Azerbaijan Medical University
Department of Biological Chemistry
Training program on the subject "Biological Chemistry" (syllabus)

"I CONFIRM"
Head of the Biological Chemistry Department
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SYLLABUS

LECTURES AND LABORATORY CLASSES ON STATIC BIOCHEMISTRY.CALENDAR-TOPIC PLANS. QUESTIONS FOR CLASSES, COLLOQUIUMS AND EXAMS PREPARING. PRESENTATION TOPICS ON STATIC BIOCHEMISTRY

Subject code:	2406.02
Type of subject:	Obligatory
Subject teaching term:	III (Dental faculty)
Subject credits:	4
Form of teaching the subject:	full-time
Language of teaching:	Azerbaijani, russian, english
Teachers teaching the subject:	The teaching staff of the Department of Biological Chemistry

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Calendar-thematic plan on biochemistry laboratory classes for II course Dental Faculty students in autumn term of 2021/2022 academic year

№	Topics of the lessons	Biochemistry laboratiry mannual theory and methods, 2019
1.	***Acquantance with the group, internal discipline and technical safety rules. Chemical composition of the organism. Amino acids. Prioteins – 2 h.***	
2.	***Structure and classification of proteins. Peptide bond – 2 s.*** ***Lab. work:*** Color reactions on amino acids and proteins.	16-22 164
3.	***Structure and properties of enzymes. Activators and inhibitors of enzymes – 2 h.*** ***Lab. work:*** The effect of activators and inhibitors on amylase activity. Inactivation of the enzyme cholinesterase with proserin.	76-77
4.	***Colloquium: Proteins and enzymes – 2 h.***	
5.	***Biochemical properties of vitamins – 2h.*** ***Lab. work:*** Reactions on vitamins B_1, B_2, PP, B_6 and C.	86-96
6.	***Regulators of metabolism: hormones – 2 h.*** ***Lab. work:*** Reactions on adrenaline, insulin and thyroxine.	105,108 110-111
7.	***General rules of metabolism. Common stages of catabolism (I and II general pathways) and their bioenergetic value. ETC – 2 h.*** ***Lab.work:*** Quantitative and qualitative determination of catalase.	118-119
8.	***Chemistry and digestion of carbohydrates. Synthesis and breakdown of glycogen. Glycolysis and gluconeogenesis – 2 h.*** ***Lab.work:*** Determination of glucose in the blood by glucose-oxidase method.	138-139
9.	***Digestion of proteins. Formation of NH_3 and its detoxifycation – 2 h.*** ***Lab. work:*** Diagnostic value of ALAT and ASAT determi-	154-156

	nation. Determination of urea.	160
10.	***Med-term assessment (static biochemistry and metabolism of carbohydrates) – 2 h.***	
11.	***Biochemistry of blood. Synthesis and breakdown of Hemoglobin (Hb). Jaundice types – 2 h.*** ***Lab.work:*** Determination of blood hemoglobin.	178-180
12.	***Colloquium: Protein metabolism – 2 h.***	
13.	***Chemistry and digestion of lipids. Catabolism of fatty acids – 2 h.*** ***Lab. work:*** Determination of bile acids.	201-202
14.	***Functional biochemistry of teeth, bone tissue and kidney – 2 h.*** ***Lab. work:*** Analysis of normal and pathological urine. Tests on tooth tissue and saliva	228-241 255-259
15.	***The final lesson. Assessment of knowledge about lipid metabolism by tests – 2 h***.	

Totally: 30 hours.

Calendar-thematic plan on biochemistry lectures in Dental Faculties for II course students in autumn term of 2021/2022 academic year

№	Subject of lecture	Hours
1.	Biochemistry subject, its goals and objectives. Physico-chemical properties, structural features of proteins. Amino acids.	2
2.	Classification of proteins. Simple and complex proteins. Hemoglobin, its heterogeneity and cooperativeness.	2
3.	Biochemical properties of nucleic acids. Matrix biosynthesis process. Replication. Transcription.	2
4.	Biochemical properties of enzymes, their chemical nature and properties, mechanism of action. Classification of enzymes and coenzymes. Activators and inhibitors of enzymes.	2
	Vitamins structure and biochemical properties. Classifica-	2

5.	tion of vitamins, and mechanism of action.	
6.	Hormones: their classification and biochemical properties. Hormones of hypothalamus, hypophysis, thyroid gland, pancreas and adrenal glands.	2
7.	General laws of metabolism. I and II general pathways of catabolism and their bioenergetic significance. ETC.	2
8.	Chemistry, digestion, absorption and metabolism of carbohydrates. Metabolism of glycogen. Glycolysis. Gluconeogenesis. Biochemical mechanism of other hexoses entry into the glycolysis.	2
9.	Metabolism of carbohydrates. Apotomic oxidation. Biosynthesis of oligo- and polysaccharides. Disorders of carbohydrate metabolism.	2
10.	Protein digestion, decay, absorption and metabolism. General pathways of amino acid metabolism.	2
11.	Formation of ammonia, its toxic effects and ways of neutralization. Biosynthesis of non-essential amino acids. Disorders of amino acid metabolism.	2
12.	Biochemistry of blood and liver. Synthesis and breakdown of hemoglobin. Formation of bile pigments. Jaundice.	2
13.	Nucleoprotein metabolism. Metabolism and disorders of purine and pyrimidine nucleotides.	2
14.	Chemistry, digestion, absorption of lipids. Lipids re-synthesis in the intestines and their metabolism. Metabolism of fatty acids. Ketogenesis and ketolysis. Metabolism of cholesterol. Disorders of lipid metabolism.	2
15.	Functional biochemistry of organs and tissues. Kidneys, muscle, connective, bone and nerve tissue.	2

Totally: 30 hours.

COLLOQUIUM QUESTIONS

Biochemical properties of amino acids, proteins and nucleic acids. Matrix biosynthesis

1. Classification of amino acids based on different principles: according to the side chain, charge in the side chain, the number of amino- and carboxyl groups, the biological role, and the polarity of the residue.
2. Structure of proteinogenic and non-proteinogenic amino acids (give an example), their general characteristics and role in metabolism.
3. Physico-chemical characteristics of amino acids: stereoisomerism, optical activity, solubility and dissociation ability. Impact of environment pH on amino acid charge. Titration curve of amino acids and isoelectric point, their significance for the organism.
4. Distribution of proteins in organism, protein representatives with functions. Methods of protein analysis: extraction from biological materials (homogenization, extraction, fractionation). Salting out and change of its rate depending on the ionic strength of solution. Hofmeister series. Chromatography and electrophoresis, their types and principles of techniques.
5. Physico-chemical properties of proteins: shape, ability to dissolve, optical activity, amphotericity, isoelectric point. Denaturation, action of denaturation factors. Sedimentation and the factors leading to sedimentation, the using of sedimentation reactions in practice and their significance in the study of protein properties.
6. Different classification types for proteins. Structural features and functions of fibrous proteins. Collagen: the amino acid composition, the structure of collagen protomer, namely tropocollagen: molecule-stabilizing bonds. Keratin: occurrence in the nature, α- and β -keratins, their amino acid composition.
7. Primary structure of proteins and bonds stabilizing it. Spatial configuration of proteins: bonds stabilizing secondary, tertiary and quaternary structure of proteins.
8. Simple proteins: the principle of their classification. Albumins and globulins, prolamines and glutelins, protamines and histones. Human blood protein fractions (proteinogram), and its changes in the pathology.

9. Metalloproteins: their representatives, occurrence, significance, bonds that bind the protein part to the metal. Metalloid proteins.
10. Phosphoproteins: representatives, occurrence, bonds binding the protein part to the prosthetic group. Significance of proteins phosphorylation and dephosphorylation.
11. Glycoproteins and proteoglycans: representatives, biological role, occurrence, composition and percentage of carbohydrates in these proteins (give examples), the significance of sialic acids. Bonds for linkage between carbohydrate component and the protein moiety. Diagnostic value of sialic acid determination by Hess method.
12. Lipoproteins and proteolipids: physico-chemical properties, occurrence in the living organisms, localization in the body, bonds involved in protein-lipid interactions, types of apo-proteins. Lipoprotein fractions of blood plasma, their structural characteristics, functions.
13. Chromoproteins: classification, representatives. Flavoproteins, hemeproteins: occurrence, role in metabolism. Structure of heme.

Biochemical characteristics of enzymes and vitamins

1. Chemical nature of enzymes, their difference from inorganic catalysts. Ribozyme. Simple and complex enzymes.
2. The main properties of enzymes: their specificity types, thermolability, the impact of environmental pH on the enzymes activity.
3. 3. Mechanism of enzymatic action. Organization of active center. Activation energy, Michaelis-Menten kinetics. Koshland theory as an induced-fit model; the concept of orientation and deformation in enzymatic action. Catalysis types: acid-base, electrophilic, nucleophilic, covalent.
4. The impact of substrate and enzyme concentration on the reaction rate. Michaelis coefficient: the relation between the substrate concentration and reaction rate.
5. Activators of enzymes. Activators affecting the active center: cofactors, substrates, metal ions. Activators, that affect off-center sites. Activation of proenzymes by partial proteolysis. Enzyme

activation by enzyme sulfhydryl groups reduction and dissociation of inactive enzyme complexes.

6. Two main enzyme inhibition ways (reversible and irreversible). Inhibitor types: competitive, non-competitive and uncompetitive (give example), difference in their impact on the enzyme activity. Reactivators (give example).
7. Enzymes nomenclature and classification; six main classes of enzymes, their subclasses; enzyme code.

Biochemical characteristics of vitamins

1. Vitamin A, its chemical and biological names, structure, vitamers, provitamins, biochemical functions, hypo- and hypervitaminosis, occurrence in the nature.
2. Vitamin D, its chemical and biological names, structure. Metabolism of vitamin D, its conversion into hydroxilated active derivatives and their biochemical functions; avitaminosis, hypervitaminosis, natural sources.
3. Vitamin E, its chemical and biological names, vitamers, metabolism, antioxidant activity, avitaminosis, natural sources.
4. Vitamin K, its chemical and biological names, vitamers, metabolism, biochemical functions, imbalance, occurrence in the nature.
5. Biochemical characteristics of enzymes-vitamins: nomenclature (name by physiological effect, chemical name), classification (by physical and chemical properties, biological effect), vitamers, provitamins, antivitamins, vitamin disbalance.
6. Vitamin B_1, its chemical and biological names, structural features, metabolism; Coenzyme structural features (co-carboxylase). Role of vitamin B_1 in metabolism, avitaminosis, natural sources.
7. Vitamin B_2, its chemical and biological names, structural features, metabolism, coenzyme forms (FMN and FAD), their synthesis, structure. Biochemical function of vitamin B_2, avitaminosis, occurrence in the nature.

8. Pantothenic acid (vitamin B_3), its chemical and biological names, structural features, metabolism, coenzyme forms, biochemical functions, deficiency, occurrence in the nature.
9. Vitamin PP (nicotinic acid), its chemical and biological names, structure, metabolism. Coenzymes NAD^+ and $NADP^+$, their biosynthesis, structure, biochemical functions, deficiency, natural sources.
10. Vitamin B_6, its chemical and biological names, vitamers, their structure, metabolism. Coenzymes PALP and PAMP, their structure, biochemical functions, avitaminosis, occurrence in the nature.
11. Folic acid, its chemical and biological names, structural features, metabolism, coenzyme forms and biochemical functions, cause of deficiency and its manifestations, natural sources.
12. Vitamin B_{12}, its chemical and biological names, chemical nature, metabolism, coenzymes, biochemical functions, causes and manifestations of deficiency, occurrence in the nature.
13. Vitamin C, its chemical and biological names, structure, metabolism, biochemical functions, avitaminosis, occurrence in the nature.

Biochemical characteristics of hormones

1. Characteristics of hormones: general concept, nomenclature, types according to classification.
2. Regulation mechanism of hormone synthesis and secretion: feedback principle, synergism, antagonism, permissiveness.
3. Transmission of hormonal signals through protein-receptors. Differences in hormonal effect based on receptor localization. G-proteins and secondary messengers. Hormones action mechanism: adenylate cyclase, guanylate cyclase, calcium polyphospho-inositol systems.
4. Hormones with intracellular mechanism of action. Intracellular and intranuclear receptors. The role of hormones in the regulation of the transcription.
5. Hormones of the adenohypophysis: somatotropin (growth hormone), prolactin, their chemical nature and effects. Diseases associated with

the pituitary gland endocrine function disorders: pan-hypopituitarism, hyper- and hyposecretion of somatotropin.

6. Hormones of the pituitary gland: thyrotropin and gonadotropins. POMC derivatives: adrenocorticotropin, lipotropic and melanocyte-stimulating hormones: their chemical nature, biochemical effects, hyper- and hyposecretions.
7. Hormones of neurohypophysis: oxytocin and vasopressin, their chemical nature, biological effects. Violation of vasopressin and oxytocin secretion.
8. Hormones of the pineal gland: melatonin, serotonin and adreno-glomerulotropin, their structure, biological effects. Diseases associated with disorders of these hormones. Biologically active substances synthesized in thymus.
9. Thyroid hormones: their structure, biological effects, metabolism. İodine intake. Disorders of thyroid hormone secretion.
10. Hormones affecting calcium metabolism: parathormone, calcitonin, calcitriol, their chemical nature, biological effects, violation of secretion resulting in fibrous osteochondro-dystrophy, tetany, and spasmophilia.
11. Pancreatic hormones. İnsulin: chemical nature, regulation of secretion, influence on carbohydrate, protein, lipid metabolism. Violation of insulin secretion, causes of diabetes mellitus & metabolic changes in this disease.
12. Glucagon, somatostatin and pancreatic peptide, their chemical nature & biological effects.
13. Hormones of the adrenal medulla, catecholamines: dopamine, adrenaline, noradrenaline and isopropyl adrenaline.
14. Hormones of the adrenal cortex: their different groups.

The basic patterns of energy metabolism. Biological oxidation. General pathways of catabolism. Metabolism of carbohydrates

1. Bioenergetics. Catabolism of basic nutrients. General patterns of metabolism.
2. Reactions of I general pathway of catabolism and its energetic value.

3. II general pathway of catabolism. Reactions of tricarboxylic acid cycle. The main substrates of tricarboxylic acid cycle and its energetic value.
4. Biological oxidation and tissue respiration. Energy supply reactions (oxidative reactions), enzymes of process. Structure, function of the respiratory chain. Sequential localization of the components in the respiratory chain (according to the values of their redox potentials). The scheme of the protons and electrons transfer in the chain.
5. The concept of the chemistry of carbohydrates.
6. Digestion of carbohydrates. Dietary carbohydrates, the amylolytic enzyme of saliva decomposing them in the oral cavity. Amylolytic enzymes of pancreas and intestinal juice.
7. Mechanism of monosaccharides absorption, transport through membranes. Fate of monosaccharides in the cells.
8. Metabolism of glycogen. Regulation of glycogenesis and glycogenolysis.
9. Reactions of glycolysis (scheme) and its biological value. Glycolytic oxydo-reduction.
10. Aerobic breakdown of carbohydrates and its energetic value.
11. Glyconeogenesis (scheme). Substrates of gluconeogenesis. Cori cycle.
12. Sequential reactions of the pentose phosphate pathway oxidation of carbohydrates and its biological significance.
13. Regulation of carbohydrate metabolism. Hypoglycemia and hypergly¬cemia. Glucosuria
14. Diabetes mellitus. The causes of disease. Manifestations and complications.

Metabolism of proteins. Functional biochemistry of blood.

1. The completeness of food proteins. The nitrogen balance. Sources and fate of the amino acid fund. Proteinases of tissue proteins.
2. Digestion of proteins in stomach. Composition of gastric juice: pepsin, HCl, gastricsin.
3. Digestion of proteins in the intestine. Composition of pancreatic juice, proteolytic enzymes. Proteinases of intestinal juice. Disorders of amino acids absorption in the intestine. The malabsorption syndrome.

4. The decay of amino acids in colon. Neutralization of products of rotting. PAPS and UDPGA.
5. Deamination of amino acids. The mechanism of oxidative deamination.
6. Transamination of amino acids. Transaminases, their diagnostic importance. Trans-deamination
7. Decarboxylation of amino acids. Detoxification of biogenic amines formed in these reactions.
8. Ammonia formation. Mechanism of ammonia toxic effect. Neutralization of ammonia: reactions of synthesis of urea (ornithine cycle) and other ways of ammonia neutralization.
9. Blood functions. Specificity of metabolism of blood cells (red blood cells, leukocytes, thrombocytes)
10. Synthesis of hemoglobin. Porphyrias.
11. Decomposition of heme.
12. Jaundice types.
13. Biochemical composition of blood. Proteins of blood serum and plasma. Enzymes of blood serum.

Metabolism of lipids

1. Biochemical properties of lipids.
2. Digestion of lipids. Bile acids: their structure and significance in digestion.
3. Digestion of fats and phospholipids in the intestine. Lipase and phosphorlipases.
4. Absorption of products of fat hydrolysis and re-synthesis of lipids in the intestine and their transport to the tissues.
5. Intracellular lipolysis. β-oxidation reactions of fatty acids and energetic value of this process.
6. Synthesis of fatty acids, energy sources for this process.
7. Synthesis reactions of ketone bodies (ketogenesis). Hydrolysis reactions of ketone bodies (ketolysis). Ketonemia and ketonuria, causes of occurrence.
8. Cholelithiasis.

Functional biochemistry of kidneys

1. Main properties of normal and pathological urine.
2. The normal chemical components of urine. Diagnostic significance of creatinine determination in the urine.
3. Pathological components of urine. Kidney stone disease.

Functional biochemistry of the nervous tissue

1. Specificity of carbohydrate, lipids, protein and amino acids metabolism in the nervous tissue.
2. The role of mediators in the transmission of nervous excitement. Cholinergic and adrenergic receptors.

Functional biochemistry of muscle tissue

1. The chemical composition of the muscle tissue. Proteins of muscles.
2. Non-protein nitrogenous extractive substances of muscles. Their significance. Nitrogen-free organic compounds of muscle.
3. Specificity of the chemical composition of the cardiac muscle and smooth muscle.
4. Specificity of energy supply for the muscular activity.
5. Biochemical mechanism of muscle contraction.
6. Biochemical disorders in the muscles in pathologies and muscle damage.

Biochemistry of connective tissue

1. General information about connective tissue: its functions and main cells, main proteins: collagen and elastin.
2. Non-collagen proteins of connective tissue.
3. Glycosaminoglycans and proteoglycans of connective tissue.
4. Chemical composition of bone tissue. Disorders of bone tissue metabolism.
5. Chemical composition of dental tissues. Tooth caries, pulpitis. Gingivitis (practicum).

Biochemistry of saliva

1. Chemical composition of saliva.
2. Methods of biochemical research in saliva: the importance of determining the activity of acid and alkaline phosphatase enzymes, determination of thiocyanates and lactic acid.

QUESTIONS FOR PREPARING FOR LABORATORY CLASSES

LESSON II
Physico-chemical properties of amino acids. Peptide bond

1. General information about proteins.
2. Classification and structure of amino acids.
3. Proteinogenic amino acids.
4. Peptide communication.
5. Color reactions on proteins (lab. work.).
6. Physical and chemical properties of amino acids.
7. Sedimentation reactions on proteins (lab. work.).
8. Classification of proteins. Simple and complex proteins.

LESSON III
Structure and properties of enzymes. Activators and inhibitors of enzymes

1. The concept of enzymes.
2. Properties of enzymes, their thermolability. Dependence of enzyme activity on the pH of the medium. Determination of the optimum temperature and optimal pH of the salivary amylase (lab. work.).
3. Specificity of enzymes and their types. Detection of the specificity of salivary amylase and sucrose (lab. work.).
4. Enzyme activators. Activators and inhibitors action on amylase activity (lab. work.).
5. Enzyme inhibitors.

LESSON V
Biochemical properties of vitamins

1. General information about vitamins. Provitamins, antivitanins.
2. Fat-soluble vitamins.
3. Vitamins B_1, B_2, PP, B_6.
4. Biochemical properties of vitamin C.
5. Reactions on vitamins B_1, B_2, PP, B_6 and C (lab. work.).
6. Application of vitamins in medicine.

LESSON VI
Hormones as regulators of metabolism

1. General overview on the endocrine system. Specific features of hormones, their classification.
2. Types of relationship between the endocrine glands and their interaction.
3. Mechanisms of hormonal action.
4. Adenylate cyclase system.
5. General overview on the endocrine function of the thyroid gland. Detection of iodine in the thyroid gland (lab. work.).
6. General overview on the endocrine function of the pancreas. Qualitative reactions to insulin (lab. work.).
7. General overview on the hormones of the adrenal glands medulla.

LESSON VII
General patterns of metabolism. General stages of catabolism (I and II general pathways) and their bioenergetic significance. ETC

1. Catabolism of main nutrients. Patterns of metabolism.
2. I general pathway of catabolism and its energetic significance.
3. II general pathway of catabolism and its energetic significance.
4. Overview on the electron transport chain.
5. Qualitative and quantitative determination of catalase in the blood.

LESSON VIII

Chemistry and digestion of carbohydrates. Glycogen synthesis and breakdown. Glycolysis and gluconeogenesis

1. Overview on carbohydrates. Classification of carbohydrates and their biological significance .
2. Digestion of carbohydrates in the oral cavity. Composition and properties of saliva.
3. Intestinal digestion of carbohydrates.
4. Glycogen synthesis.
5. Breakdown of glycogen.
6. Determination of blood glucose by glucose oxidase method (lab. work.).

LESSON IX

Digestion of proteins. Formation and neutralization of NH_3

1. Digestion of proteins in the stomach.
2. Digestion of proteins in the small intestine.
3. The main common ways of amino acid metabolism.
4. The mechanism of ammonia toxic effect in the body.
5. Formation of urea. Determination of urea (lab. work.).
6. Diagnostic significance of ALAT and ASAT.

LESSON XI

Blood biochemistry. Synthesis and breakdown of hemoglobin. Jaundice

1. Features of blood cell elements metabolism.
2. Blood plasma proteins.
3. Enzymes of blood serum.
4. Overview of the hemoglobin biosynthesis.
5. Breakdown of hemoglobin.
6. Diagnostic value of hemoglobin assessment in the blood (lab. work.).

7. Jaundice, its types.

LESSON XIII
Chemistry and digestion of lipids. Catabolism of fatty acids

1. Overview of lipids. Lipids classification.
2. Lipid digestion.
3. The role of bile acids in lipid digestion.
4. Quantitative reactions to bile acids (lab. work.).
5. Fatty acids catabolism types.
6. β-oxidation of fatty acids (scheme) and its energetic significance.
7. Gall-stone disease (cholelitiasis).

LESSON XIV
Functional biochemistry of bone tissue, teeth and kidneys

1. Chemical composition and metabolic features of bone tissue, its chemical composition.
2. Chemical composition of teeth. Determination of protein in tissue of teeth (lab. work.).
3. Tooth caries. Determination of calcium in teeth tissue (lab. work.).
4. Pulpit, gingivitis. Determination of phosphates in teeth tissue (lab. work.).
5. Chemical composition of saliva. Determination of rhodanides (lab. work.).
6. Chemical composition of urine, specific gravity of urine and its determination (lab. work.).
7. Turbidity of urine, pH of urine and its determination (lab. work.).
8. Pathological components of urine, determination of protein and sugar in urine.

COLLOQUIUM PROCEDURES

The purpose of the lesson: to determine the degree of mastery of the subject amig students via an individual survey.

The teacher calls 4 students to answer. The date of the month, the student's last name, and the ticket number are indicated on the sheet.

The ticket contains 4 questions with 2.5 points each: 3 colloquium questions, and one situational task. If the structure or scheme is required in the question, but the student can not write them, giving only an oral answer, the answer is evaluated with a maximum of 1 point. It is not necessary to write the full text of the answer.

When students answer questions, it is important to pay attention to the extent to which they have mastered the subject.

Finally, the teacher explains the next lesson subject according to the calendar-theme plan.

PRESENTATION TOPICS FOR INDEPENDENT STUDY ON STATIC BIOCHEMISTRY

The teacher distributes the presentation topics individually for each group.

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