Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Head of the Phystech School of Biological and Medical Physics
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Work program of the course (training module)

course: Bioorganic Chemistry/Биоорганическая химия
major: Biotechnology
specialization: Biomedical Engineering/Биомедицинская инженерия
Phystech School of Biological and Medical Physics
Department of Molecular and Biological Physics
term: 3
qualification: Bachelor

Semesters, forms of interim assessment:
6 (spring) - Grading test
7 (fall) - Exam

Academic hours: 120 AH in total, including:
lectures: 60 AH.
seminars: 0 AH.
laboratory practical: 60 AH.

Independent work: 120 AH.

Exam preparation: 30 AH.

In total: 270 AH, credits in total: 6

Author of the program: E.E. Kulikov, candidate of biological sciences, associate professor

The program was discussed at the Department of Molecular and Biological Physics 04.06.2020

Annotation

The course of Bioorganic chemistry was developed specifically for MIPT students. It takes one year and consists of a lecture course and a laboratory workshop. This course is integrative in nature, allowing future young specialists in the field of life sciences to perceive the chemistry of living systems through the prism of fundamental sciences-chemistry, biology, physics. This course covers both classic topics for the course of biochemistry (enzymes, proteins, biochemical cycles), as well as additional chapters on the biochemistry of organs and systems, medical chemistry, and so on. The laboratory workshop allows students to master the methods of research of biological molecules necessary for further work in the laboratories of basic departments.

1. Study objective

Purpose of the course

study of the basics of modern biological chemistry (with elements of organic chemistry and molecular biology), preparing students to learn other courses of biological profile.

Tasks of the course

- students ' acquisition of basic knowledge in the field of biological chemistry;
- acquisition of theoretical knowledge in the field of studying the most important processes of biological metabolism in a living cell, coordination and regulation of this exchange, and coupling of metabolic cycles;
- providing advice and assistance to students in the areas of molecular biology and biochemistry that are necessary for the implementation of their own theoretical and practical work;
- formation of students' skills of independent work with special scientific literature of biological orientation.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
	Gen.Pro.C-1.2 Build mathematical models, make quantitative measurements and estimates
	Gen.Pro.C-1.3 Determine the applicability limits of the obtained results
Pro.C-4 Critically assess the applicability of applied methods and techniques	Pro.C-4.1 Apply the numerical order of values in respective professional settings
	Pro.C-4.2 Understand the causes of measurement errors and inaccuracies, estimate them, verify the validity of experimental results
	Pro.C-4.3 Provide evidence to support the cause-effect relationship of applied concepts and models

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- fundamental concepts, laws, and theories of classical and modern biological chemistry;
- numerical values characteristic to structure of biomolecules;
- structures and functions of the main metabolites of energy and plastic metabolism of the cell;
- modern problems of biochemistry;
- modern approaches used in practical biology (biotechnology);
- experimental foundations of biological chemistry.

be able to:

- to relate the processes occurring in the living cell, with physical and chemical processes;
- navigate the structural formulas of the main components of the cell (carbohydrates, including polysaccharides, amino acids, proteins, nucleotides, nucleosides, nucleic acids (DNA, RNA), lipids, vitamins, steroid hormones);
- apply the obtained theoretical knowledge about experimental approaches in biological chemistry to solve specific experimental problems;
- use your knowledge to solve fundamental and applied problems and technological problems;
- draw correct conclusions from comparing the results of theory and experiment;
- make numerical order of magnitude estimates;
- make qualitative conclusions when moving to the limit conditions in the studied problems;
- recognise biochemical content of biological problems;
- develop new subject areas, theoretical approaches, and experimental techniques;
- get the best estimates of the measured values and correctly assess their reliability;
- work on modern, including unique, experimental equipment;
- effectively use information technology and computer technology to achieve the necessary theoretical and applied results.

master:

- skills to master a large amount of information;
- skills of independent work in the laboratory and on the Internet;
- culture of setting and modeling biological problems;
- skills for the proper processing of the results of the experiment and comparison with theoretical data;
- practice of research and solving theoretical and applied problems.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Water as a solvent. Acid / base properties of biomolecules.	4			2
2	Structure and properties of biologic molecules: amino acids, carbohydrates, fatty acids, nucleic acids.	4			2
3	Protein structure and function.	4			2
4	Enzymes. Cell energetics.	4			2
5	Membranes and intracellular signal transduction.	4			2
6	Glycolysis and pyruvate oxidation.	4			2
7	Citric acid cycle, oxidative phosphorylation.	6			3
8	Gluconeogenesis, glycogen metabolism.	2			4
9	Fatty acid and triglyceride metabolism.	4			4
10	Amino acid metabolism.	4			4
11	Integration of carbohydrate, lipid and amino acid/protein metabolism.	4			4
12	Purine/pyrimidine metabolism.	4			4
13	RNA transcription and control of gene expression.	4			4
14	Protein synthesis and degradation. The genetic code, mutations.	4			4
15	Nutrition and tissue biochemistry.	4			4

16	General properties of aminoacids and proteins.			18	8
17	Methods of study of proteins.			10	7
18	Separation of proteins.			14	9
19	Enzimes and enzymatic kinetics.			4	8
20	Methods for investiation of nucleic acids.			2	8
21	Carbohydrates.			2	8
22	Lipids.			2	8
23	Glycolysis and the tricarboxylic acid cycle. Biological oxidation.			2	9
24	Metabolism of nitrogenous compounds.			6	8
AH in total		60		60	120
Exam preparation		30 AH.			
Total complexity		270 AH., credits in total 6			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 6 (Spring)

1. Water as a solvent. Acid / base properties of biomolecules.

Water as a universal medium in biochemistry. Electrolytes and non-electrolytes, electrolytic dissociation, acid-base concepts. Acid/base properties of biomolecules.

2. Structure and properties of biologic molecules: amino acids, carbohydrates, fatty acids, nucleic acids.

The possibility of biological catalysis by proteins due to the presence of ordered self-organizing structures and a wide choice of functional groups (amino acid radicals).

The most important representatives of the class of carbohydrates (monosaccharides, disaccharides). Reducing and non-reducing sugars. Ring-chain tautomerism, optical isomerism of sugars. Polysaccharides. Structural role of carbohydrate components of the cell. Energy metabolites based on phosphoric esters of glucose and fructose. The main reactions of carbohydrates: polycondensation and hydrolysis.

Basic structural and functional characteristics of nucleic acids. The main classes of nucleic acids found in the cell: DNA and RNA. Subclasses of nucleic acids. Nucleotides and nucleosides. Macroergic compounds as a single energy currency of the cell. Structures of nucleic acids in the cell, and interactions that stabilize them (hydrogen bonds, stacking interactions).

3. Protein structure and function.

Protein structure and function. Levels of structural complexity, analysis of protein structure, model proteins (hemoglobin/myoglobin).

The primary structure of a protein is its unique sequence of amino acids. Secondary structure, found in most proteins, consists of coils and folds in the polypeptide chain. Tertiary structure is determined by interactions among various side chains (R groups). Quaternary structure results when a protein consists of multiple polypeptide chains. Denaturation by pH, salt concentration, temperature, or other environmental factors.

Chaperonins. Diseases associated with misfolded proteins: Alzheimer’s, Parkinson’s, and mad cow diseases.

Main functions of proteins: structure (collagen, keratin - instead of cellulose in plants), catalysis (all enzymes except ribozymes), movement (motor and contractile proteins - actin, myosin, etc.),

transport (ion channels, transmembrane transporters, hemoglobin), hormones (insulin, erythropoetin, HGF), protection (antibodies, complement, fibrin), storage (casein, ovalbumin, transferrin), regulation (gene expression control). Important protein properties: UV light absorption, salting in/out, pH-dependent conformation. Sickle-Cell Disease: A Change in Primary Structure. Hemoglobin affinity to oxygen is dramatically reduced in acidic tissues. Bohr's effect.

4. Enzymes. Cell energetics.

Enzymes. Cell energetics. Biologic catalysts, active site properties. kinetics, inhibition and regulation. Cellular regulatory strategies.
The possibility of biological catalysis by proteins due to the presence of ordered self-organizing structures and a wide choice of functional groups (amino acid radicals). The concept of an enzyme as a catalyst of protein nature. The main classes of enzymes and the reactions they catalyze. Thermodynamics of enzymatic catalysis. Kinetics of enzymatic reactions, research methods, activators and inhibitors of enzymes. Molecular mechanism of action of enzymes on the example of urease. Protein denaturation, the effect of pH, ionic strength, and temperature on the activity and specificity of enzymatic reactions. Catalytic antibodies (abzymes). Enzymes of non-protein origin (ribozymes, telomerases). Coenzymes and vitamins.

5. Membranes and intracellular signal transduction.

Membranes and intracellular signal transduction. Membrane structure and composition, membrane transport
Basic lipids of biological membranes. Structure and composition of membranes. Interaction of proteins with membranes. Glycoproteins. Structure of the bacterial cell wall. Transmembrane proteins, their synthesis, folding and functions. Covalent interactions of membrane proteins with the membrane. Posttranslational modification. The microphysics of membrane: viscosity, fluidity, asymmetry of the leaves. Membrane rafts. Receptor-induced and spontaneous endocytosis. Cell adhesion molecules. NO as a mediator. Diffusion through membranes: passive, lightweight, energy-dependent. Ion channel. Sodium-potassium ATPase and the occurrence of transmembrane ion potentials. Transporter proteins. Models of channel operation.

6. Glycolysis and pyruvate oxidation.

Glycolysis and pyruvate oxidation. Regulation, interface with other pathways, medical significance. Fermentations.
Fermentation type of carbohydrate metabolism. The ability to extract energy by anaerobic metabolism of substrates. Glycolysis as the basic way of glucose processing. Types of fermentation (homofermentative, heterofermentative), the main metabolites of the glycolytic pathway. Pyruvic acid as a donor of the C2 fragment, an acetyl derivative of coenzyme A. Further cleavage of acetyl-COA via the aerobic pathway.

7. Citric acid cycle, oxidative phosphorylation.

Citric acid cycle, electron transport chain, oxidative phosphorylation. Respiration. Regulation, interface with other pathways, medical significance.
Tricarboxylic acid cycle. TCA intermediates as raw materials for the synthesis of amino acids. ATP production by the cell during respiration. The role of reduced coenzymes (NADH, NADPH, FADH2) obtained in TCA. Electron transport chain. Conversion of the energy of the electrochemical gradient of protons into the energy of ATP.

Semester: 7 (Fall)

8. Gluconeogenesis, glycogen metabolism.

Gluconeogenesis, glycogen metabolism. Regulation, interface with other pathways, medical significance. Minor carbohydrates (ribose, fructose, galactose).

9. Fatty acid and triglyceride metabolism.

Fatty acid and triglyceride metabolism. Fatty acid metabolism, mobilization and oxidation. Steroids and other lipids and lipid-related compounds.

10. Amino acid metabolism.

Amino acid metabolism. Ammonium production and urea cycle. Amino acid degradation and biosynthesis. Clinical significance of amino acid and related metabolism.

11. Integration of carbohydrate, lipid and amino acid/protein metabolism.

The need to coordinate metabolic processes in the cell. Integration of carbohydrate, lipid and amino acid/protein metabolism. Hormonal regulation: insuline, glucagone, epinephrine, glucocorticoids. Well-fed/fasting/starvation states, an overview of model metabolic disease – type 1 diabetes
Ways to synchronize metabolic processes in prokaryotic cells.

12. Purine/pyrimidine metabolism.

Purine/pyrimidine metabolism. Organisation, synthesis and repair of DNA. Recombinant DNA.
Purine synthesis. 5-Phosphoribosyl-1-Pyrophosphate Synthesis, Phosphoribosylamine Synthesis.
Production of AMP and GMP from a Common IMP Precursor. Purine Salvage.
Degradation of purines to uric acid. Pyrimidine synthesis.
Synthesis of Pyrimidine Nucleotides from Orotate. Pyrimidine Salvage.
Deoxyribonucleotide synthesis. Nucleotide phosphate interconversion.
Diseases related to nucleotide metabilism.
Lesch-Nyhan Syndrome. Adenosine Deaminase Deficiency.

13. RNA transcription and control of gene expression.

The Central dogma of molecular biology. The main vector of information, regulation of the process of gene expression. messenger rna. Synthesis and processing of mRNA as a way to regulate the number and composition of proteins synthesized by the cell. Promoters and their mechanism of action. Modular organization of prokaryotic RNA polymerases. Sigma factors, and other transcription factors. Attenuated promoters on the example of a tryptophan operon promoter. Enhancers of transcription. The operon hypothesis of Jacob and Mono. Differences in biology of the gene in prokaryotes and eukaryotes. Monocistronic and polycistronic organization. Mechanism of regulation of lactose operon genes. Antisense RNAs, the ability to control gene expression through RNA interference. Methods for analyzing gene expression, transcriptomics. Creating and applying libraries to DNA.

14. Protein synthesis and degradation. The genetic code, mutations.

Protein synthesis and degradation. The genetic code, mutations.
Protein molecules as effectors of genetic information. Implementation of three-dimensional structures based on information encoded by one-dimensional nucleic acids. Factors necessary for protein synthesis. Transport RNAS. Genetic code, its discovery, basic properties, and physical implementation of triplet code decoding. Ribosomes. Factors of protein synthesis. Protein processing and folding. Modular evolution of proteins. Antibiotics that affect translation. Posttranslational modification.

15. Nutrition and tissue biochemistry.

Nutrition and tissue biochemistry. Energy and matter requirements. Digestion, absorption. Nitrogen balance and essential amino acids. Micronutrients: vitamins, minerals, electrolytes, trace elements. Muscle contraction, blood clotting, liver metabolism of xenobiotics and ethanol.

16. General properties of aminoacids and proteins.

Laboratory work on the topic "General properties of aminoacids and proteins."

17. Methods of study of proteins.

Laboratory work on the topic "methods of protein research".

18. Separation of proteins.

Laboratoty work "Separation of proteins".

19. Enzimes and enzymatic kinetics.

Laboratory work on topic "Enzimes and enzymatic kinetics".

20. Methods for investiation of nucleic acids.

Laboratory work on topic "Methods for investiation of nucleic acids."

21. Carbohydrates.

Laboratory work on the topic "Carbohydrates".

22. Lipids.

Laboratory work on the topic "Lipids".

23. Glycolysis and the tricarboxylic acid cycle. Biological oxidation.

Laboratory work on the topic "Glycolysis and the tricarboxylic acid cycle. Biological oxidation".

24. Metabolism of nitrogenous compounds.

Laboratory work on the topic "Metabolism of nitrogenous compounds".

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

Computerised laboratories equipped with a projector.
A room specially equipped for conducting a laboratory workshop on biochemistry with the necessary reagents and equipment: spectrophotometers, gel electrophoresis units, centrifuges, pH meters.

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

Recommended additional literature:

1. John W. Pelley. Elsevier's integrated rewiev biochemistry. 2nd edition. Elsevier Sounders. 2012.
2. Robert K. Delong, Qiongqiong Zhou. Introductory experimants on biomolecules and their interactions. Elsevier. 2015.

Additional literature

Recommended additional literature:

1. John W. Pelley, Edward F. Golian. Rapid rewiev biochemistry. 3rd edition. Mosby Elsevier. 2011.
2. Jan Koolman, Klaus-Heinrich Roehm. Color Atlas of Biochemistry. 2nd edition. Thieme. 2005.

7. List of web resources that are necessary for the course (training module) mastering

Not used

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

MS Office software package: MS Word, MS Power Point, MS Visio. Acrobat Reader, DJVU Reader.

9. Guidelines for students to master the course

A student studying a discipline must, on the one hand, master the General conceptual apparatus, and on the other hand, must learn to apply theoretical knowledge in practice.

As a result of studying the discipline, the student must know the basic definitions of the discipline, be able to apply the knowledge gained to solve various problems.

Successful completion of the course requires:

- attend all classes provided for in the curriculum for the discipline;
- keeping notes of classes;
- intense independent work of the student.

Independent work includes:

- reading recommended literature;
- study of educational material, preparation of answers to questions intended for self-study;
- solving problems offered to students in the classroom;
- preparation for the tasks of the current and intermediate certification.

An indicator of material proficiency is the ability to answer questions on the topics of the discipline without a synopsis.

It is important to gain an understanding of the material being studied, and not to memorize it mechanically. If it is difficult to study certain topics, questions, you should seek advice from the teacher.

Intermediate control of students ' knowledge is possible in the form of solving problems in accordance with the subject of classes.

SUPPLEMENT

Assessment funds for course (training module)

major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия
	Phystech School of Biological and Medical Physics
	Department of Molecular and Biological Physics
term:	3
qualification:	Bachelor

Semesters, forms of interim assessment:

6 (spring) - Grading test

7 (fall) - Exam

Author: E.E. Kulikov, candidate of biological sciences, associate professor

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
	Gen.Pro.C-1.2 Build mathematical models, make quantitative measurements and estimates
	Gen.Pro.C-1.3 Determine the applicability limits of the obtained results
Pro.C-4 Critically assess the applicability of applied methods and techniques	Pro.C-4.1 Apply the numerical order of values in respective professional settings
	Pro.C-4.2 Understand the causes of measurement errors and inaccuracies, estimate them, verify the validity of experimental results
	Pro.C-4.3 Provide evidence to support the cause-effect relationship of applied concepts and models

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- fundamental concepts, laws, and theories of classical and modern biological chemistry;
- numerical values characteristic to structure of biomolecules;
- structures and functions of the main metabolites of energy and plastic metabolism of the cell;
- modern problems of biochemistry;
- modern approaches used in practical biology (biotechnology);
- experimental foundations of biological chemistry.

be able to:

- to relate the processes occurring in the living cell, with physical and chemical processes;
- navigate the structural formulas of the main components of the cell (carbohydrates, including polysaccharides, amino acids, proteins, nucleotides, nucleosides, nucleic acids (DNA, RNA), lipids, vitamins, steroid hormones);
- apply the obtained theoretical knowledge about experimental approaches in biological chemistry to solve specific experimental problems;
- use your knowledge to solve fundamental and applied problems and technological problems;
- draw correct conclusions from comparing the results of theory and experiment;
- make numerical order of magnitude estimates;
- make qualitative conclusions when moving to the limit conditions in the studied problems;
- recognise biochemical content of biological problems;
- develop new subject areas, theoretical approaches, and experimental techniques;
- get the best estimates of the measured values and correctly assess their reliability;
- work on modern, including unique, experimental equipment;
- effectively use information technology and computer technology to achieve the necessary theoretical and applied results.

master:

- skills to master a large amount of information;
- skills of independent work in the laboratory and on the Internet;
- culture of setting and modeling biological problems;
- skills for the proper processing of the results of the experiment and comparison with theoretical data;
- practice of research and solving theoretical and applied problems.

3. List of typical control tasks used to evaluate knowledge and skills

Current monitoring of academic performance is carried out based on the results of performing and passing laboratory work and answers to control questions on the lecture material.

Examples of control questions:

1. What practical applications are there for enzymes in the practice of science and in everyday life? Is enzymatic catalysis a reversible process?
2. What quantitative parameters characterize enzymatic catalysis? What are the inhibitors and activators of enzymes? Tell us about the known variants of the kinetics of enzymatic reactions?
3. Describe the classes of nucleic acids you know. What, in your opinion, is the order of occurrence of these classes in the course of the evolution of life? What is the fundamental difference in the biological chemistry of these classes?
4. Tell us about the known monomers of nucleic acids, the ways of synthesis and the variety of forms of nucleic acids in the cell. What biological processes are mainly involved in certain forms of nucleic acids?
5. What is the role of nucleic acids? Are they able to catalyze biological reactions (if so, give examples)? Tell us about bacteriophages, prophages, and plasmids.
6. Tell us about the nucleotide derivatives that serve as universal energy metabolites of the cell. What are macroergic compounds? How is energy stored in nucleotide triphosphates? What is re-phosphorylation?
7. Tell us about the main methods of isolation and research of nucleic acids. What biological information can be obtained using these methods?
8. Describe the main methods of genetic engineering that you know. What are restriction endonucleases? What are the enzymes of the metabolism of nucleic acids used in genetic engineering?
9. Tell us about the basic laws that determine the process of DNA replication. What is the role of DNA replication? How does "quality control" work during replication? Describe the main stages of prokaryotic genome replication.
10. Tell us about the classification of enzymes according to their functions. How exactly does enzymatic catalysis occur (for example, urease or another protein)?

4. Evaluation criteria

Credit is awarded based on the results of completing and submitting reports on the tasks of the laboratory workshop.

List of standard control questions for differential credit:

1. What are biogenic elements? What are the general properties of biogenic elements? Give examples of biogeochemical cycles, and the importance of their individual stages.
2. Tell us about the most ambitious discoveries in biological chemistry. What is the role of biochemistry in the structure of modern knowledge?
3. Tell us about the principles of classification of amino acids. What is stereospecificity? Why are amino acids the most suitable for creating biological catalysts?
4. Describe the main properties of the peptide bond. What levels of protein structure organization do you know? What is the advantage of polypeptide chains as a building block?
5. Tell us about the main variants of protein classification. How can the emergence of new protein variants occur? Is abiogenic evolution possible?
6. Describe the methods of protein research that you know. What biological problems can be solved by these methods?
7. What methods can be used to isolate and separate proteins? Tell us about chromatographic and electrophoretic methods of working with proteins.
8. What is proteomics? What fundamentally new biological data can be obtained by its methods?
9. Tell us about the classification of enzymes according to their functions. How exactly does enzymatic catalysis occur (for example, urease or another protein)?
10. What practical applications are there for enzymes in the practice of science and in everyday life? Is enzymatic catalysis a reversible process?
11. What quantitative parameters characterize the enzymatic catalysis? What are enzyme inhibitors and activators? Tell us about the known variants of the kinetics of enzymatic reactions?

12. Describe the classes of nucleic acids you know. What, in your opinion, is the order of occurrence of these classes in the course of the evolution of living things? What is the fundamental difference in the biological chemistry of these classes?

13. Tell us about the known monomers of nucleic acids, the ways of synthesis and the variety of forms of nucleic acids in the cell. What biological processes mainly involve certain forms of nucleic acids?

14. What is the role of nucleic acids? Are they capable of catalyzing biological reactions (if so, give examples)? Tell us about bacteriophages, profages, and plasmids.

15. Tell us about the nucleotide derivatives that serve as universal energy metabolites of the cell. What are macroergic compounds? How is energy stored in nucleotide triphosphates? What is rephosphorylation?

16. Tell us about the main methods of isolation and research of nucleic acids. What biological information can be obtained by these methods?

List of standard control questions for passing the exam:

1. Biogenic nitrogen cycle. Nitrogen fixation and reduction of oxidized forms of nitrogen.
2. The Relationship between amino acids and ketoacids. The reaction of transamination. Pyridoxal-dependent enzymes.
3. Urea cycle and its relationship with the tricarboxylic acid cycle.
4. Exchange of purines and pyrimidines.
5. Synthesis of nucleotides. Structural analogues of nucleotides as a means of antimetabolic therapy.
6. Exchange of glutamine and glutamate as key components of nitrogen metabolism.
7. Main components of biological membranes. Lipids and their classes.
8. Phospholipids, Sterol derivatives, sphingolipids, cerebrosides, gangliosides, isoprenoids.
9. Biologically active Sterol derivatives. Steroid hormones, bile acids.
10. Types of cell membranes and their lipid composition. Ultrastructure of the membrane.
11. Membrane proteins and their modifications.
12. The structure of the cell wall of bacteria.
13. Glycoproteins and their biological functions.
14. Glycoproteins as molecules of biological specificity. Blood group. Structure of cartilage tissue.
15. Integral and surface membrane proteins. Mechanisms of protein-membrane Association. Covalent and non-covalent interactions of proteins and modifiers. Basic structures of membrane proteins.
16. The lipoproteins. Posttranslational modifications on the Example of RAS protein farnesylation.
17. Physics of biological membranes. Asymmetry of the lipid composition and its biological meaning. Association of membrane structures, membrane rafts.
18. Interaction of membranes and cytoskeleton. Endocytosis and its mechanisms.
19. Cell adhesion molecules. Selectins, galectins.
20. Facilitated diffusion and active transport through membranes.
21. Ion channels, their structure and functions.
22. The basic mechanisms of transport through the membrane: symport, antiport, uniport.
23. Sodium-potassium pump: structure and biological meaning.
24. ABC-transporters and transport of various groups of substances to and from cells.
25. Hormones: classification, synthesis, mechanisms of action. Peptide and steroid hormones, map kinase cascades, and direct effects on gene expression.
26. Membrane receptors. Basic structures and mechanisms of action.
27. Phosphorylation / dephosphorylation of proteins as a method of regulating metabolism. Signal protein kinases and protein phosphatases.
28. The Mechanism of signal transmission and amplification through the coupling of the receptor with the G-protein. Cyclic nucleotides as secondary messengers.
29. Coupling of proteins into cascades on the example of the Ras protein. The role of signaling in oncogenesis.
30. Membranes as a source of secondary messengers.
31. Protein kinase a And its role in the cell.
32. The emergence of bio-electricity.
33. Structure and function of synapses. Synthesis and reuptake of neurotransmitters, their main classes and activity groups.

34. The transmission of nerve impulses.
35. The structure of muscle cells. Muscle contraction. Actin-myosin complex and its enzymatic activity.
36. The structure and function of the excretory system. Structure of the nephron.
37. Mechanisms of urine concentration and excretion / excretion of metabolic products.
38. Coupling of exchange processes. ATP system and thermodynamics of metabolism.
39. Potential of phosphorylation and its practical meaning.
40. Biochemistry of nutrition and digestion.

Ticket 1

1. Membrane receptors. Basic structures and mechanisms of action.
2. Phosphorylation / dephosphorylation of proteins as a method of regulating metabolism. Signal protein kinases and protein phosphatases.

The mark is excellent (10 points) - it is given to a student who has shown comprehensive, systematic, deep knowledge of the curriculum of the discipline, who has an interest in this subject area, has demonstrated the ability to confidently and creatively put them into practice in solving specific problems, and a free and proper substantiation of decisions.

The mark is excellent (9 points) - it is given to a student who has shown comprehensive, systematic, in-depth knowledge of the curriculum of the discipline and the ability to confidently put them into practice in solving specific problems, free and proper substantiation of the decisions made.

The mark is excellent (8 points) - given to a student who has shown comprehensive, systematic, in-depth knowledge of the curriculum of the discipline and the ability to confidently apply them in practice in solving specific problems, correct justification of decisions made, with some shortcomings.

A mark is good (7 points) - it is put up for a student, if he knows the material firmly, sets it up competently and in essence, knows how to apply the knowledge gained in practice, but does not competently substantiate the results obtained.

Evaluation is good (6 points) - it is put up to a student, if he knows the material firmly, sets it up correctly and in essence, knows how to apply this knowledge in practice, but admits some inaccuracies in the answer or in solving problems.

A mark is good (5 points) - it is given to a student, if he basically knows the material, correctly and essentially sets it out, knows how to apply this knowledge in practice, but allows a sufficiently large number of inaccuracies to answer or solve problems.

Grade satisfactorily (4 points) is given to a student who has shown the fragmented, fragmented nature of knowledge, insufficiently correct formulations of basic concepts, violations of the logical sequence in the presentation of program material, but at the same time he has mastered the main sections of the curriculum necessary for further education and can apply knowledge is modeled in a standard situation.

Grade satisfactorily (3 points) - given to a student who showed the fragmented, scattered nature of knowledge, making mistakes in formulating basic concepts, disrupting the logical sequence in presenting program material, poorly masters the main sections of the curriculum required for further education and even applies the knowledge gained in a standard situation.

The rating is unsatisfactory (2 points) - is given to a student who does not know most of the main content of the curriculum of the discipline, makes gross mistakes in the wording of the basic principles and does not know how to use this knowledge when solving typical tasks.

Unsatisfactory mark (1 point) - is given to a student who does not know the main content of the discipline's curriculum, makes gross errors in the wording of the basic concepts of the discipline and does not have any skills to solve typical practical problems.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

When conducting an oral differential test, the student is given 40 minutes to prepare.

The duration of the differentiated credit for each student must not exceed two astronomical hours from the date of receipt of the ticket.