

**THE MINISTRY OF HEALTH OF THE REPUBLIC AZERBAIJAN
AZERBAIJAN MEDICAL UNIVERSITY**



**TRAINING PROGRAM
ON BIOLOGICAL CHEMISTRY**

(070104 – Dentist)

BAKU - 2021

AZERBAIJAN MEDICAL UNIVERSITY

"CONFIRMED"
Vice-rector for Teaching and Treatment,
Prof. S.J.Aliyev

TRAINING PROGRAM
ON BIOLOGICAL CHEMISTRY

2406.02 – BIOCHEMISTRY

BAKU – 2021

TRAINING PROGRAM ON BIOLOGICAL CHEMISTRY

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Prerequisites:

Subject that must be taught in advance for the teaching of the subject: Biophysical and bio-organic chemistry.

Corequisites:

During the teaching of this subject no other subjects are required simultaneously

Description of the subject:

Biochemistry taught at the Medical University studies the biochemical properties of organic substances, namely proteins, nucleic acids, carbohydrates, lipids, vitamins, hormones, along with non-organic molecules which are participants of the human body various tissues and cells and/or are the amplifiers of the reactions; biochemistry is aimed at studying their participation and role in enzymatic biochemical transformations as well. In addition, the study of the biochemical properties, energy exchange that takes place during these transformations is one of the tasks of the subject.

The purpose of the subject:

The main purpose of the course: to teach students the theoretical and clinical foundations of static, dynamic, functional biochemistry and pathobiochemistry.

Learning Outcomes:

As a result of mastering the subject, students learn the biochemical properties of organic substances in organs and tissues, gain detailed information about the metabolism of these substances, learn the biochemical indicators that play an important role in the diagnostics.

At the end of the course,**a) the student should know:**

1. The functions of proteins, the classification of their building blocks, namely amino acid based on different principles and the physiological role of individual amino acids in the body.
2. Structural levels of proteins and their changes during the denaturation.
3. Classification of enzymes and the principle of their action. Medical enzymology branches.
4. Classification and impact of vitamins on metabolism.
5. Classification of hormones and mechanism of their action.
6. General pathways of catabolism.
7. Carbohydrate metabolism: sequence of reactions and their energetic value.
8. Lipid metabolism reactions, energetic value of different processes, and diseases following metabolism disturbances.
9. Enzymes required for digestion of proteins and mechanism of amino acids absorption.
10. Specific pathways of amino acid metabolism and diseases that appear at enzymopathology.
11. Catabolism and biosynthesis of nucleic acids.
12. The role of hormones in the regulation of biochemical processes.

b) the student should also be able to:

1. centrifugate the blood sample for separation plasma from blood cells.
2. work on a spectrophotometer.
3. work in automatic and semi-automatic biochemical analyzer.
4. determine the amount of total protein and albumin in blood plasma.
5. determine the glucose in blood plasma and in blood from a finger as well.
6. determine the amount of urea and uric acid in the blood plasma.
7. determine the different fractions of bilirubin in blood plasma.
8. analyze the urine by different biochemical methods (determine the protein, ketone bodies etc. in the urine).

a) *the student should have the following information and abilities:*

1. Information on the principle of automatic and semi-automatic biochemical analyzers operation.
2. Information on the principle of the enzyme-linked immunosorbent assay operation.
3. Safety rules and safe handling of laboratory equipment.
4. Ability to analyze, interpret and draw conclusions from laboratory tests.

BIOLOGICAL CHEMISTRY COURSE PROGRAM

INTRODUCTION

In modern times, people's life activities have expanded in various fields, and environmental conditions have changed significantly. It should be noted that irrational nutrition, drop in oxygen concentration in the inhaled air, congenital genetic defects, and sometimes the use of toxic and/or pharmacological substances can cause deep disorders that change the rate of certain biochemical reactions in the human body, affects the tissue structures and lowers functional activity of organs. In this regard, the study of regulatory mechanisms and biochemical reactions that occur at the level of the body, tissue, and cell during various physiological and pathological processes is of particular interest.

Modern biological chemistry is the basis of theoretical medicine. Clinical biochemistry, which studies the biochemical processes in the body during pathological processes, is an important part of theoretical medicine and greatly contributes to the development of clinical medicine. Due to the development of clinical biochemistry, its significant progress has clarified the mechanism of disease development, diagnosis and monitoring of the treatment course.

Knowledge of clinical biochemistry helps to determine the pathogenesis of the disease, make a correct diagnosis, prevent possible complications, choose treatment tactics and predict the outcomes.

It is impossible to accurately assess the biochemical changes during disease and pathological processes without the knowledge of general biochemistry and an understanding biochemical parameters of a healthy and ill organism.

Without knowledge of the general biochemistry and the biochemical parameters of a healthy organism, it is impossible to accurately assess biochemical changes during diseases and pathological processes.

OBJECTIVES OF THE SUBJECT

Thus, the goals and objectives of biological chemistry include:

1. To be aware of what chemical compounds constitute a living organism and to study the structure of high-molecular compounds that make up biological objects;
2. The study of the enzymes catalytic action mechanism;
3. The study the types and proportions of substances important for the normal nutrition of human and other living organisms;
4. The study of the mechanism of chemical processes resulting in the formation of basic substances building living cells from dietary compounds;
5. To study the mechanism of the energy generation during the oxidation of substances and its supply for various processes in cells;
6. To study the structure of a living cell and the relationship between the chemical processes and the functions of different cell organelles;
7. To be aware of the relationship between cell growth and proliferation, and chemical reactions that take place during these processes in the living cell;
8. To get acquainted with the mechanism of maintaining stable internal fluid environment in the body that ensures the normal functioning of cells;

9. To study the mechanism of hereditary information storage in the cell nucleus (chromosomes), its transmission to next generation, and the transfer of the properties copied during somatic cell division to new cells;
10. To be aware of the chemical mechanisms of defense (immune response) against foreign presenters, especially microorganisms entering the body in illness, especially COVID infection;
11. To be able to detect changes in blood parameters and other biochemical values during various diseases.

Modern biological chemistry comprises 3 main branches:

1. Static biological chemistry - studies the chemical composition of the organism; The study of the structure of substances that compose a living organism and the proportions of compounds in living organism belong to the tasks of static biological chemistry.
2. Dynamic biological chemistry - studies the interconversions of chemical compounds in the cells & tissues of the body, the associated energy exchange and ways of using the energy generated during different processes.
3. Functional, clinical and pathological biochemistry - studies the quantitative and qualitative changes of chemical compounds in the norm and pathology, as well as the relationship of these changes with metabolic processes.

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, heme proteins: 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. 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 hydroxylated 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 B₁, its chemical and biological names, structural features, metabolism; Coenzyme structural features (co-carboxylase). Role of vitamin B₁ in metabolism, avitaminosis, natural sources.
7. Vitamin B₂, its chemical and biological names, structural features, metabolism, coenzyme forms (FMN and FAD), their synthesis, structure. Biochemical function of vitamin B₂, avitaminosis, occurrence in the nature.

8. Pantothenic acid (vitamin B₅), 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 B₆, 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 B₁₂, 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. Iodine 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. Insulin: 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 hyperglycemia. 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, gastrin.
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. Porphyrins.
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 phospholipases.
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.

- Synthesis reactions of ketone bodies (ketogenesis). Hydrolysis reactions of ketone bodies (ketolysis). Ketonemia and ketonuria, causes of occurrence.
- Cholelithiasis.

Functional biochemistry of kidneys

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

Functional biochemistry of the nervous tissue

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

Functional biochemistry of muscle tissue

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

Biochemistry of connective tissue

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

Biochemistry of saliva

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

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	Hours
1.	<i>Acquaintance with the group, internal discipline and technical safety rules. Chemical composition of the organism. Amino acids. Proteins .</i>	2
2.	<i>Structure and classification of proteins. Peptide bond . <u>Lab. work:</u> Color reactions on amino acids and proteins.</i>	2
3.	<i>Structure and properties of enzymes. Activators and inhibitors of enzymes.</i>	2

	Lab. work: The effect of activators and inhibitors on amylase activity. Inactivation of the enzyme cholinesterase with proserin.	
4.	Colloquium: Proteins and enzymes.	
5.	Biochemical properties of vitamins. Lab. work: Reactions on vitamins B ₁ , B ₂ , PP, B ₆ and C.	2
6.	Regulators of metabolism: hormones. Lab. work: Reactions on adrenaline, insulin and thyroxine.	2
7.	General rules of metabolism. Common stages of catabolism (I and II general pathways) and their bioenergetic value. ETC. Lab.work: Quantitative and qualitative determination of catalase.	2
8.	Chemistry and digestion of carbohydrates. Synthesis and breakdown of glycogen. Glycolysis and gluconeogenesis. Lab.work: Determination of glucose in the blood by glucose-oxidase method.	2
9.	Digestion of proteins. Formation of NH₃ and its detoxification. Lab. work: Diagnostic value of ALAT and ASAT determination. Determination of urea.	2
10.	Med-term assessment (static biochemistry and metabolism of carbohydrates).	2
11.	Biochemistry of blood. Synthesis and breakdown of Hemoglobin (Hb). Jaundice types. Lab.work: Determination of blood hemoglobin.	2
12.	Colloquium: Protein metabolism.	2
13.	Chemistry and digestion of lipids. Catabolism of fatty acids. Lab. work: Determination of bile acids.	2
14.	Functional biochemistry of teeth, bone tissue and kidney. Lab. work: Analysis of normal and pathological urine. Tests on tooth tissue and saliva	2
15.	The final lesson. Assessment of knowledge about lipid metabolism by tests.	2

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
5.	Vitamins structure and biochemical properties. Classification of vitamins, and mechanism of action.	2
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 ON DINAMIC AND FUNCTIONAL BIOCHEMISTRY

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. I general pathway of catabolism and its energetic significance. Sequential reactions (scheme).
3. II general pathway of catabolism. Reactions of tricarboxylic acid cycle, its energetic value.
4. The ways of oxygen consumption. Biological oxidation and tissue respiration. Modern theory of bio-oxidation, structure, function of the respiratory chain. Sequential localization of the components of the respiratory chain according to the values of the redox potential. The scheme of the transfer of protons and electrons in the chain.
5. Oxidative phosphorylation. P/O ratio. Modern theory explaining the mechanism of oxidative phosphorylation (Mitchell's theory). The mechanism of formation of the proton potential on the inner membrane of the mitochondria. H⁺-ATP synthase and ADP-ATP-translocase - their structure, localization and function.
6. Respiratory control. The mechanism of regulation of the process of heat formation in the body (free oxidation, muscle tremors, brown fat). Chemical compounds, uncoupling the processes of oxidation and phosphorylation. Hypoenergetic states.
7. Peroxidase reactions and their value. Lipid peroxidation. Quantitative and qualitative determination of catalase in blood (laboratory work).
8. Anaerobic glycolysis (scheme) and its biological significance. Glycolytic oxydoreduction.
9. Aerobic metabolism of glucose and its energetic value.
10. Digestion of poly- and oligosaccharides in the oral cavity. The composition and properties of saliva.
11. Digestion of carbohydrates in the intestines. Amylolytic enzymes of pancreas and intestinal juice.
12. Mechanism of absorption of monosaccharides in the intestines. The fate of adsorbed monosaccharides. Reactions of glycogen synthesis in the liver.
13. Breakdown of glycogen. Regulation of glycogenesis and glycogenolysis.
14. Glyconeogenesis (scheme). Substrates of gluconeogenesis. Cori cycle.
15. Regulation of carbohydrate metabolism.
16. Disturbances of digestion and absorption of carbohydrates. Disorders of intermediate metabolism of carbohydrates.
17. Hyperglycemia and hypoglycemia. Glucosuria. Diabetes mellitus. The causes of these diseases. Classification, signs of glycogenesis and glycosidosis.

Metabolism of simple proteins and amino acids

1. Value and norms of protein in nutrition. The nitrogen balance.
2. Digestion of proteins in stomach. HCl. Pepsin. Gastric juice.
3. Analysis of normal and pathological gastric juice (practical work).
4. Digestion of proteins in the intestines. Trypsin. Chymotrypsin. Elastase. Proteinases of intestinal juice. The absorption of protein digestion products in the intestines.
5. The reactions of decay of amino acids in colon. Formation and neutralization of poisonous products of rotting of PAPS and UDPGA.
6. Disorders of the processes of digestion and absorption of hydrolysis products of protein and amino acids in the intestines.
7. Decomposition of proteins in tissues. Tissue proteases.
8. The fate of adsorbed amino acids. Glucogenic and ketogenic amino acids.
9. Deamination reactions of amino acids. The mechanism of oxidative deamination.
10. Transamination of amino acids. Transaminases, their diagnostic importance.
11. Reactions of amino acid decarboxylation. Neutralization of formed proteinogenic amines.
12. The ways of formation of ammonia. Mechanism of toxic effect of ammonia.
13. Neutralization of ammonia. Reactions of synthesis of urea. Ornithine cycle. Sources of nitrogen atoms in urea.
14. Other ways of ammonia neutralization.
15. The fate of hydrocarbon residues of amino acid. The synthesis of non-essential amino acids.
16. Features of metabolism of phenylalanine and tyrosine.
17. Features of metabolism of proline and hydroxyproline.
18. Diseases associated with the disorders of amino acids metabolism (acquired).
19. Hereditary disorders of metabolism of amino acids (phenylalanine, tyrosine).

Metabolism of complex proteins

1. Digestion and absorption of chromoproteins in gastro-intestinal tract.
2. Reactions of synthesis of hemoglobin (heme). Disorder of porphyrin metabolism.
3. Determination of hemoglobin in blood and its value (practical work).
4. Reactions of decomposition of heme in tissues and formation of bile pigments.
5. Neutralization reactions of bilirubin and its excretion from the body.
6. Disorders of neutralization process of bile pigments. Jaundice.
7. Determination of bilirubin in blood serum and its diagnostic value (practical work).
8. Reactions of breakdown of purine nucleotides in tissues.
9. Reactions of breakdown of pyrimidine nucleotides in tissues.
10. Determination of uric acid in blood and urine and its diagnostic value (practical work).
11. Disorders of metabolism of purine and pyrimidine bases (gout, xanthinuria, Lesch-Nyhan syndrome, orotic aciduria).
12. Biosynthesis of protein. Stages of biosynthesis.
13. Activation of amino acids.
14. Regulation of protein synthesis. Inductors and inhibitors of protein synthesis.

Metabolism of lipids

1. Digestion of lipids in gastrointestinal tract. Bile acids: their structure and functions.
2. Reactions of digestion of fats and phospholipids in the intestines. Lipase and phospholipases.
3. Absorption and transfer of products of hydrolysis of lipids.
4. Resynthesis reactions of triacylglycerides and phospholipids in the intestinal wall.
5. Intracellular lipolysis and mobilization of lipids from adipose tissue.

6. Reactions of β -oxidation of fatty acids and energetic value of this process.
7. Biosynthesis of fatty acids, regulation and energy sources.
8. Reactions of synthesis of ketone bodies (ketogenesis). Reactions of hydrolysis of the ketone bodies (ketolysis). Their causes.
9. Reactions of biosynthesis of cholesterol and its regulation. Determination of cholesterol in blood and its diagnostic importance (practical work).
10. Neuro- endocrine regulation of lipid metabolism.
11. Disorders of the process of digestion, absorption and transport of lipids in the tissue. Determination of total lipids in blood (laboratory work).
12. Fatty infiltration and dystrophy of liver. Their causes. Lipotropic factors.
13. Pathology of cholesterol metabolism. Cholelithiasis.

FUNCTIONAL BIOCHEMISTRY

Functional biochemistry of blood

1. Chemical composition of blood plasma. Proteins of blood plasma and serum.
2. Enzymes of blood serum.
3. Residual nitrogen. Azotemia, its types.
4. Nitrogen-free organic and non-organic components of blood plasma.
5. Acid-base balance of blood. Buffer systems of blood.
6. Blood coagulation system. Factors of coagulation. Mechanism of coagulation.
7. Blood anticoagulation system and fibrinolysis.

Functional biochemistry of liver

1. The role of liver in carbohydrate and lipid metabolism.
2. The role liver in protein and amino acid metabolism.
3. Excretory and antitoxic function of liver.

Functional biochemistry of kidneys

1. Mechanism of urine formation. Reabsorption of glucose and protein.
2. The role of kidneys in the acid-base balance.
3. Physical and chemical properties of urine. The composition of normal urine.
4. Pathological components of urine. Renal stone disease.

Functional biochemistry of nervous tissue

1. Chemical composition of nervous tissue (lipids, carbohydrates, nucleotides, minerals).
2. Metabolism of carbohydrates, lipids, proteins and amino acids in the nervous tissue.
3. Biochemical mechanisms of formation and transfer of nerve impulses.
4. The role of mediators in the transmission of nervous excitement. Cholinergic synapses.
5. Adrenergic receptors.

Biochemistry of connective, tooth and bone tissue

1. Chemical composition of connective tissue (pathological and clinical chemistry).
2. Chemical composition of bone tissue (pathological and clinical chemistry).
3. Chemical composition of tooth tissue. Caries, pulpitis, gingivitis (practical work).
4. Determination of proteins, Ca^{2+} , phosphate and sulphates in tooth tissue (laboratory work, practical work).

Biochemistry of saliva

1. Chemical composition of saliva (practical work).
2. Biochemical methods for the study of saliva. Determination of rhodanides of saliva (practical work).
3. Determination of the activity of acid and alkaline phosphatase, enzymes of saliva.
4. Determination of lactic acid in saliva (practical work).

Thematic plan of laboratory classes in dynamic and functional biochemistry for second-year students of the Stomatological Faculty for the spring semester of the academic year 2020/2021

№	Lesson subject	Hours
1.	<i>Introduction to the program of dynamic biochemistry. Common stages of catabolism and energy metabolism. Biological oxidation – 4 h.</i>	4
2.	<i>Biological oxidation – 2 h.</i> <i>Laboratory works:</i> Qualitative and quantitative analysis of catalase	2
3.	<i>Central ways of catabolism (I and II general pathways). Aerobic and anaerobic glycolysis.</i> <i>Laboratory works:</i> Determination of pyruvic acid in the blood. Definition of succinate dehydrogenase activity.	2
4.	<i>Metabolism of carbohydrates. Digestion of carbohydrates. Synthesis and decomposition of glycogen. Gluconeogenesis. Disturbances of carbohydrate metabolism – 2 h.</i> <i>Laboratory works:</i> Quantitative determination of glucose in blood with glucose oxidase method. Glucose tolerance test. Significance of determination of glycosylated hemoglobin.	2
5.	<i>Colloquium: Biological oxidation. General pathways of catabolism. Metabolism of carbohydrates.</i>	2
6.	<i>Metabolism of proteins and amino acids. Nitrogen balance. The main sources of amino acids and their utilization ways. Specific metabolism of phenylalanine and tyrosine.</i> <i>Laboratory works:</i> Determination of phenylpyruvic acid in urea.	2
7.	<i>Digestion, absorption and decay of proteins – 2h.</i> <i>Laboratory works:</i> Qualitative and quantitative analysis of gastric juice. Protein digestion by pepsin and trypsin.	2
8.	<i>Central ways of metabolism of amino acids. Synthesis of urea. Toxicity of ammonia and its detoxification - 2 h.</i> <i>Laboratory work:</i> Determination of urea	2
9.	<i>Metabolism of complex proteins: heme- and nucleoproteins. Synthesis and degradation of hemoglobin. Degradation of purine and pyrimidine nucleotides..</i> <i>Laboratory works:</i> Determination of hemoglobin in blood. Quantitative determination of bilirubin in blood.	2
10.	<i>Colloquium: Metabolism of proteins and nucleic acids. – 2 h.</i>	2
11.	<i>Metabolism of lipids. Digestion and absorption of lipids. Disorders of digestion, absorption and transport of lipids. Energetic significance of fatty acids.</i> <i>Laboratory work:</i> Determination of bile acids.	2
12.	<i>Usage of acetyl CoA: synthesis of cholesterol. Pathology of cholesterol metabolism. Regulation of lipid metabolism and disturbance of lipid metabolism – 2 h.</i> <i>Laboratory work:</i> Quantitative determination of cholesterol in blood.	2
13.	<i>Functional biochemistry of bone tissue, teeth and kidney.</i>	4

	Laboratory works: Analysis of normal and pathological compounds of urine. Qualitative reaction of tooth tissue and compounds of saliva.	
14	Biochemistry of blood, liver, kidney, nervous tissue, teeth and saliva.	2
15	Colloquium: Metabolism of lipids. Biochemistry of tissues. Acceptance of presentations.	3

Totally: 35 hours

Calendar-thematic plan of lectures in dynamic and functional biochemistry for second-year students of the Stomatological Faculty for spring semester of academic year 2019/2020

№	Lecture subject	Hours
1	The basic patterns of energy metabolism. I and II general pathways of catabolism, their energetic value. Biological oxidation. <i>Metabolism of carbohydrates:</i> digestion and absorption of carbohydrates.. Glycolysis, types of glycolysis.	2
2	Metabolism of glycogen. PPP- Pentose phosphate pathway of carbohydrates oxidation in tissues. Gluconeogenesis. Disturbances in carbohydrate metabolism. <i>Metabolism of proteins:</i> digestion and decay of proteins.	2
3	General pathways of metabolism of amino acids. The ways of ammonia formation and its toxicity. Neutralization of ammonia. Biosynthesis of non-essential amino acids. Disturbances of amino acid metabolism.	2
4	Synthesis and degradation of hemoglobin. Formation of bile pigments. Jaundices. <i>Metabolism of nucleoproteins:</i> metabolism of purine and pyrimidine nucleotides. Disturbances of purine and pyrimidine metabolism	2
5	<i>Metabolism of lipids:</i> digestion, absorption and re-synthesis in the intestine of lipids. Metabolism of fatty acids. Synthesis and breakdown of ketone bodies. Metabolism of cholesterol. Disturbances of lipid metabolism. Biochemistry of bone tissue and teeth. Caries.	2

Totally: 10 hours

METHODOLOGICAL SUPPORT

1. Lippincott's Illustrated Reviews: Biochemistry Fifth Edition 2011, 489 p.
2. Harpers, Illustrated Biochemistry, 28th Edition 2016, 818 p.;
3. William J .Marshall Clinical Biochemistry Third Edition 2014, 932 p.;
4. Azizova G.I., Dadashova A.R., Amirova M.F., Vahabova G.R. Biochemistry laboratory manual theory and methods, Baku, 2019, 288 p.
5. Vahabova G.R., Amirova M.F., Dadashova A.R. Biochemical laboratory classes (tutorial), Baku, 2010, 264 p.
6. Islamzade F.I., Efendiyev A.M., Islamzade F.Q. Fundamentals of human biochemistry (textbook, volume I). Baku, 2015.
7. Islamzade F.I., Islamzade F.Q., Efendiyev AM. Fundamentals of human biochemistry (textbook, volume II). Baku, 2015.
8. Efendiyev A.M., Islamzade F.Q, Qarayev A.N., Eyyubova A.A. "Laboratory exercises on biological chemistry" (textbook). Baku, 2015.
9. Efendiyev A.M., Eyyubova A.A., Qarayev A.N. "Pathological and clinical biochemistry" (textbook). Baku, 2019.
10. Qarayev A.N. Biological chemistry (funds for preparation for residency). 2018.
11. Lecture material.

TECHNICAL EQUIPMENT

1. Spectrophotometer
2. pH meter
3. Centrifuge
4. Refrigerator
5. Water bath
6. Thermostat
7. Chromatograph
8. Electrophoresis apparatus
9. Various reagent kits for determination of biochemical parameters
10. Flasks, test tubes, gas lamp, porcelain bowls, pipettes (simple and automatic).
11. Computer, projector for presentations.

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