THE MINISTRY OF HEALTH OF THE REPUBLIC AZERBAIJAN

AZERBAIJAN MEDICAL UNIVERSITY

TRAINING PROGRAM

ON BIOLOGICAL CHEMISTRY

(070101 – General Medicine)

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

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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.

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

№	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.	4
3.	***Central ways of catabolism (I and II general pathways). Aerobic and anaerobic glycolysis.*** **Laboratory works:** Definition of pyruvic acid in the blood. Determination of succinate dehydrogenase activity	4
4.	***Metabolism of carbohydrates. Digestion of carbohydrates. Synthesis and decomposition of glycogen. Gluconeogenesis. Pentose Phosphate Pathway. Disturbances of carbohydrate metabolism.*** **Laboratory works:** Quantitative determination of glucose in blood with glucose oxidase method. Glucose tolerance test. Significance of determination of glycosylated hemoglobin.	4
5.	***Colloquium: Biological oxidation. General pathways of catabolism. Metabolism of carbohydrates.***	4
6.	***Metabolism of proteins and amino acids. Nitrogen balance. The main sources and ways of utilization of amino acids. Specific ways of amino acid metabolism .*** **Laboratory works:** Determination of phenylpyruvic acid in the urine	4
7.	***Digestion, absorption and decay of proteins.*** **Laboratory works:** Qualitative and quantitative analysis of gastric juice. Protein digestion by pepsin and trypsin	4

8.	***General ways of amino acid metabolism. Synthesis of urea. Disorders of amino acid metabolism.*** **Laboratory works:** Determination of ALAT and ASAT activity, its diagnostic value. Determination of urea in blood. Qualitative reaction of phenylpyruvic acid. Assay of hyperaminoaciduria, principles of methods. ***Seminar: Disturbances of intermediate metabolism of amino acids.***	6
9.	***Metabolism of complex proteins: heme- and nucleoproteins. Synthesis and degradation of hemeglobin. Degradation of purine and pyrimidine nucleotides. .*** **Laboratory works:** Determination of hemoglobin in blood. Quantitative determination of bilirubin in blood. Determination of uric acid.	4
10.	***Colloquium: Metabolism of proteins and nucleic acids.***	4
11.	***Metabolism of lipids. Digestion and absorption of lipids. Disturbances of digestion, absorption and transport of lipids. Energetic value of fatty acids.*** **Laboratory works:** Reactions on bile acids.	4
12.	***Usage ways of acetyl CoA: synthesis of fatty acids and cholesterol. Pathology of cholesterol metabolism. Ketogenesis and ketolysis. Ketonemia and ketonuria.*** ***Laboratory works:*** Quantitative determination of cholesterol in the blood. Determination of total lipids in the blood. ***Seminar: Hyperlipidemia. Fatty infiltration of liver and liver dystrophy. Fat Depot Pathology.***	6
13.	***Functional biochemistry of blood and kidneys.*** **Laboratory works:** Determination of total protein in the blood. Analysis of normal and pathological urine.	4
14.	***Functional biochemistry of liver, muscle, nervous and connective tissues.***	4
15.	***Colloquium:Metabolism of lipids. Biochemistry of tissues.*** ***Acceptance of presentations.***	1

Totally: 65 h.

Calendar-thematic plan of lectures in dynamic and functional biochemistry for second-year students of the Treatment-Prophylactic Faculty y 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 hemeglobin. 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 and cholesterol metabolism. Hereditary lipidoses	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. 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. 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 functions.
6. Regulation of the tissue respiration and oxidative phosphorylation: respiratory control. The mechanism of heat formation in the body (free oxidation, muscle shivering, specificity of brown fat). Chemical compounds, uncoupling the processes of oxidation and phosphorylation. Hypoergic states.
7. Oxygenase reactions: mono- and dioxygenases. Microsomal oxidation, microsomal chain, its components and significance. Cytochrome P_{450}, its role in the oxidation of exogenous and endogenous substrates.
8. Peroxidase reactions, their significance. Free radical oxidation. Active oxygen forms (superoxide anion, singlet oxygen, hydroxyl radical). Lipid peroxidation. Formation of malonic dialdehyde, epoxides, ketones, lipo-peroxides. Prooxidants.
9. Antioxidants. Mechanism of body protection from the oxygen toxic action. Enzymes, vitamins and vitamin-like substances with antioxidant activity.
10. Digestion of carbohydrates. Dietary carbohydrates, the amylolytic enzyme of saliva decomposing them in the oral cavity. Amylolytic enzymes of pancreas and intestinal juice. Mechanism of monosaccharides absorption, transport through membranes. Fate of monosaccharides in the cells.
11. Metabolism of glycogen. Regulation of glycogenesis and glycogenolysis.
12. Reactions of anaerobic glycolysis (scheme) and its biological value. Glycolytic oxydo-reduction. Inclusion of glucose and galactose into glycolysis.
13. Aerobic breakdown of glycose and its energetic value.
14. Glyconeogenesis (scheme). Substrates of gluconeogenesis. Cori cycle.
15. Sequential reactions of the pentose phosphate pathway oxidation of glucose and its biological significance.
16. Regulation of carbohydrate metabolism. Hypoglycemia and hyperglycemia. Glucosuria
17. Diabetes mellitus. The causes of disease. Manifestations and complications. Hereditary and acquired disorders of intermediate metabolism of carbohydrates. Fructosuria, fructose intolerance disease. Galactosemia. Glycogenoses, glycosidoses.
18. Features of metabolism of ethyl alcohol in human organism.

Metabolism of simple and complex proteins

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 such as trypsin, chymotrypsin, elastase, carboxypeptidase. Proteinases of intestinal juice.
4. The decay of amino acids in colon. Neutralization of products of rotting. PAPS and UDPGA.
5. The absorption of protein digestion products in the intestine. Disorders of digestion of protein and absorption of amino acids in the intestine. The malabsorption syndrome.

6. Deamination of amino acids. The mechanism of oxidative deamination.
7. Transamination of amino acids. Transaminases, their diagnostic importance. Trans-deamination
8. Decarboxylation of amino acids. Detoxification of biogenic amines formed in these reactions.
9. Ammonia formation. Mechanism of ammonia toxic effect. Neutralization of ammonia: reactions of synthesis of urea (ornithine cycle) and other ways of ammonia neutralization.
10. The fate of hydrocarbon sceletons of amino acid. Glucogenic and ketogenic amino acids. The synthesis of non-essential amino acids.
11. Specificity of metabolism of glutamic and aspartic acids and their amides.
12. Specificity of sulfur-containing amino acids metabolism
13. Specificity of tryptophan metabolism.
14. Specificity of metabolism of phenylalanine and tyrosine.
15. Hereditary and acquired disorders of amino acids metabolism
16. Metabolism of hemeproteins, their digestion and absorption. Synthesis of hemoglobin. Porphyrias.
17. Decomposition of heme: formation and detoxification of bile pigments, their excretion from organism. Jaundice types.
18. Digestion and absorption of nucleoproteins in gastro-intestinal tract. Breakdown of nucleic acids in tissues.
19. Breakdown of purine nucleotides in tissues.
20. Breakdown of pyrimidine nucleotides in tissues.
21. Biosynthesis of purine nucleotides.
22. Biosynthesis of pyrimidine nucleotides. Synthesis of deoxyribonucleotides.
23. Disorders of purine and pyrimidine bases metabolism (gout, xanthinuria, Lesch-Nyhan syndrome, orotic aciduria).

Metabolism of lipids

1. Digestion of lipids. Bile acids: their structure and significance in digestion.
2. Digestion of fats and phospholipids in the intestine. Lipase and phospholipases.
3. Absorption of products of fat hydrolysis and re-synthesis of lipids in the intestine and their transport to the tissues.
4. Intracellular lipolysis. Different ways of fatty acids catabolism. Catabolism of glycerol.
5. β-oxidation reactions of fatty acids and energetic value of this process. Catabolism of fatty acids with an odd carbon atoms.
6. Synthesis of fatty acids, regulation and energy sources for this process.
7. Features of metabolism of unsaturated fatty acids.
8. Synthesis reactions of ketone bodies (ketogenesis). Hydrolysis reactions of ketone bodies (ketolysis). Ketonemia and ketonuria, causes of occurrence.
9. Synthesis of triacylglycerols and phospholipids. Lipotropic factors.
10. Synthesis of cholesterol. Diagnostic importance of cholesterol determination in the blood. Pathology of cholesterol metabolism. Cholelithiasis.
11. Neuro- endocrine regulation of lipid metabolism.
12. Disorders of the digestion, absorption and transport of lipids to the tissues. Hyperlipemia types.
13. Hereditary lipidoses. Fatty infiltration and fatty dystrophy of liver. Fat Depot Pathology.

FUNCTIONAL BIOCHEMISTRY

Functional biochemistry of blood

1. Blood functions. Specificity of metabolism of blood cells (red blood cells, leukocytes, thrombocytes)
2. Biochemical composition of blood. Proteins of blood serum and plasma. Enzymes of blood serum. Diagnostic importance of total protein and albumin determination in blood serum.
3. Nitrogenous non-protein compounds of serum. Residual nitrogen. Azotemia types.

4. Nitrogen-free organic and non-organic components of blood plasma. Microelements.
5. Acid-base balance of blood. Buffer systems of blood. Acidosis and alkalosis.
6. Respiratory function of blood. The effect of external and internal factors.
7. Blood coagulation system. Factors of coagulation. Mechanism of coagulation.
8. Blood anticoagulation system. Inhibitors of blood coagulation enzymes. Fibrinolysis.

Functional biochemistry of liver

9. Features of liver morpho-functional structure and blood supply to the liver.
10. The role of liver in carbohydrate metabolism.
11. The role of liver in lipid metabolism. Composition of bile, its main properties and significance.
12. The role of the liver in nitrogen and pigment metabolism.
13. Excretory and antitoxic function of liver.
14. Syndromes of liver damage.

Functional biochemistry of kidneys

1. Morpho-functional features of the kidneys. Mechanism of urine formation.
2. Features of metabolism in the kidneys.
3. Regulation of the acid-base balance by kidneys.
4. Main properties of normal and pathological urine.
5. The normal chemical components of urine. Diagnostic significance of creatinine determination in the urine.
6. Pathological components of urine. Kidney stone disease.

Functional biochemistry of the nervous tissue

1. Lipids of the nervous tissue and their metabolism.
2. Chemical composition of carbohydrates in the nervous tissue and specificity of energy supply of this tissue
3. Chemical composition and metabolism of proteins, neuropeptides and nucleic acids in the nervous tissue.
4. Biochemical mechanisms of excitation and transmission of nerve impulses.
5. The role of mediators in the transmission of nervous excitement. Cholinergic and adrenergic receptors.
6. Biochemical mechanisms of memory.

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.

2. Main proteins of intercellular matrix of connective tissue: collagen and elastin.
3. Non-collagen proteins of connective tissue.
4. Glycosaminoglycans and proteoglycans of connective tissue.

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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