LIST OF QUESTIONS
for the course exam in the discipline "Biological Chemistry"
for 2nd year students of GomSMU

1. The subject and tasks of biochemistry. Objects and methods of biochemical research in the clinic and experiment. A brief historical background of biochemistry. The importance of biochemistry for the physician.
2. Protein structure. Levels of protein structural organization: characterization of the bonds that form each level. Species specificity of proteins. Protein polymorphism. Types of natural ligands and mechanisms of their interaction with proteins.
3. Conformational changes in protein structure as the basis for its functioning. Biological functions and classification of proteins. Oligomeric proteins. Multyenzyme complexes. Protein folding, the role of chaperones.
4. Methods for the qualitative and quantitative determination of protein, methods for isolation and purification. Protein denaturation and renaturation: mechanisms, characteristics, use in medical and laboratory practice.
5. Biological catalysis. Types of biological catalysts (enzymes, ribozymes, abzymes). Similarities and differences between biological (enzymes) and non-biological (inorganic) catalysts. Enzyme structure: active and allosteric centers. Specificity of enzyme action (examples).
6. Enzyme structure. Simple and conjugated enzymes, the role of cofactors, coenzymes. The structure and mechanism of action of vitamins that make up FAD, FMN, $NAD(P)^+$, TPP, pyridoxal phosphate, THF. Enzyme properties: sensitivity to pH, thermal stability, specificity.
7. The mechanism of the substrate and enzyme interaction (hypotheses of E. Fischer, D. Koshland and modern concepts). Stages of interaction of the enzyme and the substrate. Intermediate theory. Basic concepts of thermodynamics of enzymatic catalysis (average energy, activation energy, energy barrier).
8. Kinetics of enzymatic reactions (factors affecting the rate of enzymatic reactions). Michaelis-Menten equation. K_M - definition, physiological significance. Allosteric enzymes, features of the kinetics of allosteric enzymes.
9. Regulation of enzyme activity (the role of hormones, cAMP, Ca^{2+}, IP_3, $C_{20:4}$ metabolites). Chemical modification of enzymes (limited proteolysis, phosphorylation cycle-dephosphorylation, etc.). Allosteric regulation.
10. Enzyme inhibition: types of inhibitors, mechanisms of their action, examples. Drugs and metabolites as modulators of enzyme activity.
11. Enzyme nomenclature and classification (examples of reactions for each class). Units of enzyme activity. Principles of qualitative detection and quantitative determination of enzyme activity.
12. Intracellular enzyme localization. Marker and organ-specific enzymes. Isozymes: origin, biological significance. Changes in the activity of enzymes in ontogenesis.
13. Main directions of medical enzymology. Enzyme diagnostics: objects, goals, and objectives. The clinical value of enzyme activity determination in myocardial infarction, liver, kidney disease, etc.
14. Enzymopathies: causes, mechanisms of development, examples, degree of clinical manifestations, principles of diagnosis and treatment of primary and secondary enzymopathies.
15. Enzyme therapy: routes of administration and indications for use. Concept of liposomes and viral vectors. The use of enzymes in laboratory practice.
16. Metabolism as a condition for life. Integration of anabolism and catabolism of carbohydrates, lipids and proteins. Bioenergetics: historical background (the theory of Bakh-Engler, Palladin-Wieland).
17. Transformation and transfer of energy in the cell. Thermodynamic coupling of reactions. Redox reactions, redox potential (ORP). The essence of biological oxidation (BO). BO substrates: scheme of their formation, localization and characteristics of the main stages of BO. The value of BO for the organism. The concept of "proton" and "sodium" bioenergetics (H^+-ATPase and Na^+/K^+-ATPase).

18. The main ways of oxygen consumption. General characteristics of mitochondria (Mt). The concept of tissue respiration. Paths of formation and biological role of ATP. Macroergic phosphates, nature of macroergicity. ATP/ADP cycle - pathways for ATP formation and use.

19. TCA: localization, enzymes, coenzymes, reactions, regulation, biological significance.

20. The structure and characteristics of the components of the electron-transporting chain (ETC). Localization, basic principles of functioning and structural organization of Mt ETC complexes. ETC abnormalities, inhibitors of ETC complexes.

21. Oxidative phosphorylation (OP). OP points, P/O ratio. P. Mitchell's chemiosmotic hypothesis. Coupled and uncoupled respiration, mechanisms of coupling and uncoupling. OP uncouplers.

22. Low energy state: characteristics, causes and effects. Mitochondrial genome. Mitochondrial diseases: causes, clinical manifestations, principles of treatment.

23. Microsomal oxidation: localization, structure and characteristics of ETC components. Comparative characteristics of mitochondrial and microsomal ETC. The biological significance of microsomal oxidation.

24. Peroxidation. The electronic structure of oxygen atom. Reactive oxygen species formation. Antioxidant defense (enzymatic and non-enzymatic). The role of peroxide processes in health and disease.

25. Biological role of carbohydrates. Digestion of carbohydrates in the gastrointestinal tract, digestive-transport conveyor: enzymes, their characteristics, mechanisms of digestion. Impaired digestion and absorption of carbohydrates: main causes and clinical manifestations.

26. Mechanisms of carbohydrate transport across membranes. The role of glucose transporters (GLUT, SGLT) and Na^+/K^+-ATPase in glucose transport in various organs and tissues.

27. Pathways of glucose metabolism in the body. Mechanism and significance of glucose activation. The role of ATP and insulin. Difference between hexo- and glucokinase.

28. Glycogen metabolism (synthesis and catabolism), the role of hormones, cAMP and Ca^{2+} ions. Glycogenosis: classification, main causes and clinical manifestations.

29. Glycogenolysis and anaerobic glycolysis: localization, reactions, enzymes, regulation. The mechanism of glycolytic oxidoreduction. Kinase reactions of glycolysis and substrate-level phosphorylation. Energy balance of lactic acid fermentation.

30. Alcohol fermentation: reactions and enzymes. Similarities and differences between alcohol and lactic acid fermentation. Ethanol metabolism in the body. Metabolic disorders in acute and chronic ethanol intoxication.

31. PDH complex: structure, localization, regulation, biological role. Pasteur effect. Diagram of the pathway of complete aerobic oxidation of 1 glucose molecule, energy balance. The role of vitamins (B_1, B_2, pantothenic acid, PP, lipoic acid) in carbohydrate metabolism.

32. Gluconeogenesis (GNG): localization, substrates, reactions, enzymes, biological significance. Substrate, energy and hormonal regulation of GNG. Cori and Felig's cycles, their mechanisms and meaning.

33. Pentose phosphate pathway: localization, regulation, reactions, enzymes, biological role.

34. The role of glucose homeostasis in the vital activity of the organism. Mechanisms of blood glucose regulation (urgent and permanent), the role of insulin and counter-insular hormones. Causes, mechanisms of hypo- and hyperglycemia in normal and pathological conditions, their main clinical manifestations.

35. Diabetes mellitus: types, cases of the absolute and relative insulin deficiencies, biochemical disorders and clinical manifestations.

36. Diabetes mellitus: complications, diagnosis by clinical manifestations and laboratory parameters, principles of treatment. Glycemic curve plotting technique.

37. Conversion of galactose and fructose to glucose. Galactosemia and fructosuria: main causes and clinical manifestations.

38. Main classes of lipids, their biological role and structure. PL biosynthesis: localization, reactions and enzymes, biological role of PL. Main features of erythrocyte membrane structure; outer and inner Mt membrane.

39. Lipid digestion in adults and children: enzymes, emulsification mechanism (structure, metabolism and role of bile acids). Resynthesis of lipids in enterocytes. Causes and consequences of steatorrhea.

40. Transport of lipids in the blood, structure, composition and classification of lipoproteins (LP). LP metabolism. The role of apoproteins and enzymes of LPL, LCAT, ACAT in LP metabolism.
41. Impairments of LP metabolism in pathology: dislipoproteinemia, atherosclerosis, fatty liver infiltration.
42. Regulation of lipid metabolism: the role of hormones, cAMP and Ca^{2+}. Mechanisms of triglycerides deposition and mobilization in adipose tissue: reactions, enzymes.
43. β-oxidation of fatty acids: localization in the cell, the role of carnitine, energy balance. Relationship of the β-oxidation system with TCA and Mt ETC. Genetic defects of the β-oxidation system, their clinical manifestations.
44. β-oxidation of odd numbered carbon atoms fatty acids and unsaturated fatty acids, energy balance. The role of peroxisomes in long-chain fatty acids oxidation.
45. Metabolic pathways of acetyl-CoA (formation and utilization). Ketone bodies: metabolism, role. Causes, mechanism of occurrence and diagnostic value of ketonemia and ketonuria.
46. Cholesterol biosynthesis: reactions up to mevalonic acid: reactions, enzymes, regulation, biological role. The formula of cholesterol. The causes of hypercholesterolemia and atherosclerosis.
47. Biosynthesis of saturated fatty acids: localization, reactions, enzymes, structure poly-enzyme complex, connection with glycolysis, pentose phosphate pathway and TCA, the role of CO_2, ATP, NADPH, biotin. Unsaturated FA biosynthesis reactions.
48. Biosynthesis of triglycerides in liver and adipose tissue: localization, reactions, enzymes. The biological role of triglycerides.
49. Hormonal regulation of carbohydrate and lipid metabolism. Randle's fat-carbohydrate cycle, its biological significance. Integration of carbohydrate and lipid metabolism, pathways for the formation and use of common metabolites. Hormones that control food behavior. Obesity.
50. Lipid peroxidation (LPO): mechanism, reactions, metabolites. The biological significance of LPO in health and disease. Antioxidant defense.
51. The biological value of protein. Protein digestion (enzymes and their activation, role of pH gradient) and AA absorption. HCl: role, mechanism and regulation of secretion. Putrefaction of proteins in the large intestine. Neutralization of protein putrefaction products in the liver.
52. Amino acids: essential and non-essential, glycogenic and ketogenic. Ways of entering of amino acids into TCA. Biosynthesis of nonessential AA from glucose (examples). Amino acid pool of the cell. Nitrogen balance.
53. Types of deamination. Direct and indirect oxidative deamination of AA. Transamination (enzymes and coenzymes). Ammonia, its toxicity. Binding and release of ammonia (Felig cycle, ammoniogenesis), the importance of these processes for cells.
54. Urea cycle (UC): localization, reactions, enzymes, meaning. The connection of the UC with the TCA and amino acids metabolism, the energetical cost of UC. UC enzymopathies.
55. Amino acids decarboxylation (5-hydroxytryptophan, Dopa, His, Glu): enzymes, coenzymes, the role of biogenic amines. Pro, Lys, Phe hydroxylation (role of ascorbate, NADPH, cytochrome P450), hydroxylation products and their role in organism.
56. Metabolism of Ser and Gly: biosynthesis of choline, ethanolamine, purine bases, heme, creatine, GSH, hippuric acid, bile acids. The role of THF in Ser and Gly metabolism. Gly metabolism disorders.
57. Glu and Asp: biological role of amination, deamination, transamination, decarboxylation of the amino acids and their derivatives. Glu and Asp role in metabolism.
58. Met metabolism. S-adenosyl methionine (SAM): its role in the synthesis of choline, adrenaline, carnitine, creatine, anserine, etc.
59. Phe and Tyr metabolism: biosynthesis of catecholamines, thyroid hormones. Phe and Tyr metabolic disorders (phenylketonuria, alkaptonuria, albinism).
60. Nucleoproteins: digestion and absorption. The main functions of mononucleotides (FMN, ATP, GTP, cAMP) and dinucleotides (NAD^+, $NADP^+$, FAD).
61. DNA and RNA: structural features, levels of organization, types, localization in the cell, biological role. Features of the structure of mtDNA. The structure of the human genome. The concept of transposons, short tandem repeats and single nucleotide polymorphism.
62. Biosynthesis of pyrimidine nucleotides: enzymes, reactions, biological significance. The role of THF in the synthesis of pyrimidine nucleotides.

63. Pyrimidine nucleotides catabolism: localization, enzymes, reactions, biological significance.
64. Purine ring synthesis scheme. Purine nucleotide biosynthesis: initial substrates, enzymes, reactions, regulation, biological role.
65. Catabolism of purine nucleotides and peroxide processes. Purine recycling. Disorders of purine metabolism (gout, Lesch-Nyhan syndrome).
66. Matrix mechanism of DNA synthesis (replication and reparation): stages, enzymes, substrates, biological role. Characterization of the genetic code. Inhibitors of DNA matrix biosynthesis: medicines, viral and bacterial toxins.
67. Transcription: stages, enzymes, substrates, products. RNA types. mRNA processing and splicing. Alternative splicing. Features of transcription in viruses, the role of revertase.
68. Central dogma of molecular biology. Translation: stages, enzymes, substrates, biological role. Problem processing, its mechanisms: chemical modification, limited proteolysis, self-assembly of molecules.
69. Vitamin D: synthesis reactions, their tissue localization. Ca-P metabolism regulation. Parathyroid hormone and calcitonin. Impairments of Ca-P metabolism (rickets, osteomalacia, osteoporosis): causes and main clinical manifestations.
70. Vitamins A, E, K: chemical nature, role in metabolism. The manifestation of hypo- and hypervitaminosis.
71. Vitamin PP and its coenzymes: chemical nature, role in metabolism (by the example of PDH, TCA, glycolysis, PPP, FA and CS synthesis, participation in Mt ETC, etc.). Manifestation of hypovitaminosis.
72. Vitamin B_1 and its coenzyme: chemical nature, role in metabolism (oxidative and direct decarboxylation, transketolase reactions of PPP). Manifestation of hypovitaminosis.
73. Vitamin B_2 and its coenzymes: chemical nature, role in metabolism (by the example of TCA, fatty acids β-oxidation, PDH, the structure of Mt ETC complexes, etc.). Manifestation of hypovitaminosis.
74. Vitamin B_6 and its coenzyme form: chemical nature, role in metabolism (by the example of decarboxylation reactions (5-hydroxytryptophan, DOPA, His, Glu) and amino acid transamination (Asp, Ala)). Manifestation of hypovitaminosis.
75. Vitamin H and its coenzyme form: chemical nature, role in metabolism (for example, carboxylation reactions in GNG, odd-numbered carbon atoms fatty acids β-oxidation, synthesis of fatty acids). Manifestation of hypovitaminosis.
76. Vitamin B_9 and its coenzyme form: chemical nature, role in metabolism (synthesis of pyrimidine and purine bases, role in Met, Ser and Gly metabolism). Vitamin B_{12} and its coenzymes. Chemical nature, role in metabolism (reactions of odd-numbered carbon atoms fatty acids β-oxidation, role in Met metabolism). Manifestation of hypovitaminosis.
77. Vitamin C. Chemical nature, role in metabolism (hydroxylation reactions, AOD, participation in Mt ETC). Manifestation of hypovitaminosis.
78. Vitamins: general characteristics. Intervitamin interactions on the example of PDH, vitamins B_9 and B_{12}. Synergism of antioxidant vitamins. Participation of vitamins in the synthesis of coenzyme forms of other vitamins. The causes of hypo- and hypervitaminosis development.
79. Hormones: definition, properties, nomenclature, classification; principles of organization and functioning of the neuroendocrine system (examples). The mechanism of action of hormones (catecholamines, peptide, steroid, thyroid). Characterization of receptors (1-TMS, 7-TMS, intracellular).
80. TSH: chemical nature, mechanism of action, regulation of secretion. T_3 and T_4: chemical nature, biosynthesis, regulation of secretion, mechanism of action, role in metabolism, main clinical manifestations of hypo- and hypersecretion.
81. STH: chemical nature, mechanism of action, regulation of secretion, main clinical manifestations of hypo- and hypersecretion of the hormone. Regulation of secretion and the role of IGFs.
82. Insulin: chemical nature, stages of synthesis, regulation of secretion, mechanism of action, role in metabolism. The main clinical manifestations of hypo- and hypersecretion of insulin.
83. Glucagon: chemical nature, regulation of secretion, mechanism of action, role in metabolism.

84. ACTH: chemical nature, mechanism of action, regulation of secretion, main clinical manifestations of hypo- and hyperproduction. Glucocorticoids: structure, regulation of secretion, mechanism of action, role in metabolism, main clinical manifestations of hypo- and hypersecretion.

85. Mineralocorticoids: chemical nature, regulation of secretion, mechanism of action, role in metabolism, main clinical manifestations of hypo- and hypersecretion.

86. Catecholamines: chemical nature, synthesis (reactions, enzymes), regulation of secretion, mechanism of action, role in metabolism, main clinical manifestations of hypersecretion.

87. Gonadotropins (FSH and LH): chemical nature, mechanism of action, regulation of secretion. Estrogens: chemical nature, mechanism of action, regulation of secretion, main clinical manifestations of hypo- and hypersecretion.

88. Gonadotropins (FSH and LH): chemical nature, mechanism of action, regulation of secretion. Androgens: chemical nature, mechanism of action, regulation of secretion, main clinical manifestations of hypo- and hypersecretion.

89. The adaptive role of hormones. The concept of stress. Hormonal regulation of energy metabolism under stress.

90. Blood, its composition and functions. The level of total protein, residual nitrogen, urea, amino acids, uric acid, total bilirubin, calcium, iron, glucose, total cholesterol, ketone bodies, arterial and venous blood pH in normal and pathological conditions.

91. Blood plasma proteins: general characteristics, classification, fractionation methods, characteristics of individual representatives of each class. Changes in blood protein spectrum in pathology, proteinemia types.

92. Residual nitrogen: composition, origin, diagnostic value of individual components. Types of azotemia and their causes.

93. The concept of the acid-base state: principles of organization, mechanisms of regulation (physicochemical and physiological), classification of disorders (types, causes and mechanism of development of acidosis and alkalosis), mechanisms of correction.

94. Erythrocytes: general characteristics, structure, metabolic features. Antioxidant defense of red blood cells. Glutathione, its structure and function.

95. Hemoglobin: types, structure, properties, functions, derivatives. Comparative characteristics of Hb and myoglobin. Synthesis and role of 2,3-BPG. Thalassemias, hemoglobinopathies.

96. Heme biosynthesis: reactions, enzymes, localization, regulation and biological role. Porphyrias.

97. Hb catabolism in RES cells. Metabolism of bilirubin in liver and its conversion in the gastrointestinal tract. The causes and laboratory diagnosis of jaundice (hemolytic, parenchymal and obstructive).

98. Fe metabolism: absorption, transport in the blood, deposition, entry into tissues. Metabolic disorders Fe: hemochromatosis, anemia (iron deficiency, sideroblastic).

99. Features of leukocyte metabolism. Biochemical basis of phagocytosis, respiratory burst. Features of the structure and metabolism of platelets, the role in hemostasis.

100. The mechanism and stages of urine formation: filtration, reabsorption, secretion. The mechanism of active transport in the tubules of glucose, amino acids, etc. Impairments of the processes of filtration, reabsorption, secretion and their laboratory diagnostics. Clearance in normal and pathological conditions, its clinical and diagnostic value.

101. Organic (urea, uric acid, amino acids, creatinine) and inorganic components of urine in normal and pathological conditions. Pathological components of urine (blood, protein, glucose, bilirubin): the reasons for their appearance and diagnostic value.

102. Homeostatic functions of kidney. The role of kidney in the regulation of total blood volume, blood pressure, electrolyte balance, ABB (mechanisms of acido- and ammoniogenesis), blood glucose (especially GNG in kidney), the level of biologically active substances, erythropoiesis, etc.

103. The role of kidney in metabolism and the features of carbohydrates, lipids, proteins metabolism in kidney. Metabolic heterogeneity of renal tissue.

104. The causes for the development and the main metabolic disorders in acute (ARF) and chronic renal failure (CRF). Kidney stones, their composition, causes and mechanism of occurrence.

105. Liver function. Features of the metabolism of hepatocytes in the pericentral and periarterial zones. The role of liver in interorgan metabolism (Cori cycle, Felig cycle, creatine synthesis).

106. The role of liver in carbohydrate metabolism. Clinical and diagnostic value of blood glucose level analysis. Loading with galactose and fructose.

107. The role of liver in lipid metabolism. Causes and mechanism of development of fatty infiltration and liver degeneration. Clinical and diagnostic value of determining the concentration of cholesterol, TAG, ketone bodies, atherogenic coefficient, etc. in the blood.

108. The role of the liver in nitrogen metabolism: proteins and amino acids metabolism, creatine, nucleic acids, etc. Clinical and diagnostic value of the analysis in blood of total protein and its fractions, urea, etc.

109. The main stages and pathways of xenobiotic metabolism (characteristics and role of cyt P450, the role of UDPGA, PAPS, etc.).

110. Features of muscle tissue metabolism, characterizing its relative autonomy. The role of muscle tissue in interorgan substrate metabolism (cycles of Cori, Felig, creatine biosynthesis).

111. Structural, functional and metabolic characteristics of muscle fibers (white, red). Pathways of ATP synthesis in muscle tissue (substrate-level and oxidative phosphorylation, reactions catalyzed by CPK, adenylate kinase, the role of AMP deaminase, purine nucleotide cycle).

112. Characterization of muscle tissue proteins (actin G, and F, myosin, actomyosin, tropomyosin, troponins T, C, I, etc.). Mechanism of electromechanical coupling (theory of muscle contraction). Features of smooth muscles contraction.

113. Features of myocardial metabolism. Biochemical mechanisms of heart failure development. Adaptive changes in the myocardial structure and metabolism.

114. Restriction of motor activity (hypokinesia). The main elements of hypokinetic syndrome pathogenesis.

115. General characteristics of nervous system metabolism: carbohydrate, lipid, protein metabolism. Features of brain metabolism in normal and hypoxic conditions.

116. Neurotransmitters (catecholamines, acetylcholine, GABA, dopamine, histamine, serotonin): characteristics, synthesis and inactivation (enzymes, reactions), receptors, effects.

117. Biochemical mechanisms of electrogenesis in nervous tissue. Mechanism of synaptic transmission: the role of membranes, receptors, enzymes and mediators.

118. Biochemical mechanisms of alcohol, drugs (opioids, cocaine, amphetamines) action onto brain. Pathological conditions of nervous system (depression, parkinsonism, schizophrenia).

119. Characterization of connective tissue (CT) fibrous structures. Features of collagen and elastin structure and metabolism. Collagen processing and metabolism in norm and disease. Changes in CT with aging, collagenosis, wound healing. CT in case of vitamin C deficiency. Non-collagenic structural glycoproteins - fibronectin, its structure, properties and functional role.

120. Scheme of glycosaminoglycans biosynthesis, their functional role. The structure and function of proteoglycans. Structural organization of intercellular matrix. Mucopolysaccharidoses: main causes and clinical manifestations.

121. Bone and cartilage tissue, chemical composition and metabolic features. Bone metabolism and factors affecting it (vitamin D, calcitonin, parathyroid hormone, growth hormone, etc.) The mechanism of bone mineralization.

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