

**MINISTRY OF HEALTH OF UKRAINE  
NATIONAL UNIVERSITY OF PHARMACY  
Biological chemistry Department**



**BIOLOGICAL CHEMISTRY**

**Methodical recommendations**

**for the students extracurricular work to**

**higher education applicants**

**in specialties / educational program**

**«Pharmacy»**

**Kharkiv**

**2017**

**NPhU**

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Methodical recommendations are developed in accordance with the working programs of compulsory discipline "Biological chemistry", educational-professional program of training and educational and qualification characteristics of specialist / master's degree in specialties / educational programs "Pharmacy", is studied by the applicants of higher education. Methodical recommendations contain theoretical questions for extracurricular work, the criteria for assessing the knowledge of higher education graduates, the example of the examination paper.

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## CONTENT

	<b>Pages</b>
<b>Introduction</b>	
<b>Questions for extracurricular work</b>	
<b>Rating system of estimation</b>	
<b>Examination paper example</b>	
<b>List of metodical and scientific literature</b>	

## Introduction

Syllabus on Biological chemistry is created for universities of medicine (pharmacy) of Ukraine (III-IV levels of accreditation) for the speciality 8.110201 -“Pharmacy” in accordance with the plan of study, which was approved by order № 422 from 09.06.2011 at NUoP. Period of students' study for such speciality is equal to 5,0 years. According to the plan of study preparing on biochemistry is realized in semesters V and VI.

Biological chemistry as discipline to study:

- a) is based on students' knowledge of inorganic, analytic, physical and colloid, organic chemistry, botany, physiology and microbiology, and is integrated with such disciplines;
- b) supplies students with basic information on clinic biochemistry, laboratory diagnostics, biotechnology, that supposes certain integration of teaching with these disciplines and formation of skills to apply knowledge on biochemistry in the process of further education and in professional activity;
- c) supplies students with principles of healthy way of life, understanding for humans of importance of various biomolecules to prevent metabolism abnormalities in the processes of life activities.

Organization of study process is fulfilled on the credit-module system according to demands of the Bologna education process.

Program of the discipline “Biological chemistry” includes II Modules, which in turn are divided into 6 concept modules:

### **MODULE I.** Structure of biological macromolecules. Principles of metabolism

Concept modules:

1. Structure, occurrence and biological role of proteins.
2. Structure and functions of biomolecules.
3. Introduction into metabolism

### **MODULE II.** Metabolism and its regulation

Concept modules:

1. Metabolism of carbohydrates and lipids.
2. Metabolism of proteins.
3. Integration and regulation of metabolism.

## **GOALS OF THE DISCIPLINE STUDING**

Biochemistry as a subject to study points such tasks:

- to prepare specialists-pharmacists which possess a sufficient extent of theoretical knowledge and practical skills as to biochemical basis of life: chemical structure of organic compounds and characteristics of metabolic pathways, which take place in the human organism;

- to form knowledge about structure of compounds, that form living organisms, and the relation to their main biochemical functions;
  - to form contemporary knowledge about principles of structural organization of the main classes of biomacromolecules – proteins, nucleic acids and others;
  - to form knowledge about appropriateness of liberation, accumulation and use of energy in biological systems;
  - to form knowledge of the main metabolic pathways in the organism, their relationships and molecular mechanisms of regulation;
  - to form knowledge of molecular basis of genetic information transfer, protein biosynthesis and mechanisms of their regulation;
  - acquaintance with contemporary methods of biochemical diagnostics of metabolism state in the organism;
  - formation of scientific analysis skills and generalization of phenomena and facts which are observed;
  - to supply a theoretical base to study other medical and biological disciplines: pharmacology, pharmacotherapy with pharmacokinetics, clinic pharmacology and some pharmaceutical disciplines.
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**SCHEDULE OF STUDENT'S SELF-INSTRUCTION  
FOR MODULE I**

№	T o p i c	Quantity of hours
1.	Structure, functions and biological role of individual amino acids and peptides. Use of amino acids, peptides and proteins in medical practice. Pharmpreparations on amino acid basis.	7
2.	Determination of amino acid composition of proteins. Methods of chromatography and electrophoresis. Methods of research of protein structure and physico-chemical properties. Extraction and purification of proteins.	8
3.	Structure and functions of diol phospholipids, plasmalogenes, lysolipids. Structure and function of bacterial carbohydrates.	7
4.	Description, functions and properties of individual chromo-, glyco-, lipo-, phospho- and metaloproteins.	7
5.	Investigation of physicochemical properties of nucleic acids. Pharmpreparations – nucleotide derivatives.	7
6.	Enzymopathies of amino acid, carbohydrate, lipid and mineral metabolism. Enzymes as medical preparations.	7
7.	Methods of research of protein, carbohydrate, lipid and mineral metabolism.	7
8.	Microsomal oxidation as a kind of biological oxidation in the human organism. Biological role of the enzymes – cytochromes P <sub>450</sub> - in the reactions of microsomal oxidation of xenobiotics. Lipid peroxidation.	7
	Total	57

## **MODULE I. Structure of biological macromolecules. Principles of metabolism**

*Concept module 1.* Structure, occurrence in nature and biological role of peptides and simple proteins.

### Concrete aims:

*To analyze status and perspectives of biochemistry development, using its achievements in clinic and industrial pharmacy.*

*To explain amino acid composition, structural organization, physico-chemical peculiarities, methods of extraction and clearance of proteins.*

*To interpret a lot of functions and biological characteristics of proteins and peptides.*

**Topic 1.** Introduction to biochemistry. Amino acid composition of proteins and peptides.

Structure, nomenclature, classification of amino acids. Proteinogenic amino acids; formation of peptides and proteins. Biological role of proteins and peptides.

1. As a result of oxidation reactions, hydrogen peroxide is formed, which is toxic to the body. Glutathione plays an important role in its disinfection. What are the amino acids that are part of glutathione?

2. In a clinic for parenteral protein nutrition, pharmaceutical preparations for the hydrolyzate of proteins are used. The full value of the hydrolyzates is determined by the presence of essential amino acids. Name what amino acids belong to the irreplaceable.

3. Electrophoretic study of blood serum of the patient revealed interferon. In the area of which is the protein fraction of the plasma of blood is this protein?

4. The basis of the structural classification of amino acids is the structure of the lateral radical. Which of the protein amino acids are diammonocarbonic?

5. Some proteins in the body exhibit buffering properties. What is the amino acid, due to the content of which its buffering properties detects hemoglobin?

6. One of the mechanisms of neutralization of medicinal substances in the body is methylation. The donor of the methyl group for the methylation reactions is the active form of one of the amino acids. Name this amino acid.

7. The protein consists of proteinogenic amino acids. In what position is the amino group in protein amino acids?

8. With electrophoretic separation of blood serum proteins, albumin exhibits the most detectable electronegative properties. What amino acid is present in large quantities in albumin molecules and determines their acidic properties?

9. What specific reaction can be found in the aromatic amino acids that are part of natural proteins?

10. In the analysis of the dipeptide it was found that the N-terminal  $\alpha$ -amino acid is tyrosine, and the C-terminal is serine. Write the formula for this dipeptide.

**Topic 2.** Structural organization and physico-chemical peculiarities of proteins.

Primary, secondary, tertiary, quaternary structure of a protein molecule. Physico-chemical peculiarities of proteins. Classification and biological role of simple proteins.

Control of *concept module 1.*

*Concept module 2.* Structure and functions of biomolecules.

### Concrete aims:

*To analyze peculiarities of structure and functions of the most important for humans carbohydrates and lipids.*

*To explain classification and characteristics of simple and conjugated proteins, importance of some representatives.*

*To consider the nucleic acids as important biopolymers; to analyze peculiarities of structure of nucleosides, nucleotides, polynucleotides as structural constituents of RNA and DNA.*

1. One of the indicators of metabolism is the level of total protein in serum. What name does the reaction on which the quantitative determination of protein in clinical and biochemical laboratories is based?

2. Proteins have a high level of spatial organization. What bonds are involved in the formation and stabilization of the secondary structure of the protein macromolecule?

3. Albumins are blood plasma proteins that are synthesized in the liver and perform certain functions. What are the main functions of albumin?

4. The drug tannin is used in practical medicine as astringent for acute and chronic bowel diseases. What is the ability to bind the tannin action?

5. When heat treatment of food occur irreversible changes in the spatial structure of the protein. What is the name of this process?

6. Hemoglobin erythrocytes binds and transfers oxygen from the lungs to the tissues. What level of structural organization of hemoglobin provides the respiratory function of the blood?

7. One of the functions of proteins is the protection of the body against infectious diseases. What is a prophylactic antiviral drug of nonspecific protection recommended during an epidemic of influenza?

8. The structural feature of fibrillar proteins is the formation of multicomponent filamentous complexes - fibrils that consist of several parallel polypeptide chains. What is the fibrillary protein that is part of the hair, skin and nails.

9. In many diseases, for the confirmation of a diagnosis in biochemical laboratories, an analysis of protein fractions is carried out using an electrophoretic method. What is the property of proteins in the basis of this method?

10. Chronic kidney disease may bind swelling. At the same time in the biochemical analysis of blood hypoproteinemia is detected. With a decrease in the content of which fraction of blood plasma proteins is most likely to be associated with such a condition?

**Topic 3. Structure and functions of carbohydrates and lipids.**

1. An extract from the yeast was added to the sample with an unknown substrate. After 10 minutes of incubation, the mixture in the test tube gives a positive Feling reaction. What is the substrate in the test tube? The main reserve of glucose in the human body and higher animals is a certain polysaccharide, which is deposited predominantly in the liver and muscles. Name it.

2. Fruit fibers, which are components of the wall of plant cells, play an important role in the prevention of diseases of the organs of the gastrointestinal tract. What is the main polysaccharide contained in the cell walls of plants?

3. The main structural component of the cell wall of the plant cells is homopolysaccharide of cellulose. It consists of glucose residues, as well as starch, and unlike the latter in the digestive tract, human not split. Why?

4. Which compound is the final product of starch hydrolysis?

5. To reduce the activity of the blood coagulation system, a natural anticoagulant, which according to the chemical nature is polysaccharide, is prescribed. Name it.



6. At an atherosclerotic lesion of vessels there is a violation of the functioning of the plasma membranes due to increased their rigidity and strength. Increasing the level of which component of the biomembrane leads to this?

7. The deficiency of any compounds in the intestine can be a cause of a violation of absorption of fats?

8. The drug "Lineotol" is used in medical practice for correction of lipid metabolism. Which essential fatty acid (polyunsaturated) is included in its composition?

9. In the bile contains bile acids. Call bile acids known to you.

10. After the transmitted viral hepatitis to prevent fatty degeneration of the liver, doctors prescribe lipotropic factors. Name substances that have lipotropic properties.

**Topic 4.** Classification and characteristics of conjugated proteins.

Occurrence in nature and biological role of chromo-, glyco-, lipo-, phospho- and metalloproteins.

1. There are both simple and complex proteins in the human body. What differ in structure proteins from simple ones?

2. In a closed garage, the driver was in the car with the engine turned on. After a while he felt headache, vomiting began. The formation of which compound leads to this state?

3. Along with normal types of hemoglobin in an adult's body may be pathological. Specify the pathological types of hemoglobin known to you.

4. Hemoglobin has the property to form with carbon monoxide a very stable, life-threatening compound. Give it a name.

5. Sickle-cell anemia is due to a mutation of the gene responsible for the synthesis of the protein part of the hemoglobin. In this case, the polar amino acid is replaced by non-polar, which leads to a decrease in the solubility of hemoglobin and changes in the solubility of red blood cells. Indicate which substitution occurs in the hemoglobin molecule?

6. In the study of blood revealed structural changes in red blood cells and hemoglobin. Replacing an amino acid in the  $\beta$ -chain of hemoglobin can lead to this?

7. Cyanides are powerful poisons for the human body. Specify which connection will best link them?

8. Failure to observe the safety rules in the air increased the concentration of carbon monoxide. What is the rise of which derivative hemoglobin?

9. Oxides of nitrogen can oxidize  $Fe^{2+}$  in the hemoglobin molecule to  $Fe^{3+}$  with the formation of its derivative, not able to attach oxygen. Name this substance.

10. Hemoglobin refers to complex proteins, which transports oxygen to the body and removes carbon dioxide from it. Specify which class of complex proteins it belongs to.

**Topic 5.** Characteristics and biological role of nucleoproteins.

Chemical composition, classification, occurrence, biological role of the nucleic acids.

Control of *concept module 2*.

*Concept module 3.* Introduction into metabolism

Concrete aims:

*To explain chemical nature of enzymes and their features as biocatalysts as well as classification and nomenclature of enzymes, specificity of their action.*

*To interpret kinetics of enzymatic reactions.*

*To analyze hypotheses of enzyme action mechanism, stages of enzyme catalysis, types of enzyme action inhibition.*

*To explain enzymopathology, enzymodiagnostics, enzymotherapy.*

*To analyze energy sources of the human organism, phases of energy liberation from foodstuffs. Importance of the tricarboxylic acid cycle.*

*To explain species of biological oxidation, structural organization of the mitochondrion.*

*To interpret key standings of the chemiosmotic hypothesis of oxidative phosphorylation mechanism, influence of various (including medical) factors on substance oxidation and production of ATP.*

1. What proteins stabilize nucleic acids in the cell and participate in the regulation of reading genetic information from DNA molecules?
2. The structure of nucleoproteins includes a large number of simple proteins, which stabilize their structure and have a basic character. Name these proteins.
3. A patient who was diagnosed with gastric cancer was prescribed a drug that is a derivative of the pyrimidine nitrogen base, i.e. its antimetabolite. Name this drug.
4. In the chromosomes of DNA nuclei, histones are bound to proteins and form structures called nucleosomes. The core of the nucleosome form eight histone molecules. What amino acids are in large quantities included in these proteins?
5. The composition of nitrogenous bases of DNA and RNA is different. Which heterocyclic nitrogen base is not part of the DNA?
6. The primary structure of nucleic acids is a linear polynucleotide chain that has a certain structure and arrangement of nucleotides. What connections stabilize this structure?
7. Nucleotides are monomers of nucleic acids. What compounds can be formed with full hydrolysis of ribonucleotides?
8. Chromatin consists of histone proteins having a positive charge. Which of the amino acids in a large number is part of the histone proteins and has a positive charge?
9. What is the antitumor activity of 5-fluorouracil?
10. Nucleotides are monomers of nucleic acids. What compounds can be formed with full hydrolysis of ribonucleotides?

#### **Topic 6. Enzymes.**

Notion of enzymes; their peculiarities as biocatalysts. Classification and nomenclature of enzymes, specificity of their action. Kinetics of enzyme reactions, mechanism of their action. Isozymes. Immobilized enzymes. Enzymes – pharmpreparations.

1. To prevent intestinal atony, physicians appoint a competitive inhibitor of acetylcholinesterase. Name it.
2. A pharmaceutical preparation of asparaginase is used in the treatment of leukemia. Specify the mechanism of its action.
3. In the biochemical examination of blood revealed high content of enzymes: creatine kinase (MB-isoform), AsAT and LDG1,2. What pathology should be firstly assumed in this case?
4. Enzymes (biological catalysts) are used as pharmacological agents. What is the mechanism of action of enzymes in biochemical reactions?
5. When treating purulent wounds use bandages with an immobilized enzyme on them. Name this enzyme.
6. An enzyme carries out the transport of a structural fragment from one substrate to another with the formation of two products. To what class, according to the international classification of enzymes, is this enzyme?

7. Plasma blood of the patient revealed increased activity of LDG4, LDG5, alanine aminotransferase, gamma-glutamyltransferase, carbamoyl-ornittransferase. What is the pathology of an organ shown by the results?

8. Pharmacological preparations of proserin, fizostigmine are used in myasthenia, paralysis, atony of the intestine. They prolong the action of a neurotransmitter in a synaptic cleft by inhibition of a particular enzyme. Name it.

9. Determine the activity of which enzyme in blood plasma is used in clinical practice for the early diagnosis of muscular dystrophy?

10. Enzymes catalyze the course of biochemical processes in the body. What is the optimal temperature for their action?

**Topic 7.** Introduction into metabolism. The tricarboxylic acid cycle.

Estimation of nutrients as energy sources for the human organism. Phases of energy liberation from foodstuffs. Chemical conversions in the tricarboxylic acid cycle. Structure of the dehydrogenase coenzymes.

1. Hypoenergetic state may be associated with a violation of the functional state of cytochromes of the respiratory chain of mitochondria. To what class of complex proteins are cytochromes?

2. The formation of which coenzyme inhibits the drug isoniazid? Which enzymes are inhibited when taking this drug? What are the other compounds that have an inhibitory effect on these enzymes?

3. Explain why at the oxidation of FADN2 in the respiratory chain 2 molecules of ATP are formed.

4. What are the substances (including medicines) that inhibit NADN-dehydrogenase? What process is disturbed in the body during inhibition of this enzyme? Please explain the answer.

5. List the vitamins and their coenzyme forms that are part of the complexes of the respiratory chain of mitochondria, which are used in cases of violation of the biological oxidation process. Write the circuit diagram of the respiratory chain and indicate the areas of their placement.

6. List the substances that poisoning causes to block the transport of electrons through NADN-CoQ-reductase. What process is broken in this case? How does the blood pH change when inactivated this enzyme? Please explain the answer. What antibiotic blocks the transfer of electrons from cytochrome b to cytochrome c1?

7. What is the enzyme of the respiratory chain of the mitochondria suppressed by carbon monoxide? What inhibitors of the process is cyanide? What drug should be administered to a patient when poisoning with these toxic substances?

8. Which process inhibits oligomycin when multiplying tuberculosis sticks? What inhibitor is enzyme oligomycin? What process catalyzes this enzyme? Schematically describe the structural organization of this enzyme.

9. What substance is a universal battery, donor and energy transformer in the body?

10. As a result of inhibition of which of the enzyme of the respiratory chain of the mitochondria, the respiration process (the process of electrons transferring to oxygen) is completely blocked? Please explain the answer. What are the other substances that inhibit this enzyme?

**Topic 8.** Biological oxidation. Tissue respiration. Oxidative phosphorylation mechanism hypotheses; influence of medicines on biological oxidation reactions. Microsomal oxidation.

1. Hypoenergetic state may be associated with a violation of the functional state of cytochromes of the respiratory chain of mitochondria. To what class of complex proteins are cytochromes?

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Control of *concept module 3*.

**Topic 9.** Final Module control.

## **MODULE II. Metabolism and its regulation**

*Concept module 4. Metabolism of carbohydrates and lipids.*

Concrete aims:

*To explain stages of digestion of oligo- and polysaccharides in different parts of the GIT. Ways of using of glucose in organs and tissues.*

*To interpret mechanisms of carbohydrate conversion in anaerobic and aerobic conditions; chemical reactions of these pathways.*

*To analyze the regulation of carbohydrate metabolism by hormones; carbohydrate metabolism abnormalities under Diabetes mellitus.*

*To explain the role of non-hormonal sugar lowering preparations and insulin preparations.*

*To explain peculiarities of lipid digestion in different parts of GIT in various age of humans; emulsification of lipids.*

*To analyze ways of further use of the food lipids digestion products, and pathways of biosynthesis and degradation of the intercellular lipids.*

*To interpret stages of the  $\beta$ -oxidation of carbonic acids, oxidation of glycerol, biosynthesis of ketone bodies, biosynthesis of specific fats.*

**Topic 10.** Metabolism of carbohydrates.

Biological role of monosaccharides, and oligo- and polysaccharides, their occurrence in organs and tissues of the human body.

Digestion of carbohydrates. Glycolysis, glycogenolysis, alcohol fermentation. Regulation and pathologies of carbohydrate metabolism.

1. What chemical bond splits amyolytic enzymes? What are the enzymes that split disaccharides in the process of contact (parietal) digestion of carbohydrates. Specify which monosaccharides are split sucrose, maltose, lactose. When hereditary deficiency of any enzyme is broken lactose splitting? What is homopolysaccharide not digested in the gastrointestinal tract of the human body? Why is this happening?

2. Indicate when a deficiency of any enzyme in the child when the milk comes vomiting, diarrhea, after a certain time there is cloudy lens (cataract), in the urine is galactose. Please explain the answer. Write the reaction catalyzed by the enzyme data.

3. What is the enzyme that cleaves  $\alpha$ -1,4-glycoside bond in polysaccharide molecules? Determination of the activity of which enzyme in the blood is a diagnostic criterion of acute pancreatitis? Please explain the answer.

4. The patient has glucose content in the blood within the normal range, but glucosuria has been detected. As a result of which violations in the patient's body arose glucosuria?

5. Indicate intracellular localization of enzymatic glycolysis reactions; Krebs cycle? What is the process of glucose metabolism, which occurs in tissues under hypoxia. What is the end metabolite of this process accumulates in tissue cells in these conditions? What is the fate of this metabolite? What process is the main source of energy for erythrocytes? What is the energy value of this process? Which glucose conversion product is formed mainly in adrenal medulla, which is characterized by an anaerobic type of metabolism?

6. What activity of the enzyme glycolysis is activated in hepatocytes with hyperglycemia? What hormone regulates the activity of this enzyme after the use of high-carbohydrate foods? What reaction is catalyzed by this enzyme? Is the decrease or enzyme specified by the reaction product? For which enzyme, the product of this reaction in high concentrations is an inhibitor? Write the above reaction. Write a second reaction to glycolysis. What is the enzyme that catalyzes this reaction?

7. What process is a source of energy for muscle contraction in a trained person? Specify the compounds (with the writing of their structure), whose energy is used to synthesize ATP in anaerobic conditions in glycolysis? What is the name of this process? Due to what reactions muscles are provided with energy at intense physical activity? Specify the metabolic pathways that include these reactions. Write the reaction data.

8. In which organs is predominantly postponed glycogen in humans and higher animals? Write down the first glycogen decomposition reaction; indicate the enzyme that

catalyzes this reaction and the link that breaks down the enzyme. What hormones activate this enzyme? Specify the mechanism of their action on this enzyme.

9. Write the reactions of the oxidative decarboxylation of the ketoacids (pyruvate,  $\alpha$ -ketoglutarate); indicate the enzymes that catalyze these reactions, and the coenzymes that are part of their composition. What vitamins are involved in this process?

10. Indicate the main product formed during the oxidative decarboxylation of the pyruvate. In what cell organelle is this process done? Further fate of the specified reaction product. In the chemical reactions of which process is the final oxidation of carbohydrates, amino acids and fatty acids? The energy value of this process. For what reason, did the physician recommend to the athlete to take citric acid or products containing it? Please explain the answer.

### **Topic 11.** Lipid metabolism.

Biological role of simple and complex lipids. Emulsification of lipids and their digestion in the GIT. Use of the lipid digestion products. Pathways of degradation and biosynthesis of simple and complex lipids. Biosynthesis and utilization of the ketone bodies.

Regulation and pathologies of lipid metabolism.

1. With a violation of the synthesis of which enzyme is hyperlipoproteinemia and type I, accompanied by high levels of chylomicrons in the blood, especially after eating the enriched fats? Where is this enzyme localized and which reaction catalyzes? Indicate where chylomicrons are formed; Describe the composition and biological role of these lipoproteins.

2. List the substances (with the writing of their structure), inadequate intake of which in the human body occurs fatty degeneration of the liver. What is their influence? Describe the mechanism of action of such substances.

3. What is the chemical bond in the lipids, which hydrolysis catalyzes the lipolytic enzymes of the gastrointestinal tract?

4. Name the compound from which the ketone (acetone) body is synthesized. The source for synthesis of what other compounds is it? What compounds are for ketone bodies? List them and write the structural formulas.

5. What changes occur in lipid metabolism in diabetes mellitus? Explain the mechanism of the occurrence of these changes. What kind of pathology can be shown by the increased level of total lipids in the blood [16 g / l] and elevated blood glucose levels [8.0 mmol / l]?

6. What is the enzyme found in the poison of some snakes, which, if it enters the body, can lead to the formation of substances with a strong hemolytic action. What substance does it have? Give an example of the structure of such a compound and indicate the relationship to which this enzyme acts. What compounds are formed in this case?

7. Name the products of cholesterol metabolism, which are formed in the liver and play an important role in the process of digestion of lipids. List them with the structural formulas, name their main functions.

8. What is called the form of transport of higher fatty acids through the intestinal wall during sucking - complexes of fatty acids, which contain more than 14 carbon atoms, with bile acids? How are fatty acids transported in the blood?

9. In what cell organelles is oxidation of fatty acids? What kind of vitamin-like compound is necessary for the transfer of fatty acids through the mitochondrial membrane? For what purpose does it appoint to athletes? What biochemical indicator is most likely to increase in plasma when it is deficient? Write down the chemical structure of this substance.

10. Name the additional enzyme necessary for the oxidation of unsaturated fatty acids. How many FAD and NAD + molecules are recovered during one cycle of beta-oxidation of fatty acids in mitochondria and how many ATP molecules can be formed due to oxidative phosphorylation in the respiratory chain? Please explain the answer.

Control of *concept module 4*.

*Concept module 5*. Metabolism of proteins.

Concrete aims:

*To explain species of nitrogen balance in the human organism. To consider protein digestion on different stages in various parts of the GIT; putrefaction of proteins in the large gut. Role of cathepsins in the renewal of tissue proteins.*

*To analyze ways of use of free amino acids in the human organism.*

*To interpret the processes of transamination, deamination, decarboxylation of amino acids; stages of the urea formation.*

*To explain phases of digestion of chromo- and nucleoproteins in the human GIT.*

*To interpret occurrence of the processes of degradation and biosynthesis of heme for chromoproteins as well as nitrogen-containing bases (nucleosides, nucleotides) for the nucleic acids.*

*To analyze a character of pathology under jaundices, porphyrias and gout in the human organism.*

*To analyze the ways of hereditary information transfer.*

*To explain peculiarities of the genetic code.*

*To interpret role of enzymes and nonenzymic proteins on different stages of the genetic information transfer.*

*To analyze stages of protein biosynthesis.*

**Topic 12.** Enteral metabolism of simple proteins. Pathways of amino acid metabolism.

Protein digestion in different parts of the GIT. Putrefaction of proteins. Ways of the formation of free amino acids pool in the cell, and further directions of amino acid usage.

1. Proteins are composed of amino acids. What structural component can you judge about the intensity of protein metabolism? Describe the types of nitrogen balance. In what conditions is there a negative balance of nitrogen, a positive balance of nitrogen, a state of nitrogen balance? List the biochemical parameters that need to be determined in serum for the protein metabolism. What is the enzyme deficiency in albinism? With the violation of the metabolism of which amino acids is the occurrence of this disease? Describe the signs of this pathology.

2. With the increase in the formation of which biogenic amine is associated with the development of an allergic reaction, which is accompanied by itching, swelling and reddening of the skin? What amino acid is the precursor of this biogenic amine? As a result of which reaction is it formed? In which tissues is formed to a greater extent? How does the blood vessels and stomach secretion affect?

3. What condition can develop due to changes in the protein content of blood plasma when performing heavy physical work in high ambient conditions? Please explain the answer.

4. Lack of formation of which biogenic amine causes increased excitability of the nervous system. Why? What substance is the precursor of this biogenic amine? In what reaction and with the participation of which vitamin it is formed? What violations in the

activity of the central nervous system can be observed when its formation is reduced? What are the preparations of this biogenic amine and the pathology in which they are used.

5. What changes in protein fractions of blood plasma can be expected in diseases of the gastrointestinal tract, accompanied by a violation of the processes of digestion, absorption, as well as severe weight loss? Please explain the answer.

6. What amino acid is a precursor and what transformation is subjected to the formation of a biogenic amine, which has a vasoconstrictive effect? In the regulation of which processes in the central nervous system involved this amine?

7. What can be the reason for the next state of a small child: general weakness, dizziness, fatigue, lag in mental development; urine has a specific odor (maple syrup)? Interruption of exchange of amino acids occurs?

8. What are the enzymes that neutralize the biogenic amines in the tissues. What reaction do they catalyze? Indicate which prosthetic group is included in monoamine oxidase?

9. What substance deficiency can cause phenylketonuria? What kind of enzyme defect can cause this pathology?

10. Give examples of biogenic amines that are subject to inactivation under the action of MAO. For the treatment of which states are MAO inhibitors used? Why?

**Topic 13.** Formation of the end products of protein metabolism.

Temporary and ultimate ammonia detoxification. Proteins and amino acids as pharmaceuticals.

1. Due to which enzyme is provided the clearance of histamine? What compound is its coenzyme. By which reaction does this biogenic amine deactivate?

2. What disadvantages of certain enzymes leads to a violation of digestion of proteins in the stomach and small intestine? Name the chemical bond they split. Under the action of which substance is the conversion of pepsinogen to pepsin? Describe the mechanism for such activation. The activity of which enzyme of the stomach will be reduced by decreasing the concentration of hydrochloric acid in gastric juice or achlorhydria?

3. What function does the protein that is included in the pill acidine-pepsin? What are the enzymes that split proteins in the stomach? What is the enzyme of gastric juice, active in children, which exhibits activity at pH 4.0-5.0.

4. For which disease is characterized by the following symptoms: joint pain, serum of blood, increased concentrations of C-reactive protein and oxyproline?

5. Specify the normal pH limits of gastric juice in an adult. What disease is characterized by a significant increase in the acidity of gastric juice (120 units)? What is the hormone that stimulates the secretion of HCl, causing the hyperacid state, and pepsinogen in the stomach.

6. What is the enzyme deficiency under albinism? With the violation of the metabolism of which amino acids is the occurrence of this disease? Describe the signs of this pathology.

7. Describe the mechanism of action of the drug "Ranitidine".

8. What are the enzymes that split the proteins into the duodenum? Lack of a factor in the intestine inhibits the transformation of pro-enzymes from the pancreas into an active form? What is the name of such activation mechanism? Describe the mechanism of activation of all progenies of the pancreas, as well as the mechanism of action of active enzymes.



9. Digestion and absorption of certain substances is disturbed in chronic pancreatitis, when there is a decrease in the synthesis and secretion of trypsin? Please explain the answer. What are the drugs that are prescribed for acute pancreatitis to avoid pancreatic autolysis. Lack of what substance will reduce the transport of amino acids in the enterocyte of the intestine?

10. Bloating, diarrhea, and flatulence after the use of protein foods indicate a violation of digestion of proteins and an increase in their decay. What are the substances that are the products of decay of proteins in the intestine and the compounds from which they are formed. Write 3 examples of the reactions of formation of such toxic substances.

**Topic 14.** Metabolism of conjugated proteins.

Enteral metabolism of chromo- and nucleoproteins. Tissue degradation of heme and formation of the bile pigments. Jaundice characteristics. Porphyrrias. Degradation and biosynthesis of the nucleic acids (mononucleotides) in tissues. Gout.

1. What is the regulatory enzyme for the synthesis of hemoglobin. What compound is an inhibitor of this enzyme?

2. During the catabolism of hemoglobin, iron is released. What transport protein carries it to the bone marrow?

3. What pathologies are caused by hereditary disorders of biosynthesis of porphyrins? What are the main types of these pathologies? Describe their main clinical manifestations.

4. What are the characteristics of Gunther's disease? Indicate the main signs of acute intermediate porphyria; the violation of the biosynthesis of which compound is the cause of the disease?

5. When decomposition of any compound is formed indirect bilirubin? What proteins transport it in the blood? In what body is its neutralization? With what connection does this happen? What enzyme catalyzes the detoxication of free bilirubin? Specify the product names for this reaction.

6. What increase of a biochemical index of blood is observed at jaundice? What types of jaundice exist? Describe the signs of hemolytic jaundice, the causes of its occurrence.

7. Indicate the causes of parenchymal jaundice. Describe her signs. What blood count will be raised at the height of the indicated jaundice?

8. What are the signs of obstructive (mechanical) jaundice? Specify the reasons for its occurrence. The absence of any bile pigment results in discoloration of faeces?

9. Explain the cause of the occurrence of nuclear jaundice in newborns; with an insufficiency of which enzyme it is connected; what process is broken? Describe her signs.

10. What are the symptoms of gallstone disease? What kind of jaundice are they like?

**Topic 15.** Genetic information transfer. Protein biosynthesis.

The genetic code. Storage, multiplication and transfer of hereditary information from the nucleic acids to proteins. Characteristics of protein biosynthesis stages. Regulation of the protein biosynthesis.

1. Using the enzyme is made by different genes synthesis of messenger RNA to DNA in genetic engineering (the enzyme catalyzes the process opened in RNA viruses)?

2. The patient with a malignant tumor was prescribed chemotherapy with cytostatics. What is the mechanism of action of these drugs? Give examples of such drugs with the writing of their structure.

3. What scientists have proposed a scheme for regulating biosynthesis of proteins at the level of transcription in bacteria? Describe the concept of the operon.

4. Violation of which process is one of the factors that reduce wound healing in patients with diabetes?

5. What enzyme is necessary for the formation of a transport form of amino acids for the synthesis of protein on ribosomes? What process catalyzes this enzyme?

6. In the diagnosis of HIV infection, the polymerase chain reaction [PCR] method is used. What is the basis of PCR?

7. Explain what are the features of the genetic code such as universality and degeneracy.

8. Specify an enzyme that catalyzes the synthesis of the RNA seed necessary for the DNA replication process. What substrates are necessary for the synthesis of RNA-seed, its purpose and the further fate.

9. In terms of prolonged intoxication animals tetrachloroethene was no significant decrease in activity of aminoacyl-tRNA synthetase in hepatocytes. What metabolic process is violated in this case? Describe the role of these enzymes.

10. When respiratory viral infection is often prescribed interferon. What is the biochemical process and at what stage inhibits interferon?

Control of *concept module 5*.

*Concept module 6*. Integration and regulation of metabolism.

Concrete aims:

*To explain significance of vitamins for the human organism, their classification and nomenclature, their chemical structures.*

*To analyze influence of fat-soluble vitamins on biochemical processes in organs and tissues.*

*To explain signs of hypo- and avitaminoses.*

*To interpret lipovitamins as pharmpreparations.*

*To analyze influence of water-soluble vitamins on metabolism as co-factors for most enzymes.*

*To explain clinic manifestations of hydrovitamin insufficiency, and antivitamin usage in medical practice.*

*To interpret hydrovitamins and their derivatives as pharmpreparations.*

*To explain significance of endocrine system for the human organism as well as classification, chemical nature and features of hormones.*

*To interpret mechanisms of hormone modifying action on metabolic processes in the target cells.*

*To analyze a character of the regulating action of hormones of hypothalamus, hypophysis and epiphysis, and hormones of the peripheral endocrine glands on the organs- and tissues-targets.*

*To interpret use of natural hormones and their synthetic analogues as pharmpreparations aiming to correct abnormalities of the endocrine glands functions.*

*To explain II principal phases of xenobiotic and drug detoxification in the human organism. To consider chemical reactions of several key types of the detoxification.*

**Topic 16.** General characteristics of vitamins. Fat-soluble vitamins: structure, biological role, signs of hypo- and avitaminoses. Chemical structure, biological role, signs of hydrovitamins insufficiency.

Chemical structure, occurrence, biological role of retinols, calciferols, tocopherols, naphthoquinones, vitamin P. Features of lipovitamins insufficiency. Lipovitamins as pharmpreparations.

Chemical structure, occurrence, biological role of vitamins of groups B and P, vitamins C, H and some vitamin-like compounds. Features of hypo- and avitaminoses. Antivitamins. Hydrovitamins and their derivatives as pharmpreparations.

**Topic 17.** General characteristics of hormones, their classification. Mechanisms of action. Hormones of thyroid, parathyroid and pancreatic glands. Hormones of other peripheral and central endocrine glands.

Characteristics and classification of hormones. Interaction of the CNS and endocrine system. Mechanisms of hormone action. Hormones of thyroid, parathyroid and pancreatic glands. Hypo- and hyperfunctions of these glands.

Main hormones of adrenal glands, gonads, thymus, epiphysis, hypothalamus, hypophysis. Features of hypo- and hyperfunctions of the above glands. Hormones – pharmpreparations.

1. Hormones regulate numerous metabolic processes. Some hormones have a stimulating effect on protein biosynthesis. What are the hormones that have pronounced anabolic activity, and the endocrine glands in which they are produced.

2. The patient has been shown to appoint steroid anabolic drugs. Synthetic analogues of which hormones have been used in medicine as drugs with anabolic effect?

3. At what state the patient is observed: hyperglycemia, glucosuria, high urine density; high blood glucocorticoid levels in the blood; in blood and urine, increased concentration of 17-keto steroids?

4. Patients with Itsenko-Cushing's syndrome have persistent hyperglycemia and glucosuria. Synthesis and secretion of which hormone increases in this case?

5. Administration of glucocorticoids to the patient leads to an increase in blood glucose levels. What process is activated?

6. Inadequate dietary intake of carbohydrates, the need for them in the body is compensated by gluconeogenesis. What hormones have a stimulating effect on gluconeogenesis?

7. Adrenal glands produce some hormones that have anti-inflammatory effects. What is the main hormone that performs this function?

8. Steroid hormones activate the synthesis of a phospholipase A2 inhibitor, exhibiting anti-inflammatory action. Synthesis of which substances is at the same time depressed?

9. The molecular mechanism of anti-inflammatory action of glucocorticoids is associated with an increase in their contribution to the synthesis of specific proteins that inhibit the activity of phospholipase A2. Releasing what substance from membrane phospholipids catalyzes this enzyme?

10. Patients for a long time with curative purpose appointed cortisol. Name, the derivative of which compound is this substance.

**Topic 18.** Pharmaceutical biochemistry.

II principal phases of xenobiotic and drug detoxification in the human organism. Defensive pathways and enzymes. Chemical reactions of several key types of the detoxification.

1. Give the definition of "xenobiotics" and "biogenic medicines". Give examples. What group of drugs includes insulin from the body of animals?

2. What happens at the first stage of the introduction of the drug substance into the body? What process is called the active transport of substances through the plasma membrane?

3. Name and describe the basic mechanisms of membrane transport of drugs. Why waste energy when passing drugs through the membranes in the middle of cells?

4. The process of conjugation in the second phase of neutralizing toxic substances is carried out by joining to their functional groups certain chemical compounds. List them

5. Specify the type of splitting reaction in the human body of acetylsalicylic acid [aspirin]. What products are formed in the indicated reaction?

6. What types of reactions are the process of conjugation of xenobiotics or their metabolites? In what phase of biotransformation of medicinal substances are the following transformations carried out? Specify the main types of conjugation mechanisms of pharmaceuticals or their metabolites. What compounds are used in conjugation reactions?

7. In the cells of which body is the most active metabolism of medicinal substances? Indicate the intracellular localization of the enzymes for their metabolism. Name and describe the phases of disinfection of medicinal substances in the body.

8. Name and describe the basic mechanisms of membrane transport of drugs. Why waste energy when passing drugs through the membranes in the middle of cells?

9. As a result of which reaction is most often the neutralization of toxic compounds in the body? What kind of system provides such neutralization? Indicate its intracellular localization. In what body is this carried out mainly? What pharmaceutical product has an inducing effect on this system, namely, on the cytochrome P450?

10. What is the enzyme of the class of oxidoreductase involved in the process of microsomal oxidation? The enzymes of which system are involved in the hydroxylation of 17-keto steroids?

Control of *concept module 6*.

**Topic 19.** Final control of *Module II* “**Metabolism and its regulation**”.

## EXAMPLE OF THE EXAMINATION PAPER

### MINISTRY OF HEALTH OF UKRAINE NATIONAL UNIVERSITY OF PHARMACY

Educational background Master  
program subject area 1201 Pharmacy  
Specialty 8.12020101 Pharmacy Semester 5th  
Educational program Biological chemistry  
(Course Unit Name)

#### EXTRACURRICULAR WORK NO. 1

#### EXAMINATION PAPER No. 1

1. Active site of enzyme. How is it composed? What amino acids are more frequently included in its structure? Allosteric site of enzyme.
2. Vitamin B2: nomenclature, sources, chemical structure, biological role, hypovitaminosis, pharmpreparations.

Approved at the Biological Chemistry Department Meeting \_  
Examination Record No. 2 from 13th of October 2017

Department Chairman, Prof. \_\_\_\_\_

Zagayko A. L.

Examiner, Prof. \_\_\_\_\_

Zagayko A. L.

**THE ANSWER FOR THE EXAMINATION PAPER  
(AN EXAMPLE)**

**MINISTRY OF HEALTH OF UKRAINE  
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**EXTRACURRICULAR WORK NO. 1**

**EXAMINATION PAPER No. 1**

1. Active site of enzyme. How is it composed? What amino acids are more frequently included in its structure? Allosteric site of enzyme.

An active site is the part of an enzyme that directly binds to a substrate and carries a reaction. It contains catalytic groups which are amino acids that promote formation and degradation of bonds. By forming and breaking these bonds, enzyme and substrate interaction promotes the formation of the transition state structure. Enzymes help a reaction by stabilizing the transition state intermediate. This is accomplished by lowering the energy barrier or activation energy- the energy that is required to promote the formation of transition state intermediate. The three dimensional cleft is formed by the groups that come from different part of the amino acid sequences. The active site is only a small part of the total enzyme volume. It enhances the enzyme to bind to substrate and catalysis by many different weak interactions because of its nonpolar microenvironment. The weak interactions includes the Van der Waals, hydrogen bonding, and electrostatic interactions. The arrangement of atoms in the active site is crucial for binding specificity. The overall result is the acceleration of the reaction process and increasing the rate of reaction. Furthermore, not only do enzymes contain catalytic abilities, but the active site also carries the recognition of substrate. The enzyme active site is the binding site for catalytic and inhibition reactions of enzyme and substrate; structure of active site and its chemical characteristic are of specific for the binding of a particular substrate. The binding of the substrate to the enzyme causes changes in the chemical bonds of the substrate and causes the reactions that lead to the formation of products. The products are released from the enzyme surface to regenerate the enzyme for another reaction cycle.

2. Vitamin B2: nomenclature, sources, chemical structure, biological role, hypovitaminosis, pharmpreparations.

Riboflavin, also known as vitamin B2, is a vitamin found in food and used as a dietary supplement. Riboflavin functions as a coenzyme, meaning that it is required for enzymes (proteins) to perform normal physiological actions. Specifically, the active forms of riboflavin flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) function as cofactors for a variety of flavoproteine enzyme reactions: Flavoproteins of electron transport chain, including FMN in Complex I and FAD in Complex II, FAD is required for the production of pyridoxic acid from pyridoxal

(vitamin B6) by pyridoxine 5'-phosphate oxidase, The primary coenzyme form of vitamin B6 (pyridoxal phosphate) is FMN dependent, Oxidation of pyruvate,  $\alpha$ -ketoglutarate, and branched-chain amino acids requires FAD in the shared E3 portion of their respective dehydrogenase complexes, Fatty acyl CoA dehydrogenase requires FAD in fatty acid oxidation, FAD is required to convert retinol (vitamin A) to retinoic acid via cytosolic retinal dehydrogenase, Synthesis of an active form of folate (5-methyltetrahydrofolate) from 5,10-methylenetetrahydrofolate by Methylenetetrahydrofolate reductase is FADH<sub>2</sub> dependent, FAD is required to convert tryptophan to niacin (vitamin B3), Reduction of the oxidized form of glutathione (GSSG) to its reduced form (GSH) by Glutathione reductase is FAD dependent, For the molecular mechanism of action see main articles Flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD)

Approved at the Biological Chemistry Department Meeting \_  
Examination Record No. 2 from 13th of October 2017 \_

Department Chairman, Prof. \_\_\_\_\_

Zagayko A. L.

Examiner, Prof. \_\_\_\_\_

Zagayko A. L.

## **PROCEDURE FOR PERFORMANCE AND FORMATION EXTRACURRICULAR WORK BY APPLICANTS FOR HIGHER EDUCATION**

During the study of the discipline "Biological Chemistry", the applicant of higher education performs 2 written independent (extra-curriculum) papers. At the first practical lesson of each semester, applicants of higher education receive from the teacher tickets that contain questions on which applicants of higher education should give a written answer.

Answers must be made in a notebook or white sheets of A4 format, written by hand and contain substantiated answers to the questions. Students who have completed their work must deliver to the teacher no later than 1 calendar month before the end of the semester.

### **ESTIMATION CRITERIA**

The total number of points that a higher education student can get for his work is 5 points. The points awarded are added to the current points that a higher education student receives during the semester.

When developing the evaluation criteria, the completeness and correctness of the answer to the question are taken as a basis. In addition, the ability of higher education graduates to differentiate, integrate and unify knowledge is taken into account.

### **SYSTEM OF ESTIMATION**

Rating score, points	Criteria for evaluation
4-5	is exhibited by a higher education student who, upon answering the questions, has shown comprehensive, systematic, deep knowledge of the program material, demonstrates the knowledge of the information sources provided by the program and creatively uses this knowledge when answering the problematic issues.
2-3	is exhibited by a higher education student who, upon answering a question, showed full knowledge of the program material, provided at the level of similar reproduction, but suggested some minor failures
1-2	is exhibited by a higher education student who, when answering a question, revealed insufficient knowledge of the main software material to the extent necessary for further study and work provided by the program at the reproductive level
0-1	if, upon answering the question, the applicant of higher education revealed serious gaps in the knowledge of the main material, committed fundamental errors



## LIST OF METHODOICAL AND SCIENTIFIC LITERATURE

### **Main:**

1. Biological Chemistry: Textbook for the self-study of students / A.L. Zagayko, L.M. Voronina, G.B. Kravchenko, K.V. Strel'chenko.– Kharkiv: NUPh; Original, 2011. - 264p.
2. Clinical biochemistry: An illustrated colour text / A. Gaw, M.J. Murphy, R.A. Cowan and oth. – ELSEVIER Ltd., 2008.- 179p.
3. Textbook of biochemistry: with clinical correlations / edited by Thomas M. Devlin.- John Wiley & Sons, Inc., 2011. - 1204p.

### **Additional:**

- Lieberman M., Marks A. Marks' basic medical biochemistry: a clinical approach. – Lippincott Williams & Wilkins, a Wolters Kluwer business., 2009. – 1011p.
2. Bhagavan N.V., Chung-Eun H. Essentials of medical biochemistry: with clinical cases. – ELSEVIER Inc., 2011. – 581p.

### **Internet sites**

1. Biological chemistry department site: <http://biochem.nuph.edu.ua/>.
2. NUPh library: e-mail [library@nuph.edu.ua](mailto:library@nuph.edu.ua)
3. Website of distance learning <http://www.pharmel.kharkiv.edu/>.

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***BIOLOGICAL CHEMISTRY  
Methodical recommendations  
for the students extracurricular work to  
higher education applicants  
in specialties / educational program  
«Pharmacy»***