ASSESSMENT FUND

for discipline «Biochemistry»

The level of higher education

SPECIALTY

Direction of preparation

Specialisation 560001 - KR General medicine

(the code and Direction of preparation)

2026

The assessment fund is designed to control the knowledge of students in the direction of preparation (specialisation) *General medicine* in the discipline (practice) "Biochemistry".

The assessment fund is reviewed and approved at the meeting of the department
Base and Clinical Pharmacy, Chemistry and Biochemistry

Record of 7.09. 2026. № 2

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1. STUDENTS' COMPETENCIES RESULTING FROM THE COURCE UNIT (MODULE)

Formation of competence	Planned learning outcomes in the discipline, characterizing the stages of competencies formation	Types of assessment tools/ section code in this document
PC-6: In order to address professional tasks a student is capable and ready to assess the morphofunctional and physiological states and pathological processes in the human body in different age and gender groups.	**Knowledge:** - To characterize biochemical processes in normal conditions and at during age and gender groups for the purpose of addressing professional tasks.	Block **A, D -** tasks of the reproductive level - *Oral discussion* - *Control work* - *Test* - *Exam (oral answer)*
	Skills: - To use biochemical methods to solve professional tasks, taking into account age and gender groups.	Block **B, D** - tasks of the reconstructive level: - *Solving situational cases* - *Report*
	Expertise: To understand the molecular mechanisms of disease pathogenesis; skills in assessing the diagnostic and prognostic significance of biochemical analysis results.	**Block D** – practice-oriented and/or research level assignments - *Solving situational cases*
PC-7: Capable and ready to conduct and interpret patient interviews, physical examinations and clinical assessments, as well as the results of modern laboratory and instrumental tests and to complete outpatient and inpatient medical records.	**Knowledge:** The range of modern biochemical tests required for the examination of outpatients and inpatients.	Block **A, D -** tasks of the reproductive level - *Oral discussion* - *Control work* - *Test* - *Exam (oral answer)*
	Skills: To Interpret the results of modern biochemical tests required for the assessment of outpatients and inpatients.	Block **B, D** - tasks of the reconstructive level: - *Solving situational cases* - *Report*
	Expertise: The Skills in the analysis and clinical-biochemical interpretation of laboratory tests.	**Block D** – practice-oriented and/or research level assignments - *Solving situational cases*
DC-7: Capable of applying fundamental physicochemical, mathematical, and natural science concepts and methods to solve professional problems.	**Knowledge:** Fundamental physicochemical principles underlying the vital processes of the organism. Major pathways of protein, lipid, carbohydrate, and energy metabolism, and their interrelationships.	Block **A, D -** tasks of the reproductive level - *Oral discussion* - *Control work* - *Test* - *Exam (oral answer)*
	Skills: Apply physicochemical and mathematical methods to solve biochemical problems. Explain the mechanisms of key metabolic processes using concepts from the natural sciences	Block **B, D** - tasks of the reconstructive level: - *Solving situational cases* - *Report*
	Expertise: Skills in applying physicochemical methods to the study of biological systems and using knowledge from the natural sciences to explain the mechanisms of pathological changes.	**Block D** – practice-oriented and/or research level assignments - *Solving situational cases*

The planning sheet of discipline

Discipline Biochemistry
Area/specialization General Medicine
Course/semester 1/2
Credit units (CU) 4

Title of module according to WPD	Type of control	Forms of control	Minimal credit points	Maximal credit points	Week of control
Module 1					
Module 1. **Molecular basics of structural cellular organization**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks	5	8	4
	Midterm examination	Evaluation test	5	8	
Module 2					
Module 2. **Neuroendocrine regulation of cellular activity**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks	5	9	7
	Midterm examination	Evaluation test	5	9	
Module 3					
Module 3. **Molecular basics of vital functions and pathology**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks, writing of reports	5	9	12
	Midterm examination	Evaluation test	5	9	
Module 4					
Module 4. **Biological oxidation, cell energetics and carbohydrate metabolism.**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks	5	9	16
	Midterm examination	Tests	5	9	
Total for semester			40	70	
Midpoint assessment			20	30	
Summative assessment			60	100	

The planning sheet of discipline

Discipline Biochemistry
Area/specialization General Medicine
Course/semester 2/3
Credit units (CU) 4

Title of module according to WPD	Type of control	Forms of control	Minimal credit points	Maximal credit points	Week of control
Module 1					
Module 1. **Metabolism and functions of lipids**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks	4	7	3
	Midterm examination	Evaluation test	6	11	
Module 2					
Module 2. **Metabolism of proteins and amino acids**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks, writing of reports	4	7	6
	Midterm examination	Evaluation test	6	11	
Module 3					
Module 3. **Molecular mechanisms of transfer of genetic information**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks.	3	5	10
	Midterm examination	Tests	3	5	
Module 4					
Module 4. **Functional biochemistry of organs and tissues.**	Formative assessment	Activity, attendance, lecture notes, performance and presentation of lab works, individual work with tables, discussion of situational tasks, reports	6	10	16
	Midterm examination	Evaluation test	8	14	
Total for semester			40	70	
Midpoint assessment			20	30	
Summative assessment			60	100	

3. STANDARD CONTROL TASKS AND OTHER MATERIALS IMPORTANT FOR EVALUATING PLANNED LEARNING RESULTS IN THE DISCIPLINE "BIOCHEMISTRY" (ASSESSMENT TOOLS)

Block A

A.0 Fund of tests for the discipline.

Composition of living matter. Proteins and peptides.

1. Match: which peptide containing all cyclic amino acids

1) Ser-met-gln-arg
2) Asn-ser-tre-gln
3) Gly-glu-tre-asp
4) Fen-trp-pro-tyr

2. The secondary structure of a protein is

1) quantity, quality and sequence of amino acids in the polypeptide chain
2) a three-dimensional spatial structure formed between amino acid radicals located at a considerable distance from each other in the polypeptide chain.
3) spatial structure formed as a result of interactions between functional groups of the peptide bonds.
4) Consists of several protomers

3. Oligomeric protein

1) consists of several protomers
2) quantity, quality and sequence of amino acids in the polypeptide chain
3) a three-dimensional spatial structure formed between amino acid radicals located at a considerable distance from each other in the polypeptide chain.
4) spatial structure formed as a result of interactions between functional groups of the peptide bonds.

4. What is the isoelectric point of proteins?

1) pH value at which the protein is active
2) the state of the protein in which it has hydrophilic properties
3) the concentration of hydrogen ions at which the protein moves towards the anode in an electric field
4) pH value at which the protein is electrically neutral

5. What is the name of the process of division of proteins from low molecular weight compounds?

1) dialysis
2) hydrolysis
3) denaturation
4) chromatography

6. Indicate the variant of hemoglobin in which in the 6th position of the β-chain the glutamic amino acid is replaced by valine:

1) HbA;
2) HbC;
3) HbS;

4) HbH;

7. Myoglobin

1) transports O2
2) transports CO2
3) participates in muscle contraction
4) O2 depot

8. Transport of iron in the blood into heme-synthesizing cells occurs in combination with protein:

1) ferritin;
2) ceruloplasmin;
3) transferrin;
4) hemosiderin;

9. Which substance consists from only amino acids upon hydrolysis?

1) histones
2) RNA protein
3) phosphoproteins
4) myoglobin

10. What compounds are included in the prosthetic group of lipoproteins

1) phosphoglycerides
2) glycolipids
3) steroids
4) thymidylic acid

11. Name the molecular defect in hemoglobin S

1) replacement of beta chains with alpha chains
2) replacing valine with glutamic acid
3) replacement of alpha chains with beta chains
4) replacing glutamic acid with valine

12. What amino acids form the basis of collagen

1) meth, gly, lys
2) ala, cis, gly
3) gly, pro, lys
4) lei, glu, arg

13. The primary structure of nucleic acids is stabilized by:

1) hydrophobic bonds;
2) 3′,5′-phosphodiester bonds;
3) hydrogen bonds;
4) ionic bonds.

14. The secondary structure of DNA is:

1) α-helix;
2) “clover leaf”;
3) double helix;
4) triple helix.

15. In nucleoproteins, between the protein component and the nucleic acid, the following is formed:

1) hydrophobic bond;
2) 3′,5′-phosphodiester bond;
3) hydrogen bond;
4) ionic bond.

16. Complementary nitrogenous bases are:

1) adenine and thymine;
2) adenine and cytosine;
3) adenine and guanine;
4) cytosine and uracil.

17. As part of chromatin, the DNA molecule is associated with:

1) globulins;
2) protamines;
3) histones;
4) glutelins.

18. Chromoproteins are proteins that have as a prosthetic group:

1) DNA;
2) lipids;
3) carbohydrates;
4) pigments;

19. A hemoglobin molecule can bind:

1) 2 oxygen molecules;
2) 1 molecule of oxygen;
3) 4 oxygen molecules;
4) 3 oxygen molecules.

20. Glycoproteins are complex proteins that contain a prosthetic group, which is:

1) heme;
2) lipid derivatives;
3) derivatives of carbohydrates;
4) nucleotides;

21. Nucleic acids perform the following functions in the body:

1) energy source
2) storage and transmission of hereditary information
3) depot
4) hormonal
5) regulatory

22. In proteoglycans, the prosthetic group is:

1) neuraminic acid;
2) sialic acid;
3) hyaluronic acid;
4) mannose;
5) galactosamine.

23. Indicate the types of bonds between the protein and carbohydrate components in proteoglycans:

1) ionic and hydrogen;

2) hydrogen and hydrophobic;
3) O-, N-glycosidic and ionic;
4) O-glycosidic and N-glycosidic;
5) O-, N-glycosidic and hydrophobic.

24. Lipoproteins are complex proteins that contain a prosthetic group, which is:

1) heme;
2) lipid derivatives;
3) derivatives of carbohydrates;
4) nucleotides;
5) vitamins group B.

25. Currently, the general accepted model of the structure of the cell membrane is:

1) trilaminar
2) liquid mosaic
3) lipid-protein structure
4) lipid bilayer

26. The main lipid components (80-90%) of plasma biomembranes are:

1) neutral lipids
2) glycolipids
3) phospholipids
4) steroids
5) free fatty acids

27. The main properties of biomembranes include:

1) dynamism, isolation
2) elasticity, asymmetry, closeness
3) isolation, dynamism, asymmetry
4) asymmetry, dynamism

28. Membrane fluidity is determined by the following factors:

1) the size of protein molecules
2) the length of hydrocarbon radicals of higher fatty acids
3) the nature of the carbohydrate component
4) degree of unsaturation of higher fatty acids
5) the presence of neutral lipids

29. List the types of passive transport:

1) simple diffusion
2) Na^+-, K^+-pump
3) facilitated diffusion
4) phagocytosis
5) pinocytosis

30. Facilitated diffusion as opposed to simple due to:

1) carried out against a concentration gradient
2) requires energy consuming
3) has a certain speed limit
4) typical only for polar compounds

5) depends on the concentration of carrier proteins

31. Glucose can enter the cell by:

1) facilitated diffusion
2) symport with Na+ ions
3) facilitated diffusion and symport with Na+ ions
4) antiport with Na+ ions

32. The work of the Na+/K+ pump provides:

1) high concentration of K+ ions outside the cell, Na+ ions inside the cell
2) high concentration of K+ ions inside the cell, Na+ ions outside the cell
3) high concentration of K+ and Na+ ions inside the cell

33. Secondary active transport is carried out due to:

1) direct hydrolysis of ATP
2) energy stored in ion gradients
3) direct hydrolysis of ATP and energy stored in ion gradients

34. Active transport is:

1) two different substances are simultaneously transported into the cell
2) transport of the substance occurs together with part of the plasma membrane
3) the transfer of a substance occurs against its concentration gradient
4) passive transport of substance without carrier proteins
5) transport of a substance along its concentration gradient with the participation of carrier proteins

35. Simport is:

1) two different substances are simultaneously transported into the cell
2) transport of the substance occurs together with part of the plasma membrane
3) the transfer of a substance occurs against its concentration gradient
4) passive transport of substance without carrier proteins
5) transport of a substance along its concentration gradient with the participation of carrier proteins

36. Simple diffusion is:

1) two different substances are simultaneously transported into the cell
2) transport of the substance occurs together with part of the plasma membrane
3) the transfer of a substance occurs against its concentration gradient
4) passive transport of substance without carrier proteins
5) transport of a substance along its concentration gradient with the participation of carrier proteins

37. Facilitated diffusion is:

1) two different substances are simultaneously transported into the cell
2) transport of the substance occurs together with part of the plasma membrane
3) the transfer of a substance occurs against its concentration gradient
4) passive transport of substance without carrier proteins
5) transport of a substance along its concentration gradient with the participation of carrier proteins

38. Select a protein-peptide hormone from the following:

1) adrenaline

2) insulin
3) testosterone
4) corticosterone
5) thyroxine

39. Select from the following a hormone - a derivative of amino acids:

1) thyroxine
2) glucagon
3) estriol
4) insulin
5) corticosterone

40. Select a steroid hormone from the following

1) oxytocin
2) thyrotropin
3) progesterone
4) insulin
5) glucagon

41. From the list below, select the second stage in the mechanism of action of hormones acting through the adenylate cyclase mechanism

1) change in adenylate cyclase activity
2) interaction with the receptor on the cell surface
3) activation of protein kinases
4) change in c-AMP concentration
5) activation of G proteins

42. Indicate the role of G protein in hormonal signal transmission:

1) Enhances hormonal signal transmission
2) Causes proteolysis of the receptor
3) Binds ATP
4) Binds to a hormone
5) Binds to c-AMP

43. The main effect of aldosterone is:

1) Increased reabsorption of potassium in the renal tubules
2) Decreased proton excretion
3) Decrease in circulating blood volume
4) Increased sodium reabsorption in the renal tubules
5) Increased proton excretion

44. Hormones influence the metabolism of proteins, fats and carbohydrates are:

1) Adrenaline
2) Insulin
3) Parathyroid hormone
4) Calcitonin
5) Glucocorticoids

45. Select the incorrect statement about insulin:

1) Activates pyruvate dehydrogenase, alpha-ketoglutarate dehydrogenase, hexokinase

2) Inhibits glycogen phosphorylase
3) Activates phosphoenolpyruvate carboxykinase (gluconeogenesis)
4) Activates acetyl-CoA carboxylase
5) Has an anabolic effect

46. Which hormone affects protein metabolism like insulin:

1) Glucagon
2) Growth hormone
3) Glucocorticoids
4) Adrenaline
5) Oxytocin

47.Indicate true statements:

1) liver, muscle and adipose tissue - target organs for insulin
2) excess insulin causes an increase in blood glucose levels
3) hypersecretion of insulin contributes to excess accumulation of glycogen
4) brain, red blood cells, bone tissue - target organs for insulin
5) under the influence of insulin, the accumulation of neutral fats is stimulated

48. Explain the possible causes of hyperglycemia in a healthy person:

1) eating
2) insulin hypersecretion
3) physical inactivity
4) activation of sex
5) insulin deficiency.

49. What role do Ca^{++} ions not play in the body:

1) hormone
2) xanthine dehydrogenase activator
3) participant in blood clotting
4) phosphorylase inhibitor
5) participant in muscle contraction.

50. Determine the hierarchy of action of hormones under hypothalamic-pituitary regulation:

1) CNS→releasing factors→adenopituitary→target organs;
2) CNS→releasing factors→anterior pituitary gland→blood→target organs;
3) CNS→hypothalamus→posterior pituitary gland→blood→target organs;
4) CNS→hypothalamus→releasing factors→pituitary gland→blood→peripheral endocrine gland→target organs
5) there is no correct answer

51. Indicate the class of enzymes whose representatives require energy consuming to carry out catalysis:

1) oxidoreductases;
2) transferases;
3) lyases;
4) isomerases;
5) ligases

52. Lipase, α-amylase and trypsin belong to the class:

1) oxidoreductase
2) transferases
3) lyase
4) hydrolase
5) isomerase

53. NAD+-dependent anaerobic dehydrogenases include:

1) aspartate aminotransferase;
2) lactate dehydrogenase;
3) succinate dehydrogenase;
4) methyltransferase;
5) alanine aminotransferase.

54. Enzymes that split a substrate molecule into two fragments with the addition of a water molecule at the site of the break belong to the class:

1) ligases;
2) isomerases;
3) hydrolases;
4) lyases;
5) transferases

55. The following vitamin has an antihemorrhagic effect:

1) ergocalciferol;
2) retinol;
3) phylloquinone;
4) riboflavin;
5) ascorbic acid.

56. In the animal body the following is synthesized from tryptophan:

1) nicotinamide adenine dinucleotide;
2) riboflavin;
3) pantothenic acid;
4) vikasol;
5) tocopherol.

57. Vitamin takes part in transmethylation reactions:

1) routine;
2) retinol;
3) niacin;
4) folic acid;
5) lipoic acid.

58. Name the disease caused by hypovitaminosis D3:

1) seborrhea;
2) gout;
3) beri-beri;
4) megaloblastic anemia;
5) rickets.

59. Hemolytic anemia in newborns can be caused by vitamin deficiency:

1) B1;

2) B12;
3) K;
4) E;
5) B9.

60. Which of the following metabolites is not formed in the pentose phosphate pathway:

1) fructose-6-phosphate
2) fructose-1-phosphate
3) erythrose-4-phosphate
4) CO2
5) sedoheptulose-7-phosphate.

61. Muscle glycogen is not involved in maintaining blood glucose levels because:

1) muscles do not contain glucokinase
2) muscles do not contain glycogen phosphorylase
3) muscles do not contain glucose-6-phosphatase
4) muscles do not contain hexokinase
5) muscles do not contain glucose-1-phosphatase

62. Gluconeogenesis:

1) occurs exclusively in the cytosol
2) uses amino acids as a substrate
3) uses fatty acids as a substrate
4) occurs in the mitochondrial matrix
5) all statements are true

63. Which of the following components cannot participate in gluconeogenesis:

1) lactate
2) acetyl-CoA
3) glycerin
4) alanine
5) pyruvate

64. Which molecules involved in the formation of surface layer of lipoproteins?

1) triacylglycerols
2) cholesterol esters
3) phospholipids
4) proteins
5) cholesterol

65. Which tissue is not capable of using fatty acids as an energy source?

1) liver
2) kidneys
3) skeletal muscles
4) heart muscle
5) brain

66. In which organs and tissues cholesterol synthesis is not occur?

1) in the liver
2) in the intestines

3) in the skin
4) in the brain
5) red blood cells

67. How much cholesterol is synthesized per day?

1) 500 mg
2) 800 mg
3) 200 mg
4) 100 mg
5) 400 mg

68. What hormones stimulate cholesterol synthesis?

1) insulin
2) thyroid hormones
3) glucagon
4) prolactin
5) vasopressin

69. How many fatty acids are synthesized simultaneously in a multienzyme complex

1) 2
2) 1
3) 4
4) 3
5) 6

70. Which fatty acid is a precursor of prostaglandins

1) palmitic
2) arachidonic
3) myristic
4) linolenic
5) linoleic

71. Which enzyme is activated by heparin:

1) pancreatic lipase
2) lipoprotein lipase
3) triglyceride lipase
4) colipase
5) lingual lipase

72. Transamination of amino acids is not:

1) is a stage of amino acid catabolism
2) can serve for the synthesis of amino acids
3) does not lead to a change in the total number of amino acids
4) leads to an increase in the total amount of amino acids
5) accompanied by the formation of ammonia

73. Not typical for direct deamination

1) transamination with alpha-ketoglutarate
2) the process is not associated with transamination
3) deamination of glutamic acid

4) NAD+ is involved
5) oxidases are involved.

74. What processes are not accompanied by the formation of ammonia in the body?

1) deamination of amino acids
2) neutralization of biogenic amines
3) breakdown of urea
4) deamination of purine and pyrimidine bases
5) amination of alpha-ketoglutarate

75. The coenzyme of transaminases is a vitamin derivative

1) B1
2) B2
3) B3
4) B6
5) B12

76. What compound is formed from alanine during transamination?

1) pyruvate
2) oxaloacetate
3) glutamate
4) serine
5) malate

77. The physiological minimum of proteins is

1) 100-120 g/day
2) 30-45 g/day
3) 120 g/day
4) 60 g/day
5) < 30 g/day

78.Which amino acids are not involved in the synthesis of urea?

1) ornithine
2) histidine
3) citrulline
4) arginine
5) aspartate

79. How much urea is excreted in urine per day?

1) 30 g
2) 50 g
3) 100g
4) 40 g
5) 70 g

80. Neutralization of biogenic amines occurs with the participation of enzymes

1) monoamine oxidases
2) diamine oxidases
3) decarboxylase
4) L-amino acid oxidases

5) transaminases.

81. What biogenic amine is formed during the decarboxylation of glutamic acid?

1) serotonin
2) histamine
3) gamma-aminobutyric acid
4) tryptamine
5) histidine

82. What functions does histamine not perform?

1) dilates blood vessels
2) constricts blood vessels
3) has a pro-inflammatory effect
4) has an anti-inflammatory effect
5) stimulates the secretion of gastric juice

83.What methods of transmembrane transport is used for reabsorption?

1) simple diffusion
2) facilitated diffusion
3) active transport
4) vesicular transport
5) osmosis

84. Uric acid is the end product of metabolism of:

1) purine nucleotides
2) pyrimidine nucleotides
3) neutral lipids
4) proteins
5) amino acids

85. Glucosuria is observed when the blood glucose level increases above

1) 5.55 - 6.0 mmol/l
2) 8.3 - 8.8 mmol/l
3) 9.6 - 10.3 mmol/l
4) 3.3-5.5 mmol/l
5) 5.5-7.0 mmol/l

86. What organs and tissues do you think are not involved in the regulation of acid-base balance?

1) kidneys
2) stomach
3) lungs
4) liver
5) bone tissue

87. Select the synthesis and secretion of which hormone is increased in response to an increasing osmotic pressure:

1) Aldosterone
2) Cortisol
3) Vasopressin
4) Adrenaline

5) Glucagon

88. What factors can cause disruption of the primary structure of collagen?

1) vitamin C deficiency;
2) mutations in fibroblast DNA;
3) copper deficiency;
4) lack of vitamin A;
5) oxygen deficiency.

89. The metabolism of connective tissue is proved by excretion in urine of:

1) urea
2) hydroxyproline
3) glycine
4) uric acid
5) hyaluronic acid

90. Actin is characterized by:

1) the presence of two forms: globular and fibrillar;
2) formation of a complex with myosin in the presence of ADP;
3) formation of a complex with tropomyosin;
4) ability to hydrolyse ATP;
5) lack of ATPase activity.

91. Properties of myosin:

1) spontaneously form fibers at physiological pH values;
2) enzymatic activity;
3) bind the polymerized form of actin;
4) spontaneously form a bond with tropomyosin;
5) during muscle contraction, thin myosin filaments can change their thickness and slide along the actin filaments.

92. Tropomyosin is:

1) globular protein;
2) fibrillar protein;
3) a protein that folds onto actin, closing the binding center with the myosin head;
4) a protein that activates the ATPase activity of myosin;
5) protein that binds 7 actin globules.

93.Indicate the main source of energy for normal brain function

1) ketone bodies
2) glucose
3) creatine phosphate

94. How does GABA inactivation occur?

1) methylation
2) transamination
3) decarboxylation

95. Which of these neurotransmitters perform exclusively excitatory functions in the central nervous system?

1) Aspartate and glutamate.
2) Acetylcholine and glycine.

3) Dopamine and GABA.
4) Serotonin and norepinephrine.

96. Which ions play the most important role in the formation of the action potential?

1) K+, Na+.
2) Na+, Mg2+.
3) K+, Li+.
4) Na+, Li+.

97. Select from the following compounds the one that is not a neurotransmitter in the human nervous system:

1) Serotonin.
2) Nitric oxide.
3) Acetylcholine.
4) β-alanine.

98. At rest, the brain is supplied with energy almost entirely by:

1) Anaerobic glycolysis.
2) Pentose phosphate oxidation of glucose.
3) Aerobic breakdown of glucose.
4) Catabolism of ketone bodies.

99. Ammonia detoxification in nervous tissue is carried out by:

1) Urea synthesis.
2) Reductive amination of α-ketoglutaric acid.
3) Glutamine synthetase reaction.
4) Reductive amination of α-ketoglutaric acid and glutamine synthesis.

100. Select a neurotransmitter from the compounds below:

1) Oxytocin.
2) Serotonin.
3) Histamine.
4) Cortisol.

101. During prolonged muscular work:

1) The level of insulin in the blood increases.
2) Gluconeogenesis from glycerol in the liver is increased.
3) Glycogen breakdown occurs in the muscles.
4) Glycogen breakdown occurs in the liver.
5) Glucogenesis from lactate in the liver is increased.

102. The concentration of glucose in the blood at different periods of time is maintained due to:

1) Mobilization of muscle glycogen.
2) Mobilization of liver glycogen.
3) Gluconeogenesis from pyruvate, acetyl-CoA, glycerol and alanine.
4) Gluconeogenesis from pyruvate, glycerol, lactate and alanine.

103. The reactions of the pentose phosphate pathway are the least intense:

1) in the liver;
2) in the adrenal cortex;

3) in adipose tissue;
4) in skeletal muscles;
5) in breast tissue.

104. The regulatory enzyme of the pentose phosphate cycle is:

1) transketolase;
2) transaldolase;
3) glucose-6-phosphate dehydrogenase;
4) 6-phosphogluconate dehydrogenase;
5) glucose-6-phosphatase.

105.Transport of oxaloacetate from mitochondria to the cytoplasm during gluconeogenesis occurs as follows:

1) with the help of carnitine;
2) in the form of citrate;
3) in the form of malic acid;
4) in the form of oxaloacetate.

106. The third bypass for reactions of gluconeogenesis occurs with the participation of the enzyme:

1) glucose-6-phosphatase;
2) phosphoglucomutase;
3) fructose-1,6-biphosphatase;
4) phosphofructokinase;
5) hexokinase.

107. Activators of gluconeogenesis are:

1) adrenaline and glucagon;
2) insulin;
3) glucocorticoids;
4) prostaglandins;
5) mineralocorticoids

108. The main place of accumulation of vitamin B 12 in the human body is:

1) Brain.
2) Kidneys.
3) Cardiac muscles.
4) Liver.
5) Adrenal glands

109. What is the daily requirement for pantothenic acid?

1) 5–10 mg.
2) 2–5 mg.
3) 40 mg.
4) 2.5 mg.
5) 20 mg

110. What is the name of vitamin deficiency B12?

1) Beri-Beri.
2) Malignant anemia.
3) Pellagra.

4) Night blindness.
5) Rickets.

111. Name the disease caused by hypovitaminosis PP (B3):

1) seborrhea;
2) Beri-Beri;
3) gout;
4) iron deficiency anemia;
5) pellagra.

112. Specify the coenzyme containing pantothenic acid:

1) coenzyme A;
2) coenzyme Q;
3) pyridoxal phosphate;
4) tetrahydrofolic acid;
5) thiamine pyrophosphate.

113. Select a vitamin of animal origin:

1) thiamine
2) routine
3) ascorbic acid
4) cobalamin
5) folacin.

114. With a deficiency of which vitamin, pyruvate does not turn into OAA:

1) biotin
2) B6
3) B12
4) B1
5) B2

115. What vitamin is necessary for the synthesis of THFA from folic acid:

1) ascorbic acid
2) PP (B3)
3) B12
4) B6
5) B2

116. What is the mechanism of action of a competitive inhibitor?

1) binding to the active center of the enzyme
2) binding to the allosteric center of the enzyme
3) denaturation of the enzyme molecule
4) formation of a stable, non-dissociating enzyme-substrate complex

117. What is the mechanism of action of a non-competitive inhibitor?

1) binding to the active center of the enzyme
2) binding to the allosteric center of the enzyme
3) denaturation of the enzyme molecule
4) formation of a stable, non-dissociating enzyme-substrate complex

118. Simple enzymes are:

1) proteins

2) oligopeptides
3) lipids
4) carbohydrates

119. Complex enzymes consist of:

1) carbohydrates
2) phospholipids
3) polysaccharides
4) proteins and non-protein components

120.The active center is:

1) unique sequence of amino acid residues
2) coenzyme
3) a unique combination of amino acid residues
4) allosteric center.

121. Which of the presented substances are macroergs?

1) creatine phosphate
2) S-adenosylmethionine
3) ribose phosphate
4) inositol triphosphate

122. What is formed during the oxidative decarboxylation of pyruvate:

1) citrate
2) acetyl-CoA
3) succinyl-CoA
4) lactate

123. The pyruvate dehydrogenase complex is a multienzyme system because it contains:

1) 5 enzymes and 5 coenzymes
2) 3 enzymes and 3 coenzymes
3) 3 enzymes and 5 coenzymes
4) 6 enzymes and 3 coenzymes

124.What food substances are precursors of pyruvate?

1) carbohydrates
2) fatty acids
3) cholesterol
4) cellulose

125.Where do the Krebs cycle reactions occur?

1) cytoplasm
2) mitochondrial membrane
3) intermembrane space
4) mitochondrial matrix

126.The essence of oxidative phosphorylation is:

1) inactivation of respiratory chain enzymes
2) inhibition of proton permeability of membranes
3) inhibition of the proton pump

4) use of the energy of the electrochemical potential for the formation of a phosphoester bond

127.Where does oxidative phosphorylation occur?

1) in mitochondria
2) in lysosomes
3) in the cytoplasm
4) in EPR

128. The sequence of arrangement of enzymes of the respiratory chain is determined by their:

1) redox potential
2) lipophilicity
3) hydrophilicity
4) molecular weight

129.According to the chemiosmotic theory, protons "return" from the intermembrane space to the mitochondrial matrix

1) through factor F1 of ATP synthetase
2) through factor Fo ATP synthetase
3) with the help of respiratory chain enzymes
4) anywhere on the membrane along the concentration gradient

130. When is a positive nitrogen balance observed in the body?

1) growth period
2) aging
3) acute inflammatory process
4) fasting.

131. When is a negative nitrogen balance observed in the body?

1) growth period
2) recovery
3) aging
4) pregnancy

132. Hydrolysis of proteins in the stomach of newborns catalyzes by:

1) trypsin
2) carboxypeptidase
3) rennin
4) elastase

133. Hydrolysis of proteins in the stomach catalyzes by:

1) chymotrypsin
2) carboxypeptidase
3) dipeptidase
4) pepsin

134.Protein hydrolysis in the small intestine catalyzes by:

1) pepsin
2) trypsin
3) gastrixin
4) rennin

135.Indicate amino acids that are essential for adults and partially replaceable for children:
1) alanine and valine
2) glutamate and aspartate
3) histidine and arginine
4) tryptophan and tyrosine.
136.Which lipoproteins are called antiatherogenic factors:
1) VLDL
2) LDL
3) HDL
4) chylomicrons
137.Which lipoproteins are called atherogenic factors:
1) VLDL
2) LDL
3) HDL
4) chylomicrons
138. Which molecule does participate in the transfer of acetyl-CoA from mitochondria to the cytoplasm:
1) citrate
2) malate
3) carnitine
4) oxaloacetate
139. Which molecules can be synthesized from cholesterol:
1) fatty acids
2) diacylglycerols
3) bile acids
4) proteins
140. A common metabolite in the synthesis of TAG and phosphatidylcholine is:
1)phosphatidic acid
2)phosphatidylinositol
3) ethanolamine
4)choline.
141. What does resynthesise in intestinal enterocytes:
1) triacylglycerols
2) fatty acids
3) bile acids
4) ketone bodies
142. To provide diffusion of micelles which are include fatty acids and monoacyglycerols, the composition of bile should include:
1) bile salts
2) essential fatty acids
3) fat-soluble vitamins
4) bile pigments.

143.Nucleoside triphosphate is specifically involved in the synthesis of phospholipids:
1)ATP
2) CTP
3)GTP
4)UTP
144.The first stage in the biosynthesis of cholesterol is formed:
1) mevanolate
2) isopentyl pyrophosphate
3) farnesyl pyrophosphate
4) squalene
145. Select the pathology in which ketonemia is observed:
1) rheumatism
2) myocardial infarction
3) atherosclerosis
4) diabetes mellitus.
146.Which compound is not used in tissues as a source of energy and is excreted from the body:
1) β-hydroxybutyrate
2) acetoacetate
3) acetone
4) acetyl-CoA
147.Name the protein located in the center of the palmitate synthase complex:
1) albumin
2) globulin
3) myosin
4) acyl carry protein
148.The composition of the acyl carry protein (ACP) includes the vitamin:
1) thiamine
2) biotin
3) riboflavin
4) pantothenic acid
149.Indicate the process that is the source of NADPH+H+ for the synthesis of higher fatty acids:
1) Krebs cycle
2) glycolysis
3) oxidative decarboxylation of pyruvate
4) pentose phosphate cycle of glucose oxidation
150.Acetone bodies are:
1) acetyl-CoA and succinyl-CoA
2) acetoacetate and β-hydroxybutyrate
3) acetoacetyl-CoA and propionyl-CoA
4) pyruvate and malate.

A.1 Questions for oral discussion:
(AUTUMN SEMESTER)

Module 1. Molecular basis of the structural organization of the cell

Topic 1. *Levels of structural organization and physicochemical properties of proteins.*

1.1 Biomolecules. Main classes. Their role.
1.2 Amino acids. Their role in the body. Essential amino acids.
1.3 Physico-chemical properties of proteins.
1.4 Acidic and basic amino acids that form proteins, their characteristics.
1.5 Monoamino,monocarboxylic acids that are part of proteins, their characteristics.
1.6 Conformation of protein molecules: a) secondary, b) tertiary. Bonds that stabilize these structures. Dependence of protein conformation on primary structure.
1.7. Types of bonds between amino acids in a protein molecule. Denaturation of proteins.
1.8 Comparative physicochemical characteristics of proteins and peptides (colloidal solutions, denaturation, sedimentation, isoelectric point of proteins).
1.9 Biological functions of proteins and peptides.
1.10 Dependence of the biological activity of a protein on the spatial structure of the molecule and the formation of the active center.

Topic 2. *Simple and complex proteins*

3.1. What is the difference between simple and complex proteins?
3.2. Classification of simple proteins, their structure, properties and biological functions.
3.3. Characteristics of histones.
3.4. Characteristics of albumins.
3.5. Characteristics of globulins.
3.6. What functions do complex proteins perform in organisms?
3.7. What are chromoproteins? Their biological role.
3.8. What are phosphoproteins? Their biological role.
3.9. What are flavoproteins? Their biological role.
3.10. What are metalloproteins? Their biological role.

Topic 3. *Complex proteins - supramolecular protein complexes.*

4.1. What is the difference between simple and complex proteins?
4.2. What are the products of nucleoprotein hydrolysis?
4.3. How is the prosthetic group of glycoproteins constructed?
4.4. DNA, structure, properties, functions. Nucleotides included in the composition DNA.
4.5. RNA, types, properties, functions. Nucleotides that make up RNA.
4.6. m-RNA. Structure, properties, functions. tRNA. Structure, properties, functions.
4.7. What are proteoglycans? Their composition and biorole.
4.8. What glycoproteins do you know? Their biological role.

4.9. Lipoproteins. Their biological role.
4.10. Classification of lipoproteins.

Module 2. Neuroendocrine regulation of cellular activity
Topic 1. *Biological membranes.*
5.1.Main structural macromolecules of membranes. Properties and biological functions of biomembranes.
5.2.Main types of cell membranes.
5.3.Models of structural organization of membranes.
5.4. Comparative chemical composition of some cell membranes.
5.5. Main classes of membrane lipids.
5.6.Phospholipids, their composition.
5.7. Membrane proteins (peripheral and integral proteins). Functions of membrane proteins.
5.8.Glycoproteins are outer membrane proteins of plasma membranes.
5.9. Membrane glycolipids.
5.10.Mechanism of transmembrane transfer of substances. Inhibitors and activators of transmembrane transport.

Topic 2.3. *Neuroendocrine regulation of cell functions. Mechanisms of hormonal signal transmission into cells.*
6.1. Neuroendocrine regulatory systems of the body.
6.2. Hormones. Definition. Classification. Regulation of their secretion, transport, inactivation.
6.3. The mechanism of action of hormones is the early and late effects of hormonal action.
6.4. Adenylate cyclase and guanylate cyclase mechanisms of hormonal signal transmission.
6.5. Insulin receptor and Ca-messenger systems.
6.6. Hormonal receptors of cell membranes.
6.7. Secondary messengers of hormonal signal transmission into the cell.
6.8. Activation of enzymes of key biochemical reactions.
6.9. Changes in cell membrane permeability and initiation. transport of substances into the cell.
6.10. Changing the number of enzymes in a cell through induction and repression of genes.

***Module* 3. Molecular basis of life activity and pathology.**
Topic 1. *Enzymes, structure, mechanism of action.*
1.1. What are enzymes? Their difference from an inorganic catalyst.
1.2. List the properties of enzymes due to their protein nature.
1.3. Define “holoenzyme”, “apoenzyme”, “cofactor”, “coenzyme”, “prostatic group of the enzyme”.

1.4. How is the active center of an enzyme formed, what bonds are involved in its formation?
1.5. Factors influencing the formation of the active center. Possible mechanisms of their action.
1.6. List the “cofactors” and “coenzymes” known to you that are part of the active center of complex enzymes.
1.7. What is the essence of Konshand’s theory of induced (forced) correspondence between enzyme and substrate during their contact? What is the role of the resulting stresses?
1.8. What effects in the process of catalysis help speed up the reaction? What are they due to?
1.9. Multienzyme systems. What is their biological role?
1.10. What is the active site of an enzyme? Describe the active center of protein enzymes and protein enzymes.

Topic 2. *Properties of enzymes. Kinetics of enzymatic reactions.*
2.1. Specificity of enzyme action. What is it due to?
2.2. The main types (types) of specificity of enzyme action:
a) absolute substrate specificity
b) absolute group substrate
c) relative group substrate
d) relative substrate specificity
2.3.Factors influencing the rate of enzymatic reactions (depict graphically)
a) thermolability, temperature optimum
b) pH of the environment. Optimum pH for pepsin, trypsin, salivary amylase and pancreas, lipase, arginase
c) substrate concentration
d) enzyme concentration
2.4. Kinetics of enzymatic reactions. Michaelis’s constant. What does she express?
2.5. Practical significance of the dependence of enzymatic activity on pH.
2.6. What are enzyme activators? What is their mechanism of action?
2.7. Regulation of enzyme action:
a) allosteric mechanism of regulation. Allosteric effectors - modulators;
b) regulation by protein inhibitors;
c) regulation of enzymes by phosphorylation and dephosphorylation;
d) adenylate cyclase system;
e) activation by partial proteolysis;
f) activators - metals (cofactors);
g) induction of enzyme synthesis – adaptive (inducible) and constitutive enzymes.
2.8. Enzyme inhibitors - reversible and irreversible, competitive and non-competitive, allosteric.

Topic 3. *Nomenclature and classification of enzymes.*
3.1. On what basis are enzymes divided into classes?

3.2. Rational and digital nomenclature of enzymes.
3.3. To which class of enzymes do dehydrogenases belong? Their types, their structure and functions.
3.4. The structure of monooxygenase enzymes (hydroxylases). Their functions.
3.5. Decarboxylases of alpha-keto acids and amino acids. Their coenzymes. Their role.
3.6. Isoenzymes. What is the biological significance of the existence of multiple forms of enzymes?
3.7. Multienzyme systems, their biological role?
3.8. Enzymopathology. Name the types of enzymopathies. Describe them.
3.9. Enzymodiagnostics. Changes in enzymatic activity in blood serum under pathological conditions (hepatitis and myocardial infarction), enzyme specter of blood.
3.10. Hereditary enzymopathies, mechanisms of their origin.

Topic 4. *Water-soluble vitamins.*
4.1. What are vitamins and provitamins?
4.2. Sources of vitamins and human needs for vitamins.
4.3.What do the terms vitamin deficiency, polyavitaminosis, hypovitaminosis, hypervitaminosis, antivitamins mean? Causes of vitamin deficiency.
4.4. Classification and nomenclature of vitamins.
4.5. The mechanism of action of vitamins. Relationship between vitamins and enzymes.
4.6. What vitamins can be synthesized in the body?
4.7. Active forms of vitamins (coenzymes). Write the formulas NAD+, NADP, FAD, FMN, CoA, TPP, PLP. Their role in biochemical reactions. Write catalyzed reactions.
4.8. Violation of protein nutrition as a cause of vitamin deficiencies.

Topic 5. *Biological role of fat-soluble vitamins.*
5.1. List the biochemical effects of derivatives of vitamin A.
5.2. Early and late effects of vitamin A deficiency.
5.3. What is the role of vitamin A in vision and metabolism?
5.4. Why does vitamin A hypervitaminosis develop when eating the liver of marine animals?
5.5. What vitamin Q compounds do you know? Which of them have biological activity? Mechanism of action.
5.6. Why is vitamin A hypovitaminosis popularly called “night blindness”?
5.7. When the body is exposed to ionizing radiation, the patient is prescribed vitamin E. Explain the biochemical mechanism of action.
5.8. List the antivitamins of vitamin K and explain their mechanism of action.
5.9. Explain the absorption process of fat-soluble vitamins.
5.10. What is the role of vitamin K in metabolism?

Module 4. Biological oxidation, cell energy and carbohydrate metabolism.

Topic 1. *Specific and general pathways of catabolism*

1.1. What is the biological role of the processes of decomposition of organic substances in the body?

1.2. Name the most common high-energy compounds in cells.

1.3. What substances are formed during the reaction of oxidative decarboxylation of pyruvic acid and during carboxylation of pyruvic acid?

1.4.Specific pathways of catabolism of carbohydrates, fats and proteins. Formation of common (unified) products of exchange (scheme).

1.5. What is the essence of the tricarboxylic acid cycle? What is its biological significance? Where is it located in cells?

1.6. What is the relationship between the metabolism of carbohydrates, fats, proteins and the tricarboxylic acid cycle?

1.7. What is substrate phosphorylation?

1.8. Name the oxidation substrates in the tricarboxylic acid cycle. What is the fate of the hydrogen (electrons and protons) released during the dehydrogenation of these substrates?

1.9. Which enzymes of the tricarboxylic acid cycle are regulatory? What metabolites and how do they affect them?

1.10. What is meant as amphibolic function of the tricarboxylic acid cycle?

Topic 2. *Tissue respiration is the terminal stage of biological oxidation.*

2.1. Modern idea of biological oxidation. The essence of oxidation in tissues and the role of oxygen.

2.2. What is meant by biological oxidation?

2.3. What is tissue respiration? What is meant by aerobic and anaerobic oxidation?

2.4. In what cell structures do biological oxidation processes occur? Enzymes of biological oxidation.

2.5. What bonds are called as macroergic? Name the most common high-energy substances.

2.6. What is meant by an electron transport chain? Where in the cell are electron transport chains located?

2.7. What is the biological role of the respiratory chain?

2.8. The respiratory chain, its organization in mitochondria. Transfer of protons and electrons. Collector function of NADH dehydrogenase (FP) and ubiquinone.

2.9. What is a shortened electron transport chain? How many ATP molecules are formed when electrons pass through it?

2.10. Regulation of tissue respiration. Uncouplers of tissue respiration and oxidative phosphorylation. Thermoregulatory function of tissue respiration.

Topic 3. *Carbohydrates. Digestion, absorption, transport into cells. Glycolytic pathway of carbohydrate oxidation. Synthesis and mobilization of glycogen in body cells.*

3.1. Carbohydrates. Classification. The role of carbohydrates in the body.

3.2. Digestion and absorption of carbohydrates. Types of transport. Active transport of carbohydrates into cells.
3.3. Phosphorylation of monosaccharides. Hexokinases, their isoenzyme spectrum. Characteristics of hexokinase isoenzymes.
3.4. What is lactic acid and alcohol fermentation?
3.5. What is the concentration of glucose in the blood of a healthy person?
3.6. At what stages of glycolysis is ATP formed?
3.7. In what tissues does glycolysis occur? Name the cells in which the aerobic phase of glycolysis is absent. Why?
3.8. What is the energy value of aerobic transformation of carbohydrates?
3.9. Name the reaction of substrate phosphorylation in the process of glycolysis.
3.10. Lactate dehydrogenase isoenzymes. Their characteristics.

Topic 4. *Key reactions and enzymes of gluconeogenesis. Pentose phosphate pathway for glucose conversion.*
4.1. Stages of pentose phosphate shunt.
4.2. List the tissues where the pentose phosphate conversion of glucose-6-phosphate takes place.
4.3. What is the significance of the pentose phosphate shunt?
4.4. What disorders are observed with glucose-6-phosphate dehydrogenase deficiency?
4.5. What is gluconeogenesis?
4.6. What is the role of biotin and acetyl-CoA in activating pyruvate carboxylase in oxaloacetate synthesis? Transport of oxaloacetate into the cytoplasm.
4.7. List the intermediate metabolic products from which glucose can be formed in cells.
4.8. How does lactate produced in contracting muscle turn into glucose in the liver?
4.9. AMP and ATP as allosteric modulators of the enzymes fructokinase and fructose-1-6-diphosphatase.
4.10. The effect of alcohol on glucose synthesis.

Topic 5. *Regulation of carbohydrate metabolism and energy production in cells body. Disorders of carbohydrate metabolism.*
5.1. The role of the nervous system in the regulation of carbohydrate metabolism.
5.2. The mechanism of action of insulin, adrenaline, glucagon, glucocortcoids, thyroxine and other hormones on carbohydrate metabolism.
5.3. Regulation of carbohydrate metabolism by substrates (examples). Regulation of carbohydrate metabolism through regulatory enzymes in glycolysis, in the TCA cycle.
5.4. The relationship between glycolysis and the Krebs cycle. Pasteur effect.
5.5. The role of the ATP/ADP ratio in the regulation of carbohydrate metabolism.
5.6. Blood sugar. Hypo- and hyperglycemia. Glycosuria.
5.7. Types of glucosuria. Diabetes. The mechanism of its development.

5.8. Hereditary enzymopathies. Glycogenosis, galactosemia, fructosuria, lactose intolerance. Glycogen store diseases.
5.9. Regulation of glycolysis and gluconeogenesis. Mechanisms of regulation. Hormonal and nucleotide effectors;
5.10. Types of glucosuria. Diabetes. The mechanism of its development.

A.1 Questions for oral discussion:
(SPRING SEMESTER)
Module 1. Lipid metabolism and functions
Topic 1. *Chemistry and lipid metabolism.*
1.1. Classification of lipids, characteristics of classes.
1.2. Structure, properties and functions of human tissue lipids.
1.3. Digestion and absorption of food lipids. The role of bile acids.
1.4. Resynthesis of fat in intestinal cells. Formation of chylomicrons.
1.5. Blood lipoproteins - chylomicrons, VLDL (very low density lipoproteins), LDL (low density lipoproteins), HDL (high density lipoproteins). Their composition and functions.
1.6. Intermediate lipid metabolism.
1.7. β-oxidation of fatty acids. Connection with the Krebs cycle and the respiratory chain.
1.8. Carnitine acyltransferase and transport of fatty acids into mitochondria.
1.9. Features of the oxidation of fatty acids with an odd number of carbon atoms. Metabolism of propionyl-CoA.
1.10. Functions and pathways of transformation of polyene fatty acids in the human body:
a) peroxide oxidation of unsaturated higher fatty acids,
b) conversion of polyene fatty acids into endoperoxides: prostaglandins. Thromboxanes, prostacyclins, leukotrienes.
Topic 2. *Intermediate lipid metabolism*
2.1. Intermediate products of carbohydrate and protein metabolism as building materials for lipid synthesis.
2.2. Acetyl - CoA. Its formation and use in the body.
2.3. Synthesis of higher fatty acids in body cells. Organization of the multienzyme complex for the synthesis of fatty acids.
2.4 Formation of phosphoglycerol. Connection with glycolysis. Biosynthesis of triacylglycerides. The role of acyl-CoA.
2.5 Phospholipid synthesis. The role of CTP, ATP, methionine, choline, unsaturated higher fatty acids.
2.6.Synthesis of cholesterol in the body. The role of acetyl-CoA, ATP, NADPH2.
2.7. Regulation of cholesterol metabolism. Excretion of cholesterol metabolic products.
2.8. Hormonal regulation of lipid metabolism. The relationship between carbohydrate and lipid metabolism.

2.9. Lipid metabolism disorders: the role of LDL and VLDL in the occurrence of atherosclerosis and obesity. Diabetes.
2.10. List the vitamins and cofactors that take part in enzymatic reactions in the synthesis of fatty acids and phospholipids.

Module* 2. *Metabolism of proteins and amino acids

Topic 1. *Digestion and absorption of protein hydrolysis products.*

1.1. Protein nutrition. Nutritional value of proteins. Sources of amino acids in the blood. Nitrogen balance.
1.2. Protein Digestion: Sources of Proteolytic Enzymes of the Gastrointestinal Tract
1.3. Formation of active forms of enzymes, substrate specificity, mechanism of action of peptidase enzymes using the example of chymotrypsin or carboxypeptidases
1.4. Digestion of proteins in the stomach. The role of hydrochloric acid.
1.5. Digestion of proteins in the intestines. Parietal digestion.
1.6. Transformations of amino acids under the influence of intestinal microflora. Biologically active amines and other toxic substances.
1.7. Absorption of protein breakdown products and ways of using blood amino acids in the body.
1.8. Mechanisms of neutralization in the liver of toxic products of the transformation of amino acids into the intestines.
1.9. Protein digestion disorders.
1.10. Protein starvation and vitamin deficiencies.

Topic 2. *Intermediate metabolism of amino acids.*

2.1. What is the fate of absorbed amino acids into the body?
2.2 Transport of amino acids across cell membranes.
2.3. Four types of amino acid deamination reactions.
2.4 Reactions of oxidative deamination of glutamic acid.
2.5.Transamination reactions. Coenzyme function of pyridoxal phosphate.
2.6. Reductive amination reactions. Their role in the synthesis of non-essential amino acids.
2.7. Neutralization of ammonia in brain cells, muscle and other tissues.
2.8. The mechanism of ammonia neutralization in the liver and kidneys. Write reactions.
2.9. Diagnostic value of determining the activity of blood aminotransferases in liver diseases and myocardial infarction.
2.10. The role of glutamic and alpha-ketoglutaric acids in transdeamination reactions

Topic 3. *Metabolism of individual amino acids.*

3.1. Decarboxylation of amino acids: formation of biogenic amines. Their role in the body.

3.2. Exchange of serine and glycine. Formation of one-carbon groups. The role of H4-folate (THFA - tetrahydrofolic acid).
3.3. Metabolism of methionine and cysteine
3.4. Metabolism of phenylalanine and tyrosine. Formation of catecholamines.
3.5. Exchange of tryptophan and histidine.
3.6. What role does GABA play in the central nervous system? What acid is it formed from?
3.7. Write the reaction of creatinine synthesis.
3.8. Write the methylation reaction of norepinephrine. Name the enzyme and its coenzyme group involved in methylation reactions.
3.9. Decomposition of biogenic amines. The role of monoamine oxidases (MAO).
3.10. Hereditary disorders of amino acid metabolism.

***Module* 3. *Molecular mechanisms of genetic information transfer*.**
Topic 1. *Nucleotide exchange.*
1.1.What are nucleotides? Nucleosides? List the functions of nucleotides.
1.2. Write the purine and pyrimidine rings and show the origin of their atoms.
1.3.Write the reactions for the synthesis of purine nucleotides:
a) formulas up to glycinamide ribonucleotide, b) further in the form of a diagram up to IMP. How is the synthesis of purine nucleotides regulated?
1.4. Write the reactions for the formation of AMP and HMP from inosinic acid.
1.5. What is the role of the coenzyme THPA and PRPP in the synthesis of nucleotides? List the features of the synthesis of purine and pyrimidine nucleotides.
1.6. Write the reaction for the synthesis of pyrimidine nucleotides to OMP. Show the transformation of OMP into UMP and CMP. How is the synthesis of pyrimidine nucleotides regulated?
1.7. How does deoxyribonucleotide synthesis occur? What is the role of thioredoxin?
1.8. Write the breakdown of adenylic and guanylic acids to uric acid. What is the role of xanthine oxidase?
1.9. Write the breakdown of cytidylic and thymidylic acids. Name the final products of decomposition.
1.10. What is gout and Lesch-Nyhan syndrome? What are the causes of their occurrence, symptoms and principles of treatment?

Topic 2. *Biosynthesis of nucleic acids (replication and transcription).*
2.1. What are nucleic acids? List the differences between DNA and RNA. How are nucleotides - monomers of nucleic acids - related to each other?
2.2.What is replication? Name the components required for replication. Describe the functions of replication enzymes.
2.3. Name the stages of replication. Describe the processes occurring at each stage (give a diagram). Name the enzymes and protein factors which are involved.
2.4. What are Okazaki fragments? Show them their education. What is their role?

2.5. What is an RNA primer? What is his role? What are primase and primosome?
2.6. What is transcription? Name the components necessary for transcription. What is the role of DNA-dependent RNA polymerase?
2.7. Write the reaction schemes for the synthesis of RNA from the corresponding nucleotides and the reaction for the formation of the 5'-3' phosphodiester bond.
2.8. Name and characterize the types of reactions that occur during RNA processing.
2.9. What is a cap and a polyA tail? Their role.
2.10. The role of polynucleotide phosphorylase in RNA synthesis.

Topic 3. *Biosynthesis of proteins. Post-translational protein modification.*
3.1. Components of the protein synthesizing system - ribosomes, m-RNA, t-RNA, amino acids, enzymes, protein factors.
3.2.Substrate specificity of aminoacyl-tRNA synthetase. tRNA, its adapter function.
3.3. Initiation of translation.
3.4. Elongation of translation. Peptidyl transferase and peptidyl translocase reactions. Energy supply. The role of protein factors.
3.5. Termination of translation. The role of stop codons and protein factors.
3.6. Name the energy-dependent reactions of protein biosynthesis. How much ATP and GTP are needed to form one peptide bond?
3.7. What is protein processing? List the types of post-translational chemical modifications of proteins.
3.8. Explain the regulation of protein biosynthesis by the type of induction. Give an example.
3.9. Explain the regulation of protein biosynthesis by the type of repression. Give an example.
3.10. Define the concepts "operator", "promoter", "structural genes", "operon", "inducer", "corepressor"

Module* 4. *Functional biochemistry of organs and tissues.
Topic 1. *Biochemistry of liver.*
1.1. Features of energy metabolism, blood supply and oxygen supply to the liver.
1.2.Integration (regulatory-homeostatic) function of the liver
1.3.The role of the liver in carbohydrate, lipid and protein metabolism
1.4.Participation of the liver in vitamin metabolism
1.5. Participation of the liver in the exchange of nitrogenous bases
1.6. Participation of the liver in water-mineral metabolism
1.7. Bile formation and excretory function of the liver.
1.8. Antitoxic function of the liver: neutralization of ammonia - biosynthesis of urea;
1.9. Mechanisms for neutralizing toxic substances formed in the body and coming from outside: microsomal oxidation; conjugation reactions
1.10. The role of the liver in pigment metabolism (heme catabolism).

Topic 2. *Biochemistry of blood*
2.1 Blood, composition, biochemical and physiological functions.

2.2 Biochemical features of blood cells and their functions.
2.3 Basic proteins, blood plasma and their functions.
2.4 Blood plasma enzymes, their origin and diagnostic value of determination.
2.5 Blood plasma lipoproteins.
2.6. Nitrogenous and nitrogen-free low-molecular organic components of blood, their significance.
2.7. Unlimited blood components.
2.8. The regulatory function of blood is kinins.
2.9. Hemoglobin. Synthesis. Hemoglobinopathies.
2.10. Blood buffer systems.

Topic 3. *Biochemistry of the kidneys.*
3.1. Water. Physicochemical characteristics. The role of water in the structural organization of biomolecules.
3.2. The role of water, macro- and microelements in the body
3.3. Basic functions of the kidneys. The role of the kidneys in regulating water-salt metabolism and maintaining homeostasis in the body.
3.4. Chemical composition and properties of urine. Organic and inorganic components of urine.
3.5. Pathological components of urine. Diagnostic value of their determination in urine.
3.6. Regulation of phosphorus-calcium metabolism.
3.7. Hormonal regulation of water-salt metabolism.
3.8. What substances appear in urine during pathology?
3.9. Explain the meaning of the terms “glucosuria”, “proteinuria”, “xtonuria”, “hematuria”, “phenylketonuria”, “galactosuria”, “bilirubinuria”.
3.10. Nitrogen-containing substances in the urine of adults.

Topic 4. *Biochemistry of connective tissue*
4.1. Types of connective tissue. Features of the structure. Role in the body.
4.2. Structural organization of connective tissue: a) types of cellular elements. Their functions; b) intercellular organic matrix.
4.3. Name the biopolymers of connective tissue.
4.4. Types of collagen, its content in various types of connective tissue and its role.
4.5. Features of the amino acid composition and physicochemical properties of collagen.
4.6. Features of collagen biosynthesis and bonds that stabilize collagen molecules.
4.7. Factors involved in the regulation of collagen metabolism. Hormones, enzymes, vitamins, etc.
4.8. Features of the structure and physicochemical properties of elastin.
4.9. Proteoglycans. Their composition. Role.
4.10. Glucosaminoglycans-mucopolysaccharides: hyaluronic acid, chondroitin sulfates and others. Their biological role.

Topic 5. *Biochemistry of muscles.*
5.1.Features of structure, metabolism and energy production in muscle tissue.
5.2. The most important proteins of myofibrils: myosin, actin, actomyosin, tropomyosin, troponin, their structure and role
5.3. Molecular structure of myofibrils
5.4. Biochemical mechanisms of muscle contraction and relaxation, the role of the concentration gradient of calcium ions and monovalent ions
5.5. Sarcoplasmic proteins, their functions (myoglobin).
5.6. Muscle extractives, their role
5.7. Features of energy metabolism in muscles. Creatine phosphate.
5.8. Biochemical changes in muscles during pathology.
5.9. Mechanisms of energy supply to muscle tissue
5.10. Features of the structure and metabolism of smooth muscles and myocardium

Topic 6. *Biochemistry of nervous tissue.*
6.1 Biochemistry of nervous tissue, features of chemical composition and metabolism.
6.2 Features of energy in nerve cells.
6.3 Chemical basis of the origin and conduction of nerve impulses.
6.4 The role of mediators.
6.5 Active brain peptides.
6.6 Mediators: acetylcholine, serotonin, GABA, histamine, catecholamines.
6.7 The role of vitamins B1, B6, B12, THFA, HS-CoA in the synthesis of mediators.
6.8 Features of protein and amino acid metabolism in nervous tissue
6.9 Features of lipid metabolism
6.10 GABA-shunt

A.2 Questions for midterm control (colloquium)
(AUTUMN SEMESTER)
Module 1. Molecular basis of the structural organization of the cell.
Topic 1. Levels of structural organization and physicochemical properties of proteins.
1.1. Biomolecules. Main classes, their role.
1.2. Amino acids. The role of amino acids in the body. Essential amino acids.
1.3. Peptides. Structure and properties. Biological functions.
1.4. Proteins. Levels of structural organization of proteins.
1.5. Conformation of protein molecules - secondary and tertiary structures. Bonds that stabilize these structures. Factors influencing the spatial organization of the peptide chain and the formation of the active center of the protein molecule.
1.6. Quaternary structure of protein. Oligomeric proteins - hemoglobin, lactate dehydrogenase, phosphorylase B and A. Dependence of biological activity on cooperative changes in protomer conformation.
1.7. Physicochemical properties of proteins and peptides.
1.8. Denaturation of proteins, its mechanism. Application in medical practice.

1.9. Comparative physicochemical characteristics of proteins and peptides (colloidal solutions, denaturation, sedimentation, isoelectric point of proteins).
1.10.Biological functions of proteins and peptides.

Topic 2. *Simple and complex proteins.*
3.1. Globular and fibrillar proteins. Features of their amino acid composition and structural organization.
3.2. Albumins, globulins, histones, collagen, keratin proteins. Features of the structure. Biological role.
3.3. Natural peptides - neuropeptides, hormone peptides, opiate peptides, glutathione, bradykinin, kallidin and others. Structure and biological role.
3.4. Complex proteins - chromoproteins (hemoproteins, flavoproteins, retinolproteins, chlorophylproteins), phosphoproteins and metalloproteins.
3.5. Hemoproteins - hemoglobin, myoglobin, cytochromes, catalase structure topic. Bonds that stabilize hemoprotein molecules;
3.6. Structure and functions of prosthetic groups of hemoglobin, myoglobin, cytochromes, catalase;
3.7. Features of the structure of protein chains of physiological and pathological hemoglobins and the hemoglobin family of patients with beta thalassemia.
3.8.Molecular mechanisms of oxygen capture and release by hemoglobin.
3.9.Physiological and pathological derivatives of hemoglobin. Diagnostic value of their determination.
3.10. Comparative characteristics of the structure and properties of hemoglobin and myoglobin. Oxygenation curve of hemoglobin and myoglobin.
3.11. Phosphorylation and dephosphorylation of proteins as a mechanism of their activation and inactivation.

Topic 3. *Complex proteins - supramolecular protein complexes.*
4.1.Nucleoproteins - deoxyribonucleoproteins and ribonucleoproteins.
4.2.Nucleic acids. Structure, levels of structural organization of DNA and RNA.
4.3.Structure of nucleotides and nucleosides. Minor nucleotides.
4.4. Types of nucleic acids (DNA, m-RNA, t-RNA, r-RNA). Structural and functional organization of DNA in chromosomes and r-RNA in ribosomes. Their functions.
4.5. Protein components of chromosomes and ribosomes. Classification of histones, their amino acid composition and functions.
4.6.Lipoproteins: structural (proteolipids) and transport-reserve, features of their composition and structure. Biorole.
4.7. Carbohydrate-protein complexes: glycoproteins and proteoglycans. Composition and structure of prosthetic groups. Biological functions.

Module 2. Neuroendocrine regulation of cellular activity
Topic 1. *Biological membranes.*
5.1. Structural components of membranes. Structure and their characteristics.

5.2.Structural organization of biological membranes. Main types of membrane structures.
5.3. Physico-chemical characteristics of macromolecules in biomembranes.
5.4. Main functions of biological membranes.
5.5.Mechanisms of transmembrane transfer of substances.

Topic 2,3. Neuroendocrine regulation of cell functions. Mechanisms of hormonal signal transmission into cells
6.1. Neuroendocrine regulatory systems of the body.
6.2. Hormones. Definition, classification. Regulation of their secretion, transport, inactivation.
6.3. The mechanism of action of hormones is the early and late effects of hormonal action.
6.4. Adenylate cyclase and guanylate cyclase mechanisms of hormonal signal transmission.
6.5. Hormonal receptors of cell membranes.
6.6. Secondary messengers of hormonal signal transmission into the cell.
6.7. Changes in the permeability of cell membranes and initiation of transport of substances into the cell.
6.8. Activation of enzymes of key biochemical reactions.
6.9. Changing the number of enzymes in a cell through induction and repression of genes.
6.10. The structure and biorole of neurohormones of the hypothalamus and triple hormones of the pituitary gland.
6.11.Biological role of hormones of the parathyroid glands and “C” cells of the thyroid gland.

***Module* 3. Molecular basis of life activity and pathology**
Topic 1. Enzymes, structure, mechanism of action
1.1. What are enzymes? Their difference from inorganic catalysts.
1.2. What is the energy barrier of a reaction?’ What is activation energy? What is meant by an “activated” transition state?
1.3. List the properties of enzymes due to their protein nature.
1.4. What is the active site of an enzyme? Describe the active center of protein enzymes and proteid enzymes.
1.5. How is the active center of an enzyme formed, what bonds are involved in its formation? Factors influencing the formation of the active center. Possible mechanisms of their action.
1.6. List the “cofactors” and “coenzymes” known to you that are part of the active center of complex enzymes.
1.7. How is the active center of an enzyme formed, what bonds are involved in its formation?
1.8. Factors influencing the formation of the active center. Possible mechanisms of their action.

1.9. Describe the active site regions of enzymes. Their functions.
The structure of some coenzymes and prostatic groups: FAD, FMN, Heme. UDP, c-AMP, CDP.
1.10. What are multienzyme systems? What is their biological role?

Topic 2. *Properties of enzymes. Kinetics of enzymatic reactions.*
2.1. Specificity of enzyme action. What is it due to?
2.2. The main types (types) of specificity of enzyme action:
a) absolute substrate specificity;
b) absolute group substrate specificity;
c) relative group substrate specificity;
d) relative substrate specificity.
2.3. Factors influencing the rate of enzymatic reactions (depict graphically).
a) thermolability, temperature optimum;
b) pH of the environment. Optimum pH for pepsin, trypsin, salivary and pancreatic amylase, lipase, arginase.
c) substrate concentration;
d) enzyme concentration.
2.4. Kinetics of enzymatic reactions. Michaelis constant. What does she express?
2.5. Methods of determination and units of enzyme activity.
2.6. What are enzyme activators? What is their mechanism of action?
2.7. Regulation of enzyme action:
a) allosteric mechanism of regulation. Allosteric effectors-modulators;
b) regulation by protein inhibitors;
c) regulation of enzymes by phosphorylation and dephosphorylation;
d) adenylate cyclase system;
e) activation by partial proteolysis;
f) activators - metals (cofactors);
g) induction of enzyme synthesis
2.8. Enzyme inhibitors - reversible and irreversible, competitive and non-competitive, allosteric.
2.9. The role of inhibitors in the regulation of enzyme activity - inhibitors as drugs, as a means of studying the mechanism of action of enzymes in various biochemical cycles.
2.10. Michaelis constant as an indicator of enzyme activity.

Topic 3. *Nomenclature and classification of enzymes.*
3.1. On what basis are enzymes divided into classes? Characteristics of each class of enzymes.
3.2. Rational and coded nomenclature of enzymes.
3.3. What class of enzymes do dehydrogenases belong to? Their varieties, structure and functions.
3.4.Reductase enzymes, their structure and functions.
3.5. Flavin enzymes, their structure and functions.

3.6. The structure of monooxygenase enzymes (hydroxylases). Their functions.
3.7. Methyltransferase enzymes. their structure and role in enzymatic reactions.
3.8. Enzymes formyltransferase, acyltransferase, aminotransferase, phosphotransferase (kinase), glycosyl transferase. Their structure and functions.
3.9. Esterase, glycosidase, peptidase enzymes. Their structure and functions.
3.10. Decarboxylases of alpha-keto acids and amino acids. Their coenzymes. Their role.
3.11. Hydratese enzymes. Their structure and role.
3.12. Isoenzymes. What is the biological significance of the existence of multiple forms of enzymes?
3.13. Multienzyme systems, their biological role.
3.14. Enzymopathology. Name the types of enzymopathies. Describe them.
3.15. Enzymodiagnostics. Changes in enzymatic activity in blood serum under pathological conditions (hepatitis and myocardial infarction). Enzyme spectra of blood.

Topic 4. *Water-soluble vitamins.*
4.1. What are vitamins and provitamins?
4.2. Sources of vitamins and human needs for vitamins.
4.3. What do the terms vitamin deficiency, polyavitaminosis, hypovitaminosis, hypervitaminosis, antivitamins mean? Causes of vitamin deficiency.
4.4. Classification and nomenclature of vitamins.
4.5. The mechanism of action of vitamins. Relationship between vitamins and enzymes.
4.6. What vitamins can be synthesized in the body?
4.7. The active forms of vitamins are coenzymes. Write the formulas for NAD, NADP, FAD, FMN, CoA, TPP (thiamine diphosphate), pyridoxal phosphate. Their role in biochemical reactions. Write catalyzed reactions.
4.8. Violation of protein nutrition as a cause of vitamin deficiencies.
4.9. Vitamins: classification, structure, properties, biological role, participation of vitamins in the construction of coenzyme.
4.10. Thiamine: structure, properties, role in metabolism.
4.11. Nicotinamide: properties, role in biological oxidation.
4.12. Riboflavin: structure, properties, participation in electron transfer.

Topic 5. *Biological role of fat-soluble vitamins.*
5.1. List the biochemical effects of derivatives of vitamin A.
5.2. Early and late signs of vitamin A deficiency.
5.3. When the body is exposed to ionizing radiation, the patient is prescribed vitamin E. Explain the biochemical mechanism of action.
5.4. List the antivitamins of vitamin K and explain their mechanism of action.
5.5. Explain the absorption process of fat-soluble vitamins.
5.6. What is the role of vitamin K in metabolism? How does hypovitaminosis K manifest?

5.7. Biological role of vitamin D. Hypovitaminosis D
5.8. What compounds are related to vitamin F? What is the biological role of polyunsaturated essential fatty acids?
5.9. What biological reactions is vitamin K involved in?
5.10. What is the biological role of vitamin E? What are the symptoms of hypovitaminosis E?

***Module* 4. Biological oxidation, cell energy and carbohydrate metabolism.**
Topic 1. *Specific and general pathways of catabolism*
1.1. Energy resources of the body:
a) stages of transformation of organic substances and release of energy (free energy);
b) high-energy compounds.
1.2. Structural and functional organization of oxidation enzymes in the cytosol and mitochondria of the cell.
1.3. Specific pathways of catabolism of carbohydrates, fats and proteins. Formation of common (unified) products of exchange (scheme).
1.4. Common pathways of catabolism:
a) pyruvic acid - ways of its transformation.
b) Krebs tricarboxylic acid cycle.
1.5. Sequence of reactions. Enzymes and coenzymes. Reaction products of the Krebs cycle.
1.6. Biochemical functions of the Krebs cycle:
a) integration of all types of metabolism;
b) generator of NADH2 and FADH2;
c) Anabolic function;
d) Energy - substrate phosphorylation, GTP synthesis.
1.7. What is the biological role of the processes of decay of organic substances in the body?
1.8. What interatomic bonds are called macroergic? Name the most common macroergic substances.
1.9. Can the process of oxidative decarboxylation of pyruvate occur in the absence of thiamipyrophosphate, why?
1.10. What is the essence of the tricarboxylic acid cycle? What is the relationship between the metabolism of carbohydrates, fats, proteins and TCA?

Topic 2. *Tissue respiration is the terminal stage of biological oxidation.*
2.1. Modern idea of biological oxidation. The essence of oxidation in tissues and the role of oxygen.
2.2. Enzymes and coenzymes of biological oxidation: 1) dehydrogenases. Coenzymes NAD and FAD. Structure, biological role. 2) Enzymes and coenzymes of tissue respiration - carriers of protons and electrons:
a) flavoprotein 1. FMN. Role;
b) metalloproteins - iron-sulfur proteins;
c) ubiquinone structure, biological role;

d) cytochromes - heme-containing enzymes.
2.3. The respiratory chain, its organization in mitochondria. Transfer of protons and electrons. Collector function of NADH dehydrogenase, FMN and ubiquinone.
2.4. Redox potentials of the components of the respiratory chain, the sequence of their location. Redox potential.
2.5. The mechanism of coupling of respiration and phosphorylation in the light of Mitchell's chemiosmotic theory.
2.6. Regulation of tissue respiration - respiratory control:
a) inhibitors that block electron transfer in the respiratory chain;
b) uncouplers of tissue respiration and oxidative phosphorylation.
2.7. Biological role of tissue respiration. The relationship of the respiratory chain with oxidative decarboxylation of pyruvate, beta-oxidation of fatty acids, the Krebs cycle, oxidative deamination of amino acids and other compounds.
2.8. Microsomal oxidation. Connection with the oxidative pathway of the pentose phosphate cycle. Biological role of microsomal oxidation.
2.9. Which parts of the respiratory chain provide coupling between oxidation and phosphorylation? What enzyme in the coupling device ensures the use of the energy of the transmembrane potential?
2.10. What substances are uncoupling agents? What is free oxidation? In what cases does it intensify?

Topic 3. *Carbohydrates. Digestion, absorption, transport into cells. Glycolytic pathway of carbohydrate oxidation. Synthesis and mobilization of glycogen in body cells.*
3.1. Carbohydrates. Classification. The role of carbohydrates in the body.
3.2. Digestion and absorption of carbohydrates. Lightweight transport.
Active transport of carbohydrates into cells. Phosphorylation of monosaccharides.
3.3. Hexokinases, their isoenzyme spectrum. Characteristics of hexokinase isoenzymes.
3.4. Interconversion of hexoses.
3.5. Glucose-6-phosphate - the main pathways of transformation in the cells of the body (diagram).
3.6. Glycolytic pathway for the conversion of glucose-6-phosphate. Sequence of reactions. Characteristics of glycolytic enzymes. Their localization in the cell. Key reactions of glycolysis. Lactate dehydrogenase isoenzymes.
3.7. Switching glycolysis to the aerobic oxidation pathway, their relationship. Reaction products. Malate aspartate and glycerophosphate transport mechanisms outside mitochondrial hydrogen. Energy of anaerobic and aerobic phases of glycolysis.
3.8. The biological role of glycolysis during intense muscular work and hypoxic conditions. Features of glycolysis in various forms of pathology - malignant tumors, anemia, inhibition of respiratory enzymes (poisoning).
3.9. Alcohol and lactic acid fermentation.
3.10. Inclusion of other carbohydrates in the process of glycolysis.

Topic 4. *Key reactions and enzymes of gluconeogenesis. Pentose phosphate pathway for glucose conversion*

4.1. The pentose phosphate pathway of glucose conversion is a generator of reducing equivalents of NADPH2 and pentose-5-phosphates in tissues with active biosynthesis - liver, adipose tissue, mammary gland, adrenal cortex, RBCs, etc.

4.2. Stages of pentose phosphate shunt:

a) oxidative (phosphogluconate) pathway. Enzymes and coenzymes. The role of reaction products;

b) non-oxidative pathway. Interface of the pentose phosphate shunt with glycolysis. Enzymes and coenzymes. Reversibility of reactions. The role of reaction products.

4.3. Pathways for the conversion of glucose-6-phosphate (fructose-6-phosphate) depending on the cell's need for NADPH2, ribose-5-phosphate and ATP.

4.4. Impaired activity of enzymes of the pentose phosphate pathway.

4.5. Gluconeogenesis:

a) diagram of gluconeogenesis pathways;

b) key enzymes of gluconeogenesis. Their characteristics, gluconeogenesis reactions;

c) the commonality of a number of enzymes of glycolysis and gluconeogenesis;

4.6. Precursors of glucose are products of amino acid metabolism, lactate, glycerol. Their inclusion in the process of gluconeogenesis.

4.7. Glucose-lactate cycle (Cori), glucose-alanine cycle

4.8. Regulation of glyconeogenesis. The role of glucocorticoids.

4.9. Glycogen synthesis and mobilization.

Topic 5. *Regulation of carbohydrate metabolism and energy production in cells body. Disorders of carbohydrate metabolism.*

5.1.Glycogen - as a reserve and source of glucose in the cells of the body.

5.2. Hormonal regulation of glycogen synthesis and mobilization. Features of glycogen mobilization in muscles and liver.

5.3. Regulation of glycolysis and gluconeogenesis. Mechanisms of regulation. Hormonal and nucleotide effectors.

5.4. Regulation of the glucose monophosphate pathway for the conversion of glucose-6-phosphate.

5.5. Oxidative decarboxylation of pyruvic acid and synthesis of oxaloacetate. Mechanisms of regulation. Effectors.

5.6. Tricarboxylic acid cycle. Mechanisms of regulation. Effectors.

5.7. Disorders of carbohydrate metabolism. 1) hypoglycemia, hyperglycemia, glucosuria, renal threshold for glucose, sugar curves and their diagnostic value; 2) types of glucosuria.

5.8. Diabetes. The mechanism of its development.

5.9. Hereditary enzymopathies. Galactosemia, fructosuria, lactose intolerance, glycogenosis, glycogen store diseases.

5.10. The mechanism of action of insulin, adrenaline, glucagon, glucocorticoids, thyroxine and other hormones on carbohydrate metabolism.
5.11. Regulation of carbohydrate metabolism by substrates (examples). Regulation of carbohydrate metabolism by changing the activity of regulatory enzymes of glycolysis and the TCA cycle.

SPRING SEMESTER

Module 1. Lipid metabolism and functions

Topic 1. *Chemistry and lipid metabolism.*

1.1.Classification of lipids. Characteristics of classes.
1.2.Structure, properties and functions of human tissue lipids.
1.3.Digestion and absorption of food lipids. The role of bile acids. Fat resynthesis. Chylomicron formation and fat transport, Lipoprotein lipase.
1.4. Blood lipoproteins - chylomicrons, VLDL, LDL, HDL. Their composition and functions. Blood lipoprotein lipase.
1.5. Intermediate lipid metabolism: a) intracellular lipolysis; b) β-oxidation of fatty acids, connection with the Krebs cycle and the respiratory chain. Energy balance of palmitate oxidation.
1.6. Metabolism of ketone bodies.
1.7. Functions and pathways of conversion of polyene fatty acids into endoperoxides: prostaglandins, thromboxanes, prostacyclins, leukotrienes. Their role.
1.8. Carnitine acyltransferase and transport of fatty acids into mitochondria.
1.9. Features of the oxidation of fatty acids with an odd number of carbon atoms.
1.10. Natural antioxidants-inhibitors of lipid peroxidation.

Topic 2. *Intermediate lipid metabolism.*

2.1 Diagnostic value of determining lipids and their metabolic products in blood and urine.
2.2 Intermediate products of carbohydrate and protein metabolism as building materials for lipid synthesis.
2.3 Synthesis of fatty acids in the body.
2.4 Multienzyme complex for fatty acid synthesis. Regulation.
2.5 Formation of phosphoglycerol. Connection with glycolysis. Biosynthesis of triacylglyderides.
2.6 Phospholipid synthesis. The role of CTP, ATP, methionine, choline. The role of phospholipids in the body. Lipoic factors.
2.7 Biosynthesis of cholesterol. The role of cholesterol.
2.8 Hormonal regulation of lipid metabolism. The relationship between carbohydrate and lipid metabolism.
2.9 Lipid metabolism disorders: the role of LDL and VLDL in the occurrence of atherosclerosis and obesity.

Module* 2. *Metabolism of proteins and amino acids

Topic 1. Digestion and absorption of protein hydrolysis products.
1.1. Nutritional value of food proteins. Sources of amino acids in the blood. Nitrogen balance.
1.2.Digestion of proteins. Proteolytic enzymes of the gastrointestinal tract.
1.3.Digestion of proteins in the stomach. The role of hydrochloric acid.
1.4. Digestion of proteins in the intestines. Parietal digestion.
1.5. Transformations of amino acids under the influence of intestinal microflora
1.6. Biologically active amines and toxic substances are products of protein decay.
1.7. Mechanisms of neutralization of toxic products of amino acid metabolism in the liver.
1.8.Pathological changes in the acidity of gastric juice. Diagnostic value of their determination.
1.9. Diagnostic value of determining paired sulfuric acids and glucuronids in urine.
1.10. Positive and negative nitrogen balance. The meaning of their definition.

Topic 2. *Intermediate metabolism of amino acids*
2.1 Transamination reactions. Aminotransferases and their coenzymes. blood aspartate and alanine aminoferases, the diagnostic value of their determination.
2.2 Deamination reactions. Enzymes and coenzymes.
2.3 Oxidative deamidation of glutamic acid.
2.4 Indirect deamination of amino acids (scheme). The role of reactions.
2.5 The fate of nitrogen-free amino acid residues - five points of their inclusion in the tricarboxylic acid cycle (scheme).
2.6. Neutralization of ammonia in body cells. Transport it both liver and kidneys.
2.7.Ornithine cycle of urea formation in the liver.
2.8. Reductive transamination reactions - synthesis of non-essential amino acids.

Topic 3. *Metabolism of individual amino acids*.
3.1 Transport of amino acids across cell membranes. Judges and absorbed amino acids in the body.
3.2 Decarboxylation of amino acids - the formation of biogenic amines. Examples. Their role in the body.
3.3 Formation of polyamines: spermidine and spermine, putrescine and cadaverine. Write their formulas. Their role in the cells of the body.
3.4 The role of monoamine oxidases (MAO) and diamine oxidases in the inactivation of biogenic amines.
3.5. Exchange of serine and glycine. Formation of one-carbon groups The role of THFA (tetrahydrofolic acid).
3.6. Write the reactions for the synthesis of creatine phosphate. Its role in cells
3.7. The role of S-adenosylmethionium in the synthesis of creatine, choline, adrenaline.
3.8. Metabolism of phenylalanine and tyrosine. Formation of catecholamines.
3.9. Exchange of tryptophan and histidine.
3.10. Hereditary disorders of amino acid metabolism.

Module* 3. *Molecular mechanisms of transfer of genetic information

Topic 1. *Nucleotide exchange.*

1.1.Nucleotides, their structure. Properties of complementary interaction of nucleotides.

1.2. The role of nucleotides as the building material of nucleic acids, coenzymes, and energy metabolism.

1.3. Sources of nucleotides in the body. Synthesis of purine nucleotides.

1.4.Synthesis of pyrimidine nucleotides

1.5.Features of the synthesis of purine and pyrimidine nucleotides: the role of individual amino acids and one-carbon groups (methyl, formyl-THFA, CO2) in the synthesis of purine and pyrimidine nucleotides.

1.6. Decomposition products of purine nucleotides.

1.7. Decomposition products of pyrimidine nucleotides.

1.8. Disorders of nucleotide metabolism in the body. Hyperuricemia and gout. Lesch-Nyhan syndrome is a defect of hypoxanthine guanine phosphoribosyltransferase. Orotaciduria.

1.9. Allosteric activation and inhibition of key enzymes for the synthesis of pyrimidine nucleotides (UTP), the synthesis of purine nucleotides (AMP and GMP).

1.10. How does deoxyribonucleotide synthesis occur? What is the role of thioredoxin?

Topic 2. *Biosynthesis of nucleic acids (replication and transcription).*

2.1 What are nucleic acids? List the differences between DNA and RNA. How are nucleic acid monomers related to each other?

2.2 Name and characterize the main stages of the implementation of genetic information.

2.3 What is replication? Name the components required for replication. Describe the functions of replication enzymes.

2.4 Show a diagram and explain the essence of the semi-conservative mechanism of DNA synthesis.

2.5 Name the stages of replication. Describe the processes occurring at each stage (give a diagram). Name the enzymes and protein factors involved.

2.6 What are Okazaki fragments? Show them their education. What is their role?

2.7 What is a primer? What is his role? What are primase and primemosome?

2.8 What is transcription? Name the components necessary for transcription. What is the role of DNA-dependent RNA polymerase?

2.9 Name and characterize the types of reactions that occur during RNA processing. What is a cap and a polyA tail? Their role. Give the splicing scheme.

2.10 The role of polynucleotide phosphorylase in RNA synthesis.

Topic 3. *Biosynthesis of proteins. Post-translational protein modification.*

3.1 Components of the protein synthesizing system - ribosomes, m-RNA, t-RNA, amino acids, enzymes, protein factors.

3.2 Substrate specificity of aminoacyl-t-RNA synthetase. t-RNA, adapter function of t-RNA.
3.3 Initiation of translation. Write the reaction for the formation of N-formyl-methionyl-tRNA. Role in initiating translation.
3.4 Name the functional centers of ribosomes. What are they and what is their role?
3.5 Elongation of translation. Peptidyl transferase and peptidyl translocase reaction. Energy supply. The role of protein factors.
3.6 Termination of translation. The role of stop codons and protein factors.
3.7 What is protein processing? List the types of post-translational chemical modifications of proteins.
3.8 Explain the regulation of protein biosynthesis by the type of induction. Give an example.
3.9 Explain the regulation of protein biosynthesis based on the type of repression. Give an example.
3.10 Define the concepts “operator”, “promoter”, “structural genes”, “opera”, “inducer”, “corepressor”.

Module* 4. *Functional biochemistry of organs and tissues.

Topic 1. *Biochemistry of the liver.*
1.1.The role of the liver in carbohydrate metabolism.
1.2.The role of the liver in protein metabolism.
1.3.The role of the liver in lipid metabolism.
1.4. Antitoxic function of the liver. The role of PAPS, UDPGT.
1.5. Microsomal oxidation.
1.6. The role of the liver in pigment metabolism.
1.7. Depositing, endocrine, excretory functions of the liver.
1.8. Bile formation and excretory function of the liver.
1.9. Ammonia neutralization - urea synthesis.
1.10. The role of the liver in pigment metabolism (heme catabolism).

Topic 2. *Biochemistry of blood*
2.1 Blood. Composition, biochemical and physiological functions.
2.2 Biochemical features of blood cells and their functions.
2.3 The main proteins of blood plasma and their functions.
2.4 Blood plasma enzymes, their origin and diagnostic value of determination.
2.5 Blood plasma lipoproteins.
2.6 Nitrogenous and nitrogen-free low molecular weight organic components of blood, their significance.
2.7 Inorganic blood components.
2.8 Regulatory and hormonal function of blood - kinins.
2.9 Blood plasma enzymes.
2.10.Pathological changes in blood composition.

Topic 3. *Biochemistry of the kidneys.*

3.1 The role of water, macro- and microelements in the body.
3.2 Basic kidney functions.
3.3 The role of the kidneys in the regulation of water-salt metabolism and maintaining homeostasis in the body.
3.4 Chemical composition and properties of urine. Organic and inorganic components of urine.
3.5 Pathological components of urine. Diagnostic value of their determination in urine.
3.6 Hormonal regulation of water-salt metabolism.
3.7 Water. Physicochemical characteristics. The role of water in the structural organization of biomolecules.
3.8 The role of water, macro- and microelements in the body

Topic 4. *Biochemistry of connective tissue*.
4.1. Types of connective tissue. Features of the structure. Role in the body.
4.2. Structural organization of connective tissue: a) types of cellular elements. Their functions; b) intercellular organic matrix.
4.3.Features of the chemical composition of connective tissue biopolymers.
4.4. Formation and catabolism of proteoglycans.
4.5.Features of the structure and metabolism of collagen
4.6. Features of the structure and metabolism of elastin
4.7. Regulators of metabolism in connective tissue. The role of hormones and vitamins and other factors.
4.8. Biochemical changes in connective tissue during aging and some pathological processes. Diagnostic tests.

Topic 5. *Biochemistry of muscles.*
5.1. Muscle proteins.
5.2. Sources and features of energy supply for muscle activity.
5.3. The mechanism of muscle contraction. The role of non-protein nitrogenous extractives.
5.4. Biochemical changes in muscles during pathology.
5.5. The role of creatine and creatine phosphate in providing energy for muscle contraction.
5.6. Features of energy metabolism in muscles.
5.7.Biochemical mechanisms of muscle contraction and relaxation.
5.8.The most important proteins of myofibrils: myosin, actin, actomyosin, propomyosin, troponin, their structure and role.

Topic 6. *Biochemistry of nervous tissue.*
6.1 Features of structure, metabolism and energy production in nervous tissue.
6.2 Molecular mechanisms of synaptic transmission. Mediators.
6.3 Chemical basis of the origin and conduction of nerve impulses.
6.4 Active brain peptides.

6.5 Mediators: acetylcholine, serotonin, GABA, histamine, catecholamines.
6.6 The role of vitamins B1, B6, B12, THFA, HS-CoA in the synthesis of mediators.
6.7 Features of protein and amino acid metabolism in nervous tissue
6.8 Features of lipid metabolism
6.9 GABA-shunt

Block B

B.1 Situational cases:

AUTUMN SEMESTER

Module 1. Molecular basis of the structural organization of the cell

Topic 1. *Levels of structural organization and physicochemical properties of proteins.*

1.1 Case. What bonds can occur in a globular protein between the radicals of the following amino acids: a) leucine and valine; b) serine and glutamine; c) tryptophan and phenylalanine; d) lysine and aspartic acid.

1.2 Case. Write the formulas of the polypeptides and give them names: 1) ala-lys-tyr-asp-pro-his; 2) ser-val-met-arg-phe; 3) leu-cys-tre-glu-trp. How are these peptides charged in water? Identify the N-terminal and C-terminal amino acids in them. What color reactions can be used to discover these peptides?

1.3 Case. A fragment of the pentapeptide chain is given: seryl-lysyl-leucyl-cysteyl-valine. Select amino acids that may participate in the formation of:

1. – Hydrogen bond.
2. – Ionic bond.
3. – Hydrophobic interaction.

A. Serin.
B. Lysine.
C. Leucine.
D. Cysteine.
E. Valin.

Topic 2. Simple and complex proteins

3.1 Case. Write the formula of a fragment of a polypeptide chain containing phosphoserine and phosphotyrosine. Give examples of the most common phosphoproteins and characterise their biorole.

3.2 Case. Draw up a diagram of the transfer of oxygen and carbon dioxide by hemoglobin. Draw a curve of oxygen saturation of myoglobin and hemoglobin. Explain the allosteric properties of hemoglobin.

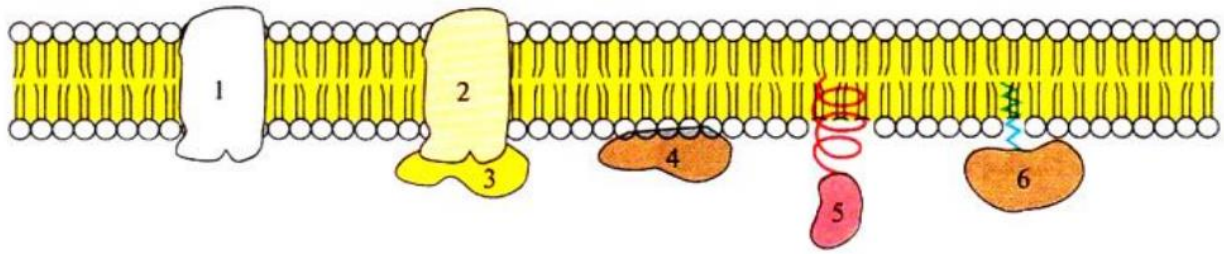
3.3 Case. As a result of a mutation in the hemoglobin β-chain gene, in the hydrophobic "pocket" where the binding of the protein part to heme occurs, phenylalanine replaced by serine. What is the mechanism of development of hemoglobinopathy? For an answer explain this question:

1) What role do the hydrophobic amino acids of the "pocket" where heme is located play in the functioning of hemoglobin;

2) Why does oxygen easily pass into the active center and bind to heme iron, but water does not:
3) Why does such a replacement lead to disruption of binding with oxygen;
how many oxygen molecules can such a mutant protein bind.

Topic 3. Complex proteins - supramolecular protein complexes.
4.1 Case. Check the statements specific to very low density lipoprotein (VLDL), low density lipoprotein (LDL), and high density lipoprotein (HDL):
1. synthesized in the liver;
2. transport endogenous triglycerides;
3. are cleaved by hepatic triglyceride lipase;
A. VLDL
B. LDL
C. HDL
4.2 Case. Write structural formulas of heteropolysaccharide monomers
(hyaluronic acid, chondroitin sulfate, keratan sulfate, dermatan sulfate).
4.3 Case. Mild hydrolysis of nucleic acids carried out in the laboratory showed that they break down into the following products: a nitrogenous base combined with ribose, as well as ribose combined with phosphoric acid. Based on this, establish the structure of the nucleotide.
Write the formula for AMP and justify the correctness of this representation of the mononucleotide.

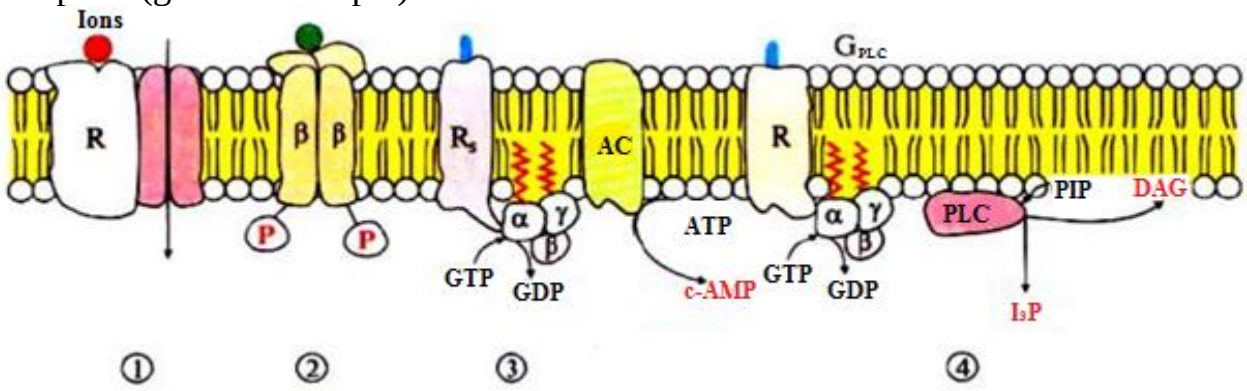
Module 2. Neuroendocrine regulation of cellular activity
Topic 1. Biological membranes.
5.1. Case. Using the drawing, characterize the membrane proteins (depending on their position in the membrane).



5.2. Case. In the process of preparing animals for hibernation, the phospholipid composition of membranes increases: the content of polyunsaturated fatty acids in the composition of phospholipids increases. How will this change affect the structure of the bilayer at low temperature?
5.3. Case. Based on your knowledge of the structure of the plasma membrane, explain why phospholipase causes red blood cell lysis and
protease and neuraminidase are not.

Topic 2,3. *Neuroendocrine regulation of cell functions. Mechanisms of hormonal signal transmission into cells.*

6.1. Case. Match the numbers in the diagram with the corresponding membrane receptors (give an example).



6.2. Case. Determine the hierarchy of hormone action; using hypothalamic-pituitary regulation:
1. CNS→releasing factors→adenopituitary gland→target organs;
2.CNS→releasing factors→anterior pituitary gland→blood→target organs;
3. CNS → hypothalamus → posterior pituitary gland → blood → target organs;
4.CNS → hypothalamus → releasing factors → pituitary gland → blood → peripheral endocrine gland → target organs.
6.3. Case. Explain the mechanism by which glucose transport increases in insulin-treated cells.

***Module* 3. Molecular basis of life activity and pathology**
Topic 1. *Enzymes, structure, mechanism of action.*
1.1. Case. The reaction A+B→C proceeds at a rate of 1. When a substance isolated from animal tissue is added to the reaction mixture, the reaction rate increases 10,000 times. What did the substance contain?
1.2. Case. Explain the biochemical meaning of some of the requirements (underlined) for the storage and use of enzymes drugs:

- dissolving the dry deposition with distilled water at room temperature
- temperature.
- When dissolving the drug, stir carefully.
- storage of the drug solution at low temperature.
- if long-term storage is necessary, dry the drug and seal it in evacuated ampoules.

1.3. Case. Compare enzymes with inorganic catalysts:
1. – similarity with inorganic catalysts;
2. – differences from inorganic catalysts.
A. Capable of regulating activity.
B. Only thermodynamically possible reactions are accelerated.
C. They are not consumed during the reaction.
D. They have high catalytic activity.
E. They do not shift the equilibrium of a chemical reaction.

F. Act under mild conditions (T, pH).
G. They have high specificity of action.

Topic 2. *Properties of enzymes. Kinetics of enzymatic reactions.*
2.1. Case. Write the reaction equations catalyzed by protein phosphatase and protein kinase. Explain the reason for the change in the activity of the protein that is exposed to these enzymes.
2.2. Case. Glutamate decarboxylase catalyzes the reaction:
Glutamic acid → GABA + CO2
Changes in the concentration of which substances can characterize the activity of the enzyme?
2.3. Case. The optimal incubation conditions for arginase chanced from pH 9.5 and t = 37°C - to pH 5.0 and t = 70°C, the activity of the enzyme changes. Indicate the main reason for the change in enzyme activity. Pick up matching pairs.
1. Change in the conformation of the enzyme molecule.
2. Change in the degree of ionization of the functional groups of the enzyme.
3. Change in the degree of ionization of the functional groups of the substrate.
4. Hydrolysis of peptide bonds.
5. Violation of weak bonds in the enzyme molecule.
A. Only when temperature changes.
B. Only when the pH changes.
C. When both conditions change.
D. Does not occur with any changes.

Topic 3. *Nomenclature and classification of enzymes.*
3.1. Case. Write the equation for the reaction of converting glucose-6-phosphate into 6-phosphoglucono-δ-lactone. Give the name of the enzyme according to systematic nomenclature, determine its class and subclass. Specify enzyme cofactor and the vitamin from which this cofactor is formed.
3.2. Case. What is the purpose determine the amount and ratio of creatine phosphokinase isoenzymes in the blood of a patient complaining of sharp chest pain?
3.3. Case. Write the reaction equation for the splitting of urea to ammonia and carbon dioxide. Give the name of the enzyme according to systematic nomenclature, determine its class and subclass.

Topic 4. *Water-soluble vitamins.*
4.1. Case. Avidin is a strong specific inhibitor of biotin enzymes. Which of the following reactions will be blocked when avidin is added to the cell homogenate?
1. Oxaloacetate-----glucose
2. Glucose-----pyruvate
3. Pyruvate -----oxaloacetate
4. Glucose-----ribose-5-phosphate
5. Lactate-----pyruvate
4.2. Case. Why is vitamin B12 prescribed intramuscularly but not in tablet form?

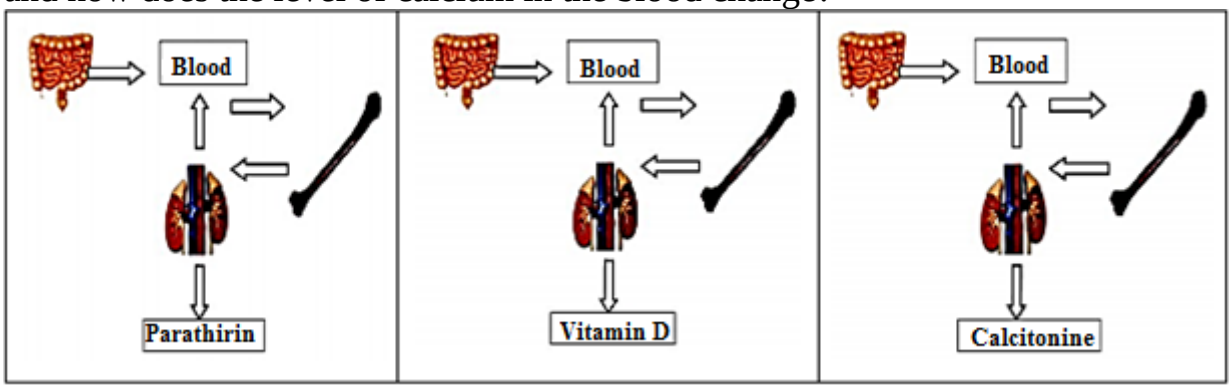
4.3. Case. The amount of vitamin B1 contained mainly in the shell of cereal seeds, decreases significantly when producing high-grade flour. The predominance of refined cereals or bread made from premium flour leads to hypovitaminosis B1. Will the rate of conversion of glutamate into α-ketoglutarate and GABA change with such hypovitaminosis? Support your answer with reaction equations and descriptions of enzymes and their cofactors.

Topic 5. *Biological role of fat-soluble vitamins*

5.1. Case. Vitamins A and D can be taken in an amount that is sufficient to maintain their levels for several weeks, but B vitamins must be taken much more often. Why?

5.2. Case. Patient V., 50 years old, was admitted to the clinic with complaints of loss of appetite, weight loss, weakness, and pain in the stomach. Laboratory:
erythrocytes in the blood $1.7x10^{12}$/l (normal - $5x10^{12}$/l);
gastric secretion is 0.4 l per day (the norm is 2.5 l per day);
The pH of the gastric juice is 7.0 (the norm is 1.5).
Red blood cells have an unusual shape and large size (diameter 12-14 microns, the norm is 7-8 microns). Diagnosis? How to help a patient?

5.3. Case. How parathyrin, calcitonin and vitamin D act on metabolism of calcium in the indicated organs (sign the arrows: "increases" or "decreases" in the figure) and how does the level of calcium in the blood change?



***Module* 4.** *Biological oxidation, cell energy and carbohydrate metabolism.*

Topic 1. *Specific and general pathways of catabolism.*

1.1.Case. How will deficiency of vitamins B1, B2, PP affect the functioning of the Krebs cycle? To answer, indicate what connection between these vitamins and Krebs cycle enzymes.

2. Case. Select statements that correctly reflect the features of the regulation of reactions in the general catabolic pathway. Explain your answer.
   a) isocitrate dehydrogenase is an allosteric enzyme;
   b) the activity of Pyruvate-dehydrogenase complex does not depend on the concentration of citrate;
   c) the rate of the Krebs cycle does not depend on the NAD+/NADH ratio;
   d) uncouplers of oxidation and phosphorylation do not affect the rate of reactions of the general catabolic pathway.

2.1.Case. Consider the oxidation of acetyl-CoA in the Krebs cycle under hypoxia and normoxia. How much ATP is produced in this process?

Topic 2. *Tissue respiration is the terminal stage of biological oxidation.*

2.1. Case. Calculate the amount of ATP that can theoretically be formed during the oxidation of succinic acid to oxaloacetic acid and isocitrate to succinyl-CoA, provided that the mitochondria are not uncoupled.

2.2. Case. In the past, attempts have been made to use 2,4-dinitrophenol as a weight loss agent. High toxicity refused this idea, although those who took it did lose weight. Explain what the effect of 2,4-dinitrophenol is based on?

2.3. Case. How many ATP molecules are formed during the complete oxidation of the following compounds to CO2 and H2O (assume that we are talking about liver, kidney or heart cells):

1) Phosphoenolpyruvate;
2) acetyl-CoA;
3) dihydroxyacetone phosphate;
4) glycerin;
5) pyruvate;
6) NADH;
7) fructose-1,6-diphosphate;
8) glucose;
9) glyceraldehyde-3-phosphate;
10) sucrose.

Topic 3. *Carbohydrates. Digestion, absorption, transport into cells. Glycolytic pathway of glucose oxidation. Synthesis and mobilization of glycogen in body cells.*

3.1. Case. In the experiment, saliva was added to a solution containing sucrose, lactose, starch and cellulose and incubated under optimal conditions. Write reaction schemes (indicating enzymes) that can happen in this experience. Indicate the reason for the impossibility of some reactions.

3.2. Case. Complete the diagram of glucose catabolism with the missing substrates, name the process and the enzymes involved:

glucose → gl-6- P → ... → fr -1,6-BP → …→ 3- GAP → … → PEP → …

→ Acetyl-SCoA

3.3. Case. Match the indicated glucose transporters and working organs:

1. GLUT-1	A. liver
2. GLUT -2	B. muscles
3. GLUT -3	C. heart
4. GLUT -4	D. brain
	E. adipose tissue
	F. placenta
	G. red blood cells

Topic 4. *Key reactions and enzymes of gluconeogenesis. Pentose phosphate pathway for glucose conversion*

4.1. Case. Make a diagram of the glucose-alanine cycle, completing the missing components and naming the processes. Explain what it is function of this cycle. Name what other cycle operates between these tissues.

4.2. Case. Make a diagram of the pentose monophosphate pathway, completing the missing components and naming the processes. Explain what it is
function of this path.

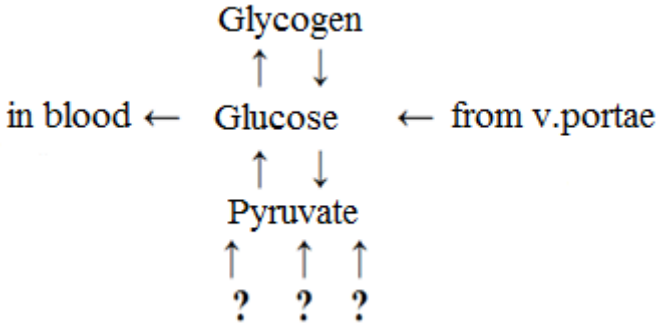
4.3. Case. Which metabolic pathways for glucose metabolism in the liver, shown in the diagram, predominate under the following conditions:

A) 1 hour after eating a meal containing 200 g of carbohydrates

B) when fasting after 48 hours

C) 10-15 minutes after the start of heavy physical work.

Include in the diagram substances that can be a source of pyruvate during gluconeogenesis. Justify your answer.



Topic 5. *Regulation of carbohydrate metabolism and energy production in cells body. Disorders of carbohydrate metabolism.*

5.1. Case. Eating confectionery and sweets causes vomiting and diarrhea in a child. He does not tolerate sweet tea well, while milk does not cause negative reactions. Suggest a molecular defect.

5.2. Case. Two types of diseases have been described. One is characterized by a defect in muscle phosphorylase, the other - in the liver. Name the signs of these diseases. How will the lactate concentration in the blood change after exercise?
load? What is the reaction of patients to the administration of glucagon?

5.3. Case. Which carbohydrate - glucose or fructose is healthier for the patient?
diabetes?

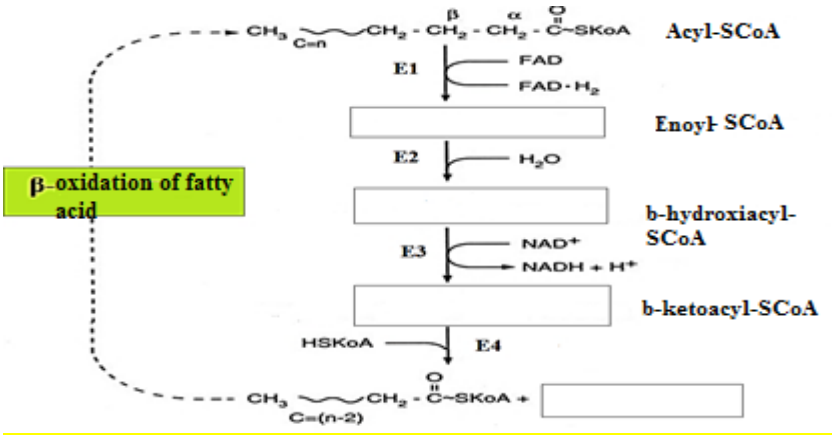
SPRING SEMESTER

Module 1. Lipid metabolism and functions

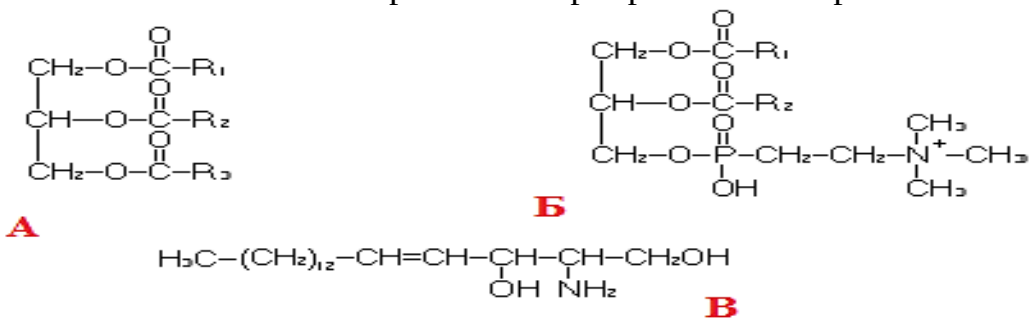
Topic 1. *Chemistry and lipid metabolism.*

1.1. Case. Calculate the energy balance in ATP during complete oxidation of 1 g. palmitic acid to CO2 and H2O?

1.2. Case. Дополните схему «β-окисление жирных кислот» - напишите формулы, назовите ферменты. Покажите связь данного процесса с циклом Кребса и тканевым дыханием



1.3. Case. The formulas of two lipids and a lipid precursor are present.

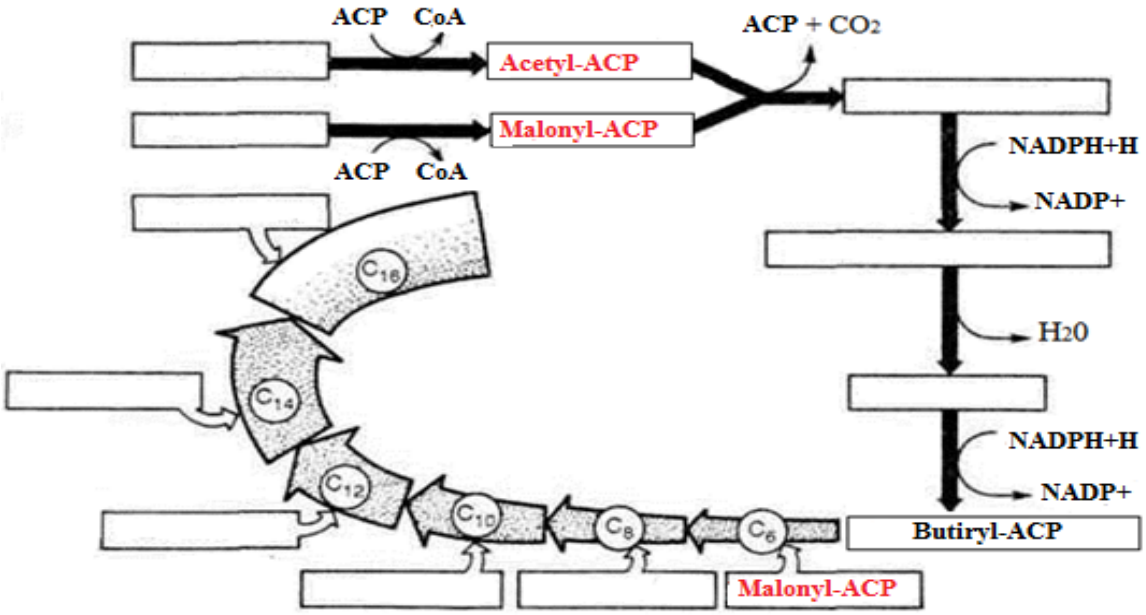


a) Name these compounds (A, B, C) and describe their role in the body.
b) Write a scheme for the synthesis of compound B in the liver.
c) What transport forms of lipids contain compound B?

Topic 2 *Intermediate lipid metabolism*

2.1. Case. How many high-energy phosphate bonds are needed for the biosynthesis of one cholesterol molecule?

2.2. Case. Complete the diagram "Synthesis of fatty acids." Write the substances involved in the reactions, intermediate products, enzymes at each stage. What is a source of NADPH2?



2.3. Case. Write a diagram of the metabolic pathway for converting phosphatidylserine into phosphatidylcholine, and formation of lysophosphatidylcholine and glycerolphosphocholine. Which amino acid in its active form is involved in this process? Describe the biological roles of lysophosphatidylcholine (lysolecithin) and glycerolphosphacholine.

Module 2. *Metabolism of proteins and amino acids*

Topic 1. *Digestion and absorption of protein hydrolysis products.*

1.1 Case. Pepsin hydrolyzes peptide bonds in proteins during their digestion in the stomach. What class of enzymes does it belong to? What type of chemical bonds does this enzyme break down? Give examples of substrates for this enzyme. Is pepsin a simple or complex enzyme? What is its optimum pH?

1.2 Case. Healthy rats were kept for a long time on an artificial protein diet excluding the methionine and lysine. How will the nitrogen balance change in these animals? Explain your answer. To do this: Define nitrogen balance; Name which group of amino acids methionine and lysine belong to.

1.3 Case. Write the diagram "γ-glutamyl transport system." Label the enzymes E1-E5. Write the formulas of the substrates and reaction products.

Topic 2. *Intermediate metabolism of amino acids*

2.1.Case. The catabolism of amino acids begins with the loss of amino groups. This occurs due to deamination or transamination reactions. The final collector of amino groups is α-ketoglutarate, which, by attaching an amino group is converted into glutamic acid.

a) Write the reaction catalyzed by aspartate aminotransferase.

b) Write the amination reaction of α-ketoglutarate.

c) Write the process by which the amino group of glutamate is converted into the final product of nitrogen metabolism.

2.2.Case. Write the reactions included in the general pathways of amino acid metabolism and the products of these reactions.

2.3.Case. Healthy rats were kept for a long time on an artificial protein diet excluding TRYPTOPHAN. Will the nitrogen balance change in these animals? If it changes, HOW and WHY? Describe the nitrogen balance.

Topic 3. *Metabolism of individual amino acids*

3.1.Case. Elevated concentrations of ammonia and citrulline were found in the patient's blood and urine. Give a possible reason for this. How can you test your assumption?

3.2.Case. Complete the diagram of the pathway of tyrosine catabolism in the liver, substituting the names of intermediate metabolites instead of numbers:

TYROSINE → 1 → 2 → 3 → FUMARATE + ACETOACETATE

With a hereditary defect in one of the enzymes of this metabolic pathway, patients' urine turns black when exposed to air. Name the disease and the defective enzyme that leads to the disease. Write the reaction that will be blocked.

3.3.Case. What amino acid is adrenaline formed from? Write the reactions indicating the intermediate products and their role in the body?

Module* 3. *Molecular mechanisms of genetic information transfer

Topic 1. *Nucleotide exchange.*

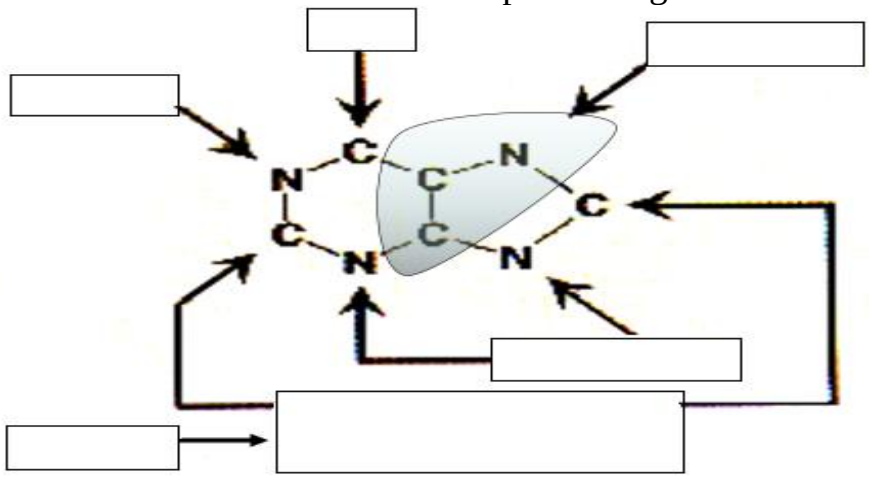
1.1 Case. During the synthesis of nucleotides and DNA, an important role is played by the vitamin coenzyme that transfers one-carbon fragments. With its deficiency, hematopoiesis is disrupted and macrocytic anemia occurs.

a) Name this coenzyme.

b) From what vitamin and with the help of what enzyme is it formed?

c) What one-carbon fragments does it transport?

1.2 Case. Indicate the sources of the purine ring atoms.



1. *1.3 Case.* Biosynthesis of deoxyribonucleotides. Find a match:

А. Glutamine	1. required for the biosynthesis of nucleoside triphosphates;
Б. β-alanine	
В. ATP	2. necessary for the synthesis of orotic acid;
Г.NAD	3. breakdown product of uracil and cytosine;
Д. Carbomoyl-phosphate	4. necessary for the conversion of xanthosine-5-monophosphate to guanosine-5-monophosphate;
	5. necessary for the conversion of inosinic acid to xanthyl acid.

Topic 2. *Biosynthesis of nucleic acids (replication and transcription).*

2.1. Case. Describe the structure, properties and mechanism of action of RNA polymerase. Provide a diagram of the sequential arrangement of nucleotides in an mRNA fragment synthesized on a template **-dG-dA-dG-dT-dC-dT-dA-dG-dT-** with the participation of DNA-dependent RNA polymerase.

2.2. Case. Construct the sequence of mRNA processing:

A. Attaching to the 3' end of the polyadenyl tail
B. Excision of sections transcribed by introns during splicing
C. Attaching to the 5’ end of the “Cap”
D. Cutting off “extra” terminal sequences
E. Methylation of adenine and cytosine

2.3. Case. Find matches:

Enzyme function:	Ферменты:
A. Carries out the growth of the leading strand of DNA.	1. DNA-polymerase α
B. Carries out the growth of the lagging DNA strand.	2. DNA -ligase
C. Synthesizes a primer.	3. DNA - polymerase β
D. Participates in the formation of the replication fork.	4. DNA - polymerase δ
	5. DNA - topoisomerase ε

Topic 3. *Biosynthesis of proteins. Post-translational protein modification.*

3.1 Case. Most amino acids have more than one code, more than one tRNA. Write all possible anticodons for the 4 histidine codons GGU-GGC-GGA-GGG.

3.2 Case. A fragment of m-RNA molecule has the nucleotide sequence: UUATCUGGCCAGTCUACGUTC. How many thymine nucleotides does the gene region from which this m-RNA was transcribed contain? How many amino acids are encoded in this region of mRNA?

3.3 Case. The initial part of one chain of the macromolecule of normal human hemoglobin has the structure His-Val-Ley-Ley-Tre-Pro-Glu-Glu. What is the structure of the corresponding part of the hemoglobin gene? Diagram the stages of translation and transcription.

Module* 4. *Functional biochemistry of organs and tissues.

Topic 1. *Biochemistry of the liver.*

1.1 Case. In a patient with persistent hypoglycemia, the blood did not change significantly after the administration of adrenaline. The doctor suggested liver problems. What changes in liver function are we talking about?

1.2 Case. All the main pathways of carbohydrate metabolism are carried out in the liver: glycolysis, glycogenesis, glycogenolysis, PPP, gluconeogenesis, interconversion of monosaccharides, inclusion of carbohydrates in other metabolisms. The rate of these processes is regulated through metabolic control or neurohumoral control.

a) Which of the listed processes are carried out in the absorptive period, and which in the post-prandial period?

b) Which hormones regulate the metabolism of carbohydrates in the liver in the absorptive period, and which in the post- prandial period?

1.3 Case. The young man had mild jaundice after the flu. Laboratory analysis results: hemoglobin - 110 g/l; in serum total bilirubin - 60 μmol/l, indirect bilirubin

- 56 μmol/l, alkaline phosphatase - 74 U/l (<150 U/l), AST - 35 U/l (<40 U/l) -, in urine There is no bilirubin. Are liver functions impaired? Suggest a diagnosis.

Topic 2. *Biochemistry of blood*

2.1 Case. When analyzing the patient's blood, the residual nitrogen was 48 mmol/l, urea 15.3 mmol/l. The results of this analysis indicate a disease of which organ?

2.2 Case. Some people have a disease after taking drugs such as aspirin and sulfonamides which leads to hemolysis of red blood cells. What biochemical defects underlie the disease?

2.3 Case. In the diagnosis of many diseases, the results of determining the activity of enzymes in blood serum are used. Tissue enzymes enter the blood mainly during pathologies associated with cell destruction. The most important diagnostic determination is of organ-specific enzymes, in particular isoforms. Damage to which organ can be assumed if:

a) the content of LDH4 and LDH5 in the blood serum increased;
b) the content of LDH1 in the blood serum increased;
c) the content of LDH3 in the blood serum increased.

Topic 3. *Biochemistry of the kidneys.*

3.1 Case. Under normal conditions, the inevitable daily loss of water for an adult is about 2500 ml. How much water is lost: a) with exhaled air; b) with urine; c) through the skin in the form of sweat?

3.2 Case. Name the pathologies in which the following compounds are found in significant quantities in the urine:

a) glucose, acetoacetate, acetone, β-hydroxybutyrate;
b) phenylpyruvic acid, phenylacetic acid and phenyllactic acid;
c) albumin.

3.3 Case. Determine which metabolic pathology causes the following conditions:

A. proteinuria	1. Glomerulonephritis
B. glycosuria	2. Diabetes mellitus
C. ketonuria	3. Porphyria
D. porphyrinuria	4. Intense muscle load
E. creatinuria	5. Myopathy
F. hematuria and hemoglobinuria.	

Topic 4. *Biochemistry of connective tissue*

4.*1 Case.* Which stage of collagen biosynthesis is disrupted during scurvy and why?

4.*2 Case.* Under what pathological conditions does the amount of acidic glycosaminoglycans increase in the intercellular substance of connective tissue? The formation of this group of hereditary diseases is associated with a genetic defect of which enzymes?

4.*3 Case.* List the biochemical parameters used in clinical practice for describtion bone resorption.

Topic 5. *Biochemistry of muscles.*

1.1 *Case.* List the main sources of energy in muscles. Which ATP resynthesis pathway is the fastest? Mark it in red.

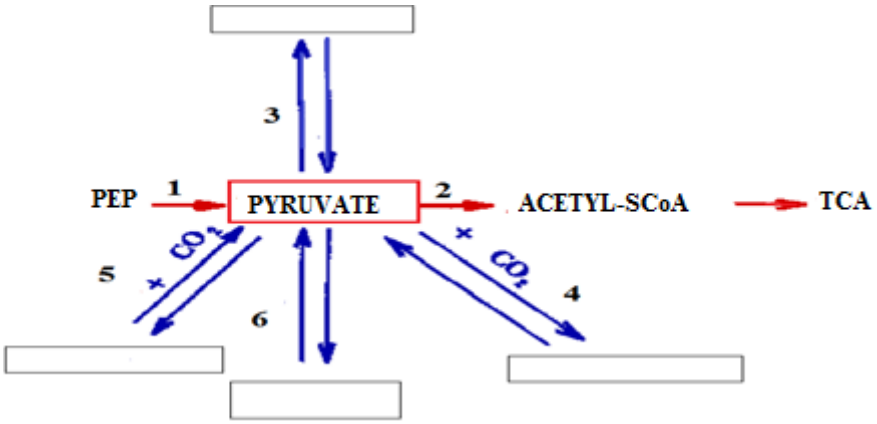
1) _____
2) _____
3) _____
4) _____

1.2 *Case.* In a hereditary disease, as a result of a defect in the enzymes involved in the synthesis of carnitine, its concentration in skeletal muscles is reduced. How will this affect the ability to perform long-term physical activity and why?

1.3 *Case.* The body was subjected to short-term but strong physical stress. What compounds were used as the main energy substrate? How has the production of adrenaline, ACTH, glucocorticosteroids, insulin, and glucagon changed?

Topic 6. *Biochemistry of nervous tissue.*

6.1 *Case.* Complete the diagram "Pathways of pyruvate metabolism in the brain": indicate enzymes, metabolites.



6.2 *Case.* The toxic effect of ammonia on brain cells is explained, in particular, by a disruption in the formation of neurotransmitters. The synthesis of which neurotransmitter known to you will be disrupted first?

6.3 *Case.* Why does nervous tissue and, above all, the brain use glucose as the main oxidation substrate? At the same time, fatty acids, a generally recognized energy accumulator, are not used by nervous tissue. How can this be explained, taking into account the fact that nervous tissue is characterized by and really needs a high level of energy metabolism?

LIST OF THEMES OF ABSTRACTS FOR INDIVIDUAL STUDENTS' WORK:

1. Directions and perspectives of biochemistry development.
2. Essential dietary sources for nutrition of healthy and sick people (essential amino acids, unsaturated fatty acids).

3. Amino acids as drugs.
4. Pathology related to lack of amino acids in the body.
5. The specific role of proteins in the phenomenon of life.
6. Characteristics of peptide bonds.
7. Chemiosmotic theory of oxidative phosphorylation associated with tissue respiration.
8. Glycogen synthesis and its mechanism.
9. Tricarboxylic acid cycle, the consequence of reactions.
10. Oxidation of fatty acids.
11. Resynthesis of triacylglycerols in the intestinal epithelium, phosphatidic and beta – monoglycerides pathways of resynthesis.
12. Coenzyme A and its role in the metabolism of fatty acids.
13. The fate of foreign compounds in the body, detoxification, increase of their activity or toxicity.
14. Antagonism and synergism of antioxidants. Methods of research of antioxidant properties.
15. Chemistry of neutralization of toxic substances in the liver.
16. Parenteral protein nutrition: advantages and disadvantages.
17. Dietary proteins: chemical composition, structure, biological role.
18. Proteins of blood plasma
19. Disintegration of tissue proteins. The role of lysosomal enzymes.
20. Activators and mechanism of proteases activation in the gastrointestinal tract.
21. Disorders of urea cycle. The hyperammonemia.
22. Disorders of metabolism of sulphur-containing amino acids.
23. The fate of phenylalanine in the body.
24. Disorders of phenylalanine metabolism.
25. Disorders of tryptophan metabolism.
26. Disorders of metabolism of glutamic and aspartic acids.
27. Types of mononucleotides and their role.
28. The role of nucleic acids in protein biosynthesis.
29. The breakdown of hemoglobin. Differential diagnosis of jaundice.
30. Inhibitors of enzymes and antienzymes as therapeutic agents.
31. Isoenzymes and their role in medicine.
32. Digestive enzymes in replacement enzyme therapy.
33. Enzymes of blood plasma.
34. Enzymopathies: hereditary, toxic and nutritional.
35. Biocatalytic function of water-soluble vitamins.
36. Vitamin-like compounds and their role in metabolism.
37. The biological role of vitamin C.
38. The history of the development of hormone theories.
39. The role of second messengers in the transmission of the hormonal signal.
40. Tissue hormones and their role.
41. Prostaglandins as drugs.
42. Mechanism of insulin action.

43. Mechanisms of memory. Tissue hormones: neurotransmitters, derivatives of arahidonic acid, cyclic nucleotides, active peptides and their role in the regulation of metabolism.
44. P.Mitchell received the Nobel prize in chemistry in 1978 for his chemiosmotic theory of oxidative phosphorylation.
45. Hormones that regulate blood sugar level. The place of their synthesis and mechanism of their action.
46. Biochemical features of diabetes mellitus.
47. Hereditary metabolic diseases of glycogen (glycogenosis).
48. Non-enzymatic glycosylation of proteins.
49. Catabolism of glucose in anaerobic and aerobic conditions.
50. Biosynthesis of glucose (gluconeogenesis).
51. Metabolism of fructose and galactose, disorders of their metabolism.
52. Biological membranes, structure, role of phospholipids and cholesterol.
53. Hormonal regulation of lipid metabolism.
54. Metabolism of cholesterol in the body.
55. Plasma lipoproteins.
56. Hyperlipoproteinemia, types, symptoms.
57. Biochemistry of atherosclerosis.
58. Change of metabolism during starvation.
59. Biochemical features of nerve tissue.
60. Characteristic of muscle proteins.
61. Pathology of biochemical changes in muscles.
62. Biochemical changes in the connective tissue due to pathology and aging.
63. Biochemical changes in muscles due to muscular dystrophy and coronary heart disease.

Block D

AUTUMN SEMESTER

Module 1. Molecular basis of the structural organization of the cell

1. Questions to check the level "KNOWLEDJE"

1. Write the structure of the following polypeptides: gly-ala-val-ley-ile; tre-asp-lys-tyr-glu-his. What is the predominant charge of mentioned molecules?
2. Write the structure of the following polypeptides: tre-asp-lys-tyr-glu; ser-cys-ala. How does each of these substances behave in different color protein reactions?
3. What is the mechanism of the color protein reactions?
4. What is hydrolysis of proteins and what types of hydrolysis do you know?
5. How do amino acids and proteins behave in water solution and in the presence of excess of acids or alkalines?
6. What is the isoelectric point of a protein? What is the range of IEP of animal tissue proteins?
7. What does protein solubility depend on? What factors stabilize protein in solution?

8. What are the general mechanisms for protein precipitation from solution?
9. What methods do you know by which you can precipitate proteins without their denaturation?
10. What is the salting out of proteins?
11. What is protein denaturation? What substances can cause protein denaturation?
12. How can albumins and globulins of muscle tissue be separated?
13. By what method can you determine the amount of protein in a solution?
14. How are calibration curves constructed when quantifying protein using the biuret method?
15. What types of chromatographic methods for separating substances do you know?
16. What is the meaning of divided chromatography of amino acids on paper?

Cases/tasks to check the level "SKILLS"
1. What is the difference between protein precipitation and protein denaturation?
2. What is clinical and diagnostic significance of the quantitative determination of total protein content in blood?
3. Compare the types for the secondary structure of the protein. Give examples.
4. Compare the structure of globular and fibrillar proteins.
5. Compare the protein quaternary structure for globular and fibrillar proteins.
6. Compare salting out and denaturation methods.

Cases/tasks to check the level "EXPERTISE"
1. Below are the names of 19 natural proteins and 7 functions they perform in the body. Name the function that each of these proteins performs.
Protein name: 1. Ribonuclease, 2. Antibodies, 3. Hemoglobin, 4. Actin, 5. Serum albumin, 6. Insulin 7. Casein (milk), 8. Keratin, 9. Ferritin, 10. Trypsin, 11. Thrombin, 12. Growth hormone, 13. Collagen, 14. Myosin, 15. Egg albumin, 16. Elastin, 17. Tubulin, 18. Glucagon, 19. Pepsin
Function: I. Enzymatic, II. Transport, III. Food and storage, IV. Contractile, motor, V. Structural, VI. Protective, VII. Regulatory.
2. Find in which pH (neutral, acidic or alkaline) the IEP of a polypeptide consisting of the following amino acid residues localises: arg-his-glu-cys. In what direction will this peptide move when peptides are separated by electrophoresis in a buffer solution with a neutral pH value? How will the charge and direction of movement of peptide in electric field change, if arginine is replaced with leucine?

Module 2. Neuroendocrine regulation of cellular activity
Questions to check the level "KNOWLEDJE"
1. Which structural components of biomembranes do you know.
2. Give characteristics of structural organization of biological membranes. Name main types of membrane structures.
3. Describe physico-chemical characteristics of macromolecules in biomembranes.
4. Which basic functions of biological membranes do you know.
5. Mechanisms of transmembrane transfer of substances.

6. Structural and functional characteristics of cellular organelles.

Cases/tasks to check the level "SKILLS"

1. Give a comparative description of the outer and inner layers of the biological membrane.
2. Why are polar and nonpolar molecules transported across the membrane in different ways?
3. What is the difference between primary and secondary active transport?
4. Give a comparative description of biomembrane proteins.
5. What is the difference between early and late hormonal effects on a cell?
6. Why does disruption of insulin binding to its receptor lead to a decrease in glucose concentration in muscle tissue?

Cases/tasks to check the level "EXPERTISE"

3. Complete the "chain" task.
1. The receptor of hormone in the cytoplasmic membrane is:
A. adenylate cyclase
B. G protein
C. protein kinase
D. adrenergic receptors
2. These proteins can activate the enzyme:
A. adenylate cyclase
B. phosphodiesterase
C. protein kinase C
D. protein kinase A
3. The enzyme you have chosen is part of:
A. adenylate cyclase system
B. steroid hormone signal transduction systems
C. guanylate cyclase system
D. inositol phosphate system
4. Activation of this enzyme leads to an increase in the concentration in the cell:
A. Ca2+
B. cAMP
C. AMP
D. calmodulin
5. This substance activates
A. protein kinase A
B. Ca2+calmodulin-dependent protein kinase
C. protein kinase C
D. phospholipase C
6. This leads to:
A. dissociation of the enzyme into protomers
B. enzyme phosphorylation
C. increasing Ca-calmodulin enzyme activity

D. protomer associations
7. Activated enzyme
A. interacts with membrane lipids
B. phosphorylates proteins
C. catalyzes phosphodiesterase
D. catalyzes the formation of cAMP

Module 3. Molecular basis of life activity and pathology

1. Questions to check the level "KNOWLEDJE"

1. What is the essence of divided chromatography of amino acids on paper?
2. What substances are called enzymes? What is their chemical nature?
3. What basic criteria apply to enzymes that are also characteristic of inorganic catalysts?
4. How does enzyme activity depend on temperature?
5. How does the pH value of the medium affect enzymatic activity?
6. What is the specificity of enzyme action and how is it determined?
7. What substances are called enzyme activators and inhibitors? Give examples.
8. What qualitative methods are used to study the action of enzymes?
9. What quantitative methods are used to study the action of enzymes?
10. What units of enzyme activity do you know?
11. Why do many structural analogues of substrates react as inhibitors of the corresponding enzymes?
12. What consequences can occur as a result of an inhibitor of a particular enzyme entering the body?
13. List the types of specificity. Give examples of enzymes for the types of specificity you named?
14. How can you verify the specificity of an enzyme experimentally?
15. What type of specificity have enzymes: arginase, amylase, sucrase, urease?
16. What are vitamins and why are they called such?
17. How are vitamins classified?
18. What are vitamin deficiencies and hypovitaminosis and what are the causes of their occurrence?
19. What are the specific signs of vitamin deficiencies caused by the lack of vitamins B1, B2, B6 in food?
20. What are the specific signs of vitamin deficiencies caused by the lack of vitamins PP and C in food?
21. What diseases occur due to the lack of vitamins A, D and K in food?
22. What is the relationship between vitamins and enzymes?
23. What qualitative reactions to vitamins do you know? Give examples.
24. Write the formula of the coenzyme, which contains vitamin B1.
25. Write the formula of the coenzyme, which includes vitamin B2
26. Write the formula of the coenzyme, which includes vitamin B6
27. Write the formula of oxidoreductase coenzymes, which contain vitamins.

28. What is the chemical nature of oxidoreductase?
29. What properties of riboflavin underlie its biological activity?
30. What is biological role of niacin?

Cases/tasks to check the level "SKILLS"

1. What is the structure of enzymes? What is the difference in the structure of simple and complex enzymes?
2. Which similarities between enzymes and inorganic catalysts do you know?
3. How proteins can be separated from low molecular weight compounds?
4. What is the method for determining amylase activity based on and what is the diagnostic value of this determination?
5. How is blood catalase activity determined?
6. Explain the clinical significance of determining enzymes in biological fluids.
7. What is the relationship between vitamins and enzymes?
8. Compare the mechanism of action of water-soluble and fat-soluble vitamins.
9. Why does hemerolopia develop with a lack of vitamin A?
10. What is pellagra? It associated with what vitamin deficiency?
11. What is beriberi? It associated with what vitamin deficiency?
12. What biochemical changes develop with a lack of vitamin D?

Cases/tasks to check the level "EXPERTISE"

1. The enzyme pepsin can break down the peptide bonds of proteins. Why activity of pepsin can inactivate many enzymes? To justify your answer, remember:
1. What are enzymes?
2. What class of enzymes does pepsin belong to?
3. Which amino acids (which peptide bonds) are affected by it?
2. During the Battle of Britain, British aviation bore the brunt of the attack and was able to withstand many times superior enemy forces, mainly thanks to the skill of British pilots. However, many pilots experienced difficulties with flying at night due to visual impairment. After introducing increased amounts of milk, butter, eggs and carrots into the diet, this problem completely disappeared. Explain why.
3. M, a 44-year-old alcoholic, had a very poor appetite. One weekend he felt very unwell after drinking a large amount of alcohol on an empty stomach. When going to the hospital, the following were noted: pulse - 104 per minute, low blood pressure, chronic heart failure, disorientation in time and space. What vitamin deficiency can cause this?

***Module* 4. Biological oxidation, cell energy and carbohydrate metabolism.**

1. Questions to check the level "KNOWLEDJE"

1. What are the mechanisms of action of uncoupling agents?
2. Biological significance of TCA cycle.
3. What is "substrate phosphorylation"?
4. Features characteristic of aerobic and anaerobic glycolysis.

5. Which of the processes of glucose breakdown provides energy for the metabolism of erythrocytes?
6. What compound is formed in the body from ethanol?
7. What is microsomal oxidation? List microsomal enzyme systems.
8. Catabolism and anabolism, their relationship.
9. Central metabolic pathways.
10. ATP and other high-energy compounds.
11. Biological oxidation.
12. Structural organization of the respiratory chain.
13. Carbohydrates and their biological role in the body.
14. Classification of carbohydrates. What property of carbohydrates underlies their classification into mono, oligo- and polysaccharides.
15. What enzymes are involved in the digestion of carbohydrates?
16. What are hypoglycemia and hyperglycemia?

Cases/tasks to check the level "SKILLS"

1. How will the coefficient of oxidative phosphorylation P/O change in the presence of uncoupling agents?
2. Write the dehydrogenation reactions in TCA cycle. Connection with the respiratory chain.
3. How is the synthesis and breakdown of glycogen regulated?
4. The TCA cycle is the general pathway of catabolism (reaction equations, enzymes, the importance of ATP, ADP, NAD, NADH in the regulation of the Krebs cycle, connection with the respiratory chain).
5. Coupling of oxidation with phosphorylation. Respiratory chain inhibitors and uncouplers.
6. Write a scheme for the hydrolysis of disaccharides - maltose, lactose, sucrose.
7. The relationship between glycolysis in muscles and gluconeogenesis in the liver (Cori cycle). Allosteric mechanisms of regulation of aerobic and anaerobic pathways of glucose breakdown and gluconeogenesis.
8. Mobilization of glycogen, regulation of these processes. The role of insulin, glucagon, adrenaline.
9. What is the energetic effect of aerobic and anaerobic glucose oxidation?
10. What is the final product of glycolysis and what is its physiological effect on the body?
11. What are the mechanisms for maintaining a constant concentration of glucose in the blood?
12. Features of hydrolysis of carbohydrates during digestion and their absorption. What enzymes speed up this process in the digestive system? What conditions are necessary for the action of these enzymes?

Cases/tasks to check the level "EXPERTISE"

1. How many ATP molecules are synthesized during the oxidation of one molecule of pyruvate to 2-oxoglutarate; one molecule of isocitrate to succinate; one molecule

of succinate to oxaloacetate, if dehydrogenase reactions are coupled to the respiratory chain?
For calculations:
a) Write the sequence of reactions in the indicated sections of the Krebs cycle.
b) Indicate the reactions associated with the respiratory chain.
c) Remember how much ATP is formed from the oxidation of NADH and FADH2.
3. What will happen to the Krebs cycle if the outflow of reduced equivalents (NADH) from it stops? To answer, indicate the reactions in which NADH is formed and the routes for its further transformation.
3. Match the metabolic pathways with the corresponding letter answer:

1). Breakdown of amino acids to pyruvate	A. Specific pathway
2). Conversion of glycerol to pyruvate	B. Nonspecific pathway
3). Breakdown of amino acids to acetyl-CoA	
4). Breakdown of fatty acids to acetyl-CoA	
5). Conversion of pyruvate to acetyl-CoA	
6). The breakdown of acetyl-CoA to CO_2 and H_2O.	

SPRING SEMESTER

Module 1. Lipid metabolism and functions

1. Questions to check the level "KNOWLEDJE"

1. Classification of lipids. Characteristics of classes.
2. Structure, properties and functions of human tissue lipids.
3. Digestion and absorption of food lipids. The role of bile acids. Fat resynthesis. Chylomicron formation and fat transport.
4. Carnitine acyltransferase and transport of fatty acids into mitochondria.
5. Features of the oxidation of fatty acids with an odd number of carbon atoms. Metabolism of propionyl-S-CoA.
6. Mobilization of TAG in adipose tissue. Regulation of the process and fate of lipolysis products.
7. Stages of fatty acid biosynthesis: reactions, enzymes. Regulation of the biosynthesis process of high FA.
8. Mobilization of TAG in adipose tissue. Regulation of the process and fate of lipolysis products.
9. Scheme of synthesis of glycerophospholipids. An idea of the role of lecithin in the functioning of lung surfactant.
10. TAG biosynthesis: sequence of reactions, substrates, enzymes. Features of synthesis in the liver, adipose tissue, enterocytes. Process regulation.
11. Structure and functions of cholesterol in the human body.
12. Fund, ways of using and removing cholesterol in the body. Metabolic and hormonal regulation of biosynthesis.
13. Functions of bile acids and its regulation. Enterohepatic circulation of bile acids, biological significance.

14. Biological significance and structures of ketone bodies. Synthesis of ketone bodies in the liver; regulation of synthesis. Understanding ketonemia, ketonuria and ketoacidosis.
15. Classification of drugs. Structure and composition of plasma lipoprotein particles. Apoproteins and their functions. Enzymes involved in drug metabolism. Catalyzed reactions, their role in drug metabolism.

Cases/tasks to check the level "SKILLS"

1. Comparative characteristics of blood lipoproteins: chylomicrons, VLDL, LDL, HDL. Their composition and functions. Blood lipoprotein lipase.
2. β-oxidation of fatty acids, connection with the Krebs cycle and the respiratory chain.
3. Energy balance of palmitate oxidation.
4. Natural antioxidants-inhibitors of lipid peroxidation and their use in medicine.
5. Diagnostic value of determining lipids and their metabolic products in blood and urine.
6. Intermediate products of carbohydrate and protein metabolism as building materials for lipid synthesis.
7. Formation of phosphoglycerol. Connection with glycolysis. Biosynthesis of triacylglycerides.
8. Phospholipid synthesis. The role of CTP, ATP, methionine, choline. The role of phospholipids in the body.
9. Relationship between carbohydrate and lipid metabolism.
10. Lipid metabolism disorders: the role of LDL and VLDL in the occurrence of atherosclerosis and obesity

Cases/tasks to check the level "EXPERTISE"

1. Calculate the energy balance in ATP during complete oxidation of 1 g. palmitic acid to CO2 and H2O?
2. From what substrates is glycerophosphate formed in adipose tissue and muscles, with what processes are they associated? Write a diagram of the reaction.
3. What is the role of Krebs cycle metabolites in the synthesis of fatty acids?
4. What differences might there be in cholesterol levels between vegetarians and people whose diet includes a lot of meat, milk, and eggs?
5. Explain why ketonemia occurs in diabetes mellitus?
6. The immediate precursor of ketone bodies is beta-hydroxy-beta-methylglutaryl CoA, which is synthesized from acetyl-CoA. Acetyl-CoA is formed from glucose and fatty acids. However, acetyl-CoA derived from fatty acids is used to synthesize ketone bodies. Give a scheme for the synthesis of ketone bodies. Explain.
7. What substances are necessary for the synthesis of phosphatidylserine, phosphatidylethanolamine, and phosphatidylcholine in the body?

8. The patient has had his gallbladder removed. What is impaired in him - the absorption of proteins, carbohydrates or fats? Why?

Module* 2. *Metabolism of proteins and amino acids

1. Questions to check the level "KNOWLEDJE"

1. Nutritional value of various proteins. Nitrogen balance.
2. Clinical manifestations of a lack of protein in food.
3. Digestion of proteins in the gastrointestinal tract. Biological significance of digestion. Process diagram. Characteristics of digestive enzymes.
4. The formation of hydrochloric acid and its role in the digestion of proteins. Regulation of hydrochloric acid secretion.
5. Transformations of amino acids under the influence of intestinal microflora.
6. Biologically active amines and toxic substances are products of protein decay.
7. Transamination reactions. Aminotransferases and their coenzymes.
8. Deamination reactions. Enzymes and coenzymes. Oxidative deamidation of glutamic acid.
9. Indirect deamination of amino acids (scheme). The role of reactions.
10. Neutralization of ammonia in body cells. Transport it both liver and kidneys.
11. Ornithine cycle of urea formation in the liver.
12. Reductive transamination reactions - synthesis of non-essential amino acids.
13. Decarboxylation of amino acids - the formation of biogenic amines. Examples.
14. Formation of the polyamines spermidine and spermine, putrescine and cadaverine. Write their formulas. Their role in the cells of the body.
15. The role of monoamine oxidases (MAO) and diamine oxidases in the inactivation of biogenic amines.
16. Exchange of serine and glycine. Formation of one-carbon groups. The role of THFA (tetrahydrofolic acid).
17. Write the reactions for the synthesis of creatine phosphate. Its role in cells.

Cases/tasks to check the level "SKILLS"

1. Mechanisms of neutralization of toxic products of amino acid metabolism in the liver, their clinical significance.
2. Pathological changes in the acidity of gastric juice. Diagnostic value of their determination.
3. Pathological components of gastric juice.
4. Diagnostic value of determining paired sulfuric acids and glucuroids in urine.
5. Positive and negative nitrogen balance. The meaning of their definition.
6. Diagnostic value of determining aspartate and alanine aminoferase in blood.
7. The fate of nitrogen-free amino acid residues - five points of their inclusion in the tricarboxylic acid cycle (diagram).
8. Gluconeogenesis from nitrogen-free amino acid residues (scheme).
9. Explain the significance of the ornithine urea cycle.
10. Write the reactions for the synthesis of non-essential amino acids.

11. Transport of amino acids across cell membranes. The fate of absorbed amino acids in the body.
12. The role of biogenic amines in the body, their formation.
13. The role of S-adenosylmethionine in the synthesis of creatine, choline, adrenaline.
14. Disorders of phenylalanine and tyrosine metabolism, explain the mechanism of development

Cases/tasks to check the level "EXPERTISE"

1. Name the enzymes that catalyze the following reactions:
aspartate + alpha-ketoglutarate → OAA + glutamate; alanine + alpha-ketoglutarate → pyruvate + glutamate
What is the clinical significance of increasing the activity of each of them in the blood serum?
2. Write the reactions ofthe formation of the following biogenic amines: histamine, serotonin, gamma-aminobutyric acid/GABA/, dopamine. Their role.
3. What role do glutamic and aspartic acids play in the neutralization of NH3 in the body? Write these reactions.
4. Give a diagram of the glucose-alanine cycle. What is his role?
5. Adrenaline is formed from which amino acid? Write the reactions indicating the intermediate products and their role in the body?
6. During the oxidation of alanine, 5 mol of ATP and 1 mol of CO2 were formed. What product is formed by these reactions?
7. How will the function of the glucose-alanine cycle change in a patient with diabetes mellitus, during physical activity and at rest?
8. Elevated concentrations of ammonia and citrulline were found in the patient's blood and urine. Give a possible reason. How can I check your offer?
9. Explain the mechanism of activation of pepsinogen, trypsogen and chymotrypsogen. What is the essence of the activation of these proenzymes?
10. In the urine of a sick child, the amount of indican, paired sulfuric and glucuronic acids is increased. Explain why?
11. Prove the correctness of the expression - "Fats burn in the flame of carbohydrates." What is the biochemical essence of this expression?
12. The patient has had his gallbladder removed. What is impaired in him - the absorption of proteins, carbohydrates or fats? Why?
13. Enzymes involved in the digestion of proteins in the stomach and intestines are characterized by a fairly broad substrate specificity. Can we consider on this basis that they are not sufficiently perfect enzymes?

Module* 3. *Molecular mechanisms of genetic information transfer

1. Questions to check the level "KNOWLEDJE"

1. Nucleotides, their structure.
2. Properties of complementary interaction of nucleotides.

3. The role of nucleotides as the building material of nucleic acids, coenzymes, in energy metabolism,
4. Sources of nucleotides in the body.
5. Synthesis of purine and pyrimidine nucleotides. Features of the synthesis of purine and pyrimidine nucleotides: the role of individual amino acids and one-carbon groups (methyl, formyl-THFA, CO2) in the synthesis of purine and pyrimidine nucleotides.
6. Decomposition products of purine and pyrimidine nucleotides.
7. Disorders of nucleotide metabolism in the body. Hyperuricemia and gout. Orotaciduria.
8. DNA biosynthesis. Main stages of DNA replication.
9. RNA biosynthesis – transcription of matrix, transport and ribosomal RNAs.
10. Protein synthesis system.
11. Genetic code of m-RNA. Adapter function of t-RNA.
12. Stages of protein biosynthesis.
13. Post-translational modification of a protein molecule.
14. Regulation of protein synthesis. Inhibitors of matrix biosynthesis.
15. DNA repair.

Cases/tasks to check the level "SKILLS"

1. Write the reactions for the formation of 5-phosphoribosyl-1-amine from ribose-5-phosphate. Indicate the sources of ribose-5-phosphate in the cell. How and why does the rate of this process change with the accumulation of AMP and GMP in the cell?
2. Write the reaction for the synthesis of adenosine monophosphate from adenine, indicate the name of the enzyme and the biological role of this transformation.
3. Write the reaction for the synthesis of guanosine monophosphate from guanine, indicate the name of the enzyme. What disorders will be observed with a genetic defect of this enzyme?
4. Write the reactions for the formation of adenosine monophosphate from inosine monophosphate. What further transformations can adenosine monophosphate undergo?
5. Write the formula for adenosine monophosphate. Indicate the origin of each of the nitrogen and carbon atoms of AMP.
6. Write the formula for guanosine monophosphate. Indicate the origin of each of the nitrogen and carbon atoms of GMP.
7. Write the reactions catalyzed by xanthine oxidase. List the diseases that can occur with increased formation of the final breakdown product of purine nitrogenous bases.
8. Write the UMP formula. Indicate the origin of each of the nitrogen and carbon atoms of UMF. How and why does the rate of initial reactions of pyrimidine synthesis change when UTP and CTP accumulate in the cell?

Cases/tasks to check the level "EXPERTISE"

1. List the vitamins that take part in the synthesis of purine nitrogenous bases. Indicate the role of these vitamins in the synthesis of purines.
2. Present in the form of a diagram the breakdown of guanine to the final product.
3. List the diseases that can occur with increased formation of the final breakdown product of purine nitrogenous bases.
4. Present in the form of a diagram the formation of UMP.
5. Present in the form of a diagram the catabolism of UMP.
6. List the enzymes involved in the recycling of purine nitrogenous bases. Indicate the disorders that will be observed with genetic defects of these enzymes.
7. Present in the form of a diagram the process of reduction of nucleoside diphosphates into deoxynucleoside diphosphates.
8. Indicate the role of thioredoxin and the source of hydrogen for its reduction.
9. Indicate the metabolites from which uric acid can be formed.
10. Indicate in what cases the formation of uric acid may increase.

Module* 4. *Functional biochemistry of organs and tissues.

Questions to check the level "KNOWLEDJE"

1. List the main protein fractions isolated during the electrophoretic separation of blood proteins, indicate their content.
2. Indicate normal values for the level of total protein in blood.
3. Name the possible causes of hypoproteinemia and hypoalbuminemia.
4. Formed elements of blood. Features of metabolism in erythrocytes and leukocytes.
5. Hemoglobin, structure and functions. Types of human hemoglobin, change of types in ontogenesis. Cooperative properties of hemoglobin. Hemoglobinopathies.
6. Protein-synthesizing function of the liver. Sources and ways of using amino acids in the liver.
7. The role of the liver in maintaining nitrogen balance.
8. Biological role of the liver in the regulation of carbohydrate metabolism.
9. The role of the liver in the metabolism of lipids and ketone bodies.
10. Features of metabolism and energy metabolism in the cells of striated muscles and myocardium.
11. Characteristics and role of fibrillar and regulatory proteins in the process of muscle contraction.
12. The mechanism of muscle contraction, stages.
13. Name the main stages (phases) of neutralization of toxic products in the liver, indicate the essence of the reactions.
14. List the possible causes and nature of changes in the color and transparency of urine.
14. List bile acids synthesized in the liver and their possible conjugates. Describe the biological role of bile acids.

Cases/tasks to check the level "SKILLS"

1. Explain why determining the activity of plasma indicator enzymes has diagnostic significance.

2. Present in the form of a diagram the structure of plasma lipoprotein.
3. List the fractions of blood lipoproteins, indicate the places of their formation and functions.
4. List the main inorganic components of blood plasma. Indicate how the ionic composition of blood plasma changes a) with insufficient secretion of aldosterone; b) with excessive secretion of aldosterone; c) when the secretion of parathyroid hormone and calcitonin changes.
5. Present in the form of a diagram the reactions included in the system of protecting the erythrocyte from excess superoxide and hydrogen peroxide. Indicate the names of the enzymes that catalyze these reactions.
6. Write the reaction for the formation of glucose from glucose-6-phosphate, indicate the enzyme.
7. List the pathways for the formation of glucose in the liver, name their physiological role.
8. Write the reaction for the formation of glucose-1-phosphate from glycogen, indicate the enzyme. List the hormones that regulate the rate of this reaction.
9. Present in the form of a diagram the ways in which glucose is used in the liver, indicate the significance of each process.
10. List the changes in the composition and properties of urine in diabetes insipidus. Explain the mechanism of these changes.
11. Indicate what endocrine disorder leads to the development of diabetes insipidus.
12. List the compounds involved in the transport of lipids in the blood. Indicate the compositional features and specific role of each of these compounds.
13. List the components of “residual nitrogen” in the blood. Indicate where and from which metabolites the components of “residual nitrogen” in the blood are formed? What is the further fate of the various components of residual nitrogen?
14. Present in the form of a diagram the exchange of iron in the body. Indicate the proteins involved in the transport and storage of iron.
15. Present the synthesis of heme as a diagram. Name the regulatory enzyme for heme synthesis and its effector.
16. Present heme catabolism as a diagram. Indicate the localization of each stage of formation of bile pigments.
17. Indicate which endocrine disorder leads to the development of diabetes insipidus.
18.List the compounds involved in the transport of lipids in the blood. Indicate the compositional features and specific role of each of these compounds.
19. List the components of “residual nitrogen” in the blood. Indicate where and from which metabolites the components of “residual nitrogen” in the blood are formed? What is the further fate of the various components of residual nitrogen?
20. Present the exchange of iron in the body as a diagram. Indicate the proteins involved in the transport and storage of iron.
21. Present the synthesis of heme as a diagram. Name the regulatory enzyme for heme synthesis and its effector.

22. Present heme catabolism as a diagram. Indicate the location of each stage bile pigment formation.

Cases/tasks to check the level "EXPERTISE"

1. Indicate the enzymes whose activity determination is used to diagnose pathology of the liver and pancreas.
2. Present in the form of a diagram of the functioning of the enzymatic antioxidant system of erythrocytes. Indicate the consequences of disruption of the functioning of this system.
3. List the main blood buffer systems. Indicate which one has the most power.
4. Describe the functioning of the bicarbonate buffer system. Explain how blood pH changes during hypo- and hyperventilation.
5. Present in the form of a diagram the possible pathways for the exchange of glucose-6-phosphate in erythrocytes. Indicate the physiological function of these metabolic processes and the possible consequences of disruption of these processes.
6. During a clinical examination, C-reactive protein (CRP) was detected in a person's blood. What kind of substance is this, what is its origin? Can this person be considered healthy?
7. Present as a diagram the exchange of glycogen in the liver. Name the hormones that control the speed of processes
8. Present as a diagram the synthesis of acetoacetate in liver cells. Name the conditions accompanied by increased ketogenesis.
9. List the physicochemical properties of urine. Give the values of normal indicators. Explain the dependence of these indicators on the nature of nutrition and water consumption in a healthy person.
10. List the nitrogen-containing compounds in normal urine of an adult. Name the possible reasons for changes in the daily excretion of each of these compounds.
11. List the changes in the composition and properties of urine in diabetes mellitus. Explain the mechanism of these changes.
12. Present the synthesis of urea as a diagram. Indicate where this process occurs and what is the further fate of the resulting urea. Indicate what determines the amount of urea formed in the human body.
13. Diagram the "alanine cycle" and the "Cori cycle". Indicate the localization and physiological role of the processes.
14. Present in the form of a diagram the stages of neutralization and transport of ammonia, the formation and excretion of the final products of nitrogen metabolism in the body. Specify the localization of processes.
15. Present in the form of a diagram the process of formation of free glucose from malic acid. Label the irreversible reactions of this process. Describe the physiological role of this process. Write the first reaction of this process.

INTERMEDIATE CONTROL EXAMINATION TICKET № 1 (record)

TICKET № 1

Questions to check the level "KNOWLEDJE"

1. Squirrels. Levels of structural organization of proteins. Primary structure of proteins.

Cases/tasks to check the level "SKILLS"

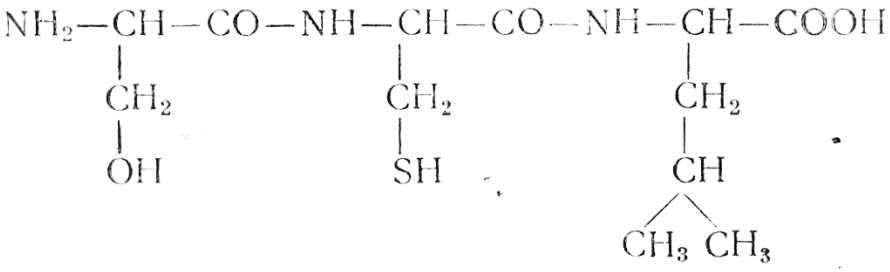
2. Write the chemical formula of the C-terminal fragment of the pentapeptide (glu-asn-his-met-lys) of the polypeptide chain.

Cases/tasks to check the level "EXPERTISE"

3. Explain the essence of the regulation process using the adenylate cyclase mechanism.

TICKET № 2

1. Name the acidic amino acids.
2. Name the tripeptide:



1. Can a substance be named a protein if the biuret and ninhydrin reactions are positive?

TICKET 3

1. What is tissue respiration?
2. Write all the reactions for the conversion of glucose-6-phosphate to ribulose-6-phosphate.
1. Give a diagram of TCA (write the names of the substances, reaction products - H2 and CO2 and show the connection of the cycle with tissue respiration with signs $H_2 \rightarrow H_2O$
$\searrow$ 3ATP

INTERMEDIATE CONTROL EXAMINATION TICKET № 2 (exam)

Examination card No. 1

in the course "Biochemistry" special. General Medicine

1. Physico-chemical properties of proteins. Colloidal properties of protein solutions: amphotericity, isoelectric point, precipitation, denaturation and others.
2. Glycolysis. Two stages of glycolysis. Energy efficiency of glycolysis.

3. Sources of nucleotides in the body. Synthesis of pyrimidine nucleotides. Decomposition products. Orotaciduria.
4. There are two runners at a distance: the sprinter completes the 100-meter race, the stayer completes the 10th kilometer. Indicate the difference in the energy supply to the muscles of these runners.

Examination card No. 2

in the course "Biochemistry" special. General Medicine

1. Lipid composition of membranes. Membrane proteins. Glycoproteins and membrane glycolipids. Structural organization of biological membranes. Types of membranes.
2. The structure and biorole of the pancreatic hormone - insulin. Mechanism of action.
3. Oxidative decarboxylation of pyruvic acid. Pyruvate dehydrogenase complex. Sequence of reactions, connection with the Krebs cycle and the respiratory chain.
4. A patient excretes 1.5 g of uric acid in the urine per day (the norm is 0.6 g), and its content in the blood is increased (hyperuricemia). The doctor prescribed the medication allopurinol and recommended limiting meat intake. What disease are you supposing? How does allopurinol work?

4. METHODOLOGICAL MATERIALS DETERMINING PROCEDURES FOR ASSESSING KNOWLEDGE, ABILITIES, SKILLS

The assessment scales

Abstract evaluation criteria

Points	5	4	3	2
Contents	The work is fully completed.	Practically the most important components of the work are completed but not fully.	Not all important components of the work are completed.	The work is done partially with the teacher’s help.
	The work demonstrates deep understanding of the described processes.	The work demonstrates understanding of the main points but some details are not specified.	The work demonstrates partial understanding of the described processes.	The work demonstrates little understanding of the described processes.
	The work contains interesting discussion material. Scientific vocabulary is used correctly.	There is some discussion material. Scientific vocabulary is used, but sometimes not correctly.	Discussion material is present but does not help to understand the problem. Scientific terminology is used but not correctly.	Minimal discussion material is present. Few scientific terms are used.

	The student provides his own interpretation or development of the topic (generaliza-tions, applications, analogies).	The student offers his own interpretation or development of the topic in most cases.	The student sometimes offers his interpretation.	Interpretation is limited or is not related to the subject.
Literacy	No error - grammatical or syntactic.	Minimal errors are present.	There are errors making the meaning difficult to understand.	A lot of errors, making the material difficult to read.
Report	The student clearly explains the abstract content and makes visual contact with the audience.	The student clearly explains the content of the essay.	The student clearly explains the content of the essay.	The student reports incorrect information.

51-- 60 points – 5
41 – 50 points – 4
31 – 40 points – 3
Less than 30 points – 2.

Assessment criteria for answers to situational tasks:
5 points - student gives precise answers to all questions on situational problems using terms and definitions from basic, main and additional literature.
4 points - student correctly, but not in details, answers to all the questions with minimal errors using references from basic and main literature.
3 points - student correctly solves the problem, but doesn't answer all the questions (70 - 89%), omitting details, answers with errors using references from basic literature.
2 points – student correctly solves the fragments of the task, doesn't answer all the questions making mistakes and using references from basic literature.
1 point – student demonstrates isolated fragments of knowledge could not solve the whole problem.
0 points - student does not solve the task, gives wrong answers, the answers do not relate to the task questions.

The criteria for test assessment
5 points – 85 - 100% of correct answers
4 points – 76 - 85% of correct answers
3 points – 61 - 75% of correct answers
2 points – 0 - 60% of correct answers

Assessment criteria for exam questions:
1. Knowledge of the basic processes, functions and laws of the subject, depth and completeness of answers to question.
2. Knowledge of terms and concepts, their use in the response.
3. Ability to explain the meaning of processes, laws, mechanisms, to make conclusions and summarization, ability to explain cause-and-effect relations.
4. Ability to answer questions.
5. Use of literary language, scientific terms, logic and consistency of answers, ability to express his/ her opinion.