processes in the human body; disclosure of practical aspects of bioorganic chemistry, ways and methods use of its achievements in medical practice. | The goals of studying the discipline "Biological and Bioorganic Chemistry" are: to teach students the general principles of chemical reactions of bioorganic compounds as the basis of biochemical processes in the human body; formation of the relationship between the structure and function of bioorganic compounds; to reveal practical aspects of bioorganic chemistry, ways and methods of use its achievements in medical practice. |
| 4. Competencies and learning outcomes | |
| Learning outcomes: <i>Integrative final learning outcomes</i> , the formation of which is facilitated by the discipline: "Biological and Bioorganic Chemistry" as an academic discipline lays the foundation for the further formation of the following program learning outcomes in accordance with the Standard of Higher Education of Ukraine for undergraduate training of specialists of the second (master's) level of the specialty 222 "Medicine": <ul style="list-style-type: none"> - to determine the relationship between the state of the environment and the state of health of a particular contingent; - to develop preventive measures on the basis of data on the relationship between the state of the | |

- to evaluate information on the diagnosis, using a standard procedure based on the results of laboratory and instrumental studies.
- to determine the necessary medical nutrition in the treatment of the disease.
- to determine the principles and nature of treatment (conservative, operative) of the disease.
- to determine the tactics of emergency medical care on the basis of a diagnosis of emergency.
- to identify negative environmental factors; analyze health status.

Learning outcomes for the course: On completion of study of discipline

" Biological and Bioorganic Chemistry " students must **know:**

- classification of bioorganic compounds according to the structure of the carbon skeleton and the properties of functional groups;
- classes of bioorganic compounds according to the properties of their functional groups;
- biological role of basic organic compounds;
- structure and properties of alcohols, phenols;
- structure and properties of aldehydes and ketones;
- structure and properties of carboxylic acids;
- classification, structure and properties of lipids;
- structure and properties of amino acids;
- structure and properties of peptides and proteins;
- basic heterocyclic compounds;
- structure of nucleosides, nucleotides and nucleic acids.

to be able:

- To determine the class of organic compounds by the structure of the carbon skeleton and the nature of the functional group.
- To analyze the spatial structure of organic compounds and its impact on biological activity.
- To analyze the principles of the IUPAC nomenclature: substitute and radical-functional.
- To interpret the dependence of the reactivity of bioorganic compounds on the nature of the chemical bond and the electronic effects of the substituents.
- To explain the mechanisms of chemical reactions of different classes of organic compounds that have in vivo analogies.
- To be familiar with certain representatives of hydrocarbons, alcohols, phenols, thiols, aldehydes and ketones and carboxylic acids, which are metabolites or drugs.
- To analyze the general and specific properties of heterofunctional compounds.
- To interpret the structure of α -amino acids as the basis of biopolymers - proteins that are structural components of all body tissues.
- To draw conclusions about the variants of transformations in the body of α -amino acids and to analyze the dependence of the formation of physiologically active compounds (FAS) on them from the structure and reactivity.
- To explain the mechanism of formation of biogenic amines and their influence on physiological functions of the organism.
- To explain the dependence of physicochemical properties of proteins on their amino acid composition.
- To carry out qualitative α -amino acid reactions to determine the amino acid composition of proteins and use to quantify proteins.
- To draw conclusions about the existence of monosaccharides in different tautomeric forms, which affects their reactivity and allows laboratory research of monosaccharides in biological fluids.
- To interpret the peculiarities of the structure and transformations in the body of homopolysaccharides as nutrients - sources of energy for the processes of his life.
- To analyze the principles of methods for detection and determination of monosaccharides in blood, urine, saliva.

- To explain the mechanisms of the biological role of heteropolysaccharides (glycosaminoglycans) in biological fluids and tissues.
- To explain the dependence of the reactivity of heterocyclic compounds on their structure, in the context of their biosynthesis and laboratory synthesis in order to obtain drugs.
- To draw conclusions about the biological activity of heterofunctional derivatives of the heterocyclic series under the conditions of peculiarities of their structure and chemical behavior.
- To analyze the value of mononucleotides for the construction of nucleic acids and the action of nucleotide coenzymes.
- To interpret the mechanisms of vitamin participation in the construction of coenzymes that catalyze biochemical reactions in the body.

In accordance with the requirements of the Standard, the discipline of biological and bioorganic chemistry provides students with the acquisition of competencies:

- integral
- general
- special (professional, subject).

Matrix of competencies

| № | Competence | Knowledge | Skills | Communication | Autonomy and responsibility |
|---|---|--|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| Integrated competence | | | | | |
| Ability to solve typical and complex specialized problems and practical problems in a professional health care activity, or in a learning process that involves research and / or innovation and is characterized by the complexity and uncertainty of conditions and requirements. | | | | | |
| General competencies | | | | | |
| 1 | Ability to apply knowledge in practical situations | To have specialized conceptual knowledge acquired in the learning process. | To be able to solve complex problems and problems that arise in professional activities. | Clear and unambiguous communication of own conclusions, knowledge and explanations that substantiate them to specialists and non-specialists. | To be responsible for making decisions in difficult conditions. |
| 2 | Knowledge and understanding of the subject area and understanding of the profession | To have deep knowledge of the structure of professional activity. | To be able to carry out professional activities that require updating and integration of knowledge. | Ability to effectively form a communication strategy in professional activities | To be responsible for professional development, ability to further professional training with a high level of autonomy. |
| | Ability to exercise self-regulation, lead a healthy lifestyle, ability to adapt and act in a new situation. | To know ways to self-regulate, lead a healthy life. | To be able to apply the means of self-regulation, be able to lead a healthy lifestyle and adapt to new situations (circumstances) of life and activity. | To establish appropriate connections to achieve results. | To be responsible for a healthy lifestyle and timely use of self-regulation methods. |

| | | | | | |
|----|--|---|---|---|--|
| 4 | Ability to choose a communication strategy; ability to work in a team; interpersonal skills | To know the tactics and strategies of communication, laws and ways of communicative behavior | To be able to choose ways and strategies of communication to ensure effective teamwork | To use communication strategies and interpersonal skills | To be responsible for the choice and tactics of communication. |
| 5 | Ability to communicate in the native language both orally and in writing; ability to communicate in another language | To have a perfect knowledge of the native language and basic knowledge of a foreign language | To be able to apply knowledge of the native language, both orally and in writing, be able to communicate in a foreign language. | To use the native language in professional and business communication and in the preparation of documents. Use a foreign language in a professional activities. | To be responsible for fluency in the native language, for the development of professional knowledge. |
| 3 | Skills in the use of information and communication technologies | To have deep knowledge in the field of information and communication technologies used in professional activities | To be able to use information and communication technologies in the professional field, which requires updating and integration of knowledge. | To use information and communication technologies in professional activities. | To be responsible for the development of professional knowledge and skills. |
| 4 | Ability to abstract thinking, analysis and synthesis, the ability to learn and be modernly trained. | To know the methods of analysis, synthesis and further modern learning. | To be able to analyze information, make informed decisions, be able to acquire modern knowledge. | To establish appropriate connections to achieve goals. | To be responsible for the timely acquisition of modern knowledge. |
| 8 | Ability to evaluate and ensure the quality of work performed. | To know the methods of evaluating performance indicators. | To be able to ensure quality work. | To establish connections to ensure quality work. | To be responsible for the quality of work. |
| 9 | Determination and perseverance are persistent in the tasks and responsibilities. | To know the responsibilities and ways to perform the tasks. | To be able to set goals and objectives to be persistent and conscientious in the performance of duties. | To establish interpersonal relationships to effectively perform tasks and responsibilities. | To be responsible for the quality of the tasks. |
| 10 | The ability to act socially in accordance with public consciousness. | To know your social and community rights and responsibilities. | To form one's civic consciousness, to be able to act according to it | Ability to convey one's public and social position. | To be responsible for your civic position and activities. |
| 11 | The desire to preserve the environment. | To know the problems of environmental protection and ways to preserve it. | To be able to form requirements for themselves and others to preserve the environment. | To make proposals to the relevant authorities and institutions on measures to preserve and protect the environment. | To be responsible for the implementation of environmental protection measures within its competence. |

| Special competencies | | | | | |
|----------------------|--|--|---|---|--|
| 1 | Ability to evaluate results laboratory and instrumental research. | To have specialized knowledge about the person, his organs and systems, know the standard methods of laboratory and instrumental research (according to list 4). | To be able to analyze the results of laboratory and instrumental studies and on their basis to assess information about the diagnosis of the patient (according to list 4). | It is reasonable to assign and evaluate the results of laboratory and instrumental research (according to list 4). | To be responsible for deciding on the evaluation of laboratory and instrumental research results. |
| 2. | Ability to determine the principles and nature of disease treatment. | To have specialized knowledge of algorithms and standard schemes for the treatment of diseases (list 2). | To be able to determine the principles and nature of treatment of the disease (according to list 2). | To form and communicate to the patient and specialists their own conclusions about the principles and nature of treatment (according to list 2). | To be responsible for deciding on the principles and nature of treatment of the disease (according to list 2). |
| 3. | Ability to diagnose emergencies. | To have specialized knowledge about the person, his organs and systems, standard methods of human examination (at home, on the street, in a health care facility) in the absence of information. | To be able, in the absence of information, using standard techniques, to by making an informed decision to assess the human condition and make a diagnosis (according to list 3). | Under any circumstances, in compliance with the relevant ethical and legal norms to make an informed decision to assess the human condition, diagnosis and organization of the necessary medical measures depending on the human condition; fill in the relevant medical documents. | To be responsible for the timeliness and effectiveness of medical measures to diagnose emergencies. |
| 4. | Ability to determine therapeutic nutrition in the treatment of diseases. | To have specialized knowledge about man, his organs and systems; knowledge of algorithms and standard schemes of medical nutrition in the treatment of diseases (according to list 2). | To be able to determine, on the basis of a preliminary clinical diagnosis, the nature of therapeutic nutrition in the treatment of diseases (according to list 2). | To form and convey to the patient, specialists conclusions on therapeutic nutrition in the treatment of the disease (according to list 2). | To be responsible for the validity of the definition of therapeutic nutrition in the treatment of the disease (according to list 2). |

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| 5. | Ability to assess the impact of the environment on the health of the population (individual, family, population). | To know the methods of assessing the health of the population (individual, family, population); environmental factors that negatively affect the health of the population; methods of statistical analysis and laboratory research (according to list 4), assessment of the health of certain contingents, assessment of environmental factors and methods of determining the relationship between them; measures to prevent the negative impact of environmental factors on public health. Know the principles of risk groups, risk areas, time and risk factors. | To be able to assess the health of the population, assess the state of the environment and the negative factors influencing the health of the population. To have methods of statistical and laboratory (according to list 4) analysis of the state of health of different groups of the population. | To draw conclusions about the state of health of the population, based on data on communication with environmental factors and make proposals to the relevant authorities and institutions for preventive measures. Interact with specialists of sanitary and hygienic profile and heads of enterprises, institutions and relevant departments on nature protection, environment. | To be responsible for timely conclusions about the state of health of the population on the basis of data on the negative impact of environmental factors; for timely submission of proposals for appropriate preventive measures. |
|----|---|--|--|---|--|

5. Organization of course training

The volume of the course

| | |
|-------------------|----------------------------------|
| Type of lesson | Total amount of hours 240 |
| Lectures | 40 |
| Practical classes | 110 |
| Independent work | 90 |

Course signs

| | | | |
|--|------------------------------|---|----------------------|
| Semesters: The 2 nd , the 3 rd , the 4 th | Specialty 221 "Dentistry" | Course (year of study): the 1st, the 2nd | Normative discipline |
|--|------------------------------|---|----------------------|

Course thematics

The syllabus is structured into 3 modules:

Module 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.

Module 2. General patterns of metabolism. Metabolism of carbohydrates, lipids, and its regulation.

Module 3. Molecular biology. Biochemistry of intercellular communications. Biochemistry of tissues and physiological functions.

THEMATIC PLAN OF LECTURES

| The 2nd semester | | |
|--|---|-----------|
| № | Topic | Hours |
| <i>Module 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.</i> | | |
| 1. | Bioorganic chemistry as a science. Classification, structure and reactivity of bioorganic compounds. | 2 |
| 2. | Classification, structure and chemical properties of carbohydrates. | 2 |
| 3. | Structure and chemical properties of lipids. | 2 |
| 4. | Structural organization and physicochemical properties of proteins. | 2 |
| 5. | Structure, properties and biological role of nucleic acids. | 2 |
| Total | | 10 |
| The 3rd semester | | |
| <i>Module 2. General patterns of metabolism. Metabolism of carbohydrates, lipids, and its regulation.</i> | | |
| 1. | Bioenergetics: general pathways of carbohydrate, lipid and amino acid metabolism. Tricarboxylic acid cycle. Biological oxidation and oxidative phosphorylation. | 2 |
| 2. | Study of the structure and physicochemical properties of enzyme proteins. Determination of enzyme activity. Types of reactions of the main classes of enzymes. | 2 |
| 3. | Carbohydrate metabolism. Glycolysis, aerobic and anaerobic oxidation of glucose, gluconeogenesis. Alternative ways of metabolism of monosaccharides. | 2 |
| 4. | Glycogen metabolism, gluconeogenesis. Regulation and pathology of carbohydrate metabolism. Diabetes mellitus. | 2 |
| 5. | Lipid metabolism. Catabolism of triacylglycerols: oxidation of fatty acids and glycerol; ketogenesis. | 2 |
| Total | | 10 |
| The 4th semester | | |

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|-----|---|-----------|
| 1. | Lipid metabolism. Lipogenesis. Cholesterol metabolism. Regulation and pathology of lipid metabolism: obesity, atherosclerosis. | 2 |
| 2. | Protein metabolism. General pathways of transformation of amino acids. | 2 |
| | <i>Module 3. Molecular biology. Biochemistry of intercellular communications. Biochemistry of tissues and physiological functions.</i> | |
| 3. | Regulation of gene expression. | 2 |
| 4. | Molecular genetic basis of health. Regulation of metabolism. Biochemical mechanisms of hormone action. | 2 |
| 5. | Blood biochemistry. Acid-base state of the blood. The role of erythrocytes and plasma proteins. | 2 |
| 6. | Biochemical principles of realization of immune processes. | 2 |
| 7. | Biochemical functions of the liver. Biochemistry of jaundices. Biotransformation of foreign compounds in the liver. | 2 |
| 8. | Biochemical functions of the kidney. Biochemistry of urine and urine formation. Patobiochemistry of urine. | 2 |
| 9. | Biochemistry of the connective and bone tissues. Factors of osteoporosis risk. | 2 |
| 10. | Nervous tissue biochemistry: features of brain metabolism. Neurotransmitters. Pathobiochemistry of mental disorders. | 2 |
| | Total: | 20 |

THEMATIC PLAN OF PRACTICAL CLASSES

| The 2 nd semester | | |
|--|--|-------|
| № | Topic | Hours |
| <i>Module 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.</i> | | |
| 1. | Classification, nomenclature and isomerism of bioorganic compounds. Nature of the chemical bond. | 2 |
| 2. | Classification of chemical reactions. Reaction ability of alkanes, arenes, alcohols, phenols, amines. | 2 |
| 3. | Structure and properties of aldehydes and ketones. | 2 |
| 4. | Structure, properties and biological importance of carboxylic acids. | 2 |
| 5. | High fatty acids. Lipids. Phospholipids. | 2 |
| 6. | Structure, reaction ability and biological importance of heterofunctional compounds (hydroxyacids, α -, β -, γ -amino acids, ketoacids and phenolacids). | 2 |
| 7. | Practical skills and solving situational problems on the topic: "THEORETICAL FUNDAMENTALS OF THE STRUCTURE AND REACTIVITY OF BIORGANIC COMPOUNDS" | 2 |
| 8. | Amino acid composition peptides and proteins. | 2 |
| 9. | Structural organization of proteins. Physico-chemical properties of proteins. Reactions of protein precipitation. Denaturation. | 2 |
| 10. | Carbohydrates. Structure and chemical properties of monosaccharides. | 2 |
| 11. | Structure and functions of di- and polysaccharides. | 2 |
| 12. | Classification, structure and functions of biologically important heterocyclic compounds. | 2 |

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| 13. | Structure and biochemical functions of nucleosides and nucleotides. | 2 |
| 14. | Structure and biological role of nucleic acids. | 2 |
| 15. | Diff.credit (Final modular control 1). | 2 |
| | Total | 30 |
| The 3rd semester | | |
| Module 2. General patterns of metabolism. Metabolism of carbohydrates, lipids, and its regulation. | | |
| 1. | Analysis of structure, physical and chemical properties of protein enzymes. Measurement of enzymic activity. Units of catalytic activity of enzymes. Analysis of enzymic processes by the reaction type of main classes of enzymes. | 2 |
| 2. | Research of the mechanism of enzymic action and kinetics of enzyme catalysis. | 2 |
| 3. | Research of regulation of enzyme processes. | 2 |
| 4. | Medicinal enzymology. | 2 |
| 5. | Analysis of the role of cofactors and coenzyme vitamins in catalytic activity of enzymes. | 2 |
| 6. | Fundamental principles of metabolism. Common metabolic pathways of proteins, carbohydrates, lipids. Analysis of the tricarboxylic acid cycle. | 2 |
| 7. | Bioenergetics processes: biological oxidation, oxidative phosphorylation. | 2 |
| 8. | Analysis of aerobic and anaerobic oxidation of glucose. | 2 |
| 9. | Analysis of catabolism and biosynthesis of glycogen. Regulation of glycogen metabolism. Gluconeogenesis. | 2 |
| 10. | Analysis of mechanisms of metabolic and hormone regulation of carbohydrate metabolism. | 2 |
| 11. | Analysis of catabolism and biosynthesis of triacylglycerols. Determination of molecular mechanisms of regulation of lipolysis. | 2 |
| 12. | β -oxidation of fatty acids. Analysis of metabolism of fatty acids and ketone bodies. | 2 |
| 13. | Biosynthesis and biotransformation of cholesterol. Analysis of deficiencies of lipid metabolism: steatorrhea, atherosclerosis, obesity. | 2 |
| 14. | Analysis of amino acid metabolism (transamination, deamination, decarboxylation). | 2 |
| 15. | Diff.credit. | 2 |
| | Total | 30 |
| The 4th semester | | |
| 1. | Analysis of ammonia detoxication and urea biosynthesis. | 2 |
| 2. | Biosynthesis of porphyrins. Hereditary disorders of porphyrin metabolism. | 2 |
| 3. | Final modular control 2. | 2 |
| Module 3. Molecular biology. Biochemistry of intercellular communications. Biochemistry of tissues and physiological functions. | | |
| 4. | Structure and functions of nucleic acids. | 2 |
| 5. | Biosynthesis and catabolism of purine and pyrimidine nucleotides. Analysis for the end products of their metabolism. | 2 |
| 6. | DNA replication and RNA transcription. Biosynthesis of proteins in ribosomes. Initiation, elongation and termination in the synthesis of polypeptide chain. Inhibitory action of antibiotics. | 2 |

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| 7. | Study of molecular-cellular mechanisms of action of peptide and protein and steroid hormones on target cells. Hormones of hypothalamus and hypophysis. | 2 |
| 8. | Study of role of thyroid hormones and biogenic amines in regulation of metabolic processes. | 2 |
| 9. | Hormones of the pancreas. Hormones of the gastrointestinal tract. | 2 |
| 10. | Hormonal regulation of calcium homeostasis. | 2 |
| 11. | Physiologically active eicosanoids. | 2 |
| 12. | Study of digestion of nutrients: proteins, carbohydrates in the gastrointestinal tract. | 2 |
| 13. | Study of digestion of nutrients: lipids in the gastrointestinal tract. | 2 |
| 14. | Study of the functional role of fat-soluble vitamins in metabolism and realization of cell functions. | 2 |
| 15. | Study of blood plasma proteins: proteins of acute inflammation phase, own enzymes and indicator enzymes. | 2 |
| 16. | Study of acid-base condition of blood and respiratory function of erythrocytes. Pathological forms of hemoglobins. | 2 |
| 17. | Study of nitrogen balance and nonprotein nitrogenous components of blood – end products of heme catabolism. | 2 |
| 18. | Biochemical principles of realization of immune processes. Immunodeficiency conditions. | 2 |
| 19. | Biochemistry of the liver. Patobiochemistry of jaundices. | 2 |
| 20. | Study of processes of biotransformation of xenobiotics and endogeneous toxins. Microsomal oxidation, cytochrome P-450. | 2 |
| 21. | Study of normal and pathologica components of urine. | 2 |
| 22. | Biochemistry of muscle tissue. | 2 |
| 23. | Biochemistry of connective tissue. Biochemistry of bone tissue. Risk factors of osteoporosis. | 2 |
| 24. | Biochemistry of nervous tissue. | 2 |
| 25. | Final modular control 3. | 2 |
| | Total: | 50 |

THEMATIC PLAN OF INDEPENDENT WORK OF STUDENTS (IWS)

| The 2nd semester | | |
|------------------|--|-------|
| № | Topic | Hours |
| | Module 1. <i>Biologically important classes of bioorganic compounds. Biopolymers and their structural components.</i> | |
| 1. | Preparation for the practical classes - theoretical preparation and working off the practical skills. | 26 |
| 2. | Working off the topics which are not included into the classes plan: | |
| 2.1. | Isomerism of bioorganic compounds. Electronic effects. | 4 |
| 2.2. | Characteristics of nucleophiles and electrophiles. Reactivity of alkanes, alkenes, arenes, amines. | 4 |
| 2.3. | Functional derivatives of carboxylic acid compounds. | 4 |
| 2.4. | Structure, reactivity and biological significance of heterofunctional compounds of phenolic acids. | 4 |

| | | |
|------------------------------------|--|-----------|
| 2.5. | Structure of phospholipids, their biological significance. | 4 |
| 3. | Preparation for the final control of mastering of the module 1. | 4 |
| | Total | 50 |
| The 3rd semester | | |
| | Module 2. General patterns of metabolism. Metabolism of carbohydrates, lipids, and its regulation. | |
| 1. | Preparation for the practical classes - theoretical preparation and working off the practical skills. | 12 |
| 2. | Working off the topics which are not included into the classes plan: | |
| 2.1. | Subject and tasks of biochemistry. Aim and methods of biochemical research, its clinical and diagnostic value. | 1 |
| 2.2. | Ascorbic acid as a derivative of hexose, the biological role of vitamin C. | 1 |
| 2.3. | The role of glucuronic acid, glucosamine and galactosamine in the formation of heteropolysaccharides. | 1 |
| 2.4. | Structure and biochemical functions of nucleosides and nucleotides. | 1 |
| 3. | Preparation for the final control of mastering of the module 2. | 4 |
| | Total | 20 |
| The 4th semester | | |
| | Module 3. Molecular biology. Biochemistry of intercellular communications. Biochemistry of tissues and physiological functions. | |
| 1. | Preparation for the practical classes - theoretical preparation and working off the practical skills. | 12 |
| 2. | Working off the topics which are not included into the classes plan: | |
| 2.1. | Chromatography. The principle of ascending distribution chromatography on paper. | 1 |
| 2.2. | Methods of isolation, purification and fractionation of proteins. | 1 |
| 2.3. | Hyper- and hypoproteinemias, their causes and consequences. | 1 |
| 2.4. | Biological properties of water- and fat-soluble vitamins, role in metabolism, manifestations of insufficiency and hypervitaminosis. | 1 |
| 3. | Preparation for the final control of mastering of the module 3 | 4 |
| | Total: | 20 |

6. Course evaluation system

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|----------------------------------|--|
| General course evaluation system | <p>Current control is performed based on the control of theoretical knowledge, skills and abilities in practical classes. Independent study students are assessed in practical classes, and is an integral part of the final grade of the student. Current control is performed during the training sessions and aims at checking the assimilation of students learning the material. Forms of current control are:</p> <p>a) test tasks with a choice of one correct answer, with the definition of the correct sequence of actions, with determination of the conformity, defining the specific portion of the photo or diagram ("detection");</p> <p>b) individual oral questioning, interview;</p> <p>c) the solution of typical situational tasks;</p> |
|----------------------------------|--|

d) control of practical skills;
 e) the typical problems of genetics and medical genetics.
 Grades on the national scale ("excellent" - 5, "good" - 4, "satisfactory" - 3, "unsatisfactory" - 2), received by students, are displayed in the journals of attendance and academic group performance.

Final control

The final control is the form of a differentiated credit at the end of the 1st semester and an exam at the end of the 2nd semester upon completion of the course of medical biology.

The semester exam is a form of final control of mastering by the student of theoretical and practical material on academic discipline. The final control (exam) is carried out at the last control lesson.

Students are admitted to the FC who have attended all the classes provided by the curriculum in the discipline and while studying the module scored the number of points not less than the minimum (**72 points**). A student who, for good or bad reasons, has missed classes, is allowed to rework academic debt for a certain period of time.

Evaluation of current educational activities. During the assessment of mastering each topic for the current educational activity of the student scores are set on a 4-point (national) assessment scale. This takes into account all types of work provided by the discipline program. The student must receive a score on each topic. Scores on the traditional scale are converted into points. The final assessment of the current academic activity is the arithmetic mean (the sum of scores for each lesson is divided by the number of lessons per semester) and translated into points according to **Table 2**.

Table 2. Conversion of the average score for the current activity into a multi-point scale (for disciplines completed by diff.credit, exam)

| 4-point scale | 120-point scale | 4-point scale | 120-point scale | 4-point scale | 120-point scale | 4-point scale | 120-point scale |
|---------------|-----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|
| 5 | 120 | 4,45 | 107 | 3,91 | 94 | 3,37 | 81 |
| 4,95 | 119 | 4,41 | 106 | 3,87 | 93 | 3,33 | 80 |
| 4,91 | 118 | 4,37 | 105 | 3,83 | 92 | 3,29 | 79 |
| 4,87 | 117 | 4,33 | 104 | 3,79 | 91 | 3,25 | 78 |
| 4,83 | 116 | 4,29 | 103 | 3,74 | 90 | 3,2 | 77 |
| 4,79 | 115 | 4,25 | 102 | 3,7 | 89 | 3,16 | 76 |
| 4,75 | 114 | 4,2 | 101 | 3,66 | 88 | 3,12 | 75 |
| 4,7 | 113 | 4,16 | 100 | 3,62 | 87 | 3,08 | 74 |
| 4,66 | 112 | 4,12 | 99 | 3,58 | 86 | 3,04 | 73 |
| 4,62 | 111 | 4,08 | 98 | 3,54 | 85 | 3 | 72 |
| 4,58 | 110 | 4,04 | 97 | 3,49 | 84 | <3 | Not enough |
| 4,54 | 109 | 3,99 | 96 | 3,45 | 83 | | |
| 4,5 | 108 | 3,95 | 95 | 3,41 | 82 | | |

The maximum number of points that a student can collect for current educational activity during semester in order to be admitted to the exam is 120 points.

The minimum number of points that a student can collect for current educational activity during semester in order to be admitted to the exam is 72 points.

Calculating of the number of points is based on obtained marks of student according to traditional scale while learning subject during the semester, by calculating the arithmetic mean (AM) that is rounded to two signs after comma.

Evaluation of independent work of students. Independent work of students, which is provided by the topic of the lesson together with the classroom work, is evaluated during the current control of the topic in the relevant lesson. Assimilation of topics that are submitted only for independent work is checked during the final module control.

Evaluation of final control.

The maximum number of points that a student can score during the exam is 80 points.

The final control is considered credited if the student scored at least 60% of the maximum amount of points (for a 200-point scale - at least 50 points).

Determining the number of points that a student scored in the discipline: the number of points that a student scored in the discipline is defined as the sum of points for the current academic activity (Table 1) and for the final control (diff.credit, exam) (Table 3).

Table 3. Scale of assessment of differentiated (exam) credit:

| Traditional scale | Points |
|-------------------|--------|
| «5» | 70-80 |
| «4» | 60-69 |
| «3» | 50-59 |

Requirements for written work

The final written work is performed in the form of a test.

Practical classes

Classroom work

The 1st course. The 2nd semester

Module 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.

Topics 1-14:

Classroom work - score from 2 to 5 for each topic.

Topic 15: Differentiated credit (semester control) Semester control at the end of the 2nd semester is provided in the form of Differentiated credit. (Table 2). Provides a final grade on a 120-point scale as the sum of grades for the current control of knowledge (oral examination, written survey, tests, abstracts).

Semester control is evaluated from 50 to 80 points and consists of:

Test control - 40 tests = 40 points (1 point for the correct answer to 1 test).

Answer to 2 theoretical questions of 20 points for each = 40 points. Amount: 80.

Amount: minimum 72 + 50 = 122, maximum 120 + 80 = 200

The 2nd course. The 3rd semester

Module 2. General patterns of metabolism. Metabolism of carbohydrates, lipids, and its regulation.

Topics 1-14:

Classroom work - from 2 to 5 points for each topic.

Topic 15: Differentiated credit (semester control) Semester control at the end of the 2nd semester is provided in the form of Differentiated credit. (Table 2). Provides a final grade on a 120-point scale as the sum of grades for the current control of knowledge (oral examination, written survey, tests, abstracts).

Semester control is evaluated from 50 to 80 points and consists of:

Test control - 40 tests = 40 points (1 point for the correct answer to 1 test).

Answer to 2 theoretical questions of 20 points for each = 40 points. Amount: 80.

Amount: minimum $72 + 50 = 122$, maximum $120 + 80 = 200$

The 2nd course. The 4th semester

Module 3. Molecular biology. Biochemistry of intercellular communications. Biochemistry of tissues and physiological functions.

Topics 1-24:

Classroom work - from 2 to 5 points for each topic.

Topic 25: Final module control 3. Written test control consists of 40 tasks.

Evaluation criteria

| Score | «3» | «4» | «5» |
|---------------------------|-------|-------|-------|
| Number of correct answers | 20-29 | 30-34 | 35-40 |

At the end of the course there is an exam.

The structure of the examination card

1. Theoretical question
2. Theoretical question
3. Theoretical question
4. Practical skills

Criteria for evaluation practical skills and theoretical knowledge

- 1 question (theoretical question) - from 0 to 20 points;
- 2 questions (theoretical question) - from 0 to 20 points;
- 3 questions (theoretical question) - from 0 to 20 points;
- 4 questions (practical skills) - from 0 to 20 points;

The exam is rated from 50 to - 80 points.

The minimum score for the exam is 50 points. The maximum points for the exam is 80.

Rating scale:

| National scale | Points scale |
|----------------|--------------|
| «5» | 70-80 |
| «4» | 60-69 |
| «3» | 50-59 |

**THE LIST OF THEORETICAL QUESTIONS FOR PREPARATION OF STUDENTS
FOR THE EXAM**

1. Bioorganic chemistry as a science: definition, subject, aims, branches, research methods. Importance in high medical education.
2. Classification of organic compounds by the structure of hydrocarbon radical and nature of functional groups.
3. Classification of the most important classes of bioorganic compounds by structure of functional groups: alcohols, phenols, thiols, aldehydes, ketones, carboxylic acids, esters, amides, nitric compounds, amines.
4. Nomenclature of organic compounds: common, rational, international. Principles of naming organic compounds with the IUPAC nomenclature; nomenclature of substituents, radical-functional.
5. Nature of chemical bonds in organic compounds: hybridization of orbitals, electron structure of compounds of carbon.
6. Spatial structure of organic compounds: stereof formulas; configurations and conformations. Stereoisomers: cis-, trans, optical, conformers.
7. Optical isomerism; chirality of molecules of organic compounds. D/L- and R/S stereochemical nomenclatures. Enantiomers and diastereomers of bioorganic compounds. Correlation of spatial structure and physiologic activity.
8. Types of reactions in bioorganic chemistry. Classification (examples).
9. Carbonyl compounds in bioorganic chemistry. Chemical properties and biological importance of aldehydes and ketones.
10. Carboxylic acids in bioorganic chemistry: structure and chemical properties, functional derivatives of carboxylic acids (anhydrides, amides, esters). Decarboxylation reactions.
11. Structure and properties of dicarboxylic acids: oxalic, malic, succinic, glutaric, fumaric.
12. Lipids: definition, classification. Higher fatty acids: palmitic, stearic, oleic, linoleic, linolenic, arachidonic. Simple lipids. Triacylglycerols (neutral fats): structure, biological importance, hydrolysis.
13. Complex lipids. Phospholipids: phosphatidic acid, phosphatidylethanolamine, phosphatidylcholine, phosphatidylserine. Sphingolipids. Glycolipids. Role of complex lipids in biomembranes.
14. Amines: nomenclature, properties. Biological importance of biogenic amines (epinephrine, norepinephrine, dopamine, tryptamine, serotonin, histamine) and polyamines (putrescine, cadaverine).
15. Aminoalcohols: structure, properties. Biological role of ethanolamine (colamine), choline, acetylcholine.
16. Hydroxyacids in bioorganic chemistry: structure and properties of monocarboxylic (lactic and β -hydroxybutyric), dicarboxylic (malic, tartaric) hydroxyacids.
17. Amino acids: structure, stereoisomerism, chemical properties. Biological importance of L- α -amino acids. Biochemical transformations of amino acids: deamination, transamination, decarboxylation.
18. Amino acid composition of proteins and peptides; classification of proteinogenic L- α -amino acids. Chemical and physico-chemical properties of the amino acids. The ninhydrin reaction, its importance in analysis of amino acids.
19. Proteins and peptides: definition, classification, biological functions. Types of bonds between amino acid moieties in protein molecules. The peptide bond: formation, structure; the biuret reaction.
20. Organizational levels of protein structure: primary, secondary, tertiary, quaternary. Oligomeric proteins.
21. Physico-chemical properties of proteins; their molecular mass. Methods of sedimentation. Denaturation of proteins.
22. Carbohydrates: definition, classification. Monosaccharides (aldoses and ketoses; trioses, tetroses, pentoses, hexoses, heptoses), biological importance of certain representatives.

23. Monosaccharides: pentoses (ribose, 2-deoxyribose, xylose), hexoses (glucose, galactose, mannose, fructose) – structure, properties. Qualitative reactions for glucose.
24. Structure and properties of derivatives of monosaccharides. Amino derivatives: glucosamine, galactosamine. Uronic acids. L-ascorbic acids (vitamin C). Products of reduction of monosaccharides: sorbitol, mannitol.
25. Oligosaccharides: structure, properties. Disaccharides (sucrose, lactose, maltose), their biomedical importance.
26. Polysaccharides. Homopolysaccharides: starch, glycogen, cellulose, dextrans – structure, hydrolysis, biomedical importance. Qualitative reactions for starch.
27. Heteropolysaccharides: definition, structure. Structure and biomedical importance of glycosaminoglycans (mucopolysaccharides) – hyaluronic acid, chondroitin sulfates, heparin.
28. Five-membered heterocycles with one heteroatom (pyrrole, furan, thiophene). Biomedical importance of tetrapyrrole compounds: porphins, porphyrins, heme.
29. Indole and its derivatives: tryptophane and reactions of formation of tryptamine and serotonin; indoxyle, skatole, skatoxyle – role in the processes of protein decomposition in the intestine.
30. Five-membered heterocycles with two nitrogen heteroatoms. Pyrazole, pyrazolone; derivatives of pyrazolone-5 as medicines (antipyrine, amidopyrine, analgin). Imidazole and its derivatives: histidine, histamine.
31. Five-membered heterocycles with two different heteroatoms: thiazole, oxazole. Thiazole as a structure component of the thiamine molecule (vitamin B₁).
32. Six-membered heterocycles with one nitrogen atom: pyridine. Nicotinamide (vitamin PP) as the component of reduction-oxidation pyridine coenzymes. Pyridoxine and molecular forms of vitamin B₆.
33. Six-membered heterocycles with two nitrogen atoms. Diazines: pyrimidine, pyrazine, pyridazine. Nitrogenous compounds – derivatives of pyrimidine (uracil, cytosine, thymine).
34. Derivatives of pyrimidine as medical preparations: 5-fluorouracil, potassium orotate. Barbituric acid; barbiturates as sedatives and antiepileptic compounds (phenobarbital, veronal).
35. Purine and its derivatives. Amino derivatives of purine (adenine, guanine), their tautomeric forms; their biochemical role in formation of nucleotides and coenzymes.
36. Hydroxyderivatives of purine: hypoxanthine, xantine, uric acid. Methylated derivatives of xantine (caffeine, theophylline, theobromine) as physiologically active compounds that act on the central nervous system and the cardiovascular system.
37. Nucleosides, nucleotides. Nitrogenous bases of the purine and pyrimidine series as components of nucleotides. Minor nitrogenous bases.
38. Nucleosides. Nucleotides as phosphorylated derivatives of nucleosides (nucleoside mono-, di- and triphosphates). Nomenclature of nucleosides and nucleotides as RNA and DNA components.
39. Structure and biochemical functions of free nucleotides: nucleotide coenzymes, cyclic nucleotides 3',5'-cAMP and 3',5'-cGMP.
40. Nucleic acids (deoxyribonucleic, ribonucleic) as polynucleotides. Polarity of polynucleotide chains of DNA and RNA.
41. Structure and properties of DNA; nucleotide composition, complementarity of nitrogenous bases. Primary, secondary and tertiary structure of DNA.
42. RNA: structure, types of RNA, their role in protein biosynthesis.
43. Vitamins: general characteristics; coenzyme action of vitamins. Structure and properties of the vitamins B₁, B₂, B₆, PP.
44. Prove presence of formaldehyde in a solution with the Trommer's test. Make conclusions.
45. Explain the iodineformic test for acetone. Make conclusions.
46. How and why does the color of KMnO₄ solution change when oleic acid is added?
47. Why is the Wagner's test for unsaturation of fat qualitative? Analyze the results.
48. Explain difference in chemical behaviour of salole and aspirin in their reactions with FeCl₃. Explain the conclusions.
49. Explain steps of obtaining Fehling's reagent. Where is it used?

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|--|--|
| <p>50. Why does the reaction of glucose and lactose with Fehling's reagent differ from the interaction of sucrose with Fehling's reagent?</p> <p>51. What is the qualitative reaction for starch?</p> <p>52. Why are different products obtained in the reaction of glucose with $\text{Cu}(\text{OH})_2$ at different conditions (room temperature and heating)? Explain your reasoning.</p> <p>53. Explain qualitative reactions for amino acids and proteins:</p> <ol style="list-style-type: none"> xantoproteic; ninhydrin; Fohl's; biuret. <p>Why solutions of different colors are obtained?</p> <p>54. What reaction can be used to differentiate peptides from proteins?</p> <p>55. How do ammonium sulfate, trichloroacetic acid and sulfosalicylic acid react with proteins? Explain your reasoning.</p> <p>56. How and why does the composition of nucleic acids change in hydrolysis. Determine components of the hydrolysate. Make conclusions.</p> | |
| <p>Circumstance of admission to the final control</p> | <ol style="list-style-type: none"> Semester control at the end of the 1st semester is provided in the form of a differential credit. (Table 2) Provides a final score on a 120-point scale as the sum of scores for the current control of knowledge (oral examination, written survey, tests, abstracts), the results of 3 modules. Students are allowed to take the differentiated credit, exam only if there is no debt for the implementation of the curriculum. |
| <p>7. Course policy</p> | |
| <p>The organization of the educational process is carried out with the use of the European Credit Transfer System (ECTS) to assess student performance. The points gained in the current survey, independent work and points of the final control are credited. This must take into account the student's presence in class and his activity during practical work. Inadmissible: absences and late classes; use of a mobile phone, tablet or other mobile devices during the lesson (except for the cases provided by the curriculum and methodical recommendations of the teacher); copying and plagiarism; untimely performance of the task, the presence of unsatisfactory grades for 50% or more of the submitted theoretical and practical material.</p> | |
| <p>8. RECOMMENDED LITERATURE</p> | |
| <p>1. Basic:</p> <ol style="list-style-type: none"> J. Komarytsia. Organic Chemistry. Handbook for medical students. Lviv 2005.- 74p. Stoker, H.S. (2001). Organic and biological chemistry. Houghton Mifflin. 2001. 556p. Catch Up Chemistry: For the Life and Medical Sciences. Mitch Fry; 2005 by Scion Publishing. Clinical Chemistry: Concepts and Applications. Shauna C. Anderson, Susan Cockayne; 2002 by McGraw-Hill Medical. | <p>Additional:</p> <ol style="list-style-type: none"> L.G. Wade Jr. Organic Chemistry. 8th edition. - Pearson. 2013. - 547p. T. Graham Solomons, Craig B. Fryhle. Organic Chemistry. Tenth edition. Hoboken, NJ. - 2011. - John Wiley and Sons, Inc. - 1218 p. David C. Eaton. Laboratory investigation in Organic Chemistry. - MCGRAW-HILL BOOK COMPANY. - New York - Toronto. - 893 p. |

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