THE MINISTRY OF HEALTH OF THE REPUBLIC AZERBAIJAN

AZERBAIJAN MEDICAL UNIVERSITY

TRAINING PROGRAM

ON BIOLOGICAL CHEMISTRY

(050806 – Pharmaceutical)

BAKU - 2021

AZERBAIJAN MEDICAL UNIVERSITY

"CONFIRMED"

Vice-rector for Teaching and Treatment,

Prof. S.J.Aliyev

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TRAINING PROGRAM
ON BIOLOGICAL CHEMISTRY

2406.02 – BİOCHEMİSTRY

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 methabolism.
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 diffeent 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 transmittion 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 interconvertions 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 (depending on side chain structure, charge of radical, radical polarity, the number of amino- and carboxylic groups, nutritional requirements).
2. Proteinogenic and non-proteinogenic amino acids' structure (with examples), their general characteristics and role in metabolism.
3. Physico-chemical characteristics of amino acids: stereoisomerism, optical activity, electric charge of amino acids depending on the pH of the medium, solubility and dissociation ability of amino acids, their value for organism, titration curves, isoelectric point and their importance for human body.
4. Chemical composition of proteins, their distribution in organism, representatives, differed by their functions. Obtaining from biological materials (homogenization, extraction, fractionation), salting out and impact of this process on ionization stage of the solution. Hofmeister series. Chromatografy, electrophoresis, their types and principles of techniques.
5. Physico-chemical properties of proteins: shapes, solubility, optical activity, amphotericity, izoelectric point. Denaturation, features of denaturing factors' action, renaturation. Protein sedimentation factors, use these reactions in methods of protein's features investigation.
6. Different types of protein classification. Fibrous proteins' structural features and functions. Collagen: amino acid composition; structure of collagen's protomer – tropocollagen and molecule-stabilizing bonds. Keratin: occurrence in the human body, α- and β-keratins, their amino acids composition.
7. Proteins' structural organization levels, their features. Primary structure and peptide bond. Methods of amino acids determination in the protein molecule: hydrolysis (types and their limitations). Determination of N- and C-terminal amino acids and disulfide bonds in the polypeptide chain. Common and specific color reactions for proteins and amino acids, their principles and value.

8. Spatial configuration of proteins: bonds stabilizing secondary, tertiary and quaternary structure of protein. Protein domain concept. Folding of proteins molecules. The concept of chaperones.
9. Natural peptides: their classification, representatives according to the origin, and specific ways of action. Angiotensin and kinins, their precursors, scheme of formation and enzymes involving in this process. Glutathion, carnosine, anserine – their structure, value, occurrence.
10. Simple proteins, prinsiple of their classification. Albumines and globulines; prolamines and glutelins, protamines and histones. Human blood protein fractions (proteinogram), and its changes in the pathology.
11. Metalloproteins, their representatives, occurrence, value; linkage types, formed between metals and the peptide chain. Metalloid proteins.
12. Phosphoproteins: representatives, occurrence, types of linkage between prostetic group and protein part. Significance of proteins phosphorylation and dephosphorylation.
13. Glycoproteins and proteoglycans: representatives, biological role, occurrence, composition and the percentage of carbohydrate component (examples). Bonds for linkage between carbohydrate component and the protein moiety. Diagnostic value of sialic acid determination by Hess method.
14. Lipoproteins and proteolipids: physico-chemical properties, occurrence, localization in organism, bonds involved in protein-lipid interactions, types of apoproteins. Blood plasma lipoprotein fractions, their structural features and functions.
15. Chromoproteins: classification, representatives. Flavoproteins, hemoproteins: occurrence, role in metabolism. Structure of heme.
16. Structural features of hemoglobin: heterogeneity, chemical properties, effect of cooperativeness, Bohr effect, allosteric regulators. The methods of scarce blood detection in biological materials.
17. Different forms of hemoglobin: oxyhemoglobin, carbhemoglobin, methemoglobin, and carboxyhemoglobin – their structure and functional features, the significance of blood saturation with oxygen. Hemoglobinoses and hemoglobinopathies.
18. Myoglobin and other representatives of hemoproteins (catalase, peroxydase, cytochromes), their structural and functional features.
19. General characteristics of nucleic acids. Purine and pyrimidine bases: lactam and lactim forms, nucleic acid minor forms and nitrogen bases that are not included in the nucleic acids composition. Nucleoside and nucleotide structures, their syn- and anti-configurations.
20. Primary, secondary and tertiary structure of DNA. Chargaff rules. Formation of nucleosome and chromatin.
21. The main structural features of different types of RNA. Formation of secondary and tertiary structure of RNA.
22. The role of transcription in the biosynthesis of proteins. The concept of amino acid codons.
23. Recognition of amino acids. Translation, its stages.
24. Regulation of protein biosynthesis, the effect of inducers and inhibitors on protein biosynthesis.
25. Post-translational modification of proteins.

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 pH of medium on the enzymes activity.
3. Mechanism of enzymatic action. Organization of active center. Activation energy, Michaelis-Menten kinetics. Koshland theory as and 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. Classification of coenzymes. Vitamin- and non-vitamin coenzymes: nucleotide coenzymes, metalloporphyrins, prosthetic groups of metallo-enzymes; phosphorous esters of monosaccharides and glutathione as coenzymes, their biological role.

6. Polyenzyme systems: 3 types of their organization (give an example). Localization of enzymes in cells, organelles, organs and tissues. Isoenzymes: clinical significance, enzyme-diagnostics.
7. 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.
8. The two main ways of enzyme inhibition (reversible and irreversible). Inhibitor types: competitive, non-competitive and uncompetitive (give example), difference in their impact on the enzyme activity. Reactivators (give example).
9. The ways of enzymes intracellular regulation: quantitative change via induction or repression, compartmentalisation, shuttle mechanisms; the principle of feedback (retro-inhibition), conversion of proenzymes into active enzymes, chemical modification of enzymes, allosteric regulation.
10. Enzymes nomenclature and classification; six main classes of enzymes, their subclasses; enzyme code.
11. Enzymes usage in medicine: "immobilized enzymes", enzyme-pathology, enzyme-therapy and enzyme-diagnostics.
12. Vitamin A, its chemical and biological names, structure, vitamers, provitamins, biochemical functions, hypo- and hypervitaminosis, natural sources.
13. 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.
14. Vitamin E, its chemical and biological names, vitamers, metabolism, antioxidant activity, avitaminosis, natural sources.
15. Vitamin K, its chemical and biological names, vitamers, metabolism, biochemical functions, imbalance, natural sources.
16. Vitamin B_1, its chemical and biological names, structural features, metabolism; Coenzymes structural features (co-carboxylase). Role of vitamin B_1in metabolism, avitaminosis, natural sources.
17. 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, natural sources.
18. Pantothenic acid, its chemical and biological names, structural features, metabolism, coenzyme forms, biochemical functions, deficiency, natural sources.
19. Vitamin PP (nicotinic acid), its chemical and biological names, structure, metabolism. Coenzymes NAD^+ and $NADP^+$, their biosynthesis, structure, biochemical functions, deficiency, natural sources.
20. Vitamin B_6, its chemical and biological names, vitamers, their structure, metabolism. Coenzymes PALP and PAMP, their structure, biochemical functions, avitaminosis, natural sources.
21. Folic acid, its chemical and biological names, structural features, metabolism, coenzyme forms and biochemical functions, cause of deficiency and its manifestations, natural sources.
22. Vitamin B_{12}, its chemical and biological names, chemical nature, metabolism, coenzymes, biochemical functions, causes and manifestations of deficiency, natural sources.
23. Vitamin H (biotin), its chemical and biological names, structure, metabolism, biochemical functions, deficiency, natural sources. Avidin.
24. Vitamin C, its chemical and biological names, structure, metabolism, biochemical functions, avitaminosis, natural sources.
25. Vitamin-like substances: vitamins P, B_{15}, U and F, carnitine: chemical names and chemical nature, metabolism, biochemical functions, avitaminosis, natural sources.
26. Inositol, lipoic, orotic and paraaminbenzoic (PABA) acids, choline, ubiquinone: their structures, metabolism, biochemical functions, natural sources.
27. Vitamin therapy in treatment of various diseases; use of vitamins-, coenzymes- and antivitamins-based drugs in medicine.

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 synthesis, secretion, circulation, metabolism and excretion.
6. Hormones of the hypothalamus: somatoliberin, corticoliberin, thyroliberin, prolactoliberin, gonadoliberins (luliberin and folliberin), melanoliberin, melanostatin, somatostatin and prolactostatin; their chemical nature, effects and violation of secretion.
7. Hormones of the adenohypophysis: somatotropin(growthhormone), prolactin, their chemical nature and effects. Diseases associated with the pituitary gland endocrine function disorders: pan-hypopituitarism, hyper- and hyposecretion of somatotropin.
8. Hormones of the pituitary gland: thyrotropin and gonadotropins. POMC derivatives: adrenocorticotropin, lipotropic and melanocyte-stimulatinghormones: their chemical nature, biochemical effects, hyper- and hyposecretions.
9. Hormones of neurohypophysis: oxytocin and vasopressin, their chemical nature, biological effects. Violation of vasopressin and oxytocin secretion.
10. 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.
11. Thyroid hormones: their structure, biological effects, metabolism. İodine intake. Disorders of thyroid hormone secretion.
12. Hormones affecting calcium metabolism: parathormone, calcitonin, calcitriol, their chemical nature, biological effects, violation of secretion resulting in fibrous osteochondro-dystrophy, tetany, and spasmophilia.
13. Pancreatic hormones. İnsulin: chemical nature, regulation of secretion, influence on carbohydrate, protein, lipid metabolism. Violation of insulin secretion, causesof diabetes mellitus&metabolic changes in this disease.
14. Glucagon, somatostatin and pancreatic peptide, their chemical nature and biological effects.
15. Hormones of the adrenal medulla,catecholamines: dopamine, adrenaline, noradrenaline and isopropyl adrenaline, their structure. Synthesis of adrenaline, its biological effects depending on receptor types. The main ways of catecholamine catabolism.
16. Hormones of the adrenal cortex: their different groups. Glucocorticoids: representatives, structure, regulation of secretion and biological role. Diseases associated with hyper- and hyposecretionof glucocorticoids (Itsenko-Cushing's disease, Cushing's syndrome, steroid diabetes, Addison's disease and Addison's syndrome).
17. Mineralocorticoids: representatives, their structure, regulation of secretion, biological effects, catabolism. Diseases associated with changes in mineralocorticoid concentration: aldosteronism (Conn's syndrome), adrenogenital syndrome.
18. Male sex hormones: their structure and biological effects and disorders of endocrine function.
19. Female sex hormones: their structure, biological role, dysfunction. Endocrine function of the placenta (chorio-gonadotropin, choriomammotropin).
20. Hormones of the digestive system; their chemical nature. Eicosanoids, their chemical nature and biological effects. Cytokines. Blood kinin system.

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

№	Topics of the lessons	Hours
1.	***Acquaintance with the group, internal discipline and technical safety rules. Chemical composition of the organism. Amino acids .***	2
2.	***Structure, classification, physico-chemical properties of amino acids. Peptide bond.*** ***Lab. work.:*** Color reactions on amino acids and proteins.	2
3.	***Structure, physico-chemical properties of proteins .*** ***Lab. work.:*** Protein sedimentation reactions. Determination of the isoelectric point of proteins.	2
4.	***Simple proteins. Biologically active natural peptides .*** ***Lab. work.:*** Quantitative determination of blood serum total protein by biuret method. Determination of albumin in the blood serum.	2
5.	***Complex proteins. Phospho-, glyco-, lipo-, metallo-proteins .*** ***Lab. work.:*** Reactions on phospho- and glycoproteins.	2
6.	***Chromoproteins. Structural features of hemoglobin .*** ***Lab. work.:*** Reactions on hemoglobin.	2
7.	***Nucleoproteins. Structural properties of nucleic acids. Matrix biosynthesis.*** ***Lab. work.:*** Hydrolysis of nucleoproteins.	2
8.	***Colloquium***: ***Simple and complex proteins .***	2
9.	***Structure and properties of enzymes. Coenzymes .*** ***Lab. work.:*** Thermolability, specificity of enzymes and the effect of optimum pH on the activity of enzymes.	2
10.	***Acceptance of independent study presentations. Interpretation of situational tasks .***	2
11.	***Mechanism of enzymatic action. Determination of enzyme activity. Classification of enzymes .***	2
12.	***Activators and inhibitors of enzymes. Regulation of enzymatic activity .*** ***Lab. work.:*** The effect of activators and inhibitors on amylase activity. Inactivation of the enzyme cholinesterase with proserin.	2
13.	***Vitamins: classification, vitamin disbalances. Antivitamins. Fat-soluble vitamins.***	2
14.	***Water-soluble vitamins. Vitaminotherapys.*** ***Lab. work.:*** Reactions on vitamins B_1, B_2, PP, B_6 and C.	2
15.	***Acceptance of independent study presentations .***	2
16,	***Structural features and biochemical properties of hormones, Classification, synthesis and regulation of hormones .***	2
17.	***Mechanism of hormones action. Intracellular receptors of hormones .***	2
18.	***Biochemical properties of some hormones: their structure, secretion and biological action; hypo- and hypersecretion of hormones .*** ***Lab. work.:*** Reactions on adrenaline, insulin and thyroxine.	2
19.	***Preparation for med.-term assessment with situational tasks and tests .***	2
20.	***Med.-term assessment (simple and complex proteins, enzymes, vitamins) – 2 s.***	2
21.	***Biochemical characteristics of carbohydrates .*** ***Lab. work.:*** Reactions on carbohydrates.	2
22.	***Chemistry of lipids .*** ***Lab. work.:*** Emulsification of fats. Determination of fatty acids. Qualitative reactions on cholesterol.	2
23	***Acceptance of independent study presentations .***	2
	Colloquium: Biochemical properties of hormones .	2

24		
25	***Final lesson. Term points calculations .***	2

Totally: 50 hours.

Calendar-thematicplanonstatic biochemistry lectures for III course students of Pharmaceutical Faculty. Autumn term of 2021/2022 academic year

№	Subject of lecture	Hours
1.	Biochemistry subject, its goals and objectives. Role of biochemistry in medicine. Physico-chemical properties and structural features of proteins. Amino acids.	2
2.	Diversity of proteins. Hemoglobin, its heterogeneity and cooperativeness, Immunoglobulins. Structural features of different nucleic acid types. Matrix biosynthesis: replication, transcription.	2
3.	Protein biosynthesis, its stages and regulation. Protein folding and participation of chaperones in that process. Biochemical properties of enzymes: their chemical nature, properties, mechanism of action, regulation of enzyme activity.	2
4.	Classification of enzymes and coenzymes. Structure and biochemical properties of water-soluble vitamins. Use of enzymes and their inhibitors in medicine. Clinical enzimology.	2
5.	Biochemical properties of hormones: overview on hormones, mechanisms of their synthesis and secretion. Transmission of hormonal signals. Metabolism of some hormones, metabolic changes in hyper- and hyposecretion of some hormones.	2

Totally: 10 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. 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 glycose 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 glycolgenolysis.

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 glycogenosis 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. Gastricsin.
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 mechnisms of formation and transfer of nerve impulses.

4. The role of mediators in the transmission of nervous excitement. Cholinergic synapses.
5. Adrenergic receptors.

Drug metabolism

1. Features of the metabolism of medicinal compounds.
2. Biochemical mechanisms of xenobiotic metabolism. Reactions catalyzed by oxidoreductases and hydrolases.
3. Alkylation and acetylation. Reactions with thiosulfate and glucuronyl sulphate.
4. Deactivation, activation, detoxification, toxification reactions.
5. Determination of salicylic acid and morphine
6. Factors affecting the metabolism of drugs.
7. Absorption and release of drugs from the body.
8. Specific and non-specific blood systems transporting medicinal substances.

Thematic plan of laboratory classes in dynamic and functional biochemistry for third-year students of the Pharmaceutical Faculty for the spring semester of the academic year 2019/2020

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

	Acceptance of presentations.	
15	***<u>Colloquium:</u> Metabolism of lipids. Biochemistry of tissues.*** ***Acceptance of presentations.***	3

Totally: 35 hours

Calendar-thematic plan of lectures in dynamic and functional biochemistry for third-year students of the Pharmaceutical 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. *Metabolism of carbohydrates:* 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. *Metabolism of proteins:* digestion, absorption 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. *Metabolism of nucleoproteins:* metabolism of purine and pyrimidine nucleotides. Disturbances of purine and pyrimidine metabolism	2
5	*Metabolism of lipids:* 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. Detoxification of the medicine preparations in the liver.	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.

Head of the

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