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

APPROVED
Head of Landau Phystech-School of Physics & Research
A.V. Rogachev

Work program of the course (training module)

course:	Molecular Physiology Of The Nervous System/Молекулярная физиология нервной системы
major:	Applied Mathematics and Physics
specialization:	General and Applied Physics/Общая и прикладная физика
	Landau Phystech-School of Physics & Research
	Chair of Biophysics
term:	1
qualification:	Master

Semester, form of interim assessment: 2 (spring) - Exam

Academic hours: 30 AH in total, including:
lectures: 30 AH.
seminars: 0 AH.
laboratory practical: 0 AH.

Independent work: 30 AH.

Exam preparation: 30 AH.

In total: 90 AH, credits in total: 2

Number of course papers, tasks: 2

Author of the program: I.V. Manukhov, doctor of biological sciences

The program was discussed at the Chair of Biophysics 04.04.2022

Annotation

In the course of lectures, students will be given contemporary information about the formation of the nervous system; modular and hierarchical organization of the brain, about the types of intercellular interactions, architecture and physiological properties of the main protein modules that ensure the functioning of the nervous system. The proposed course of lectures will detail the fundamentals of electrophysiological and imaging research methods (microelectrode and patch clamp technique, confocal and 2-photon microscopy), methods for visualizing of specific receptors and channels, as well as visualizing functional proteins, including genetically encoded biosensors.

1. Study objective

Purpose of the course

The goal of the course is to introduce students to modern ideas about the evolution, molecular organization and function of the nervous system and the brain, about the key unsolved problems of the functioning of the human brain, to provide information about the molecular mechanisms of some pathologies of the nervous system and approaches to their treatment.

Tasks of the course

1) Acquaintance of students with contemporary information about the formation of the nervous system
2) Acquaintance of students with modular and hierarchical organization of the brain, about the types of intercellular interactions, architecture and physiological properties of the main protein modules that ensure the functioning of the nervous system
3) Acquaintance of students with fundamentals of electrophysiological and imaging research methods

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
UC-1 Use a systematic approach to critically analyze a problem,and develop an action plan	UC-1.1 Systematically analyze the problem situation, identify its components and the relations between them
	UC-1.2 Search for solutions by using available sources
	UC-1.3 Develop a step-by-step strategy for achieving a goal, foresee the result of each step, evaluate the overall impact on the planned activity and its participants
UC-4 Use modern communication tools in the academic and professional fields, including those in a foreign language	UC-4.1 Exchange business information in oral and written forms in Russian and at least one foreign language
	UC-4.2 Use the acquired skills to write, translate, and edit various academic texts (abstracts, essays, reviews, articles, etc.)
	UC-4.3 Present the results of academic and professional activities at various academic events, including international conferences
	UC-4.4 Use modern ICT tools for academic and professional collaboration
UC-6 Determine priorities and ways to improve performance through self-assessment	UC-6.1 Achieve personal growth and professional development, determine priorities and ways to improve performance
	UC-6.2 Evaluate performance results in correlation with the set objectives and applied methods
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of physical and mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional settings

Gen.Pro.C-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings
	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form within professional communication
Gen.Pro.C-3 Select and/or develop approaches to professional problem-solving with consideration to the limitations and specifics of different solution methods	Gen.Pro.C-3.1 Analyze problems, plan research strategy to achieve solution(s), propose, and combine solution approaches
	Gen.Pro.C-3.2 Employ research methods to solve new problems and apply knowledge from various fields of science (technology)
	Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations of the implementation of the obtained solutions in practice
Gen.Pro.C-4 Successfully perform a task, analyze the results, and present conclusions, apply knowledge and skills in the field of physical and mathematical sciences and ICTs	Gen.Pro.C-4.1 Apply ICT knowledge and skills to find and study scientific literature and use software products
	Gen.Pro.C-4.2 Apply knowledge in the field of physical and mathematical sciences to solve problems, make conclusions, and evaluate the obtained results
	Gen.Pro.C-4.3 Justify the chosen method of scientific research
Gen.Pro.C-5 Undertake professional training, achieve professional growth, and become a team leader in a professional sphere, tolerant of social, ethnic, religious, and cultural differences	Gen.Pro.C-5.1 Tolerate social, ethnic, religious, and cultural differences in teamwork
	Gen.Pro.C-5.2 Manage a small professional team
	Gen.Pro.C-5.3 Apply new knowledge and achieve personal and professional growth
Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems and obtain new scientific results	Pro.C-1.1 Locate, analyze, and summarize information on current research findings within the subject area
	Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model
	Pro.C-1.3 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results
Pro.C-3 Use research and testing equipment (devices and installations, specialized software) in a selected subject field	Pro.C-3.1 Understand the operating principles of the equipment and specialized software

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

As a result of studying the course the student should:

know:

1) contemporary information about the formation of the nervous system
2) modular and hierarchical organization of the brain, about the types of intercellular interactions, architecture and physiological properties of the main protein modules that ensure the functioning of the nervous system
3) fundamentals of electrophysiological and imaging research methods

be able to:

1) Apply the methods of biophysics to solve fundamental professional problems;
2) Creatively use in scientific activity knowledge about the possibilities of applying modern methods of biophysics;
3) Highlight and systematize the main ideas in scientific texts;
4) Critically evaluate any incoming information, regardless of the source;
5) Generate new ideas and methodological solutions;
6) Carry out the design of their scientific activities;
7) Present your scientific results in oral reports.

master:

1) Methods of theoretical and experimental research;
2) Skills of search (including using information systems and databases), processing, analysis and systematization of information;
3) Skills of critical analysis and assessment of modern scientific achievements.

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	Introduction to nervous system. Key components of the nervous system	2			2
2	Evolution of nervous system, modular and hierarchical organization of the brain	2			2
3	Part 1. Key modules and components of the nervous system: neurons. Part 2. Key modules and components of the nervous system: glial cells	2			2
4	Architecture and physiological properties of the main modules of nervous system. Synapses and ion channels	2			2
5	Ion channels of the nervous system. Crystal structure and molecular principles of functioning	2			2
6	Formation of synapses and synaptic plasticity	2			2
7	Molecular organization and function of presynaptic terminals	2			2
8	Key modules of electrical information transfer. Part 1. Molecular basis and principles of the voltage-gated ion channels functioning. Part 2. Molecular architecture of voltage-gated ion channels	2			2
9	Part 1. Synaptic transition. Molecular organization of neurotransmitters and receptors. Part 2. Synaptic transition. Architecture and molecular basis of excitatory receptors and synapses functioning	2			2
10	Part 3. Synaptic transition. Inhibitory ionotropic receptors of nervous system: GABA- and glycine Cys-Loop receptors	2			2
11	Part 1. Metabotropic receptors. General principles of G-proteins functioning	2			2
12	Part 2. Metabotropic receptors. Metabotropic glutamate. Glutamate, GABA and AX receptors	2			2
13	Channelopathies - diseases caused by dysfunction of ion channels	2			2

14	General principles and techniques of electrophysiological recordings	2			2
15	Methods for visualizing of specific receptors and channels. Methods for monitoring and modulation activity of cells in neuronal system	2			2
AH in total		30			30
Exam preparation		30 AH.			
Total complexity		90 AH., credits in total 2			

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

Semester: 2 (Spring)

1. Introduction to nervous system. Key components of the nervous system

Main features, structure and function of the nervous system. Molecular and modular organization of the nervous system. Types of intercellular interactions: electrical, humoral and synaptic communications. The synapse is a key multimolecular complex of the nervous system. Chemical and electrical types of synapses. Neurotransmitters in nervous system.
Neural circuits. Central nervous system and peripheral nervous system. Somatic and autonomic nervous systems. Hierarchical organization of the nervous system.

2. Evolution of nervous system, modular and hierarchical organization of the brain

Stages of evolution of nerve cells, nervous systems. The pattern of sequential brain development - cephalization. Evolution of vertebrate brain. The enlargement of the cerebral cortex in the process of primate evolution. Facts and myths about the brain. Nervous system of vertebrates and invertebrates.

3. Part 1. Key modules and components of the nervous system: neurons. Part 2. Key modules and components of the nervous system: glial cells

The main components of the nervous system: neurons and glial cells. Camillo Golgi and Santiago Ramon y Cajal - the founders of neuroscience. Neuronal doctrine. Structure and function of cellular elements. Typical neuron morphology, electrical properties and functions. Classification of neurons. Neurons - elementary analogue-digital modules.

Main types of glial cells: astrocytes, oligodendrocytes, microglia, ependymal cells, satellite and Schwann cells.
Main functions of glial cells.

4. Architecture and physiological properties of the main modules of nervous system. Synapses and ion channels

Synapses are a key module of the nervous system. A brief history. Types of synapses: chemical excitatory and inhibitory, electrical synapses.
Ionic channels fundamental instruments of excitation and inhibition: types of channels and general principles of organization.

5. Ion channels of the nervous system. Crystal structure and molecular principles of functioning

Families of ion channels of the nervous system.
Ionotropic and metabotropic receptors.
General architecture and crystal structure of voltage-gated and receptor-operated channels.

How do ion channels operate? Single-channel properties. Molecular principles of ionic selectivity. How activation of channels integrates in synaptic potentials.

6. Formation of synapses and synaptic plasticity

Multi-storey architecture of synapses. Principles of the molecular organization of excitatory and inhibitory synapses.

Plasticity of synaptic transmission. Dendritic spines - morphological modules of brain plasticity. Spine mobility. The role of the actin cytoskeleton and calcium in the synaptic plasticity.

7. Molecular organization and function of presynaptic terminals

Basic organization of presynaptic terminals.

Key steps of neurotransmitter release.

Termination of the neurotransmitter action.

Presynaptic vesicles organization and function.

Delivery of neurotransmitter to presynaptic terminals. Anterograde and retrograde axonal transport. Motor proteins: dyneins and kinesins.

Molecular organization of the main proteins that ensure the fusion of vesicles with the presynaptic membrane: SNARE complex and Synaptotagmin. Neuropathology associated with impaired axonal transport.

8. Key modules of electrical information transfer. Part 1. Molecular basis and principles of the voltage-gated ion channels functioning. Part 2. Molecular architecture of voltage-gated ion channels

Basic properties of neurons. The main types of voltage-gated channels. Action potential: main components. Sodium channels: molecular organization. Variety of sodium channels Sodium channel blockers.

Calcium channels organization and function.

Potassium channels: molecular organization. Molecular basis of ionic selectivity. Families of voltage-gated ion channels. Crystal structure of potassium and sodium channels. Specific blockers of potassium and sodium channels.

Some diseases resulted from dysfunction of voltage-gated channels.

9. Part 1. Synaptic transition. Molecular organization of neurotransmitters and receptors. Part 2. Synaptic transition. Architecture and molecular basis of excitatory receptors and synapses functioning

Diversity and classification of neurons. Anatomy of neurons. Signal transmission by excitatory and inhibitory synapses. Types of synaptic contacts. Fast and slow synaptic transmission: ionotropic and metabotropic receptors

Classes of neurotransmitters. Receptor families of rapid synaptic transmission. Ionotropic glutamate receptors: classification and pharmacology. Crystal structure of NMDA and AMPA glutamate receptors. Unique complexity of organization and management of NMDA receptors: block by Mg ions; high permeability to calcium ions and co-activation with glycine or serine.

10. Part 3. Synaptic transition. Inhibitory ionotropic receptors of nervous system: GABA- and glycine Cys-Loop receptors

Families of synaptic receptor-operated channels.

Cys-loop receptor channels. GABA - the main inhibitory neurotransmitter in the central nervous system. Structural organization of GABA receptors. Ionotropic GABAA and GABAC receptors.

How activation of GABA receptors causes inhibition. Pharmacology of GABA receptors.

Glycine is the main inhibitory neurotransmitter in the spinal cord. Some functions of glycine receptors. Classification of glycine receptor subunits. Distribution of glycine receptors in nervous system. Pathologies of the glycinergic system.

11. Part 1. Metabotropic receptors. General principles of G-proteins functioning

What are metabotropic receptors? What are G protein receptors? Types of G-protein subunits. Basic principles of action. Some pathologies resulted from dysfunction of metabotropic receptors.

12. Part 2. Metabotropic receptors. Metabotropic glutamate. Glutamate, GABA and AX receptors

Functional modules and types of metabotropic receptors. Distribution of metabotropic glutamate receptors. Mechanisms of glutamate receptors physiological functioning. Modulation of endocannabinoid-dependent neurotransmitter release. Some other physiological functions

Short history of metabotropic GABA receptor. Structure organization, distribution, pharmacology and main functions.

Muscarinic acetylcholine receptors. Molecular architecture, main families, distribution, pharmacology and physiological functions.

13. Channelopathies - diseases caused by dysfunction of ion channels

Main classes of channelopathies.

Inherited channelopathies: neurological and cardiac channelopathies.

Autoimmune channelopathies: Myasthenia gravis; Lambert-Eaton myasthenic syndrome; Paraneoplastic cerebellar degeneration (PMD); Limbic encephalitis.

14. General principles and techniques of electrophysiological recordings

Short history of electrophysiology. Main approaches for cellular electrical signals recording: intracellular microelectrode recording; voltage-clamp and current clamp; patch-clamp technique; extracellular recording; heterologous expression of ionic channels in cell lines and Xenopus oocytes. What information can be obtained from recording of electrical signals.

15. Methods for visualizing of specific receptors and channels. Methods for monitoring and modulation activity of cells in neuronal system

How to visualize specific molecules in living cells? Fluorescence and luminescent process. Visualizing of functional proteins using genetically encoded biosensors. Confocal and multiphoton microscopy.

Optosensoric and photopharmacology and optogenetic.

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

1. Classroom with a media projector and screen, Internet access.
2. Required software.
3. Providing independent work - databases on logs.

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

Main literature

1. Мозг, познание, разум: введение в когнитивные нейронауки [Текст] : в 2 т. = Cognition Brain and Consciousness / Б. Баарс, Н. Гейдж; пер. 2-го англ. изд. под общ. ред. В. В. Шульговского .— М : БИНОМ.Лаборатория знаний, 2014 .— Т. 1. - 2014. - 544 с.

2. Мозг, познание, разум: введение в когнитивные нейронауки [Текст] : в 2 т. = Cognition Brain and Consciousness / Б. Баарс, Н. Гейдж; пер. 2-го англ. изд. под общ. ред. В. В. Шульговского .— М : БИНОМ.Лаборатория знаний, 2014 .— Т. 2. - 2014. - 464 с.

3. Brodal, P. (2004). The central nervous system: structure and function. oxford university Press.
4. Hille, B. (2001) Ion Channels of Excitable Membranes, 3rd edition
5. Alberts, B., Bray, D., Wilson, J. H., Lewis, J., Raff, M., Roberts, K., & Watson, J. D. (1989). Molecular biology of the cell (Vol. 2). Courier Corporation.
6. Николлс Дж.Г, Мартин А.П., Валлас Б.Дж., Фукс П.А. От нейрона к мозгу. Едиториал УРСС, 672 стр., 2003
7. Aschcroft F.M. Ion channels and disease. Academic Press, 481 pages, 2000
8. Bear M.F., Connors B.W., Paradiso M.A. Neuroscience. Exploring the brain. Lippincott Williams and Wilkins, 928 pages, 2006.
9. Eric R. Kandel, J. H. Schwartz & T. M. Jessell "Principles of neural science", 3rd edn. Elsevier, 1991.
10. Брежестовский П.Д. (2010) Физиология синапса: от молекулярных модулей до ретроградной модуляции. Российский физиологический журнал. 96(9), 841-860
11. Брежестовский П.Д. (2011) Архитектура ионных каналов биологических мембран. Биофизика, 56 (1), 51–64.
12. Брежестовский, П. Д., & Зефиров, А. Л. (2019). Оптогенетика и фотофармакология—эффективные инструменты управления активностью клеток с помощью света. Казанский медицинский журнал, 100(1).

Additional literature

1. Yeagle, P. 2000. The Structure of Biological Membranes, CRC Press LC
2. Stillwell, W. 2013. An Introduction to Biological Membrane:From Bilayers to Rafts, Elsevier.
3. Petty, H., L. 1993. Molecular Biology of Membranes (Structure and Function), Plenum Press, New York.
4. Ghysen, A. (2003). The origin and evolution of the nervous system. International Journal of Developmental Biology, 47(7-8), 555-562.
5. Gordon M. Shepherd "The synaptic organization of the brain", 3rd edn. Oxford, 1990.
6. Neher E. and Sakmann B. Single-channel recording, Springer, Boston, MA, 1995.

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

https://www.youtube.com/watch?v=Q-gAXMMwT3Y
https://youtu.be/ZZQzMeFoZY0
https://www.youtube.com/watch?v=HYLyhXRp298
https://www.youtube.com/watch?v=XHT9QxEINSo
https://www.youtube.com/watch?v=ZBSo_GFN3qI

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

When preparing and conducting lectures, the Internet is used.
In addition, Libre Office is used, as well as the Ink Scape graphics package.

9. Guidelines for students to master the course

A student studying the 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 and concepts, be able to apply the knowledge gained to solve various problems.
Successful completion of the course requires:
- attendance of all classes provided for by the curriculum for the discipline;
- keeping a synopsis of classes;
- student's intense independent work.

Independent work includes:
- reading recommended literature;
- study of educational material, preparation of answers to questions intended for independent study;
- solving problems offered to students in the classroom;

- preparation for the performance of tasks of the intermediate certification.

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

It is important to achieve an understanding of the material being studied, not its mechanical memorization. If a student finds it difficult to study certain topics, questions, he/she should seek advice from a teacher.

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

SUPPLEMENT

Assessment funds for course (training module)

major:	Applied Mathematics and Physics
specialization:	General and Applied Physics/Общая и прикладная физика Landau Phystech-School of Physics & Research Chair of Biophysics
term:	1
qualification:	Master

Semester, form of interim assessment: 2 (spring) - Exam

Author: I.V. Manukhov, doctor of biological sciences

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
UC-1 Use a systematic approach to critically analyze a problem,and develop an action plan	UC-1.1 Systematically analyze the problem situation, identify its components and the relations between them
	UC-1.2 Search for solutions by using available sources
	UC-1.3 Develop a step-by-step strategy for achieving a goal, foresee the result of each step, evaluate the overall impact on the planned activity and its participants
UC-4 Use modern communication tools in the academic and professional fields, including those in a foreign language	UC-4.1 Exchange business information in oral and written forms in Russian and at least one foreign language
	UC-4.2 Use the acquired skills to write, translate, and edit various academic texts (abstracts, essays, reviews, articles, etc.)
	UC-4.3 Present the results of academic and professional activities at various academic events, including international conferences
	UC-4.4 Use modern ICT tools for academic and professional collaboration
UC-6 Determine priorities and ways to improve performance through self-assessment	UC-6.1 Achieve personal growth and professional development, determine priorities and ways to improve performance
	UC-6.2 Evaluate performance results in correlation with the set objectives and applied methods
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of physical and mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional settings
Gen.Pro.C-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings
	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form within professional communication
Gen.Pro.C-3 Select and/or develop approaches to professional problem-solving with consideration to the limitations and specifics of different solution methods	Gen.Pro.C-3.1 Analyze problems, plan research strategy to achieve solution(s), propose, and combine solution approaches
	Gen.Pro.C-3.2 Employ research methods to solve new problems and apply knowledge from various fields of science (technology)
	Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations of the implementation of the obtained solutions in practice
Gen.Pro.C-4 Successfully perform a task, analyze the results, and present conclusions, apply knowledge and skills in the field of physical and mathematical sciences and ICTs	Gen.Pro.C-4.1 Apply ICT knowledge and skills to find and study scientific literature and use software products
	Gen.Pro.C-4.2 Apply knowledge in the field of physical and mathematical sciences to solve problems, make conclusions, and evaluate the obtained results
	Gen.Pro.C-4.3 Justify the chosen method of scientific research

Gen.Pro.C-5 Undertake professional training, achieve professional growth, and become a team leader in a professional sphere, tolerant of social, ethnic, religious, and cultural differences	Gen.Pro.C-5.1 Tolerate social, ethnic, religious, and cultural differences in teamwork
	Gen.Pro.C-5.2 Manage a small professional team
	Gen.Pro.C-5.3 Apply new knowledge and achieve personal and professional growth
Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems and obtain new scientific results	Pro.C-1.1 Locate, analyze, and summarize information on current research findings within the subject area
	Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model
	Pro.C-1.3 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results
Pro.C-3 Use research and testing equipment (devices and installations, specialized software) in a selected subject field	Pro.C-3.1 Understand the operating principles of the equipment and specialized software

2. Competency assessment indicators

As a result of studying the course the student should:

know:

1) contemporary information about the formation of the nervous system
2) modular and hierarchical organization of the brain, about the types of intercellular interactions, architecture and physiological properties of the main protein modules that ensure the functioning of the nervous system
3) fundamentals of electrophysiological and imaging research methods

be able to:

1) Apply the methods of biophysics to solve fundamental professional problems;
2) Creatively use in scientific activity knowledge about the possibilities of applying modern methods of biophysics;
3) Highlight and systematize the main ideas in scientific texts;
4) Critically evaluate any incoming information, regardless of the source;
5) Generate new ideas and methodological solutions;
6) Carry out the design of their scientific activities;
7) Present your scientific results in oral reports.

master:

1) Methods of theoretical and experimental research;
2) Skills of search (including using information systems and databases), processing, analysis and systematization of information;
3) Skills of critical analysis and assessment of modern scientific achievements.

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

Examples of topics of individual courseworks/reports:

1. Molecular organization of the main proteins that ensure the fusion of vesicles with the presynaptic membrane: SNARE complex and Synaptotagmin. Neuropathology associated with impaired axonal transport.
2. Families of voltage-gated ion channels. Some diseases resulted from dysfunction of voltage-gated channels.
3. Crystal structure of NMDA and AMPA glutamate receptors. Unique complexity of organization and management of NMDA receptors.
4. GABA - the main inhibitory neurotransmitter in the central nervous system.
5. Glycine is the main inhibitory neurotransmitter in the spinal cord.
6. Visualizing of functional proteins using genetically encoded biosensors.

4. Evaluation criteria

Checking questions:
What is the nervous system supposed to do?
Key components for the functioning of the nervous system?
Point out a few differences between the nervous system of invertebrates and vertebrates
What changes in the brain characterize more advanced vertebrates?
Which cells (neurons or glia are more expressed in the cerebral cortex and cerebellum?
What cells are important for the formation of myelin in the peripheral nervous system?
General principles of the molecular architecture of receptor-gated and voltage-gated channels.
Ionotropic and metabotropic receptors main differences
How can different types of receptors and channels be co-localized in the postsynaptic membrane?
Which cells perform myelin isolation of the axons of the neurons of the central nervous system?

Examples of exam question papers:
Question paper 1.
1. What is the nervous system supposed to do?
2. What cells are important for the formation of myelin in the peripheral nervous system?
Question paper 2.
1. Key components for the functioning of the nervous system?
2. General principles of the molecular architecture of receptor-gated and voltage-gated channels.

Assessment “excellent (10)” is given to a student who has displayed comprehensive, systematic and deep knowledge of the educational program material, has independently performed all the tasks stipulated by the program, has deeply studied the basic and additional literature recommended by the program, has been actively working in the classroom, and understands the basic scientific concepts on studied discipline, who showed creativity and scientific approach in understanding and presenting educational program material, whose answer is characterized by using rich and adequate terms, and by the consistent and logical presentation of the material;

Assessment “excellent (9)” is given to a student who has displayed comprehensive, systematic knowledge of the educational program material, has independently performed all the tasks provided by the program, has deeply mastered the basic literature and is familiar with the additional literature recommended by the program, has been actively working in the classroom, has shown the systematic nature of knowledge on discipline sufficient for further study, as well as the ability to amplify it on one’s own, whose answer is distinguished by the accuracy of the terms used, and the presentation of the material in it is consistent and logical;

Assessment “excellent (8)” is given to a student who has displayed complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently performed all the tasks stipulated by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (7)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in the answer, has independently performed all the tasks provided by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (6)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently carried out the main tasks stipulated by the program, studied the basic literature recommended by the program, showed systematic character of his knowledge of the discipline, which is sufficient for further study;

Assessment “good (5)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, mastered the basic literature recommended by the program, made some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors by himself;

Assessment “satisfactory (4)” is given to a student who has discovered knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, learned the main literature but allowed some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors under the guidance of a teacher;

Assessment “satisfactory (3)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, not showed activity in the classroom, independently fulfilled the main tasks envisaged by the program, but allowed errors in their implementation and in the answer during the test, but possessing necessary knowledge for elimination under the guidance of the teacher of the most essential errors;

Assessment “unsatisfactory (2)” is given to a student who showed gaps in knowledge or lack of knowledge on a significant part of the basic educational program material, who has not performed independently the main tasks demanded by the program, made fundamental errors in the fulfillment of the tasks stipulated by the program, who is not able to continue his studies or start professional activities without additional training in the discipline in question;

Assessment “unsatisfactory (1)” is given to a student when there is no answer (refusal to answer), or when the submitted answer does not correspond at all to the essence of the questions contained in the task.

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

The course is graded at an exam. The questioning starts with a random task assigned to each student and time given for completion of the task. No aids are allowed. The student then proceeds to a chat with the examiner, at which he/she presents his/her solution to the assigned task. The examiner then asks the student several questions that evenly cover the course content. A final grade is assigned based on the quality of answers and demonstrated level of understanding.