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**MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA**

**Federal State Budgetary Educational Institution  
of higher education**

**«I.N. Ulianov Chuvash State University»  
(FSBEI of HE «I.N. Ulianov Chuvash State University»)**

Medical Faculty

Department of Pharmacology, Clinical Pharmacology and Biochemistry

«APPROVE»

Vice-rector for Academic Affairs

  
I.E. Poverinov

« 13 » 04 2022

**Working programs of the discipline (module)  
«Биохимия / Biochemistry»**

Direction of training / specialty 31.05.03 Стоматология / Dentistry  
Graduate's qualification Врач-стоматолог / Dental Practitioner

Direction (profile) / specialization «Dentistry»

Form of training – очная / intramural

Course – 2

Term – 3, 4

Total academic hours/credit points – 216/6

The year of beginning the training – 2022

The fundamental document for compiling the working program of the discipline (module)  
Федеральный государственный образовательный стандарт высшего образования -  
специалитет по специальности 31.05.03 Стоматология (приказ Минобрнауки России от  
12.08.2020 г. № 984)

Approved by:  
Senior Lecturer N.N. Viktorovich

The working program was approved at the meeting of the Department of Pharmacology,  
Clinical Pharmacology and Biochemistry,  
24.03.2022, protocol № 8  
Head of the department S.I. Pavlova

Approved by  
Dean of the Medical Faculty V.N. Diomidova  
Acting Head of the Educational and Methodological Department E.A. Shirmanova

## **1. The purpose and objectives of training in the discipline (module)**

The purpose of the discipline - to study the chemical composition and properties of substances that make up living systems, their interconversions in the process of metabolism, as well as the role of metabolic processes in the functioning of various organs and tissues in normal and pathological conditions.

The objectives of the discipline - 1) to familiarize students with the structure and function of the most important biological substances of the human body

2) to teach students to master the metabolic processes occurring in cells

3) to acquaint with the possible causes and consequences of violations of metabolic reactions in the body

4) to teach biochemical methods for diagnosing diseases and monitoring the state of human health

## **2. The place of practical training in the structure of the educational program of higher education**

The discipline «Биохимия / Biochemistry» относится к обязательной части учебного плана refers to the mandatory part in the curriculum of the educational program of higher education (hereinafter referred to as the EP of HE) in the field of training / specialty 31.05.03 Стоматология, direction (profile) / specialization of the program «Dentistry».

Previous academic disciplines (modules) and (or) practices that form the knowledge, skills and abilities necessary for training in the discipline (module):

Молекулярная биология / Molecular Biology

Анатомия / Anatomy

Биология / Biology

Химия / Chemistry

Медицинская физика / Medical Physics

Учебная практика (ознакомительная практика) / Educational practical training (introductory practical training)

История и культура Чувашии / History and culture of Chuvashia

История (история России, всеобщая история) / History (history of Russia, General History)

Русский язык и деловые коммуникации / The Russian Language and Business Communications

Knowledge, skills and abilities formed as a result of training in a discipline (module) are necessary when teaching in the following disciplines (modules) and (or) practices:

Производственная практика (практика общеврачебного профиля) / On-the-job training (general medical practice)

Производственная практика (поликлиническая практика) / On-the-job training (outpatient practice)

Подготовка к сдаче и сдача государственного экзамена / Preparation for passing and passing the state exam

Инфекционные болезни, эпидемиология / Infectious Diseases, Epidemiology

Медицинская генетика / Medical Genetics

Патофизиология / Pathophysiology

Клиническая иммунология и аллергология / Clinical Immunology and Allergology

Топографическая анатомия и оперативная хирургия / Topographic Anatomy and Operative Surgery

Фтизиатрия / Phthisiology

Функциональная диагностика / Functional Diagnostics

Производственная практика (клиническая практика, помощник врача амбулаторно-поликлинического учреждения) / On-the-job training (clinical practice, assistant to an outpatient-polyclinic doctor)

**3. Planned learning outcomes in the discipline (module), correlated with the planned learning outcomes**

Planned learning outcomes in the discipline (module), correlated with the planned learning outcomes

Code and name of the competence	Code and name of the competence achievement	Descriptors for the indicator of competence achievement (learning)
ОПК-8 Способен использовать основные физико-химические, математические и естественнонаучные понятия и методы при решении профессиональных задач / He/she is able to use the basic physical-chemical, mathematical and natural science concepts and methods in solving professional problems	ОПК-8.1 Владеет знаниями об основных физико-химических, математических и естественнонаучных понятиях и методах / He/she is aware of the basic physical-chemical, mathematical and natural science concepts and methods	A list of laboratory and instrumental research methods for assessing the patient's condition, the main medical indications for conducting research and interpreting the results. Basics of general and medical human biochemistry; as natural chemical reactions in cells (metabolism) and in the body as a whole (poison exchange); Identify clinical signs of conditions requiring urgent medical care. Interpret clinical analysis data to make a diagnosis of the disease; studies of selective optimal biochemical and other methods for assessing the patient's condition; Master the methods of laboratory and instrumental studies to assess the patient's condition. Modern biochemical research methods;
ОПК-8 Способен использовать основные физико-химические, математические и естественнонаучные понятия и методы при решении профессиональных задач / He/she is able to use the basic physical-chemical, mathematical and natural science concepts and methods in solving professional problems	ОПК-8.2 Способен анализировать процессы описываемые основными физико-химическими, математическими и естественнонаучными понятиями и методами / He/she is able to analyze the processes described by the basic physicochemical, mathematical and natural science concepts and methods	spatial organization, regulation and provision of energy to cells and at the molecular level in the norm and changes that occur in pathology; evaluate the significance of biochemical research methods; skills of taking biological material for biochemical research;
ОПК-8 Способен использовать основные	ОПК-8.3 Способен принимать решения на	ways to correct changes in metabolism in pathology.

физико-химические, математические и естественнонаучные понятия и методы при решении профессиональных задач / He/she is able to use the basic physical-chemical, mathematical and natural science concepts and methods in solving professional problems	основе физико-химических, математических и естественнонаучных понятиях и методах / He/she is able to make decisions based on physicochemical, mathematical and natural science concepts and methods	competently formulate and plan research tasks in theoretical and practical biochemistry. information about the functioning and regulation of basic human biochemical processes.
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#### 4. Structure, scope and content of the discipline (module)

Educational activities in the discipline (module) are carried out:

- in the form of students' face-to-face work with the teaching staff of the organization and (or) persons involved by the organization to implement the educational programs on other terms (hereinafter - contact work);

- in the form of students' independent work.

Face-to-face work can be classroom-based, extramural, as well as it can be conducted in an electronic information and educational environment (EIEE).

Learning sessions in the discipline (module) and interim assessment of students are conducted in the form of face-to-face work and in the form of students' independent work.

During learning sessions in the discipline (module) face-to-face work includes: lecture-type classes, seminar-type classes and (or) group consultations, and (or) individual work of students with the teaching staff of the organization and (or) persons involved by the organization to implement the educational programs on other terms (including individual consultations).

Legend:

Lec – lectures, Lab – laboratory work, Pr – practical classes, ICW – individual face-to-face work, IW – independent work.

#### 4.1. Content of the discipline (module)

Section name	The section's content	Formed competences	Competence achievement indicator
Structure and function of amino acids, peptides, proteins and nucleic acids.	Introduction. Safety precautions when working in biochemical laboratories. Proteinogenic amino acids.		
	Physico-chemical properties of amino acids, peptides, simple and complex proteins.		
	Physico-chemical properties of DNA and RNA.		
Structure and function of enzymes and vitamins.	Chemical nature of enzymes, active center,		

	regulation.		
Structure and function of enzymes and vitamins.	Classification of enzymes.		
	Витамины: жирорастворимые и водорастворимые.		
Bioenergetics. Metabolism of carbohydrates.	Energy exchange.		
	Metabolic pathways of carbohydrate metabolism.		
	The exchange of carbohydrates. Regulation and pathology of carbohydrates.		
Biomembranes. lipid metabolism.	Classification of lipids. Metabolic pathways of lipid metabolism.		
	lipid metabolism. regulation of lipid metabolism.		
	Structure and functions of biological membranes. Pathology of lipid metabolism.		
Exchange of simple and complex proteins.	Exchange of simple proteins. Nitrogen exchange.		
	Metabolism of amino acids, ornithine cycle.		
	Metabolism of complex proteins.		
Features of the exchange of individual tissues of organs.	Biochemistry of blood, kidney and urine formation.		
	Biochemistry of teeth.		
	Biochemistry of hormones.		
Individual contact work	Individual contact work.		

#### 4.2. Scope of the discipline and types of academic work

Forms of control and types of academic work	Labor intensity of the discipline (module)		
	3	4	total

1. Face-to-face work:	48	48,3	96,3	
In-class learning in total, including:	48	48	96	
Лекционные занятия (Лек)	16	16	32	
Лабораторные занятия (Лаб)	32	32	64	
Индивидуальная контактная работа (ИКР)		0,3	0,3	
2. Independent work of the student:	60	23,7	83,7	
3. Intermediate certification (exam) (экзамен)		Эк		
Total:	academic hours	108	108	216
	credit units	3	3	6

№ item	The section's (theme's) name	Face-to face work, including in the electronic information and educational environment, academic hours				IW, academic hours	Total, academic hours
		Lect.	Pr.	Lab.	ICW		
	Structure and function of amino acids, peptides, proteins and nucleic acids.						
1	Introduction. Safety precautions when working in biochemical laboratories. Proteinogenic amino acids.	1		2		8	11
2	Physico-chemical properties of amino acids, peptides, simple and complex proteins.	2		4		8	14
3	Physico-chemical properties of DNA and RNA.	2		4		10	16
	Structure and function of enzymes and vitamins.						
4	Chemical nature of enzymes, active center, regulation.	2,2		4		8	14,2
5	Classification of enzymes.	1		4		8	13
6	Витамины: жирорастворимые и водорастворимые.	2		2		8	12
	Bioenergetics. Metabolism of carbohydrates.						
7	Energy exchange.	2		4		4	10
8	Metabolic pathways of carbohydrate metabolism.	1,8		4		4	9,8

9	The exchange of carbohydrates. Regulation and pathology of carbohydrates.	2		4		2	8
	Biomembranes. lipid metabolism.						
10	Classification of lipids. Metabolic pathways of lipid metabolism.	2		2		1	5
11	lipid metabolism. regulation of lipid metabolism.	2		2		1	5
12	Structure and functions of biological membranes. Pathology of lipid metabolism.	2		5		2	9
	Exchange of simple and complex proteins.						
13	Exchange of simple proteins. Nitrogen exchange.	2		6		4	12
14	Metabolism of amino acids, ornithine cycle.	2		2		2	6
15	Metabolism of complex proteins.	2		6		3,7	11,7
	Features of the exchange of individual tissues of organs.						
16	Biochemistry of blood, kidney and urine formation.	2		2		8	12
17	Biochemistry of teeth.	1		2		1	4
18	Biochemistry of hormones.	1		5		1	7
	Individual contact work						
19	Individual contact work.				0,3		0,3
Total academic hours		32		64	0,3	83,7	216

#### 4.3. Summary of the discipline (module), structured by sections (topics)

### Раздел 1. Structure and function of amino acids, peptides, proteins and nucleic acids.

#### Тема 1. Introduction. Safety precautions when working in biochemical laboratories.

##### Proteinogenic amino acids.

Лекционное занятие.

Introduction. The place of biochemistry among other biological disciplines. Physico-chemical methods used in biochemical research. Structure, function and classification of proteinogenic amino acids.

Лабораторное занятие. Lab session 1.

Safety rules for working in a biochemical laboratory. Amino acids: classification, structure, properties and functions. Chemical modification of amino acid radicals. Qualitative reactions to amino acids and proteins.

#### Тема 2. Physico-chemical properties of amino acids, peptides, simple and complex proteins.

Лекционное занятие. Lecture 2

Proteins: classification, structure and functions. Biologically active peptides:

structure and function. Levels of structural organization of proteins: primary, secondary, tertiary, quaternary. Simple proteins: albumins, histones, protamines. Complex proteins: chromoproteins, glycoproteins, lipoproteins.

Лабораторное занятие. Laboratory lesson 2.3.

Properties of biologically active peptides: glutathione, vasopressin, oxytocin. Levels of structural organization of proteins. Quaternary structure of proteins on the example of hemoglobin. Classification of proteins.

### **Тема 3. Physico-chemical properties of DNA and RNA.**

Лекционное занятие. Lecture 3

Structure and function of nitrogenous bases and nucleotides. Nucleoside triphosphates and their participation in energy metabolism, formation of active forms, coenzymes, second messengers. Types of nucleic acids: DNA and RNA. Features of their structural organization.

Лабораторное занятие. Lecture 3

Structure and function of nitrogenous bases and nucleotides. Nucleoside triphosphates and their participation in energy metabolism, formation of active forms, coenzymes, second messengers. Types of nucleic acids: DNA and RNA. Features of their structural organization.

## **Раздел 2. Structure and function of enzymes and vitamins.**

### **Тема 4. Chemical nature of enzymes, active center, regulation.**

Лекционное занятие. Лекция 4.

Ферменты. Особенности ферментативного катализа. Специфичность действия ферментов (абсолютная, стереохимическая, групповая). Зависимость скорости ферментативных реакций от температуры, pH, концентраций фермента и субстрата. Простые и сложные ферменты. Регуляция активности ферментов: изостерические и аллостерические модификаторы.

Лабораторное занятие. Лабораторное занятие 6.

Структура, физико-химические свойства ферментов. Кинетика ферментативных реакций. Коферменты, кофакторы и простетические группы ферментов и их роль. Методы определения активности ферментов.

### **Тема 5. Classification of enzymes.**

Лекционное занятие. Lecture 5

Classification of enzymes: types and examples of catalyzed reactions. organ-specific enzymes. localization of enzymes. The use of enzymes in medicine. Enzymodiagnosics, enzyme therapy, enzymopathology.

Лабораторное занятие. Лабораторное занятие 7,8.

Классификация ферментов: оксидоредуктазы, трансферазы, гидролазы, лиазы, изомеразы, лигазы. Примеры ферментативных реакций.

### **Тема 6. Витамины: жирорастворимые и водорастворимые.**

Лекционное занятие. Лекция 6.

Витамины: классификация, структура, образование активных форм и участие их в биохимических реакциях. Коферментные формы витаминов. Авитаминозы, гиповитаминозы, гипертитаминозы. Использование витаминов в медицине.

Лабораторное занятие. Лабораторное занятие 9,10.

Общие представления о витаминах. Структуры и биологическая роль водо- и жирорастворимых витаминов. Антивитамины и витаминоподобные соединения.

## **Раздел 3. Bioenergetics. Metabolism of carbohydrates.**

### **Тема 7. Energy exchange.**

Лекционное занятие. Lecture 6.7.

Metabolism: catabolism and anabolism. Metabolic pathways: central, secondary, cyclic, helical, amphibolic and anaplerotic. Regulation, localization, interaction, energy supply of metabolism. Redox reactions. Cellular bioenergetics. Krebs cycle: localization, function, regulation.

Лабораторное занятие. Laboratory lesson 11.12.

Energy exchange. Metabolism. Central, secondary, spiral, amphibolic, anaplerotic metabolic pathways. Cellular respiration (electron transport chain). Tricarboxylic acid cycle: localization, enzymatic provision, regulation.

#### **Тема 8. Metabolic pathways of carbohydrate metabolism.**

Лекционное занятие. Lecture 7

Carbohydrates: classification, structure and function. Digestion of carbohydrates in the gastrointestinal tract and the processes of absorption of monosaccharides. Pancreatic amylase: activation and its role in the breakdown of carbohydrates. Complete oxidation of glucose. Anaerobic oxidation of glucose. Glycogenesis and glycogenolysis: enzyme provision, regulation.

Лабораторное занятие. Laboratory lesson 13.14.

Structure, classification and functions of carbohydrates. Digestion of carbohydrates in the gastrointestinal tract and the processes of absorption of monosaccharides. Gluconeogenesis from amino acids, pyruvic acid, lactic acid and glycerol. Metabolism of glucose, fructose, galactose.

#### **Тема 9. The exchange of carbohydrates. Regulation and pathology of carbohydrates.**

Лекционное занятие. Лекция 8.

Регуляция углеводного обмена: метаболический контроль, нейрогуморальная. Механизм действия адреналина и глюкагона на гликогенфосфоорилазу. Связь углеводного обмена с обменом других соединений. Патология углеводного обмена: наследственная и приобретенная. Биохимия сахарного диабета. Изменения в углеводном обмене при сахарном диабете.

Лабораторное занятие. Лабораторное занятие 15,16.

Пентозофосфатный путь: локализация, функция, регуляция. Синтез уоновых кислот: локализация, функция, регуляция. Патология углеводного обмена (наследственные заболевания и приобретенные). Роль печени в обмене углеводов.

#### **Раздел 4. Biomembranes. lipid metabolism.**

#### **Тема 10. Classification of lipids. Metabolic pathways of lipid metabolism.**

Лекционное занятие. Lecture 9

Lipids: classification, structure and function. Digestion and absorption of lipids in the gastrointestinal tract (GIT). Bile acids, structure of paired bile acids, properties and their role in lipid digestion. Fatty acid oxidation: activation in the cytoplasm, transport to mitochondria, and beta-oxidation to mitochondria. Energy balance of complete oxidation of fatty acids. Transport forms of lipids: VLDL, LDL, HDL and chylomicrons.

Лабораторное занятие. Laboratory lesson 17,18

Structure, classification and functions of lipids. Digestion of lipids in the gastrointestinal tract and processes of absorption of decay products. Lipolysis of triglycerides. Oxidation of saturated fatty acids with an even number of carbon atoms: (for example, the oxidation of palmitate).

#### **Тема 11. lipid metabolism. regulation of lipid metabolism.**

Лекционное занятие. Lecture 10

Biosynthesis of fatty acids: localization, enzymatic provision, formation of malonyl-CoA, stages of synthesis, sources of NADPH, bioenergetics of the process. Citrate-shuttle mechanism of substance transport.

Synthesis of cholesterol and ketone bodies in the liver, ways of their use. Familial hypercholesterolemia, causes and consequences.

Лабораторное занятие. Laboratory lesson 19.20.

Synthesis of triacylglycerides in adipocyte and hepatocyte. Further fate of triacylglycerides. Synthesis of ketone substances, cholesterol. The role of hormones in the regulation of lipid metabolism. Peroxidation of membrane lipids, causes and consequences.

**Тема 12. Structure and functions of biological membranes. Pathology of lipid metabolism.**

Лекционное занятие. Lecture 11

The structure and function of biological membranes, the role of lipids and proteins in the functioning of membranes. Transport of substances through membranes: active, passive, uniport, symport, antiport. Pathology of lipid metabolism (fatty infiltration of the liver, atherosclerosis, obesity, hereditary diseases), causes and consequences. The use of membrane components in the synthesis of second messengers, eicosanoids, organic osmolytes.

Лабораторное занятие. Lab 21, 22.

Synthesis of triacylglycerols and glycerophospholipids, features of synthesis in white adipose tissue and liver. Fatty infiltration of the liver, causes, consequences, lipotropic compounds. Topography, structure and types of adipose tissue, features of glucose metabolism in white adipose tissue. Mechanism of thermogenesis in brown adipose tissue.

**Раздел 5. Exchange of simple and complex proteins.**

**Тема 13. Exchange of simple proteins. Nitrogen exchange.**

Лекционное занятие. Lecture 12

nitrogen balance. Digestion of proteins in the gastrointestinal tract: biosynthesis of hydrochloric acid and pepsinogen. Proteases of the pancreas and intestines. Activation of zymogens in the gastrointestinal tract, the specifics of the action of each of the proteases. Cellular protein proteolysis. Neutralization of protein decay products in the liver. Amino acid catabolism strategy. Reactions of deamination, decarboxylation, transamination. Protein decay.

Лабораторное занятие. Laboratory lesson 23.24.

Protein metabolism and their biological significance. Digestion of proteins in the gastrointestinal tract and absorption of digestion products into enterocytes. Common pathways of amino acid catabolism. Proteolysis of proteins in cells, the role of lysosomes and proteosomes. Ways of using hydrolysis products. Reactions of transamination and deamination, their role in the metabolism of amino acids and other compounds. Diagnostic value of determining the activity of transaminases in the blood.

**Тема 14. Metabolism of amino acids, ornithine cycle.**

Лекционное занятие. Lecture 13

Entry of carbon skeletons of amino acids into the Krebs cycle. Metabolism of glutamate. Glyconeogenesis and lipogenesis from amino acids. Metabolism of sulfur-containing, dicarboxylic, aromatic, diamine amino acids. Pathologies of their metabolism. regulation of amino acid metabolism. Temporary neutralization of ammonia. ornithine cycle.

Лабораторное занятие. Lab 25.26

Pathways for the entry of amino acid carbon skeletons into the Krebs cycle. Non-proteinogenic amino acids: ornithine and citrulline, their structure and function. alanine metabolism. Synthesis of alanine from pyruvate and aspartate. Oxidation of alanine to final products, bioenergetics of the process.

**Тема 15. Metabolism of complex proteins.**

Лекционное занятие. Лекция 14.

Обмен нуклеопротеидов: синтез и распад нуклеотидов. Обмен гемопротеидов:

синтез и распад гема. Патология обмена нуклеотидов. патологии обмена гемопротеидов: порфирии. Этапы реализации генетической информации: репликация, транскрипция, трансляция, терминация.

Лабораторное занятие. Лабораторное занятие 27,28

Обмен нуклеопротеидов. Синтез пуриновых и пиримидиновых нуклеотидов. Ортотовая ацидурия: причины и признаки. Гемопротеиды. Синтез гема: предшественники. локализация. ферментное обеспечение. Распад гема: ферментное обеспечение. Патологии нарушения обмена гемопротеидов. Желтуха: виды, причины. признаки.

## **Раздел 6. Features of the exchange of individual tissues of organs.**

### **Тема 16. Biochemistry of blood, kidney and urine formation.**

Лекционное занятие. Лекция 15.

Кровь: состав и функция. Особенности белкового состава в крови. Особенности метаболизма в эритроцитах и лейкоцитах. Кислотно-щелочное равновесие. Буферные системы крови. Биохимический анализ крови. Использование его в диагностических целях. Гемостаз.

Лабораторное занятие. Лабораторное занятие 29,30.

Белки плазмы крови: структура. функции. Особенности метаболизма форменных элементах крови.

### **Тема 17. Biochemistry of teeth.**

Лекционное занятие. Лекция 16.

Структура и функция почек. Механизмы образования мочи: клубочковая фильтрация, реабсорбция и секреция. Особенности белкового, углеводного и липидного обмена в почках.

Лабораторное занятие. Лабораторное занятие 31.

Структура почки. Особенности обмена в мозговом и корковом веществе почек.

### **Тема 18. Biochemistry of hormones.**

Лекционное занятие. Лекция 16.

Гидрофильные гормоны: химическая природа, характер взаимодействия с клетками мишенями. Липофильные гормоны: химическая природа, характер взаимодействия с клетками мишенями. Гормоны поджелудочной железы (инсулин, глюкагон): образование, влияние на обмен веществ, утилизация. Биохимия сахарного диабета.

Лабораторное занятие. Лабораторное занятие 32.

Гормоны щитовидной железы. Гипо- и гипертиреозы, механизмы возникновения и последствия.

Гормоны мозгового слоя и коркового слоя надпочечников: синтез, влияние на обмен веществ, типы рецепторов, физиологические реакции. Гормоны надпочечников.

## 5. Educational technologies

To implement the competence-based approach in the study of the discipline (module), extensive use of active and interactive methods of conducting classes in the educational process is provided:

The constituent elements of educational technologies are:

-lectures an interactive form of the lesson is also used to present new material;

-laboratory classes

-the use of multimedia tools (projectors) - to improve the quality of perception of the studied material.

## 6. Forms of control and types of evaluation materials for the discipline (module)

Intermediate attestation - evaluation of intermediate and final results of training in the discipline (module).

### 6.1. Sample list of questions for the credit test

There is no set-off.

### 6.2. Sample list of questions for the examination

1. Amino acids: classification, structure, general properties, biologic function.
2. Classification of proteins: shape, structure and function. Give examples.
3. The role of proteins in the human body, classification of proteins by complexity, shape and function.
4. Chemical modification of amino acid radicals in proteins. Write reaction of phosphorylation of serin.
5. Biologically active peptides: structure and functions.
6. Electron transport chain: structure and biological role. Mitchell's chemiosmotic hypothesis.
7. Krebs cycle: localization, enzymes and coenzymes, regulation, bioenergetics of the process. The relationship between the Krebs cycle and the Electron transport chain.
8. Structure, classification and role of carbohydrates in the body.
9. Digestion in the gastrointestinal tract, absorption of hydrolysis products.
10. Glycolysis in conditions of normal oxygen content: localization, stages, reactions, enzymes and coenzymes, bioenergetics, significance for the body.
11. Gluconeogenesis: substrates, cellular localization, reactions, enzymes and coenzymes, regulation, significance for the body (consider the reaction of gluconeogenesis from lactate).
12. Glycogenolysis in the liver: reactions, enzymes, regulation, significance for the body. The role of the liver in maintaining normal blood glucose levels.
13. Anaerobic glycolysis: localization, stages, reactions, enzymes and coenzymes, bioenergetics of the process, significance for the body. Features of glycolysis in erythrocytes.
14. Glycolysis in hypoxia: localization, stages, reactions, enzymes and coenzymes, bioenergetics of the process, significance for the body.
15. The pentose phosphate pathway: localization of the process, reactions, enzymes and coenzymes, regulation, significance for the body, features in different organs.
16. Hereditary pathologies of carbohydrate metabolism: glycogenoses, fructosuria, galactosemia, lactose intolerance, etc.
17. Lipids: classification, structure, physico-chemical properties, biological role. Digestion of lipids in the gastrointestinal tract and the role of bile acids in this process.
18. Transport forms of lipids: formation, structure, classification, role and their subsequent disposal.
19.  $\beta$ -Oxidation of saturated fatty acids with an even number of carbon atoms (on the example of palmitate oxidation).

20. Synthesis of triacylglycerols and glycerophospholipids, features of synthesis in white adipose tissue and liver.

21. Ketone bodies: structure, ketogenesis, utilization. Regulation of ketogenesis. Ketonemia, ketoacidosis.

22. Cholesterol: structure, biological role. Biosynthesis of cholesterol in liver. Hypercholesterolemia: causes and consequences.

23. Biosynthesis of fatty acids, localization, stages of synthesis. Citrate shuttle, malonyl-CoA formation. NADPH sources.

24. Triacylglycerols lipolysis in adipocytes: reactions, enzymes, regulation. Ways to use free fatty acids.

25. Structure and function of biological membranes. The role of lipids and proteins in maintaining the function of membranes. Transport of substances through cell membranes, modes of transport.

26. Formation of secondary messengers and their role in the regulation of metabolism in the cell. Write the structure of camp, diacylglycerol and Inositol-1,4,5- trisphosphate.

27. Digestion of proteins in the gastrointestinal tract, biosynthesis of hydrochloric acid and pepsinogen in the stomach. Proteases of the pancreas and intestines. Activation of zymogens in the gastrointestinal tract, the specifics of the action of each of the proteases.

28. The entrance of amino acids into the Krebs cycle. Draw the scheme.

29. Common ways of amino acid conversion. Examples of reactions. Give the name of enzymes and the role of these transformations.

30. Transamination of amino acids. Give examples of reactions. Name the reaction enzymes and the role of transamination of amino acids.

31. Amino acids decarboxylation. Biologically active amines derived from amino acids. Structure. Function.

32. Metabolism of phenylalanine and tyrosine. Synthesis of hormones and neurotransmitters (catecholamines, thyroxine, triiodothyronine). Phenylketonuria, albinism, alkaptonuria.

33. Alanine metabolism. Synthesis of  $\alpha$ -alanine from pyruvate and aspartate. Catabolism of  $\alpha$ -alanine to final products. Role of alanine in transport ammonia from skeletal muscles.

34. Glutamate metabolism. Glutamate dehydrogenase reaction, its significance. Synthesis of glutamine and  $\gamma$ -aminobutyric acid from glutamate.

35. Methionine metabolism. Formation of S-adenosyl methionine and its participation in methylation reactions. Catabolism of methionine to end products, bioenergetics of the process.

36. Synthesis of ammonia in the body. Toxicity of ammonia to brain cells. Temporary and final neutralization of ammonia in the body. Urea Cycle.

37. Pathologies of amino acid metabolism. Causes and symptoms.

38. Protein biosynthesis: activation, initiation, elongation, termination, posttranslational modification.

39. Nucleoprotein exchange: purine breakdown. Violation of nucleoprotein metabolism.

40. Chromoprotein metabolism: heme synthesis. Porphyrin.

41. Chromoprotein metabolism: heme destruction. Obstruction, parenchymal and hemolytic jaundice.

42. Biochemistry of diabetes mellitus.

43. Draw the scheme of interaction of lipids, proteins, carbohydrates and lipids metabolism.

44. Pathological components of urine, detection and causes.

45. Buffer systems of blood. Violations of acid-base balance, causes, correction.
46. Blood clotting, external and internal pathways.
47. Pathological changes in the composition of the blood, methods of detection. Usage of blood test in diagnostic purposes.
48. Blood: composition, function, features of metabolism in erythrocytes and leukocytes.
49. Blood: composition, function, structure. Plasma proteins and function.
50. Kidney biochemistry: urine formation in nephrons (ultrafiltration, reabsorption and secretion), urine composition in normal and pathological conditions.
51. Metabolism of proteins, carbohydrates and lipids in to the kidneys.
52. Lipophilic hormones: chemical nature, nature of interaction with target cells, features of cellular response to interaction with certain hormones.
53. Hydrophilic hormones: chemical nature, nature of interaction with target cells, features of cellular response to interaction with certain hormones.
54. Thyroid hormones: effect on metabolism. Hypo- and hyperthyroidism, mechanisms of occurrence and consequences.
55. Adrenaline: synthesis, effect on metabolism, types of adrenergic receptors, physiological reactions.

### **6.3. Suggested themes of term papers (projects)**

Term papers are not provided.

### **6.4. Suggested themes of term projects**

Term papers are not provided.

### **6.5. Suggested topics of calculation and graphic works**

Calculation and graphic works are not provided.

## **7. Educational, methodological, informational and software support of the discipline (module)**

The electronic catalog and electronic information resources provided by the scientific library of the FSBEI of HE "I. N. Ulianov Chuvash State University" are available at the link <http://library.chuvsu.ru/>

### **7.1. Regulatory documents, standards and rules**

1) Приказ № 118 Минздрава РФ "О введении в действие санитарно-эпидемиологических правил и нормативов – СанПиН" от 03.06.2003 г.

2) Национальный стандарт Российской Федерации. Медицинские изделия для диагностики *in vitro*. Часть 1. Автоматические анализаторы для биохимических исследований. Утвержден и введен в действие Приказом Федерального агентства по техническому регулированию и метрологии. Год издания: 2014

3) Письмо Минздрава РФ № 01И-231/07 "О государственном метрологическом контроле и надзоре за изделиями медицинского назначения" от 29.03.2007 г.

1) Order No. 118 of the Ministry of Health of the Russian Federation "On the introduction of sanitary and epidemiological rules and regulations - SanPiN" dated 03.06.2003.

2) The National Standard of the Russian Federation. Medical devices for *in vitro* diagnostics. Part 1. Automatic analyzers for biochemistry research. Approved and put into effect by the Order of the Federal Agency for Technical Regulation and Metrology. Year of publication: 2014

3) Letter of the Ministry of Health of the Russian Federation No. 01I-231/07 "On state metrological control and supervision of medical devices" dated 29.03.2007.

## 7.2. Recommended basic educational and methodological literature

№ item	Name
1	

## 7.3. Recommended supplementary educational and methodological literature

№ item	Name
1	

## 7.4. List of resources of the "Internet" information and telecommunication network

№ item	Name	Link to the resource
1		

## 7.5. Software, professional databases, information and reference systems, electronic educational resources and electronic library systems

Software, professional databases, information and reference systems provided by the Informatization Department of the FSBEI of HE "I.N. Ulianov Chuvash State University" are available for download at the link <http://ui.chuvsu.ru> //. The Unified Register of Russian programs for electronic computers and databases, including freely distributed ones, is available at the link [reestr.minsvyaz.ru/reestr/](http://reestr.minsvyaz.ru/reestr/).

### 7.5.1. Licensed and freely distributed software

Microsoft Windows operating System and/or Unix-like operating system and/or mobile operating system;

Office software packages:

Microsoft Office and/or LibreOffice  
and (or) OpenOffice and (or) analogues;

Browsers, including Yandex.Browser.

List of software:

### 7.5.2. Lists of professional databases and (or) information reference systems and (or) electronic library systems and (or) electronic educational resources

## 8. Material and technical support of the discipline

Classrooms for lecture-type classes in the discipline are equipped with a teacher's automated workplace consisting of: a personal computer/laptop, multimedia equipment with a screen and (or) SMART interactive whiteboard/SMART TV.

The premises for students' independent work are equipped with computer equipment enabling to connect to the Internet and provide access to the electronic information and educational environment of the FSBEI of HE "I.N. Ulianov Chuvash State University".

№ item	Lesson type	Brief description and characteristics of the composition of installations, measuring and diagnostic equipment, computer equipment and experimental automation tools
1		Учебная аудитория для занятий семинарского типа, текущего контроля и промежуточной аттестации. Оборудование: учебная доска, учебная мебель, мультимедийное оборудование (проектор, экран, компьютер), монокулярные микроскопы, микроскоп МИКМЕД-5
2	Лек	Учебные аудитории для занятий лекционного типа, семинарского типа. Оборудование: учебная доска, учебная мебель, мультимедийное оборудование (проектор, экран, персональный компьютер или ноутбук с необходимым программным обеспечением для тематических иллюстраций и демонстраций, соответствующих программе дисциплины)

### **9. Means of adapting the discipline teaching to the needs of persons with physical conditions**

If necessary, persons with physical conditions can be offered one of the following options for perceiving information, taking into account their individual psychophysical characteristics:

1) using e-learning and distance learning technologies.

2) using special equipment (enginery) and software in accordance with the students' health restrictions in the Training Centers for Persons with Disabilities and Physical Conditions (hereinafter referred to as special needs) available at the university.

In the course of training, if necessary, the following conditions are provided for persons with visual, hearing and musculoskeletal disorders:

- for persons with visual impairments: educational and methodological materials in printed form in enlarged font; in the form of an electronic document; in the form of an audio file (conversion of educational materials into audio format); in printed form in Braille; individual consultations involving a tactile interpreter; individual assignments and consultations.

- for people with hearing impairments: educational and methodological materials in printed form; in the form of an electronic document; video materials with subtitles; individual consultations involving a sign language interpreter; individual assignments and consultations.

- for persons with disorders of the musculoskeletal system: educational and methodological materials in printed form; in the form of an electronic document; in the form of an audio file; individual assignments and consultations.

### **10. Guidelines for students to perform independent work**

The purpose of the student's independent work (IW) is to consolidate the theoretical knowledge gained and to acquire practical skills in using and performing research of algorithms and data structures when designing application software programs. IW includes independent study of educational issues, preparation for laboratory classes, performing calculation and graphic work, preparation for a test and an exam.

The list of questions and tasks for independent work to prepare for laboratory classes is given in the corresponding methodological instructive regulations in the description of each laboratory work.

The list of questions and tasks for independent work to carry out calculation and graphic work is given in the relevant methodological instructive regulations.

Independent work of students is an integral part of the educational process. The purpose of independent work of students is to master fundamental knowledge, professional skills and skills, experience in creative, research activities.

The main forms of organizing independent work of students are: classroom independent work under the guidance and supervision of a teacher (at lectures, laboratory classes, etc. and consultations); extracurricular independent work under the guidance and supervision of a teacher (at consultations, during research work), extracurricular independent work - planned educational, educational research, scientific-research work of students, carried out during extracurricular time according to the assignment and with the methodical guidance of the teacher, but without his direct participation.

Students, when performing independent work, should rely mainly on the knowledge.

### **11. Methodological instructive regulations for students studying the discipline (module)**

The purpose of the training is the preparation of a modern competent specialist and the formation of abilities and skills for continuous self-education and professional improvement, which involves solving the following tasks:

- high-quality development of theoretical material in the discipline under study, deepening and expanding theoretical knowledge with a view to their application at the level of interdisciplinary connections;
- systematization and consolidation of the received theoretical knowledge and practical skills;
- formation of skills for the search and use of normative, legal, reference and special literature, as well as other sources of information;
- development of cognitive abilities and activity, creative initiative, independence, responsibility and organization;
- formation of independent thinking, abilities for self-development, self-education, self-improvement and self-realization;
- development of research skills;
- formation of the ability to solve practical problems (in professional activities), using the acquired knowledge, abilities and skills.

#### **11.1. Methodological instructive regulations for preparing for seminar-type classes**

To prepare for a seminar-type lesson, the student needs to study the theoretical material on this topic, remember the basic definitions and terms, and analyze the lecture material. To consolidate the material covered, the student also needs to do homework in accordance with the assignment received in the previous laboratory lesson. In case of difficulties in its implementation, it is recommended to seek help from the teacher at the time allotted for consultations.

Stages of preparation for a seminar type lesson:

- study of the theoretical material received at the lecture and in the process of independent work;
- study and analysis of the recommended literature;
- taking notes of what was read during the study of the recommended literature;
- doing homework;
- self-examination on control questions of the topic.

#### **11.2. Methodological instructive regulations for preparing for an examination**

The exam aims to assess the development of competencies by students for a certain course: the theoretical knowledge gained, their strength, the development of logical and creative thinking, the acquisition of independent work skills, the ability to analyze and synthesize the knowledge gained and put into practice the solution of practical problems.

The exam is conducted on tickets approved by the head of the department. The examination ticket includes two questions and a task. The wording of the questions coincides with the wording of the list of questions brought to the attention of students one month before the examination session. In the process of preparing for the exam, a pre-examination consultation is held for all study groups. The result of the exam is expressed as "excellent", "good", "satisfactory".

In order to clarify the assessment, the examiner may ask several additional questions that do not go beyond the requirements of the work program of the discipline (module). An additional question is a question that is not related to the subject matter of the ticket questions. An additional question, as well as the main questions of the ticket, requires a detailed answer. In addition, the teacher can ask a number of clarifying and leading questions related to the subject of the main questions of the exam ticket. The number of clarifying and leading questions is not limited.

A student is allowed to take the exam if he/she has completed in full the tasks provided for in the work program of the discipline (module). In case of missing any types of training sessions for good or bad reasons, the student independently performs and submits for verification in writing the general or individual tasks determined by the teacher. The theoretical course examination takes place in oral or written form (determined by the teacher) on the basis of a list of questions that reflect the content of the current work program of the academic discipline. Students are encouraged to:

- prepare for the exam by carefully reading all the exam questions;
- make a plan for answering each question, highlighting the key points of the material.

The answer must be reasoned. The results of the exam are assessed as "excellent", "good", "satisfactory" or "unsatisfactory".

### **11.3. Methodological instructive regulations for preparing for a test**

Account is not provided.

### **11.4. Methodological instructive regulations for performing computational and graphical**

Settlement and graphic works are not provided.

### **11.5. Methodological instructive regulations for performing a control work**

Control work is not included.

### **11.6. Methodological instructive regulations for performing a course work (project)**

Coursework is not included.

### List of additions and changes

The name and details (if any) of the document attached to the Working Program of the discipline (module) containing the text of updates	Department's decision		Full name of department head:
	Date	Protocol №	