**FSBEI of HE OrSMU of the Health Ministry of Russia**

**Department of biological chemistry**

**The Full-time studying, specialist**

**Speciality: 31.05.01 – General medicine**

**Discipline: Biochemistry**

**METHODICAL RECOMMENDATION FOR LECTURERS ON THE ORGANIZATION OF THE DISCIPLINE BIOCHEMISTRY**

Orenburg, 2019

**1. Guidelines for the lecture course**

**Methodical development of lectures**

**Module 1. Static biochemistry**

**Lecture №1.**

**1. Topic:**

**Introduction to biochemistry. Basic understanding of the structure and functions of proteins. Enzymes - specific proteins, their structure and properties.**

2. Purpose:

To show the importance of studying biochemistry in the formation of the personality of the future pediatrician. Reveal the role of enzymes in the course of chemical processes in the body.

3. Abstract of the lecture

The importance of biochemistry in the formation of the future doctor is shown. The General properties of enzymes are stated, the nature of chemical catalysis and features of enzymes as biocatalysts are shown: high efficiency, dependence on physical and chemical conditions of the medium (temperature, ion force, pH), specificity of action, dependence on the presence of inhibitors and activators. The classification of enzymes, their nomenclature and indexing are given. Students ' attention is focused on the structure of simple and complex enzymes. The structure of the active center (adsorption and catalytic sites) and the role of allosteric center, its regulatory functions are explained

4. Lecture organization form

The lecture uses the following teaching methods: for didactic purposes - the lecture is thematic, the role in the educational process – introductory, the content and system of construction – mixed

5. Methods used in the lecture (including active and interactive).

The purpose of the lecture is introductory, but also aimed at the acquisition of knowledge by students. According to the type of cognitive activity at the lecture, reproductive and problem methods of presentation of the material are used, visual methods of teaching in the form of illustrations (posters, drawings, diagrams, tables) are used. Active teaching methods are represented by the situation - assessment.

6. Means of training:

- didactic: (tables – "Classification of enzymes", "Thermolability of enzymes".

- material and technical (chalk, Board, multimedia projector).

**Module 2. "Introduction to metabolism. Biological oxidation»**

**Lecture №2.**

**1. Topic: "Introduction to metabolism. Biological oxidation. Enzymes of biological oxidation. Tissue respiration. Of the electron transport chain".**

2. Purpose: to form students ' modern ideas about biological oxidation, biological oxidation enzymes, tissue respiration and CTE.

3. Abstract of the lecture. This lecture reveals the concept of metabolism, stages of metabolism (I –intake of substances , II-intracellular metabolism – metabolism, III - the formation of final products and excretion from the body), the value of metabolism. The theoretical material on biological oxidation, stages of biological oxidation, enzymes of class I "Oxidoreductase" is given in more detail, as well as the third stage – tissue respiration. In the form of schemes intends to respiratory chain transport of electrons I and II type.

4. Form of organization of the lecture. The lecture uses the following teaching methods: the lecture is thematic, on the role in the educational process – introductory, on the content and system of construction – mixed.

5. Methods used in the lecture. The purpose of the lecture is aimed at the acquisition of knowledge by students, the development of creative activity, as well as the consolidation of educational material. According to the type of cognitive activity at the lecture, reproductive and problem methods of presentation of the material are used, visual methods of teaching in the form of: tables, drawings, diagrams, formula material are used. Active teaching methods are presented: situation – exercise, situation – assessment, situation – problem.

6. Means of training:

- didactic - table: "the structure of the cofactor NAD+, NADP+, Structure of the cofactor FMN, FAD", "Catabolism of nutrients", "the Structure of ubiquinone", "the current structure of the respiratory chain (stand)".

- material and technical - chalk, Board, multimedia projector.

**Lecture №3.**

**1. Topic: "The Common path of catabolism."**

2. The purpose of the lesson: to form in students the concept of a common pathway of catabolism, which includes: the reaction of oxidative decarboxylation of pyruvate, the structure of the pyruvate dehydrogenase complex; citrate cycle (Krebs cycle or tricarboxylic acid cycle, CTC).

3. Abstract of the lecture: the lecture focuses on the concept of the common pathway of catabolism, the sequence of biochemical reactions (5) oxidative decarboxylation of PVC, the biological role and regulation of this process, as well as the sequence of biochemical reactions (8), the biological role and regulation of CTC.

4. Form of organization of the lecture. The lecture uses the following teaching methods: the lecture is thematic, the role in the educational process – the installation, the content and system of construction – mixed.

5. Methods used in the lecture. The purpose of the lecture is aimed at the acquisition of knowledge by students, the development of creative activity, as well as the consolidation of educational material. According to the type of cognitive activity at the lecture, reproductive and problem methods of presentation of the material are used, visual methods of teaching in the form of: tables, drawings, diagrams, formula material are used. Active teaching methods are presented: situation – exercise, situation – assessment, situation – problem.

6. Means of training:

- didactic - table: "the Scheme of reactions of oxidative decarboxylation of PVK", "Diagram of reaction of the TCA", "the current structure of the respiratory chain (stand)", "the structure of the cofactors NAD, FAD, TDF OVER»

- material and technical - chalk, Board, multimedia projector.

**Module 3. Carbohydrate metabolism**

**Lecture №4.**

**1. Topic: Anaerobic oxidation of carbohydrates. Gluconeogenesis**

2. Purpose: to show the possibility of dichotomous oxidation of glucose in aerobic and anaerobic conditions, to emphasize the importance of anaerobic oxidation of glucose. Show the value of gluconeogenesis to maintain blood glucose levels.

3. Abstract of the lecture. Ways of receipt and use of blood glucose are shown, the norm of blood glucose is given, the concept of Hypo-, hyperglycemia is given. The concept of neonatal hypoglycemia is given. The importance of glucostatic liver function is emphasized. The sequence of glycolysis reactions to lactic acid, irreversible glycolysis reactions, allosteric effectors of key enzymes are shown. The total equation and energy yield of glycolysis processes are given. The role of PVC as a temporary acceptor of electrons and protons, the importance of anaerobic oxidation of glucose for adults and children is emphasized. The differences between glycolysis and gluconeogenesis are explained, the workarounds and the biological role of GNG are shown.

4. The form of organization of the lecture is traditional, the lecture with a basic outline.

5. Methods used in the lecture. The purpose of the lecture is aimed at the acquisition of knowledge by students, the development of creative activity, as well as the mastery of new educational material. According to the type of cognitive activity at the lecture reproductive and problem methods of presentation are used. Active teaching methods are represented by situation-exercise, situation - assessment, situation – problem.

6. Means of training:

- material and technical (chalk, Board, multimedia projector)

**Lecture №5.**

**1. Topic: Aerobic oxidation of glucose. Pentosephosphate cycle**

2. Purpose: to show the energy effect of dichotomous oxidation of glucose in aerobic taking into account the two Shuttle mechanisms, to emphasize the importance of aerobic oxidation of glucose. Show the chemistry and biological role of direct glucose oxidation.

3. Abstract of the lecture. The ways of aerobic oxidation of glucose, especially the oxidation of glucose in anaerobic and aerobic conditions are shown. The stages of oxidation of glucose to CO2 and water in aerobic conditions are listed, the final equation of aerobic oxidation of glucose, the energy balance is given. The concept of the hexose-monophosphate pathway of glucose oxidation (HMF) is given: the sequence of reactions of the oxidative pathway, its limiting and regulatory links. Shows a General diagram of the second phase GMP-ways; its reversibility, the role in ensuring a balance between the processes of formation and utilization of various monosaccharides, points of conjugation of different metabolic pathways. The proportion of GMP-the way to the total utilization of glucose by cells of different types; the mechanisms of its Autonomous self-regulation. Functional role of the GMF pathway in the cells of adipose tissue, liver, adrenal cortex and gonads, in erythrocytes.

4. The form of organization of the lecture is traditional, the lecture with a basic outline.

5. Methods used in the lecture. Students, the development of creative activity, as well as the mastery of new educational material aim the purpose of the lecture at the acquisition of knowledge. According to the type of cognitive activity at the lecture, reproductive and problem methods of presentation are used. Active teaching methods are represented by situation-exercise, situation - assessment, situation – problem.

6. Means of training:

- material and technical (chalk, Board, multimedia projector)

**Module 4. Lipid metabolism and functions.**

**Lecture №6.**

1. **Topic: lipid Catabolism. Blood lipoproteins**

2. Purpose: to Form students ' understanding of the biological role of food lipids in human life, as well as the conditions of their digestion and entry into the internal environment of the body. To study the main pathways of catabolism of TAG and phospholipids. To form an idea of the composition and biological role of plasma lipoproteins.

3. Abstract of the lecture: Lipids, physiological role, sources, need. The idea of digestion and absorption of lipids. Resynthesis of the TAG in the intestinal wall. Common blood lipids. Transport of exogenous and endogenous lipids. Lipoproteins: chemical composition, structure, biological role, metabolism. The blood known as lipoprotein lipase, its biological role. Intracellular catabolism of TAG. Lipolysis, germanosilica (tissue) lipase. Intracellular glycerol oxidation. Intracellular oxidation of fatty acids. β-oxidation and CTC. Total energy effect of complete oxidation.

4. Form of organization of the lecture: traditional.

5. Methods used in the lecture:

- visual: demonstration of tables, presentation;

- verbal: lecture.

6. Means of training:

- didactic, tables, presentation

- material and technical: chalk, Board.

**Lecture №7.**

**1. Topic: Lipid Anabolism.**

2. Objective: to Consider the biosynthesis of HFA, TAG and phospholipids.

3. Abstract of the lecture: Characterization of SWC synthase. Chemistry of the biosynthesis of FA. Sources of NADPH∙H+. Biosynthesis of triacylglycerides (TAG) and phospholipids.

4. Form of organization of the lecture: traditional.

5. Methods used in the lecture:

- visual: demonstration of tables and presentations

- verbal: lecture.

6. Means of training:

- didactic, tables, presentation

- material and technical: chalk, Board, multimedia projector.

**Lecture 8.**

**1. Topic: Exchange of cholesterol and ketone bodies. Pathology of lipid metabolism**

2. Objective: to Form students ' understanding of the biological role, metabolism and transport of cholesterol. To study the role and metabolism of ketone bodies

3. Abstract of the lecture: cholesterol Biosynthesis. The role oxymethylphenyl-COA reductase in the biosynthesis of cholesterol. Transport cholesterol in the blood. The role of VLDL, LDL and HDL. LHAT – reaction and its role in the metabolism of HS. The transformation of cholesterol into bile acids. The excretion of bile acids and cholesterol from the body. . Ketogenesis. The biological role of ketone bodies. Catabolism of acetoacetate. Ketosis: acetonemia, acetonuria.

4. Form of organization of the lecture: traditional.

5. Methods used in the lecture:

- visual: demonstration of tables and presentations

- verbal: lecture.

6. Means of training:

- didactic, tables, presentation

- material and technical: chalk, Board, multimedia projector.

**Module 5. Exchange and functions of nitrogen-containing compounds.**

**Lecture №9.**

**1. Topic: Common pathways of amino acid catabolism.**

2. Objective: to Study the physiological role of proteins, sources and need for proteins. Consider the common pathways of amino acid catabolism. To study the General pathways of amino acid catabolism, mechanisms of direct and indirect deamination.

3. Abstract of the lecture: the Importance of protein in nutrition and life. Sources and daily value of protein. Chemical and biological value of different proteins. The concept of nitrogen balance. The main ways of receipt and use of amino acids in the human body (scheme). Common pathways of amino acid catabolism. Deamination of amino acids and its types. Oxidative (direct) deamination. Transamination. Manifold function of a-Ketoglutarate and glutamate. Transdeamination amino acids (indirect deamination). De Ritis coefficient.

4. Form of organization of the lecture: traditional.

5. Methods used in the lecture:

- visual: demonstration of tables and presentations

- verbal: lecture.

6. Means of training:

- didactic, tables, presentation

- material and technical: chalk, Board, multimedia projector.

**Lecture №10.**

**1. Topic: Ways of formation and ways of ammonia detoxification.**

2. Purpose: to Consider the main mechanisms of ammonia formation in the body, the causes of its toxicity and ways of neutralization.

3. Abstract of the lecture: Sources and main ways of NH3 formation(scheme). The main ways of neutralization. Hyperammonemia. Mechanisms of toxic effects of ammonia.

4. Form of organization of the lecture: traditional.

5. Methods used in the lecture:

- visual: demonstration of tables and presentations

- verbal: lecture.

6. Means of training:

- didactic, tables, presentation

- material and technical: chalk, Board, multimedia projector.

**Lecture 11.**

**1. Topic: Nucleotide Exchange**

2. Objective: to Study the biosynthesis and catabolism of purine and pyrimidine nucleotides. To systematize the knowledge of students on the mechanisms of matrix biosynthesis regulation, obtained in the study of biology.

To systematize the knowledge of students on the mechanisms of matrix biosynthesis regulation, obtained in the study of biology.

3. Abstract of the lecture: Nucleoproteins. Admission and digestion. Intracellular cleavage of purine nucleotides and pyrimidine nucleotides. Idea of biosynthesis of purine and pyrimidine nucleotides. Violation of the exchange of purine nucleotides.

4. Form of organization of the lecture: traditional.

5. Methods used in the lecture:

- visual: demonstration of tables and presentations

- verbal: lecture.

6. Means of training:

- didactic: tables, PowerPoint slides.

- material and technical: chalk, Board, multimedia projector, screen.

**Module 6. Regulation of metabolism. Hormones.**

**Lecture №12.**

**1. Topic: Hormones and their characteristics. Mechanisms of hormonal regulation of metabolism.**

2. Purpose: to form students ' modern ideas about the properties and mechanism of action of hormones, their role in the regulation of metabolic processes in the cell.

3. Abstract of the lecture

 The lecture provides a modern definition and classification of hormones, outlines the basic properties of hormones as bioregulators, provides characteristics of cells and target organs, the structure and properties of receptors and their role in the implementation of hormonal effects on the cell. The General provisions concerning the mechanisms of action of hormones, the value of secondary mediators in the provision of the membrane-intracellular mechanism are presented. Presents data on the functioning of adenylyl cyclase and guanilatziklazy systems, and the role of metabolites of phospholipids (DAG and IP3 ) in the realization of hormonal signal. Data on the cytosolic mechanism of action of hormones are given.

4. Lecture organization form:

The lecture uses the following teaching methods: for didactic purposes - the lecture is thematic, the role in the educational process – introductory, the content and system of construction – mixed.

5. Methods used in the lecture

The purpose of the lecture is aimed at the acquisition of knowledge by students, the development of creative activity, as well as the consolidation of educational material. According to the type of cognitive activity at the lecture, reproductive and problem methods of presentation of the material are used, visual methods of teaching in the form of illustrations ( posters, drawings, diagrams, tables) are used. Active teaching methods are represented by situation-exercise, situation-assessment, situation – problem.

6. Means of training:

- didactic: (tables – "Membrane-intracellular mechanism of action", "Cytosolic mechanism of action of hormones", "Structure of adrenaline", "adenylate Cyclase system", "Structure of catecholamines", schemes – "Scheme of insulin synthesis", "Scheme of glucagon synthesis", posters – "Hierarchy of regulatory systems", "Regulation of metabolism".

- material and technical: chalk, Board, multimedia projector.

**Lecture №13**

**1. Topic: Private endocrinology: thyroid hormones and adrenal cortex**

2. Purpose: to form students ' modern ideas about the role of thyroid hormones in metabolism. Consider the metabolic effects of gluco-and mineralocorticoids.

3. Abstract of the lecture

 The lecture provides a modern definition of the role of iodine, daily needs. Set out the steps in the synthesis of thyroid hormones. Hypo - and hyperfunction of the thyroid gland and adrenal cortex is described.

4. Lecture organization form:

The lecture uses the following teaching methods: for didactic purposes - the lecture is thematic, the content and system of construction – mixed.

 5. Methods used in the lecture

The purpose of the lecture is aimed at the acquisition of knowledge by students, the development of creative activity, as well as the consolidation of educational material. According to the type of cognitive activity at the lecture, reproductive and problem methods of presentation of the material are used, visual methods of teaching in the form of illustrations ( posters, drawings, diagrams, tables) are used. Active teaching methods are represented by situation-exercise, situation-assessment, situation – problem.

6. Means of training:

- didactic: (tables – "Stages of synthesis of thyroid hormones»

- material and technical: chalk, Board, multimedia projector.

**Lecture 14.**

**1. Topic: Regulation of water-salt metabolism. Calcium and phosphorus metabolism**

2. Purpose: to form students ' knowledge about the role of minerals in the human body and the mechanisms of hormonal regulation of water metabolism and mineral salts.

3. Abstract of the lecture

The lecture provides data on the properties, biosynthesis and participation in the regulation of phosphorus-calcium metabolism of hormones such as parathyrin, calcitriol, calcitonin. It contains information about the pathology of the endocrine glands that produce these hormones, as well as the causes of Hypo - and hypercalcemia.

 4. Lecture organization form:

The lecture uses the following teaching methods: for didactic purposes - the lecture is thematic, the role in the educational process – the installation, the content and system of construction – information.

 5. Methods used in the lecture

 The purpose of the lecture is aimed at the acquisition of knowledge by students, the development of creative activity, as well as the consolidation of educational material. According to the type of cognitive activity at the lecture, reproductive and problem methods of presentation of the material are used, visual methods of teaching in the form of illustrations ( posters, drawings, diagrams, tables) are used. Active teaching methods are represented by situation-exercise, situation - assessment, situation – problem.

6. Means of training:

- didactic: (tables – "Cytosolic mechanism of action", "Mechanism of action of vasopressin", "Structure of vitamin D", "Structure of calcitriol", scheme – "Scheme of synthesis of angiotensins", "Scheme of synthesis of parathyrin".

- material and technical: chalk, Board, multimedia projector.

**Module 7 "The private Issues of biochemistry»**

**Lecture №15**

**1. Topic: Hemoglobin metabolism and its disorders. Jaundices.**

2. Purpose: to give an idea of the metabolic ways to maintain the chemical homeostasis of blood and the causes of their changes. Show the processes of synthesis and decomposition of hemoglobin. Formulate clear criteria for biochemical differentiation of jaundice.

3. Abstract of the lecture. The chemical composition of blood is shown. The characteristic of some parameters of the protein spectrum of plasma, residual nitrogen, nitrogen-free organic compounds, blood minerals is given. Attention is paid to the diagnostic significance of the definition and reference intervals of the most important ones. The features of the chemical composition and metabolism of red blood cells. The concept of hemoglobinopathies, thalassemia, iron deficiency anemia, hemochromatosis. The role of liver, spleen and bone marrow in hemoglobin metabolism is emphasized. Special attention is paid to the disintegration of hemoglobin in tissues: the formation of bilirubin; its further transformations; the fate of bile pigments. This overview of jaundice and its variants (hemolytic, obstructive, parenchymatous, neonatal jaundice). Clear criteria of biochemical differentiation of jaundice are formulated.

4. The form of organization of the lecture is traditional, the lecture with a basic outline.

5. Methods used in the lecture. The purpose of the lecture is aimed at the acquisition of knowledge by students, the development of creative activity, as well as the mastery of new educational material. According to the type of cognitive activity at the lecture reproductive and problem methods of presentation are used. Active teaching methods are represented by situation-exercise, situation - assessment, situation – problem.

6. Means of training:

- material and technical (chalk, Board, multimedia projector)

**Methodical recommendations for practical lessons**

**MODULE № 1 STATIC BIOCHEMISTRY. PROTEINS.**

**ENZYMES. VITAMINS.**

**Topic 1: SIMPLE PROTEINS. STRUCTURE AND FUNCTION**

**Type of study session** - training workshop

**Purpose:** recall structure and function of the proteins

**Questions for lesson:**

1. Proteins: functions of the proteins.

2. Primary structure of proteins.

3. Secondary structure.

4. Tertiary structure of proteins.

5. Protein folding. Role of chaperones in protein folding

6. Quaternary structure.

7. Classification of proteins

8. Other biologically important peptides.

Lesson plan

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work №1 «Determination of total protein by a biuret method» | 60 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 10 min |

Means of education:

- didactic - input control options

- logistical chalk, board, reagents, laboratory glassware

**Topic 2: PHYSICAL AND CHEMICAL PROPETIES OF PROTEINS**

**Type of study session** - training workshop

**Purpose:**

1. to perform and assess color reactions for proteins and amino acids.

2. to learn physical and chemical properties of proteins: ionization, hydration, solubility.

3. to obtain knowledge about precipitation of proteins, general techniques for separation, purification and quantitation of the proteins.

**Questions for lesson:**

1. Color reactions for proteins and amino acids (Biuret reaction, Ninhydrin reaction, Xantoprotein test, Milon’s reaction, Nitriprusside Test).

2. Physical and chemical properties of proteins: ionization, hydration, solubility. Isoelectric point of protein.

3. Forming the protein’s hydration shell.

4. Precipitation of proteins (reversible and irreversible). Salting out.

5. Denaturation of protein. Factors of denaturation. Properties of denatured protein.

6. Renaturation (reversible denaturation).

7. General techniques for separation, purification and quantitation of the proteins.

Lesson plan

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 60 |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory works:Ninhydrin reaction,Xantoprotein reaction,Milon’s reaction,Nitriprusside reaction | 60 |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 10 min |

Means of education:

- didactic - input control options

- logistical chalk, board, reagents, laboratory glassware

**Topic 3: ENZYMES. STRUCTURE AND GENERAL PROPERTIES OF ENZYMES**

**Type of study session** - training workshop

**Purpose:**

1. to learn structure and general properties of enzymes.

2. to analyze some properties of α- amylase in the saliva

**Questions for lesson:**

1. Chemical nature and structure of enzymes. Holo-enzymes. Structure. Classification of the cofactors. Apo-enzymes, co-enzymes, prosthetic groups.

2. Isoenzymes. Zymogens.

3. General properties of enzymes.

4. Influence of pH and temperature on the activity of enzymes.

5. Specificity of enzymes. Specificity types.

6. Principles of qualitative estimation of enzymes’ activity.

7. Nomenclature and classification of enzymes.

Lesson plan

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 60 |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory works:Detection of α- amylase in the saliva,Investigation of influence of pH on activity of α- amylase | 60 |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 10 min |

Means of education:

- didactic - input control options

- logistical chalk, board, reagents, laboratory glassware

**Topic 4: MECHANISM OF ENZYME ACTION. REGULATION OF ENZYME ACTIVITY**

**Type of study session** - training workshop

**Purpose:**

1. acid-base behavior of amino acids (see *Appendix I*)

2. chemical and physical properties of protein

3. levels of structural organization of protein

4. chemical nature and structure of enzymes

5. general properties of enzymes

6. principles of thermodynamics

**Questions for lesson:**

1. Active center of enzymes. Structure and properties.

2. Allosteric center of enzymes. Allosteric enzymes. Key enzymes.

3. Mechanisms of enzyme action.

4. Factors affecting enzyme activity: enzyme concentration, substrate concentration, product concentration. Michaelis constant.

5. Regulation of enzyme activity. Covalent modification.

6. Activation of enzyme activity.

7. Inhibition (reversible and irreversible, competitive and non-competitive).

\*8. Clinically useful competitive inhibitors of enzyme activity.

\*9. Enzymes in diagnostics and therapy.

\*10. Immobilized Enzymes.

Lesson plan

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 60 |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work:Influence of activators and inhibitors on α- amylase activity  | 60 |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 10 min |

Means of education:

- didactic - input control options

- logistical chalk, board, reagents, laboratory glassware

**Topic 5: WATER-SOLUBLE AND LIPID-SOLUBLE VITAMINS. VITAMINS AS COFACTORS. ASCORBIC ACID**

**Type of study session** - training workshop

**Purpose:**

1. to learn general characteristics of vitamins.

2. to compare two types of vitamins: water-soluble and lipid-soluble

3. to obtain knowledge about vitamins as cofactors

**Questions for lesson:**

1. Vitamins. General characteristics of the vitamins.

2. Nomenclature and classification of vitamins .

3. Comparison of two types of vitamins: water-soluble and fat- soluble.

4. Vitamin**-**deficient states (diseases).

5. The structure and metabolism of Ascorbic acid.

6. Biochemical functions of Ascorbic acid.

7. Ascorbic acid as antioxidant.

8. Deficiency manifestations of Vitamin C.

Lesson plan

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 60 |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work:Quantitate determination of vitamin C in food | 60 |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 10 min |

Means of education:

- didactic - input control options

- logistical chalk, board, reagents, laboratory glassware

**Topic 6: SIMPLE PROTEINS. ENZYMES. VITAMINS. FINAL CONTROL**

**Type of study session** - training workshop

**Purpose:**

to obtain knowledge about simple proteins, enzymes and vitamins.

**Questions for lesson:**

1. Proteins: functions of the proteins.
2. Primary structure of proteins.
3. Secondary structure.
4. Tertiary structure of proteins.
5. Protein folding. Role of chaperones in protein folding
6. Quaternary structure.
7. Classification of proteins 8. Biologically important peptides.
8. Color reactions for proteins and amino acids (Biuret reaction, Ninhydrin reaction, Xantoprotein test, Milon’s reaction, Nitriprusside Test).
9. Physical and chemical properties of proteins: ionization, hydration, solubility. Isoelectric point of protein.
10. Formation of the protein’s hydration shell.
11. Precipitation of proteins (reversible and irreversible). Salting out.
12. Protein denaturation. Factors of denaturation. Properties of denatured protein.
13. Renaturation (reversible denaturation).
14. General techniques of separation, purification and quantitation of proteins.
15. Chemical nature and structure of enzymes. Holo-enzymes. Structure. Classification of the cofactors. Apo-enzymes, co-enzymes, prosthetic groups.
16. Isoenzymes. Zymogens.
17. General properties of enzymes.
18. Influence of pH and temperature on enzymes’ activity.
19. Specificity of enzymes. The types of specificity.
20. Principles of qualitative estimation of enzymes.
21. Nomenclature and classification of enzymes.
22. Active center of enzymes. Structure and properties.
23. Allosteric center of enzymes. Allosteric enzymes. Key enzymes.
24. Mechanism of enzyme action.
25. Factors affecting enzyme activity: enzyme concentration, substrate concentration, product concentration. Michaelis constant.
26. Regulation of enzyme activity. Covalent modification.
27. Activation of enzyme activity.
28. Inhibition (reversible and irreversible, competitive and non-competitive).
29. Clinically useful competitive inhibitors of enzyme activity.
30. Enzymes in diagnostics and therapy.
31. Vitamins. General characteristics of vitamins.
32. Nomenclature and classification of vitamins (see Appendix I).
33. Comparison of two types of vitamins: water-soluble and lipid-soluble.
34. Vitamin deficient states.
35. The Structure and metabolism of Ascorbic acid.
36. Biochemical functions of Ascorbic acid.
37. Ascorbic acid as antioxidant.
38. Clinical manifestations of ascorbic acid deficiency.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min |
| 2 | Test control | Method of testing control | 30 min |
| 3 | Verification of theoretical knowledge | Method of written control | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students). | Method of decision of situational tasks | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | summarizing classes | 10 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, computer

**MODULE № 2. GENERAL METABOLISM. BIOLOGICAL OXIDATION**

**Practical lesson №1**

**Topic 1: General metabolism. Intermediary metabolism**

**Type of study session** - training workshop

**Purpose:**

* to obtain knowledge about general metabolism;
* to characterize the stages of catabolism and biological oxidation;
* to learn the function of ATP in the intermediary metabolism;
* to perform quantitative determination of pyruvic acid in the blood.

Questions for lesson:

1. Introduction to metabolism. Catabolism and anabolism.
2. The final common metabolic pathway. Central, cyclic and specific metabolic pathways.
3. Free energy, the standard state. High-energy compounds: structure and functions. ATP-cycle.
4. Metabolic pathways (central and specific, linear and cyclic).
5. Stages of catabolism and oxidation of foodstuffs.
6. General characteristic of biological oxidation. Stages of biological oxidation:
* The first phase of biological oxidation - the formation of acetyl - CoA
* The second phase of biological oxidation - the tricarboxylic acid cycle (TCA);
* The 3rd phase of biological oxidation - the terminal, the final - aerobic - tissue respiration. The role of oxygen in biological oxidation.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 50 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work «Estimation of pyruvic acid concentration in blood» | 50 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №2**

**Topic 2: Biological oxidation. Electron transport chain**

**Type of study session** - training workshop

**Purpose:**

to learn general characteristic of enzymes’ class - oxidoreductases;

to obtain knowledge about oxidative phosphorylation and compounds affecting electron transport chain.

Questions for lesson:

1. Draw structure of NAD+ and acceptance of hydrogen scheme by NAD+.
2. Numerate NAD+ linked dehydrogenases.
3. Draw structure of FAD and acceptance of hydrogen scheme by FAD.
4. Numerate NAD+ linked dehydrogenases.
5. Draw structure of Co- enzyme Q and acceptance of hydrogen scheme by Co-enzyme Q.
6. Draw the scheme of electron transport chain I type.
7. Draw the scheme of electron transport chain II type.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work «Reactions of oxidative phosphorylation» | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №3**

**Topic 3: Bioenergetics and oxidative phosphorylation.**

**Type of study session** - training workshop

**Purpose:**

to understand hypotheses for coupling mechanism. Mitchell’s chemiosmotic theory;

to know regulation of ATP synthesis. Respiratory control;

to learn inhibitors of electron transport chain and oxidative phosphorylation.

Questions for lesson:

1. Oxidative phosphorylation (ATP synthesis). P/O ratio.

3. Hypotheses for coupling mechanism. Mitchell’s chemiosmotic theory.

4. Regulation of ATP synthesis. Respiratory control.

5. Inhibitors of electron transport chain and oxidative phosphorylation.

6. Uncouplers of oxidative phosphorylation.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work «Effect of 2,4-dinitrophenol (2,4-DNP) on oxidative phosphorylation» | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №4**

**Topic 4: Oxidative decarboxylation of pyruvic acid. Krebs cycle.**

**Type of study session** - training workshop

**Purpose:**

to characterize the central metabolic pathway;

to learn the most significant mechanism of CO2 generation;

to obtain knowledge concerning the functions and regulation of the central metabolic pathway

Questions for lesson:

1. Central metabolic pathway. Definition, localization in the cell.

2. Pyruvate dehydrogenase complex. Structure and regulation.

3. Biological significance of the oxidative decarboxylation of pyruvic acid.

4. Sources and utilization of acetyl CoA.

5. Functions of the citric acid cycle (CAC).

6. Reactions of the Krebs cycle.

7. Biological significance of the CAC.

8. Regulation of the CAC.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work «TCA cycle functioning manifested by the formation of CO2» | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №5**

**Topic 5: General metabolism. Biological oxidation» Module**

**Type of study session** - training workshop

**Purpose:**

* to obtain the knowledge about metabolism, biological oxidation.

Questions for lesson:

1. Metabolism. The purposes of the metabolism.
2. Catabolism and anabolism.
3. Metabolic pathways (central and specific, linear and cyclic).
4. Stages of catabolism and oxidation of foodstuffs.
5. General characteristic of primary metabolism (digestion).
6. General characteristic of secondary (intermediary) metabolism.
7. General characteristic of tertiary metabolism (internal respiration).
8. Pantothenic acid and Co-enzyme A. Structure and biological functions. Deficiency of pantothenic acid.
9. The definition and the stages of biological oxidation.
10. The characteristics of the enzymes’ class - oxidoreductases. Flavin- linked and niacin- linked dehydrogenases.
11. Cytochromes.
12. Co-enzyme Q.
13. Organization of electron transport chain.
14. Oxidative phosphorylation (ATP synthesis). P/O ratio.
15. Hypotheses for coupling mechanism. Mitchell’s chemiosmotic theory.
16. Regulation of ATP synthesis. Respiratory control.
17. Inhibitors of electron transport chain and oxidative phosphorylation.
18. Uncouples of oxidative phosphorylation.
19. Reactive oxygen species.
20. Generation of free radicals.
21. Stages of the lipid peroxidation.
22. Clinical significance of free radicals.
23. Free radicals scavenger systems.
24. Antioxidants.
25. Lipid-soluble vitamins. General characteristics.
26. Vitamin E. Biochemical role of vitamin E.
27. Deficiency manifestations of vitamin E.
28. Vitamin C as antioxidant.
29. Central metabolic pathway. Definition, localization in the cell.
30. Pyruvate dehydrogenase complex. Structure and regulation.
31. Biological significance of the oxidative decarboxylation of pyruvic acid.
32. Sources and utilization of acetyl CoA.
33. Functions of the citric acid cycle (CAC).
34. Reactions of the Krebs cycle.
35. Biological significance of the CAC.
36. Regulation of the CAC.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Test control | Method of testing control | 20 min |
| 3 | Verification of theoretical knowledge | Method of written control | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students). | Method of decision of situational tasks | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, computer

**MODULE № 3 СARBOHYDRATE METABOLISM AND FUNCTION**

**Practical lesson №1**

**Topic 1: Carbohydrates: biological functions and classification. Metabolic pathway of carbohydrates. Glycogen metabolism**

**Type of study session** - training workshop

**Purpose:**

-to obtain knowledge about metabolic pathway of carbohydrates;
-to characterize the digestion of carbohydrates;
-to obtain knowledge concerning glycogen metabolism;
- to perform detection of glucose in the urine.

Questions for lesson

1. Functions of the carbohydrates in organism.
2. The staples abundant to monosaccharides, disaccharides and polysaccharides.
3. Digestion of the polysaccharides and disaccharides.
4. Absorption of glucose, galactose and fructose.
5. Blood glucose. Regulation.
6. Metabolism of glycogen. Glycogenolysis and glycogenesis. Regulation.

\*7. Glycogen storage diseases.

\*8. Abnormal degradation of disaccharides in the gastrointestinal tract.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory workDetection of glucose in the urineFelling probeNylander probe | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №2**

**Topic 2: Glycolysis: reaction, regulation, energy balance. Aerobic oxidation of glucose. Shuttle systems: malat-aspartate and glycerol phosphate**

**Type of study session** - training workshop

**Purpose:**

-to learn the major specific metabolic pathway for glucose- glycolysis;

-to understand regulation of glycolysis;

-to understand significance of Cori cycle;

-to obtain knowledge about aerobic oxidation of glucose;

-to perform quantitative determination of glucose in the serum.

Questions for lesson

1. Functions of the carbohydrates in organism.
2. The staples abundant to monosaccharides, disaccharides and polysaccharides.
3. Digestion of the polysaccharides and disaccharides.
4. Absorption of glucose, galactose and fructose.
5. Blood glucose. Regulation.
6. Metabolism of glycogen. Glycogenolysis and glycogenesis. Regulation.

\*7. Glycogen storage diseases.

\*8. Abnormal degradation of disaccharides in the gastrointestinal tract.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 40 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory workQuantitative determination of glucose in the serum | 60 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №3**

**Topic 3: Gluconeogenesis. Pentose- phosphate pathway. Fructose and galactose metabolism**

**Type of study session** - training workshop

**Purpose:**

- to obtain knowledge about glyconeogenesis;

- to understand biological significance of pentose phosphate pathway;

- to know fructose and galactose metabolism and its disorders.

Questions for lesson

1. Gluconeogenesis. Definition. Reactions.

2. Regulation and biological significance of gluconeogenesis.

3. Pentose- phosphate pathway (PPP) of glucose oxidation. Reactions of the oxidative phase in details.

4. Biological significance and regulation of PPP.

5. Fructose metabolism in details.

6. Hereditary fructose intolerance.

7. Galactose metabolism in details.

8. Galactosemia.

9. Galactokinase deficiency.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory workEffect of hormones on blood glucose content | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №4**

**Topic 4: Metabolic pathway of carbohydrates. Final control**

**Type of study session** - training workshop

**Purpose:**

**-** to know the most important biochemical processes in the metabolism of carbohydrates, methods of their evaluation in the laboratory, metabolic disorders and the possibility of correction;

- be able to apply this knowledge when solving situational tasks.

Questions for lesson:

1. Functions of the carbohydrates in organism.

2. The staples abundant to monosaccharides, disaccharides and polysaccharides.

3. Digestion of the polysaccharides and disaccharides.

4. Absorption of glucose, galactose and fructose.

5. Blood glucose. Regulation.

6. Metabolism of glycogen. Glycogenolysis and glycogenesis. Regulation.

7. Glycogen storage diseases (types Ia, III, IV, V).

8. Abnormal degradation of disaccharides in the gastrointestinal tract.

9. Glycolysis. Definition, localization and reaction in details.

10. Regulation of glycolysis. Key enzymes of glycolysis.

11.Glycogenolysis in the muscles.

12.Cory cycle. Biological significance.

13.Aerobic oxidation of glucose in details.

14.Regulation of aerobic oxidation of glucose.

15.Energy balance of glycolysis and aerobic oxidation of glucose in the different organs.

16.Gluconeogenesis. Definition. Reactions.

17.Regulation and biological significance of gluconeogenesis.

18.Pentose- phosphate pathway (PPP) of glucose oxidation. Reactions of the oxidative phase in details.

19.Biological significance and regulation of PPP.

20.Fructose metabolism in details.

21.Hereditary fructose intolerance.

22.Galactose metabolism in details.

23.Galactosemia.

24.Galactokinase deficiency.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Test control | Method of testing control | 20 min |
| 3 | Verification of theoretical knowledge | Method of written control | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Method of decision of situational tasks | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, computer

**MODULE № 4 METABOLIC PATHWAY OF LIPIDS**

**Practical lesson №1**

**Topic 1: LIPIDS: BIOLOGICAL FUNCTIONS AND CLASSIFICATION. METABOLIC PATHWAY OF LIPIDS. DIGESTION AND CATABOLISM**

**Type of study session** - training workshop

**Purpose:**

-to obtain knowledge about metabolic pathway of lipids;

-to characterize the digestion of lipids;

-to obtain knowledge concerning metabolism of bile acids;

- to learn lipids catabolism.

Questions for lesson:

1. Functions of the lipids in organism.
2. The staples abundant to triacylglycerols (TG), phospholipids (PL) and cholesterol esters (CE).
3. Stages of lipids metabolism. Conditions for lipid’ digestion.
4. Digestion of the TG, PL and CE.
5. Bile acids and saults. Biological significant of the bile acids.
6. Enterohepatic circulation of bile acids.
7. Mixed micelle formation.
8. Resynthesize of TG, PL and CE.
9. Structure of chylomicron. Metabolism of the chylomicrons.
10. Extracellular lipoprotein lipase (LPL).
11. Abnormalities in absorption of lipids.
12. Oxidation of even chain fatty acids in details. Regulation, biological significance, energetics.
13. Oxidation of glycerol in details. Regulation, biological significance, energetics.
14. Mechanism activation of hormone sensitive lipase.
15. Lipolysis in details. Biological significant.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 30 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work Action of the pancreatic phospholipases, Kinetics of pancreatic lipase | 70 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №2**

**Topic 2: ANABOLISM OF LIPIDS. METABOLISM OF KETONE BODIES**

**Type of study session** - training workshop

**Purpose:**

-to learn the synthesis of TAG, PL in the liver and adipose tissue;

- to learn the synthesis of fatty acids;

-to understand regulation of lipogenesis;

- to understand significance of ketone bodies;

-to obtain knowledge about metabolism of ketone bodies;

-to perform detection of ketone bodies in the urine.

Questions for lesson:

1. Synthesis of fatty acids. Transport of acetyl CoA to cytosol by malate- oxaloacetate shuttle system.
2. Biosynthesis of malonyl CoA. Regulation.
3. Characteristic of fatty acid synthase complex.
4. De novo synthesis of fatty acid in details.
5. Synthesis of TAGs and PLs in details.
6. Ketogenesis and degradation of ketone bodies.
7. Biological significance of ketone bodies.
8. Diabetic ketoacidosis.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work: Qualitative reactions on urinary ketone bodies (acetoacetate, acetone)  А) Reaction for iodoform formation (Liben probe, specific reaction)B) Sodium nitroprusside reaction (Legal’s probe, non-specific reaction) | 40 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №3**

**Topic 3: TRANSPORT OF LIPIDS BY BLOOD. METABOLISM OF CHOLESTEROL. PATHOLOGY OF LIPID METABOLISM**

**Type of study session** - training workshop

**Purpose:**

- to obtain knowledge about transport of lipids;

- to understand biological significance of cholesterol;

- to know cholesterol metabolism;

- to obtain knowledge concerning pathology of lipid metabolism- cholelithiasis and atherosclerosis;

***-*** to make quantitative determination of cholesterol in the serum***.***

Questions for lesson:

1. Transport of lipids by blood.
2. Chylomicrons, VLDL, LDL, HDL. Metabolism, structure, functions
3. Synthesis of cholesterol. Stages of synthesis.
4. Synthesis of mevalonic acid in details. Regulation.
5. Fate of cholesterol.
6. Formation of bile acids and bile salts. Regulation.
7. Cholelithiasis.
8. Atherosclerosis. Stages of formation.
9. Risk factors for atherosclerosis

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work «Quantitative determination of total serum cholesterol in the serum using an enzymatic method» | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №4**

**Topic 4: METABOLIC PATHWAY OF LIPIDS. FINAL CONTROL**

**Type of study session** - training workshop

**Purpose:**

- to obtain the knowledge about metabolic pathway of lipids

Questions for lesson:

1. Functions of the lipids in organism.
2. The staples abundant to triacylglycerols (TG), phospholipids (PL) and cholesterol esters (CE).
3. Stages of lipids metabolism. Conditions for lipid’ digestion.
4. Digestion of the TG, PL and CE.
5. Bile acids and saults. Biological significant of the bile acids *(see Appendix I*).
6. Enterohepatic circulation of bile acids (*see Appendix I)*.
7. Mixed micelle formation .
8. Resynthesize of TG, PL and CE.
9. Structure of chylomicron. Metabolism of the chylomicrons *(see Appendix I*).
10. Extracellular lipoprotein lipase.
11. Abnormalities in absorption of lipids.
12. Oxidation of even chain fatty acids in details. Regulation, biological significance, energetics.
13. Oxidation of glycerol in details. Regulation, biological significance, energetics.
14. Mechanism activation of hormone sensitive lipase.
15. Lipolysis in details. Biological significant.
16. Synthesis of fatty acids. Transport of acetyl CoA to cytosol by malate- oxaloacetate shuttle system.
17. Biosynthesis of malonyl CoA. Regulation.
18. Characteristic of fatty acid synthase complex.
19. De novo synthesis of fatty acid in details.
20. Synthesis of TGs and PLs in details.
21. Ketogenesis and degradation of ketone bodies.
22. Biological significance of ketone bodies.
23. Diabetic ketoacidosis.
24. Transport of lipids by blood.
25. Chylomicrons, VLDL, LDL, HDL. Metabolism, structure, functions.
26. Synthesis of cholesterol. Stages of synthesis.
27. Synthesis of mevalonic acid in details. Regulation.
28. Fate of cholesterol.
29. Formation of bile acids and bile salts. Regulation.
30. Cholelithiasis.
31. Atherosclerosis. Stages of formation.
32. Risk factors for atherosclerosis.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Test control | Method of testing control | 20 min |
| 3 | Verification of theoretical knowledge | Method of written control | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Method of decision of situational tasks | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, computer

**MODULE № 5. NITROGEN- CONTAINING BIOMOLECULES. METABOLIC PATHWAY OF AMINO ACIDS NUCLEOTIDE METABOLISM**

**Didactic unit № 1 «Metabolic pathway of amino acids»**

**Practical lesson №1**

**Topic 1: Digestion of protein**

**Type of study session** - training workshop

**Purpose:**

* to obtain knowledge about metabolic pathway of amino acid;
* to characterize the digestion of proteins;
* to obtain knowledge concerning using of amino acids;
* to characterize the process of putrefaction of non-absorbed amino acids;
* to learn the mechanisms of detoxification toxic products;

**Questions for lesson:**

1. Functions of the protein in organism.
2. Source of protein. Requirement in protein
3. Essential, non-essential, semi-essential amino acids.
4. Nitrogen balance.
5. Nutritional indices. Biological value of protein. Net protein utilization. Protein efficiency ratio. Chemical score.
6. General characteristics of proteases. Endopeptidases, exopeptidases.
7. Role HCl in digestion of protein.
8. Digestion in stomach, duodenum, small intestine. Specificity of enzymes.
9. Absorption of free amino acids.
10. Putrefaction of amino acids. Detoxification of toxic products.
11. Putrefaction of Tryptophan. Detoxification of indole.
12. Putrefaction of Tyrosine. Detoxification of phenol.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work«Determination of gastric juice pH»«Determination of gastric juice acidity»«Lactic acid reaction» | 40 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №2**

**Topic 2: General ways of amino acid catabolism**

**Type of study session** - training workshop

**Purpose:**

to understand common ways of conversion of amino acids;

to can explain conversion for α- amino group;

to can explain conversion for α- carboxyl group.

Questions for lesson:

1. Amino acid pool in the cell. Way use of amino acid in the organism.
2. Conversion of α- NH2 group, α- COOH group and carbon skeleton.
3. Transamination. Chemical reactions this process. Characteristics enzymes (transaminase). Cofactor role of vitamin B6.
4. Role of pyruvate, oxaloacetate, ketoglutarate in process of transamination. Collector function of ketoglutarate and glutamate. Biological significance of reactions transamination.
5. Biological significance of ALT and AST.
6. Deamination for D- and L- amino acids. Oxidative deamination of glutamic acid. Chemical reactions this process. Biological significance.
7. Transdeamination. Scheme. Biological significance.
8. Reactions decarboxylation of α- carboxyl group. General characteristic of biogenic amines.
9. Biosynthesis of GABA, serotonin, histamine, dopamine in details. Biological significance.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 40 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | «Laboratory workDetermination of alanine aminotransferase (ALT) activity» | 60 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №3**

**Topic 3: Ways of formation and disposal of ammonia in the organism.**

**Type of study session** - training workshop

**Purpose:**

* to learn mechanisms of conversion of α- amino group;
* to understand mechanism of toxic action of ammonia;
* to understand significance of urea cycle;

Questions for lesson:

1. Disposal of ammonia from tissues. Transport forms for ammonia.

2. Mechanism of toxic action of ammonia and detoxification of ammonia in the nervous tissue.

3. Local ammonia detoxification:

a) Reductive amination of ketoglutorate;

b) amidation of glutamate and aspartate;

c) Glucose- alanine cycle. Biological significance.

4. General ways of ammonia detoxification:

a) Ammoniogenesis in kidney. Biological significance.

b) Synthesis of urea. Ornithine cycle. Chemical reactions. Role aspartate in the process. The origin of atoms in urea.

5. Urea cycle. Regulation, biological significance, disorders of urea cycle. Connection of Urea cycle with Krebs cycle.

6. Violations of synthesis of urea. Hyperammonemia and its types

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work«Determination of urea in urine» | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №4**

**Topic 4: Specific metabolic pathways of amino acids and their violations.**

**Type of study session** - training workshop

**Purpose:**

to obtain knowledge about fates of carbon skeletons;

to know metabolism of essential amino acids (phenylalanine and methionine);

to understand biological significance of transmethylation reactions;

to obtain knowledge concerning creatine metabolism;

to know biosynthesis of carnitine, phosphotidylcholine, adrenaline.

Questions for lesson:

1. Transmethylation. The role of S-adenosylmethionine.

2. Metabolic fate of methionine. Biological significance of transmethylation reactions.

3. Synthesis of creatine. Biological significance of creatine phosphate.

4. Metabolic fate of phenylalanine. Phenylketonuria.

5. Metabolic fate of tyrosine. Biosynthesis of catecholamines. Parkinsonism.

6. Biosynthesis of melanin. Albinism.

7. Catabolism of tyrosine in liver. Alcaptonuria.

8. Biosynthesis of carnitine, phosphotidylcholine, adrenaline.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 70 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work«Determination of creatinine in the urine» | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №5**

**Topic 5: Metabolic pathway of amino acids final control » Module**

**Type of study session** - training workshop

**Purpose:**

to obtain the knowledge about metabolic pathway of amino acids.

Questions for lesson:

1. Functions of the protein in organism. Source of protein. Requirement in protein. Essential, non-essential, semi-essential amino acids.
2. Nitrogen balance. Nutritional indices. Biological value of protein. Net protein utilization. Protein efficiency ratio. Chemical score.
3. General characteristics of proteases. Endopeptidases, exopeptidases.
4. Digestion in stomach. Specificity of enzymes. Role HCl in digestion of protein.
5. Digestion in duodenum. Specificity of enzymes.
6. Digestion in small intestine. Specificity of enzymes.
7. Absorption of free amino acids.
8. Putrefaction of Tryptophan. Detoxification of indole.
9. Putrefaction of Tyrosine. Detoxification of phenol.
10. Amino acid pool in the cell. Way use of amino acid in the organism. Conversion of α- NH2 group, α- COOH group and carbon skeleton.
11. Transamination. Chemical reactions this process. Characteristics enzymes (transaminase). Cofactor role of vitamin B6.
12. Role of pyruvate, oxaloacetate, ketoglutarate in process of transamination. Collector function of ketoglutarate and glutamate. Biological significance of reactions transamination.
13. Biological significance of ALT and AST.
14. Deamination for D- and L- amino acids. Oxidative deamination of glutamic acid. Chemical reactions this process. Biological significance.
15. Transdeamination. Scheme. Biological significance.
16. Reactions decarboxylation of α- carboxyl group. General characteristic of biogenic amines.
17. Biosynthesis of GABA, serotonin, histamine, dopamine in details. Biological significance.
18. Disposal of ammonia from tissues. Transport forms for ammonia. Mechanism of toxic action of ammonia and detoxification of ammonia in the nervous tissue.
19. Local ammonia detoxification. Reductive amination of ketoglutorate.
20. Local ammonia detoxification. Amidation of glutamate and aspartate.
21. Local ammonia detoxification. Glucose- alanine cycle. Biological significance.
22. General ways of ammonia detoxification. Ammoniogenesis in kidney. Biological significance.
23. General ways of ammonia detoxification. Synthesis of urea. Ornithine cycle. Chemical reactions. Role aspartate in the process. The origin of atoms in urea.
24. Urea cycle. Regulation, biological significance, disorders of urea cycle. Connection of Urea cycle with Krebs cycle.
25. Violations of synthesis of urea. Hyperammonemia and its types
26. Transmethylation. The role of S-adenosylmethionine.
27. Metabolic fate of phenylalanine. Phenylketonuria.
28. Metabolic fate of tyrosine. Biosynthesis of catecholamines. Parkinsonism.
29. Biosynthesis of melanin. Albinism.
30. Catabolism of tyrosine in liver. Alcaptonuria.
31. Metabolic fate of methionine. Biological significance of transmethylation reactions.
32. Biosynthesis of carnitine, phosphotidylcholine, adrenaline.
33. Synthesis of creatine. Biological significance of creatine phosphate.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Test control | Method of testing control | 20 min |
| 3 | Verification of theoretical knowledge | Method of written control | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students). | Method of decision of situational tasks | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board, computer

**Didactic unit № 2 «** **Metabolism of nucleotides»**

**Practical lesson №6**

**Topic 6: Metabolic pathway of nucleotides catabolism and anabolism**

**Type of study session** - training workshop

**Purpose:**

to obtain knowledge about metabolic pathway of nucleotides;

to know degradation of purine and pyrimidine nucleotides;

to understand mechanisms formation of gout and Lesch- Nyhan syndrome.

Questions for lesson:

1. Intake and digestion nucleorotheids in the gastrointestinal tract.

2. Absorption of nucleorotheids.

3. Degradation of purine nucleotides.

4. Gout, symptoms, treatment.

5. Degradation of pyrimidine nucleotides.

6. Biosynthesis de novo purine nucleotides. Regulation.

7. Biosynthesis de novo pyrimidine nucleotides. Regulation.

8. Synthesis of deoxyribonucleotides. Regulation.

9. Lesch- Nyhan syndrome, symptoms.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 100 min |
| 4 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board

**Practical lesson №7**

**Topic 7: Matrix biosynthesis. Biosynthesis of DNA and RNA**

**Type of study session** - training workshop

**Purpose:**

to knowstructure of nucleic acid and their biological role. Types RNA.

to obtain knowledge about replication, transcription.

to understand processing of mRNA.

Questions for lesson:

1. Structure of nucleic acid and their biological role. Types RNA.

2. Types of genetic information transfer.

3. Replication of DNA (initiation, elongation, termination). Сonditions, enzymes.

4. Transcription (initiation, elongation, termination). Сonditions, enzymes.

5. Processing of mRNA.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 100 min |
| 4 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board

**Practical lesson №8**

**Topic 8: Biosynthesis of protein and its regulation**

**Type of study session** - training workshop

**Purpose:**

to obtain knowledge about translation;

to know posttranslational processing. Chaperones;

to understand regulation of biosynthesis of protein on transcription’s level.

Questions for lesson:

1. Stage of biosynthesis of protein (translation):

a. Cytosol stage:

- activation of amino acids, formation of aminoacyl-tRNA, specificity of ARS-ase enzymes;

- characteristics tRNA, mRNA, rRNA;

- modern ideas about the structure ribosome.

b. Ribosomal stage:

- Initiation;

- Elongation;

- Termination.

2. Posttranslational processing. Chaperones.

3. Regulation of biosynthesis of protein on transcription’s level.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 100 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic – incoming control options

- logistical chalk, board

**MODULE № 6 METABOLISM REGULATION. HORMONES**

**Practical lesson №1**

**Topic 1: Mechanisms actions of hormones. Adrenaline. Glucagone. Insulin.**

**Type of study session** - training workshop

**Purpose:**

**-** to know the definition of hormones, their classification, general properties, mechanisms of action

-to know the metabolic effect of hormones: adrenaline, insulin, glucagon.

Questions for lesson

1. Terminology and classification of hormones by the site of synthesis, chemical structure.

2. Peculiarities of hormones biological action.

3. Concept ―hormone receptor― Classification and structure of receptors: intracellular receptors, receptors of a plasma membrane.

4. Mechanisms of amino acid-derived, protein-peptide hormones action. The role of G-proteins, secondary messengers (cyclic nucleotides, IP3, Са2+, diacylglycerol), proteinkinases.

5. Hormones of the adrenal medulla: chemical structure, precursor, type of receptor in target-tissue, realization of epinephrine and norepinephrine effect at a cellular level. Pheochromocytoma.

6. Insulin and glucagon: chemical structure, insulin synthesis, types of receptors in target-tissues for glucagon and insulin, realization of pancreatic hormone effect at a cellular level. Effects on carbohydrate, lipid, protein metabolism.

7. Diabetes mellitus. Types, causes. Disorders of carbohydrate, lipid, protein metabolism. Biochemical diagnosis of diabetes. Construction of sugar curves.

8. Diabetes mellitus: mechanism of ketonemia. Glucose metabolism in insulin-independent tissues.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 55 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory workInsulin color reactionsQualitative reaction to adrenaline with ferric chloride | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №2**

**Topic 2: Thyroid hormones. Glucocorticoid hormones.**

**Type of study session** - training workshop

**Purpose:**

**-**to know of the chemical structure, metabolic effects of corticosteroid hormones;

-to disassemble the mechanisms of biosynthesis and the influence on the metabolism of thyroid hormones;

-to form an understanding of the structure and effect on the metabolism of sex hormones

Questions for lesson

1. Iodine-containing thyroid hormones. The chemical nature, the synthesis of T3 and T4.

2. Mechanism of signal transduction, effects on metabolism.

3. Hypo- and hyperthyroidism.

4. Hormones of the adrenal cortex: glucocorticoids and mineralocorticoids. The chemical nature, structure of receptors.

5.Mechanism of signal transduction, effects on metabolism.

6.Cushing’s syndrome, Addison’s disease (―Bronze disease‖).

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 40 min |
| 4 | Training conference | 1. Female sex hormones. Chemical nature, mechanism of action, effect on metabolism.2. Male sex hormones. Chemical nature, mechanism of action, effect on metabolism. | 60 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board

**Practical lesson №3**

**Topic 3: Water and mineral metabolism**

**Type of study session** - training workshop

**Purpose:**

**-**to know the biological role of water and minerals in the human body;

-to form an idea of the modern mechanisms of regulation of water-mineral metabolism;

-to know the manifestations of certain disorders of the synthesis and secretion of hormones regulating the exchange of calcium and phosphorus;

- to perform detection of serum calcium.

Questions for lesson

1. The norms of water requierement and excretion. The content and the role of water in the body.

2. Sodium, potassium. The role in metabolism.

2. Hormonal regulation of salt and water balance: Renin-angiotensin system, the role of aldosterone, vasopressin, atrial natriuretic factor.

3. Vasopressin, chemical nature, hormonal signal transduction mechanism, effects. Diabetes insipidus.

4. The renin-angiotensin system and its role in the regulation of water-mineral metabolism.

5. Calcium and phosphorus. Daily requirement, food sources, role in metabolism, metabolic disorders. Hormonal regulation of calcium and phosphorus metabolism.

6. Hormones regulating calcium and phosphorus metabolism: parathyroid hormone (PTH); calcitriol; calcitonin (CТ). Chemical nature, mechanism of signal transduction in target-cells, biological action.

7. The role of iron in the organism (absorption, transport, intracellular metabolism). Iron deficiency states and iron-deficient anemias.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 55 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory workDetermination of serum calcium | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №4**

**Topic 4: Metabolism regulation. Hormones. Final control**

**Type of study session** - training workshop

**Purpose:**

**-** check students' knowledge in the section "regulation of metabolism. Hormones"

Questions for lesson:

1. Terminology and classification of hormones by the site of synthesis, chemical structure.

2. Peculiarities of hormones biological action.

3. Concept ―hormone receptor― Classification and structure of receptors: intracellular receptors, receptors of a plasma membrane.

4. Mechanisms of amino acid-derived, protein-peptide hormones action. The role of G-proteins, secondary messengers (cyclic nucleotides, IP3, Са2+, diacylglycerol), proteinkinases.

5. Hormones of the adrenal medulla: chemical structure, precursor, type of receptor in target-tissue, realization of epinephrine and norepinephrine effect at a cellular level. Pheochromocytoma.

6. Insulin and glucagon: chemical structure, insulin synthesis, types of receptors in target-tissues for glucagon and insulin, realization of pancreatic hormone effect at a cellular level. Effects on carbohydrate, lipid, protein metabolism.

7. Diabetes mellitus. Types, causes. Disorders of carbohydrate, lipid, protein metabolism. Biochemical diagnosis of diabetes. Construction of sugar curves.

8. Diabetes mellitus: mechanism of ketonemia. Glucose metabolism in insulin-independent tissues.

9. Iodine-containing thyroid hormones. The chemical nature, the synthesis of T3 and T4.

10. Mechanism of signal transduction, effects on metabolism.

11. Hypo- and hyperthyroidism.

12. Hormones of the adrenal cortex: glucocorticoids and mineralocorticoids. The chemical nature, structure of receptors.

13.Mechanism of signal transduction, effects on metabolism.

14.Cushing’s syndrome, Addison’s disease (―Bronze disease‖).

15. The norms of water requierement and excretion. The content and the role of water in the body.

16. Sodium, potassium. The role in metabolism.

17. Hormonal regulation of salt and water balance: Renin-angiotensin system, the role of aldosterone, vasopressin, atrial natriuretic factor.

18. Vasopressin, chemical nature, hormonal signal transduction mechanism, effects. Diabetes insipidus.

19. The renin-angiotensin system and its role in the regulation of water-mineral metabolism.

20. Calcium and phosphorus. Daily requirement, food sources, role in metabolism, metabolic disorders. Hormonal regulation of calcium and phosphorus metabolism.

21. Hormones regulating calcium and phosphorus metabolism: parathyroid hormone (PTH); calcitriol; calcitonin (CТ). Chemical nature, mechanism of signal transduction in target-cells, biological action.

22. The role of iron in the organism (absorption, transport, intracellular metabolism). Iron deficiency states and iron-deficient anemias.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Test control | Method of testing control | 20 min |
| 3 | Verification of theoretical knowledge | Method of written control | 60 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Method of decision of situational tasks | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, computer

**MODULE № 6 BIOCHEMISTRY OF ORGANS AND TISSUES**

**Practical lesson №1**

**Topic 1: PHYSICAL AND CHEMICAL PROPERTIES OF THE BLOOD.**

**Type of study session** - training workshop

**Purpose:**

* to study physical and chemical properties of the blood, to consolidate knowledge of the origin of plasma components and their physiological concentrations, buffer blood systems

Questions for lesson

1. Chemical composition of plasma (physiological concentrations of the most important plasma components and their origin).
2. The most important blood buffer systems: bicarbonate, hemoglobin, phosphate, protein (components and their proportion, mechanism of action, capacity). The notion of acid-base disturbances (acidosis, alkalosis).
3. Blood plasma proteins. Main protein fractions: albumins, globulins, fibrinogen (content, functions); albumin-globulin ratio and its diagnostic value.
4. Blood plasma enzymes (secretory, indicator, excretory). Diagnostic value of plasma enzymes activity determination.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 55 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory work:Determination of nonprotein blood nitrogen | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №2**

**Topic 2: Features of erythrocyte metabolism. Synthesis and decomposition of hemoglobin. Jaundices.**

**Type of study session** - training workshop

**Purpose:**

**-** to know the structure and functioning of hemoglobin and diagnostic significance of the most important biochemical blood components.

- to study the types of jaundice and their diagnosis

Questions for lesson

1. Features of erythrocyte metabolism. Structure and properties of hemoglobin.

2. Functions of hemoglobin. Derivatives of hemoglobin: oxyhemoglobin, carboxyhemoglobin, methemoglobin, carbenecillin, cyanmethemoglobin. Hemoglobin buffer.

3. Types of hemoglobin in humans: fetal hemoglobin (HbP), fetal (HbF), adult hemoglobin (HbA1, HbA2). Variations of the primary structure and properties of hemoglobin.

4. Pathological forms of hemoglobins. Hemoglobinopathies (HbS), thalassemia (HbH).

5. Hemoglobin exchange. The synthesis of hemoglobin. Disorders of hemoglobin synthesis: the porphyrias.

 6. Intracellular decomposition of hemoglobin in tissues: direct and indirect bilirubin, structure and properties.

7. Disorders in the metabolism of bilirubin: jaundice (hemolytic, hepatocellular, obstructive).

8. Diagnostic value of bilirubin determination in blood serum and urine. Urobilinogen and its diagnostic value.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min10 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 55 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory workHemoglobin determination in blood by hemoglobin-cyanide method | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 15 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №3**

**Topic 3: BIOCHEMISTRY OF THE URINE. PHYSIOLOGICAL AND PATHOLOGICAL COMPONENTS OF THE URINE**

**Type of study session** - training workshop

**Purpose:**

**-** to know how to use knowledge of physiological and pathological components of the urine to solve questions of diagnosis, prevention and prognosis of diseases associated with renal and extrarenal pathology.

Questions for lesson

1. Normal characteristics of urine volume, density, color, transparency, pH.

2. Inorganic and organic components of the urine.

3. Diagnostic significance of the urine pathologic components and their determination:

a) Renal and extrarenal proteinuria;

b) Glucosuria in diabetes mellitus, renal glucosuria;

c) Renal and extrarenal hematuria;

d) Ketonuria in fasting, diabetes.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

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| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min5 min5 min |
| 2 | Incoming control of students' knowledge and skills (if provided; the forms and methods of input control are listed). | Method of written control | 10 min |
| 3 | Theoretical analysis of the material | Individual survey | 15 min |
| 4 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Laboratory workDetermination of urine density, Determination of urine acidity, Determination of urine acidity, Qualitative determination of organic urine components: protein, glucose, ketone bodys | 30 min |
| 5 | The final part of the lesson:Summary, conclusions on the topic.Quality control of the formed competences (their elements) of students on the subject of the lesson (if provided, lists the forms and methods for testing the knowledge and skills of students).Homework (if provided). | Verification of laboratory work protocols, summarizing classes | 30 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, reagents, laboratory glassware

**Practical lesson №4**

**Topic 4: Final lesson. Test control on the biochemistry of organs and tissues**

**Type of study session** - training workshop

**Purpose:**

- assess students ' knowledge of organ and tissue biochemistry

Questions for lesson

1. Chemical composition of plasma (physiological concentrations of the most important plasma components and their origin).
2. The most important blood buffer systems: bicarbonate, hemoglobin, phosphate, protein (components and their proportion, mechanism of action, capacity). The notion of acid-base disturbances (acidosis, alkalosis).
3. Blood plasma proteins. Main protein fractions: albumins, globulins, fibrinogen (content, functions); albumin-globulin ratio and its diagnostic value.
4. Blood plasma enzymes (secretory, indicator, excretory). Diagnostic value of plasma enzymes activity determination.
5. Features of erythrocyte metabolism. Structure and properties of hemoglobin.
6. Functions of hemoglobin. Derivatives of hemoglobin: oxyhemoglobin, carboxyhemoglobin, methemoglobin, carbenecillin, cyanmethemoglobin. Hemoglobin buffer.
7. Types of hemoglobin in humans: fetal hemoglobin (HbP), fetal (HbF), adult hemoglobin (HbA1, HbA2). Variations of the primary structure and properties of hemoglobin.
8. Pathological forms of hemoglobins. Hemoglobinopathies (HbS), thalassemia (HbH).
9. Hemoglobin exchange. The synthesis of hemoglobin. Disorders of hemoglobin synthesis: the porphyrias.
10. Intracellular decomposition of hemoglobin in tissues: direct and indirect bilirubin, structure and properties.
11. Disorders in the metabolism of bilirubin: jaundice (hemolytic, hepatocellular, obstructive).
12. Diagnostic value of bilirubin determination in blood serum and urine. Urobilinogen and its diagnostic value.
13. Normal characteristics of urine volume, density, color, transparency, pH.
14. Inorganic and organic components of the urine.
15. Diagnostic significance of the urine pathologic components and their determination:

a) Renal and extrarenal proteinuria;

b) Glucosuria in diabetes mellitus, renal glucosuria;

c) Renal and extrarenal hematuria;

d) Ketonuria in fasting, diabetes.

**Lesson plan**

*(based on the type and structure of the lesson, its goals and objectives; therefore, the stages, content and time frame may vary)*

|  |  |  |  |
| --- | --- | --- | --- |
| № | Stages and content of the lesson | Used methods (including interactive) | Time |
| 11.11.21.3 | Organizing time.Announcement of the topic, purpose of the lesson.Assessment of the readiness of the audience, equipment and students.Brief description of the stages and content of the work of students in the classroom. | 1. Clarification of issues of attendance, discipline.1.1. Conversation - message: the topic of the lesson, the purpose of the lesson, the importance and relevance of the topic.1.2 Discussions of students' incomprehensible questions1.3 Conversation - briefing: indicate the lesson plan, the significance of the lesson for mastering biological chemistry | 5 min5 min5 min5 min |
| 2 | Test control | Method of testing control | 60 min |
| 3 | Practicing practical skills (including independent work of students; types of practical tasks and exercises, types of independent work of students).  | Method of decision of situational tasks | 55 min |

Means of education:

- didactic - incoming control options

- logistical chalk, board, computer