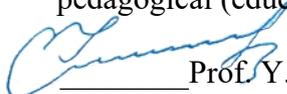


**National Pirogov Memorial Medical University, Vinnytsya**

Department of biological and general chemistry

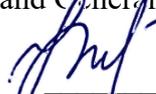
**“APROVE”**

Vice - Rector for on scientific and  
pedagogical (educational) work

  
Prof. Y.I. Guminskiy  
“ 31 ” August 2020 year

**“AGREED”**

Head of the Department of the Biological  
and General Chemistry Department

  
prof. Zaichko N.V.  
“ 28 ” August 2020 year

**SYLLABUS  
of academic discipline  
"BIOLOGICAL AND BIOORGANIC CHEMISTRY"**

training of specialists of the second (master's) level of higher education

qualification of educational “Master of Medicine”  
qualification of professional “Doctor”

Field of study 22 “Health care”

specialty 221 - “Dentistry”

2020 – 2021

## 1. Course abstract:

### Semester (s) - 2, 3 and 4

Scope of the discipline: total number of hours - 240 of them lectures - 40, practical classes - 108, independent work - 92, ECTS credits – 8.

In the general system of training a dentist, biological and bioorganic chemistry is one of the basic theoretical disciplines. The main task of the course of biological and bioorganic chemistry is to teach students basic concepts about the chemical composition of the human body, classification, functions of proteins, carbohydrates, lipids, minerals, enzymes, hormones and vitamins, biochemical composition of biological fluids and tissues, and basic ways of biochemical processes that provide homeostasis, energy balance, growth and development of the organism.

According to the curriculum, the study of biological and bioorganic chemistry is carried out in the 1st and 2nd year of study, and includes lectures and practical classes that reveal the main issues of the relevant sections of the discipline. Practical classes (seminars) provide detailed consideration by students of some theoretical provisions of the discipline with the teacher and the formation of skills and abilities of their practical application through individual performance of student-formulated tasks and solving situational problems.

Lectures cover the basic theoretical material of a particular or several topics of the discipline, which highlights the basic laws of metabolism and possible ways of their regulation, metabolism of bioorganic compounds and biochemical composition of basic biological fluids in normal and pathological conditions. The lecture "Biochemistry of tooth and saliva" is read separately.

The organization of the educational process is carried out according to the credit-module system in accordance with the requirements of the Bologna process. The amount of student workload is described in ECTS credits - credit credits, which are credited to students upon successful mastering of the module (credit).

The program of the discipline is structured into 5 modules, which are divided into 18 content modules. Bioorganic chemistry includes 1 module, which is divided into 4 semantic modules. Biological chemistry is structured into 4 modules, which are divided into 14 semantic modules. The amount of study load is described in ECTS credits, which are credited to students upon successful completion of the relevant module (credit).

Types of classes according to the curriculum are lectures, practical classes, independent work of students.

The topics of the lecture course reveal the problematic issues of the relevant sections of biological and bioorganic chemistry.

Assimilation of the topic is controlled in practical classes in accordance with specific objectives, assimilation of content modules - in practical final classes. The following means of diagnosing the level of preparation of students are used: tests, solving situational problems, filling out workbooks, performing laboratory work. Interpretation of laboratory tests and interpretation and evaluation of their results; analysis and evaluation of indicators that characterize the functions of the human body, its systems and organs; control of practical skills.

Final control is carried out upon completion of the discipline in the form of an exam. Students who have completed all types of work provided for in the curriculum and scored at least the minimum number of points in the discipline, as well as have no unfinished lectures and practical classes are admitted to the exam. The form of the exam is standardized and includes control of theoretical and practical training. The exam is conducted during the examination session according to the schedule and includes: 20 standard test tasks, each of which has one correct answer out of five proposed (evaluated by 1 point); 2 situational problems and theoretical questions, the answers to which are evaluated from 38 to 60 points. Thus, a student can score a maximum of 80 points.

Assessment of student performance in the discipline is a rating and is set on a multi-point scale and is determined by the ECTS system and the scale adopted in Ukraine.

## 2. Prerequisites:

Biological and bioorganic chemistry as a discipline is based on the study of medical chemistry and medical biology by students and is integrated with these disciplines;

### Medical biology

Topics:

*Biological features of human life. Organismal level of organization of life:* knowledge of the manifestations of general biological laws, understanding of the laws of the human body at the molecular genetic and cellular levels outline the concept of the essence of life and determine the place of man in the system of living nature.

*Cell morphology. Structural components of the cytoplasm. Cell membranes. Transport of substances through the plasmalemma:* understanding the structural and functional organization of the eukaryotic cell as an elementary unit of the human body, the function of the cell membrane is a prerequisite for understanding the features of the flow and regulation of biochemical processes in normal and pathology.

*Chromosome morphology. Human karyotype. Characteristics of nucleic acids. Gene structure of pro- and eukaryotes. Genes are structural, regulatory, tRNA, rRNA. Organization of information flow in the cell. Regulation of gene expression.* Knowledge of the structural and functional levels of hereditary material, mastering methods of studying human karyotype and principles of chromosome classification, understanding the structure of genes and the role in storing and transferring hereditary information are necessary for further understanding of hereditary information at the molecular level, pathogenesis and diagnosis of molecular diseases.

### Medical chemistry.

Topics:

*Biogenic s-, p- and d – elements, chemical properties, biological role, application in medicine.* Knowledge of the physical and chemical properties of s-, p- and d – elements will allow to evaluate their participation in chemical processes occurring in a living organism, importance in the development and treatment of diseases.

*Methods of expressing the concentration of solutions, preparation of solutions, chemical utensils:* knowledge of ways to express the concentration of solutions, the ability to prepare solutions of a certain concentration will allow you to gain skills in clinical and biochemical research.

*Acid-base balance in the body. Hydrogen index of biological fluids. Buffer systems, classification and mechanism of action. Buffer capacity. The role of buffer solutions in biosystems* Knowledge of the laws that determine the concentration of hydrogen ions is necessary to understand the buffering properties of blood and saliva, to create a biological environment for the metabolic process in the oral cavity in normal and in pathology

*Thermal effects of chemical reactions, direction of processes.* Knowledge of the basics of chemical thermodynamics is necessary to understand the energy of biochemical processes. The calculation of the thermal effect is used in dietetics to determine the caloric content of food.

*Sorption of biologically active substances at the interface between liquid-gas phases. Preparation, purification and properties of colloidal solutions, coagulation of colloidal solutions.* Knowledge of surface tension at the interface between liquid and gas phases in biological systems, dispersed systems lay the foundations for understanding the course of biochemical processes in various organs and systems in normal and in pathology.

**Post-requisites** of the discipline of biological and bioorganic chemistry - disciplines that require knowledge, skills and abilities acquired after the study of this discipline.

Biological and bioorganic chemistry as a discipline:

1) lays the foundations for students to study molecular biology, genetics, physiology and pathological physiology, professionally-oriented disciplines, which provides for the integration of teaching with these disciplines and the formation of skills to apply knowledge of biological chemistry in further study and professional activities;

2) lays the foundations for clinical diagnosis of the most common diseases, monitoring the course of the disease, monitoring the effectiveness of drugs and measures aimed at preventing the occurrence and development of pathological processes.

### 3. The purpose of the course

"Biological and bioorganic chemistry" as a discipline aims to train specialists - dentists who have a significant amount of theoretical and practical knowledge about the chemical composition of living organisms, structural organization and properties of bioorganic compounds - components of cells, tissues and organs of the human body, patterns of metabolism substances and energy at the molecular level in healthy and diseased organisms.

The ultimate goal of the course is to create a base of ideas about biochemical properties and metabolism of basic biomolecules in the human body in normal and pathological conditions, biochemical studies and evaluation of results with interpretation of clinical and diagnostic value, formation on this basis of clinical, biochemical and scientific thinking successful mastering of professionally-oriented medical and theoretical disciplines (pathological physiology, pharmacology, clinical disciplines).

The main objectives of the discipline "Biological and bioorganic chemistry" are the acquisition of knowledge and skills to conduct biochemical studies to identify normal and pathological components in biological fluids (blood, saliva, urine); interpret the results of biochemical studies for the diagnosis of the most common human diseases, congenital and acquired disorders of metabolic processes (enzymopathies, dysvitaminosis, dyslipidemia, etc.); analyze biochemical processes and their regulation at different stages of metabolism and energy, and understand their importance in ensuring the functioning of organs and systems of the human body.

### 4. Learning outcomes of the discipline:

*know:*

- the structure of bioorganic compounds and the functions they perform in the human body;
- reactivity of the main classes of biomolecules, which provides their functional properties and metabolic transformations in the body;
- general biochemical mechanisms of pathological processes in the human body;
- features of diagnostics of a physiological condition of an organism and development of pathological processes on the basis of laboratory researches;
- connection of features of structure and transformations in an organism of bioorganic compounds as bases of their pharmacological action as medicines;
- basic mechanisms of biochemical action and principles of directed application of different classes of pharmacological agents;
- biochemical and molecular basis of physiological functions of cells, organs and systems of the human body;
- - the functioning of enzymatic processes occurring in membranes and organelles to integrate metabolism in individual cells;
- norms and changes in biochemical and enzymatic parameters used to diagnose the most common human diseases;
- the importance of biochemical processes of metabolism and its regulation in ensuring the functioning of organs, systems and the whole human body.

*be able:*

- to analyze the conformity of the structure of bioorganic compounds to the biological functions they perform in the human body;
- interpret the peculiarities of the body's metabolism and the development of pathological processes on the basis of laboratory tests;
- analyze the contribution of carbohydrates, lipids, amino acids in ensuring metabolic transformations in various functional states in the body;
- to interpret the peculiarities of the structure and transformations in the body of bioorganic compounds as the basis of their pharmacological action as drugs;

- interpret the biochemical mechanisms of pathological processes in the human body and the principles of their correction;
- explain the basic mechanisms of biochemical action and the principles of targeted use of different classes of pharmacological agents;
- explain the biochemical and molecular basis of physiological functions of cells, organs and systems of the human body;
- to analyze the functioning of enzymatic processes occurring in membranes and organelles to integrate metabolism in individual cells;
- classify the results of biochemical studies and changes in biochemical and enzymatic parameters used to diagnose the most common human diseases;
- to interpret the importance of biochemical processes of metabolism and its regulation in ensuring the functioning of organs, systems and the whole human body.

*able to demonstrate:* knowledge and practical skills in the discipline; ability to independently search, analyze, synthesize and use information from various sources to solve typical and specialized tasks of professional activity;

*have the skills:* methods of laboratory research methods, interpretation of biochemical research results;

*decide for yourself:* use of knowledge and practical skills in the discipline to provide home care to patients in emergencies and victims in extreme situations;

have psychological communication skills to achieve trust and mutual understanding with colleagues, doctors, patients, consumers

### Subjects of practical employment for the 1st and 2nd year students

№	The name of a theme of practical employment	Hours
<b>1st year</b>		
<b>1.</b>	<b>Classroom work</b> Nomenclature, nature of chemical bonds in organic compounds.	2
	<b>Home work</b> Bioorganic chemistry as a science. The key concepts of Butlerov's theory. Classification of organic compounds	2
	<b>Home work</b> Conjugacy and aromaticity of biologically active compounds	8
<b>2</b>	<b>Classroom work</b> Isomers of organic compounds	2
<b>3</b>	<b>Classroom work</b> Acidity and basicity of organic compounds.	2
<b>4.</b>	<b>Classroom work</b> Reactivity of alkanes, alkenes, arenes	2
<b>5</b>	<b>Classroom work</b> Reactivity of aldehydes and ketones	2
<b>6.</b>	<b>Classroom work</b> Reactivity and biological meaning of carboxylic acids	2
	<b>Home work</b> Structure and properties of dicarboxylic acids: oxalic, malonic, succinic, glutaric, fumaric.	6
<b>7.</b>	<b>Classroom work</b> Reactivity and biological significance of (hydroxy acids and oxoacids).	2
	<b>Home work</b> Alkaloids: classification, characteristics of individual representatives, methods of selection.	4

8	HFA. Lipids. Phosphoglycerides.	2
	<b>Home work</b> Unsaponifiable lipids: definition, classification, structure of the main representatives, physicochemical properties and biomedical value.	4
9.	<b>Classroom work</b> Structure and chemical properties of $\alpha$ - amino acids.	2
10.	<b>Classroom work</b> Physical-chemical properties of proteins. Structure of proteins	2
	<b>Home work</b> Physical- chemical analysis of proteins.	6
	<b>Home work</b> Historical aspects of peptide synthesis. Basic stages and principles of peptide synthesis according to Maryfield	4
11.	<b>Classroom work</b> Monosaccharides, structure and chemical properties.	2
12.	<b>Classroom work</b> Oligo- and polysaccharides, structure and chemical properties	2
	<b>Home work</b> Heteropolysaccharides: definition, structure, physicochemical properties and biomedical value of hyaluronic acid, chondroitin sulfates, heparin, chitin.	6
13.	<b>Classroom work</b> Heterocyclic compounds, classification, structure, chemical properties. Nucleic acids, structure, biological role.	2
	<b>Home work</b> Five-membered heterocycles: classification, representatives, chemical properties, biomedical significance	4
	<b>Home work</b> Six-membered heterocycles: classification, representatives, chemical properties, biomedical significance	6
14	<b>Classroom work</b> Computer control. Practical skills	2
15.	<b>Classroom work</b> Concluding session № 1 «Biologically important classes of organic compounds, biopolymers»).	2
<b>2nd year</b>		
16.	<b>Classroom work</b> Introduction to biochemistry. Biomolecules and cellular structures. Qualitative reactions to proteins and amino acids.	2
	<b>Home work</b> History of biochemistry. Development of biochemical research in Ukraine. Ukrainian biochemical schools	2
	<b>Home work</b> Biomembranes: definition, structure, biophysical properties, general and specialized functions. Types of transmembrane transport of substances	2
17.	<b>Classroom work</b> Nomenclature, classification and structure of enzymes. Coenzymes.	2
	<b>Home work</b> Coenzymes of group I: definition, classification, structure, mechanism of action, biological role, application in medicine	2
	<b>Home work</b> Coenzymes of group II: definition, classification, structure, mechanism of	2

	action, biological role, application in medicine	
18.	<b>Classroom work</b> Properties of enzymes. Kinetics and energy of enzymatic reactions. Principles of definition and units of enzymatic activity.	2
19.	<b>Classroom work</b> Enzymes activities regulation. Activators and inhibitors of enzymes. Isoenzymes. Multienzyme complexes. Medical enzymology.	2
20.	<b>Classroom work</b> Common metabolic pathways. Oxidative decarboxylation of pyruvate. Krebs tricarboxylic acid cycle.	2
21	<b>Classroom work</b> Biological oxidation. Tissue respiration. Oxidative phosphorylation.	2
	<b>Home work</b> History of the development of the doctrine of biological oxidation. Bach's oxygen peroxide activation theory, Palladin's dehydrogenation theory, Wieland, Warburg, Engelhardt theories	4
22.	<b>Classroom work</b> Concluding session № 2 «Enzymes. Common metabolic pathways»	2
23.	<b>Classroom work</b> Digestion, absorption and transport of carbohydrates. Anaerobic and aerobic oxidation of glucose.	2
	<b>Home work</b> Alcohol fermentation: definition, localization, reactions, similarity to glycolysis, biological significance.	1
24.	<b>Classroom work</b> Glycogen metabolism. Gluconeogenesis.	2
	<b>Home work</b> Glycoconjugates: definition, biological significance, synthesis and degradation reactions. Glycosidoses.	0,5
	<b>Home work</b> Biochemistry of blood groups. The structure of blood group antigens O, A and B.	0,5
25.	<b>Classroom work</b> Pentose phosphate cycle. Fructose and galactose metabolism.	2
26.	<b>Classroom work</b> Regulation and pathology of carbohydrates metabolism.	2
27.	<b>Classroom work</b> Digestion, absorption and transport of lipids. Lipid peroxidation. Arachidonic acid cascade.	2
	<b>Home work</b> Metabolism of primary and secondary bile acids. The use of bile acids in medicine.	1
	<b>Home work</b> Inhibitors of the arachidonic acid cascade (phospholipase A2 inhibitors, COX 1 and COX 2, lipoxygenase) and their use in medicine	1
28.	<b>Classroom work</b> Lipolysis: catabolism of triglycerides, oxidation of glycerol and fatty acids.	2
29.	<b>Classroom work</b> Lipogenesis: synthesis of fatty acids, triglycerides and phosphoglycerides.	2
	<b>Home work</b> Adipose tissue hormones: representatives and their biological significance.	1

30.	<b>Classroom work</b> Metabolism of ketone bodies and cholesterol. Sphingolipidoses. Metabolism of sphingolipids. Regulation and pathology of lipid metabolism.	2
	<b>Home work</b> Antioxidants: main representatives, mechanism of action, biological significance.	1
31.	<b>Classroom work</b> Concluding session № 3 «Metabolism of carbohydrates and lipids, their regulation»	2
32.	<b>Classroom work</b> Digestion, absorption and putrefaction of proteins. Nutritional value of proteins.	2
	<b>Home work</b> Decay reactions of proteinogenic and non-proteinogenic amino acids. Neutralization of toxic decay products	2
33.	<b>Classroom work</b> Decarboxylation and transamination of amino acids.	2
34.	<b>Classroom work</b> Deamination of amino acids. Ammonia neutralization. Urea synthesis	2
35.	<b>Classroom work</b> Specialized ways of acyclic and cyclic amino acids metabolism.	2
	<b>Home work</b> Individual metabolic pathways and biological role of threonine, alanine, aspartate, asparagine, glutamate, glutamine, lysine, proline.	2
36.	<b>Classroom work</b> Metabolism of nucleotides.	2
37.	<b>Classroom work</b> Genetic code. Replication. DNA- reparation. Mutations.	2
	<b>Homework</b> Mutagens: classification, mechanism of action, representatives.	2
38.	<b>Classroom work</b> Transcription. Translation. Inhibitors of matrix processes.	2
39.	<b>Classroom work</b> Regulation of genes expression. Polymerase chain reaction. Genetic engineering.	2
	<b>Home work</b> Molecular basis of gene therapy	2
40.	<b>Classroom work</b> Concluding session № 4 «Metabolism of simple proteins. Molecular biology	2
41.	<b>Classroom work</b> Chemical nature and mechanism of action of hormones and hormone-like substances. Qualitative reactions on insulin, adrenaline, thyroxine.	2
	<b>Home work</b> Hormone-like substances: definitions, representatives, biological significance and application in medicine	2
	<b>Homework</b> Biochemistry of receptor-mediated and receptor-independent apoptosis.	2
42.	<b>Classroom work</b> Hormones of central and peripheral endocrine glands.	2
43.	<b>Classroom work</b> Hormones of mixed secretion glands. Endocrine control of Ca and P homeostasis.	2

44.	<b>Classroom work</b> Vitaminology. Vitamin-like substances. Vitamins C and P.	2
	<b>Home work</b> Biochemical bases of rational nutrition. The concept about macro- and micronutrients.	2
	Vitamin-like substances: classification, representatives, biological significance, application in medicine.	2
45.	<b>Classroom work</b> Water-soluble vitamins of group B.	2
46.	<b>Classroom work</b> Lipid soluble vitamins.	2
47.	<b>Classroom work</b> Blood biochemistry. Chemical composition and physicochemical constants of blood.	2
48.	<b>Classroom work</b> Blood proteins and enzymes.	2
	<b>Home work</b> Modern ideas about the hemostasis system. Biochemical bases of vascular-platelet, coagulation hemostasis and fibrinolysis	2
	<b>Home work</b> Biochemistry of the immune system. Structure and functions of immunoglobulins. Biochemical bases of cellular and humoral immunity. Biochemistry of the complement system. Biochemical bases of immunodeficiencies.	2
49.	<b>Classroom work</b> Biochemistry of erythrocytes and hemoglobin.	2
	<b>Home work</b> Respiratory function of erythrocytes and biochemical bases of gases exchange.	2
50.	<b>Classroom work</b> Biochemistry of liver. Pigmentary metabolism. Jaundices.	2
51.	<b>Classroom work</b> Detoxificational function of liver. Metabolism of xenobiotics.	2
52.	<b>Classroom work</b> Biochemistry of kidneys and urine. Physicochemical properties of urine. Water-mineral metabolism.	2
	<b>Home work</b> Metabolism and biological significance of trace elements (Zn, Mg, Mn, Se, Co, Cu, Mo, F, S, Cr). Biochemical bases of microelementoses.	2
53.	<b>Classroom work</b> Biochemistry of connective tissue. Biochemistry of teeth and saliva	2
54.	<b>Classroom work</b> Concluding session № 5 «Functional biochemistry»	2
	Classroom work	108
	Independent home work	92
	Lectures	40
	At all.	240

### Topic of lectures

№	Topic of lectures	Duration	Lector
<b>1st year</b>			
1	Basics of the reactivity of biologically active compounds	2,0	Associate prof. Shunkov V.S.
2	Carbonyl compounds. Lipids	2.0	Associate prof. Shunkov V.S.
3	Amino acids, peptides, proteins	2.0	Associate prof. Shunkov V.S.
4	Carbohydrates.	2,0	Associate prof. Shunkov V.S.
5	Heterocyclic compounds. Nucleic acids	2,0	Associate prof. Shunkov V.S.
<b>2nd year</b>			
6	Introduction. Enzymes. Isoenzymes. Multienzymes. Cofactors and coenzymes. Medical enzymology	2,0	Associate prof. Filchukov D.O.
7	Common metabolic pathways. Biological oxidation. Tissue respiration. Oxidative phosphorylation	2.0	Associate prof. Filchukov D.O.
8	Carbohydrate metabolism: main pathways, regulation and pathology	2.0	Associate prof. Filchukov D.O.
9	Lipid metabolism-1. Digestion of lipids in GIT. Transport forms of lipids. Lipolysis. $\beta$ -oxidation of fatty acids and glycerol	2,0	Associate prof. Filchukov D.O.
10	Lipid metabolism-2. Lipogenesis. Metabolism of cholesterol and ketone bodies. Regulation and pathology of lipid metabolism	2,0	Associate prof. Filchukov D.O.
11	Common pathways of amino acid metabolism. Ways of ammonia neutralization. Enzymopathies of the urinary cycle. Hyperamonaemia	2,0	Associate prof. Filchukov D.O.
12	Molecular biology. Directions of genetic information transfer. Genetic code. Replication. DNA repair. Transcription. Translation	2,0	Associate prof. Filchukov D.O.
13	Molecular genetics. Regulation of gene expression in prokaryotes according to Jacob and Mono. Regulation of protein synthesis in eukaryotes. Molecular mechanisms of mutations. Principles of genetic engineering	2.0	Associate prof. Filchukov D.O.
14	Molecular mechanisms of intercellular communication. Hormones: chemical nature, mechanisms of hormonal signal transduction, biological effects, pathology	2.0	Associate prof. Filchukov D.O.

15	Basic concepts of vitaminology. Biochemistry of water-soluble and fat-soluble vitamins	2,0	Associate prof. Filchukov D.O.
16	Blood biochemistry. Erythrocytes metabolism. Hemoglobin: biosynthesis, pathology.	2,0	Associate prof. Filchukov D.O.
17	Liver biochemistry. Pigmentary metabolism. Jaundices (hereditary and acquired).	2,0	Associate prof. Filchukov D.O.
18	Xenobiotics: phases and mechanisms of biotransformation, the role of cytochrome P450. Ethanol metabolism	2.0	Associate prof. Filchukov D.O.
19	Water- mineral metabolism. Biochemistry of kidneys and urine	2,0	Associate prof. Filchukov D.O.
20	Biochemistry of connective tissue, markers of damage, pathology. Biochemistry of the tooth: features of the chemical composition, metabolism in the tooth tissues. Basic functions, chemical composition, physical and chemical properties of saliva.	2,0	Associate prof. Filchukov D.O.

### Topic of independent work for the 1st and 2nd year students

№	Topic of independent home work	Hours
1st year		
1.	Bioorganic chemistry as a science. The key concepts of Butlerov's theory. Classification of organic compounds	2
2.	Conjugacy and aromaticity of biologically active compounds	8
3.	Structure and properties of dicarboxylic acids: oxalic, malonic, succinic, glutaric, fumaric.	6
4.	Alkaloids: classification, characteristics of individual representatives, methods of selection.	4
5.	Unsaponifiable lipids: definition, classification, structure of the main representatives, physicochemical properties and biomedical value.	4
6.	Physical- chemical analysis of proteins.	6
7.	Historical aspects of peptide synthesis. Basic stages and principles of peptide synthesis according to Maryfield	4
8.	Heteropolysaccharides: definition, structure, physicochemical properties and biomedical value of hyaluronic acid, chondroitin sulfates, heparin, chitin.	6
9.	Five-membered heterocycles: classification, representatives, chemical properties, biomedical significance	4
10.	Six-membered heterocycles: classification, representatives, chemical properties, biomedical significance	6
	At all. (1st year )	50
2nd year		
11.	History of biochemistry. Development of biochemical research in Ukraine. Ukrainian biochemical schools	2
12.	Biomembranes: definition, structure, biophysical properties, general and specialized functions. Types of transmembrane transport of substances	2
13.	Coenzymes of group I: definition, classification, structure, mechanism of action, biological role, application in medicine	2
14.	Coenzymes of group II: definition, classification, structure, mechanism of action, biological role, application in medicine	2
15.	History of the development of the doctrine of biological oxidation. Bach's oxygen peroxide activation theory, Palladin's dehydrogenation theory, Wieland, Warburg,	2

	Engelhardt theories	
16.	Alcohol fermentation: definition, localization, reactions, similarity to glycolysis, biological significance.	1
17.	Glycoconjugates: definition, biological significance, synthesis and degradation reactions. Glycosidoses.	0,5
18.	Biochemistry of blood groups. The structure of blood group antigens O, A and B.	0,5
19.	Metabolism of primary and secondary bile acids. The use of bile acids in medicine.	1
20.	Inhibitors of the arachidonic acid cascade (phospholipase A2 inhibitors, COX 1 and COX 2, lipoxygenase) and their use in medicine	1
21.	Adipose tissue hormones: representatives and their biological significance.	1
22.	Antioxidants: main representatives, mechanism of action, biological significance.	1
23.	Decay reactions of proteinogenic and non-proteinogenic amino acids. Neutralization of toxic decay products	2
24.	Individual metabolic pathways and biological role of threonine, alanine, aspartate, asparagine, glutamate, glutamine, lysine, proline.	2
25.	Mutagens: classification, mechanism of action, representatives.	2
26.	Molecular basis of gene therapy	2
27.	Hormone-like substances: definitions, representatives, biological significance and application in medicine	2
28.	Biochemistry of receptor-mediated and receptor-independent apoptosis.	2
29.	Biochemical bases of rational nutrition. The concept about macro- and micronutrients.	2
30.	Vitamin-like substances: classification, representatives, biological significance, application in medicine.	2
31.	Respiratory function of erythrocytes and biochemical bases of gases exchange.	2
32.	Modern ideas about the hemostasis system. Biochemical bases of vascular-platelet, coagulation hemostasis and fibrinolysis	2
33.	Biochemistry of the immune system. Structure and functions of immunoglobulins. Biochemical bases of cellular and humoral immunity. Biochemistry of the complement system. Biochemical bases of immunodeficiencies.	2
34.	Metabolism and biological significance of trace elements (Zn, Mg, Mn, Se, Co, Cu, Mo, F, S, Cr). Biochemical bases of microelementoses.	2
	At all. (2nd year )	42
	<b>At all.</b>	<b>92</b>

**The questions for the exam in the discipline «Biological and bioorganic chemistry»  
for 2nd year students**

**Enzymes and cofactors**

1. Enzymes : definition, nomenclature, classification, properties.
2. The chemical nature and structure of enzymes. Active and allosteric centers. The mechanism of action of enzymes.
3. Multienzymes and isoenzymes. The clinical significance of isoenzymes. Enzymodiagnosis and enzyme therapy.
4. Activators and inhibitors of enzymes. Competitive and non-competitive enzyme inhibitors in medicine.
5. Principles and units for determining the activity of enzymes. Methods of regulation of enzymatic activity.
6. Coenzymes involved in redox reactions: vitamin (NAD, NADP, FAD, FMN, ubiquinone), heme, glutathione: mechanisms of action, significance.
7. Coenzymes - carriers of chemical groups (TDF, PALF, CoA, biotin, THFK, methylcobalamin, vitamins K and A): mechanism of action, biological significance.

### **Common metabolic pathways. Bioenergetics.**

1. Concept of bioenergetics. The general ways of catabolism and stages of formation of energy from organic substances.
2. Oxidative decarboxylation of pyruvate. Characteristic of multienzymatic complex.
3. Krebs cycle (citric acid cycle): mechanism, regulation, significance, recruitment of metabolites.
4. Modern concept of tissue respiration. Structural organization of mitochondrial respiratory chain. Inhibitors of tissue respiration.
5. Oxidative phosphorylation: definition, mechanism, significance the formation and role of electrochemical potential  $\Delta\mu H$  in the ATP synthesis. Coefficient P/O. Disconnect of tissue respiration and oxidative phosphorylation. Macroergic compounds: examples, structure and significance of ATP.

### **Carbohydrates metabolism**

1. Carbohydrates: classification, representatives, structure, biological role.
2. The norm of carbohydrates in the diet. Digestion and absorption of carbohydrates in the digestive tract. The role of fiber (cellulose) and other dietary fiber in digestion.
3. Glycogen: structure, biological significance. Glycogen exchange and its hormonal regulation. Glycogen storage diseases
4. Anaerobic glycolysis: determination, localization, stages, biological significance. Substrate phosphorylation and glycolytic oxidoreduction.
5. Gluconeogenesis: definition, substrates, hormonal regulation and biological significance. Glucose-lactate and glucose-alanine cycles.
6. The pentose phosphate cycle: determination, localization, stages, biological significance. Hereditary impairment of glucose-6-phosphate dehydrogenase activity
7. Aerobic oxidation of glucose: stages, regulation, energy balance. Pasteur effect.
8. Neurohumoral regulation of carbohydrate metabolism. Hypoglycemia, hyperglycemia and glucosuria: definition types and causes.
9. Biochemical characteristics and diagnosis of diabetes.

### **Lipids metabolism**

1. Lipids: definition, classification, representatives and biological significance.
2. The concept of lipid peroxidation (lipid peroxidation). Formation and neutralization of reactive oxygen species. Cascade of arachidonic acid. Eicosanoids and their biological significance.
3. The norm of lipids in the diet. Digestion of lipids in the digestive tract and absorption of hydrolysis products. The structure and role of bile acids.
4. Transport forms of lipids: structure, composition, clinical diagnostic value
5. Intracellular lipolysis: determination, localization, mechanism, hormonal regulation and biological significance.
6. Oxidation of fatty acids and glycerin in tissues: mechanism, enzymes, coenzymes, value, energy balance.
7. Synthesis of saturated fatty acids: mechanism, the role of biotin (Vit B8), the structure of the multienzyme complex. Features of the synthesis of unsaturated fatty acids.
8. Neutral fats (triacylglycerides): definition, structure, biosynthesis, biological significance
9. Phosphoglycerides: definition, representatives, structure, biosynthesis, biological values. Lipotropic and lipogenic factors
10. Ketone bodies: definition, representatives, biological significance. Blood levels are normal and pathological. Metabolism of ketone bodies. Ketogenic and anti-ketogenic factors.
11. Cholesterol: structure, biosynthesis, biological significance. The norm of blood content. Transport forms
12. Neurohumoral regulation of lipid metabolism. Pathology of lipid metabolism: atherosclerosis, steatorrhea, cholelithiasis, obesity.

### **Simple proteins and amino acids metabolism**

1. Proteins: definition, composition, structure (levels of structural organization, types of chemical bonds), physicochemical properties and biological role.
2. The norm of proteins in food. Complete and defective proteins. Dynamic state of proteins: protein wear coefficient (Rubner), protein minimum and optimum, nitrogen balance.
3. Digestion of proteins in the gastrointestinal tract: mechanism, enzymes (endo- and exopeptidase) and their activation. The role of HCl in the digestion of proteins. Inhibitors of proteolytic enzymes.
4. Decay of proteins in the large intestine. Toxic products of decay: formation and disposal. Laboratory diagnosis of the intensity of decay (the value of an animal indican).
5. Decarboxylation of amino acids: determination, enzymes, coenzymes. The formation, biological significance and neutralization of biogenic amines (histamine, serotonin, catecholamines, gamma-aminobutyric acid).
6. Transamination of amino acids: definition, mechanism, enzymes and coenzymes. Clinical and diagnostic value determination of transaminases activity in the blood
7. Amino acid deamination: definition, species, enzymes and significance. Sources of ammonia in the body. The ammonia content in the blood in normal and pathological. The mechanisms of the toxic effects of ammonia.
8. Pathways of ammonia detoxification in the body. Transport forms of ammonia. Ornithine cycle: mechanism, biological significance, genetic defects. The level of urea in the blood and urine is normal and pathological.
9. The metabolism and importance of acyclic amino acids (glycine, serine, cysteine, methionine, aspartate, glutamate, arginine and branched chain amino acids). Hereditary enzymopathies (maple syrup disease, hyperhomocysteinemia).
10. Features of the exchange and the importance of cyclic amino acids (phenylalanine and tyrosine). Hereditary enzymopathies (phenylpyruvate oligophrenia, albinism, alkaptonuria).

### **Nucleic acids. Molecular biology**

1. Nucleic acids: definition, species, structural components, biological significance. The primary and secondary structure of nucleic acids. The rules of Chargaff. Watson-Crick Model.
2. Purine nucleotides: definition, structure, biological significance. Features of the synthesis and decay of purine nucleotides in tissues. Pathology of purine metabolism.
3. Pyrimidine nucleotides: definition, structure and biological significance. Features of the synthesis and decomposition of pyrimidine nucleotides. Orotaciduria.
4. DNA replication: definition, factors and mechanism. Replication inhibitors.
5. Transcription: definition, factors and mechanism. Promoters and palindromes. Processing. Transcription inhibitors
6. Genetic code and its properties. Translation: definition and translation factors. Activation of amino acids.
7. Characteristics of the main stages of translation. Post-translational modification. Translation inhibitors
8. Regulation of matrix protein synthesis in prokaryotes according to the Jacob and Monod scheme. Operon structure
9. Regulation of gene expression in eukaryotes at the level of structural organization of the genome, transcription and translation.
10. Molecular mechanisms of point mutations. DNA repair: definition, mechanism, enzymes, biological significance, pathology.

### **Hormones. Molecular mechanisms of regulatory signals transduction**

1. Hormone-like substances: definition, characteristics, mechanisms of isocrine action. Representatives and biological role of cytomedines and hormone-like substances of the gastrointestinal tract.
2. Hormones: definition, characteristics, classification by chemical nature (representatives). Regulation of hormone secretion. Cascade mechanism of amplification of the hormonal signal.

3. Membrane mechanism of action of hormones of protein-peptide nature. Characteristics of secondary messengers: c-AMP, c-GMP, Ca-calmodulin, diacylglycerol and inositol triphosphate.
4. The cytosolic mechanism of action of hormones of a steroid nature. Lipid messengers.
5. Hormones of the central endocrine glands (hypothalamus, pituitary, pineal gland): representatives, chemical nature, mechanism of action, biological role, pathology.
6. Hormones of the peripheral endocrine glands (parathyroid, thyroid, adrenal glands): representatives, chemical nature, mechanism of action, biological role, pathology.
7. Hormones of the glands of mixed functions (pancreas, sex glands, thymus): representatives, chemical nature, mechanism of action, biological role, pathology.

#### **Vitamins**

1. Classification of vitamins. Vitamine-like compounds. The basic concepts of vitaminology: hypo - polihypo - hyper- an avitaminosis, antivitamins, provitamins. The reasons of development of vitamin insufficiency.
2. Water-soluble vitamins: group B (B1, B2, B3, B5, B6, B8, B9, and B12), vitamins C and P: structure, coenzymatic forms, participation in a metabolism, clinical signs of insufficiency, food sources.
3. Lipid-soluble vitamins: A, D, E, K: the chemical nature, participation in a metabolism, clinical signs of insufficiency. Hypervitaminosis of A и D, hormonal forms of vitamins D2 and D3. Food sources. Provitamin A. Medical products - analogues and antagonists of vitamin K.

#### **Biochemistry of blood**

1. Blood as a biological fluid, functions and blood products. Plasma and blood serum. The chemical composition of the blood. Residual blood nitrogen. Azotemia: definition, types and causes
2. Physico-chemical constants of blood and their regulation. Blood buffer systems. Alkaline reserve of blood. Violation of acid-base balance.
3. Characteristics and significance of the main protein fractions of blood plasma (albumin, globulin and fibrinogen). Albumin-globulin ratio. The norm of the content of total protein in blood plasma. Hypo - and hyperproteinemia
4. Characteristics and significance of individual blood proteins:  $\alpha$ 1-antitrypsin, haptoglobin, ceruloplasmin, transferrin, immunoglobulins. Proteins of the acute phase of inflammation and pathological blood proteins.
5. Plasma enzymes: classification, representatives, clinical diagnostic value. The kinin system of blood.
6. Features of the structure, chemical composition and metabolism in red blood cells. Molecular basis of hemolytic anemia (pathology of erythrocyte proteins, pentose phosphate pathway enzymes and glycolysis).
7. Hemoglobin: structure, species, derivatives, biosynthesis and biological significance. Hemoglobinosis (hemoglobinopathies, thalassemies) and porphyries.

#### **Biochemistry of liver**

1. Functions of the liver. Its role in carbohydrates, proteins and fats metabolism
2. Hemoglobin catabolism in tissues - pigmentary metabolism. Characteristics of indirect and direct bilirubin. The norm of bilirubin in the blood.
3. Pathology of pigmentary metabolism. Jaundice: types and biochemical diagnostics.
4. Detoxification function of the liver. Xenobiotic metabolism - the main phases. Induction of xenobiotic metabolizing enzymes. Metabolic activation.
5. I phase of xenobiotic metabolism: name, localization, types of reactions, enzymes, coenzymes, electron transport chains, biological significance. The role of cytochromes P450.
6. II phase of xenobiotic metabolism: name, localization, types of reactions, enzymes, endogenous substrates, biological significance.
7. Ethanol metabolism in the human body. The mechanisms of the toxic effects of ethanol. The value of endogenous ethanol.

### **Water-mineral metabolism. Biochemistry of kidneys and urine.**

1. Water and its biological role. The content and distribution of water in the body. Hormonal regulation of water metabolism. Pathology of water metabolism.
2. Mineral substances: classification and a biological role.
3. The biological role, participation in the metabolism and the normal content of sodium and potassium in the blood serum. Regulation and pathology of their metabolism.
4. The biological role, participation in metabolism and the normal content of serum calcium and phosphorus. Regulation and pathology of their metabolism.
5. Biochemical mechanisms of urination and their regulation. Creatinine clearance and its importance
6. Biochemical mechanisms of kidney involvement in the regulation of blood pressure and acid-base balance.
7. Urine as a biological fluid. Physico-chemical properties of urine. Inorganic and organic components of urine are normal and pathological.

### **Biochemistry of tissues**

1. Biochemistry of connective tissue: chemical composition features (collagen, elastin, extracellular matrix) and significance. Stages of collagen synthesis. Biochemical indices of the state of connective tissue.
2. Biochemical composition of tooth tissues (enamel, dentin, pulp) and features of metabolism. Soluble and insoluble proteins of tooth tissue, their characteristics, structure, maturation and the role of collagen. Carbohydrates, lipids, nucleic acids of the organic matrix of the tooth. Tooth mineral matrix and mineralization processes. Biochemical changes in tooth tissues in pathology. Vitamins and hormones as regulators of metabolism in tooth tissues.
3. The biological role of saliva. Physico-chemical properties, chemical composition of saliva. The mechanism of saliva secretion. Changes in the chemical composition of saliva and its properties with age and in pathological conditions.

**6. Types of training sessions:** lecture, practical lesson, consultation.

**7. Form of study:** daily.

**8. Teaching methods:** verbal, explanatory and demonstration.

**9. Control methods:** oral, written, test.

**10. Forms of final control:** final modular control: exam.

**11. Tools for diagnosing learning success:** questions for current control, tasks, tests.

**12. Language of instruction:** Ukrainian, Russian, English.

**13. Value system of student's academic**

### **Value system of student's academic performance in biological chemistry**

Instructions for assessing exams and differential tests by the decision of the Academic Council of VNMU from 27.09.2012 (In the main provisions for the organization of the educational process).

The maximum number of points that a student can score for the current progress in studying the module is 120.

The minimum number of points that a student must score for the current progress and is an admission to the final control - 72.

The maximum number of points for the final control is 80 points.

Final control - the exam is credited to the student if he scored at least 50 points.

The maximum number of points for the exam is 80.

<b>Score on a 4-point scale</b>	<b>Number of points</b>
«5»	71-80
«4»	61-70
«3»	50-60

COURSE ASSESSMENT: calculated as the sum of the number of points that the student has scored on the current academic record (72-120) plus points on the exam (50-80).

The maximum number of points that a student can score in the discipline is 200 points.

The minimum number of points that a student must score when studying the discipline to obtain a positive zinc is 122 points.

Independent work of students, which is provided in the topic along with classroom work, is evaluated during the current control of the topic in the relevant lesson.

Points for individual independent work (IIW) are awarded to the student only if it is successfully completed and defended. To unify the assessment of different types of individual tasks of the student at the departments should use a scale for calculating the number of points:

A. 12 points (from the point assessment indicated in the work programs), which are added to the assessment in the discipline - are added for prizes at interuniversity competitions in the discipline and international scientific student conferences in the presence of printed work.

B. 11-10 points - added for prizes at intra-university competitions in the discipline.

B. 9-8 points - are added to the assessment of the discipline for participation (if the student participated but did not receive a prize) in interuniversity competitions in the discipline and international scientific student conferences in the presence of printed work.

G. 7-6 points - are added to the assessment of the discipline for participation (if you made a report, but did not receive a prize) in international scientific student conferences without the presence of printed work.

D. 4-5 points - are added to the assessment of the discipline for the manufacture of schemes at the departments, tables of multimedia software and videos - taking into account the importance of the work performed.

The number of points in the discipline is entered in the statement, then the dean's office makes a ranking protocol for the discipline.

### **Compliance with the scales for assessing the quality of learning material**

The grade in the discipline "Biological Chemistry" is exhibited on a 200-point scale and is defined as the sum of grades of current educational activities in points (maximum number of points – 120) and grades of final control-exam (maximum number of points – 80). Credits are credited for the studied discipline provided that the student accumulates 122 points (which corresponds to the minimum value of the E grade on the ECTS Scale).

### **Assessment of knowledge in the discipline is carried out taking into account the relevant scales:**

The sum of points for all types of educational activities	Rating ECTS	Score on a national scale	
		for exam, course project (work), practices	for credit exam
<b>180-200</b>	<b>A</b>	Excellent	Passed
<b>170-179,99</b>	<b>B</b>	Good	
<b>160-169,99</b>	<b>C</b>		
<b>141-159,99</b>	<b>D</b>	Satisfactory	
<b>122-140,99</b>	<b>E</b>		
<b>60 – 121</b>	<b>FX</b>	unsatisfactory with the possibility retaking the exam	not credited with the possibility retaking the exam

1 – 59	F	unsatisfactorily with required re-study of the discipline	not credited with required re-study of the discipline
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Upon receiving an unsatisfactory grade in the discipline within 60-121 points (FX), the student has the right to retake it: once to the department commission with the participation of the head of the department, the last time — the commission with the participation of the head of the department and the dean's office.

Upon receipt of an unsatisfactory grade in the discipline within 1-59 points (F), the student is obliged to re-study it. The decision is made by the management of VNMU according to the regulatory documents approved in accordance with the established procedure.

**14. Politics in terms of remote learning.** Distance learning regulated by the Regulations of the elements of remote learning in National Pirogov Memorial Medical University, Vinnytsya (<https://www.vnmu.edu.ua/> General information). The main training platforms for studying are Microsoft Team and Google Meets. Practical classes and lectures, exercises and consultations during distance learning is published on the website of the department (<https://www.vnmu.edu.ua/> department of biological and general chemistry).

## 15. List of educational and methodical literature

### References:

1. Harper's Illustrated Biochemistry / V.W. Rodwell, D.A. Bender, K.M. Botham et al. – Mc Graw Hill Education, 2015. – 817 p.
2. Gubsky Yu. Biological chemistry. – Vinnytsia : Nova Knyha. – 2016. – 512 p.
3. Chattarjea M. N., Shinde R. Textbook of Medical Biochemistry (Eight Ed.). Jaypee Brothers Medical Publishers, 2012. 894 p.
4. Satyanarayana U., Chakrapani U. Biochemistry (Third Ed.). Arunabha Sen BOOKS AND ALLIED (P) Ltd, 2013. 799 p.
5. Lecture material.
6. Smirnova O.V., Zaichko N.V., Melnyk A.V. transl. from Ukr./ Shunkov V. S. Polyfunctional, heterofunctional and heterocyclic biologically active compounds: study guide. Винниця: Вид. «Твори»; 2019, 95 с.
7. Melnyk A.V., Smirnova O.V., Marchak T.V. Module 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components. Workbook /transl. from Ukr./ Shunkov V.S. – 1 th. ed.: – Vinnytsia, 2020. 77 p.

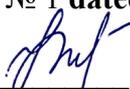
### Information resources:

website address departments: [http:// biochem.vsmu.edu.ua/](http://biochem.vsmu.edu.ua/)

library: <http:// library.vsmu.edu.ua>

**Discussed and recommended at a meeting of the Department of Biological and General Chemistry of VNMU. E. Pirogov Protocol № 1 dated August 27, 2020**

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