NATIONAL ACADEMY OF SCIENCES OF UKRAINE
INSTITUTE OF CELL BIOLOGY NAS OF UKRAINE

APPROVED
The Scientific Council
Institute of Cell Biology
NAS of Ukraine
Protocol No. 7
dated July 12, 2016

Chairman of the Scientific Council
Institute of Cell Biology
NAS of Ukraine,
Academician of NAS of Ukraine

_____ A.A. Sybirny

EDUCATIONAL PROGRAM

FIELD OF KNOWLEDGE	09 - BIOLOGY
SPECIALTY	091 - BIOLOGY
LEVEL OF EDUCATION	THIRD (EDUCATIONAL-SCIENTIFIC)

Lviv - 2016

Program Profile - Doctor of Philosophy in Biology
Type of diploma and scope of work - Doctor of Philosophy diploma, first academic degree, 4 academic years, 40 ECTS credits
Scientific Institution - Institute of Cell Biology, NAS of Ukraine, Lviv
Accrediting Institution - Ministry of Education and Science of Ukraine, Ukraine,
10 Pobedy Ave., Kyiv, 01135
Accreditation period is 2016
Program Level - QF for EHEA - Third Cycle, EQF for LLL - Level 8; NQF of Ukraine - level 8

1. General characteristics of educational and scientific program

Educational-scientific program of preparation of Doctor of Philosophy is valid at the Institute of Cell Biology of NAS of Ukraine

Degree: Doctor of Philosophy in Knowledge 09 Biology, specialty 091 Biology.
Specializations: Cytology, cell biology, histology; Microbiology.
Educational level: the third (educational-scientific) level of higher education.
Regulatory period of study: four years.
Form of study: full-time, part-time.

The fulfillment of the educational-scientific program is a necessary condition for the academic preparation of the specialist of qualification of Doctor of Philosophy in the specialty 091 Biology.
The program establishes:
- the normative content of training at the Institute of Cell Biology of the NAS of Ukraine, the volume and level of assimilation in the process of preparation in accordance with the requirements of educational and qualification characteristics of "Doctor of Philosophy" in the field of knowledge 09 Biology, specialty 091 Biology;
- a list of training courses for the doctor of philosophy;
- training period.

The program is intended for certification of Doctor of Philosophy and attestation of graduate student at the Institute of Cell Biology of NAS of Ukraine

2. Contents of the educational and scientific program

The educational and scientific program consists of educational and scientific components:
1. Professional theoretical training that provides for the improvement of educational level in the relevant specialty and which contains the normative and free choice of graduate student, divided between the following components: in-depth knowledge of the specialty, general competences, universal skills and linguistic competences.
2. Research work.
3. Preparation and defense of the dissertation.

The distribution of the components of the educational program of training of Doctor of Philosophy and compulsory study time in cycles is shown in Table 1.

№	Cycle of Disciplines	Teaching hours	Credits
1	Professional Theoretical Training	1200	40
1.1	Regulatory Courses	660	22
1.1.1	In-depth knowledge of the specialty	210	7
1.1.2	General Scientific Competences	120	4
1.1.3	Universal Skills	120	4
1.1.4	Language competences	210	7
1.2	Disciplines for choosing a graduate student	540	18
1.2.1	In-depth knowledge of the specialty	270	9
1.2.2	General competencies	270	9
2	Research	–	–
3	Preparation and defense of the thesis	–	–

Normative content of educational program:

1. Knowledge system in the form of a list of disciplines with a minimum number of teaching hours / credits.
2. Annotations of academic subjects.
3. Assignment of the qualification of Doctor of Philosophy in Knowledge 09 Biology is carried out after completing the educational component and defending the dissertation.
4. The Institute has the right to change the names of the disciplines according to the established procedure.

3. The purpose and objectives of the educational and scientific program

The purpose of the educational program for the preparation of the Doctor of Philosophy in Biology is to develop general and professional competences for providing training of higher qualification personnel for research, analytical work, scientific consulting, as well as in scientific and pedagogical activity.
The main tasks include:
- Deepening of theoretical and professional training.
- Increasing the level of professional and teaching skills.
- Acquisition of theoretical knowledge, skills and other competences sufficient to produce new ideas, to solve complex problems in the field of biology.
- Development of research skills for independent research.
- Development of skills in writing and designing the results of scientific works.
- Acquiring knowledge and practical teaching skills at higher education institutions.

4. Evaluation system

The results of the graduate student's educational activity are evaluated on a 100-point scale. Forms of control - exam or credit.
The ratio of classroom hours to hours for independent work is 0.818.

5. Research work of the graduate student

The graduate student conducts scientific research in accordance with the individual plan of scientific work, which defines the content, timing and scope of research work. The individual plan of the scientific work of the applicant agrees with the scientific supervisor and the Scientific Council of the Institute approves the plan within two months from the date of enrollment of the applicant for graduate study.

6. Postgraduate pedagogical practice

The graduate student completes the pedagogical practice according to the plan during the second and third year of postgraduate study.

7. Graduate programmatic competencies

As a result of postgraduate study, the applicant must be competent to solve complex problems in the field of professional and / or research and innovation activities, which involves a deep rethinking of existing and creation of new holistic knowledge and / or professional practice, which include:
- The most advanced conceptual and methodological knowledge in the field of research and / or professional activity and at the border of subject areas (Knowledge and understanding).
- Development and implementation of projects, including their own research, which make it possible to rethink existing and create new holistic knowledge and / or professional practice, and to solve significant social, scientific, cultural, ethical and other problems (application of knowledge and understanding).
- Critical analysis, evaluation and synthesis of new and complex ideas (Formation of statements).
- Communicating in a dialogue mode with a broad scientific community and the public in a specific field of scientific and / or professional activity (Communication skills).
- Initiation of innovative complex projects, leadership and complete autonomy during their implementation. Social responsibility for strategic decision-making. Ability to self-develop and self-improve throughout life, responsible for teaching others (Learning Skills).

8. Distribution of the content of the educational and scientific program and study time by the disciplines of preparation

Discipline	Total volume	
	Credits	Hours
1. NORMATIVE DISCIPLINES		
Problems of modern biology	3	90
Scientific Workshop	4	120

Philosophy	4	120
Teaching Practice	4	120
Foreign language by profession	7	210
Total	22	660
2. DISCIPLINES OF FREEDOM OF CHOICE OF ASPIRANTS		
1) Cytology and histology 2) Methods of cell biology 3) Animal cell biochemistry	3	90
1) General Microbiology 2) Fundamentals of biotechnology 3) Physiology and biochemistry of microorganisms	3	90
1) Microbial production of proteins 2) Regulation of cell proliferation, differentiation and apoptosis	3	90
1) Pedagogy of higher education 2) Methodology for preparing the scientific publication	3	90
1) Psychology of higher education 2) Preparation of a research and innovation project	3	90
1) Information technology and programming 2) Intellectual property and technology transfer	3	90
Total	18	540
Total of during the study	40	1200

9. Annotations of disciplines

1. NORMATIVE DISCIPLINES

"Problems of modern biology"

Purpose: formation of a complex of knowledge about current problems of biology, study of the main problems and trends in the development of modern biology, as well as the analysis of applied aspects of the application of the achievements of modern biology in medicine and biotechnology of organisms.
Subject: systematic approach to the study of the peculiarities of the functioning of different living organisms and systems of organisms; the concept of a genome, transcript, proteome, glyc, interact, physio, as well as methods of studying these systems; disturbances in the functioning of living organisms; bioethical standards to be observed in the study of living organisms.
Course Content:
• Current problems of biology in the world and in Ukraine.
• Modern methods of monitoring and controlling the state of biosystems.
• Systems biology and its main problems.
• Biological aspects of integrated medicine.
• Social and ethical issues in biology and medicine.
• The cellular and subcellular organization of prokaryotes and the functions they determine.
Place of discipline in the structure of the course: the graduate student studies in the first year of study.

Scientific Workshop

Purpose: improving the skills of presenting their own scientific results (including in a foreign language), analyzing reports of other scientists on new results, concepts and theories, qualified conducting of scientific discussions.
Subject: new results, concepts, theories, scientific report preparation (text, presentation), answers to questions, discussion.
Place of discipline in the course structure: the graduate student participates in a scientific seminar during the first or fourth years of study.

"Philosophy"

Purpose: to form a complex of knowledge about the main features of the philosophical and intellectual process in the XX - early XXI centuries in their connection with modern civilizational, social, cultural and scientific progress.

Subject: worldview, spiritual-practical, moral-ethical and theoretical attitude of man to reality and the main intellectual factors of his transformation and subjective transformation of the person.

Course Content:

• The emergence of philosophy and its relevance: worldview, philosophy, metaphysics and science. Global Challenges to Mind and Philosophy.
• Linguistic turn, the origins of analytical philosophy and its current state.
• Positivist and existential traditions in contemporary philosophy as paradigmatic manifestations of Scientism and anti-Scientism.
• Metaphysics and ontology in the aspect of non-classical philosophy.
• The nature of knowledge, its sources of truth and the limits of scientific knowledge.
• Problems of mind and consciousness and its understanding in phenomenology and hermeneutics.
• The philosophy of the "embodied mind" in the aspect of the development of cognitive science.
• Classical, non-classical and post-classical models of science development.
• Philosophical anthropology and the problem of man.
• Social philosophy and philosophy of history and culture.
• The situation of postmodernism in contemporary philosophy and its semiotic conditionality.

Place of discipline in the course structure: PhD students study in the first year of study.

"Pedagogical practice"

Aim: improvement of knowledge, formation of postgraduate system of skills of self-organization of pedagogical activity, acquisition of pedagogical experience of organization of educational process in higher educational institution.

Subject: Practical pedagogical activity as a teacher, adaptation to the educational environment of a higher educational institution.

Content of practice:

• Attendance and analysis of educational activities conducted by teachers at higher education institutions.
• Definition of conceptual principles of organization of pedagogical activity in higher education.
• Familiarity with the work program, the content of the training course (specialty).
• Planning of structure, development of methodology and implementation of preparation for conducting lectures, seminars, practicals, and laboratory classes.
• Preparation of educational and methodological support of the educational process in higher education.
• Writing syllabus notes.
• Contacting and organizing pedagogical interaction with students.
• Conducting different types of training.
• Carrying out an analysis of colleagues and self-organized training sessions;
• Organization of students' independent work.
• Introduction of innovative educational technologies and copyright techniques into the educational process.
• Analysis of pedagogical situations and independent decision making on problem solving.

Place of discipline in the structure of the course: postgraduate students pass in the third year of study.

“Foreign language by profession”

Objective: To develop the language competencies of C-1 graduate students, which will enable them to communicate freely and effectively achieve scientific and professional goals in a foreign language.

Subject: Grammar, stylistic and discursive aspects of a foreign language of scientific and professional orientation.

Course Content:

• basic morphological and syntactic categories of foreign language broadcasting;
• Leading characteristics of scientific style;
• means of expressing certain communicative intentions;
• techniques for reading scientific texts in foreign languages;

• formal rules of semantic and textual models for the generation of utterances inherent in the scientific field;
• techniques for writing annotations and abstracts;
• creating presentations for international scientific conferences;
• structure and composition of the main types of scientific texts;
• structure and composition of oral messages on scientific topics;
• algorithms for writing scientific texts;
• types of scientific and professional correspondence in foreign languages.
Place of discipline in the course structure: postgraduate students study in the first year of study.

2. DISCIPLINES OF FREEDOM OF CHOICE OF ASPIRANTS

Cytology and Histology

Purpose: to give an idea of the place of cytology and histology in the system of biological sciences, to present features of the structural and functional organization of prokaryotic and eukaryotic cells, to describe the current state of development and the role of cytology and histology in normal and pathological physiology.

Subject:
• Research methods of cytology and histology, cyto- and histochemistry.
• Structural and functional organization of the cell.
• Intercellular interactions. Chemotaxis. Contact structures of cells. Synapses of nerve cells. Cellular interactions during the immune response.
• General histology. Basic tissues and systems of the human body.

Course Content:
- Principles of collecting, fixing and staining of material for cytological and histological examination.
- Microscopy: light, phase contrast, interference, dark field, polarization, luminescent, electron, confocal.
- Separation of cellular populations. Labeling of cells. Flow cytofluorimetry. Immunomagnetic cell separation.
- Lifetime cultivation of cells and tissues. Cryopreservation of cells.
- The general plan of structure of a cell. Extracellular matrix. Non-cellular forms of living matter organization.
- Plasma membrane. Glycocalyx. Cytoplasm. Subcellular organelles and inclusions. Cytoskeleton. Golgi apparatus. Lysosomes. Peroxisomes. Mitochondria and plastids. Nuclear apparatus of cells and chromatin.
- Cell life cycle. Mitosis. Meios. Cell differentiation. Aging and death (apoptosis) of cells.
- Histological technique. Devices and materials for fixation of tissue preparations. Microtome.
- Early human embryogenesis. Characteristics of gametes and gametogenesis. Fertilization. Early human embryogenesis. Crushing, implantation. Gastrulation. Histo- and organogenesis. Extracellular organs. Critical periods of embryogenesis.
- The concept of fabrics. Classification of fabrics.
- Epithelial tissue.
- Glands.
- Blood and lymph. Hemopoiesis. Calculation of leukocyte formula.
- Connective tissues. Cartilage. Bone tissue.
- Muscle tissue.
- Nervous tissue. Central nervous system. Peripheral nervous system. The organs of vision. The organs of hearing and balance.
- Skin and its derivatives.
- Cardiovascular system.
- Organs of hematopoiesis and immune protection.

- Endocrine system (central organs). Endocrine system (peripheral organs).
- General characteristics of the digestive system. Morphofunctional characteristics of the stomach and intestines.
- Large salivary glands. Large digestive glands (liver and pancreas).
- Respiratory system.
- Urinary system.
- Male sexual system.
- Female reproductive system. Ovogenesis, ovary, oviduct. Female reproductive system. Uterus, ovarian-menstrual cycle.

Place of discipline in the course structure: studies for the graduate student of the second year of study.

"Methods of cell biology"

The purpose of the course is to acquaint the students with the basic methodological approaches used in the work with experimental cell models to study the functioning of cells and tissues outside the body.

Course subject:

• Conditions for cell growth outside the body
• Devices and materials needed to maintain cell viability in vitro
• Polypeptide growth factors
• Study the features of the cell cycle
• Methods and instruments needed to study the functioning and dying of animal and human cells;

Course Content:

- Introduction. A brief history of animal cell culture in vitro.
- Methods of isolation of cells from tissues and organs of animals and humans and methods of cryopreservation.
- Checking the purity and quality of cell cultures. Detection of bacterial, fungal, mycoplasma and viral infection of cell cultures. Evaluation of malignant cell transformation.
- Reagents, materials and appliances used for cell cultivation in vitro. The chemical composition of the culture medium.
- High molecular weight polypeptide growth promoters that are part of the culture medium. Serum as a major source of polypeptide growth factors. Properties of serum from different sources. Other sources of growth factors.
- Polypeptide growth factors are the main regulators of animal and human cell proliferation and differentiation. Brief description of different families of growth factors.
- Physical factors required for successful cell cultivation: temperature, humidity, gas supply (5% CO2), free substrate surface for the cell. Contact inhibition of cell growth and its mechanisms.
- Cell cycle as the main indicator of cell proliferative activity, determination of the main parameters of the cell cycle, cell synchronization in culture, methods of synchronization and its meaning, the concept of restriction point, its biochemical content.
- methods of studying the proliferative activity of cells, checking their viability; operating principles of flow cytofluorimeter.
- Specific receptors of polypeptide growth factors and determination of indicators (kinetics) of interaction of growth factors with specific receptors.
- Light and fluorescence microscopy in the study of cytomorphological processes. Characterization of fluorescent labels. Green fluorescent protein and its use in cell biology.
- Basic biochemical processes occurring in cells and methods of their study (Western blot analysis of cellular proteins, electrophoretic study of DNA fragmentation of apoptotic cells, DNA comet analysis).
- Basic approaches for the detection of apoptotic cells (test with Annexin 5, lectin-cytochemical study of the redistribution of glycoconjugates on the cell surface, chromatin condensation, nucleus fragmentation, formation of apoptotic bodies).
- Hybridoma biotechnology and monoclonal antibodies. "Humanization" of antibodies.
- Detection and isolation of specific cells by functional nanoparticles.

Place of discipline in the course structure: the graduate student studies in the second year of study.

"Genertal microbiology"

Aim: Acquaintance with diversity of prokaryotic and eukaryotic microorganisms and viruses, structure of prokaryotic cell, methods of microorganism cultivation and sterilization of nutrient media.

Presentation of the classic and modern methods used in bacterial classification. Explanation of the major catabolic and anabolic processes in microorganisms including pathways involved in accumulation of different fermentation products. It is also planned to display main aspects of genetic exchange in bacteria, methods of gene cloning and regulation of gene expression in bacteria. One additional goal is acquainting with geochemical activities and biotechnological use of microorganisms. After course is completed, the students acquire knowledge on varieties of microorganisms including their appearance in different biotopes as well as on the practical use of microorganisms.

Subject: Prokaryotic (bacteria) and eukaryotic (yeasts, filamentous fungi) microorganisms as well as viruses of animals, plants and bacteria.

The content of the course:

- Which organisms studies microbiology?;
- Microorganism spread in nature, their geochemical role;
- Cell structure of prokaryotic and eukaryotic microorganisms;
- Cell wall structure of Gram-positive and Gram-negative bacteria;
- Methods of growth assay in microorganisms;
- Phylogenetic and artificial classification of bacteria;
- Main groups of bacteria according to Bergey manual;
- Viruses, their structure and propagation;
- Fungi, their structure, propagation and classification;
- Biotechnological role of microorganisms;
- Main catabolic and anabolic pathways in microorganisms;
- Fermentations and their metabolic pathways;
- Exchange of genetic materials in bacteria;
- Mutagenesis, recombination and reparation;
- Methods of molecular cloning;
- Regulation of gene expression in bacteria and yeasts.

The position of the discipline in the structure of teaching: PhD student has the course "General microbiology" at the second year of studies.

"Physiology and biochemistry of microorganismsв"

Aim: to spread and deepen knowledge on peculiarities of structure and functions of microorganisms, systematize modern ideas on metabolic capacities of various physiological groups of microorganisms, their important role in ecological processes, utilization in biotechnology and importance for medicine.

Subject:

- Structure and functions of pro- and eukaryotic cell, varieties of main and alternative metabolic pathways;
- Microbial nutrition, growth and their control, mechanisms of solute transport, energy production in microorganisms;
- Pathways of lipid, amino acid, nucleotide and organic acid biosynthesis and industrial production of these compounds using microorganisms;
- Interaction between microorganisms and their stress response.

The content of the course:

- Cell structure and function.
- Membrane transport. Specific transport systems. Metabolite movement inside the cell and their storage. Protein secretion.
- Growth and cell differentiation.
- Microbial nutrition. Growth and cultivation of microorganisms.
- Diversity of metabolic processes in microorganisms. Central pathways of carbohydrate metabolism. Aerobic and anaerobic respiration. Fermentations. Regulation of respiration and fermentation.
- Characteristics of partial oxidation. Oxidation of one-carbon compounds.
- Oxidation of inorganic substrates by microorganisms.
- Bacterial photosynthesis.

- Biosynthesis of macromolecules. Mechanisms of nitrogen, phosphorus, sulfur, one-carbon fragments assimilation.
- Biosynthesis and carbohydrates, purine and pyrimidine nucleotide.
- Biochemistry and genetics of nitrogen fixation. Nitrogen fixation by symbiotic and free-living bacteria. Regulation of nitrogen fixation. Synthesis of main families of microorganisms.
- Secondary metabolism. Compound transformation by microorganisms.
- Bioluminescence.
- Microorganisms as part of ecosystem. Cell-cell interaction, quorum-sensing.
- Cell response to stress factors in microorganisms.

The position of the discipline in the structure of teaching: PhD student has the course "Physiology and biochemistry of microorganisms" at the second year of studies.

"Basics of of Biotechnology"

Aim: To get acquainted with the history of biotechnology development, the main products of biotechnological production and the producers used in this: microorganisms, animal and plant cells and tissues. Acquaintance with the main components of biotechnology (technical microbiology, engineering enzymology, cell and genetic engineering) and with the connection of biotechnology with other sciences. The course will provide information on classical and molecular methods of selection of biotechnological producers, regulation of enzyme activity and gene expression in prokaryotic and eukaryotic producers and methods of disruption of normal regulation. Materials on the production of major biotechnological products such as biofuels, antibiotics, recombinant proteins, monoclonal antibodies, amino acids, vitamins and more will be presented. Material will be presented on the production and use of enzymes for biological synthesis processes as well as for analytical purposes, including biosensors.

Subject: Microorganisms and cells of higher organisms capable of cost-effective production of low molecular weight chemical compounds and biopolymers.

Course Content:

• What is biotechnology;
• History of biotechnology development;
• Major biotechnology products;
• Major biotechnology producers;
• Methods of regulation of cellular metabolism;
• Regulation of gene expression in prokaryotes and eukaryotes;
• Classic methods of selection of high-yielding strains;
• Genetic engineering methods;
• Designing recombinant producers;
• Animal and plant cells in biotechnology;
• Hybridoma and monoclonal antibodies;
• Low molecular weight compounds and enzymes in biotechnology;
• Immobilized enzymes;
• Analytical biotechnology and biosensors;
• Prospects for the development of biotechnology.

Place of discipline in the course structure: the graduate student studies in the second year of study.

"Animal cell biochemistry"

Objective: To consider, for the first time at the level of systemic cell biology, the physiological processes that occur in the body in the process of life, as well as during the development of pathological conditions (cancer, diabetes, autoimmune diseases) and their treatment. System of all genes-genomics, all information RNAs - transcriptomics, all proteins - proteomics, all carbohydrate-containing compounds - glycomics, all lipid-containing compounds - lipidomics, interaction of all cell biomolecules, first of all, protein-protein or DNA interactomics, and other biological systems. Mechanisms of interaction of different regulatory systems of normal and pathological cells, first of all, of tumor cells, will also be considered.

Subject:

• A systematic approach to the study of the functioning of normal and pathological cells;

• Genomics, transcriptomics, proteomics, glycomics, lipidomics, interactomics, other omics, methods of investigation of these systems and their importance for biomedicine;
• Disruption of systemic (molecular) cell function in common diseases such as cancer, diabetes and autoimmune diseases).

Course Content:

- From classical biology to genomics and proteomics.
- From genomics and proteomics to phenomenology. From phenomenology to the reconstruction of living systems.
- Characterization of the relationship between individual "omics" in the cell.
- Interactomics: protein-DNA and protein-protein interactions.
- Gene regulatory networks of cells.
- Bio-informatics: main methodological approaches, role in modern biology.
- Cell cycle, its structure and regulation. Cell cycle structure, restriction points in the cell cycle and their biochemical content. Cell cycle synchronization in a cell population. The role of Cdk-cyclin complexes in the regulation of the cell cycle.
- Cytokines are a new class of hormone-like regulators of cellular functions. Definition and general characterization of cytokines.
- Oncogens. Proto-oncogens and oncogenes. Molecular mechanisms of action of protein products of protooncogens in a cell. Intracellular localization and biological properties of protein products of protooncogens. Proto-oncogens and oncogenes. Mechanisms of activation of protooncogens. The association of oncogenes with polypeptide growth factors.
- Antioncogens - tumor suppressor genes. Molecular mechanisms of action of antioncogens in a cell.
- Cellular reception. Structure of the Plasma Membrane and Membrane Receptors. Clustering and internalization of ligand-receptor complexes and its biological role.
- Intracellular signaling. Plasma membrane receptors and G proteins: their coupling and role in the mechanisms of action of cytokines. Protein kinase cascades and their role in regulatory signaling in the cell: the Ras / MAPK signaling pathway. Signaling functions of phospholipid cleavage products. Involvement of protein kinases A and C in the transmission of regulatory signals in the cell. JAK / STAT signaling pathway in animal cells. The role of Smad proteins in the regulation of beta-type transforming growth factor cytokines by regulatory signals.
- Regulation of gene expression at different levels. Transcription factors (for example, NF-kB).
- Mechanisms of protein destruction in cells. The role and mechanisms of proteasome function. The role of chaperone proteins in the cell.
- Mechanisms of protein translocation in the cell and mechanisms that determine the localization of proteins in the cell. Secreted and membrane proteins - the practical application of targeted protein localization.
- Molecular mechanisms of cell aging. Theories of animal cell aging.
- Physiological (programmed) cell death (apoptosis) in multicellular eukaryotic organisms. Cytomorphological and biochemical characterization of apoptosis. Inductors of apoptosis. Suppressors of apoptosis. The evolution of apoptosis and its biological role.
- Autophagy - type 2 programmed cell death: cytomorphological and biochemical characteristics.
- Necrosis - unprogrammed (accidental) cell death. Comparative characteristics of cell death by apoptosis and necrosis.
- Phenotypic signs of malignant and transformed cells. Features of regulation of cell proliferation during malignant growth.
- Stem cells. The main sources and methods of obtaining stem cells. Biomedical and ethical problems in the production and use of stem cells.
- Differentiation of cells of multicellular eukaryotic organisms. Features of cell proliferation and differentiation during embryogenesis. Genetic and epigenetic information during development processes. The concept of morphogens.
- Nanobiotechnology and nanomaterials in cell biology and medicine.

Place of discipline in the course structure: the graduate student studies in the second year of study.

Biotechnology of Microbial Protein Production

Aim: mastering of microbiological and genetic-molecular bases of modern bioengineering of proteins: selection of microbial protein overproducers, design of expression cassettes for overproduction and

secretion of protein products, technologies of obtaining hybrid (fusion) proteins, features of post-translational modification of proteins in different types of organisms, chemical modification of proteins *in vitro*, immobilization of enzymes in construction of bioreactors, mastering of the modern fundamentals of protein engineering, approaches for production of artificial, semi-synthetic proteins, non-proteinous enzymes, argumentation of the advantages of using genetically modified proteins in scientific research, molecular diagnostics and biotechnology.

Subject: principles and techniques of modern methods used in modern biotechnology for microbial production of proteins, basics of designing microbial overproducers and modification of protein products for their efficient use in practical biotechnology, molecular diagnostics and therapy.

Course Content:

• microbiological selection of producers of proteins and enzymes;
• basics of modern genomics and proteomics;
• protein overproduction methodology in *E. coli* and yeast cells;
• protein biopreparation and tagging techniques;
• features of post-translational modification of recombinant proteins;
• secretion of recombinant proteins and their stabilization *in vivo* and *in vitro*;
• basic approaches to protein engineering and their application in biotechnology;
• modern methodology for producing monoclonal antibodies and their "humanization";
• hybrid proteins: their production and using in research and pharmacology;
• artificial proteins: chemical modification of proteins, synthetic and semi-synthetic enzymes, abzymes, DNA-zyms as SELEX products;
• Fundamentals of enzymatic engineering; immobilization of enzymes in the design of bioreactors;
• use of modified proteins in Analytical Biotechnology and Biosensorics.

Place of discipline in the course structure: the second year of the PhD study.

"Regulation of cell proliferation, differentiation and apoptosis"

Aim of the course:

to bring knowledge about the basics of the functioning of living organisms at the cellular and molecular levels;

to acquaint the students with the basic approaches for maintaining the activity of cells and tissues outside the body;

to study the basic biochemical processes involved in the regulation of proliferation, differentiation and death of animal and human cells during the normal development of these eukaryotic organisms and malignant growth.

Course subject:

• The mechanisms underlying the reproduction of animal and human cells;
• Features of these mechanisms in tumor and embryonic cells;
• Mechanisms of differentiation of animal and plant cells;
• The conditions and factors necessary to maintain the life of cells of animals and humans outside the body;
• Mechanisms of programmed cell and human cell death.

Course Content:

- Introduction. The subject and tasks of cell biology: the role of processes of proliferation, differentiation and death of cells in the development of living organisms. A brief history of the study of the functioning of animal cells in vitro.
- Polypeptide growth factors - the main regulators of animal and human cell proliferation and differentiation. The concept of endocrine, paracrine and autocrine regulation of cellular functions. The value of studying the mechanisms of regulation of cell proliferation, differentiation and apoptosis for biology and medicine.
- The main families of polypeptide growth factors and the characteristics of their representatives.
- Cell cycle, structure and mechanisms of functioning, regulators of cell cycle; the concept of restriction point, Cdc (Cdk) proteins and cyclins.

- Cultivation of animal and human cells in vitro. Conditions of successful cultivation, methods of obtaining isolated cells from tissues and organs, methods of studying the proliferative activity of cells and checking their viability and malignant transformation.
- Specific receptors of polypeptide growth factors in the composition of the plasma membrane of an animal cell, the structure of the receptor molecule, kinetics of interaction of ligands with specific receptors.
- Cytomorphological processes that occur during the interaction of polypeptide growth factors with specific receptors on the surface of target cells. Methods of labeling the ligand molecules for studying the behavior of their receptors in the target cell. Clustering and internalization of ligand-receptor complexes, and their biological significance.
- Major biochemical processes that occur in target cells under the influence of polypeptide growth factors. Transport of substances through the plasma membrane in animal cells, conjugation of polypeptide growth factor receptors with regulatory systems of target cells, role of G-proteins, cascade phosphorylation involving protein kinases.
- Molecular mechanisms for the transmission of growth factor regulatory signals from membrane receptors to intracellular molecular targets: phosphoinositide metabolism and value of its products, adenylate cyclase signaling system, RAS / MAP kinase signaling system, JAK-STAT signaling system, transforming beta growth factor beta signaling system.
- Features of regulation of proliferation, differentiation and apoptosis of cells during malignant growth in animals and humans. The main phenotypic characteristics of transformed and malignant cells. Autocrine regulation of the functions of these cells. The theory of multistage carcinogenesis.
- Oncogenes and their role in carcinogenesis. Molecular mechanisms of carcinogenesis. Chemical and viral carcinogenesis. Structure of retroviruses. Oncogenes and protooncogens. Mechanisms of activation of protooncogens. Relationship of the oncogenes with the polypeptide growth factors and their signaling systems.
- Tumor suppressors (antioncogens) and their biological role. Natural factors that inhibit malignant growth.
- Mechanisms of regulation of differentiation of animal and human cells. The development of amphibians as a convenient experimental model for studying cell differentiation processes. The concept of morphogens. Mechanisms of induction of mesoderm formation in the amphibians. Genetic and epigenetic (positional) information during early animal development. The value of intercellular interaction. Parallels of embryogenesis and carcinogenesis.
- Molecular mechanisms of formation of the immunological diversity. T-cell and B-cell immunity. Hybridoma biotechnology and monoclonal antibodies.
- Programmed cell death - apoptosis and autophagy. Basic differences of apoptosis and cell necrosis. Inducers and suppressors of apoptosis. The "biological clock" and the role of telomerase. Major biochemical processes that occur during apoptosis (caspase cascade, p53 protein, proapoptotic and antiapoptotic proteins of the Bcl-2 family, the role of translocation of cytochrome C from mitochondria to cytoplasm, apoptosome formation. Physiological clearance of apoptotic cells in the body.
- Features of cell proliferation and differentiation in plants. Features of structure and function of plant cells. Regulators of cell proliferation and differentiation in plants. The use of cell culture in plants. Callus culture. Transgenic plants.

Place of discipline in the course structure: studies of the graduate students in the second year of study.

"Pedagogy of high school"

Purpose: formation of the system of theoretical knowledge and practical skills of organization of educational process, pedagogical orientation and personal concept of teaching activity in higher education.

Subject: Philosophy of Higher Education, Pedagogical Activities of the Higher School Teacher as a System, Organization of the Higher Education Educational Process.

Course Content:

• Theoretical and methodological principles of organization of the educational process in higher education.

• Purpose, functions of pedagogical activity, duties of the teacher of the high school.
• Scientific and pedagogical, moral values of the teacher.
• The system of pedagogical skills of the teacher in higher education.
• Ingredients, teaching aids, non-verbal behavior of the teacher.
• Features, directions of organization of dialog communication with students.
• Organization of pedagogical interaction in accordance with the individual-typological characteristics of students (type of temperament, type of intelligence, style of educational and cognitive activity, type of social behavior).
• Criteria for professional ethics, pedagogical tact of the teacher.
• Features, methods, techniques of emotional and educational influence on student behavior.
• Ways, ways to resolve discipline and student conflict.
• Structure, psychological and pedagogical aspects of the organization of students' educational and cognitive activity.
• Formation of scientific concepts, practical abilities and skills of students.
• Modern strategies, methods of teaching students.
• Structure, content, process of organizing a lecture, practical-seminar (laboratory) class, independent work of students.
• Ways to form a positive motivation for student learning.
• Norms, criteria for assessing knowledge, students' skills, organizing feedback in the learning process.

Place of discipline in the course structure: postgraduate students study in the second year of study.

"Methodology for preparing a scientific publication"

Purpose: To acquire the necessary knowledge and practical skills that will allow the graduate student to prepare the results of experimental studies in the international and domestic professional periodicals in order to familiarize them with the results of other scientists working in the relevant fields; to approve the results of the dissertation at international and national scientific conferences.

Subject: basic principles of preparation of scientific publications, scientific-metric bases of professional publications, types of scientific publications, structure of scientific article, rules of registration of scientific publication in accordance with the requirements of scientific publications.

Course Content:

• Structure of the scientific publication (scientific article, conference abstracts and materials, patent, monograph).
• Scientific-metric databases of professional publications. Rating of scientific journals. Impact factor of the magazine. Poor Scholar Index.
• Critical analysis of the scientific literature in contemporary areas of research. Use of information from literature and reference sources to analyze experimental results.
• Design of abstracts and materials of scientific conference.
• The logic of construction and rules for designing a scientific article, its preparation for publication.

Place of discipline in the course structure: the graduate student studies in the second year of study.

"Psychology of Higher Education"

Objective: To develop knowledge about the psychological features of students and teachers in the educational process and practical psychological skills necessary to develop effective teaching methods, effective use of the properties of cognitive mental processes and personal qualities of students to achieve educational goals in higher educational goals .

Subject: subject-subject relations of the participants of educational process in higher education, psychological peculiarities of teacher and student in their developmental interaction

Course Content:

• Higher education as a subject of psychological analysis. The subject, tasks and methods of psychology of high school.
• Age characteristics of student youth.
• Psychological principles of management of the educational process in high school.
• Student activity, teacher activity.
• Student and teacher motivation. Studying students' educational motivation.
• Higher education as an institution for human socialization. The personality of the student and the teacher.
• Individual characteristics of the student and his / her adaptation to higher education.

• Cognitive activities of students Learning styles, studies of different types of learning styles and their correction.
• Psychological theories as the basis of modern teaching methods in higher education. Application of psychological theories to create effective teaching methods in higher education.
• The role of the experiences and volitional processes and qualities of the individual in the educational process in higher education.
• Communication in higher education. Developing effective communication skills. Psychological foundations of online learning.
• Planning the time and career of students and faculty.
• Formation and development of the student group, its role in the educational process.
Place of discipline in the course structure: postgraduate students study in the second year

"Psychology of Higher Education"

Objective: To develop knowledge about the psychological features of students and teachers in the educational process and practical psychological skills needed to develop effective teaching methods, effective use of the properties of cognitive mental processes and personal qualities of students to achieve educational goals in higher education goals .
Subject: subject-subject relations of participants of educational process in higher education institution, psychological peculiarities of teacher and student in their developmental interaction
Course Content:
• Higher education as a subject of psychological analysis. The subject, tasks and methods of psychology of high school.
• Age characteristics of student youth.
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• Communication in higher education. Developing effective communication skills. Psychological foundations of online learning.
• Planning the time and career of students and faculty.
• Formation and development of the student group, its role in the educational process.
Place of discipline in the course structure: postgraduate students study in the second year of study.

Preparation of scientific and innovative project

Aim: to develop practical skills that will allow to prepare a scientific and innovative project: the ability to present a summary of the project, describe the problem of the research with the object and subject of the study, to analyze the status of the study regarding specific problem, to formulate the aim, main tasks of the project, to justify the relevance of the tasks, to determine the approaches, methods and means of project implementation, to predict the results of project implementation, their scientific novelty and practical value.
Subject: request for financing of a research and innovation project; formulation of a problem, object, tasks, and aim of the research; analysis of information about the "state of art" in the chosen topic; forecasting of scientific novelty and practical value of expected results.
Course Content:
• Abstract - summary of the project.
• Problems of the research - the problem addressed by the project object.
• State of art in the related topic.
• The aim, the idea and working hypotheses of the project, the main tasks and their relevance.

• The approach, its novelty, methods, tools and features of the project research.
• Expected results of the project implementation and their scientific novelty.
• Practical value to the economy and society.
• Project authors' backgrounds and experience.
• Project implementation stages - work plan, content of implementation stages, expected results for each stage, reporting documents.
• Financial justification for project implementation costs.

Place of discipline in the course structure: the second year of the PhD study.

Information Technology and Programming

Purpose: formation of a system of basic knowledge of modern information technologies with elements of programming in the program of scientific training of graduate students; gaining knowledge of the capabilities of modern computers for practical applications; learning how to use standard features of your computer's operating system; studying the methods of organizing scientific-educational work using computers.

Subject: Mathematical and Systematic Principles of Modern State-of-the-Art Computing; programming as a method of solving problems; computer operating system and applications; methods of editing text documents with elements of software processing; tabular and graphical representation of research data and automatic analysis programming; organization of databases and database support systems; planning and creating computer presentations with programmable controls applied aspects of working on a global and local computer network.

Course Content:
• Mathematical and systematic principles for modern computers.
• Discrete-mathematical bases of modeling of methods of scientific researches.
• The algorithm and its properties. Decomposition of the algorithm into the basic elements of the executable application.
• Computer operating system and applications. Organize user interaction with your computer.
• Methods for editing text documents.
• Automate text processing based on algorithms and programming elements.
• Table and graphical representation of research data, use of spreadsheets to solve common problems.
• Databases and their application.
• Planning and creating computer presentations.
• Global and local computer networks.

Place of discipline in the course structure: the graduate student studies in the second year of study.

"Intellectual property and technology transfer"

Purpose: to develop theoretical knowledge and practical skills that allow you to master the basic principles of the intellectual property institute, to study the legal regulation and the position of jurisprudence on the peculiarities of court cases in this category, to solve specific legal situations.

Subject: Theoretical Foundations of the Emergence of Intellectual Property Rights, Principles of Their Exercise and Protection, Characteristics of the Basic Institutions of Intellectual Property (Copyright, Patent Law, Means of Individualization of Goods and Participants, Agreements on Transfer of Property Rights of Intellectual Property).

Course Content:
• Subjects and objects of intellectual property rights
• Content of intellectual property rights
• Copyright and related rights
• Intellectual property right for invention, utility model, industrial design
• Trademark Intellectual Property
• Intellectual property right to a business name
• Intellectual property rights to geographical indications
• Intellectual property rights to other intellectual property
• Protection of intellectual property rights
• Transfer of intellectual property rights
• State regulation of technology transfer activities
• Regulation of intellectual property relations in EU and US countries

Place of discipline in the structure of the course: Persons receiving a PhD study in the second year of study.

10. The postgraduate student implementation schedule of the individual research plan

Year of study	Work on dissertation	Publication of articles	Participation in conferences
First year			
Semester 1	Work with literary sources on the topic of the thesis. Choice of experimental research methods. .	–	–
Semester 2	Optimization of experimental research methods.	1	1
Second year			
Semester 3	Literary review design. Conducting experimental studies.	–	–
Semester 4	Conducting experimental studies.	1	2
Third year			
Semester 5	Conducting experimental studies.	–	–
Semester 6	Generalization of experimental results.	1	2
Fourth year			
Semester 7	Formulation of conclusions.	2	–
Semester 8	Registration of the dissertation. Filing it for protection. Protection.	–	–

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