MINISTRY OF SCIENCE AND HIGHER EDUCATION OF RUSSIAN FEDERATION
Federal State Autonomous Educational Institution of Higher Education
Far Eastern Federal University
(FEFU)
SCHOOL OF BIOMEDICINE

AGREED
Head of OP
_____
(Signed) (Full name)

CLAIM
Director of the Department of Medical Biology and Biotechnology
_____
(Signed) (Acting Name)
December 06, 2022

WORK PROGRAM OF THE DISCIPLINE
Molecular biology
Direction of training 06.04.01 Biology
Educational program in the profile "Molecular and Cell Biology (in English)"
Form of training: full-time

Course 1, Semester 1
Lectures – 6 hours
Practical classes – 36 hours.
Seminar classes – not provided
Including with the use of MAE - 4/8 hour.
The total hours of classroom load are 54 hours.
Including with the use of MAE 12 hours.
Independent work – 54 hours.
Credit 1 semester

The work program is drawn up in accordance with the requirements of the Federal State Educational Standard in the direction of training 06.04.01 Biology, approved by the order of the Ministry of Education and Science of Russia dated 11.08.2020 No. 934

The work program was discussed at the meeting of the Department of Medical Biology and Biotechnology Protocol dated December 06, 2022 No. 2

Director of the Department of Implementing Structural Unit Ph.D., Associate Professor Kumeiko V.V.
Compiled by: Ph.D.V.V. Kumeiko

Vladivostok
2022

Reverse side of the RPD cover page

1. The work program was revised at the meeting of the Department / department / department (implementing the discipline) and approved at the meeting of the Department / department / department (issuing structural unit), the protocol from "_____ __ № _____

2.The work program was revised at the meeting of the Department / department / department (implementing the discipline) and approved at the meeting of the Department / department / department (issuing structural unit), the protocol from "__ № _____

3.The work program was revised at the meeting of the Department / Department / Department (implementing the discipline) and approved at the meeting of the Department / Department / Department (issuing structural unit), the protocol from "____ № _____

4.The work program was revised at the meeting of the Department / Department / Department (implementing the discipline) and approved at the meeting of the Department / Department / Department (issuing structural unit), the protocol from "_____ __ № _____

5.The work program was revised at the meeting of the Department / Department / Department (implementing the discipline) and approved at the meeting of the Department / Department / Department (issuing structural unit), the protocol from "_____ __ № _____

Abstract of the work program of the discipline
"Molecular Biology"

The work program of the academic discipline B1.B.05 "Molecular Biology" is compiled for students in the educational program of the magistracy 06.04.01 Biology "Molecular and cellular biology (together with the NSCMB FEB RAS)" in accordance with the requirements of the Federal State Educational Standard, approved by the order of the Ministry of Education and Science of Russia dated 11.08.2020 No. 934

Discipline B1.B.05 "Molecular biology" is included in the basic part of the compulsory disciplines of the educational program of the magistracy 06.04.01 Biology "Molecular and cell biology (together with the NSCMB FEB RAS)".

The total amountof work inmastering the discipline is 3 credit units (108 hours). The curriculum provides for lectures (18 hours), practical classes (36 hours), independent work (54 hours). Evaluation of learning outcomes: credit.

"Molecular Biology" is a fundamental discipline of biology training. It reveals the molecular structures and mechanisms of vital activity of cells.

The purpose of mastering the discipline "Molecular Biology" is to deepen the theoretical training of students in the field of molecular biology - a branch of cell biology that studies the basic properties and manifestations of life at the molecular level.

Tasks of mastering the discipline:

− development of students' holistic view of the molecular level of cell organization;

− obtaining modern knowledge about the structure, dynamics and functioning of molecular ensembles of cells, molecular mechanisms of cell development and functioning.

As a result of studying this discipline, students form the following competencies:

General professional competencies of graduates and indicators of their achievement

Name of the category (group) of general professional competencies	Code and name of general professional competence (the result of mastery)	Code and name of the competency achievement indicator
	OPK-1Is able to use and apply fundamental biological concepts and modern methodological	OPK -1.1 Conducts monitoring of modern topical problems, main discoveries and methodological developments in the field of biological and related sciences.

	approaches to pose and solve new non-standard tasks in the field of professional activity	OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training.
		OPK -1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.
	OPK-8 Is able to use modern research equipment and computer technology to solve innovative problems in professional activities.	OPK -8.1 Works with technical documentation, if necessary, prepares proposals for the modification of technical means to solve innovative problems in professional activities.
		OPK-8.2 Uses types of modern equipment for field and laboratory research in the field of professional activity.
		OPK -8.3 Uses modern research equipment and computer equipment to solve innovative problems in professional activities.

Code and name of the competency achievement indicator	Name of the assessment indicator (the result of training in the discipline)
OPK -1.1 Conducts monitoring of modern topical problems, main discoveries and methodological developments in the field of biological and related sciences.	Knows the main methodological developments in the field of biology
	Able to monitor current topical biological problems
	Owns the methods of working with scientific information
OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training.	Knows the trends in the development of scientific research and practical developments in the chosen field of professional activity
	Able to formulate innovative proposals for solving non-standard tasks
	Owns methods of solving scientific problems
OPK -1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.	Knows modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity
	He is able to apply modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.
	Owns modern methodological approaches and methods for

Code and name of the competency achievement indicator	Name of the assessment indicator (the result of training in the discipline)
	setting and solving new non-standard tasks in the field of professional activity.
OPK -8.1 Works with technical documentation, if necessary, prepares proposals for the modification of technical means to solve innovative problems in professional activities.	Knows the technical documentation
	Able to prepare proposals for the modification of technical means to solve innovative problems in professional activities
	Owns the technical means to solve innovative problems in professional activities
OPK-8.2 Uses types of modern equipment for field and laboratory research in the field of professional activity.	Knows the types of modern equipment for field and laboratory research in the field of professional activity
	Able to use equipment for field and laboratory research in the field of professional activity
	Proficient in laboratory research methods
OPK -8.3 Uses modern research equipment and computer equipment to solve innovative problems in professional activities.	Knows modern research equipment and computer equipment for solving innovative problems in professional activities
	Able to use modern research equipment and computer technology to solve innovative problems in professional activities
	Has the skills to work with research equipment and computer technology

1. Labor intensity of discipline and types of training sessions in the discipline

The total labor intensity of the discipline is 3 credit units (108 academic hours).

Types of training sessions and work of the student in the discipline can be:

Designation	Types of training sessions and work of the student
Lek	Lecture
Ave	Practical exercises
WED	Independent work of the student during the period of theoretical training
Control	Independent work of the student and contact work of the student with the teacher during the period of intermediate certification

Structure of the discipline:

Form of study – full-time

№	Name of the section Discipline	Semester	Number of hours by types of training sessions and work of the student						Forms of intermediate certification, current control of academic performance
			Lek	Lab	Ave	OK	WED	Control	
1	Introduction to Molecular Biology. Structural hierarchy and molecular organization of the cell	1	2		2		9		UO-3, PR-1, PR-11
2	Structure and molecular dynamics of cell membranes		2		4		9		UO-3, PR-1, PR-11
3	Chromatin structure, molecular mechanisms of DNA replication, repair and recombination		4		6		9		UO-3, PR-1, PR-11
4	Transcription. Regulation of gene expression		4		6		9		UO-3, PR-1, PR-11
5	Genetic code. Translation engine		2		6		9		UO-3, PR-1, PR-11
6	Cytoskeleton: Architecture, Transport and Molecular Dynamics		4		6		9		UO-3, PR-1, PR-11
	Total:	1	18		36		54		Credit

To form the above competencies within the discipline "Molecular Biology", the following methods of active / interactive learning are used: practical classes (seminar).

I. STRUCTURE AND CONTENT OF THE THEORETICAL PART OF THE COURSE (18 hours)

Section 1. Introduction to Molecular Biology. Structural hierarchy and molecular organization of the cell – 2 hours.

Lecture plan:

1. Introduction. History of the emergence and development of molecular biology.

2.Methods of molecular biology

2. Prokaryote and eukaryotic cells: structural plan, compartmentalization, evolutionary dynamics.

3.Molecularstructure and dynamics of proteins, molecular organization of nucleic acids.

Section 2. Structure and molecular dynamics of cell membranes - 2 h.

Lecture plan:

1. Organization of biological membranes.

2. Transport functions of membranes.

3. Proteins that are part of biological membranes. Classification of membrane proteins by position relative to the lipid bilayer. Methods of fixation of proteins in the membrane. Lateral and rotational diffusion of proteins in the membrane.

4. Carbohydrate-containing biopolymers (glycoconjugates) in the composition of membranes: glycoproteins and proteoglycans, glycolipids. The main classes of glycosaminoglycans in the body. Functions of carbohydrate-containing polypeptides and proteins in the body. Structure and function of glycolipids.

Section 3. Chromatin structure, molecular mechanisms of DNA replication, repair and recombination - 4 hours.

Lecture plan:

1. Structure and classification of chromosomes. Euchromatin and heterochromatin. Coding and non-coding DNA.

2. Major DNA-binding proteins and their role in the organization of the three-dimensional structure of chromatin. Histone proteins. Non-hystone chromatin proteins.

3. Chromosomal territories and nuclear matrix. Functional aspects of the structural organization of chromatin. Gene expression and chromatin structure.

4. General principles of DNA replication. The principle of polymerase chain reaction (PCR) and its significance for molecular biology. Stages of the PCR cycle, PCR events occurring on different cycles.

Section 4. Transcription. Regulation of gene expression - 4 hours.

Outline of the lecture:

1. Central dogma of molecular biology. The concept of transcription. Gene, structural organization of the gene, transcribed and non-transcribed regions, discontinuous gene structure (exons, introns). The role of promoters and consensus sequences in the mechanism of transcription initiation. RNA polymerases of prokaryotes and eukaryotes: structural and functional features. Participation of transcription factors (TF) in the mechanism of transcription initiation. Transcription termination.

2. Post-transcriptional changes in eukaryote mRNA: capping, splicing, polyadenylation. Alternative splicing. The effect of the position of genes. Inactivation of the X chromosome of mammals. The main levels of regulation of gene activity. Acetylation of histones. The main levels of regulation of gene activity. DNA methylation, varieties.

3. The main levels of regulation of gene activity. Post-transcriptional level of regulation. Regulation of gene activity by transcription activators. The principle of classification of transcription factors by Wingender. The main superclasses of TF.

Section 5. Genetic code. Translation mechanismand - 2 hours.

Lecture plan:

1. Discovery, decoding and properties of the genetic code. Adaptor hypothesis of the implementation of the genetic code.

2. Structure and properties of transport RNAs. Organization and assembly of ribosomes of prokaryotes and eukaryotes.

3. Synthesis and processing of ribosomal RNAs (rRNA). Ribosome proteins. Sites of the active center of ribosomes. Stages of translation: initiation, elongation, termination. The mechanism of formation of the initiator complex, factors of initiation of prokaryote translation (IF).

Section 6. Cytoskeleton: architecture, transport and molecular dynamics-4 hours.

Lecture plan

1. The main fibrillar structures of the cytoskeleton, their molecular composition and tissue specificity. Classification, structure and properties of molecular motors. Properties of myosins, dynein and kinesin as the main molecular motors of the cell. Mechanochemical conjugation and actin-activated ATPase activity of myosin. Regulation of the interaction of actin and myosin by myosin-

ATP-intermediates, weak and strong interaction. Actin-linked regulation of muscle work on the example of the cycle of skeletal striated muscles of mammals.

2. The role of Ca2+ and the troponin complex in triggering the reduction. Myosin-related regulation of muscle work on the example of the cycle of smooth muscle in mammals. The role of Ca2+, calmodulin and its kinase in the mechanism of contraction. Actin-mediated regulation of the smooth muscles of mammals. Functioning of specialized smooth muscles of animals with a state of locking tone (catch state).

3. Molecular mechanisms of myopathies. Individual development, cytoskeleton and morphogenetic movements. The role of methods for identifying molecular species of cytoskeletaltrees in laboratory diagnostics of the tissue nature of malignant neoplasms.

II. STRUCTURE AND CONTENT OF THE PRACTICAL PART OF THE COURSE

Practical training (36 hours)

Session 1. Structural hierarchy and molecular organization of the cell (2 hours).

- Prokaryote and eukaryotic cells: structural plan, compartmentalization, evolutionary dynamics.
- Molecular structure and dynamics of proteins.
- Molecular organization of nucleic acids.
- Molecular types of lipids and their role in the organization of cell membranes.
- Structure and properties of glycopolymers.

Session 2.3. Structure and molecular dynamics of cell membranes (4 hours).

- Organization of biological membranes.
- Transport functions of membranes.
- Horizontal heterogeneity and vertical asymmetry of membranes.
- Proteins that make up biological membranes. Classification of membrane proteins by position relative to the lipid bilayer. Methods of fixation of proteins in the membrane.
- Carbohydrate-containing biopolymers (glycoconjugates) in the composition of membranes: glycoproteins and proteoglycans, glycolipids. The main classes of glycosaminoglycans in the body. Functions of carbohydrate-

containing polypeptides and proteins in the body. Structure and function of glycolipids.

- Types of intercellular contacts (isolating - dense compounds; anchoring - adhesive contacts, desmosomes, focal contacts and semidesmosomes; communication - slotted contacts).

Session 4, 5, 6. Chromatin structure, molecular mechanisms of DNA replication, repair and recombination (6 hours).

- Structure and classification of chromosomes. Euchromatin and heterochromatin. Coding and non-coding DNA.

- Major DNA-binding proteins and their role in the organization of the three-dimensional structure of chromatin. Histone proteins. Non-hystone chromatin proteins. Chromosomal territories and the nuclear matrix.

- Functional aspects of the structural organization of chromatin. Modifications of histones and their role in the functional activity of chromatin.

- General principles of DNA replication. The structure of the replication fork, the main participants in the replication process.

- DNA polymerases of prokaryotes and eukaryotes: organization and features of functioning. 5'→3'- and 3'→5'- exonuclease activity of DNA polymerases. Nick translation, PolI*E. coli* structure, Klenov fragment model, and replication error autocorrection principle. Processivity of DNA polymerases. The role of the PCNA protein and the β subunit of DNA polymerase III (PolIII) in ensuring the processivity of the enzymatic replication complex.

- Primers, primary activity of replication enzymes, features of replication initiation.

- The principle of polymerase chain reaction (PCR) and its significance for molecular biology. Thermostable DNA polymerases. Stages of the PCR cycle, PCR events occurring on different cycles. Varieties of PCR.

- Spatio-temporal organization of replication events. Leading and lagging chains, okazaki fragments. Directions of replication and implementation of replication difficulties in the spatial organization of the replication "machine".

- Features of mitochondrial DNA replication. Sites began replicating the leading and lagging chains, the D-loop.

- Features of telomeric DNA replication. Structure and functioning of telomerases, telomerase RNA, the principle of reverse transcription in work

telomerase. L. Hayflick's limit and telomerase activity. Debatable questions about the role of telomerases in ensuring the "immortality of cells".

- DNA damage and DNA repair mechanisms. The base removal mechanism and the nucleotide removal mechanism are the main repair pathways. Glycosilases

and AP-endonucleases. DNA polymerases that provide DNA repair. Alternative mechanisms of direct chemical transformation of damaged DNA.

- General recombination of DNA - recombination of homologous DNA (general recombination, homologous recombination). The role of total recombination in DNA repair. Meiotic recombination.

- Mobile genetic elements, transposition and site-specific recombination. DNA transposons. Retrotransposons: retroviral and nonretroviral type. Functioning of mammalian retrotransposons on the example of retrotransposonL1. Conservative site-specific recombination and bacteriophage λ.

Session 7, 8, 9. Transcription. Regulation of gene expression (6 hours).

- Central Dogma of Molecular Biology. The concept of transcription. Gene, structural organization of the gene, transcribed and non-transcribed regions, discontinuous gene structure (exons, introns). The role of promoters and consensus sequences in the transcription initiation mechanism.

- RNA polymerases of prokaryotes and eukaryotes: structural and functional features. The participation of transcription factors (TF) in the mechanism of transcription initiation, the role of TFIID and σ - a subunit of prokaryote RNA polymerase in the formation of the initiator complex. Participation of elongation factors in the provision of transcription. Transcription termination.

- Post-transcriptional changes in eukaryote mRNA: capping, splicing, polyadenylation. Alternative splicing.

- The effect of the position of genes. Inactivation of the X chromosome of mammals.

- The main levels of regulation of gene activity. Acetylation of histones.

- The main levels of regulation of gene activity. DNA methylation, varieties.

- The main levels of regulation of gene activity. Post-transcriptional level of regulation.

- Regulation of gene activity by transcriptional activators.

Sessions 10, 11, 12. Genetic code. Broadcast mechanism (6 hours).

- Discovery, decoding and properties of the genetic code.

- Adaptor hypothesis of the implementation of the genetic code. Structure and properties of transport RNAs (tRNAs): acceptor peduncle, dihydrouridin, pseudouridin and anticodone loops, variable handle, inosine and its role in codon recognition, primary, secondary and tertiary structure of tRNA.

- Aminoacylation of tRNA, aminoacyl-tRNA synthetase, selectivity and accuracy of translation.

- Organization and assembly of ribosomes of prokaryotes and eukaryotes. Synthesis and processing of ribosomal RNAs (rRNA). Ribosome proteins. Sites of the active center of ribosomes: mRNA-binding site, A-, P-, E-sites.

- Translation stages: initiation, elongation, termination. The mechanism of formation of the initiator complex, factors of initiation of prokaryote translation (IF). Eukaryote initiation factors. Elongation factors (EF), termination factors (RF). Participation of GTF in the broadcast.

- Post-translational modifications of proteins, control of the functional activity of proteins using post-translational processing.

Sessions 13, 14, 15. Cytoskeleton: Architecture, Transport and Molecular Dynamics (6 hours).

- The basic fibrillar structures of the cytoskeleton, their molecular composition and tissue specificity.

- Classification, structure and properties of molecular motors. Properties of myosins, dynein and kinesin as the main molecular motors of the cell.

- Mechanochemical conjugation and actin-activated ATPase activity of myosin.

- Actin-linked regulation of muscle function on the example of the cycle of skeletal striated muscles of mammals. The role of Ca2+ and the troponin complex in triggering the reduction.

- Myosin-linked regulation of muscle function on the example of the mammalian smooth muscle cycle. The role of Ca2+, calmodulin and its kinase in the mechanism of contraction. Actin-mediated regulation of mammalian smooth muscle. The functioning of specialized smooth muscles of animals with a state of locking tone (catchstate).

Sessions 16, 17, 18. Intercellular communications, signaling pathways, control of cell reproduction and differentiation (6 hours).

- The concept of communication between cells. Communicative processes of bacteria and yeast. The types and nature of the signals perceived by the cell. The concepts of a signal-feeding cell and a target cell. The concepts of ligand and receptor. Principles of intracellular signal transmission mechanisms (secondary messengers and effector molecules). Types of effector molecules and possible signaling results.

- General classification of signaling pathways depending on the distance of the ligand from the cell secreting the signaling molecule. Contact-dependent signaling. Behavioral reactions of cells in the microenvironment of signaling molecules. Signaling molecules as morphogens.

III.EDUCATIONAL AND METHODICAL SUPPORT OF INDEPENDENT WORK OF STUDENTS

Educational and methodological support for the independent work of students in the discipline "Molecular Biology" is presented in Appendix 1 and includes:

– schedule for the implementation of independent work on the discipline;

– characteristics of tasks for independent work of students and methodological recommendations for their implementation;

– requirements for the presentation and design of the results of independent work;

– criteria for assessing the performance of independent work.

IV. MONITORING THE ACHIEVEMENT OF COURSE OBJECTIVES

No p/n	Supervised modules/ sections / topics of the discipline	Codes and stages of competence formation		Valuation tools - name	
				current control	intermediate attestation
1	Section 1.	OPK-1.1, OPK-1.2, OPK-1.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 1 - 5
2	Section 2.	OPK-1.1, OPK-1.2, OPK-1.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 5-10
3	Section 3.	OPK-1.1, OPK-1.2, OPK-1.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 10-15
4	Section 4.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 1 5-2 0
5	Section 5.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 20 - 25
6	Section 6.	OPK-8.1, OPK-8.2,	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 25 - 30

		OPK-8.3			

Control and methodological materials, as well as criteria and indicators necessary for assessing knowledge, skills, abilities and characterizing the stages of competence formation in the process of mastering the educational program are presented in Appendix 2.

V. LIST OF EDUCATIONAL REFERENCES AND INFORMATION AND METHODOLOGICAL SUPPORT OF THE DISCIPLINE

Main literature

(electronic and printed publications)

1. Ivanishchev V.V. **Molecular biology**: textbook /. — M. : RIOR : INFRA-M, 2018. — (Higher education). — 225 p. — DOI: https://doi.org/10.12737/1731-9 - Access mode: http://znanium.com/catalog/product/916275

2. Krieger O.V. [et al.]. Molecularya biologiya [Elektronnyi resurs]: uchebnoe posob ie/— Electron. dan. — Kemerovo: KemGU, 2017. — 93 s. — Access mode: https://e.lanbook.com/book/103922

3. Andrusenko, S. F. Biochemistry and molecularya biologiya [Elektronnyi resurs]: uchebno-metodicheskoe posobie / S. F. Andrusenko, E. V. Denisova. — Electron. text data. — Stavropol: North Caucasus Federal University, 2015. — 94 p. — 2227-8397. — Access mode: http://www.iprbookshop.ru/63077.html

Further reading

1. Veresov V.G. Strukturnaya biologiya apoptosa [Elektronnyi resurs]: monografiya / V.G. Veresov. — Electron. textual data. — Minsk: Belorusskaya nauka, 2008. — 398 p. — 978-985-08-0984-1. — Access mode: http://www.iprbookshop.ru/10077.html

2. Zhimul'ev, I. F. Obshchaya i molecular'yagenetica [Elektronnyi resurs]: uchebnoe posobiye dlya vuzov / I. F. Zhimulev; ed. by E. S. Belyaev, A. P. Akif'ev. - Electron. text data. — Novosibirsk: Siberian University Publishing House, 2017. — 480 p. — 978-5-379-02003-3. — Access mode: http://www.iprbookshop.ru/65279.html

3. Barysheva, E. S. Biochemistry [Elektronnyi resurs]: uchebnoe posobie / E. S. Barysheva. — Elektron. textiye filiya. — Orenburg: Orenburgskii gosudarstvennyi universiteta, EBS ASP, 2017. — 142 p. — 978-5-7410-1888-0. — Access mode: http://www.iprbookshop.ru/78767.html

Electronic Information Educational Resources

1.The U.S. National Center for Biotechnology Information www.ncbi.nlm.nih.gov/ .

2. www.ebi.ac.uk/ European Institute of Bioinformatics.

3.www.molbiol.ru Information project supported by the Russian-speaking biological community.

4. www.membrana.ru/ popular science Internet portal.

5. Zhimulev I.F. *General and molecular genetics* pdf-version of the textbook – url: http://www.nsu.ru/education/biology/genetics/

6. Kolesnikova T.D. A selection of literature for independent reading and homework: http://engrailed.narod.ru/molbiol/ .

List of information technologies and software

In the implementation of the educational process in the discipline, the general software of computer training classes (Windows XP, Microsoft Office, etc.) is used.

VI. METHODICAL INSTRUCTIONS FOR MASTERING THE DISCIPLINE

The theoretical part of the discipline "Molecular Biology" is revealed in lecture classes, since the lecture is the main form of training, where the teacher is given the basic concepts of the discipline.

The sequence of presentation of the material in lecture classes is aimed at forming an indicative basis for students for the subsequent assimilation of the material during independent work.

In practical classes during discussions at seminars, when discussing essays and in classes using active learning methods, students learn to analyze and predict the development of medical science, reveal its scientific and social problems.

Practical classes of the course are held in all sections of the curriculum. Practical work is aimed at forming students' skills of independent research work. In the course of practical classes, the student performs a set of tasks that allow to consolidate the lecture material on the topic under study, to gain basic skills in the field of molecular genetics, genetic engineering, genomics and gene therapy in

modern medicine. The active consolidation of theoretical knowledge is facilitated by the discussion of the problematic aspects of the discipline in the form of practical work using active learning methods (MAE). At the same time, the skills of independent research activities are developed in the process of working with scientific literature, periodicals, the formation of the ability to defend one's point of view reasonably, listen to others, answer questions, and conduct a discussion.

Seminar-colloquium is a collective form of consideration and consolidation of educational material. Colloquia are one of the types of practical classes designed for in-depth study of the discipline, conducted in an interactive mode. At the classes on the topic of the colloquium, issues are analyzed, together with the teacher, their discussion is held, which is aimed at consolidating the material, forming the skills to conduct polemics, developing independence and critical thinking, the ability of students to navigate in large information flows, to develop and defend their own position on problematic issues of the discipline. As methods of interactive learning at colloquia, the following are used: a detailed conversation, discussion, press conference. A detailed conversation involves the preparation of students on each issue of the lesson plan with a single list of recommended mandatory and additional literature for all. Reports are prepared by students on a pre-proposed topic. Discussion in a group has a number of advantages. The discussion can be caused by the teacher during the lesson or planned in advance by him.During the polemic, students form resourcefulness, speed of mental reaction. Control tests. Blank or computer testing is used in the mode of selecting the correct answers, establishing the correspondence of concepts, marking details on diagrams, etc.

Methodical instructions for working with literature

An initial list of sources should be compiled. The basis may be the list of references recommended in the work program of the course. For the convenience of work, you can make your own file cabinet of selected sources (surname of the authors, title, characteristics of the publication) in the form of a working file in the computer. Such a file cabinet has an advantage, because it allows you to add sources, replace one with another if necessary, the Initial list of references can be supplemented using the electronic catalog of the FEFU library.

Working with literature on a particular topic, it is necessary not only to read, but also to learn the method of its study: make a brief summary, an algorithm, a scheme of the material read, which allows you to quickly understand it, remember it. It is not recommended to rewrite the text verbatim.

When writing essays, it is recommended to independently find the literature for it. The abstract reveals the content of the problem under study. Work on the abstract helps to deepen the understanding of individual issues of the course, to

form and defend your point of view, to acquire and improve the skills of independent creative work, to conduct active cognitive work.

The main types of independent work of students are work with literary sources and methodological recommendations, Internet resources for a deeper acquaintance with certain problems of the development of medicine. The results of the work are drawn up in the form of abstracts or reports with subsequent discussion. The topics of the essays correspond to the main sections of the course.

For current control and intermediate certification, oral surveys, control essays are conducted.

VII. MATHEMATICAL AND TECHNICAL SUPPORT OF THE DISCIPLIIN

Mastering the discipline "Molecular Biology" involves the use of the following material and technical support: A multimedia classroom equipped with broadband Internet access. Computer class. All computers are connected to the fefu corporate computer network and are in a single domain.

To perform independent work, students in fefu residential buildings are provided with Wi-Fi.

Name of equipped premises and premises for independent work	List of main equipment
Reading rooms of the FEFU Scientific Library with open access to the fund (building A - level 10)	HP All-in-One 400 All-in-One 19,5 (1600x900), Core i3-4150T, 4GB DDR3-1600 (1x4GB), 1TB HDD 7200 SATA, DVD+/-RW,GigEth,Wi-Fi,WT,usb kbd/mse,Win7Pro (64-bit)+Win8.1Pro(64-bit),1-1-1 Wty Internet access speed 500 Mbps. Workplaces for people with disabilities are equipped with Braille displays and printers; equipped with: portable devices for reading flat-printed texts, scanning and reading machines video magnifier with the ability to regulate color spectra; magnifying electronic magnifiers and ultrasonic markers
Auditorium for independent work of students Vladivostok, Russky, Ajax, 10, Building 25.1, Oud. M621 Area 44.5 m^2	Monoblock Lenovo C360G-i34164G500UDK 19.5" Intel Core i3-4160T 4GB DDR3-1600 SODIMM (1x4GB)500GB Windows Seven Enterprise - 17 pieces; Wired LAN - Cisco 800 series; wireless LANs for students are provided with a system based on access points 802.11a / b / g / n 2x2 MIMO (2SS).
Auditorium for lectures VladIvostok, Russky	Multimedia audience: Monoblock Lenovo C360G-i34164G500UDK; Projection screen

Island, Ajax village, 10, building M, room M 422	Projecta Elpro Electrol, 300x173 cm; Multimedia projector, Mitsubishi FD630U, 4000 ANSI Lumen, 1920x1080; Mortise interface with TLS TAM 201 Stan automatic cable retraction system; Avervision CP355AF Visualizer; Microphone cordless radio system UHF band Sennheiser EW 122 G3 consisting of a wireless microphone and receiver; LifeSizeExpress 220-Codeconly- Non-AES video conferencing codec; Network video camera Multipix MP-HD718; Two 47" LCD panels, Full HD, LG M4716CCBA; Subsystem of audio switching and sound amplification; centralized uninterrupted power supply
Classroom for practical exercises Vladivostok, Russky Island, Ajax, 10, building M, room M820, M823, M826	Laboratory of Biomedical Cell Technologies CFX96 Touch Real Time System Polymerase Chain Reaction with Detection of Amplification Products in Real Time Mode Camera for electrophoresis Mini-Sub Cell GT System (BioRad 1704467) Camera for vertical electrophoresis Mini-PROTEAN Tetra Cell, BioRad 1658003 Vertical electrophoresis chamber PROTEAN II xi Cell (BioRad 1651803) Gel Fix System for fixing and processing electrophoretic gels PH meter for solutions complete with electrode and calibration system PB-11-P11 Thermostatic shaker ES-20/60 Laboratory centrifuge MiniSpin Autoclavable single-channel HTL dispenser of variable volume 100-1000 µl Discovery Comfort (4046) Autoclavable single-channel HTL dispenser of variable volume 20-200 µl Discovery Comfort (4045) Autoclavable single-channel dispenser. variable volume 2-20 µl Discovery Comfort (4043) Autoclavable single-channel dispenser. variable volume 10-100 µl Discovery Comfort (4044) Automated system Biacore X100 System for the analysis of intermolecular interactions with a set of additional parts and software System for continuous observation of living cells in culture, imaging and analysis Cell-IQ MLF, Chip Technologies, Czech Republic Personal CO2 Incubator with Galaxy Cell Monitoring and Vitality Enhancement System (CO48R-230-1200) Laminar cabinet of the 2nd class of biological protection, working surface size 150 cm SafeFAST Elite215S Bactericidal UV air recirculator, UVR-M Magnetic agitator, MSH-300i Mini-roller shaker, MR-1 Thermoshaker tablet, PST-60 HL-4 Simplicity Ultrapure Water System (SIMSV00EU)

	Laboratory centrifuge for centrifugation sample preparation 5804R Low-temperature refrigerator Forma 902 Automatic single-channel variable volume dispenser 0.2-2 µl, Discovery Comfort series (DV2) Automatic vertical autoclave MLS-3020 U Adventurer Pro AV213 Series Analytical Scales Pioneer Precision Scales (PA413) Electric dispenser for serological pipettes Swiftpet PRO Distiller GFL-2008 Water bath-thermostat with stirring WB-4MS, Dry air thermostat MIR-262 Medical suctioner OM-1 Pioneer Precision Scales (PA413)

In order to provide special conditions for the education of disabled people and persons with disabilities at FEFU, all buildings are equipped with ramps, elevators, lifts, specialized places equipped with toilets, signs of information and navigation support.

Independent work of the student includes:

1) library or homework with educational literature and lecture notes;
2) independent study of individual topics of the discipline;
3) preparation for seminars and testing;
4) preparation for the exam.

The procedure for performing independent work should correspond to the calendar-thematic plan of the discipline, in which the sequence of lectures, laboratory classes, colloquia and control activities is established.

Schedule for the implementation of independent work in the discipline "Molecular Biology"

№ p/n	**Due Date/Deadlines**	**Type of independent work**	**Approximate norms of execution time**	**Form of control**
1	1 week	Work with literature and lecture notes. Preparation for Seminar No. 1.	3 hours	Work in a practical lesson, oral answer. Seminar No1.
2	Week 2	Work with literature and lecture notes. Preparation for	3 hours	Work in a practical lesson, oral answer. Seminar No2.

		Seminar No. 2.		
3	Week 3	Work with literature and lecture notes. Preparation for Seminar No. 3	3 hours	Work in a practical lesson, oral answer. Seminar No3.
4	Week 4	Work with literature and lecture notes. Preparation for Seminar No. 4.	3 hours	Work in a practical lesson, oral answer. Seminar No4.
5	Week 5	Work with literature and lecture notes. Preparation for Seminar No. 5.	3 hours	Work in a practical lesson, oral answer. Seminar No5.
6	Week 6	Work with literature and lecture notes. Preparation for Seminar No. 6.	3 hours	Work in a practical lesson, oral answer. Seminar No6.
7	Week 7	Work with literature and lecture notes. Preparation for Seminar No. 7.	3 hours	Work in a practical lesson, oral answer. Seminar No7.
8	Week 8	Work with literature and lecture notes. Preparation for Seminar No. 8.	3 hours	Work in a practical lesson, oral answer. Seminar No8.
9	Week 9	Work with literature and lecture notes. Preparation for Seminar No. 9.	3 hours	Work in a practical lesson, oral answer. Seminar No9.
10	Week 10	Work with literature and lecture notes. Preparation for Seminar No. 10.	3 hours	Work in a practical lesson, oral answer. Seminar No10.
11	Week 11	Work with literature and lecture notes. Preparation for Seminar No. 11.	3 hours	Work in a practical lesson, oral answer. Seminar No11.
12	Week 12	Work with literature and lecture notes. Preparation for Seminar No. 12.	3 hours	Work in a practical lesson, oral answer. Seminar No12.
13	Week 13	Work with literature and lecture notes. Preparation for Seminar No. 13.	3 hours	Work in a practical lesson, oral answer. Seminar No13.

14	Week 14	Work with literature and lecture notes. Preparation for Seminar No. 14.	3 hours	Work in a practical lesson, oral answer. Seminar No14.
15	Week 15	Work with literature and lecture notes. Preparation for Seminar No. 15.	3 hours	Work in a practical lesson, oral answer. Seminar No15.
16	Week 16	Work with literature and lecture notes. Preparation for Seminar No. 16.	3 hours	Work in a practical lesson, oral answer. Seminar No16.
17	Week 17	Work with literature and lecture notes. Preparation for Seminar No. 17.	3 hours	Work in a practical lesson, oral answer. Seminar No17.
18	Week 18	Work with literature and lecture notes. Preparation for Seminar No. 18.	3 hours	Work in a practical lesson, oral answer. Seminar No18.
54 hours				

Current monitoring of the results of independent work is carried out during the seminars-colloquiums, checking homework and testing. Intermediate (semester) certification is carried out in the form of an oral examination.

Guidelines for preparation for seminars-colloquia

Since the colloquium is a collective form of consideration and consolidation of educational material, all students should prepare for it. The colloquium is usually held in the form of a detailed conversation, discussion, press conference. For each colloquium, a topic and a list of questions for oral communications are announced in advance. On all issues, it is necessary to work out the relevant material from the textbook, lecture notes, additional literature and relevant laboratory work. The teacher announces the question and offers to make a message for 5-7 minutes to one of the students - either at their request or at their choice. After the message, the teacher and students ask questions and make additions and comments.

Answers to questions, speeches and activity of students in the classroom are evaluated by the current assessment.

Methodical instructions for working with literature

An initial list of sources should be compiled. The basis may be the list of references recommended in the work program of the course. For the convenience of work, you can make your own file cabinet of selected sources (surname of the

authors, title, characteristics of the publication) in the form of a working file in the computer. Such a file cabinet has an advantage, because it allows you to add sources, replace one with another if necessary, remove those that turned out not to correspond to the topic. The initial list of references can be supplemented using the electronic catalog of the FEFU library.

Working with literature on a particular topic, it is necessary not only to read, but also to learn the method of its study: make a brief summary, an algorithm, a scheme of the material read, which allows you to quickly understand it, remember it. It is not recommended to rewrite the text verbatim.

VALUATION FUNDS

FOS Passport

General professional competencies of graduates and indicators of their achievement

Name of the category (group) of general professional competencies	Code and name of general professional competence (the result of mastery)	Code and name of the competency achievement indicator
	OPK-1Is able to use and apply fundamental biological concepts and modern methodological approaches to pose and solve new non-standard tasks in the field of professional activity	OPK -1.1 Conducts monitoring of modern topical problems, main discoveries and methodological developments in the field of biological and related sciences.
		OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training.
		OPK -1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.
	OPK-8 Is able to use modern research equipment and computer technology to solve innovative problems in professional activities.	OPK -8.1 Works with technical documentation, if necessary, prepares proposals for the modification of technical means to solve innovative problems in professional activities.
		OPK-8.2 Uses types of modern equipment for field and laboratory research in the field of professional activity.
		OPK -8.3 Uses modern research equipment and computer equipment to solve innovative problems in professional activities.

Code and name of the competency achievement indicator	Name of the assessment indicator (the result of training in the discipline)
OPK -1.1 Conducts monitoring of modern topical problems, main discoveries and methodological developments in the field of biological and related sciences.	Knows the main methodological developments in the field of biology
	Able to monitor current topical biological problems
	Owns the methods of working with scientific information
OPK-1.2 Analyzes trends in the development of scientific research	Knows the trends in the development of scientific research and practical developments in the chosen field of

Code and name of the competency achievement indicator	Name of the assessment indicator (the result of training in the discipline)
and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training.	professional activity
	Able to formulate innovative proposals for solving non-standard tasks
	Owns methods of solving scientific problems
OPK -1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.	Knows modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity
	He is able to apply modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.
	Owns modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.
OPK -8.1 Works with technical documentation, if necessary, prepares proposals for the modification of technical means to solve innovative problems in professional activities.	Knows the technical documentation
	Able to prepare proposals for the modification of technical means to solve innovative problems in professional activities
	Owns the technical means to solve innovative problems in professional activities
OPK-8.2 Uses types of modern equipment for field and laboratory research in the field of professional activity.	Knows the types of modern equipment for field and laboratory research in the field of professional activity
	Able to use equipment for field and laboratory research in the field of professional activity
	Proficient in laboratory research methods
OPK -8.3 Uses modern research equipment and computer equipment to solve innovative problems in professional activities.	Knows modern research equipment and computer equipment for solving innovative problems in professional activities
	Able to use modern research equipment and computer technology to solve innovative problems in professional activities
	Has the skills to work with research equipment and computer technology

No p/n	Supervised modules/ sections / topics of the discipline	Codes and stages of competence formation		Valuation tools - name	
				current control	intermediate attestation
1	Section 1.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 1 - 5
2	Section 2.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 5-10
3	Section 3.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 10-15
4	Section 4.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 1 5-2 0
5	Section 5.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 20 - 25
6	Section 6.	OPK-8.1, OPK-8.2, OPK-8.3	Knows, can, owns	Problem solving, testing essay or presentation	Credit Question 25 - 30

Scale of assessment of the level of formation of competencies

Competence code and wording	Stages of competence formation	criteria	Indicators

OPK -1.1 Conducts monitoring of modern topical problems, main discoveries and methodological developments in the field of biological and related sciences.	knows (threshold level)	Knows the main methodological developments in the field of biology	knowledge of the basics of biology, methods of conducting scientific discussion	the ability to competently and logically consistently apply the knowledge gained in the discussion
	can (advanced)	Able to monitor current topical biological problems	the ability to operate with biological concepts in a scientific discussion; the ability to present the results of discussions on the problem under study and their own research; the ability to apply the methods and forms of scientific discussions in a non-standard situation	the ability to justify the objectivity of applying the results of scientific research as evidence or refutation of the provisions discussed during the defense
	owns (high)	Owns the methods of working with scientific information	mastery of the art of discussion - the ability to listen to the opponent and give a reasoned assessment of his statements	the ability to conduct a dialogue in a modern scientific and literate Russian language; the ability to maintain the tone of scientific discussion – to give an opportunity to express to others and convey their point of view logically and scientifically justified during the defense of the master's thesis

OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training.	knows (threshold level)	Knows the trends in the development of scientific research and practical developments in the chosen field of professional activity	knowledge of the norms and rules for conducting biological research	the ability to list on the defense the basic requirements for conducting biological research
	can (advanced)	Able to formulate innovative proposals for solving non-standard tasks	the ability to characterize the organizational and technological features of the implementation of biological research	the ability to independently make a decision in case of non-standard situations
	owns (high)	Owns methods of solving scientific problems	possession of moral and ethical standards of biological research; ensuring the security of the research process	the ability to analyze the current situations in the process of research, to justify the choice of methods and technologies used in research; the ability to take ethical and social responsibility for the decisions made
OPK -1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.	knows (threshold level)	Knows modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity	knows about various scientific schools and methodologies of scientific research	the ability to explain the existence of various scientific schools; the ability to characterize the methods and techniques of scientific research
	can (advanced)	He is able to apply modern methodological approaches and methods for setting and solving new non-standard	ability to use knowledge of methods and techniques of scientific research to solve professional problems in the field of	ability to plan your own scientific research in the field of study and conservation of biodiversity

		tasks in the field of professional activity.	biodiversity research	
	owns (high)	Owns modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.	possession of scientific research skills on the topic of a master's thesis	ability to select and use adequate research methods to solve professional problems, write and present a master's thesis
OPK -8.1 Works with technical documentation, if necessary, prepares proposals for the modification of technical means to solve innovative problems in professional activities.	knows (threshold level)	Knows the technical documentation	knowledge of the history, general concepts and methodological principles of molecular and cell biology; the concept of structural hierarchy and the principles of molecular organization; Cells; structural organization and molecular dynamics of cell membranes; chromatin structure, molecular mechanisms of DNA replication, repair and recombination; mechanisms of transcription and regulation of gene expression	the ability to use knowledge of the history, general concepts and methodological principles of molecular and cell biology; concepts of structural hierarchy and principles of molecular organization of the cell; structural organization and molecular dynamics of cell membranes; chromatin structure, molecular mechanisms of DNA replication, repair and recombination; mechanisms of transcription and regulation of gene expression; properties of the genetic code and modern information about the mechanisms of translation; organization and molecular mechanisms of cytoskeleton functioning

	can (advanced)	Able to prepare proposals for the modification of technical means to solve innovative problems in professional activities	the ability to apply theoretical knowledge and basic methodological principles of molecular and cell biology in planning and conducting their own scientific research, as well as in solving applied problems	apply theoretical knowledge and basic methodological principles of molecular and cell biology in planning and conducting our own scientific research, as well as in solving applied problems
	owns (high)	Owns the technical means to solve innovative problems in professional activities	possession of methodological methods of organization and planning of experimental activities using an arsenal of methods of molecular and cell biology	the ability to use methodological techniques for organizing and planning experimental activities using an arsenal of molecular and cell biology methods
OPK-8.2 Uses types of modern equipment for field and laboratory research in the field of professional activity.	knows (threshold level)	Knows the types of modern equipment for field and laboratory research in the field of professional activity	knowledge of methods and approaches for organizing professional events in the field of molecular biology	ability to use knowledge of methods and approaches to organize professional events in the field of molecular biology
	can (advanced)	Able to use equipment for field and laboratory research in the field of professional activity	ability to plan and implement professional activities in the field of molecular biology	ability to plan and implement professional activities in the field of molecular biology

	owns (high)	Proficient in laboratory research methods	possession of skills in planning and implementation of professional activities in the field of molecular biology	ability to plan and implement professional activities in the field of molecular biology
OPK -8.3 Uses modern research equipment and computer equipment to solve innovative problems in professional activities.	knows (threshold level)	Knows modern research equipment and computer equipment for solving innovative problems in professional activities	Knowledge of modern research equipment and computer technology	Ability to apply research literature and computing to solve professional problems
	can (advanced)	Able to use modern research equipment and computer technology to solve innovative problems in professional activities	Ability to apply scientific and technical achievements to solve professional problems	Ability to use scientific and technological achievements
	owns (high)	Has the skills to work with research equipment and computer technology	Mastery of methods of working with research equipment	Ability to work with complex research equipment to solve highly specialized tasks

Methodological recommendations that determine the procedures for assessing the results of mastering the discipline

Current and intermediate certification of students in the discipline "Molecular Biology" is carried out in accordance with local fefu regulations and is mandatory.

According to the discipline under study, the following are used for current control and intermediate (semester) certification

Valuation tools:

1. Oral questioning:

-oral interview in the form of an interview (UO-1),

- Seminar-Colloquium (UO-2);

2. Written works (PR):

tests (PR-1).

Oral questioning is the most common method of monitoring students' knowledge. During oral questioning, direct contact is established between the teacher and students, during which the teacher receives ample opportunities to assess the quantity and quality of students' assimilation of educational material. It is the most common and adequate form of monitoring students' knowledge, includes an interview (mainly in an exam and test), a colloquium, a report.

Criteria for evaluating an oral response:

"5 points" are given to the student if he gives the right answers to the questions under discussion, which are distinguished by the depth and completeness of the disclosure of the topic, is able to draw conclusions and generalizations, give reasoned answers that are logical and consistent.

"4 points" is given to the student if he gives the right answers to the questions under discussion, which differ in the depth and completeness of the disclosure of the topic, is able to draw conclusions and generalizations, but one or two errors in the answers are allowed.

"3 points" are given to the student if he gives answers to the discussed questions that do not fully disclose it, there is no logical construction of the answer, makes several mistakes.

"2 points" are given to the student if he gives answers to the questions under discussion, which show that he does not own the material of the topic, cannot give reasoned answers, serious errors are made in the content of the answer.

A seminar-colloquium can serve as a form not only of testing, but also of increasing the knowledge of students. At colloquia, all or individual topics, issues of the course being studied can be discussed.

The evaluation criteria for speeches (reports) at colloquia are the same as for oral response.

The test is a written or computer form of control aimed at checking the possession of the terminological apparatus and specific (accurate) knowledge in the field of fundamental and applied disciplines.

Test evaluation criteria:

5 points are given to a student if he answered 100-90% of all questions.

4 points are given for the correct answer to 89-80% of all questions.

3 points are given for the correct answer to 79-65% of all questions.

2 points are given for the correct answer to 64-50% of all questions.

1 point is given for the correct answer on less than 50% of all questions.

Questions for the test in the discipline "Molecular Biology"

1. To give a comparative characteristic of prokaryotic and eukaryotic cells: structural plan, compartmentalization, evolutionary dynamics.

2. Molecular structure and dynamics of proteins.

3. Molecular types of lipids and their role in the organization of cell membranes. Transport functions of membranes.

4. Proteins that are part of biological membranes. Classification of membrane proteins by position relative to the lipid bilayer. Methods of fixation of proteins in the membrane.

5. Carbohydrate-containing biopolymers (glycoconjugates) in the composition of membranes: glycoproteins and proteoglycans, glycolipids. The main classes of glycosaminoglycans in the body. Functions of carbohydrate-containing polypeptides and proteins in the body. Structure and function of glycolipids.

6. Types of intercellular contacts (insulating - dense compounds; anchoring - adhesive contacts, desmosomes, focal contacts and semidesmosomes; communication - slotted contacts).

7. Structure and classification of chromosomes. Euchromatin and heterochromatin. Coding and non-coding DNA.

8. Major DNA-binding proteins and their role in the organization of the three-dimensional structure of chromatin. Histone proteins. Non-hystone chromatin proteins. Chromosomal territories and the nuclear matrix.

9. Functional aspects of the structural organization of chromatin. Modifications of histones and their role in the functional activity of chromatin.

10. General principles of DNA replication. The structure of the replication fork, the main participants in the replication process. DNA polymerases of prokaryotes and eukaryotes. Primers, primemaz activity of replication enzymes, features of replication initiation.

11. Features of mitochondrial DNA replication. Sites began replicating the leading and lagging chains, the D-loop.

12. Features of telomeric DNA replication. Structure and functioning of telomerases. L. Hayflick's limit and telomerase activity.

13. DNA damage and repair mechanisms.

14. Total DNA recombination - recombination of homologous DNA. The role of total recombination in DNA repair. Meiotic recombination.

15. Mobile genetic elements, transposition and site-specific recombination. DNA transposons. Retrotransposons of retroviral and nonretroviral type.

16. Central dogma of molecular biology. The concept of transcription. Structural organization of the gene, transcribed and non-transcribable

regions, discontinuous gene structure. The role of promoters and consensus sequences in the transcription initiation mechanism.

17. RNA polymerases of prokaryotes and eukaryotes: structural and functional features. Participation of transcription factors (TF) in the mechanism of transcription initiation. Participation of elongation factors in the provision of transcription. Transcription termination.

18. Post-transcriptional changes in eukaryote mRNA: capping, splicing, polyadenylation. Alternative splicing.

19. The main levels of regulation of gene activity. Acetylation of histones. DNA methylation, varieties.. Post-transcriptional level of regulation. Regulation of gene activity by transcription activators.

20. Discovery, decoding and properties of the genetic code. Adaptor hypothesis of the implementation of the genetic code.

21. Structure and properties of transport RNAs (tRNAs): acceptor peduncle, dihydrouridin, pseudouridin and anticodone loops, variable pen, inosine and its role in codon recognition, primary, secondary and tertiary structure of tRNA.

22. Aminoacylation of tRNA, aminoacyl-tRNA synthetase, selectivity and accuracy of translation.

23. Organization and assembly of ribosomes of prokaryotes and eukaryotes. Synthesis and processing of ribosomal RNAs (rRNA). Ribosome proteins. Sites of the active center of ribosomes.

24. Stages of translation: initiation, elongation, termination. The mechanism of formation of the initiator complex, factors of initiation of translation of prokaryotes and eukaryotes. Factors of elongation and termination. Participation of GTF in the broadcast.

25. Post-translational modifications of proteins, control of functional activity of proteins using post-translational processing.

26. Cytoskeleton: architecture, transport and molecular dynamics. Classification, structure and properties of molecular motors.

27. Actin-linked regulation of the work of striated and smooth muscles of mammals. The role of Ca2+, troponin complex, calmodulin and its kinase in the mechanism of contraction. Actin-mediated regulation of mammalian smooth muscle.

28. Mechanisms of communication between cells. The types and nature of the signals perceived by the cell. The concepts of a signal-feeding cell and a target cell.

29. Concepts of ligand and receptor. Principles of intracellular signal transmission mechanisms (secondary messengers and effector molecules). Types of effector molecules and possible signaling results.

30. Classification of signaling pathways according to the distance of the ligand from the cell secreting the signaling molecule. Contact-dependent signaling. Behavioral reactions of cells in the microenvironment of signaling molecules. Signaling molecules as morphogens.

Assessment tools for the current attestation

Topics and questions of seminars-colloquia

Session 1. Structural hierarchy and molecular organization of the cell.

- To give a comparative characteristic of prokaryotic and eukaryotic cells: structural plan, compartmentalization, evolutionary dynamics.
- Explain the molecular structure and dynamics of proteins.
- Explain the molecular organization of nucleic acids.
- Molecular types of lipids and their role in the organization of cell membranes.
- To characterize the structure and properties of glycopolymers.

Session 2,3.Structure and molecular dynamics of cell membranes.

- Organization of biological membranes.
- Transport functions of membranes.
- Horizontal heterogeneity and vertical asymmetry of membranes.
- Proteins that make up biological membranes. Classification of membrane proteins by position relative to the lipid bilayer. Methods of fixation of proteins in the membrane.
- Carbohydrate-containing biopolymers (glycoconjugates) in the composition of membranes: glycoproteins and proteoglycans, glycolipids. The main classes of glycosaminoglycans in the body. Functions of carbohydrate-containing polypeptides and proteins in the body. Structure and function of glycolipids.
- Types of intercellular contacts (isolating - dense compounds; anchoring - adhesive contacts, desmosomes, focal contacts and semidesmosomes; communication - slotted contacts).

Session 4, 5, 6. Chromatin structure, molecular mechanisms of DNA replication, repair and recombination.

- Structure and classification of chromosomes. Euchromatin and heterochromatin. Coding and non-coding DNA.

- Major DNA-binding proteins and their role in the organization of the three-dimensional structure of chromatin. Histone proteins. Non-hystone chromatin proteins. Chromosomal territories and the nuclear matrix.

- Functional aspects of the structural organization of chromatin. Modifications of histones and their role in the functional activity of chromatin.

- General principles of DNA replication. The structure of the replication fork, the main participants in the replication process.

- DNA polymerases of prokaryotes and eukaryotes: organization and features of functioning. 5'→3'- and 3'→5'- exonuclease activity of DNA polymerases. Nick translation, PolI*E. coli* structure, Klenov fragment model, and replication error autocorrection principle. Processivity of DNA polymerases. The role of the PCNA protein and the β subunit of DNA polymerase III (PolIII) in ensuring the processivity of the enzymatic replication complex.

- Primers, primary activity of replication enzymes, features of replication initiation.

- The principle of polymerase chain reaction (PCR) and its significance for molecular biology. Thermostable DNA polymerases. Stages of the PCR cycle, PCR events occurring on different cycles. Varieties of PCR.

- Spatio-temporal organization of replication events. Leading and lagging chains, okazaki fragments. Directions of replication and implementation of replication difficulties in the spatial organization of the replication "machine".

- Features of mitochondrial DNA replication. Sites began replicating the leading and lagging chains, the D-loop.

- Features of telomeric DNA replication. Structure and functioning of telomerases, telomerase RNA, the principle of reverse transcription in the work of telomerase. L. Hayflick's limit and telomerase activity. Debatable questions about the role of telomerases in ensuring the "immortality of cells".

- DNA damage and DNA repair mechanisms. The base removal mechanism and the nucleotide removal mechanism are the main repair pathways. Glycosilases and AP-endonucleases. DNA polymerases that provide DNA repair. Alternative mechanisms of direct chemical transformation of damaged DNA.

- General recombination of DNA - recombination of homologous DNA (general recombination, homologous recombination). The role of total recombination in DNA repair. Meiotic recombination.

- Mobile genetic elements, transposition and site-specific recombination. DNA transposons. Retrotransposons: retroviral and nonretroviral type. The functioning of mammalian retrotransposons on the example of the L1 retrotransposon. Conservative site-specific recombination and bacteriophage λ.

Session 7, 8, 9. Transcription. Regulation of gene expression.

- Central Dogma of Molecular Biology. The concept of transcription. Gene, structural organization of the gene, transcribed and non-transcribed regions, discontinuous gene structure (exons, introns). The role of promoters and consensus sequences in the transcription initiation mechanism.

- RNA polymerases of prokaryotes and eukaryotes: structural and functional features. The participation of transcription factors (TF) in the mechanism of transcription initiation, the role of TFIID and σ - a subunit of prokaryote RNA polymerase in the formation of the initiator complex. Participation of elongation factors in the provision of transcription. Transcription termination.

- Post-transcriptional changes in eukaryote mRNA: capping, splicing, polyadenylation. Alternative splicing.

- The effect of the position of genes. Inactivation of the X chromosome of mammals.

- The main levels of regulation of gene activity. Acetylation of histones.

- The main levels of regulation of gene activity. DNA methylation, varieties.

- The main levels of regulation of gene activity. Post-transcriptional level of regulation.

- Regulation of gene activity by transcriptional activators.

Sessions 10, 11, 12. Genetic code. Translation mechanism.

- Discovery, decoding and properties of the genetic code.

- Adaptor hypothesis of the implementation of the genetic code. Structure and properties of transport RNAs (tRNAs): acceptor peduncle, dihydrouridin, pseudouridin and anticodone loops, variable handle, inosine and its role in codon recognition, primary, secondary and tertiary structure of tRNA.

- Aminoacylation of tRNA, aminoacyl-tRNA synthetase, selectivity and accuracy of translation.

- Organization and assembly of ribosomes of prokaryotes and eukaryotes. Synthesis and processing of ribosomal RNAs (rRNA). Ribosome proteins. Sites of the active center of ribosomes: mRNA-binding site, A-, P-, E-sites.

- Translation stages: initiation, elongation, termination. The mechanism of formation of the initiator complex, factors of initiation of prokaryote translation

(IF). Eukaryote initiation factors. Elongation factors (EF), termination factors (RF). Participation of GTF in the broadcast.

- Post-translational modifications of proteins, control of the functional activity of proteins using post-translational processing.

Sessions 13, 14, 15. Cytoskeleton: Architecture, Transport and Molecular Dynamics.

- The basic fibrillar structures of the cytoskeleton, their molecular composition and tissue specificity.

- Classification, structure and properties of molecular motors. Properties of myosins, dynein and kinesin as the main molecular motors of the cell.

- Mechanochemical conjugation and actin-activated ATPase activity of myosin.

- Actin-linked regulation of muscle function on the example of the cycle of skeletal striated muscles of mammals. The role of Ca2+ and the troponin complex in triggering the reduction.

- Myosin-linked regulation of muscle function on the example of the mammalian smooth muscle cycle. The role of Ca2+, calmodulin and its kinase in the mechanism of contraction. Actin-mediated regulation of mammalian smooth muscle. The functioning of specialized smooth muscles of animals with a state of locking tone (catchstate).

Sessions 16, 17, 18. Intercellular communications, signaling pathways, control of cell reproduction and differentiation.

- The concept of communication between cells. Communicative processes of bacteria and yeast. The types and nature of the signals perceived by the cell. The concepts of a signal-feeding cell and a target cell. The concepts of ligand and receptor. Principles of intracellular signal transmission mechanisms (secondary messengers and effector molecules). Types of effector molecules and possible signaling results.

- General classification of signaling pathways depending on the distance of the ligand from the cell secreting the signaling molecule. Contact-dependent signaling. Behavioral reactions of cells in the microenvironment of signaling molecules. Signaling molecules as morphogens.

Questions for Self-Control: "The Central Dogma of Molecular Biology"

1. Give a diagram of the structure and characterize the composition of the nucleotide molecule. Through what bonds are nucleotides connected into a polynucleotide chain?

2. To give a comparative description of the structure of DNA and RNA molecules. What connections form the DOUBLE HELIX of DNA? Explain the principle of complementarity in the construction of a double helix, name complementary pairs of nucleotides.

3. To define the concept of "transcription", to explain the molecular mechanism of transcription: what is the matrix, what enzyme is used, where do the precursors for synthesis come from?

4. Define the concept of "broadcasting". Give a diagram and explain the mechanism of ribosomes. Determine the role of each form of RNA in protein synthesis.

5. Give a brief answer to the question: what does the genetic code express? Why is the code triplet? Which molecules act as a decoding mechanism?

6. Give a brief definition and formula of the central dogma of molecular biology. What are the functions of DNA in a cell? What syntheses and why are they called matrix?

7. Based on the formula of the central dogma of molecular biology, explain what is the molecular basis of the genotype and phenotype.

8. To define the concept of "replication", to explain the molecular mechanism and purpose of DNA replication.

Questions for communication with the "Functional morphology of the cell"

9. General orthological characteristics of the nuclear apparatus of eukaryotic and prokaryotic cells.

10. The essence of the concept of chromosome continuity in the life cycle of the cell.

11. Chemical composition of chromatin. What is DNP?

12. Levels of structural organization of chromatin. Eu- and heterochromatin. What levels of chromatin organization are characteristic of the interphase nucleus?

13. What manifestations of mRNA transcription can be seen in a light and electron microscope?

14. The structure of chromosomes such as lamp brushes and polythene chromosomes, the correspondence of their details to the chromatin structures of conventional nuclei.

15. Structure and functions of the nucleus. Explain the essence of rRNA processing.

16. Structure of eukaryotic ribosome: subunits, parameters of RNA molecules, proteins.

17. What is nucleus DNA amplification? Where is it known and what is it for?

18. Nuclear matrix and nuclear envelope: their structure and importance in the organization of chromatin work.

19. Structure and functions of nuclear pores.

20. What is the pathway by which ribosome subunits are transferred from the nucleus to the cytoplasm?

Testing on passed topics

Examples of a test task

Test 1

Topic: "Structure, properties and functions of proteins"

1) Compare the solubility of the three pentapeptides at pH =7. Arrange them in order of increasing hydrophilic properties:

1) ley – fen – ile – gli – shaft;

2) glu – asp – ser – fen – ile.

3) arg – liz – tre – gis – cis.

2) Arrange the elements of the structure of the protein molecule in the sequence in which they arise during protein synthesis and the formation of its native conformation.

1. Combining protomers into an oligomeric protein.

2. Formation of α spirals and β-folded areas.

3. Formation of peptide bonds.

4. Formation of hydrophobic, hydrogen and ionic bonds between amino acid radicals.

3) Write the structural formula of the pentapeptide of the following structure:

Gis – Glu – Pro – Fen – Ser.

4) The interaction of subunits in an oligomeric protein and proteins with ligands is due to .....

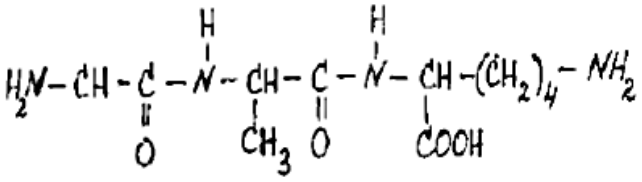
5) Amino acids serine, tyrosine and threonine, according to the classification by the chemical nature of the radical, belong to the ..... amino acids and in the formation of the tertiary structure can form .... communication.

6) Aspartic and glutamine amino acids, according to the classification by the chemical nature of the radical, belong to the ..... amino acids and in the formation of the tertiary structure can form ..... bonds with radicals of the following amino acids.....

7) The separation of proteins by electrophoresis is based on their difference in .....

8) The hemodialysis method is based on the separation of high-molecular compounds from low molecular weight impurities using .....

9) Name this tripeptide:



10) What properties of the protein are due to the presence of carboxy- and amino groups in their structure?

1. hydrophilicity and aggregate instability;
2. thermolability and solubility;
3. Ability to electrophoresis and precipitation reactions;
4. Amphotericity and electrophoresis ability.

11) To study the primary structure of the protein, the following method is used:

1. Chromatography;
2. X-ray diffraction analysis;
3. determination of the coefficient of translational friction;
4. Determination of characteristic viscosity.

12) What is the peculiarity of acidic proteins?

1. predominance of dicarboxylic amino acids;
2. equal ratio of diamin- and dicarboxylic amino acids;
3. predominance of diaminomonocarboxylic acids;
4. The protein consists of monoamine and monocarboxylic acids.

13) Proteins are characterized by:

1. amphoteric properties;
2. lack of specific molecular organization;
3. preservation of the structure of the molecule during boiling;
4. inability to crystallize.

14) Secondary structure is:

1. Alpha helix, beta folding and amorphous areas
2. polypeptide chain configuration;
3. protomer formation;
4. The way several protomers interact in space.

15) The tertiary structure of the protein is the highest stage of organization for:

1. oligomeric proteins;

2. monomeric proteins;
3. Domain proteins.
16) Connections that stabilize the α spiral:
1. hydrogen;
2. hydrophobic;
3. peptide;
4. Ionic
17) The Quaternary structure is:
1. Spatial stacking of the protomer;
2. spatial stacking of several protomers;
3. α spiral and β structure;
4. formation of domains.
18) The isoelectric point of hemoglobin is 6.8. Where does this protein migrate in an environment with a pH = 3.0 during electrophoresis?
1. migrates to the cathode;
2. remains on the start line;
3. forms a bipolar ion;
4. Migrates to the anode.

Test 2.
Theme: "The Central Dogma of Molecular Biology. Structure and functions of the cell nucleus"

Choose one correct answer:
1. What kind of dna is a participant in:
(a) Replication only;
b) replication and translation;
c) translations and transcriptions;
d) transcriptions only;
e) transcription and replication;
(e) Broadcasts only.
2. At what level of DNA compactification is transcription possible:
(a) Chromosomal;
b) nucleosomal;
c) on uncompacted DNA;
d) chromomeric;
e) nucleomeric.
3. The broadcasting process takes place:
(a) In the nucleus on chromatin filaments;

b) in the cytoplasm on the ribosomes;

c) on the plasmalemma in the receptors;

d) in chromosomes during cell division.

4. Which molecule is engaged in the direct translation of the language of nucleotides into the language of amino acids:

(a) DNA;

b) t-RNA;

c) protein;

d) r-RNA;

e) iRNA.

5. The molecular basis of the genotype is:

(a) DNA;

b) protein;

c) RNA;

d) glucose aminoglycans.

Choose all the correct answers:

6. Isolate the components of the DNA nucleotide:

(a) Deoxyribose:

b) glucose;

c) guanosine;

d) phosphoric acid;

e) ribose;

(e) Glutamate;

g) nitrogenous base.

7. Mark properly formed complementary pairs of DNA nucleotides:

(a) C-D;

b) U-A;

c) A-D;

d) A-T;

e) U-C

8. What components are necessary for transcription:

(a) Ribosome;

b) DNA;

c) DNA polymerase;

d) glucose;

e) RNA polymerase;

(e) Ribonucleotides;

g) deoxyribonucleotides.

Establish a match:

9. Establish a correspondence between the level of compactification of DNA and the corresponding proteins:

Level of DNA compactification	Protein involved in organizing this level of compactification
1. Chromonem	(a) Histone H1
2. Nucleosomal	b) histone H3
3. Nuclear	c) matrixins
	d) histone H4