

**NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES
OF UKRAINE**

Department of Biochemistry and Physiology of Animals
named after Academician Maksym Gulyi

Dean of the Faculty of Veterinary Medicine
(Mykola Tsvalkhovskiy)

“CONFIRMED”
6 / 20



“APPROVED”

at the meeting of the Department of Biochemistry
and Physiology of Animals named
after Academician Maksym Gulyi
Protocol №8 dated “_18”_04_2023.

Head of Department
(Viktor Tomchuk)

“REVIEWED”

Program Coordinator _____

Veterinary Medicine
Program Coordinator
(Nataliia Grushanska)

PROGRAM OF THE COURSE

Biochemistry of Animals with the Basics of Physical and Colloid Chemistry

Specialization 211 “Veterinary Medicine”

Educational program “Veterinary Medicine”

Faculty of Veterinary Medicine

Developers: _Liliia Kalachniuk, Professor, Doctor of Biological Sciences, Professor
(position, academic degree, academic title)

Kyiv – 2023

1. Description of the course

Biochemistry of Animals with the Basics of Physical and Colloid Chemistry

(title)

Field of knowledge, specialization, educational program, educational degree		
Educational degree	«Master's»	
Specialization	211- «Veterinary Medicine»	
Educational program	«Veterinary Medicine»	
Characteristics of discipline		
Type	Compulsory	
Total number of hours	180	
Number of ECTS credits	6	
Number of content modules	6	
Course project (work) (if applicable)	-	
Form of assessment	<i>Exam, 6 Credits</i>	
Indicators discipline for full-time and extramural study		
	Full-time form of study	Part-time form of study
Course (year of study)	2	
Semester	3, 4	
Lecture classes	60 hr.	hr.
Practical, seminar classes	- hr.	hr.
Laboratory classes	90 hr.	hr.
Self-study	30 hr.	hr.
Individual assignments	- hr.	hr.
Number of weekly classroom hours for the full-time form of study	5 hr.	

"Biochemistry of Animals with the Basics of Physical and Colloid Chemistry" is a mandatory component of the educational program "Veterinary Medicine", which provides basic concepts about the chemical composition of the animal, classification, functions of proteins, carbohydrates, lipids, minerals, enzymes, hormones and vitamins. The main ways of biochemical processes that provide homeostasis, energy balance, growth and development of animals are subject to study. Significant attention is paid to the study of the biochemical composition of biological fluids and tissues of animals and the processes that occur in them.

The study of the discipline "Biochemistry of Animals with the Basics of Physical and Colloid Chemistry" provides mastery of such general competencies as knowledge and understanding of the subject area, the ability to search, process and analyze information from various sources, the ability to apply knowledge in practical situations.

Studying the discipline "Biochemistry of Animals with the Basics of Physical and Colloid Chemistry" provides the acquisition of such professional competencies as the ability to use modern knowledge of the laws of biochemistry of different species to effectively adjust the treatment of animals and drugs.

2. The purpose and tasks (objectives) discipline

The **purpose** of "Biochemistry of Animals with the Basics of Physical and Colloid Chemistry" is to equip students by complete system of knowledge about the chemical composition of living organisms, physico-chemical and biological properties of natural compounds, the main pathways of metabolism, regulatory mechanisms and the relationship of metabolic processes that is to take on theoretical fundamentals of metabolic transformations and their regulation in animals and practical skills of their study.

Tasks (objectives) of the course "Biochemistry of Animals with the Basics of Physical and Colloid Chemistry" are to learn the basics of life organisms, namely: structure, physico-chemical and biological properties of substances and their metabolism and its regulation and metabolic changes using as feed and as medicines to promote health and improve animal productivity.

After study of the discipline, the student must

know:

- chemical fundamentals of life organisms, including chemical structure and properties of natural compounds and their complexes, major pathways and mechanisms of regulation of metabolism, biochemical mechanisms of realization of genetic information;
- theoretical and practical importance of biochemistry and its relationship with other natural sciences;
- the latest achievements of biochemistry and prospects for their use in various sectors of the national economy, especially in veterinary medicine;

be able: to orientate in biochemical studies at the present level, namely: to choose the appropriate physico-chemical and biochemical methods and methodological approaches and equipment, select biological samples, possess conventional methods of determination in biological objects of various metabolites, indexes with devices biochemical laboratory for characteristics of the physiological state of animals, and its changes.

Acquisition of competencies:

- study of the discipline "Biochemistry of Animals with the Basics of Physical and Colloid Chemistry" provides mastery of such general competencies as: 1) the ability to abstract thinking, analysis and synthesis; 2) the ability to apply knowledge in practical situations; 3) knowledge and understanding of the subject area and profession; 5) the ability to communicate in a foreign language;

- the study of the discipline "Biochemistry of Animals with the Basics of Physical and Colloid Chemistry" provides mastery of such professional competencies as: 1) the ability to establish the features of the structure and functioning of cells, tissues, organs, their systems and apparatus of animals of different classes and species - mammals, birds, insects (bees), fish and other vertebrates; 2) the ability to use tools, special devices, instruments, laboratory equipment and other technical means to carry out the necessary manipulations during professional activities; 3) the ability to follow the rules of labor protection, asepsis and antiseptics during professional activities, the ability to use modern knowledge of the laws of biochemistry of different species of animals to effectively manage the treatment of animals and the use of medicines.

Program learning outcomes: 1) to know and correctly use the terminology of veterinary medicine; 2) to determine the essence of physico-chemical and biological processes that occur in the body of animals in normal and pathological conditions; 3) to establish a connection between the clinical manifestations of the disease and the results of laboratory studies.

3. The program and structure of study discipline:

– full-time study;

Thematic Module 1. Basics of Physical and Colloid Chemistry

Theme of lecture lesson 1. Animal biochemistry is the history of its development and its place among the natural sciences.

Biochemistry. History of biochemistry as a science. Biochemistry is a science of the origin and development of life. Connection with related and applied sciences. The place of biochemistry as a discipline in the system of biological education and its significance for veterinary medicine. Modern problems and prospects of biochemistry development (introductory lecture).

Theme of lecture lesson 2. Basics of Physical Chemistry (1,2,3)

Subject and methods of physical chemistry. pH, value for the body. pH scale. Communication length and energy. Types of physicochemical interactions in the matter: chemical, physical. Hydrogen bond.

Intermolecular interactions. The physical state of substances. Gases are perfect and real. Gas laws, their significance for understanding the processes of gas exchange in the body. Boiling and evaporation of substances.

Buffer solutions, their components. Blood buffer systems. Solutions. Classification. Characteristics of the acid-base state of the organism. Diffusion. Osmosis. Osmotic pressure. Oncotic pressure.

Basics of Physical Chemistry (2)

Theories of solutions; Dilution of solutions; Solvates; Hypotonic, hypertonic and isotonic solutions; Erythrocytes hemolysis and plasmolysis. Sorption, sorption kinds. Chemical and physical nature of sorption. Adsorption, types of adsorption.

Surfactants (Surface active agents). Sorption in biological phenomena, its significance. Chromatographic and electrophoretic methods for the separation of macromolecular materials. Viscosity. Dynamic viscosity, internal friction. Fluidness of liquids.

Basics of Physical Chemistry (3)

Equilibrium in the system of solution–vapour. Raul's Laws. Measurement of osmotic pressure by methods of cryoscopy and ebullioscopy. Dispersed systems, their classification.

Surface phenomena in the dispersed systems. Surface strain, surface energy.

Theme of lecture lesson 3. Basics of Colloid Chemistry (1)

Subject and methods of colloidal chemistry. Colloidal solutions, their characteristics. Molecular-kinetic properties of colloidal solutions. Electrokinetic properties of solutions. Kinetic and aggregative resilience of colloidal solutions. Coagulation.

Syneresis. Sols. Molecular and kinetic properties of sols.

Basics of Colloid Chemistry (2)

Structure of colloidal particle. Iso-electric state of colloidal systems. Colloidal protection. Dispersed Systems Usage in Veterinarian Medicine. Optical properties of sols.

Methods for sol preparation. Purification of colloidal solution by dialysis, electrical dialysis, adsorbent. Aerosol. Gels, characteristics, classification, properties.

Thematic Module 2. Physico-chemical methods of research in biochemistry

Theme of lecture lesson 1. Physico-chemical methods of research in biochemistry (1)

Physical and chemical fundamentals of spectral analysis (spectrophotometric and colour-metric methods). Physical and chemical phenomena in a base of chromatography, electrophoresis (for example, sequencing of high molecular substances: amino acids, nucleic acids).

Solution concentration determination.

Physical-chemical methods of research in biochemistry (2)

Biosubstances and their chemical composition as objects of biochemical research, nutrient media, and preparative methods.

Selection of objects of biochemical research (for example, on energy value). The purpose of use of a medium. Homogenization. Examples of preparative methods (centrifugation). Obtaining cell compartments.

Thematic Module 3. Biochemistry: Statics

Theme of lecture lesson 1. Cell and its organic compounds. Carbohydrates (1)

General characteristics. Mono-, oligo-, polysaccharides. Glycosidic bond, types of bonds. Study of chemical properties of sucrose, lactose, starch.

Laboratory simplified tests for carbohydrates.

Cell and its organic compounds. Carbohydrates (2)

Homopolysaccharides. Heteropolysaccharides. Functions and biological importance of carbohydrates in the organism.

The functions of biological membranes and the role of carbohydrates as their structural elements. Membrane structures of animal cells.

Theme of lecture lesson 2. Lipids and biomembranes (1, 2)

Simple and complex lipids. Simple lipids: acyl glycerols, waxes (the main representatives). General characteristics: structure, physico-chemical properties and functional role. Fatty acids (saturated, mono- and polyenes), their physical and chemical properties. Eicosanoids (structure and function). Alcohols as components of simple lipids.

Lipids that could be saponificated. Surface-active properties of soap.

Complex lipids: general characteristics, structure, composition, biological significance. Phospholipids (glycerophospholipids and sphingophospholipids), glycolipids (glycosylglycerols and glycosylsphingolipids), their main representatives.

Lipids that could not be saponificated: terpenes (terpenes derivatives - carotenes and vitamin A, vitamin E) and steroids (the structure and properties of some representatives: cholesterol, bile acids, steroid hormones, vitamin D).

Theme of lecture lesson 3. Amino acids, peptides, proteins (1, 2)

Amino acids: general characteristics, classification. Non-essential and essential amino acids. The biological significance.

Methods for determination of amino acids. Ninhydrine reaction on amino acids.

Proteins: Classification of proteins, the chemical composition of proteins. Simple and complex proteins. Simple proteins: structure, properties, functions, individual members and their role.

Methods of isolation of proteins. Fractionation of proteins.

Amino acids, peptides, proteins (3)

Conjugated proteins: structure, properties and biological role chromo-proteins (flavo-proteins and hemoproteins), glycoproteins, lipoproteins, metallo-proteins, phospho-proteins and nucleoprotein. The functional role of individual proteins.

Nitrogen balance in animals. Total, protein, non-protein Nitrogen.

Theme of lecture lesson 4. Nucleosides, nucleotides and nucleic acids (NA)

Nucleosides, nucleotides, NA. Spreading and localization in the biological objects, their composition and biological role. Nitrogen containing bases. Carbohydrate components.

Chemical structure, function and use of nucleosides and nucleotides. General characteristics of DNA and RNA.

Condition of nucleic acids in the cell.

Structure and properties of DNA and RNA. Structural organization of oligo- and polynucleotides. Characterization of the primary structure of DNA. Double-stranded DNA, the bonds that stabilize the structure of DNA. The principle of complementarity. Single and double stranded DNA. Structure, properties and functions of messenger, transport and ribosomal RNA. Physico-chemical properties of DNA and RNA.

Molecular organization of nuclear chromatin and ribosomes.

Thematic Module 4. Regulatory effects of inorganic and organic substances on the metabolism

Theme of lecture lesson 1. Water and mineral balance and its effect on the metabolism

Subject and tasks of biochemistry. Contribution of the Ukrainian biochemists to the development of biochemistry. Water, its exchange and state in the organism. Sorption. Regulation. Abnormal states of water's exchange.

Quantity elements (macroelements) and essential trace elements (microelements). Biochemical functions of inorganic substances.

Electrolyte balance of organisms. Regulation and abnormal states of mineral turnover.

Theme of lecture lesson 2. Vitamins. Coenzymes

Regulators of metabolism: vitamins. Common characteristics. Vitaminology. Fat-soluble vitamins: A and D with their vitamers, E, K, and F. Water-soluble vitamins: for example, B₁ (thiamine); B₂ (riboflavin); B₃ (pantothenic acid); B₅ (nicotin amide або vitamin PP); B₆ (pyridoxal, pyridoxine, pyridoxamine or vitamin B₆); B₇or8 (H or biotin); B₉ (B_c or folic acid), B₁₂ (cyanocobalamin).

Precursors of vitamins (carotinoides - precursor of vitamin A). Sources of vitamins. Vitamin-like substances: inositol; vitamin B₄ (choline); vitamin B₁₁, (B_T, carnitine); vitamin B₁₃ (orotic acid); vitamin B₁₅ (пангамова acid); p-aminobenzoic acid (PABA). Antivitamins. Avitaminosis, hypo- and hypervitaminosis of farm animals.

Coenzymes (thiamine diphosphate, FAD, FMN, Coenzym A, NAD, NADP, pyridoxal phosphate, biocytin, lipoamides, 5'-deoxyadenosylcobalamin, methyl cobalamin) and their role in catalytic processes under action of enzymes.

Theme of lecture lesson 3. Enzymes and their kinetic properties

Common information concerning enzymes: structure, definition of substrate, active center, enzyme-substrate complex, substrate specificity. Cofactors and coenzymes. Equation of enzymatic reaction. Mechanism of enzymatic reaction with one substrate. Enzyme numbers and their classification. The enzyme classes: 1) oxido-reductase, 2) transferase, 3) hydrolase, 4) lyase, 5) isomerase, 6) ligase, and typical reactions for enzymes of each class.

The terms those are used in enzymology. Enzyme kinetics. Influence of physical and chemical factors on enzymatic activity. Activators and inhibitors of enzymes.

Theme of lecture lesson 4. Hormones and mechanisms of their influence on metabolic processes

Regulators of metabolism: hormones. General characteristics.

Structure of molecules, biosynthesis, metabolism. Types of communication between cells (direct contact, neurotransmitters, and endocrine signaling molecules). Depending on the speed of the signals those are distinguished on the following types of signaling: for neurotransmitters, it occurs and is extinguished in milliseconds signal, the receptor proteins which are ion channels postsynaptic membrane; for protein and peptide nature hormones, catecholamines, prostaglandins, signal transmission takes minutes and its receptors located on the plasma membrane; for steroid and thyroid hormone, signaling occurs over hours, days and they are perceived receptors in the cytosol and nucleus.

Mechanisms of hormonal influence on metabolic processes.

Thematic Module 5. Dynamic and functional biochemistry

Theme of lecture lesson 1. Biochemistry of digestion and features of digestive processes in different organisms

Biochemistry of digestion. Cavity, parietal, membrane, cellular digestion. Biological features of absorption of substances. Features of protein digestion in ruminants, transformation of Nitrogen-containing non-protein substances. Digestive hormones (gastrin, secretin, cholecystokinin, gastric inhibitor peptide and motylin). The formation of hydrochloric acid. Transmembrane transport of substances: simple diffusion, passive transport (facilitated and exchange diffusion), active transport (primary and secondary transport) endocytosis and exocytosis. Two types of endocytosis: phagocytosis and pinocytosis. Mechanisms of transport.

Digestion of nutrients (proteins, carbohydrates, nucleic acids, lipids, vitamins and inorganic substances, cellulose), enzyme hydrolysis (hydrolysis products: amino acids, monosaccharides, nitrogenous bases, pentose, phosphate, nucleoside, 2-monoacyl glycerol, FA, cholesterol, cellulose, lignin), re-sorbtion (hydrophilic and lipophilic substances), or transport through the blood to the liver, portal vein, lymphatic system. Digestive enzymes of proteins, carbohydrates, nucleic acids, lipids. Features of digestion in newborns.

Theme of lecture lesson 2. Metabolism of carbohydrates and its peculiarities (in ruminants) (1)

Carbohydrate metabolism. Intermediary carbohydrate metabolism in the organs and tissues. Anaerobic decomposition of carbohydrates - glycolysis (its stages, reversible and irreversible reactions, and regulation), glycogenolysis. Regulatory enzymes of glycolysis. Pasteur Effect (inhibition of glycolysis reactions in conditions of activation of cellular respiration). The value of anaerobic glycolysis.

The pathways of glucose transformation. Glucose-lactate cycle (cycle Corey). Metabolic conversion of glucose-6-phosphate in erythrocytes. Glycolysis and glycogenolysis in different states of the organism and the ways of their correction. Hypo-and hyperglycemia.

Metabolism of carbohydrates and its peculiarities (in ruminants) (2)

Peculiarities of carbohydrate metabolism in ruminants. Pentose phosphate (phosphogluconate) pathway (PPP): its stages and their functioning (including

erythrocytes). The biological significance of PPP. Hereditary deficiency of glucose-6-phosphate dehydrogenase (enzyme PPP) causing hemolysis of erythrocytes.

Synthesis of glucose, glycogen, lactose.

Gluconeogenesis, characterization by bypass reactions of glycolysis and its hormonal regulation (including insulin, glucagon, epinephrine and glucocorticoids). Glucose-lactate cycle (cycle Corey). Glucose-alanine cycle.

Propionate (product of carbohydrate metabolism by microorganisms) - the main substrate of gluconeogenesis in ruminants.

Glucogenous amino acids. Cooperation between glycolysis and gluconeogenesis.

Effect of antagonistic hormones (insulin and glucagon) and hormone-synergists (glucagon, epinephrine, corticosteroids, somatropin) on carbohydrate metabolism.

Glycogenesis, synthesis of lactose in the lactating mammary gland and non-lactating tissues.

Theme of lecture lesson 3. Amphibolic transformation of organic substances (the tricarboxylic acids cycle). Energy of biochemical processes

The tricarboxylic acids cycle (TCAC or citric acid cycle, or Krebs' cycle) TCAC: enzymes and sequence of reactions. Reduction of NAD and FAD, phosphorylation on the level of substrate. Energy balance of TCAC. Usage of metabolites of TCAC in metabolism of carbohydrates, lipids, amino acids, proteins, nucleic acids and their components (common characteristics).

Biological oxidation, types of biological oxidation.

The modern theory of tissue respiration. The theory of oxidative phosphorylation. Main macroergic compounds. Oxidation coupled with phosphorylation of ADP (substrate and oxidative phosphorylation). Principles of structural and functional organization of electron transport (respiratory) chain of mitochondria. NAD- and NADP-dependent dehydrogenase flavin enzymes, ubiquinone, cytochromes and cytochrome oxidase. Mechanisms of coupling of oxidation and phosphorylation in the respiratory chain.

Transmembrane potential of protons, ATP synthase work.

Theme of lecture lesson 4. Metabolism of lipids (1)

Exchange of lipids. Lipid digestion and absorption of the products of their hydrolysis. Role of bile acid in digestion of lipids. Intermediate lipid metabolism in the organs and tissues. Transportation forms of lipids (lipoprotein complexes) functions apo-proteins. Lipolysis (catabolism) of TAG. The molecular basis for the regulation of adipocyte triacyl glycerol lipase activity - its covalent modification by reversible phosphorylation-dephosphorylation.

Adenylate cyclase mechanism for the regulation of lipolysis. Hormonal regulation of lipolysis. Catabolism of phospholipids sterides. Ketogenesis (formation of ketone bodies: acetone, aceto acetate, beta-hydroxybutyrate). Reactions of utilization of ketone bodies. Metabolism of ketone bodies in pathological conditions.

Metabolism of lipids (2)

Exchange of glycerol and fatty acids (FA). β -oxidation of FA (sequence of reactions and their localization) and its energy. Oxidation of unsaturated fatty acids. Oxidation FA with an odd number of carbon atoms. β -oxidation FA (C_{20} and more than 20 carbon in the Carbon-chain of FA). α - and ω -oxidation of FA. Cleavage of branched of FA during α -oxidation. ω oxidation (as detoxification of intermediates of defective β -

oxidation) in the smooth endoplasmic reticulum of liver. Oxidation of glycerol and its energy. Coordinated regulation of metabolism of FA. Synthesis of FA (role multienzyme complex).

Elongation of the saturated FA. Formation of the unsaturated FA. Metabolic pathways of biosynthesis of saturated and unsaturated FA by enzyme systems in the organism. The formation of glycerol. Lipogenesis is the synthesis of neutral fats (triacylglycerols, TAG). Ways of TAG synthesis and phospholipids.

Theme of lecture lesson 5. The metabolic processes of proteins and some amino acids (1)

Biochemistry of proteins. Proteins complete and defective on essential amino acids. The biological value of proteins. Essential amino acids. Exchange of some amino acids. Absorption of amino acids. Digestion of proteins. Enzymes of digestion of proteins. Proteolysis and proteolytic enzymes. Predecessors of proteolytic enzymes (trypsinogen, himotrypsynohen, proelastase). Intracellular proteolysis of proteins in lysosomes. Degradation of proteins in proteasome which is localized in the cytoplasm.

Proteins decay in colon and disposal processes of generated toxic products. The formation of the end products of protein metabolism (H_2O , CO_2 , NH_3). Ways of removal of ammonia. Ornithine cycle of formation of urea. Abnormality of the urea cycle formation cause disorders such as argininemia.

Common ways of converting amino acids. Reactions of conversion of amino acids: deamination, decarboxylation, transamination of amino acids (aspartate aminotransferase or AST and alaninaminotransferase or ALT). Biochemical value of conversion of amino acids.

Protein synthesis. Synthesis of somel amino acids, peptides (insulin, glucagon, glutathione) and protein. Nitrogen balance in the body is primarily determined by the metabolism of protein. Protein biosynthesis (translation) and its stages (initiation, elongation, termination). Translation in prokaryotes and eukaryotes. Effect of antibiotics on the process of protein synthesis. Synthesis of insulin. Effect of insulin on glucose uptake by the cell and on metabolism glucose. Synthesis of glutathione and its antioxidant role.

Synthesis of amino acids through transamination reactions: pyruvate (glycolytic end-product) in alanine; oxaloacetate (intermediate of TCAC) in aspartate, and alpha-ketoglutarate (intermediate of TCAC) in glutamate. Synthesis of glycine and role of tetrahydrofolate.

Theme of lecture lesson 6. Catabolism and anabolism of nucleotides and nucleic acids (1)

Catabolic processes of nucleic acids (NA). Exchange of nucleic acids. Nucleoprotein digestion, absorption of hydrolysis products. Effect of antibiotics on nucleoproteins. Enzymes of hydrolysis of NA (endonuclease and exonuclease). The specificity of nucleases: RNase, DNAase, non-specific nucleases. 3'-and 5'-nuclease.

The decay of NA in tissues. Catabolism of purine or synthesis or uric acid and allantoin. Hyperuricemia (gout). The final breakdown of purines (uric acid, allantoin, alantoic acid). Catabolism of pyrimidine bases. The final decay of pyrimidines (beta-alanine, beta-amino isobutyric acid, NH_3 , CO_2).

Biosynthesis of NA. Biosynthesis of purine and pyrimidine nucleotides. Biosynthesis of polynucleotides of DNA and RNA.

Ways of synthesis of nucleotides (“saving” way and de novo way). Synthesis of purine nucleotides, for example, IMP (sequence of reactions). Synthesis of purine nucleotides (ATP and GTP). Pharmacotherapy: inhibitors of purine synthesis. De Novo synthesis of pyrimidine. Synthesis of pyrimidine nucleotides (UTP and CTP). Pharmacotherapy: inhibitors of pyrimidine synthesis. Synthesis of deoxynucleotides. De Novo synthesis of nucleotides. Formation of trinucleotides, polynucleotides of RNA, DNA. Coding of genetic information. DNA replication (replicating “fork”, stages, and enzymes).

Transcription is the synthesis of RNA (stages: initiation, elongation, termination, inhibitors of transcription). Reverse transcription. The life cycle of a retrovirus.

Thematic Module 6. Metabolism and its reflection in the biochemical parameters

Theme of lecture lesson 1. Metabolism and its characteristics by biochemical parameters of urine

Biochemistry of urine. The production of urine. ‘Thresholds’ and non ‘thresholds’ substances of primary urine. Final urine volume (normal, polyuria, oliguria, and anuria). The chemical composition of urine. The composition of urine in normal and pathological conditions (pH, cations, and anions of urine).

Examples: indicators of urine in normal and pathological states. Organic components of normal urine: urea, uric acid, creatinine, and creatine, hippuric acid, indican, amino acids (hyper-amino aciduria), lactic and pyruvic acid, as well as phosphates, NH₃, glucose, ketone bodies.

Theme of lecture lesson 2. Biochemistry of products of animal origin

Biochemistry of milk. Pathological processes during lactation of animals.

pH and chemical composition of milk. Electrophoretic composition of milk caseins. Carbohydrates in milk. Lactose intolerance. Butterfat.

Biochemistry of muscle tissue, eggs, skin and wool. Norm and pathology. Study and control of metabolism, connection with appropriate nutritional conditions.

Biochemistry of honey. Features of honey formation. Chemical composition and biochemical properties of honey. Biochemical processes in bee honey during storage.

The structure of the discipline

Titles of thematic module and themes	Hours											
	Full-time						Extramural study form					
	total	including					total	including				
		L	P	Labv	Ind	self		L	P	Labv	Ind	self
1	2	1	2	1	2	1	2	1	2	1	2	1
Content Module 1. Basics of Physical and Colloid Chemistry												
Topic 1. Biochemistry of Animals is the history of its development and its place among the natural sciences.	5	2		2								
Topic 2. Basics of Physical Chemistry	14	6		8								
Theme 3. Basics of Colloid Chemistry	12	4		6		2						
Total for content module 1	31	12		16		3						
Content Module 2. Physico-chemical methods of research in biochemistry												
Topic 1. Physico-chemical methods of research in biochemistry	22	4		8		10						
Total for content module 2	22	4		8		10						
Content Module 3. Biochemistry: Statics												
Topic 1. Cell and its organic compounds. Carbohydrates	12	4		8								
Topic 2. Lipids and biomembranes	8	2		4		2						
Topic 3. Amino acids, peptides, proteins,	10	6		4								
Topic 4. Nucleosides, nucleotides and nucleic acids	7	2		5								
Total for content module 3	37	14		21		2						
Content Module 4. Regulatory effects of inorganic and organic substances on the metabolism												
Topic 1. Biological membranes. Water and minerals in animals and plants, biochemistry of transmembrane transfers of minerals and organic substances.	7	2		4	-	1						
Topic 2. Vitamins. Coenzymes	7	2		4	-	1						
Topic 3. Enzymes and their kinetic properties	7	2		4	-	1						
Topic 4. Hormones and	7	2		4	-	1						

mechanisms of their influence on metabolic processes													
Total for content module 4	28	8		16	-	4							
Content Module 5. Dynamic and Functional Biochemistry													
Topic 1. Biochemistry of digestion and features of digestive processes in different organisms	5	2		2		1							
Topic 2. Carbohydrate metabolism and its features in different species of animals	13	4		8		1							
Topic 3. Amphibolic transformation of organic substances (TCAC). Energy of biochemical processes	7	2		4		1							
Topic 4. Metabolism of lipids	5	4		2		1							
Topic 5. The metabolic processes of proteins and some amino acids	9	4		4		1							
Topic 6. Catabolism and anabolism of nucleotides and nucleic acids	7	2		4		1							
Total for content module 5	48	18		24		6							
Content Module 6. Metabolism and its reflection in the biochemical parameters													
Topic 1. Some biochemical parameters of biological fluids as a reflection of the state of metabolism in the organism	7	2		2		3							
Topic 2. Biochemistry of products of animal origin	7	2		3		2							
Total for content module 6	14	4		5		5							
Course project (work)													
_____	-	-	-	-									
(if it is in the working educational plan)													
Total hours	180	60		90		30							

4. Seminar topics (*not planned*)

#	Topic title	Hours
1		
2		
...		

Practical class topics (*not planned*)

#	Topic title	Hours
1		
2		
...		

5. Laboratory class topics

#	Topic titles of M 1- M-3	Hours
1-2	M-1. Rules of lab-work and safety in biochemical lab. Facilities, table wires, solutions and reagents of biochemical laboratory. Basics of Physical and Colloid Chemistry Solutions. pH. Methods of pH determination: indicator and ionometric. Determination of pH in the biological samples	4
	The buffered solution. Preparation of the acetate and phosphate buffers and calculation their pH. Determination of buffer capacity. Determination of influence of dilution on the buffered solution pH and capacity.	
3-4	Osmosis. Osmotic pressure in biological systems. The effect of solutions with different osmotic pressure on cells. Osmotic pressure in the erythrocytes. Fenomenon of the blood hemolysis caused by changes of osmotic pressure. Sorption and biological phenomena. Adsorbntional ability of such sorbents as electrolytes, dyes and sols. Adsorptional ability of coal. The processes of sorption and desorption. Fuxin adsorption on glass and its desorption.	6
5-6	Colloidal solutions. The high molecular substances in biological fluids. Preparation of colloidal solutions using dispersion. Preparation of Fe(OH) ₃ by method of hydrolysis. Preparation of sol of "Berlin blue". Preparation of sol of silver. Peculiarities of colloidal solutions. Determination of charge (+ or -) of particles. Coagulation of colloidal solutions. Study of colloidal protection. Irreversible coagulation of organic colloids	6
	Content Module 1. Basics of Physical and Colloid Chemistry	
7-8	M-2 Physico-chemical methods of research in biochemistry Spectrophotometric and Colourmetric methods. Calibration graf building in the purpose of protein concentration determination with "biuret" reagent. Centrifugation. Preparation of glycogen from animal tissues by methods of Pfluger. Cell fractionation by centrifugation (model-experiment)	4
9-10	Fundamentals of electrophoretic separation of high molecular substances. Determination of protein fractions of blood serum by electrophoresis. Determination of protein fractions of blood serum by turbid-dimetric method. Methods of Chromatography. Calculation of R _f of lipid fractions in	4

	<p>muscles for experimental results of some studies by thin layer chromatography. Separation of amino acids (or dyes) mixture by the method of paper chromatography.</p> <p style="text-align: center;">ContentModule 2.</p> <p>Physico-chemical methods of research in biochemistry</p>	
	<p style="text-align: center;">M-3. Biochemistry: Statics</p> <p>Carbohydrates: colour tests on starch and glycogen. Colloidal peculiarities of starch. Acidic hydrolysis of starch. Cellulose dissolving in ammoniac solution of copper oxide (reagent of Shvaytzer).</p> <p>Carbohydrates: mono-, disaccharides. Identification of OH-groups in monosaccharaides. Reactions of oxidation of carbohydrates with aldehyde-group and reduction of metal ions in basic solution (Test of Trommer). Quantative determination of glucose in solution by Felling method. Selivanov test on ketohexose. Sucrose tests. Reduction of metal ions. Sucrose colour tests.</p>	8
11-12	<p>Lipids and their components. Fat identification. Acroleine test. Solubility of fats in different solvents. Formation of soap that is insoluble in water. Saponification of soap. In the fats, identification of unsaturated fatty acids (FA). Oxidation of unsaturated fats.</p> <p>Amino acids. Example of demonstration of amino acids separation by chromatography. Qualitative tests on amino acids: xantoprotein reaction on amino acids; tryptophan test (reaction of Adamceovich); reaction on sulfur containing amino acids (reaction of Foley). Destruction of amino acids by nitrous acid.</p>	4
13-14	<p>Amides of acids. Urea and its peculiarities: preparation nitrate-acidic salt of urea; distruction of urea at heating; biurett reaction.</p> <p>Proteins. Biuret reaction. Reversible reaction of protein sedimentation by ammonium sulfate and by alcohol. Irreversible reaction of protein sedimentation by salts of heavy metals, by reagents to alkaloids (tannin, potassium hexocianoferrat and picric acid), by concentrate inorganic acids, by organic acids and by boiling. Physical and Chemical peculiarities of proteins: determination of isoelectric point (pI) of protein (gelatin).</p>	4
15	<p>Nucleic acids and their components. Isolation of deoxyribonucleoprotein. Hydrolysis of nucleoprotein. DNA identification in deoxyribonucleoprotein. Pentose identification. Purines identification. Phosphoric acid determination in hydrolysates.</p>	5
	Content Module 3. Biochemistry: Statics	
	Total hours	45

№ 3/II	Topic title of laboratory class M 4-6	Hours
1.	<p style="text-align: center;">M-4. Regulatory effects of inorganic and organic substances on the metabolism</p> <p style="text-align: center;">Role of mineral substances in the metabolic processes.</p> <p>The role of macro- and microelements in metabolism. Determination of trace element (Fe) and macronutrients (Mg, Cl) and using different methods in biological samples.</p>	4
2.	<p style="text-align: center;">Some representatives of vitamins. Coenzymes.</p> <p>Fat-soluble vitamins, their detection and role. Qualitative reactions to vitamins A (samples with ferric chloride and sulfuric acid), E (sample with nitric acid).</p> <p>Water-soluble vitamins, their role as coenzymes. Qualitative reactions to</p>	4

	vitamins: B ₁ , B ₂ , B ₅ , and C. Quantitative determination of vitamins C and riboflavin (vitamin B ₂) in biological samples	
3.	Enzymes. Kinetic aspects Effect of temperature and pH on the activity of amylase. Specificity of enzymes (amylase). Determination of amylase activity. Effect of activators and inhibitors on enzyme activity. Kinetic properties of amylase.	4
4.	The role of hormones in metabolic processes Qualitative reactions to hormones. Qualitative reactions to adrenaline: tests with iodine and iron (III) chloride. Qualitative reactions to insulin: biuret reaction to insulin; reactions to sulfur-containing amino acids. Quantitative determination of adrenaline by colorimetric method.	4
5	Content Module 4. Regulatory effects of inorganic and organic substances on the metabolism.	2
6.	M-5. Dynamic and functional biochemistry Carbohydrate metabolism, its intermediates Investigation of the properties of mono- and disaccharides. Quantitative determination of glucose in a biosample by the Fehling method. Reaction to disaccharides. Barfed's reaction. Investigation of the properties of polysaccharides. Detection of glycogen in the liver. Isolation of glycogen by the Pfluger method. Glycogen hydrolysis. Determination of glycogen content in tissues. <i>Control work:</i> glycolysis, glycogenolysis, fermentation, pentose phosphate cycle	8
7	Biological oxidation of substances and their energy metabolism Quantitative determination of lactic acid in the serum of animals by colorimetric method and its detection in muscles; determination of muscle adenosine triphosphatase activity. <i>Control work:</i> TCAC, biological oxidation	4
8	Lipid metabolism and its intermediates Detection of fats. Acrolein test. Determination of iodine and acid number of fat. Qualitative reaction to bile acids. <i>Control work:</i> β -oxidation of FA	2
9	Protein metabolism intermediates and their characteristics (I) Influence of temperature and reaction of the environment on the solubility of proteins. Physico-chemical properties of proteins. Determination of the isoelectric point of a protein (casein). Protein precipitation reactions (organic acids: trichloroacetic, picric; organic solvents: alcohol, acetone). Quantitative determination of protein by the Lowry method. <i>Control work:</i> transformation of amino acids	2
10	Protein metabolism intermediates and their characteristics (II) Qualitative reactions to aromatic amino acids. Reaction to phenylalanine, tyrosine, and tryptophan. Reaction to tyrosine. Reaction to tryptophan. Reaction to thioamino acids. <i>Control work:</i> synthesis of urea	2
11	Nucleic acid metabolism intermediates. Isolation of nucleoproteins from the liver of animals and study of their chemical composition Detection of DNA in deoxyribonucleoprotein. Qualitative reaction to the presence of phosphoric acid <i>Control work:</i> synthesis of uric acid	2
12	Content Module 5. Dynamic and Functional Biochemistry	2
13	M-6. Metabolism and its reflection in biochemical parameters Biochemical parameters of biological fluids	2

	Determination of inorganic components of urine (determination of chlorides, sulfates, phosphates). Determination of pathological components of urine (samples for protein, sugar, pigments, acetone bodies).	
14	Biochemistry of products of animal origin Obtaining whey of milk. Precipitation and isolation of casein. Determination of milk acidity.	1
15	Content Module 6. Metabolism and its reflection in biochemical parameters	2
	Total hours	45

6. Topics of self-work

#	Topic	Number of hours
	Content Module 1. Basics of Physical and Colloid Chemistry	
1	Topic 1. Biochemistry of Animals is the history of its development and its place among the natural sciences.	1
2-3	Topic 2. Basics of Physical Chemistry	
4-5	Topic 3. Basics of Colloid Chemistry	2
	Total for content module 1	3
	Content Module 2. Physico-chemical methods of research in biochemistry	
6-8	Topic 1. Physico-chemical methods of research in biochemistry	10
	Total for content module 2	10
	Thematic Module 3. Biochemistry: Statics	
9-10	Topic 1. Cell and its organic compounds. Carbohydrates	
11-12	Topic 2. Lipids and biomembranes	2
13-14	Topic 3. Amino acids, peptides, proteins,	
15	Topic 4. Nucleosides, nucleotides and nucleic acids	
	Total for content module 3	2
1	Content Module 4. Regulatory effects of inorganic and organic substances on the metabolism	
2	Topic 1. Biological membranes. Water and minerals in animals and plants, biochemistry of transmembrane transfers of minerals and organic substances.	1
3	Topic 2. Vitamins. Coenzymes	1
4	Topic Enzymes and their kinetic properties	1
5	Topic 4. Hormones and mechanisms of their influence on metabolic processes	1
6	Total for content module 4	4
7	Content Module 5. Dynamic and Functional Biochemistry	
8	Topic 1. Biochemistry of digestion and features of digestive processes in different organisms	1
9	Topic 2. Carbohydrate metabolism and its features in different species of animals	1
10	Topic 3. Amphibolic transformation of organic substances (TCAC). Energy of biochemical processes	1
11	Topic 4. Metabolism of lipids	1
12	Topic 5. The metabolic processes of proteins and some amino acids	1
13	Topic 6. Catabolism and anabolism of nucleotides and nucleic acids	1
14	Total for content module 5	6
15	Content Module 6. Metabolism and its reflection in the biochemical parameters	
	Topic 1. Some biochemical parameters of biological fluids as a	3

	reflection of the state of metabolism in the organism	
	Topic 2. Biochemistry of products of animal origin	2
	Total for content module 6	5
	Total	30

7. Samples of control questions, tests for assessing the level of knowledge acquisition by students.

Part 1

Biochemistry (common):

1. Metabolic processes of microorganisms in rumen and their influence on living ability of cows are one of the subject of study ... (of what biochemistry)
2. Static / Dynamic / Functional biochemistry does study...
3. Who got Nobel Prize for discovery of cytric acid cycle or tricarboxylic acids cycle in 1953?
4. The indicated below substances are belong to ...
5. It's necessary to choose right definition of process presented on picture below...

Basics of Physical and Colloid Chemistry:

6. How many grams of glucose ($C_6H_{12}O_6$) and water is necessary for preparing 100 g with mass fraction of glucose 10 %?
7. What solution is isotonic? Solution is isotonic when ...
8. What index is measured with pH-meter?
9. What is the 1st law of Raul about?
10. Please, choose the right phrase about protective power of some colloids

Methods:

11. Spectral characteristics of nucleoside are determined with what device?
12. What is possibility of centrifugation? Please, give characteristic of the method.
13. In medico-biological investigation, what is used in the purpose to separate biopolymers, viruses and subcellular elements?
14. General description of electrophoretic method.
15. What is possibility of electrophoresis? Please, give characteristic of the method.
16. What is possibility of gel-filtration?
17. Common characteristics of ion-exchanged chromatography.
18. Common characteristics paper chromatography.

Carbohydrates:

19. What is monomer of polysaccharide?
20. Monomer(s) of maltose is/are ...
21. After fermentation, the disaccharide (see below) is hydrolyzed into two monomers. It's necessary to choose right equation of disaccharide hydrolysis.
22. Monomer(s) of starch is/are ...
23. What significance/role of starch is?

24. It's necessary to choose polysaccharide which has mainly monomer fructose
25. Monomer of mannan-polysaccharides is...

Lipids:

26. What saturated fatty acids do you know?
27. What significance/role of saturated acids is?
28. What unsaturated fatty acids do you know?
29. Tristearoil glycerol is composed of ...
30. What significance/role of sphingolipids are?

Proteins:

31. Structural organization of protein (common characteristics)
32. What is monomer of protein?
33. Primary structure of protein (common characteristics)
34. The first spatial structure of hemoglobin and myoglobin were determined with X-ray analysis by scientists who got Nobel Prize. These scientists are John Kendrew and ...
35. What amino acids are essential?
36. What significance/role of essential amino acids are?

Nucleic Acids:

37. What is monomer of nucleic acid?
38. What purine nucleobases do you know?
39. Primary structure of nucleic acid (common characteristics)
40. What difference between DNA and RNA?
41. What functions of DNA do you know?
42. Synthesis of ribonucleic acid (common characteristics)
43. According to the principle of complementarities, it's necessary to calculate the molar content of uracil in DNA when there are 158 mol of adenine.
44. Replication of DNA sequence of GGTTGCCAA results ...
45. What common characteristics of replication are?
46. According to the principle of complementarities, it's necessary to calculate the molar content of thymine in DNA when there are 632 mol of adenine.

Part 2

1. Formation of ethanol amine (in the activated form)
2. Build right chain of reactions of the urea cycle from citrulline
3. How does somatotropin influence gluconeogenesis in the liver?
4. Functional biochemistry does study...
5. Glycerol oxidation: glycerol phosphokinase reaction (it's necessary to choose substrates and products).
6. What peculiarities of baby-digestions (it's about enzymes in the different compartments of digestion-tract?)
7. It's necessary to write names of substrates, products and enzyme of the reaction represented below (You can make this task if you know: what pathway is represented by one reaction here).

8. Lactic acid fermentation: under fermentation by *Bact. lactis*, lactic acid is formed from glucose: $C_6H_{12}O_6 \rightarrow 2 CH_3-CHOH-COOH$;
9. ... is compartment of such enzymes as carboanhydrase, uricase, urease, aldolase, and phosphatase.
10. What enzyme does digestion of proteins?
11. Glyceraldehyde-3-phosphate dehydrogenase reaction of glycolysis:
12. (NAD-dependent) isocitric acid reaction of TCAC:

13. Enzymes can be consisted of what class of organic substances? Enzymes can be consisted of...
14. What function do biological membranes in animal organism?
15. What element takes part in the process of oxidative phosphorylation?
16. It's necessary to choose a name of biological active substance which is catalyzed by chemical processes in the organism
17. It's necessary to choose substrates and products of the carbamoyl phosphate synthase reaction of the urea cycle (substrates, products)
18. What is the second irreversible reaction of glycolysis (according to the name of enzyme)?
19. Formation of choline (in the activated form):
20. Build right chain of reactions of the TCAC starting from α -ketoglutarate:
21. All pointed out carboxylic acids belong to ...
22. Cortisol (which is belonged to glucocorticoids) ... gluconeogenesis.
23. What peculiarities of digestions in 'mature' animals (it's about enzymes in the different compartments of digestion-tract)?
24. It is necessary to choose names of substrates, products and enzyme of the reaction represented below (You can make this task if you know: what pathway is represented by one reaction here; substrates, products, enzyme, coenzyme).
25. Synthesis of TAG. It's necessary to choose right reaction of glycerol-3-phosphate formation by glycerol phosphokinase (substrate, products).
26. Catabolism of the sterol esters by enzymes (It's necessary to choose typical reaction with the pointed out substrates, products and enzyme).
27. Substrate phosphorylation in the TCAC is carried at step of transformation of...
28. Alcoholic fermentation and its brief characteristics.
29. Role of Sodium in the animal life:
30. Glycolysis. It's necessary to choose names of substrates and products of the reaction catalyzed by 'phosphoglycerate kinase'
31. The reaction of the TCAC is catalyzed by multi-enzyme complex of α -ketoglutarate dehydrogenase (substrates and products):
32. Biological role of vitamins.
33. Biological role of fat-soluble vitamins.
34. Biological role of water-soluble vitamins.
35. Biological role of vitamin A.
36. Formation of histamine is ...
37. What enzymes do digestions of polysaccharides?
38. What reaction does catalyze by lyase?
39. β -oxidation of fatty acids: what is going on in reaction catalyzed by carnithine

acyltransferase I?

40. In the humane organism, it's founded Cu-deficit that causes lowering enzyme activity of...
41. Role of choleic acid in digestion of lipids:
42. Role of fat-soluble vitamins, especially vitamin F.
43. Localisation of processes of β -oxidation (activation of FA and actually their β -oxidation):
44. Under transamination of pyruvate, it is formed such important substrate of gluconeogenesis as ...
45. Distraction of phospholipids: it's necessary to give characteristic of reaction that catalize by phospholipase D (substrates, products).
46. How it could be lowered the glucose level in the dog's blood (under conditions of diabetes melitus)?
47. Lactic acid fermentation: under fermentation by Bact. lactis, lactic acid is formed from glucose: $C_6H_{12}O_6 \rightarrow 2 CH_3-CHOH-COOH$;
48. What enzyme does digestion of proteins?
49. Glyceraldehyde-3-phosphate dehydrogenase reaction of glycolysis:
50. (NAD-dependent) isocitric acid reaction of TCAC:
51. Role of Selenium in the animal life:
52. What is biological importance of glucose-lactate cycle?
53. Carotenoids are precursors of ... vitamin
54. What is remarkable characteristic of urease?
55. What enzymes do digestion of oligosaccharides?
56. What is "a main purpose" of ornithine cycle?
57. Under transamination of oxaloacetate, it is formed such important substrate of gluconeogenesis as ...
58. What reaction is catalyzed by isomerase?
59. Enzymes of cellular respiration are mainly localized in ...
60. Butyric acid fermentation:

National University of Life and Environmental Sciences of Ukraine			
ED Master Direction of training Veterinary Medicine	Department of Biochemistry and Physiology of Animals, 20__-20__ educational. year	EXAM TEST №_1_ of discipline Biochemistry of Animals with the Fundamentals of Physical and Colloid Chemistry	Confirm Acting as Heads _____ (signature) <u>Tomchuk V.A.</u> (Fn,Init) 20__
Examination questions (The maximum score is 10 points for every question)			
1. What participants of TCAC reaction precede the formation of malate?			
2. Create a series of changes to the ribosome during protein biosynthesis, where the last step was the formation of peptide bond			
Tests of various types (The maximum score is 10 points for answers to tests)			
1 Below pointed compounds can be called ..			
...		(in the form of answers write in short)	
AMP	ADP	ATP	CMP
GMP	GDP	UDP	UMP
UTP	CDP	CTP	GGP
2. Synthesis of TAG: Describe diacylglycerol-acyltransferase reaction (substrates, products).			
A) phosphatidic acid → 1,2-diacyl glycerol + P _i			
B) dyoxyacetophosphate + NADH ⁺ + H ⁺ → glycerol-3-phosphate + NAD ⁺			
C) phosphatidic acid + acyl-CoA → 1,2-diacyl glycerol + CoASH			
D) glycerol-2-phosphate → glycerol-3-phosphate			
E) 1,2 diacylglycerol + acyl-CoA → triacyl glycerol + CoASH			
3. . The first stage of pentose phosphate pathway is called ...			
4. How are monoacyl glycerols absorbed?			
A) monoacyl glycerols are absorbed by simple diffusion;			
B) monoacyl glycerols are absorbed by pinocytosis;			
C) monoacyl glycerols are absorbed by simple diffusion or pinocytosis;			
D) monoacyl glycerols are absorbed in combination with bile acids;			
E) monoacyl glycerols are absorbed by phagocytosis;			
5. What are 3 reactions in glycolysis irreversible?			
A) mutase, phosphofructokinase, pyruvate kinase reactions			
B) hexokinase, phosphofructokinase, pyruvate kinase reactions			
C) hexokinase, phosphofructokinase, lactate dehydrogenase reactions			
D) hexokinase, aldolase, pyruvate kinase reactions			
E) triosphosphate isomerase, aldolase, enolase reactions			
6. What level of the Pentose Phosphate Pathway function effectiveness is in the tissues with a predominance of oxidative metabolism (for example, skeleton muscles)?			
A) high level;			
B) low level;			
C) stable low level;			
D) the depressed level;			
E) no changes			
7. Glucokinase reaction of glycolysis.			
A) substrate: phosphoenol pyruvate, ADP, H ₂ O; product - pyruvate, ATP			
B) substrates: glyceraldehyde-3-phosphate, P _i , NAD ⁺ ; products - 1.3 diphosphoglycerate, NADH (H ⁺);			
C) substrates: 1.3 diphosphoglycerate, ADP, NAD ⁺ ; products - 3-phosphoglycerate, ATP;			
D) substrate: glucose, ATP; product - glucose-6-phosphate, ADP;			
E) substrate: 2-phosphoglycerate, H ₂ O; product - phosphoenol pyruvate			
8. Fumarate hydratase (fumarase) of TCAC reaction has ...			
A) substrates: isocitrate, NAD ⁺ ; products: α-ketoglutarate, NADH (H ⁺), CO ₂ ;			
B) substrates: succinate, FAD; products - fumarate (trans-compound) FADH ₂ ;			
C) substrates: acetyl-CoA, oxaloacetate, H ₂ O; products - citrate, CoA-SH;			
D) substrates: isocitrate, NAD ⁺ ; Products: alpha-ketoglutarate, NADH (H ⁺);			
E) substrates: fumarate, H ₂ O; Product: Malate;			
9. What enzymes do digestion of carbohydrates?			
A) protease, trypsin, pepsin, transferase;			
B) phosphodiesterase, nukleozidase, ligase			
C) lipase, phospholipase, holesterol esterase			
D) amylase, succrase, maltase, celobiase			
E) nuclease, lipase, amylase			
10. Microelement (that has antioxidant properties) is involved in oxidative phosphorylation, along with vitamins E and produces radioprotective effect, and there is:			
A) Zn			
B) Co			
C) Mo			
D) Mn			
E) Se			

8. Teaching methods

Methods of organization and implementation of educational and cognitive activities.

According to the source of transmission and perception of educational information:

- verbal (story, conversation, lecture);
- visual (illustration, demonstration, lecture presentations, elearn);
- practical (performing chemical experiments, exercises).

According to the degree of management of educational activities. Educational work under the guidance of a teacher. Independent work of students:

- work with a book, written work, laboratory work, elearn;
- work under the guidance of a teacher;
- work on the educational and information portal of NULES of Ukraine, elearn;
- individual work of students (with a book, written, laboratory, performance of tasks).

The main types of training in the discipline "Biochemistry of animals with the basics of physical and colloid chemistry" are classes: classroom (lecture, laboratory, consultation, which can be fully or partially conducted both "online" and "offline") and extracurricular - individual student work.

9. Forms of control

To control the quality of knowledge and skills of students in the discipline "Biochemistry of animals with the basics of physical and colloid chemistry" are used: written control, oral examination, modular test tasks in the laboratory and in the ENC; individual and group interviews; test; exam.

10. Distribution of grades received by students.

Evaluation of student knowledge is carried out on a 100-point scale and is converted to national grades according to Table 1 "Regulations and Examinations and Credits at NULES of Ukraine" (order of implementation dated 03.03.2021, protocol №7)

Student rating, points	National grade based on exam results	
	Exams	Credits
90-100	Excellent	Passed
74-89	Good	
60-73	Satisfactory	
0-59	Unsatisfactory	Not passed

In order to determine the rating of a student (listener) in the discipline R_{dis} (up to 100 points), the rating from the exam R_{ex} (up to 30 points) is added to the rating of a student's academic work R_{aw} (up to 70 points): $R_{dis} = R_{aw} + R_{ex}$.

11. Educational and methodological support.

1. Biochemistry of animals with the basics of physical and colloid chemistry: study guide/ L. Kalachniuk, V. Tomchuk – Kyiv: NULES of Ukraine, 2022. - 240 p.
2. Біохімія тварин з основами фізичної і колоїдної хімії» / В.А. Томчук, В.А. Грищенко, Л.Г. Калачнюк та ін. Київ: НУБіП України, 2020. – 442 с.
3. Біохімія: практикум / Д.О. Мельничук, С.Д. Мельничук, Л.Г. Калачнюк, Г.І. Калачнюк. За загальною редакцією академіка НАН України і НААН Д.О. Мельничука (рекомендовано Міністерством освіти і науки, молоді та спорту України, лист № 1/11-16887 від 30.10.2012) - К: ВЦ НУБіП України, 2012, 528 с.
4. Методичні рекомендації до виконання лабораторних робіт з дисципліни: «Біохімія тварин з основами фізичної і колоїдної хімії» для студентів факультету ветеринарної медицини. Методичні рекомендації / С.Д. Мельничук, Л.Г. Калачнюк, Г.І. Калачнюк, Л.В. Кліх. К: Видавничий центр НУБіП України, 2013. – 148 с.

12. Recommended sources of information

- Basic;

1. D.L. Nelson, M.M. Cox. Lehninger Principles of Biochemistry. Publisher: W.H. Freeman (15th Edition), 2009, ISBN-10: 0-7167-7108-X. ISBN-13: 978-0-7167-7108-1. 1100 p.
2. Koelman J., Röhm K.-H. Color Atlas of Biochemistry. Thieme. 2013. 506 p.
3. Біохімія. Підручник / Л.І. Остапченко, Т.Р. Андрійчук, Ю.Д. Бабенюк та ін. / За ред. Л.І. Остапченко / – К.: Видавничо-поліграфічний центр «Київський університет», 2012. – 796 с.
4. Губський Ю.І. Біологічна хімія. Київ – Вінниця: Нова книга, 2007. – 655 с.
5. Thomas D. Pollard, William C. Earnshaw, Ph. D. Cell biology. – Elsevier Science (USA), 2002. – 804 p.
6. Berg J.M., Tymoczko J.L., Stryer L. Biochemistry. – New York: W H Freeman; 2002. 1515 p.
7. Кучеренко М.Є., Бабенюк Ю.Д., Войціцький В.М. Сучасні методи біохімічних досліджень. К.: Фітосоціоцентр, 2001. – 424 с.

– Supplemental.

1. Калачнюк Л.Г. Трансляційні і транс-трансляційні процеси у клітині та окремі механізми їх регуляції (монографія). – К: Компринт, 2017.–155 с.
2. Калачнюк Л.Г. Молекулярні механізми регуляції метаболічних процесів за дії екзогенних чинників (монографія). – К: Компринт, 2016. – 361 с.
3. Теоретичні та методичні засади вивчення метаболічних процесів у тварин і людини за показниками крові : навчальний посібник / Л.Г. Калачнюк, О.В. Арнаута. - Київ. – 2015. – 580 с.
4. Ishchenko L., Ushkalov V., Vygovska L. Principles of molecular diagnostics / in Laboratory practice. Manual / edited by M.Klopčič and T.Ishchenko. –SMC

VFPO. – Kyiv. 2020. – 280p. (колективний посібник)
<http://www.aglab.org/sites/default/files/manuals/Structure%20of%20the%20manual%20and%20WG.pdf>

5. *Кононський О.І.* Біохімія тварин. Київ: Вища шк., 2006. – 454 с.

Information Resources

1. Web pages of scientific journals:

- Ukrainian Biochemical Journal <http://ua.ukrbiochemjournal.org/>

- Animal Biology <http://aminbiol.com.ua/>

2. US National Library of Medicine, National Institutes of Health

<https://www.ncbi.nlm.nih.gov/pubmed/>

3. National Library of Ukraine named after VI Vernadsky [Electronic resource]: [Website]. - Electronic data. - Kyiv: NBUV, 2013-2015. - Access mode: www.nbu.gov.ua.

4. Wikipedia <https://uk.wikipedia.org/wiki/>

5. EEC "Biochemistry of animals with the basics of physical and colloid chemistry" (full term in English) <https://elearn.nubip.edu.ua/course/view.php?id=686>

6. EEC "Biochemistry of animals with the basics of physical and colloid chemistry" (full term in Ukrainian) <https://elearn.nubip.edu.ua/course/view.php?id=587>