

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
 Petro Mohyla Black Sea National University  
 Medical institute

Department of pharmacy, pharmacology, medical, bioorganic and biological chemistry




Course Discription

**BIOLOGICAL AND BIOORGANIC CHEMISTRY**


field of knowledge 22 «Health care»  
 in the specialty 222 «Medicine»

- Developer Larycheva O.M.
- Head of the Department Ogloblina M.V.
- Guarantor of Educational Program Klymenko M. O.
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### 1. Description of the educational discipline (annotation)

Title of indices	Characterization of educational discipline	
Name of the discipline	Biological and bioorganic chemistry	
Branch of knowledge	22 "Health care"	
Specialty	222 "Medicine"	
Specialization (if any)		
Educational program	Medicine	
Higher education level	Master	
Discipline status	Normative	
Curriculum	1st, 2nd	
Academic year	2020-2021	
Numbers of semesters:	Day form	Absentee form
	2nd, 3d, 4th	-
Total ECTS credits / hours	9.5 credits / 285 hours	
Course structure: - lectures - seminars (practical, laboratory, semi-group) - hours of independent work of students	Day form	Absentee form
	40 hours	-
	130 hours	
115 hours		
Percentage of classroom load	60%	
Teaching language	English	
Intermediate control form (if any)	1 <sup>st</sup> semester – Credit pass 3 <sup>d</sup> semester – Attestation	
Form of final control	4 <sup>th</sup> semester – Exam	

**1.1. Program of study of educational discipline** "Biological and bioorganic chemistry" is made in accordance with the educational program "Medicine", field of knowledge 22 "Health care", speciality 222 "Medicine", on the basis of the exemplary program of educational discipline "Biological and bioorganic chemistry" of preparation of specialists of educational qualification "Master of medicine", given by GA the "Central methodical cabinet from higher medical education of the Ministry of Health of Ukraine" and approved by the Ministry of Health of Ukraine from 03.10.2016.

**1.2. Description of educational discipline.** Biological and bioorganic chemistry as educational discipline is one of fundamental disciplines in the system of higher medical education. Educational discipline "Biological and bioorganic chemistry" is laid out for the students of the first and second courses during three semesters. On the study of educational discipline 9,5 credits of ECTS are taken – 285 hours (170 audience and 115 hours independent work of student). The program of discipline is structured on five blocks that include thirteen chapters.

**1.3. The subject of study of discipline is:**

- chemical composition of living organisms (to the organism of man) and biochemical transformations, molecules that is included in their composition are subject that;
- diagnosis and correction by pharmaceuticals of pathological conditions associated with the disruption of metabolic processes.

**1.4. Interdisciplinary connections.** “Biological and bioorganic chemistry” as educational discipline :

- is based on the study of medical biology, biophysics, medical chemistry, morphological disciplines and integrated with these disciplines;
- mortgages bases of study of molecular biology, genetics, physiology, pathology, general and molecular pharmacology, toxicology and propaedeutics of clinical disciplines, that envisages integration of teaching with these disciplines and forming of abilities to apply knowledge from biological and bioorganic chemistry, students, first of all biochemical processes that take place in the organism of healthy and sick man, in the process of further studies and professional activity;
- mortgages bases of clinical diagnostics of the most widespread diseases, monitoring of flow of disease, control after efficiency of application of medicinal facilities and events, pathological processes sent to the prophylaxis;
- theoretical gain knowledge, practical skills and abilities from discipline form the clinical thinking for students and will be used for the study of courses «Clinical biochemistry» on 4<sup>th</sup> course of studies and “Clinical biochemistry with laboratory diagnostics” on 5<sup>th</sup> and 6<sup>th</sup> of studies, that is on completion of study of basic clinical disciplines of therapeutic and surgical cycles.

## **2. Aim, task and results of study of discipline**

**2.1. The aim of teaching the educational discipline “Biological and bioorganic chemistry” is:**

- Study of biomolecules and molecular organization of cellular structures, general conformities to law of enzymatic catalysis and biochemical dynamics of transformation of basic classes of biomolecules (amino acids, carbohydrates, lipids, nucleotides, porphyrins and others like that), molecular biology and genetics of informative macromolecules (proteins and nucleic acids), that is molecular mechanisms of heredity and realization of genetic information, hormonal adjusting of metabolism and biological functions of cages, biochemistry of the special physiology functions.
- Skills to analyse the biochemical processes of metabolism and its regulation in the functioning of human organs and systems.
- An ultimate goal is a capture knowledge about biochemical properties and exchange of basic biomolecules in the organism of man in a norm and on condition of pathologies. Biochemical studies in biological liquids and evaluation of results with interpretation of their clinical and diagnostic value.

**2.2. The main tasks of the study of the discipline “Biological and Bioorganic Chemistry” are:**

- Knowledge of biochemical properties and exchange of the main biomolecules in the human body in normal and pathological conditions.
- Training in biochemical research to identify normal and pathological components in biological fluids. Analyse the results of biochemical studies to diagnose the most common human diseases.

**2.3. Competencies and learning outcomes.** The developed programme responds to the Educational and Professional Programme (EPP) and is oriented towards the development of *competences*:

***Integral Competence (IC) – ICI EPP:***

- The ability to solve typical and complex specialized problems and practical problems in the professional activity in the health sector, or in the course of studies; which involves research or innovation and is characterized by complex and uncertain conditions and requirements.

**General (GC) – GC1 EPP:**

- Ability to abstract thinking, analysis and synthesis, ability to learn and to be modern.

**Professional (PC) - PC2, PC3, PC5, PC14 EPP :**

- Ability to identify and evaluate the necessary list of laboratory and instrumentation studies.
- Ability to establish a preliminary and clinical diagnosis of a disease. The ability to determine the nature of nutrition in the treatment of diseases.
- In the setting of a health-care establishment, its subdivisions:
  1. Assign a laboratory and/or instrumental examination of the patient (according to list 4) by taking an informed decision, on the basis of the most reliable or syndromic diagnosis, according to standard schemes, using knowledge of the individual, his organs and systems, in accordance with the relevant ethical and legal norms.
  2. To carry out differential diagnosis of diseases (list 2) by taking an informed decision, according to an algorithm, using the most reliable diagnosis or syndromes, laboratory and instrumental examination data of the patient, knowledge of the individual, its organs and systems, in accordance with relevant ethical and legal norms.
  3. Establish a preliminary clinical diagnosis (list 2) by means of an informed decision and logical analysis, using the most reliable diagnosis or syndrome, laboratory and instrumental examination data of the patient, the findings of differential diagnostics, knowledge of the individual, his organs and systems, adhering to the relevant ethical and legal norms.

In accordance with the Educational and Professional Programme, the expected **Programme Results of Study (PRS)** include the skills of **PRS1, PRS4, PRS12** of the EPP:

- To know the ways of analysis, synthesis and further modern learning. To be able to analyse information, to make informed decisions, to acquire modern knowledge. Establish appropriate linkages to achieve objectives. Be responsible for the timely acquisition of up-to-date knowledge.
- To know the types and ways of adaptation, the principles of action in a new situation. To be able to use means of self-regulation, to adapt to new situations (circumstances) of life and activity. Establish appropriate linkages to achieve results. Be responsible for the timely use of self-regulation techniques.
- Evaluate information on diagnosis in the conditions of medical facility, its subdivisions, applying a standard procedure, using knowledge of the person, his organs and systems, on the basis of results of laboratory and instrumental studies (list 4).

**2.4. Results of studying:**

In accordance with the Educational and Professional Programme the students must:

**know:**

- The structure of bioorganic compounds and the functions they perform in the human body.
- The reactivity of the basic classes of biomolecules, which ensures their functional properties and metabolic transformations in the organism.
- General biochemical mechanisms of the occurrence of pathological processes in the human body.

- Features of diagnosis of the physiological state of the organism and the development of pathological processes on the basis of laboratory tests.
- Relationship of the structural features and transformations of bioorganic compounds as the basis of their pharmacological action as a medicinal product.
- Basic mechanisms of biochemical action and principles of the use of different classes of pharmacological agents.
- Biochemical and molecular basis of physiological functions of cells, organs and systems of the human body.
- Functioning of enzymatic processes occurring in membranes and organelles for the integration of metabolism in individual cells.
- Norms and changes in biochemical and enzymatic parameters used to diagnose the most common human diseases.
- Significance of biochemical processes of metabolism and its regulation in ensuring the functioning of organs, systems and the integral organism of a person.

***be able to:***

- To analyse the correspondence between the structure of bioorganic compounds and physiological functions they perform in the organism.
- Interpret features of the physiological state of the organism and the development of pathological processes based on laboratory tests.
- To analyse the reactivity of carbohydrates, lipids, amino acids, ensuring their functional properties and metabolic transformations in the organism.
- To interpret the structural features and transformations of bioorganic compounds as the basis of their pharmacological action as medicines.
- Interpret biochemical mechanisms of pathological processes in the human body and the principles of their correction.
- Explain the basic biochemical mechanisms of action and principle of the use of different classes of drugs.
- Explain the biochemical and molecular basis of physiological functions of cells, organs and systems of the human body.
- To analyse the functioning of enzymatic processes in membranes and organelles for the integration of metabolism in individual cells.
- To classify the results of biochemical studies and changes of biochemical and enzymatic parameters that are used to diagnose the most common human diseases.
- To interpret the significance of the biochemical processes of metabolism and its regulation in ensuring the functioning of the organs, systems and integrated human body.

### **3. Program of the discipline**

The educational process is organized according to the European Credit Transfer and Savings System (ECTS).

The curriculum consists of five modules, each of which is a separate and distinct unit that logically links the list of required training elements to the content of the subject.

#### ***3.1. Discipline structure by cluster and section:***

##### **Block 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components**

## **Section 1. Theoretical bases of structure and reactivity of bioorganic compounds. Carboxylic acids and their functional derivatives. Lipids**

### ***Topic 1. Classification, nomenclature and isomerism of bioorganic compounds. Nature of chemical bond. Reaction capacity of bioorganic compounds.***

Classes of organic compounds and functional groups that correspond to them. Seniority of functional groups and their name.

Nomenclature of bioorganic compounds. (trivial, international and radical-functional).

Isomeric organic compounds: isomeric structure (structural isomeria), spatial (stereoisomeric), configuration (optical, geometric and conformational isomers).

Electron structure and valence states of the Carbon atom: first valence ( $sp^3$ -hybridization, second and third valence states of the Carbon atom ( $sp^2$ -and  $sp$ -hybridization).

The mutual influence of atoms in organic compounds ( $\sigma$ - and  $\pi$ -bonds in organic compounds, electronegativity of atoms).

Distribution of electron density in organic molecules: inductive effect; mesomeric effect.

### ***Topic 2. Structure, properties and biological significance of carboxylic acids, heterofunctional compounds (hydroxy-, keto-, phenol acids).***

Classification of carboxylic acids. Nomenclature of individual monocarboxylic acids. Structure and properties of carboxylic acids. The reaction of nucleophilic substitution ( $S_N$ ) is about  $sp^2$ -hybridized carbon atom of the hydroxyl group. Etherification reactions and their biochemical value. Amydia reactions and their biochemical value.

Structure and properties of dicarboxylic and tricarboxylic acids. Chemical properties. Biological value of individual representatives (oxalate, malonate, succinate, glutarate, fumarate).

Classification and isomerization of hydroxyl acids. Asymmetric carbon atom, chirality, optical activity. Enantiomers. Diastereoisomers.

Chemical properties and biological value of hydroxyl acids and amino acids.

Structure and properties of keto acids. Biological value of keto acids and their derivatives.

Ketone bodies, diagnostic value of their determination in diabetes mellitus.

Structure and properties of phenol acids. Salicylic acid and its derivatives as anti-inflammatory and antimicrobial agents.

### ***Topic 3. Higher fatty acids. Saponifiable and unsaponifiable lipids. Phospholipids.***

The mechanism of the formation of esters is based on the example of triacylglycerols, their biological role. General notions of lipids and their classification. The biological role of different lipid classes.

Biological functions of lipids. Higher fatty acids as constituents of neutral lipids.

Physiological value of hydrolysis of neutral lipids.

Structure and properties of phospholipids. Role of phospholipids in the construction of biomembrane. Classification of phospholipids. Physico-chemical properties of phospholipids.

## **Section 2. $\alpha$ -Amino acids, peptides, proteins**

### ***Topic 4. Amino acid composition of proteins and peptides. Deamination, decarboxylation, transamination $\alpha$ -amino acids. Colour reactions.***

Classification of amino acids: by the structure of the carbon chain, by the ability to synthesize in the body, by the polarity of the radical. General properties of the amino acids. Optical properties of amino acids. Chemical properties of amino acids as heterofunctional compounds: a) formation of

functional carbonic acid derivatives (salts, esters, amides, halogen anhydrides); b) formation of amino derivatives (alkylation reactions, acylation, formation of salts with mineral acids, bases).

Acid-base properties of amino acids. Chemical reactions  $\alpha$ -amino acids *in vivo* and *in vitro*. The reaction of decarboxylation of amino acids to form biogenic amines (phenylalanine, serine, histidine, tryptophan) and their physiological functions.

The reaction of deamination, transamination, hydroxylation of amino acids and their physiological role.

Reaction of qualitative and quantitative definition of  $\alpha$ -amino acids. Reaction of polycondensation to form peptides. The mechanism of the formation of the peptide bond.

The structure and properties of individual representatives (glycine, alanine, cysteine, serine, glutamic acid, lysine, phenylalanine, tryptophan, methionine).

**Topic 5. Structural organization of proteins. Physico-chemical properties of proteins. Solubility, precipitation, dialysis, protein electrophoresis. Denaturation.**

Protein functions. Methods for the binding of  $\alpha$ -amino acids in protein molecules. Levels of structural organization of protein molecules. Primary, secondary, tertiary, quaternary structure, types of bonds that stabilize these structures. Qualitative responses to peptides, proteins.

Chemical synthesis of peptides and proteins.

Simple and complex proteins. Classification of proteins according to the nature of the prosthetic group and spatial form: globular and fibrillar.

Protein stability factors in colloidal solutions. Protein deposition mechanism. Deposition types. Reversible protein deposition and its use in medical practice. Irreversible protein deposition, factors that cause it.

Protein denaturation, its characteristics. Denaturing factors. Protein renaturation.

### **Section 3. Carbohydrates**

**Topic 6. Carbohydrates. Monosaccharides: structure, chemical properties and biological significance.**

Classification of carbohydrates. Isomerism. Tautomeric forms of monosaccharides. Mutarotation.

Chemical reactions of monosaccharides. Chemical reactions of monosaccharides with carbonyl group: oxidative-reducing reactions (qualitative to the identification of the aldehyde group).

The formation of glycosides is their role in the construction of oligo and polysaccharides, nucleosides, nucleotides and nucleic acids.

Phosphorus esters of glucose and fructose, their values in metabolic transformations of carbohydrates.

Monosaccharide derivatives. Ascorbic acid as a derivative of hexoses, the biological role of vitamin C.

**Topic 7. Structure, properties and biological role of di- and polysaccharides.**

Disaccharides. Structure, properties of sucrose, lactose, maltose. Sucrose inversion as a result of hydrolysis. The classification of the disaccharides according to their ability to oxidative-reducing reactions.

Two types of connections between monosaccharide residues and their effect on the reaction capacity of the disaccharides.

Polysaccharides. The classification of the Polysaccharides. Structure, biological role and application of starch, its components. The scheme of the structure of amylose and amylopectin. Starch hydrolysis, qualitative response to its detection.

The structure and biological role of glycogen, fibre (cellulose), its role in the functioning of the body. Heteropolysaccharides. The role of glucuronic acid, glucosamine and galactosamine in the formation of heteropolysaccharides.

#### **Section 4. Biologically active heterocyclic compounds. Nucleosides, nucleotides, nucleic acids**

##### ***Topic 8. Classification, structure and significance of biologically important heterocyclic compounds.***

Classification of heterocycles: a) by cycle size; b) by heteroatoms number and quality. Characterization of five-dimensional heterocycles and their derivatives.

Characterization of five-sided heterocycles with one and two heteroatoms and their derivatives.

Benzopyrol (indol) as a component of tryptophan and the products there of – biologically active compounds (tryptamine, serotonin).

Benzopyrol as a constituent of toxic substances (skatole, indol) and products for their decontamination.

Production of pyrazole derivatives as drugs.

Characterization of six-member heterocycles. Six-member heterocycles with one and two heteroatoms are the basis of biologically important compounds. Six-member heterocycles are components of nitrogen bases.

##### ***Topic 9. Structure and biochemical functions of nucleosides and nucleotides.***

Nucleotides and nucleosides are products of incomplete hydrolysis of nucleic acids.

Structure of nucleotides: AMP, GMP, MFI, UMP, d-TMP. Structure and significance of 3',5'-cAMP, its role in the action of hormones on cells.

Nucleotide derivatives. Phosphorylated nucleotide derivatives, the significance of ADP and ATP.

Nucleotide participation in the cofferment structure.  $\text{NAD}^+$  cofferment action mechanism.

##### ***Topic 10. Structure and biochemical functions of nucleic acids.***

Structure and function of nucleic acids. The components of DNA, RNA, the examples of the structure of their monomers, DNA and RNA monomer coupling scheme. The biological role of DNA. The principle of DNA structure, primary and spatial structure, types of chemical bond.

The principle of RNA structure, primary and spatial structure, types of chemical bond. RNA types: m-RNA, r-RNA, t-RNA, their structural organization and biological role. The role of the principle of complementarity in the realization of DNA and PHK functions. Minor bases.

### **Block 2. General principles of metabolism**

#### **Section 5. Introduction to biochemistry. Biochemical components of cells. Enzymes and coenzymes. Regulation of metabolism**

##### ***Topic 1. Control of the initial level of knowledge. Assimilation of the principles of biochemical laboratory research; substantiation and clinical and diagnostic significance of changes in biochemical parameters.***

The definition of biochemistry as a science and its place among other biomedical disciplines. Subjects of study and tasks of biochemistry. The sections of biochemistry and its significance for the



study of specialized disciplines. The world history of biochemistry and the development of biochemical research in Ukraine.

The purpose of biochemical laboratory studies is to obtain new information that can be used to understand new phenomena, explain the functioning of organs and tissues in normal and pathological conditions, and make a diagnosis, monitoring the course of the disease and the effectiveness of the treatment.

Criteria for evaluating the laboratory method used: reliability, accuracy, specificity, sensitivity and method failed. Diagnostic test material: blood, urine, spinal fluid, gastric and duodenal contents, filtered liquids (exudates and transudates), sweat, amniotic fluid, etc. Enzyme activity methods: by the quantity of a product that is produced under enzyme-per-unit conditions, by the amount of substrate spent per unit of time. Spectrophotometric methods for investigation of enzyme activity and visualization of enzymatic response results.

***Topic 2. Research of physicochemical properties of enzymes. Classification, mechanism of action, kinetics. Units of enzyme activity.***

Enzymes as biological catalysts of metabolic reactions; properties of enzymes. Units of activity and amount of enzymes: international units, catal, specific activity of the enzyme. Principles for measuring enzyme activity in biological fluids.

Nomenclature of enzymes and their classification by reaction type: oxydoreductases, transferases, hydrolases, liases, isomerases, ligases. Structural organization of enzymes. Structure of enzyme proteins; oligomer enzyme proteins; multienzyme complexes, membrano-associated enzymes and multienzyme complexes. Isoenzymes are multiple molecular forms of proteins, the result of the expression of different genetic loci.

Physico-chemical properties of enzymes: electrochemical properties, solubility. Thermodynamic stability of protein enzyme molecules; denaturation. Interaction with different chemical ligands, its mechanisms and functional meaning. Complex enzyme proteins; prosthetic groups of complex enzyme proteins.

Methods for extracting enzymes from biological objects, fractionating them (ultra-centrifugation, helium- and ion-exchange chromatography, affinity chromatography, electrophoresis) and analysing enzyme activity.

The mechanism of the action of enzymes. The stages of enzymatic catalysis, their characteristic. The hypothesis of the mechanism of the action of enzymes. The kinetics of enzymatic reactions and their dependence on: temperature, quantity of enzyme and substrate, pH of medium, etc. Michaelis-Menten equation, Michaelis constant.

***Topic 3. Research of regulation of enzymatic processes. Medical enzymology.***

Regulation of enzymatic processes. Pathways and mechanisms of regulation: allosteric interaction; covalent modification of enzymes; action of regulatory effector proteins (kalmoduline, proteinase, proteinase protein inhibitors). Cyclic nucleotides act as regulators of enzymatic reactions and cell biological functions.

Regulation of enzyme activity and its physiological value. Enzyme activators and inhibitors. Inhibition of enzyme activity and its types.

The main aspects of modern enzymodiagnostic. Cellular, secretory and exogenous enzymes. Isoenzymes in enzymodiagnostic, tissue specificity of isoenzyme distribution. Changes in plasma enzymes and blood serum activity as diagnostic indicators of development of pathological processes in organs and tissues. The application of enzymodiagnostic in cardiology, hepatology, nephrology, urology, oncology, pulmonology, orthopaedics, etc.

Violation of enzymatic processes: congenital (hereditary) and acquired claims of enzymopathy, congenital defects of metabolism, their clinical-laboratory diagnosis.

Enzymotherapy is the use of enzymes as drugs. Pharmacological application of the enzymes of the gastrointestinal tract, coagulating and fibrinolytic blood systems, calicrein-kinine and renin-angiotensin systems. Enzyme inhibitors as drugs.

***Topic 4. Research of the role of cofactors and coenzymes: chemical structure and functions.***

Cofactors and coenzymes. Structure and properties of coenzymes; vitamins as precursors to the biosynthesis of coenzymes. Classification of coenzymes according to the chemical reaction they catalyse: coenzymes-carriers of hydrogen and electron atoms; coenzymes, which are carriers of chemical groups; coenzymes of synthesis, isomerization and cleavage of carbon-carbon bonds.

The most common coenzymes: vitamin PP derivatives (nicotinamide); vitamin B<sub>2</sub> derivatives (riboflavin); vitamin B<sub>6</sub> derivatives (pyridoxin); metalophorphyrin – cytochrome coenzymes; coenzyme acylation – pantotenic acid derivatives; coenzymes – derivatives of folic acid; lipoic acid; thiamindiphosphate – derivative of vitamin B<sub>1</sub>; coenzyme biotin; coenzymes – derivatives of vitamin B<sub>12</sub>.

Isoenzymes: features of structure, localization of synthesis in the human body (based on the example of isoenzymes of lactate dehydrogenase, creatine phosphokinase; role in disease diagnosis. Immobilized enzymes and their use in industrial pharmaceuticals. Use of enzymes and their inhibitors as drugs.

**Section 6. Basic regularities of metabolism. Tricarboxylic acid cycle. Molecular bases of bioenergy.**

***Topic 5. Metabolism and energy study. Functioning, regulation and energetic effect of the tricarboxylic acid cycle.***

Relationship between energy generation and consumption in living systems. The energy of chemical bonds is the primary energy that cells use to support their life.

General notions of metabolism and energy exchange in the body. Catabolic, anabolic and amphibolic pathways of metabolism. Exergonic and endergonic biochemical reactions. Macroergic phosphates. ATP is a universal source of energy in the cell.

Stages of catabolism for exogenous and endogenous biomolecules. Common and specific catabolic pathways, end products.

Oxidative decarboxylation of pyruvate: sequence of reactions, characteristic of pyruvate dehydrogenase multienzyme complex.

Krebs cycle: localization, reaction sequence, biological role, enzyme characterization, regulation. CTA energy balance.

***Topic 6. Study of biological oxidation, oxidative phosphorylation and synthesis of ATP.***

Modern ideas about the structure and functions of mitochondria. Composition and function of the components of mitochondrial respiratory chains. Biological oxidation enzymes in mitochondria: pyridine- and flavine dependent dehydrogenases, cytochromes. The concept of oxidative-reducing pairs of donor substrates and electron acceptors. Molecular organization of the mitochondrial biological oxidation chain. Transmission sequence of electrons in the respiratory chain. The emergence of electrochemical potential on the inner membrane of mitochondria.

Biological oxidation reactions: types of reactions (dehydrogenation, oxidase, oxygenase) and their biological significance. Tissue respiration. Concept of oxidative phosphorylation. Energy release in the respiratory chain and the points at which oxidation and phosphorylation are combined. ATP-synthase of mitochondria. Oxidative phosphorylation ratio.

***Topic 7. Study of chemiosmotic theory, analysis of the mechanism of action of inhibitors and uncouplers of oxidative phosphorylation.***

Characterization of the basic provisions of chemiosmotic theory (P. Mitchell, 1961). Microsomal oxidation, its role in the body. The chemiosmotic theory of oxidative phosphorylation is a molecular mechanism of ATP generation during biological oxidation.

The electrochemical gradient of protons ( $\Delta\mu\text{H}^+$ ), which is formed during the operation of the electronic transport chain, ensures that electron transport in mitochondria is interfaced with ATP synthesis. Physico-chemical components of the electrochemical gradient.

Conditions for effective oxidation and phosphorylation in mitochondria: the integrity of the mitochondrial membrane, the presence of all components of the transport chain, the specific intramembrane topography of the carriers, the presence of sufficient amounts of ADP and inorganic phosphate.

Exogenous and endogenous uncouplers of oxidation and phosphorylation. The concept of cell respiratory control and its regulation. The action of respiratory chain inhibitors. Electron transport inhibitors (rotenone, amytal, barbiturates, antimycin A, cyanides) and uncouplers of oxidative phosphorylation (2,4-dinitrophenol, thyroid hormones, free fatty acids), their biomedical value.

Medical supplies that affect biological oxidation and oxidative phosphorylation.

**Block 3. General metabolism patterns. Metabolism of carbohydrates, lipids, amino acids and its regulation.**

**Section 7. Carbohydrate metabolism and regulation.**

***Topic 8. Study of digestion and absorption of carbohydrates. Glycolysis. Alcohol fermentation.***

Classification, structure and biological significance of different carbohydrates for the human body. Digestion and absorption of carbohydrates in the human gastrointestinal tract.

Intracellular carbohydrate catabolism pathways; aerobic and anaerobic oxidation of glucose. Anaerobic oxidation of glucose – glycolysis: enzymatic reactions of glycolysis, energetic effect, regulation. Glycolytic oxydoreduction, substrate phosphorylation in glycolysis. Contribution of the works of Embden, Meyerhoff and Ukrainian biochemist J.Parnassus to the sequence of enzymatic reactions of glycolysis (lactic-acid fermentation). Alcohol and other fermentation.

***Topic 9. Study of aerobic oxidation of glucose and alternative routes for the exchange of monosaccharides.***

Anaerobic and aerobic degradation pathways of glucose: (stages, biological role, location of stages in the cell, energy balance).

Stages of aerobic oxidation of glucose, oxidative decarboxylation of pyruvate, Multienzyme pyruvate dehydrogenase complex – features of functioning with the participation of three enzymes and five coenzymes. Comparative bioenergy of aerobic and anaerobic oxidation of glucose. Pasteur effect – switching from anaerobic to aerobic oxidation of glucose, features of regulation. Shuttle mechanisms for electron transfer from glycolytic NADH from cytoplasm to mitochondria. Malat-aspartate shuttle of transport of reducing equivalents of glycolytic NADH in mitochondria under aerobic conditions.

Pentosephosphate pathway (PPP) for oxidation of glucose; diagram, biological value, function characteristics in different tissues. The sequence of enzymatic reactions of PPP, the oxidative stage and the isomeric transformation stage of pentose, hexose and heptophosphate. The value of PPP as a donor of NADPH in the synthesis of fatty acids and steroids as a supplier of ribose-5-phosphate for the

formation of nucleotides in nucleic acid synthesis. Disorders of the pentose phosphate pathway in erythrocytes: enzymopathies of glucose-6-phosphate dehydrogenase.

***Topic 10. Fructose, sorbitol and galactose metabolism.***

General concepts of fructose, sorbitol and galactose metabolism. The metabolic pathway and enzymatic reactions of fructose transformation in the human body. Hereditary enzymopathies associated with genetic defects in the synthesis of the enzymes of fructose metabolism is the intolerance of fructose and fructosemia.

The metabolic pathway and enzymatic reactions of galactose transformation in the human body. Hereditary enzymopathy associated with genetic defects in the synthesis of galactose metabolism enzymes – galactosemia.

***Topic 11. Study of catabolism and the biosynthesis of glycogen. Glycogen exchange regulation. Glucose biosynthesis (gluconeogenesis). Pathologies of carbohydrate metabolism.***

Structure and biological role of polysaccharides. The composition and function of homo- and heteropolysaccharides in the human body. Glycogen cleavage and biosynthesis: localization, chemistry, key enzymes, physiological significance. Enzymatic reactions of glycogenesis and glycogenolysis; cascade mechanisms of cAMP-dependent regulation of glycogen phosphorylase and glycogen synthase activity. Hormone regulation of glycogen exchange in muscles and liver. Role of adrenaline, glucagon and insulin in regulation of glycogen metabolism.

Genetic disorders of glycogen metabolic enzymes: glycogenosis is an abnormally high accumulation of glycogen in organs and tissues, aglycogenosis is a lack of glycogen in tissues.

Glucose biosynthesis – gluconeogenesis: substrates, key enzymes, reactions, intramolecular localization, physiological value of the process. Power supply for gluconeogenesis. Interaction and recycling regulation of glycolysis and gluconeogenesis in the body. Lactate and alanine are like substrates of gluconeogenesis, glucose-lactate and glucose-alanine cycles.

Hormone regulation of the carbohydrate metabolism (glucagon, adrenaline, glucocorticoids, somatotropin, insulin). Glucosemia: normal and impaired (hyper-, hypoglycaemia and glucosuria). Diabetes mellitus. Clinical-biochemical characteristics of diabetes mellitus (insulin-dependent and insulin-independent types). Medicines used for treatment of diabetes mellitus.

**Section 8. Lipid metabolism and its regulation**

***Topic 12. Investigation of lipid digestion and absorption. Catabolism of triacylglycerols. Lipolysis and its regulation. Oxidation of fatty acids and glycerol.***

General characteristics, classification and biological role of lipids. Mechanism and conditions for the digestion and absorption of lipids. Bile acids: role in the digestion of lipids and the absorption of products of their hydrolysis. Lipases of the gastrointestinal tract. Role of pancreatic lipase.

Pathways of lipid metabolism. Adipocytes of adipose tissue and their role in the exchange of lipids and bioenergy processes in the body.

Catabolism of triacylglycerols in adipocytes of fatty tissue (lipolysis), sequence of reactions, mechanisms for regulating the activity of triacylglycerol lipase. Neuro-humoral regulation of lipolysis by adrenaline, noradrenaline, glucagon and insulin.

$\beta$ -Oxidation of higher fatty acids of saturated and unsaturated series. Localization and mechanism of the process. Its relation to the Krebs cycle and tissue respiration. The role of carnitine in transport of fatty acids from cytoplasm to mitochondria.

***Topic 13. Investigation of the biosynthesis of higher fatty acids, TAG and phospholipids.***

Biosynthesis of higher fatty acids. Peculiarity of composition and function of acetyl-CoA-carboxylase, palmitate synthase complex. Regulation of process. Resynthesis of triacylglycerols in the intestine and its biological role. Chemical mechanism and the biological role of the synthesis of triacylglycerols in the intestine, liver and adipose tissue. The pathways of decay and synthesis of simple lipids.

Transport forms of lipids in the blood. Blood plasma lipoproteins: classification, chemical composition, fractionation methods, metabolism and the biological role of each class. Tissue lipogenesis and glycerophospholipid lipolysis are given as phosphatidylcholine.

***Topic 14. Research of biosynthesis and biotransformation of cholesterol (vitamin D, bile acids, steroid hormones). Metabolism of ketone bodies.***

Cholesterol synthesis in the liver and its biotransformation in the human body. Features of regulation of metabolism and cholesterol transport. Biotransformation pathways of cholesterol, localization in body: etherification, formation of bile acids, steroid hormones, active forms of vitamin D<sub>3</sub>. Ketone bodies. Biosynthesis and recycling reactions of ketone bodies: localization in the body, biological significance. Ketonemia and ketonuria in diabetes mellitus, starvation.

***Topic 15. Study of lipid exchange pathologies (steatorrhea, obesity, atherosclerosis, diabetes mellitus). Transport forms of lipids.***

Lipid exchange pathologies. Atherosclerosis: the mechanisms of development, the role of genetic factors. Atherosclerosis as an immuno-inflammatory process. Biochemical mechanisms of development of atherosclerosis. Atherogenic coefficient. Atherogenic and anti-atherogenic lipoproteins.

Insulin-independent diabetes mellitus is a disease that is accompanied by hypertriglyceridemia (type I hypertriacylglycerolemia), lipolysis stimulation in the adipose tissue, activation of the synthesis of ketone bodies, relaxation of the process of the return transport of cholesterol. Pharmaceuticals in the treatment of lipid metabolism disorders.

Transport and deposit of lipids; re-synthesis of triacylglycerols in enterocytes; formation of lipoproteins of blood.

Classes of blood plasma lipoproteins: chemical composition; apoproteins. Quantitative and qualitative changes of blood lipoproteins at circulation in blood and cells.

Clinical and biochemical characterization of primary and secondary lipoproteinemias according to WHO classification. Principles of laboratory diagnosis of dislipoproteinemias.

## **Section 9. Amino acid metabolism. Enzymopathies of amino acid exchange**

***Topic 16. Protein digestion and amino acid absorption. Common ways of converting amino acids.***

The nutritional value of proteins. Daily requirement for food proteins per day. Essential amino acids. The concept of the nitrogen balance and the causes of its disturbances. The stages of digestion of proteins and peptides in the gastrointestinal tract. Proteolytic enzymes of the gastrointestinal tract. Mechanism for absorbing amino acids. Transformation of amino acids in the colon.

Pathways of forming and maintaining a pool of free amino acids in the human body, its source of formation and use in cells. General pathways of free amino acids. Turnover. Amino acid transamination: reactions; biochemical value; mechanisms of action of aminotransferase. Deamination of amino acids. Mechanism of indirect deamination of L-amino acids. Decarboxylation of amino acids: enzymes, physiological value. The formation of physiologically active compounds – biogenic amine,

histamine, serotonin, dopamine, noradrenaline, adrenaline) in tissues and amines – endogenous toxins (putrescin, cadaverin) during the degradation of proteins in the intestine. Oxidation of biogenic amines.

**Topic 17. Study of the formation and detoxification pathways of ammonia. Biosynthesis of urea.**

Pathways of ammonia production. Ammonia toxicity and mechanisms of its detoxification. Circulatory transport of ammonia (glutamine, alanine).

Biosynthesis of urea: chemical mechanism, enzymatic reactions, biological role and regulation of the ornithine cycle of urea biosynthesis. hereditary defects of enzymes (enzymopathias) of urea synthesis.

**Topic 18. Study of specific pathways of noncyclic and cyclic amino acids metabolism. Enzymopathies.**

General metabolic pathways of a nitrogen-free residues of amino acids in human body. Glycogenic and ketogenic amino acids. Specific pathways of noncyclic amino acids metabolism. metabolism of glycine and serine; role of tetrahydrofolate in transport of one-carbon fragments, inhibitors of dihydrofolatereductase as antitumor agents. Metabolism of sulfur containing amino acids; methylation reactions.

Features of the metabolism of branched chain amino acids; participation of coenzyme forms of vitamin B<sub>12</sub> in the metabolism of amino acids. Metabolism of arginine; biological role of nitrogen oxide, NO synthase.

Specific pathways of metabolism of aromatic cyclic amino acids phenylalanine and tyrosine, sequence of enzymatic reactions. Hereditary enzymopathies of phenylalanine and tyrosine – phenylketonuria, alcaptonuria, albinism. Tryptophan metabolism: Kinurenic and serotonin pathways.

**Topic 19. Research of biosynthesis of porphyrins. Hereditary disorders of porphyrin metabolism.**

Porphyrin: structure, biological role. Reaction of biosynthesis of protoporphyrin IX; formation of heme. Regulation of synthesis of porphyrin. Hereditary dysfunction of porphyrin metabolism (enzmopathia): erythropoietic porphyria, liver dependent porphyria, neurologic infringements, photodermatitis.

**Final thematic control work of mastering the material of blocks 2,3.**

#### **Block 4. Molecular biology. Biochemistry of intercellular communications**

##### **Section 10. Fundamentals of molecular biology. Fundamentals of molecular genetics**

**Topic 20. Research of the biosynthesis and catabolism of purine and pyrimidine nucleotides. Hereditary disorders of their exchange.**

Biosynthesis of purine nucleotides; scheme of reactions of IMP synthesis; synthesis of AMP, GMP, ATP, GTP. Regulation of purine nucleotides synthesis on a principle of feedback inhibition.

Biosynthesis of pyrimidine nucleotides: reactions, regulation.

Biosynthesis of deoxyribonucleotides. Formation of thymidyl nucleotides; inhibitors of dTMP biosynthesis as antitumor drugs.

Catabolism of purine nucleotides; hereditary disorders of uric acid metabolism. Biochemical background of hyperuricemia, gout, Lesch-Nyhan syndrome.

Catabolism of pyrimidine nucleotides.

**Topic 21. Research of DNA replication and transcription of RNA. Investigation of biosynthesis of protein on ribosomes. Antibiotics are the inhibitors of the template-directed synthesis. Action of viruses and toxins.**

Biological significance of DNA replication. The sense of J.Watson and F.Crick discovery (1953). Semiconservative mechanism of replication, the scheme of Meselsohn's and Stahl's experiment.

General scheme of DNA synthesis. Enzymes of DNA replication in prokaryotes and eukaryotes. Molecular mechanisms of DNA replication: topological problems (topoisomerases, helicases); meaning of antiparallel DNA chains; fragments of Okazaki. Stages of synthesis of daughter chains of DNA molecules.

General scheme of transcription; coding and noncoding chains of DNA. RNA-polymerases prokaryotes and eukaryotes. Stages and enzymes of RNA synthesis in prokaryotes and eukaryotes. Transcription signals: promoter, initiator, terminator regions of the genome.

Processing is the posttranscriptional modifications of RNA.

Features of genetic code; triplet structure, its properties. Table of genetic code.

Protein synthesis on the ribosomes. Components of protein synthesis system. Transfer RNA, aminoacyl-tRNA synthetase. Stages and mechanisms of translation: initiation, elongation, termination. Initiating and terminating codons of mRNA; the role of the protein factors of the ribosome in translation.

Post-translational modification of polypeptide chains. Regulation of translation. Molecular mechanisms of translation control on example of globin synthesis.

The influence of biologically active compounds on translation. Antibiotics as inhibitors of translation in prokaryotes and eukaryotes, their biomedical application. Biochemical mechanisms of interferon antiviral action. Inhibition of protein biosynthesis by diphtheria toxin (ADP-ribosylation of translation factors).

## **Section 11. Molecular mechanisms of hormone action on target cells. Biochemistry of hormone regulation. Biochemistry of nutrition and vitamins**

### ***Topic 22. Study of the role of protein-peptide hormones of different genesis on metabolism.***

Hormones in a system of intercellular integration of physiological functions in human organism. Classification of hormones: amino acid derivatives, peptide and protein hormones, steroid hormones, bioregulators are the derivative of arachidonic acid.

Synthesis and secretion of hormones. Cyclic nature of hormone secretion. Transport of hormones in blood. Targets of hormonal action; types of cell response to the hormone. Membrane and cytosol receptors of hormones in the cell. Biochemical systems of intracellular transduction of hormonal signals.

Molecular-cell mechanisms of action of proteins-peptide-type hormones and biogenic amines. Cascade systems for transmitting the chemical signal of the bioregulator: receptors → G-proteins → secondary messengers → proteinkinases.

Messenger functions of cyclic nucleotides, Ca/calmodulin system, phosphoinositides. Serine, threonine and tyrosine proteinkinases in effector response of the cell.

### ***Topic 23. Investigation of role of steroid and thyroid hormones. Physiologically active eicosanoids.***

Sequence of processes in the implementation of molecular-cell mechanisms of action of steroid and thyroid hormones.

Structure and properties of cytosolic receptors for steroids and thyroids. The molecular organization of regulatory DNA sites that interact with hormonal receptors.

Eicosanoids: structure, classification (prostanoids – prostaglandins, prostacyclins, thromboxanes, leukotrienes), pathways and localization of synthesis, biochemical effects. Aspirin and other nonsteroidal anti-inflammatory drugs as inhibitors of prostaglandin synthesis.

***Topic 24. Investigation of hormonal regulation of calcium and phosphates homeostasis.***

Distribution of  $\text{Ca}^{2+}$  in body; molecular forms of calcium in human blood plasma. Role of bone tissue, small intestine and kidneys in calcium homeostasis.

Hormonal regulation of calcium homeostasis (calcitonin, parathyroid hormone and calcitriol). Parathyroid hormone – structure, the mechanism of hypercalcemia action. Calcitriol: biosynthesis; effect on the absorption of  $\text{Ca}^{2+}$  and phosphate in the intestine. Calcitonin – structure, impact on calcium and phosphate.

Clinical and biochemical characteristics of disorders of calcium homeostasis (rickets, osteoporosis).

***Topic 25. Investigation of biochemistry of digestion and biochemical functions water-soluble and fat-soluble vitamins.***

General characteristic of the content of nutrients in common dietary products: a) macro components (carbohydrates, lipids, proteins); b) micro components (vitamins, microelements). Physiological requirements, energetic and biological value of principal nutritional compounds. Trace elements, biological and biochemical functions. Manifestations of micronutrient deficiencies.

General characteristics of digestion of nutrients. Enzymes, biochemical mechanisms of digestion of proteins, carbohydrates, lipids in particular sections of the digestive tract.

Digestive disorders of certain nutrients in stomach and intestine; hereditary enzymopathies of digestion. Peculiarities of cavity and membrane digestion of proteins. Proteolytic enzymes of intestinal juice. Action of trypsin, chymotrypsin, amino and carboxypeptidases. The specificity of the action of enzymes. Enzymes of cavity and membrane digestion of carbohydrates, mechanism of their action.

Biochemical changes in gastric dysfunction and their clinical and biochemical diagnosis. Disorders of the secretory function of the pancreas in acute and chronic pancreatitis, their clinical and biochemical characteristics. Types of steatorrhea: pancreatic steatorrhea (pancreatic lipase deficiency in pancreatitis), hepatogenic steatorrhea (intestinal bile deficiency), enterogenic steatorrhea (inhibition of lipolysis enzymes and triacylglycerol resynthesis). Hereditary enzymopathies of intestinal disaccharide insufficiency. Clinical and biochemical diagnosis of lactose intolerance, sucrose.

Definition of vitamins, their biological role and importance in metabolism. Classification and nomenclature of vitamins.

Chemical structure and biological functions of water-soluble vitamins. Their daily requirements and sources of intake. Coenzyme function of vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, B<sub>5</sub>, B<sub>6</sub>, B<sub>12</sub>, H, C. Exogenous and endogenous causes of vitamin deficiency. Clinical manifestations of insufficiency. Avitaminosis. The use of vitamin preparations in the prevention and treatment of diseases. Vitamin supplements, preventive and curative aspects of the disease.

Chemical structure, biological role of fat-soluble vitamins – retinols, calciferols, tocopherols, naphthoquinones, polyunsaturated higher fatty acids; their daily requirements and sources of intake. The concept of hypervitaminosis, clinical manifestations and consequences. Vitamin-like fat-soluble substances, their biological significance.

**Block 5. Biochemistry of tissues and physiological functions**

**Section 12. Biochemistry and pathobiochemistry of blood and immune processes**



***Topic 26. Research of blood functions: buffer systems, acid-base state, coagulation system. Pathological forms of hemoglobin.***

The composition of the blood is normal; physiological and biochemical functions of blood; biochemical composition of blood in normal and in pathology; hemostasis system; biochemical principles of respiratory function of erythrocytes; vascular-platelet and coagulation hemostasis.

Chemical composition and physicochemical properties of blood of a healthy person. The main fractions of plasma proteins, clinical and biochemical characteristics, changes in the content of pathologies. Hyper-, hypo-, para- and dysproteinemia.

Buffer blood systems in ensuring the acid-base balance of the blood. Indicators of acid-base status studied in the clinic. Metabolic alkalosis and acidosis, mechanisms of their occurrence. Respiratory alkalosis and acidosis, mechanisms of their occurrence Mechanisms of hypoxia.

Mechanisms of hemoglobin participation in oxygen and CO<sub>2</sub> transport, peculiarities of metabolism in formed blood elements, biochemical bases of coagulation and fibrinolytic system of blood. Variants of human hemoglobin; molecular disorders of the structure of hemoglobin – hemoglobinopathies, thalassemias.

***Topic 27. Research of blood plasma proteins: acute inflammatory phase proteins, own and indicator enzymes. Immune processes.***

Blood plasma proteins and their clinical and biochemical characteristics; blood protein fractions. Components of the system of nonspecific resistance of the organism and test proteins of the “acute phase” of inflammatory processes – (C-reactive protein,  $\alpha_2$ -macroglobulin,  $\alpha_1$ -proteinase inhibitor, fibronectin, cryoglobulin, etc.).

Clinical significance and diagnostic evaluation of “acute phase” proteins of inflammatory processes. Change in the activity of plasma enzymes in the most common diseases of the internal organs, as an accurate highly informative method of enzyme diagnostics.

Blood plasma enzymes. Study of biochemical parameters of blood plasma in pathologies. Kallikrein-kinin system. Analysis of human health in normal and under conditions of pathological processes on the basis of clinical and biochemical characteristics of the blood system.

***Topic 28. Research of nitrogen metabolism. End products: urea, uric acid, creatine, creatinine, amino acids.***

Non-protein (nitrogenous and nitrogen-free) organic compounds of blood plasma. Inorganic components of plasma.

The composition of residual nitrogen. Origin, norms and clinical-biochemical and diagnostic value of definition: urea, ammonia, uric acid, creatine, creatinine, indican, amino acids, bilirubin.

Causes of retention and productive azotemia, their connection with some forms of pathology of organs and systems. Features of the composition of residual nitrogen are characteristic of different types of azotemia.

**Section 13. Functional and clinical biochemistry of organs and tissues**

***Topic 29. Study of biliary function of the liver. Metabolism of bile pigments. Pathobiochemistry of jaundice.***

Bile-producing function of liver. Biochemical composition of bile. Changes in biochemical parameters in acute hepatitis caused by viruses or alcohol intoxication, their diagnostic evaluation. Changes in biochemical parameters in chronic hepatitis, cirrhosis, gallstone disease, dyskinesia and cholecystitis, their diagnostic evaluation. Relationship of disorders in the excretory function of the liver with disorders of digestive processes in the intestine, diagnosis of these disorders.

The role of the liver in the metabolism of bile pigments. Hemolytic (prehepatic), parenchymatous (hepatic), occlusive (posthepatic) jaundices. Enzymatic congenital jaundices: Crigler-Najjar, Gilbert disease, Dubin-Johnson syndrome, physiological in newborns.

**Topic 30. Research of biochemical functions of a liver, disturbances at separate diseases. *Microsomal oxidation.***

Biochemical patterns of liver function: carbohydrate, lipid-regulating, protein-synthesizing, urea-forming, pigment, bile-forming. The role of the liver in ensuring normoglycemia (synthesis and catabolism of glycogen, gluconeogenesis) and pathological changes - hypo-, hyperglycemia, glucosuria. Biochemical bases of development of liver failure under the conditions of chemical, biological and radiation damage.

Microsomal and mitochondrial monooxygenase systems of the liver: composition and functions of its components. The mechanism of action of cytochrome P<sub>450</sub>, its induction by drugs. The role of monooxygenase systems in the biotransformation of endogenous and exogenous substrates. Classification of xenobiotics. Phases of xenobiotic metabolism and their localization in the body. Enzymes and coenzymes of modifier enzyme systems

Types of conjugation reactions of intermediate metabolites of xenobiotics and endogenous toxins in hepatocytes, their biological significance. Ways to remove detoxification products of drugs and endogenous toxins from the body.

**Topic 31. Investigation of normal and pathological components of urine.**

Biochemical functions of the kidneys. Functions of kidneys in an organism, their role in maintenance of balance of water, electrolytes, constancy of osmotic pressure, pH, derivation of end products of an exchange.

Chemical composition and physicochemical properties of urine of a healthy person. Pathological components of urine and causes of their appearance. The role of the kidneys in the excretion of products of biotransformation of xenobiotics and endogenous toxins.

The value of urine analysis for the detection of pathology of the kidneys, assessment of their function, diagnosis and prognosis of diseases of other organs and systems.

**Topic 32. Research of biochemical functions of muscle and connective tissue. *Biochemistry of the nervous system.***

Structural organization of sarcomeres. Myofibril proteins: myosin, actin, tropomyosin, troponin. Molecular organization of thick and thin filaments.

The role of Ca<sup>2+</sup> ions in the regulation of contraction and relaxation of skeletal and smooth muscle.

Muscle tissue bioenergy: sources of ATP in muscles. The role of creatine phosphate in providing energy for muscle contraction. Muscle pathobiochemistry – myopathy. Features of bioenergetic processes in the myocardium and regulation of cardiomyocyte contraction.

Relationship of heart muscle metabolism with metabolism in the nervous, endocrine systems, liver, lungs, blood vessels. Heart damage in: thyrotoxicosis, hypothyroidism, hypercorticism, diabetes mellitus, parathyroid disease and chronic renal failure, radiation exposure, porphyria, gout, eating disorders, alcohol intoxication.

Change in the activity of blood plasma enzymes in acute myocardial infarction; diagnosis: microinfarction, angina, alcohol intoxication. Change in biochemical parameters at different stages of hypertension and their evaluation.

Neurospecific proteins of the brain. Features of the amino acid composition of the brain. The role of the glutamic acid system. Neurospecific lipids (gangliosides, cerebroside, cholesterol).

The value of aerobic oxidation of glucose in the energy supply of the brain. Changes in energy metabolism under conditions of physiological sleep and anesthesia. Excitatory and inhibitory neurotransmitters.

Peptidergic system of the brain: opioid peptides, opioid peptide receptors. Disorders of metabolism of mediators and modulators of the brain in mental disorders. Neurochemical mechanisms of action of psychotropic drugs.

### 3.2. The structure of the discipline

#### I COURSE

Names of blocks, sections and topics	Number of hours			
	total	including		
		lec.	prac.	ind.w.
<b><i>Block 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components</i></b>				
<b><i>Section 1. Theoretical foundations of the structure and reactivity of bioorganic compounds. Carboxylic acids and their functional derivatives. Lipids</i></b>				
Topic 1. Classification, nomenclature and isomerism of bioorganic compounds. The nature of the chemical bond. Reactivity of bioorganic compounds.	8	-	6	2
Topic 2. Structure, properties and biological significance of carboxylic acids, heterofunctional compounds (hydroxy-, keto-, phenolic acids).	7	1	4	2
Topic 3. Higher fatty acids. Saponifiable and unsaponifiable lipids. Phospholipids.	5	1	2	2
<b><i>Total for section 1</i></b>	<b>20</b>	<b>2</b>	<b>12</b>	<b>6</b>
<b><i>Section 2. <math>\alpha</math>-Amino acids, peptides, proteins</i></b>				
Topic 4. Amino acid composition of proteins and peptides. Deamination, decarboxylation, transamination of $\alpha$ -amino acids. Color reactions.	5	1	2	2
Topic 5. Structural organization of proteins. Physico-chemical properties of proteins. Solubility, precipitation, dialysis, protein electrophoresis. Denaturation.	7	1	4	2
<b><i>Total for section 2</i></b>	<b>12</b>	<b>2</b>	<b>6</b>	<b>4</b>
<b><i>Section 3. Carbohydrates</i></b>				
Topic 6. Carbohydrates. Monosaccharides: structure, chemical properties and biological significance.	6	2	2	2
Topic 7. Structure, properties and biological role of di- and polysaccharides.	6	2	2	2
<b><i>Total for section 3</i></b>	<b>12</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b><i>Section 4. Biologically active heterocyclic compounds. Nucleosides, nucleotides, nucleic acids</i></b>				
Topic 8. Classification, structure and significance of biologically important heterocyclic compounds.	5	1	2	2
Topic 9. Structure and biochemical functions of nucleosides and nucleotides.	7	1	4	2
Topic 10. Structure and biochemical functions of nucleic acids.	4	-	2	2
<b><i>Final control work of assimilation of material of block 1.</i></b>				
<b><i>Total for section 4</i></b>	<b>16</b>	<b>2</b>	<b>8</b>	<b>6</b>

Names of blocks, sections and topics	Number of hours			
	total	including		
		lec.	prac.	ind.w.
<b>Total for I course:</b>	<b>60</b>	<b>10</b>	<b>30</b>	<b>20</b>

## II COURSE

Names of blocks, sections and topics	Number of hours			
	total	including		
		lec.	prac.	ind.w.
<b><i>Block 2. General principles of metabolism</i></b>				
<b><i>Section 5. Introduction to biochemistry. Biochemical components of cells. Enzymes and coenzymes. Regulation of metabolism</i></b>				
Topic 1. Control of the initial level of knowledge. Assimilation of the principles of biochemical laboratory research; substantiation and clinical and diagnostic significance of changes in biochemical parameters.	4	–	2	2
Topic 2. Research of physicochemical properties of enzymes. Classification, mechanism of action, kinetics. Units of enzyme activity.	7	1	2	4
Topic 3. Research of regulation of enzymatic processes. Medical enzymology.	6,5	0,5	4	2
Topic 4. Research of the role of cofactors and coenzymes: chemical structure and functions.	4,5	0,5	4	-
<b><i>Total for section 5</i></b>	<b>22</b>	<b>2</b>	<b>12</b>	<b>8</b>
<b><i>Section 6. Basic regularities of metabolism. Tricarboxylic acid cycle. Molecular bases of bioenerg</i></b>				
Topic 5. Metabolism and energy study. Functioning, regulation and energetic effect of the tricarboxylic acid cycle.	7	1	4	2
Topic 6. Study of biological oxidation, oxidative phosphorylation and synthesis of ATP.	4,5	0,5	2	2
Topic 7. Study of chemiosmotic theory, analysis of the mechanism of action of inhibitors and uncouplers of oxidative phosphorylation.	7,5	0,5	4	3
<b><i>Total for section 6</i></b>	<b>19</b>	<b>2</b>	<b>10</b>	<b>7</b>
<b><i>Block 3. General metabolism patterns. Metabolism of carbohydrates, lipids, amino acids and its regulation</i></b>				
<b><i>Section 7. Carbohydrate metabolism and regulation</i></b>				
Topic 8. Study of digestion and absorption of carbohydrates. Glycolysis. Alcohol fermentation.	5	1	2	2
Topic 9. Study of aerobic oxidation of glucose and alternative routes for the exchange of monosaccharides.	5	1	2	2
Topic 10. Fructose, sorbitol and galactose metabolism.	4	1	2	1
Topic 11. Study of catabolism and the biosynthesis of glycogen. Glycogen exchange regulation. Glucose biosynthesis (gluconeogenesis). Pathologies of carbohydrate metabolism.	7	1	4	2
<b><i>Total for section 7</i></b>	<b>21</b>	<b>4</b>	<b>10</b>	<b>7</b>
<b><i>Section 8. Lipid metabolism and its regulation</i></b>				
Topic 12. Investigation of lipid digestion and absorption. Catabolism of triacylglycerols. Lipolysis and its regulation. Oxidation of fatty acids and glycerol.	3	1	2	-

Names of blocks, sections and topics	Number of hours			
	total	including		
		lec.	prac.	ind.w.
Topic 13. Investigation of the biosynthesis of higher fatty acids, TAG and phospholipids.	5	1	2	2
Topic 14. Research of biosynthesis and biotransformation of cholesterol (vitamin D, bile acids, steroid hormones). Metabolism of ketone bodies.	9	1	4	4
Topic 15. Study of lipid exchange pathologies (steatorrhea, obesity, atherosclerosis, diabetes mellitus). Transport forms of lipids.	5	1	2	2
<b>Total for section 8</b>	<b>22</b>	<b>4</b>	<b>10</b>	<b>8</b>
<b>Section 9. Amino acid metabolism. Enzymopathies of amino acid exchange</b>				
Topic 16. Protein digestion and amino acid absorption. Common ways of converting amino acids.	3	1	2	-
Topic 17. Study of the formation and detoxification pathways of ammonia. Biosynthesis of urea.	5	1	2	2
Topic 18. Study of specific pathways of noncyclic and cyclic amino acids metabolism. Enzymopathies.	5	1	2	2
Topic 19. Research of biosynthesis of porphyrins. Hereditary disorders of porphyrin metabolism.	3	1	2	-
<b>Total for section 9</b>	<b>16</b>	<b>4</b>	<b>8</b>	<b>4</b>
<i>Final thematic control work of mastering the material of blocks 2,3.</i>	5	-	2	3
<b>Total hours for blocks 2,3</b>	<b>105</b>	<b>16</b>	<b>52</b>	<b>37</b>
<b>Block 4. Molecular biology. Biochemistry of intercellular communications</b>				
<b>Section 10. Fundamentals of molecular biology. Fundamentals of molecular genetics</b>				
Topic 20. Research of the biosynthesis and catabolism of purine and pyrimidine nucleotides. Hereditary disorders of their exchange.	9	2	4	3
Topic 21. Research of DNA replication and transcription of RNA. Investigation of biosynthesis of protein on ribosomes. Antibiotics are the inhibitors of the template-directed synthesis. Action of viruses and toxins.	14	2	6	6
<b>Total for section 10</b>	<b>23</b>	<b>4</b>	<b>10</b>	<b>9</b>
<b>Section 11. Molecular mechanisms of hormone action on target cells. Biochemistry of hormone regulation. Biochemistry of nutrition and vitamins</b>				
Topic 22. Study of the role of protein-peptide hormones of different genesis on metabolism.	11	1	4	6
Topic 23. Investigation of role of steroid and thyroid hormones. Physiologically active eicosanoids.	8	1	4	3
Topic 24. Investigation of hormonal regulation of calcium and phosphates homeostasis.	7	-	4	3
Topic 25. Investigation of biochemistry of digestion and biochemical functions water-soluble and fat-soluble vitamins.	11	-	4	7
<b>Total for section 11</b>	<b>37</b>	<b>2</b>	<b>16</b>	<b>19</b>
<b>Block 5. Biochemistry of tissues and physiological functions</b>				
<b>Section 12. Biochemistry and pathobiochemistry of blood and immune processes</b>				
Topic 26. Research of blood functions: buffer systems, acid-base state, coagulation system. Pathological forms of hemoglobin.	12	1	4	7
Topic 27. Research of blood plasma proteins: acute inflammatory	11	1	4	6

Names of blocks, sections and topics	Number of hours			
	total	including		
		lec.	prac.	ind.w.
phase proteins, own and indicator enzymes. Immune processes.				
Topic 28. Research of nitrogen metabolism. End products: urea, uric acid, creatine, creatinine, amino acids.	5	–	2	3
<b>Total for section 12</b>	<b>28</b>	<b>2</b>	<b>10</b>	<b>16</b>
<b>Section 13. Functional and clinical biochemistry of organs and tissues</b>				
Topic 29. Study of biliary function of the liver. Metabolism of bile pigments. Pathobiochemistry of jaundice.	7	1	2	4
Topic 30. Research of biochemical functions of a liver, disturbances at separate diseases. Microsomal oxidation.	6	1	2	3
Topic 31. Investigation of normal and pathological components of urine.	4	2	2	-
Topic 32. Research of biochemical functions of muscle and connective tissue. Biochemistry of the nervous system. <i>Final thematic control work of mastering the material of blocks 4, 5.</i>	15	2	6	7
<b>Total for section 13</b>	<b>32</b>	<b>6</b>	<b>12</b>	<b>14</b>
<b>Total hours for blocks 4,5</b>	<b>120</b>	<b>14</b>	<b>48</b>	<b>58</b>
<b>Total for II course:</b>	<b>225</b>	<b>30</b>	<b>100</b>	<b>95</b>

### 3.2.1. Lecture topics

#### I COURSE

№	Name of topic	Number of hours
1	2	3
<b>Block 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components</b>		
1.	Bioorganic chemistry as a science. Classification, structure and chemical properties of carboxylic acids. Higher fatty acids. Saponifiable and unsaponifiable lipids. Phospholipids.	2
2.	L- $\alpha$ -amino acids, peptides, proteins.	2
3.	Classification, structure and chemical properties of carbohydrates: monosaccharides.	2
4.	Structure, chemical properties, biological significance of di- and polysaccharides.	2
5.	Heterocyclic compounds. Structure, properties and biological significance of nucleic acids.	2
<b>Total lecture hours for the first course:</b>		<b>10</b>

#### II COURSE

№	Name of topic	Number of hours
1	2	3
<b>Block 2. General principles of metabolism</b>		
1.	Biochemistry as a science. Enzymes: structure, properties, mechanism of action and regulation of enzymatic processes.	2
2.	Bioenergy. The cycle of tricarboxylic acids. Biological oxidation, tissue respiration and oxidative phosphorylation.	2

<b>Block 3. General metabolism patterns. Metabolism of carbohydrates, lipids, amino acids and its regulation</b>		
3.	Carbohydrate metabolism-1. Glycolysis, aerobic oxidation of glucose; alternative ways of metabolism of monosaccharides.	2
4.	Carbohydrate metabolism-2. Glycogen metabolism. Gluconeogenesis. Regulation and pathology of carbohydrate metabolism.	2
5.	Lipid metabolism-1. Oxidation and biosynthesis of fatty acids, triacylglycerols and phospholipids.	2
6.	Lipid metabolism -2. Metabolism of cholesterol and ketone bodies. Regulation and pathology of lipid metabolism.	2
7.	Metabolism of amino acids-1. General and specialized ways of converting amino acids. Hereditary enzymes of amino acid metabolism.	2
8.	Metabolism of amino acids-2. Pathways of ammonia metabolism. Urea biosynthesis.	2
<b>Block 4. Molecular biology. Biochemistry of intercellular communications</b>		
9.	Metabolism of purine and pyrimidine nucleotides. Metabolic pathologies.	2
10.	Replication and transcription processes. Protein biosynthesis. The action of drugs as inhibitors.	2
11.	Biochemical role of hormones of protein-peptide, steroid and thyroid nature.	2
<b>Block 5. Biochemistry of tissues and physiological functions</b>		
12.	Biochemistry and pathobiochemistry of blood.	2
13.	Biochemical functions of the liver. Biochemistry of jaundice. Biotransformation of xenobiotics.	2
14.	Biochemical functions of the kidneys.	2
15.	Biochemistry of muscles, connective tissue and nervous system.	2
<b>Total lecture hours for the second course:</b>		<b>30</b>

### 3.2.2. Topics of seminars (unforeseen)

### 3.2.3. Topics of practical classes

## I COURSE

<b>№</b>	<b>Name of topic</b>	<b>Number of hours</b>
<b>1</b>	<b>2</b>	<b>3</b>
<b>Block 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components</b>		
1.	Classification, nomenclature and isomerism of bioorganic compounds. The nature of the chemical bond.	2
2.	Classification of chemical reactions. Reactivity of alkanes, alkenes, arenes, alcohols, phenols, amines.	2
3.	Structure and properties of aldehydes and ketones.	2
4.	Structure, properties and biological significance of carboxylic acids.	2
5.	Higher fatty acids. Lipids. Phospholipids.	2
6.	Structure, reactivity and biological significance of heterofunctional compounds (hydroxy acids, $\alpha$ -, $\beta$ -, $\gamma$ -amino acids, keto acids and phenolic acids).	2
7.	Amino acid composition of proteins and peptides.	2
8.	Structural organization of proteins. Physico-chemical properties of proteins.	2
9.	Solubility, precipitation, dialysis, protein electrophoresis. Denaturation.	2
10.	Carbohydrates. Structure and chemical properties of monosaccharides.	2
11.	Structure and functions of di- and polysaccharides.	2

12.	Classification, structure and significance of biologically important heterocyclic compounds.	2
13.	Structure and biochemical functions of nucleosides.	2
14.	Structure and biochemical functions of nucleotides.	2
15.	Structure and biological role of nucleic acids. <i>Final thematic control work of mastering the material of block 1.</i>	2
<b>Total hours of practical classes for the first course:</b>		<b>30</b>

## II COURSE

№	Name of topic	Number of hours
<b>1</b>	<b>2</b>	<b>3</b>
<b><i>Block 2. General principles of metabolism</i></b>		
<b><i>Section 5. Introduction to biochemistry. Biochemical components of cells. Enzymes and coenzymes. Regulation of metabolism</i></b>		
1.	Control of the initial level of knowledge. Assimilation of the principles of biochemical laboratory research; substantiation and clinical and diagnostic significance of changes in biochemical	2
2.	Research of physico-chemical properties of enzymes, their classification	2
3.	The mechanism of enzymes action and the kinetics of ferment catalysis. Units of enzyme activity.	2
4.	Research of regulation of enzymatic processes.	2
5.	Intracellular organization of enzyme activity. Isoenzymes, multienzymes complexes. Medical enzymology	2
6.	Research of the role of cofactors and coenzymes: chemical structure and functions.	2
<b><i>Section 6. Basic regularities of metabolism. Tricarboxylic acid cycle. Molecular bases of bioenerg</i></b>		
7.	Research of metabolism and energy.	2
8.	Functioning, regulation and energy value of the tricarboxylic acid cycle.	2
9.	Investigation of biological oxidation, oxidative phosphorylation and ATP synthesis.	2
10.	Assimilation of chemiosmotic theory, analysis of the mechanism of action of oxidative phosphorylation inhibitors and disconnectors. <b>Control work. Block 2</b>	2
<b><i>Block 3. General metabolism patterns. Metabolism of carbohydrates, lipids, amino acids and its regulation</i></b>		
<b><i>Section 7. Carbohydrate metabolism and regulation</i></b>		
11.	Glycolysis. Alcohol fermentation	2
12.	Study of aerobic oxidation of glucose	2
13.	Research of alternative ways of monosaccharide metabolism. Metabolism of fructose, sorbitol and galactose	2
14.	Studies of glycogen catabolism and biosynthesis. Regulation of glycogen metabolism. Glucose biosynthesis (gluconeogenesis).	2
15.	Studies of mechanisms of metabolic and hormonal regulation of carbohydrate metabolism. Pathologies of carbohydrate metabolism.	2
<b><i>Section 8. Lipid metabolism and its regulation</i></b>		
16.	Lipolysis and its regulation. Studies of catabolism and biosynthesis of triacylglycerols.	2
17.	Transport forms of lipids: lipoproteins of blood plasma.	2
18.	$\beta$ -Oxidation of fatty acids and glycerol. Metabolism of ketone bodies.	2
19.	Study of fatty acid biosynthesis.	2
20.	Metabolism of complex lipids	2



21.	Studies of biosynthesis and biotransformation of cholesterol (vitamin D, bile acids, steroid hormones). Study of pathologies of lipid metabolism (steatorrhea, obesity, atherosclerosis, diabetes). Test control	2
<b>Section 9. Amino acid metabolism. Enzymopathies of amino acid exchange</b>		
22.	General ways of converting amino acids (deamination, transamination, decarboxylation).	2
23.	Biosynthesis of glutathione and creatine	2
24.	Research of ways of formation and detoxification of ammonia. Urea biosynthesis. Research of specialized ways of metabolism of noncyclic and cyclic amino acids. Enzymopathies.	2
25.	Research of specialized ways of metabolism of noncyclic and cyclic amino acids. Enzymopathies. Research of biosynthesis of porphyrins. Hereditary disorders of porphyrin metabolism.	2
26.	<b>Final control. Blocks 2,3</b>	2
	<b>Total hours for blocks 2, 3</b>	<b>52</b>
<b>Block 4. Molecular biology. Biochemistry of intercellular communications</b>		
<b>Section 10. Fundamentals of molecular biology. Fundamentals of molecular genetics</b>		
27.	Biochemical functions of nucleotides and nucleic acids.	2
28.	Research of the biosynthesis and catabolism of purine and pyrimidine nucleotides. Metabolic disorders.	2
29.	Research of DNA replication and transcription of RNA.	2
30.	Research of the biosynthesis of protein on ribosomes. Antibiotics are inhibitors of matrix synthesis. Action of viruses and toxins.	2
31.	Analysis of mechanisms of mutations, DNA reparations. Mastering the principles of genetic engineering and cloning of genes, their application in modern medicine.	2
<b>Section 11. Molecular mechanisms of hormone action on target cells. Biochemistry of hormone regulation. Biochemistry of nutrition and vitamins</b>		
32.	Investigation of the role of hormones of protein-peptide nature on metabolism.	2
33.	Investigation of the role of hormones – derivatives of amino acids and biogenic amines. Study of hormonal regulation of calcium and phosphate homeostasis in the body.	2
34.	Investigation of the role of steroid and thyroid hormones.	2
35.	Physiologically active eicosanoids.	2
36.	Research of nutrition biochemistry.	2
37.	Research of biochemical functions of water-soluble vitamins.	2
38.	Research of biochemical functions of fat-soluble vitamins. <b>Control work. Block 4</b>	2
<b>Blok 5. Biochemistry of tissues and physiological functions</b>		
<b>Section 12. Biochemistry and pathobiochemistry of blood and immune processes</b>		
39.	Investigation of blood functions: buffer systems, acid-base state. Pathological forms of hemoglobin.	2
40.	Studies of blood plasma proteins: proteins of the acute phase of inflammation, lipoproteins, indicator enzymes.	2
41.	Research of nitrogen metabolism. End products: urea, uric acid, creatine, creatinine, amino acids.	2
42.	Research of coagulation and fibrinolytic blood systems.	2
43.	Investigation of biochemical regularities of the implementation of immune processes.	2
<b>Section 13. Functional and clinical biochemistry of organs and tissues</b>		
44.	Study of biliary function of the liver. Metabolism of bile pigments. Pathobiochemistry of jaundice.	2
45.	Research of biochemical functions of a liver, disturbances at particular diseases.	2

	Microsomal oxidation.	
46.	Investigation of water-salt and mineral exchanges.	2
47.	Normal and pathological components of urine.	2
48.	Investigation of biochemical functions of muscle tissue.	2
49.	Investigation of biochemical functions of connective and bone tissues.	2
50.	Biochemistry of the nervous system. <b>Final control. Block 5</b>	2
<b>Total hours for blocks 4, 5</b>		<b>48</b>
<b>Total lecture hours for the second course:</b>		<b>100</b>

### 3.2.4. Topics of laboratory classes (not provided)

### 3.2.5. Independent work

#### I COURSE

№	Name of topic	Number of hours
1	2	3
<b>Block 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components</b>		
1.	Structural formulas of bioorganic compounds, schemes of structure of biopolymers and their structural components.	2
2.	Stereochemical structure of bioorganic compounds, optical activity of bioorganic compounds.	2
3.	Structure, reactivity and biological role of aldehydes and ketones, carboxylic acids and their derivatives. Higher fatty acids: structure and biological significance.	2
4.	Composition and structure of "ketone" bodies, ways of formation in the body, laboratory methods of determination.	2
5.	The structure of unsaponifiable lipids, the concept of polyhydric alcohols and their biological significance in the construction of complex lipids (sphingolipids and glycolipids); their importance in the construction of biomembranes.	2
6.	Biologically important chemical properties of $\alpha$ -amino acids that provide their functional properties and metabolic transformations.	2
7.	Structure and biological role of glycosaminoglycans: (hyaluronic acid, chondroitin sulfate, heparin).	2
8.	Structure and biological role in the composition of hyaluronic acid, chondroitin sulfates and heparin.	2
9.	Structure and properties of heterocyclic compounds underlying the structure of biologically important substances and drugs.	2
10.	Structure and biochemical functions of free nucleotides: nucleotides-coenzymes; cyclic nucleotides 3',5'-cAMP and 3',5'-cGMP	2
<b>Total hours of independent work hours for block 1:</b>		<b>20</b>

#### II COURSE

№	Name of topic	Number of hours
1	2	3
<b>Block 2. General principles of metabolism</b>		
1.	Rationale and clinical and diagnostic significance of changes in biochemical parameters that are determined in the clinic.	2
2.	Principles for determining the activity of enzymes in biological fluids. Interpretation of graphs of dependence of the rate of enzymatic reaction on the concentration of	2

	substrate, enzyme, changes in pH and ambient temperature.	
3.	Interpretation of graphs of dependence of the rate of enzymatic reaction on the concentration of substrate, enzyme, changes in pH and ambient temperature.	2
4.	Enzymodiagnosics. Diagnostic value of determining changes in the quantitative content and activity of isoenzymes in pathologies.	2
5.	Methods for assessing metabolites of metabolism.	2
6.	Determination and explanation of the value of the phosphorylation coefficient for aerobic oxidation reactions of substrates according to the type of coenzyme or prosthetic group of the enzyme.	2
7.	Oxidative phosphorylation inhibitors and uncouplers. <b>Preparation for the control work. Block 4</b>	3
<b><i>Block 3. General metabolism patterns. Metabolism of carbohydrates, lipids, amino acids and its regulation</i></b>		
8.	Clinical and diagnostic value of detection of metabolites of anaerobic oxidation of glucose in physiological and pathological conditions.	2
9.	Construction of schemes of alternative ways of glucose metabolism.	2
10.	Hereditary disorders of biosynthesis of glycogen metabolism enzymes. Features of metabolism of carbohydrate components of glycoconjugates and genetic disorders of their metabolism.	2
11.	Assessment of the state of hydrocarbon metabolism by biochemical parameters in normal and in pathologies	1
12.	Metabolism of ketone bodies in pathology; mechanisms of excessive growth of ketone bodies in diabetes and starvation.	2
13.	Principles of methods for determination of phospholipids in tissue homogenates and total lipids in blood serum. Sphingolipidosis - genetic abnormalities in the metabolism of sphingolipids. Lysosomal diseases.	2
14.	Cholesterol metabolism in the body. The main ways of biotransformation and excretion of cholesterol.	2
15.	Assessment of the state of lipid metabolism in normal and in pathologies. Changes in the system of circulatory transport lipids: HM, VLDL, LDL, HDL, explain their functional significance	2
16.	Study of amino acid metabolism disorders in congenital and acquired metabolic defects by biochemical parameters	2
17.	Drawing up schemes of circulatory transport of ammonia in an organism. Analysis of changes in ammonia neutralization systems in genetic abnormalities of enzymes of its metabolism	2
18.	Preparation for the final thematic control work of mastering the material of blocks 2, 3.	3
<b><i>Total hours for blocks 2,3</i></b>		<b>37</b>
<b><i>Block 4. Molecular biology. Biochemistry of intercellular communications</i></b>		
19.	Clinical and biochemical characteristics of uric acid metabolism disorders	3
20.	Influence of physiologically active compounds on translation processes	3
21.	Consequences of genomic, chromosomal and gene mutations. The mechanism of action of the most common mutagens.	3
22.	Analysis of biochemical parameters that characterize the metabolism of carbohydrates, proteins and lipids in disorders of the endocrine glands	3
23.	Mechanism of action of protein-peptide, steroid, thyroid hormones and catecholamines on target cells.	3
24.	Distribution of calcium ions in the body, forms of calcium in human blood plasma. The contribution of bone tissue, small intestine and kidneys to calcium homeostasis.	3

25.	Pathology of the thyroid gland; features of metabolic disorders in conditions of hyper- and hypothyroidism. Mechanisms of endemic goiter and its prevention	3
26.	Biological properties of fat-soluble vitamins in metabolic processes are normal in pathologies.	3
27.	<b>Preparation for the control work. Block 4</b>	4
<b><i>Blok 5. Biochemistry of tissues and physiological functions</i></b>		
28.	Biochemical bases of functioning of systems of regulation of blood pressure. The use of antihypertensive drugs - angiotensin-converting enzyme inhibitors	3
29.	Diagnostic role of proteins of the acute phase of inflammation and indicator enzymes of blood plasma according to norms and pathologies	3
30.	Investigation of nitrogen metabolism and changes in the content of nitrogen-containing non-protein components of the blood	3
31.	Hereditary and acquired disorders of vascular-platelet and coagulation hemostasis. Drugs that affect the processes of fibrinolysis. Plasminogen activators and plasmin inhibitors.	4
32.	Analysis of disorders that occur in the functioning of the human immune system. Primary and secondary immunodeficiencies	3
33.	Analysis of differential changes in biochemical parameters of blood and urine (free, conjugated bilirubin) to assess the pathobiochemistry of jaundice	4
34.	Biochemical bases of detoxification processes of xenobiotics and endogenous toxins. Assess liver detoxification function by biochemical parameters	3
35.	Molecular mechanisms of skeletal, smooth and cardiac muscle contraction. Comparative characteristic	3
36.	<b>Preparation for the final control. Block 5</b>	4
<b>Total hours for blocks 4, 5</b>		<b>58</b>
<b>Total independent work hours for the second course:</b>		<b>95</b>

### 3.2.6. Tasks for independent work

The list of tasks for independent work of students is part of the methodological support of the discipline, and their content and form should correspond to the theme of independent work on the course “Biological and Biological Chemistry” and “Regulations on the organization of the educational process of Petro Mohyla Black Sea National University”.

Independent work of students is performed in the form of preparation for practical classes (preparation-summary of theoretical questions according to the thematic plan, performance of situational tasks, mastering skills according to the topic of the lesson, writing essays, creating electronic versions of diagrams and spreadsheets, creating multimedia presentations, animations, movies, models, participation in research, etc.).

### 3.2.7. Individual tasks (Individual tasks are not provided by the program.)

## 4. The content of the discipline

### 4.1. Lecture plan

#### I COURSE

№	Name of topic
1	2
1.	<b>Bioorganic chemistry as a science. Classification, structure and chemical properties of carboxylic acids. Higher fatty acids. Saponifiable and unsaponifiable lipids. Phospholipids.</b> 1. Subject and objectives of bioorganic chemistry.

	<p>2. Theory of chemical structure of organic compounds</p> <p>3. Classification of organic compounds. The main functional groups and classes of organic compounds.</p> <p>4. Isomerism of organic compounds.</p> <p>5. Types of chemical bonds in organic molecules. Electronic structure of organic compounds.</p> <p>6. Interaction of atoms in organic compounds. Inductive and mesomeric effects.</p> <p>7. Classification of organic reactions and reagents. Types of organic reactions and types of reaction mechanisms.</p>
2.	<p><b>L-<math>\alpha</math>-amino acids, peptides, proteins.</b></p> <p>1. Classification of amino acids: the structure of the carbon chain, the ability to synthesize in the body, the polarity of the radical.</p> <p>2. General properties of amino acids. Optical properties of amino acids. Chemical properties of amino acids as heterofunctional compounds</p> <p>3. Acid-base properties of amino acids. Chemical reactions of <math>\alpha</math>-amino acids in vivo and in vitro.</p> <p>4. Reactions of qualitative and quantitative determination of <math>\alpha</math>-amino acids. Polycondensation reactions with the formation of peptides. Mechanism of peptide bond formation.</p> <p>5. Structure and properties of individual representatives (glycine, alanine, cysteine, serine, glutamic acid, lysine, phenylalanine, tryptophan, methionine).</p> <p>6. Functions of proteins.</p> <p>7. Levels of structural organization of protein molecules. Primary, secondary, tertiary, quaternary structure, types of connections that stabilize these structures. Qualitative reactions to peptides, proteins.</p> <p>8. Chemical synthesis of peptides and proteins.</p> <p>9. Simple and complex proteins. Classification of proteins.</p> <p>10. Factors of stability of existence of proteins in colloidal solutions. Denaturation of protein, its signs. Denaturing factors. Protein renaturation.</p>
3.	<p><b>Classification, structure and chemical properties of carbohydrates: monosaccharides.</b></p> <p>1. Carbohydrates</p> <p>1.1. General characteristics</p> <p>1.2. Photosynthesis</p> <p>1.3. Classification</p> <p>2. Monosaccharides</p> <p>2.1 Classification and nomenclature</p> <p>2.2. Stereoisomerism.</p> <p>2.3. Structure of monosaccharides</p> <p>3. Chemical properties</p> <p>3.1. Reactions involving open forms</p> <p>3.2. Reactions involving cyclic forms</p> <p>4. Types of fermentation of monosaccharides. Individual representatives: D-glucose.</p>
4.	<p><b>Structure, chemical properties, biological significance of di- and polysaccharides.</b></p> <p>1. Disaccharides</p> <p>1.1. Properties of sucrose, lactose, maltose</p> <p>1.2. Classification of disaccharides by their ability to redox reactions</p> <p>1.3. Two types of relationships between monosaccharide residues and their effect on disaccharide reactivity.</p> <p>2. Polysaccharides</p> <p>2.1 Classification of polysaccharides. Structure, biological role and application of starch, its components.</p> <p>2.2. Scheme of the structure of amylose and amylopectin. Hydrolysis of starch, qualitative reaction to its detection.</p> <p>2.3 Structure and biological role of glycogen.</p> <p>3. Heteropolysaccharides.</p>

5.	<p><b>Heterocyclic compounds. Structure, properties and biological significance of nucleic acids.</b></p> <ol style="list-style-type: none"> <li>1. Information about the components of nucleic acids.</li> <li>2. Classification, structure, properties and meanings of biologically important heterocyclic compounds.             <ol style="list-style-type: none"> <li>2.1. Five-membered heterocyclic compounds with one heteroatom.</li> <li>2.2. Five-membered heterocyclic compounds with two heteroatoms.</li> <li>2.3. Six-membered heterocyclic compounds with one heteroatom.</li> <li>2.4. Six-membered heterocyclic compounds with two heteroatoms.</li> <li>2.5. Condensed heterocycle systems</li> </ol> </li> <li>3. Structure and biochemical functions of nucleosides and nucleotides.             <ol style="list-style-type: none"> <li>3.1 Nucleotides and nucleosides - products of incomplete hydrolysis of nucleic acids.</li> <li>3.2. Nucleotide structure: AMP, GMP, UMP, CMP, dTMP.</li> </ol> </li> <li>4. Structure and biochemical functions of nucleic acids.             <ol style="list-style-type: none"> <li>4.1. Components of DNA, RNA, examples of the structure of their monomers, the scheme of connection of monomers of DHC and RHC.</li> <li>4.2. The principle of DNA structure, primary and spatial structure, types of chemical bonds.</li> <li>4.3. The principle of RNA structure, primary and spatial structure, types of chemical bonds. RNA types.</li> </ol> </li> </ol>
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## II COURSE

№	Name of topic
1.	<p><b>Biochemistry as a science. Enzymes: structure, properties, mechanism of action and regulation of enzymatic processes.</b></p> <ol style="list-style-type: none"> <li>1. Subject, tasks, the basic stages and modern directions of development of biochemistry. The purpose and methods of carrying out of biochemical researches, their clinical-diagnostic value.</li> <li>2. Structure and physical and chemical properties of proteins – enzymes.</li> <li>3. Units of measurements of catalytic activity of enzymes. The international classification and the nomenclature of enzymes by type of reactions.</li> <li>4. The mechanism of enzymes action and the kinetics of ferment catalysis.</li> <li>5. Regulation of enzyme processes.</li> <li>6. Medical enzymology.</li> <li>7. A role of cofactors and coenzyme vitamins in catalytic activity of enzymes.</li> </ol>
2.	<p><b>Bioenergy. The cycle of tricarboxylic acids. Biological oxidation, tissue respiration and oxidative phosphorylation.</b></p> <ol style="list-style-type: none"> <li>1. Metabolic ways. To define concepts catabolic, anabolic and amphibolic ways of a metabolism.</li> <li>2. Exoergic and endoergic reactions.</li> <li>3. Three general stages of biomolecules catabolism.</li> <li>4. Methods of studying of a metabolism.</li> <li>5. General characteristic of a tricarboxylic acid cycle.</li> <li>6. Regulation of a tricarboxylic acid cycle.</li> <li>7. Bioenergetic processes: biological oxidation, oxidative phosphorylation.</li> <li>8. Chemiosmotic theory of oxidative phosphorylation. Inhibitors and uncouplers of oxidative phosphorylation.</li> </ol>
3.	<p><b>Carbohydrate metabolism-1. Glycolysis, aerobic oxidation of glucose; alternative ways of metabolism of monosaccharides.</b></p> <ol style="list-style-type: none"> <li>1. Anaerobic glycolysis. Biological role, chemism, the mechanism of regulation.</li> <li>2. Aerobic oxidation of glucose.</li> <li>3. Clinical value of pyruvic acid determination in bioobjects.</li> <li>4. Alternative ways of an exchange of monosaccharides. Metabolism of fructose and galactose.</li> </ol>

4.	<p><b>Carbohydrate metabolism-2. Glycogen metabolism. Gluconeogenesis. Regulation and pathology of carbohydrate metabolism.</b></p> <ol style="list-style-type: none"> <li>1. Synthesis of glycogen and its infringements.</li> <li>2. Catabolism of glycogen. Regulation of an exchange of glycogen.</li> <li>3. Metabolism of carbohydrate components of glycoconjugates.</li> <li>4. Gluconeogenesis.</li> <li>5. Hormones-regulators of an exchange of glucose, effects and mechanisms of influence on a level of glucose.</li> <li>6. Glucosemia: normal condition and its infringement.</li> <li>7. Diabetes mellitus: insulin-dependent (type I) and insulin-independent (type II).</li> </ol>
5.	<p><b>Lipid metabolism-1. Oxidation and biosynthesis of fatty acids, triacylglycerols and phospholipids.</b></p> <ol style="list-style-type: none"> <li>1. Ways of metabolism of simple lipids (triacylglycerols). Mechanisms of regulation.</li> <li>2. Features of formation and transport of lipids of blood.</li> <li>3. Oxidation of fatty acids.</li> <li>4. Biosynthesis of fatty acids.</li> <li>5. Exchange of compound lipids.</li> <li>6. Genetic anomalies of an exchange of sphingolipids.</li> </ol>
6.	<p><b>Lipid metabolism -2. Metabolism of cholesterol and ketone bodies. Regulation and pathology of lipid metabolism.</b></p> <ol style="list-style-type: none"> <li>1. Biosynthesis of cholesterol.</li> <li>2. Ways of biotransformation of cholesterol.</li> <li>3. Pathology of lipid exchange.</li> <li>4. Exchange of ketone bodies</li> </ol>
7.	<p><b>Metabolism of amino acids-1. General and specialized ways of converting amino acids. Hereditary enzymes of amino acid metabolism.</b></p> <ol style="list-style-type: none"> <li>1. General ways of conversion of amino acids in tissues</li> <li>2. Transamination of amino acids</li> <li>3. Deamination of amino acids</li> <li>4. Decarboxylation of amino acids</li> <li>5. Specialized ways of metabolism of acyclic and cyclic amino acids.</li> <li>6. Synthesis of ammonium salts in the kidneys</li> <li>7. General directions of use of amino acid metabolism products</li> </ol>
8.	<p><b>Metabolism of amino acids-2. Pathways of ammonia metabolism. Urea biosynthesis.</b></p> <ol style="list-style-type: none"> <li>1. Ways of formation and detoxification of ammonia.</li> <li>2. Biosynthesis of urea - ornithine cycle</li> <li>3. Biosynthesis of porphyrins. Hereditary disorders of porphyrin metabolism.       <ol style="list-style-type: none"> <li>3.1. The structure of porphyrins</li> <li>3.2. Synthesis of porphyrins</li> <li>3.3. Hereditary disorders of porphyrin metabolism</li> </ol> </li> </ol>
9.	<p><b>Metabolism of purine and pyrimidine nucleotides. Metabolic pathologies.</b></p> <ol style="list-style-type: none"> <li>1. Structure and functions of nucleic acids.</li> <li>2. Molecular organization of nuclear chromatin and ribosomes of eukaryotic cells.</li> <li>3. Nucleoproteids.</li> <li>4. Biosynthesis of purine nucleotides. Biosynthesis of pyrimidine nucleotides. Biosynthesis of deoxyribonucleotides.</li> <li>5. Catabolism of purine nucleotides.</li> <li>6. Catabolism of pyrimidine nucleotides</li> <li>7. Metabolic pathologies.</li> </ol>
10.	<p><b>Replication and transcription processes. Protein biosynthesis. The action of drugs as inhibitors.</b></p> <p><b>Replication of DNA.</b></p>

	<ol style="list-style-type: none"> <li>1. Matrix syntheses.</li> <li>2. DNA replication <ol style="list-style-type: none"> <li>2.1. The mechanism of replication</li> <li>2.2. DNA replication in eukaryotic cells</li> </ol> </li> <li>3. DNA transcription as RNA synthesis</li> <li>4. Translation - biosynthesis of proteins in ribosomes <ol style="list-style-type: none"> <li>4.1. Genetic code and its properties</li> <li>4.2. Ribosomal protein synthesis system</li> <li>4.3. Protein biosynthesis</li> </ol> </li> <li>5. The action of drugs</li> <li>6. Gene mutations</li> </ol>
11.	<p style="text-align: center;"><b>Biochemical role of hormones of protein-peptide, steroid and thyroid nature.</b></p> <ol style="list-style-type: none"> <li>1. Synthesis and secretion of hormones.</li> <li>2. Molecular-cellular action mechanisms of protein-peptide hormones</li> <li>3. Hormones of hypothalamichypophysial system.</li> <li>4. Chemical nature and action mechanism of steroid hormones on the target cell.</li> <li>5. Action mechanism of glucocorticoids and mineralcorticoids in metabolism.</li> <li>6. Hyper- and hypofunction of adrenal cortex.</li> <li>7. Sex hormones.</li> <li>8. Hormones of adrenal cortex in stress reactions.</li> <li>9. Hormones of the thyroid gland (T3, T4).</li> <li>10. Biogenic amines with hormonal and mediatory properties.</li> </ol>
12.	<p style="text-align: center;"><b>Biochemistry and pathobiochemistry of blood.</b></p> <ol style="list-style-type: none"> <li>1. Proteins of blood plasma and their clinical-biochemical characteristics.</li> <li>2. Components of the nonspecific resistance system and test proteins of “acute phase” (PAPh) of inflammatory processes.</li> <li>3. Enzymes of blood plasma and their value in enzymodiagnosics of diseases of internal organs.</li> <li>4. The kallikrein-kinin system (KKS).</li> <li>5. Respiratory function of erythrocytes.</li> <li>6. Acid-base state of the organism.</li> <li>7. Infringements of acid-base balance.</li> <li>8. Main types of hypoxia.</li> </ol>
13.	<p style="text-align: center;"><b>Biochemical functions of the liver. Biochemistry of jaundice. Biotransformation of xenobiotics.</b></p> <ol style="list-style-type: none"> <li>1. Functions of liver.</li> <li>2. Pathochemistry of jaundices.</li> <li>3. Detoxification function of the liver.</li> <li>4. Types of reactions of biotransformation of foreign chemical compounds in the liver.</li> <li>5. Electron transport chain of the endoplasmatic reticulum.</li> <li>6. Clinical value of indican determination.</li> </ol>
14.	<p style="text-align: center;"><b>Biochemical functions of the kidneys.</b></p> <ol style="list-style-type: none"> <li>1. Biological role of the kidneys.</li> <li>2. Biochemical mechanisms of urine formation in the kidneys.</li> <li>3. Metabolism of the kidneys.</li> <li>4. Chemical composition of urine in norm.</li> <li>5. Clinical value of urine analysis.</li> <li>6. Pathobiochemistry of the kidneys and water-salt metabolism.</li> </ol>
15.	<p style="text-align: center;"><b>Biochemistry of muscles, connective tissue and nervous system.</b></p> <ol style="list-style-type: none"> <li>1. Biochemistry of the nervous system <ol style="list-style-type: none"> <li>1.1. Structural and physiological features of nervous tissue</li> <li>1.2. Chemical composition of nervous tissue</li> </ol> </li> </ol>



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| 1.3. The structure of myelin<br>1.4. Features of nervous tissue metabolism<br>1.5. Neurotransmitters: formation, inactivation, biological role<br>2. Biochemistry of muscle tissue |
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#### **4.2. Plan of practical classes**

Practical classes (p. 3.2.3. of the Programs) according to the method of their organizations are laboratory, because they provide: laboratory research on the extraction and detection of certain classes of organic compounds by the properties of their functional groups, qualitative reactions, synthesis of organic compounds, their isolation and purification, establishment of physicochemical constants.

The structure of the organization of practical classes includes:

- Frontal interview (oral and test tasks).
- Discussion and explanation of the most difficult issues of the topic.
- Execution of practical (laboratory) works. Registration of the protocol of practical employment.
- The result of the lesson.

#### **4.3. Ensuring the educational process**

1. Multimedia projectors, computers, screens for multimedia presentations, lecture presentations.
2. Demonstration screens, laptops, files in Power Point and Word with tasks “Krok-1” for practical and final classes.
3. Laboratory equipment (spectrophotometers, ionomers, ultracentrifuges, analytical balances, thermostats, heating devices, thermometers, glass laboratory glassware in the range, etc.), materials and reagents for educational laboratory experiment.
4. Examination tickets.

### **5. Final control**

#### **5.1. A list of practical skills and knowledge that a student must master in the process of studying the discipline**

1. Detection of proteins in the blood serum by biuret method. The principle of the method, clinical and diagnostic value.
2. Explain the basic principles of investigation of the salivary amylase (using the iodine test for starch and Trommer reaction).
3. Prove the relative specificity of saliva amylase. What other types of specificity characteristic of enzymes?
4. Determination of diastase of urine. The principle of the method, the rate of clinical and diagnostic value.
5. Inhibition of enzymes of TCA cycle by malonic acid.
6. Determination of glucose in the blood serum, normal glucose concentration in the blood.
7. Determination of the final product of anaerobic glycolysis - lactic acid - by Uffelmann's reaction. The principle of the method.
8. Determination of acetone (ketone bodies) in urine. Identification of ketone bodies in blood and urine. Principles of the methods. The value of determination of ketone bodies in the blood and urine.

9. Determination of pyruvic acid in biological fluids with colorimetric method. Explain the principle of the method.
10. Quantitative determination of cholesterol in the blood serum. The principle of the method. What is normal value of cholesterol in the blood serum?
11. Determination of alanine aminotransferase and aspartate aminotransferase activities. The principle of the method. Clinical and diagnostic value of these enzymes.
12. Determination of urea in urine.
13. Determination of bile pigments in urine. Explain the pathway bile pigments production in the body.
14. Qualitative reaction on phenylpyruvate. Clinical and diagnostic importance of this test.
15. Determination of the main components of nucleoproteins. Explain principle of the method.
16. Determination of uric acid in biological fluids (blood, urine). Explain principle of the method.
17. Quantitative determination of vitamin C in urine. The principle of the method.
18. Determination of the creatine in blood serum and in the urine. Explain the principle of the method.
19. Polymerase chain reaction (PCR). Explain the principle of the method.
20. Physico-chemical properties of urine: volume, color, odor, transparency, acidity (pH), its dependence from diet.

### ***5.2. The list of questions submitted for final control***

#### **I COURSE**

1. Classification, nomenclature and isomerism of bioorganic compounds.
2. Electronic structure and valence states of the carbon atom: the first valence state ( $sp^3$ -hybridization, the second and third valence states of the carbon atom) ( $sp^2$ - and  $sp$ -hybridization).
3. Interaction of atoms in organic compounds ( $\sigma$ - and  $\pi$ -bonds in organic compounds, electronegativity of atoms).
4. Distribution of electron density in organic molecules: inductive effect; mesomeric effect.
5. Classification of carboxylic acids. Structure and properties of carboxylic acids. Nucleophilic substitution reactions ( $S_N$ ). Esterification reactions and their biochemical significance. Amidation reactions and their biochemical significance.
6. Structure and properties of dicarboxylic and tricarboxylic acids. Chemical properties. Biological significance of individuals.
7. Classification and isomerism of hydroxy acids. Optical activity. Enantiomers. Diastereoisomers. Chemical properties and biological significance of hydroxy acids and amino acids.
8. Structure and properties of keto acids. Biological significance of keto acids and their derivatives.
9. Structure and properties of phenolic acids. Salicylic acid and its derivatives as anti-inflammatory and antimicrobial agents.
10. The mechanism of formation of esters on the example of triacylglycerols, their biological role. General ideas about lipids and their classification. Biological role of different classes of lipids.
11. Biological functions of lipids. Higher fatty acids as components of neutral lipids.
12. Structure and properties of phospholipids. The role of phospholipids in the construction of biomembranes. Classification of phospholipids. Physicochemical properties of phospholipids.

13. General properties of amino acids. Optical properties of amino acids. Chemical properties of amino acids as heterofunctional compounds. Acid-base properties of amino acids. Amino acid decarboxylation reactions with the formation of nutrients) and their physiological functions.

14. Reactions of deamination, transamination, hydroxylation of amino acids and their physiological role.

15. Reactions of qualitative and quantitative determination of  $\alpha$ -amino acids. Polycondensation reactions with the formation of peptides. Mechanism of peptide bond formation.

16. Functions of proteins. Methods of combining  $\alpha$ -amino acids in protein molecules. Levels of structural organization of protein molecules.

17. Simple and complex proteins. Classification of proteins depending on the nature of the prosthetic group and spatial form: globular and fibrillar.

18. Denaturation of protein, its symptoms. Denaturing factors. Protein renaturation.

19. Classification of carbohydrates. Isomerism. Tautomeric forms of monosaccharides. Mutarotation.

20. Chemical reactions of monosaccharides. Chemical reactions of monosaccharides with the participation of the carbonyl group: redox reactions (qualitative for the detection of aldehyde group).

21. Derivatives of monosaccharides. Ascorbic acid as a derivative of hexose, the biological role of vitamin C.

22. Disaccharides. Structure, properties of sucrose, lactose, maltose. Sucrose inversion due to hydrolysis. Classification of disaccharides by their ability to redox reactions.

23. Polysaccharides. Classification of polysaccharides. Structure, biological role and application of starch, its components. Scheme of the structure of amylose and amylopectin. Hydrolysis of starch, qualitative reaction to its detection.

24. Heteropolysaccharides. The role of glucuronic acid, glucosamine and galactosamine in the formation of heteropolysaccharides.

25. Characteristics of five-membered heterocycles and their derivatives. Characteristics of five-membered heterocycles with one and two heteroatoms and their derivatives.

26. Characteristics of six-membered heterocycles. Six-membered heterocycles with one and two heteroatoms are the basis of biologically important compounds. Six-membered heterocycles are components of nitrogenous bases.

27. Nucleotides and nucleosides - products of incomplete hydrolysis of nucleic acids. Nucleotide.

28. Derivatives of nucleotides. Phosphorylated nucleotide derivatives. Participation of nucleotides in the structure of coenzymes.

29. Structure and functions of nucleic acids. constituent parts of DHC, RHC, examples of the structure of their monomers, the scheme of connection of monomers of DHC and RHC.

30. The biological role of DNA. The principle of DHC structure, primary and spatial structure, types of chemical bonds.

31. The principle of RNA structure, primary and spatial structure, types of chemical bonds.

## II COURSE

1. Biological chemistry as a science. The objectives and assignments of biochemistry and its principal trends and parts. The significance of biochemistry in the development of medical science and practical health care.

2. Enzymes: definition, properties of enzymes as biological catalysts, difference between enzymes and inorganic catalysts. Specificity of enzymes.
3. Nomenclature and classification of enzymes.
4. Simple and conjugated enzymes. Role of non-protein part of conjugated enzymes. Structure of enzymes: active centres and allosteric sites. Levels of structural organization of enzymes.
5. Enzyme kinetics. Factors affecting enzymatic activity (concentration of enzyme, concentration of substrate, effect of temperature, effect of pH). Michaelis-Menten constant and equation.
6. Enzyme inhibition (reversible, irreversible, competitive, non-competitive).
7. Regulation of enzyme activity in the living system (allosteric regulation, feedback regulation, covalent modification of enzymes, activation of latent enzymes by limited proteolysis, cyclic nucleotides in regulation of enzymatic processes).
8. Diagnostical importance of enzymes (plasma specific and non-plasma specific enzymes). Changes in enzymatic activity of blood plasma and serum as diagnostic indexes (markers) of pathological processes in distinct organs – myocardial infarction, acute pancreatitis, liver disease, pathology of muscle tissue. Isoenzymes, their role in enzymodiagnosics.
9. Conception of turnover of material and energy (metabolism). Characterization of catabolic, anabolic and amphibolic reactions and their significance. Catabolic transformation of biomolecules: proteins, carbohydrates, lipids, its characterization.
10. Tricarboxylic acid (TCA) cycle (sequence of TCA cycle reactions, characterization of enzymes and coenzymes participating TCA cycle, energetic effect of TCA cycle).
11. Biological oxidation of substrates in cells. Reactions of biological oxidation and their functional significance.
12. Pyridine and dependent flavine dehydrogenases, structure of NAD, NADP, FAD and FMN, their role in reactions of oxidation and reduction.
13. Molecular organization of electron transport chain of mitochondria. Supramolecular complexes of respiratory chain in inner membrane of mitochondria.
14. Oxidative phosphorylation. Sites of oxidative phosphorylation. P/O ratio. Mechanisms of oxidative phosphorylation: chemical coupling hypothesis, chemiosmotic theory.
15. The scheme of chemiosmotic mechanism of coupling of electron transport in respiratory chain with ATP synthesis. Molecular structure and principles of functioning of ATP-synthetase. Inhibitors of electron transport in a respiratory chain of mitochondria. Uncouplers of electron transport and oxidative phosphorylation in a respiratory chain of mitochondria.
16. Glucose as an important metabolite in carbohydrate metabolism: general scheme of sources and turnover of glucose in the organism
17. Glucose oxidation under anaerobic conditions – glycolysis. Enzymatic reactions of glycolysis, energetic effect, regulation. Reactions of substrate level phosphorylation in glycolysis.
18. Metabolic pathways and substrates of gluconeogenesis, mechanisms of regulation, compartmentalization of enzymes, biological significance of the process.
19. Relations between glycolysis and gluconeogenesis (Cori cycle). Irreversible reactions of glycolysis and their shunt pathways. Glucose-lactate and glucose-alanine cycles.
20. Pentosophosphate pathway (PPP) of glucose utilization (scheme of reactions in oxidative and nonoxidative stages of PPP, enzymes and coenzymes of PPP reactions, biological significance of PPP, disorders of PPP in red blood cells, enzymopathias of glucose-6-phosphate dehydrogenase).

21. Oxidative decarboxylation of pyruvic acid: structure of multienzyme pyruvate dehydrogenase complex, peculiarities of function of pyruvate dehydrogenase complex, mechanism of oxidative decarboxylation of pyruvate, role of vitamins and coenzymes in transformation of pyruvate to acetyl-CoA.

22. Enzymatic reactions of fructose turnover in human body. Hereditary enzymopathias of fructose metabolism. Enzymatic reactions of galactose metabolism in human body. Hereditary enzymopathias of galactose metabolism.

23. Mechanism and peculiarities of enzymatic reactions of glycogenesis and glycogenolysis. Peculiarities of hormonal regulation of glycogen metabolism in liver and muscles. Hereditary disorders in enzymes of glycogen synthesis and breakdown. Glycogenoses, aglycogenoses, their characterization and causes.

24. Insulin dependent and noninsulin dependent forms of diabetes mellitus. Characterization of metabolic disorders in diabetes mellitus.

25. Catabolism of triacylglycerols: characterization of intracellular lipolysis, its biological significance; enzymatic reactions; neurohumoral regulation of lipolysis: adrenalin, noradrenalin, glucagone, insulin; energetic balance of triacylglycerol oxidation.

26. Biosynthesis of triacylglycerols and phospholipids, the significance of phosphatidic acid.

27.  $\beta$ -Oxidation of long chain fatty acids: (location of the process of  $\beta$ -oxidation of fatty acids; activation of fatty acids, the role of carnitin in transport of fatty acids into mitochondria; the sequence of enzymatic reactions in  $\beta$ -oxidation of fatty acids; energetic balance of  $\beta$ -oxidation of fatty acids)

28. Metabolism of ketone bodies. (enzymatic reactions of ketone bodies biosynthesis; reactions of utilization of ketone bodies, energetic significance; metabolism of ketone bodies in pathology. Mechanism of excessive accumulation of ketone bodies in diabetes mellitus and in starvation; the notions of ketoacidosis, ketonemia, ketonuria).

29. Biosynthesis of cholesterol in human body: (localization of the process and its significance stages of cholesterol biosynthesis, enzymatic reactions of biosynthesis of mevalonic acid regulation of cholesterol synthesis)

30. Pathways of cholesterol biotransformation (esterification, production of bile acids and steroid hormones, synthesis of vitamin D<sub>3</sub>, excretion from the body.

31. Atherosclerosis, mechanism of its development, role of genetic factors, hypercholesterolemia. Hypercholesterolemia in diabetes mellitus, myxoedema, obstructive jaundice, nephritic syndrome. Control of hypercholesterolemia

32. Pathways of formation and maintenance of free amino acid pool in human body. General pathways of free amino acid turnover.

33. Transamination of amino acids, substrates for transamination reaction. Mechanism of transamination. Reaction. Aminotransferases, their localization in tissues and organs. Clinical diagnostic significance of determination of aminotransferases activity.

34. Types of reactions of amino acid deamination their final products. Mechanism of oxidative deamination, oxidases of D- and L- aminoacids, their enzymatic activity and specificity.

35. Decarboxylation of amino acids, decarboxylases. Production of biogenic amines (GABA, histamine, serotonin, dopamine). Decarboxylation of amino acids in putrefaction of proteins in intestines. Oxidation of biogenic amines.

36. Pathways of ammonia production. Toxicity of ammonia and mechanisms of its detoxification. Circulatory transport of ammonia (glutamine, alanine).
37. Biosynthesis of urea: enzymatic reactions, hereditary defects of enzymes involved in urea synthesis (enzymopathias of urea synthesis).
38. Specific pathways of metabolism of aromatic amino acids phenylalanine and tyrosine, sequence of enzymatic reactions. Hereditary enzymopathias of phenylalanine and tyrosine metabolism – phenylketonuria, alkaptonuria, albinism.
39. Metabolism of sulfur containing amino acids, reactions of methylation.
40. Biosynthesis of porphyrins, scheme of enzymatic reactions of heme biosynthesis. Regulation of porphyrin synthesis. Classification of porphyries – erythropoietic (Gunter's disease), liver.
41. Biochemical functions of nucleic acids and nucleotides. Formation of nucleic acid chain from nucleotides.
42. Nucleic acids: structure, properties. Primary structure of nucleic acids, polarity of polynucleotides, specific features of DNA and RNA structure. Secondary structure of DNA, role of hydrogen bonds in stabilization of secondary structure (Chargaff rules, Watson-Crick model), antiparallelism of chains. Tertiary structure of DNA. Physico-chemical properties of DNA: interaction with cationic ligands; hyperchromic effect; denaturation and renaturation of DNA.
43. Structure, properties and biological functions of RNA. Types of RNA: mRNA, tRNA, rRNA, snRNA; specific features of structure (secondary and tertiary) of different RNA types.
44. Biosynthesis of pyrimidine nucleotides: reactions, regulation. Orotic aciduria.
45. Biosynthesis of deoxyribonucleotides. Formation of thymidyl nucleotides; inhibitors of dTMP biosynthesis as antitumor drugs. (structural analogs of dTMP, pterine derivatives).
46. Catabolism of purine nucleotides; hereditary disorders of uric acid metabolism. Biochemical background of hyperuricemia, gout, Lesch-Nyhan syndrome.
47. Biological significance of DNA replication. General scheme of DNA synthesis. Enzymes of DNA replication in prokaryotes and eukaryotes. Molecular mechanisms of DNA replication: topoisomerases, helicases, the significance of antiparallelism of DNA strands, Okazaki fragments. Stages of synthesis of daughter chains of DNA.
48. General scheme of transcription. Coding and noncoding DNA chains. RNA polymerases of prokaryotes and eukaryotes. Stages and enzymes of RNA synthesis. Markers of transcription: promoter, initiator, termination segments of genome.
49. Processing as posttranscriptional modification of RNA. Antibiotics, which inhibit transcription.
50. Regulation of gene expression in prokaryotes: scheme of regulation according to F. Jacob and J. Monod. Structure of Lac-operon of E. coli. structural and regulatory genes, promoter, operator, regulatory gene and production of protein repressors, repression and induction of Lac-operon function.
51. The genetic code, triplet structure, its properties. Table of genetic code.
52. Protein synthesis system of ribosomes. Components of protein synthesis system. Transfer RNA and amino acid activation. Aminoacyl-tRNA synthetases, second genetic code.
53. Stages and mechanisms of translation: initiation, elongation, termination. Initiating and terminating codons of mRNA. The role of protein factors of ribosomes in translation. Post-translational modification of peptide chains. Regulation of translation. Molecular mechanisms of translation control on example of globin synthesis.

54. The influence of biologically active compounds on translation. Antibiotics as inhibitors of transcription and translation in prokaryotes and eukaryotes, their biomedical application.
55. Hormones in a system of intercellular integration of physiological functions in human organism. Classification of hormones.
56. Mechanisms of hormonal action – amino acid derivatives, peptide and protein hormones, steroid hormones. Regulatory sites in DNA, which interacts with hormone-receptor complexes.
57. Messenger function of cyclic nucleotides, Ca/calmodulin system phosphoinositides. Serine, threonine and tyrosine protein kinases in effector response of the cell.
58. Hormones of thyroid gland. Structure and function of thyroid hormones. Pathology of thyroid gland, metabolic disorders in hypo- and hyper- thyreosis. Endemic goiter and its prevention.
59. Regulation of calcium turnover by parathyroid hormone (PTH) and calcitonin (CT). Calcitriol: biosynthesis, the effect on intestinal absorption of calcium and phosphates. Calcitonin – structure, the effect upon calcium and phosphate turnover. Biochemical characterization of disorders in calcium metabolism (rickets, osteoporosis). Hypo- and hyper- parathyroidism. Distribution of calcium in the body, molecular forms of calcium in blood plasma. Role of bone tissue, intestines and kidneys in support of calcium homeostasis.
60. Hormones of pituitary gland, their role in regulation of endocrine glands function. Hormone family “growth hormone-prolactin- gonadotropins”, pathology connected with disorders of GH, somatomedin, prolactin dysfunction.
61. Glycoprotein hormones of hypophysis – TSH, FSH, ICSH, prolactin. Proopiomelanocortin – products of processing of this hormone precursor, (ACTH, lipotropins, endorphins).
62. Hormones of neurohypophysis – oxytocin and vasopressin (ADH), pathology caused by disorder in ADH secretion.
63. Steroids of suprarenal glands. Glucocorticoids: cortisol, cortisone, corticosterone, their role in regulation of gluconeogenesis, anti-inflammatory effects. Itsenko-Cushing syndrome. Mineralocorticoids, role of aldosterone in regulation of water and mineral metabolism, Addison disease, aldosteronism.
64. Hormones of sexual glands. Estrogens – estradiol, estrone, physiological and biochemical effects, regulation of synthesis and secretion, connection with female month cycle. Androgens – testosterone, dihydrotestosterone, physiological and biochemical effects, regulation of biosynthesis and secretion.
65. Peculiarities of biochemical composition and metabolism of nervous tissue (chemical composition of brain, neurospecific proteins and lipids (gangliosides, cerebroside, cholesterol). Energetic metabolism in human brain tissue.
66. Neurotransmitters (acetylcholine, noradrenalin, dopamine, serotonin, excitatory and inhibitory amino acids), functional role, mechanism of action. Receptors for neurotransmitters and physiologically active substances.
67. Requirements of human organism in nutrients – carbohydrates, lipids, proteins. Biological value of some nutrients. Rational nutrition.
68. Enzymes, biochemistry of digestion and absorption of carbohydrates in gastrointestinal tract.
69. Enzymes, biochemistry of digestion and absorption of proteins in gastrointestinal tract.
70. Enzymes, biochemistry of digestion and absorption of lipids in gastrointestinal tract.

71. Vitamins as essential nutritional components. History of vitamins discovery and development of vitaminology. Causes of exo- and endogenous hypo- and avitaminoses.
72. Vitamin B1 and B2, their structure, biological function, sources of supplement, daily requirement. Symptoms of hypovitaminosis.
73. Structure and properties of vitamin H and pantothenic acid. Their significance in metabolism, daily requirement.
74. Vitamins B6 and PP, their structure, biological function, nutritional sources, daily requirement. Symptoms of hypovitaminosis.
75. Vitamin C and P, their structure, biological function, daily requirement, manifestations of insufficiency in human organism.
76. Vitamins of D group, their structure, biological function, nutritional sources, daily requirement. Symptoms of hypo- and hypervitaminosis, avitaminosis.
77. Vitamin A, its structure, biological function, nutritional sources, daily requirement. Symptoms of hypo and hyper- vitaminosis.
78. Vitamins E, F, their structure, biological role, mechanism of action, daily requirement. Symptoms of insufficiency.
79. Antihemorrhagic vitamins (K group), their water soluble forms, structure, biological function, nutritional sources, mechanism of action, daily requirement, symptoms of insufficiency, application in medicine.
80. Hemoglobin, its structure, properties and molecular forms. Pathology of hemoglobin: hemoglobinopathias and thalassemias.
81. The function of hemoglobin oxygenation from partial pressure of oxygen, dissociation curve of oxyhemoglobin, Bohr effect.
82. Acid-base equilibrium of blood. Regulation of pH in biological fluids, disorders of acid-base equilibrium: metabolic and respiratory acidosis, metabolic and respiratory alkalosis, mechanisms of their development.
83. Buffer systems of blood, their types, role of different buffer systems in providement of constant pH of blood.
84. Main groups of blood proteins, their composition and content in normal conditions and in pathology. Albumins and globulins. Resolution of blood plasma proteins by method of protein electrophoresis.
85. Proteins of acute phase of inflammation: C-reactive protein (CRP), ceruloplasmin, haptoglobin, cryoglobulin, alpha-1 antitrypsin, alpha-2 macroglobulin, interferon, fibronectin, their diagnostic validity.
86. Enzymes of blood plasma: genuine (secretory), excretory, indicatory (tissue) enzymes. Kallikrein-kinine and renin-angiotensine systems, their biological significance.
87. Definition of total and residual nitrogen in blood. Nonprotein nitrogen containing compounds of blood, their diagnostic significance. Nitrogenemia, its kinds and causes of development, differentiation in clinical conditions.
88. Functional and biochemical characteristics of intrinsic and extrinsic blood coagulation pathways.
89. Blood coagulation system; characteristics of coagulation factors.; intrinsic and extrinsic blood coagulation pathways. Role of vitamin K in reactions of hemocoagulation (carboxylation of glutamic acid residues, its role in Ca binding). Hereditary disorders of hemocoagulation.



90. Anticoagulation system of blood, functional characteristics of its components – heparin, antithrombin III, citric acid, prostacycline. Role of vascular endothelium.
91. Fibrinolytic system of blood: stages and factors of fibrinolysis. Medicinal influencing fibrinolytic process. Activators and inhibitors of plasmin.
92. Immunoglobulins: structure, biological function, mechanisms of immunoglobulin synthesis. Characteristics of distinct immunoglobulin classes of human blood.
93. Mediators and hormones of immune system; (interleukins, interferons, protein and peptide factors of cell growth and proliferation).
94. Role of liver in regulation of glycemia (glycogenesis and glycogen breakdown, gluconeogenesis), lipid metabolism, turnover of bile acids and bile pigments. Biochemical composition of bile.
95. Role of liver in turnover of bile pigments. Hemoglobin catabolism: production of biliverdin, its transformation to bilirubin, synthesis of bilirubin diglucuronide and excretion with bile. Pathobiochemistry of jaundices; hemolytic (prehepatic), parenchymatous (hepatic), occlusive (posthepatic). Enzymatic congenital jaundices.
96. Detoxification function of liver; biotransformation of xenobiotics and endogenous toxins. Types of reactions of biotransformation of foreign substances in liver.
97. Conjugation reactions in hepatocytes: biochemical mechanisms, functional significance.
98. Electron transport chains of endoplasmic reticulum. Genetic polymorphism and induction of biosynthesis of cytochrome P-450.
99. Biological role of water and its distribution in human body. Water balance, its types. Regulation of water and mineral metabolism, its disorders. Dehydration and rehydration.
100. Biological role of macroelements, trace elements and ultramicroelements. Human microelementoses: endogenous and exogenous causes (technogenic, yatrogenic, etc.).
101. Role of kidneys in regulation of volume, composition of electrolytes and acid-base equilibrium of biological fluids. Biochemical mechanisms of urine production (filtration, reabsorption, secretion and excretion). Characterization of renal clearance and renal threshold, their diagnostic significance.
102. Physico-chemical properties of urine: volume, color, odor, transparency, acidity (pH), its dependence from diet. Role of kidneys and lungs in regulation of acid-base equilibrium. Ammoniogenesis.
103. Pathological constituents of urine – blood, hemoglobin, creatin. Causes and pathways of their appearance in urine. Glucosuria, galactosuria and pentosuria, causes of their development. Clinical significance of their detection.
104. Clinical significance of detection and determination of indican, phenylpyruvic and homogentisic acids, ketone bodies and bile pigments in urine.
105. Fine structure and biochemical composition of myocytes; structural organization of sarcomers. Myofibril proteins: myosine, actin, tropomyosine, troponine complex. Molecular organization of thick and thin filaments.
106. Nitrogen containing and nitrogen free water soluble organic compounds of muscles, their structure and functional significance. Molecular mechanisms of muscle contraction: modern data on interaction of muscle filaments. Role of Ca ions in regulation of contraction and relax of striated and smooth muscles.
107. Modern concept on energetics of muscle contraction and relaxation. Macroergic compounds of muscles. Structure, production and role of ATP, creatine phosphate, creatine

phosphokinases, sources of ATP in muscle cell; role of creatine phosphate in energetic supply of contraction. Pathobiochemistry of muscles - myopathias.

108. Proteins of connective tissue fibers: collagen, elastin, glycoproteins and proteoglycans. Biosynthesis of collagen and formation of fibrillar structures.

109. Complex carbohydrates of amorphous matrix of connective tissue – glycosaminoglycans. Mechanisms of formation of intercellular matrix by molecules of glycosaminoglycans – (hyaluronic acid, chondroitin-, dermatan-, keratan- sulphates). Distribution of glycosaminoglycans in different human organs and tissues.

110. Pathobiochemistry of connective tissue. Biochemical mechanisms of development of mucopolysaccharidoses and collagenoses, their biochemical diagnostics.

### 5.3.1. "0" Ticket option for the test (intermediate control for the 2nd semester)

**Petro Mohyla Black Sea National University  
Medical institute**

**Department of pharmacy, pharmacology, medical, bioorganic and biological chemistry**

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*Level of higher education: Master*

*Field of knowledge: 22 "Health"*

*Specialty: 222 "Medicine"*

*Discipline: "Biological and bioorganic chemistry"*

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

#### TICKET № 0

##### Explain the questions:

1. Classification and isomerism of hydroxy acids. Optical activity. Enantiomers. Diastereoisomers. Chemical properties and biological significance of hydroxy acids. **Maximum number of points – 30.**

2. Chemical reactions of monosaccharides. Chemical reactions of monosaccharides with the participation of the carbonyl group: redox reactions (qualitative for the detection of aldehyde group). **Maximum number of points – 30.**

##### Solve the problem:

3. For carboxylic acid composition  $C_4H_8O_2$ :

a) give the structural formulas of possible isomers (among which should be both structural and functional isomers), give them a name according to the systematic nomenclature;

b) for one of the isomers write the equation of reaction with isopropanol. Give the name of the product, explain the mechanism. **Maximum number of points – 20.**

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Approved at the meeting of the Department of Pharmacy, Pharmacology, Medical, Bioorganic and Biological Chemistry, Minutes № 1 of September 2, 2020.

**Head of the Department  
The teacher who carries out  
knowledge control**

\_\_\_\_\_ **Ogloblina M.V.**

\_\_\_\_\_ **Mitryasova O.P.**

*5.3.2. Example of final control work on blocks 2, 3 (intermediate control for 3 semester)*

**Test “Krok-1”**

**Petro Mohyla Black Sea National University**

**Medical institute**

**Department of pharmacy, pharmacology, medical, bioorganic and biological chemistry**

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**Discipline: “Biological and bioorganic chemistry”**

**Final tutorial control of knowledge with  
discipline "Biological and biological chemistry"**

***Block 2. General patterns of metabolism.***

***Block 3. General patterns of metabolism. Metabolism of carbohydrates, lipids, amino acids  
and its regulation.***

**Variant № 0**

- The enzyme oxidase of D-amino acids only catalyzes a deamination of D-amino acids. Which property of enzymes is shown in this case?
  - Stereochemical specificity
  - Thermolability
  - Relative specificity
  - Dependence on pH
  - Absolute specificity
- The doctor prescribed pyridoxal phosphate for a patient according to the clinical indication. For the correction of what pathological processes was this medicine recommended?
  - Transamination and decarboxylation of amino acids
  - Oxidative decarboxylation of keto acids
  - Deamination of purine nucleotides
  - Synthesis of purine and pyrimidine bases
  - Synthesis of protein
- A forensic medicine expert performing postmortem of a 20-year-old girl's body has found that the cause of death was poisoning by cyanides. What process disturbance is the most possible cause of the girl's death?
  - Tissue respiration
  - Hemoglobin synthesis
  - Transport of oxygen by hemoglobin
  - Synthesis of urea
  - Hydrogen transport by means of malate-aspartate mechanism
- Nicotinamide is widely used in the treatment of atherosclerosis. What biochemical process is improved under the influence of this metabolite?
  - Aerobic oxidation of substrates of metabolism
  - Synthesis of antiatherogenic lipoproteins
  - Activation of glucokinase reaction
  - Inhibition of cholesterol synthesis
  - Anaerobic oxidation of glucose
- The child had vomiting and cramps after eating honey. It has been suspected a congenital intolerance to fructose. Which of the following enzyme's activity determination confirms the diagnosis?
  - Fructose-1-phosphate aldolase
  - Glycogen phosphorylase
  - Fructokinase
  - Hexokinase

E. 6-Phosphofructokinase

6. A 35-year-old man has been delivered to a hospital in the state of a stressful situation. Laboratory investigation revealed increased free fatty acids' level in the blood above normal value. Which of the following processes has led to this state?
- Breakdown of triacylglycerols in the adipose tissue
  - Synthesis of fatty acids
  - Breakdown of triacylglycerols in the gastrointestinal tract
  - Activation of lipoprotein lipase
  - Carnitine deficiency
7. A 57 year-old man, suffering from diabetes mellitus develops ketoacidosis. The biochemical cause of this state is the decreased level of acetyl-CoA utilization due to the deficiency of:
- Oxaloacetate
  - Alfa-ketoglutarate
  - Glutamate
  - Aspartate
  - Succinate
8. A 2-year-old child suffers from neurological disorders since the birth. Objectively: the signs of blindness, macrocephaly. The child's condition progressively worsens. The doctor suspected Tay-Sachs disease. The activity of which enzyme should be investigated?
- Hexosaminidase A
  - $\beta$ -Galactosidase
  - Sphingomyelinase
  - Gglycogen phosphorylase
  - Glucocerebrosidase
9. A 7-year-old child was admitted to an emergency clinic in the state of allergic shock provoked by a wasp sting. High concentration of histamine was determined in the patient's blood. Which biochemical reaction leads to the production of this amine?
- Decarboxylation
  - Hydroxylation
  - Dehydration
  - Deamination
  - Reduction
10. After a serious viral infection a 3-year-old child has repeated vomiting, loss of consciousness, convulsions. Examination revealed hyperammonemia. What caused changes of biochemical blood indices of this child?
- Disorder of ammonia neutralization in the ornithine cycle
  - Activated processes of amino acid decarboxylation
  - Disorder of biogenic amines neutralization
  - Increased degradation of proteins in intestine
  - Inhibited activity of transamination enzymes

*Total 80 questions.*

**Head of the Department**  
**The teacher who carries out**  
**knowledge control**

\_\_\_\_\_ **Ogloblina M.V.**

\_\_\_\_\_ **Larycheva O.M.**

5.3.3. "0" version of the exam ticket (final control of the course material)

Petro Mohyla Black Sea National University  
Medical institute

Department of pharmacy, pharmacology, medical, bioorganic and biological chemistry

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*Level of higher education: Master*

*Field of knowledge: 22 "Health"*

*Specialty: 222 "Medicine"*

*Discipline: "Biological and bioorganic chemistry"*

**EXAMINATION QUESTION № 0**

**Explain the questions:**

1. Pentosophosphate pathway (PPP) of glucose utilization (scheme of reactions in oxidative and nonoxidative stages of PPP, enzymes and coenzymes of PPP reactions, biological significance of PPP, disorders of PPP in red blood cells, enzymopathias of glucose-6-phosphate dehydrogenase). **Maximum number of points – 20.**

2. Blood coagulation system; characteristics of coagulation factors.; intrinsic and extrinsic blood coagulation pathways. Role of vitamin K in reactions of hemocoagulation (carboxylation of glutamic acid residues, its role in Ca binding). Hereditary disorders of hemocoagulation. **Maximum number of points – 20.**

3. Detection of proteins in the blood serum by biuret method. The principle of the method, clinical and diagnostic value. **Maximum number of points – 20.**

**Solve the problem:**

Patient 58 years old was hospitalized with complaints on pain in the retrosternal area, sudden weakness, sweating, fear, dizziness. The preliminary diagnosis – myocardial infarction. Activity of which three enzymes is necessary to determine in patient's blood? Which ones have isoenzyme form? Which isoenzyme is most informative in the early hours of myocardial infarction? **Maximum number of points – 20.**

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Approved at the meeting of the Department of Pharmacy, Pharmacology, Medical, Bioorganic and Biological Chemistry, Minutes № 1 of September 2, 2020.

**Head of the Department**  
**The teacher who carries out**  
**knowledge control**

\_\_\_\_\_ **Ogloblina M.V.**

\_\_\_\_\_ **Larycheva O.M.**

## 6. Evaluation criteria and tools for diagnosing learning outcomes

Forms of control and assessment system are carried out in accordance with the requirements of the discipline program and instructions on the system of assessment of students' learning activities under the European Credit Transfer and Accumulation System (ECTS).

**Current control.** Testing in practical classes of theoretical knowledge and the acquisition of practical skills, as well as the results of independent work of students. Supervised by teachers according to the specific purpose of the curriculum. Assessment of the level of students' training is carried out by: interviewing students, solving and analyzing situational tasks and test tasks, interpreting the results of experimental and clinical and laboratory research, monitoring the acquisition of practical skills.

**Intermediate control.** Checking the possibility of students using for clinical and diagnostic analysis of theoretical knowledge and practical skills on all topics studied, as well as the results of independent work of students. Carried out in the last lesson by section by passing practical skills, solving situational problems and testing.

**The final control work** is carried out upon completion of the study of all block topics at the last test session of the semester.

The final control is also carried out in the form of a differentiated test after the 2nd semester and certification after the 3rd semester. In order to evaluate the results of training in biological chemistry in the fourth semester final control is carried out in the form of an examination, which is recommended for academic disciplines, which is a component of integrated test examinations and “Krok-1”.

To the intermediate final control (final control work, differentiated test, certification) and final control (exam) are allowed students who have attended all provided curriculum lectures, classroom classes, performed in full independent work and in the process of learning scored the number of points, not less than minimum – **70 points in the second and third semesters and 40 points in the fourth semester.**

Only students who have **both final control works** are admitted to the exam (according to blocks 2 and 3 and blocks 4 and 5) on **biological chemistry.**

### 6.1. Distribution of points received by students

**In the second semester (block 1)** a positive assessment in each practical session can be from 4.7 to 8 points. A score below 4.7 points means “unsatisfactory”, the lesson is not credited and is subject to practice in the prescribed manner. **On the differentiated** the student can get from 50 to 80 points. Distribution of points on the test – see above in example of a credit card.

**In the third semester (blocks 2 and 3)** a positive assessment in practice can be from 2 to 4 points. A score below 2 points means “unsatisfactory”, the lesson is not credited and is subject to practice in the prescribed manner. **At the final test for blocks 2 and 3,** the student can get from 50 to 80 points.

**In the fourth semester (blocks 4 and 5)** a positive assessment in practice can be from 1.7 to 3.5 points. A score below 1.7 points means “unsatisfactory”, the lesson is not credited and must be practiced in the prescribed manner. **At the final test for blocks 4 and 5,** the student can get from 30 to 40 points. **At the exam** a student can get from 50 to 80 points. Distribution of points on the exam – see above in the example of the exam ticket.

### 6.2. Assessment of student performance

Type of activity (task)	Maximum number of points
<b>II semester (block 1)</b>	
Topic 1	8
Topic 2	8
Topic 3	8

Topic 4	8
Topic 5	8
Topic 6	8
Topic 7	8
Topic 8	8
Topic 9	8
Topic 10	8
Topic 11	8
Topic 12	8
Topic 13	8
Topic 14	8
Topic 15	8
<b>Total for block 1</b>	<b>120</b>
<b>Credit</b>	<b>80</b>
<b>Total for block 1 and credit</b>	<b>200</b>
<b>III semester (blocks 2 and 3)</b>	
Topic 1	4
Topic 2	4
Topic 3	4
Topic 4	4
Topic 5	4
Topic 6	4
Topic 7	4
Topic 8	4
Topic 9	4
Topic 10	4
Control work. Block 2	10
Topic 11	4
Topic 12	4
Topic 13	4
Topic 14	4
Topic 15	4
Topic 16	4
Topic 17	4
Topic 18	4
Topic 19	4
Topic 20	4
Topic 21	4
Test control	10
Topic 22	4
Topic 23	4
Topic 24	4
Topic 25	4
<b>Total</b>	<b>120</b>
<b>Final control work on blocks 2 and 3 (certification)</b>	<b>80</b>
<b>Total for blocks 2 and 3</b>	<b>200</b>
<b>IV semester (blocks 4 i 5)</b>	
Topic 1	3.5

Topic 2	3.5
Topic 3	3.5
Topic 4	3.5
Topic 5	3.5
Topic 6	3.5
Topic 7	3.5
Topic 8	3.5
Topic 9	3.5
Topic 10	3.5
Topic 11	3.5
Topic 12	3.5
Topic 13	3.5
Topic 14	3.5
Topic 15	3.5
Topic 16	3.5
Topic 17	3.5
Topic 18	3.5
Topic 19	3.5
Topic 20	3.5
Topic 21	3.5
Topic 22	3.5
Topic 23	3.5
Topic 24	3.5
<b>Total</b>	<b>80</b>
<b>Final control work on blocks 4 and 5</b>	<b>40</b>
<b>Total for blocks 4 and 5</b>	<b>120</b>
<b>Exam</b>	<b>80</b>
<b>Total for blocks 4 and 5, and exam</b>	<b>200</b>

### *6.3. Criteria for assessing knowledge*

**Score 8 points in the second semester (4 points in the third and 3.5 points in the fourth semester), 38-40 points for the Final control work in the fourth semester and 71-80 points on credit or exam (A on the ECTS scale and 5 on the national scale)** the student's answer is evaluated if it demonstrates a deep knowledge of all theoretical principles and the ability to apply theoretical material for practical analysis and has no inaccuracies.

**Score 6-7 points in the second semester (3 points in the third and 3 points in the fourth semester), 35-37 points for the Final control work in the fourth semester and 61-70 points on the test, credit or exam (B and C on the ECTS scale and 4 on the national scale)** the answer is evaluated if it shows knowledge of all theoretical principles, the ability to apply them in practice, but some fundamental inaccuracies are allowed.

**Score 4.7-5 points in the second semester (2 points in the third and 1.7-2 points in the fourth semester), 30-34 points for the Final control work in the fourth semester and 50-60 points on the credit, test or exam (D and E on the ECTS scale and 3 on the national scale)** the student's answer is evaluated provided that he knows the main theoretical principles and can use them in practice.



## 7. Recommended sources of information

### 7.1. Main:

1. Satyanarayana U., Chakrapani U. "Biochemistry", Fourth Edition. – 2013. – 792 p.
2. Harper's Illustrated Biochemistry. 30th edition. Lange Medical book. – 2015. – 927 p.
3. Biochemistry. The Molecular Basis of Life / Trudy McKee, James R. McKee , 2015.- 928 p.
4. Lehninger A. Principles of Biochemistry. – Sixth Edition. David L. Nelson and Michael M. Cox. – 2013. – 1010 p.
5. MCQs / Prof. Sklyarov A.Ya., Lutsik M.D., Fomenko I.S., Klymyshyn D.O., Nasadyuk C.M. – 2012. – 308 p.
6. J. Komarytsia. Organic Chemistry. Handbook for medical students. Lviv 2005.-74 p.
7. Stoker, H.S. (2001). Organic and biological chemistry. Houghton Mifflin. 2001. 556p.

### 7.2. Additional:

8. Mardashko O.O., Yasinenko N.Y. Biochemistry. Texts of lectures.-Odessa. The Odessa State Medical University, 2003.-416p.
9. Devlin T.M., ed. Textbook of Biochemistry with Clinical Correlations, 5th ed. New York: Wiley-Liss, 2002.
10. Copeland R. A. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis. - Wiley-VCH, Inc. – 2000. – 412 p.
11. Toy E.C., Seifert W. E., Strobel H.W., Harms K.P. "Case Files in Biochemistry. 2nd edition" – 2008. – 488 p.
12. Handbook of Biochemistry and Molecular Biology, Fourth Edition. Roger L. Lundblad, Fiona Macdonald. – 2010 - 1098 p.
13. L.G. Wade Jr. Organic Chemistry. 8th edition. - Pearson. 2013. - 547p.
14. T. Graham Solomons, Craig B. Fryhle. Organic Chemistry. Tenth edition. Hoboken, NJ. – 2011. - John Willey and Sons, Inc.- 1218 p.
15. David C. Eaton. Laboratory investigation in Organic Chemistry. – McGRAW-HILL BOOK COMPANY. – New York – Toronto. – 893 p.

### 7.3. Information resources:

16. GO "Testing Center": [official. site]. - URL : testcentr.org.ua
17. [www.ncbi.nlm.nih.gov/PubMed](http://www.ncbi.nlm.nih.gov/PubMed) – free access to the database of scientific data in the field of biomedical sciences.
18. <https://pubchem.ncbi.nlm.nih.gov/> - free access to the database of scientific data in the field of biomedical sciences.
19. [www.biochemistry.org.ua](http://www.biochemistry.org.ua) – official site of the Institute of Biochemistry. O.B. Palladin of the National Academy of Sciences of Ukraine.
20. [www.bpci.kiev.ua](http://www.bpci.kiev.ua) – official site of the Institute of Bioorganic Chemistry and Petrochemistry of the National Academy of Sciences of Ukraine.
21. [www.bioorganica.org.ua](http://www.bioorganica.org.ua) – scientific publication presenting works on bioorganic and medical chemistry.