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
Cell reproduction and differentiation
Direction of training 06.04.01 Biology
(Molecular and Cell Biology)
Form of training: full-time

Course 1 semester 2
lectures 18 h.
practical exercises - hour.
lab work 6 hours
total hours of classroom load 36 hours.
independent work 72 hours.
including 27 hours to prepare for the exam.
exam 2 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 ofScienceof the Republic of Russia dated 11.08.2020. № 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., Associate Professor Kumeiko V.V., Senior Lecturer Belousov A.S.

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 "_____ __ № _____

1. Goals and objectives of mastering the discipline:

Purpose: mastering knowledge about the reproduction and differentiation of cells, studying the mechanisms of their regulation, mastering the methods of cell cycle analysis, cell proliferation and differentiation.

Tasks:

1) Study of the theoretical foundations of cell reproduction, the cell cycle, its stages and mechanisms of regulation.

2) Study of molecular mechanisms of cell differentiation, principles of differential gene expression.

3) Study of cell cycle pathologies.

4) Mastering the methods of analysis of reproduction and differentiation of cells.

Professional competencies of graduates and indicators of their achievement:

Task type	Code and name of professional competence (the result of mastery)	Code and name of the competency achievement indicator
research	PC-2 is able to apply the methodological foundations of design, perform laboratory biological, environmental research, use modern equipment and computing complexes in molecular and cell biology.	PC-2.1 Develops rules and algorithms for the design, implementation of laboratory biological and environmental research.
		PC-2.2 Performs laboratory biological, environmental research using the scientific methodological foundations of fundamental research.
		PK-2.3 Applies the methodological foundations of design, laboratory biological, environmental research, uses modern equipment and computing complexes in molecular and cellular biology.

Code and name of the competency achievement indicator	Name of the assessment indicator (the result of training in the discipline)
PC-2.1 Develops rules and algorithms for the design, implementation of laboratory biological and environmental research.	Knows the rules and algorithms of designing, performing laboratory biological, environmental studies Able todevelop rules and algorithms for designing, performing laboratory biological and environmental studies Has the skills to design and perform laboratory biological, environmental research
PC-2.2 Performs laboratory biological, environmental research using the scientific methodological foundations of fundamental research.	Knowsthe scientific and methodological foundations of fundamental research Able toperform laboratory biological, environmental research Has the skills to perform laboratory biological, environmental research
PK-2.3 Applies the methodological foundations of design, laboratory biological, environmental research, uses modern equipment and computing complexes in molecular and cellular biology.	Knows the methodological foundations of design, laboratory biological, environmental research Able to apply modern equipment and computing complexes in molecular and cell biology

	Possesses the skills of designing and performing laboratory biological, environmental research using modern equipment and computer systems

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), (1 credit unit corresponds to 36 academic hours).

Types of training sessions and work of the student in the discipline are:

Designation	Types of training sessions and work of the student
Lek	Lecture
Lek electr.	
Lab	Labs
Lab Electr.	
WED:	Independent work of the student during the period of theoretical training
including 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:

The form of training is full-time.

№	Name of the section Discipline	Semester	Number of hours by types of training sessions and work of the student						Intermediate attestation forms
			Lek	Lab	Ave	OK	WED	Control	
1.	Section No1 Purpose, objectives and theoretical foundations of the study of reproduction and differentiation of human cells	2	10	8	-	-	25	10	UO-1, interview, abstract
2.	Section No2 Life cycle, reproduction and differentiation of cells	2	8	10	-	-	20	17	UO-1, interview, abstract
	Total:	2	18	18	-	-	45	27	Exam

THE STRUCTURE AND CONTENT OF THE THEORETICAL PART OF THE COURSE

Lectures 18 hours.

Section 1. Purpose, objectives and theoretical foundations of the study of reproduction and differentiation of human cells (10 hours)

Topic 1. Introduction. The purpose and objectives of the study of reproduction and differentiation of human cells (2 hours.).

Tasks of modern cytology. Cell theory is the basic law of the structure of living organisms. The merit of domestic biologists in defending the basic provisions of the cell theory.

Topic 2. Theoretical foundations of the study of reproduction and differentiation of human cells (8 hours.).

Modern model of the structure of the cell membrane. The universal nature of the structure of the membrane of all cells. The cytoskeleton of cells is its components and functions in different types of cells. Membrane organoids of the cell. Plastic metabolism. synthesis of belc, translation. Synthesis of lipids, carbohydrates. Aerobic metabolism. Energy metabolism. catabolism. Structure and meaning of the nucleus. The concept of chromatin (eu- and heterochromatin). The structure of chromosomes. The nucleus is its structure and functions.

Section 2. Life cycle, cell reproduction and differentiation (8 hours)

Topic 1: Cell life cycle. Reproduction (reproduction) of cells (2 hours.).

The concept of the life cycle of cells is its periods. DNA replication is the most important stage in the life of cells. Mitosis - its biological significance, the main phases, regulation. Varieties of mitosis. The concept of "stem" cells. The theory of "stem cells" is a breakthrough in modern biology and medicine. Meiosis is the basis of genotypic, individual, combinatorial variability. Biological significance of meiosis. Cell aging. Cancer is the uncontrolled division of cells.

Topic 2. Self-Maintenance and Differentiation. Stem Cells. Stem Cell Niche and Induction of Differentiation (3 hours)).

General overview of concepts and terms. Differentiation potential of cells. Stem cell hierarchy. Cellular differentiation in the context of ontogenesis. Determination and regulation. Self-organization and organogenesis in vitro conditions. Totipotency. Totipotency cycle in ontogeny. Germinal line of differentiation. Pluripotent stem cells. Self-sustainment mechanisms. The most important signal cascades. Induction of totipotency and pluripotency in somatic cells Differentiation factors. Asymmetric division. Mechanisms for implementing asymmetric division. Niche and regulatory factors. Extracellular matrix. Soluble factors are differentiation regulators. System of transcription factors. Epigenetic regulation of differentiation.

Topic 3. Differentiation of stem cells from different sources. Cell differentiation and pathological processes (3 hours.).

Hematopoietic stem cell. Modern ideas about the structure of the hematopoietic differon. Regulation of differentiation in hematopoiesis. Embryonic hematopoiesis. Migration of hematopoietic niches. The main known

factors of differentiation in the hematopoietic system. Hematopoiesis in vitro. Differentiation of epithelial stem cells (EpSCs). Directions of differentiation EpSK. Stem cells of the epidermis and hair follicle. Epigenetic regulation of EpSC differentiation. Dedifferentiation in the context of regeneration of the epidermis and hair follicle. Differentiation factors. Cultivation of EpSC in vitro. Cell differentiation and cancer. Tumor stem cells. Differentiation of tumor cells. Plasticity and irreversible differentiation. Transdifferentiation. Regeneration, dedifferentiation. Blastema cells.

IV. STRUCTURE AND CONTENT OF THE PRACTICAL PART OF THE COURSE AND INDEPENDENT WORK

Laboratory work 18 hours.

Laboratory work No1 "Preparation of nutrient media"

The theoretical part.

The components of the medium for growing plant cells and tissues can be divided into 6 main groups, which usually reflects the order of preparation of concentrated mother solutions: macroelements, trace elements, iron sources, vitamins, carbon sources, phytohormones.

The basis for all nutrient media for the cultivation of plant explants is a mixture of mineral salts. These are nitrogen compounds in the form of nitrates, nitrites, ammonium salts; phosphorus - in the form of phosphates; sulfur - in the form of sulfates; as well as soluble salts K +, Na +, Ca ++, Mg ++. Iron is used in the form of chelates [FeO4 or Fe2O4 + EDTA (ethylenediaminetetraacetic acid) or its sodium salt Na EDTA (trilon B)] - the most affordable form for assimilation by plant tissues.

Nitrogen, phosphorus, sulfur are part of organic compounds: proteins, fats, nucleic acids. Iron, zinc, manganese, molybdenum, cobalt in combination with porphyrins form macromolecules of photosynthetic pigments (chlorophyll), redox enzymes (catalases, peroxidase, polyphenol oxidase). Consequently, all these compounds perform a structural function in cells and tissues. At the same time, ions K +, Na +, Ca ++, Cl -, H + are necessary for regulating the pH of the environment and maintaining the physiological gradients of cells (turgor, osmotic pressure, polarity).

As a source of carbon for biological macromolecules, as well as in the cultivation of heterotrophic tissues (calluses and suspensions), carbohydrates are added to nutrient media at a concentration of 20-60 g / l. Usually these are disaccharides (sucrose), monosaccharides (hexoses: glucose and fructose, pentoses: xylose and others). Polysaccharides in nutrient media are practically not used. Only

some types of tissues (tumor) containing hydrolytic enzymes are grown on media with starch, raffinose, cellobiosis.

To stimulate biochemical reactions in the cell, biological catalysts are used - vitamins of group B (B1, B6, B12), C (ascorbic acid), PP (nicotinic acid), meso-inositol.

Thiamine (B1) is part of pyruvate decarboxylase, participates in the transformation of carbohydrates. Thiamine pyrophosphate is part of the enzymes of oxidative decarboxylation of ketoacids (pyruvic and ketoglutaric), is a coenzyme of transketolase.

Pyridoxine (B6) in the form of phosphoric acid ester is part of the enzymes of decarboxylation and transamination of amino acids.

Nicotinic acid (PP) in the form of amide is part of the dehydrogenases NAD and NADP, catalyzing the donor-acceptor chain H + (removal of H + from molecules of organic substances).

To control the processes of shaping in tissue culture, biological regulators of growth and development - phytohormones - are needed. These substances affect the differentiation and dedifferentiation of cells and tissues, initiate histogenesis, induce cell division and stretching, participate in the processes of aging and maturation, either stimulate or inhibit the growth and development of cell cultures, cause sex formation. In biotechnological studies, hormones that stimulate growth and development are more often used: auxins, cytokinins, gibberellins.

Auxins: IUQ – b-indolyl-3-acetic acid, IMC – indolyl-3-butyric acid, NUC – a-naphthylacetic acid, 2,4-D – 2,4-dichlorophenoxyacetic acid.

Cytokinins: kinetin - 6-furfurylamineopurine, zeatin, NN-biphenyl-urea, 6-BAP - 6-benzylaminopurine.

Gibberellins: Hiberrellic acid.

As biological additives for induction of primary callus, you can use plant extracts (10-15% of the total volume of the medium): coconut milk (liquid coconut endosperm), extracts from unripe corn grains (preferably during milk ripeness), which contain cytokinins - kinetin and zeatin (6 substituted aminopurins) and NN-diphenylurea.

In vitro culture, liquid and agarized (solid) media are used. Liquid media are used for the cultivation of suspensions, calluses, isolated organs and tissues, regenerative plants. At the same time, to maintain the explants, special support bridges made of filter paper or synthetic porous materials are placed in test tubes with the medium.

Agarized media are prepared on the basis of agar-agar - a polysaccharide, which is part of seaweed, which forms a gel with water at a pH of 5.6-6.0. sometimes

polyacrylamide gels (biogels) P10 and P200 are used as a seal and substitute for agar-agar.

For artificial nutrient media, solutions of macro- and microsalts are prepared in advance and used repeatedly. These are uterine (concentrated) solutions. They are stored in special conditions: macro - and microsols in the refrigerator in vessels with lapped plugs at 0 ... + 4 ° C; vitamins, phytohormones, enzymes, plant extracts - at -20 ° C in small 5-10 ml vessels with stoppers (penicillium vials).

Mother solutions of macrosalts usually exceed the working ones in concentration by 10-40 times, microsalts - by times, vitamins - by 1000 times.

It is desirable to prepare solutions of phytohormones immediately before working with media.

To prepare the mother solution of macro- and microsalts, each salt is dissolved in a separate cup when heated, then drained and brought to the desired volume. In the cooled mixture of microsalts, the solution of molybdenum salts is added last, and a solution of magnesium salts is added to the macrosalts (to prevent precipitation).

Uterine solutions of calcium chloride and iron chelate (iron sulfate + EDTA, or Na EDTA - trilon B) are prepared and stored separately from other salts.

Concentrated solutions of vitamins are prepared as follows: 10-fold attachments are dissolved in 10 ml of distilled water each separately.

Phytohormones are substances that do not dissolve well in water. Therefore, preliminarily 100 mg of the substance is dissolved in small quantities (0.5-2.0 ml) of alcohol (auxins, gibberellins), 0.5-1 n HCl or KOH (cytokinins), then heated to complete dissolution (except abscisic acid and kinetin) and brought to 100 ml of volume (1 ml contains 1 mg of the substance).

The practical part.

1. In a chemical glass with a capacity of 2 liters, place 20 g of sucrose, add distilled water to 400 ml and dissolve.

2. Add to the sucrose solution 50 ml of the mother solution of macrosalts, 1 ml of microsalts, 5 ml of iron chelate, 5 ml of calcium chloride.

3. Prepare agar: place a 7 g hunk in a glass and pour water up to 200 ml, dissolve by heating a stove or gas burner, with constant stirring. Add the finished agar to the salt solution.

4. Bring the nutrient medium to the desired volume (1 l) with distilled water. Measure the pH of the medium: if the pH exceeds 5.5-6.0, add a few drops of 0.1 n HCl, if below this value - 0.1 n KOH.

5. Pour the finished nutrient medium into test tubes for 1/3 of the volume, close the test tubes with cotton stoppers, place the test tubes in metal tripods.

6. Wrap tripods with test tubes in cellophane paper (so that plugs do not open in the autoclave).

7. Place test tube tripods in the autoclave and autoclave.

Questions for self-control:

1. What components include environments for growing plant cells and tissues.

2. On the basis of what substances agarized media are prepared.

3. What is the method of preparation of mother solutions of micro- and macrosalts.

4. What are the types of nutrient media.

5. Describe the method of preparation of liquid nutrient medium.

Laboratory work No2 "Types of cell division: mitosis, meiosis, amitosis"

The theoretical part.

One of the provisions of the cell theory says that all cells arise from their own kind as a result of their division. Both prokaryotic and eukaryotic cells divide. Cell division plays an important role in preserving life on Earth, as it ensures the growth of single-celled populations, the growth, reproduction and development of multicellular organisms. Division underlies the processes of regeneration - the replacement of dead and dead cells.

Eukaryotic cells are characterized by mitosis with its varieties and amitosis, or direct division.

The most common form of cell division is mitosis. It ensures the preservation of the constancy of the number of chromosomes and the constancy of the genotype. Daughter genetically equivalent cells are formed. This is achieved due to the previous replication of chromosomal material and a special mechanism for the distribution of chromosomes between daughter cells.

Along with the usual mitosis in plants and animals, its variety is found - endomitosis, otherwise endoreproduction. With endomitosis, replication of chromosomal material, and in particular DNA replication, is preserved, but one of the phases of the mitotic cycle falls out. This causes the mother cell not to divide into two daughter cells.

As a result, a multiple increase in the number of chromosomes occurs in the cell - polyploidy, or the chromosomes become polyty, that is, they turn out to consist of a large number of chromonemas.

All organisms that reproduce sexually are characterized by another form of cell division - meiosis. With meiosis, the constancy of the number of chromosomes is not preserved, but there is a reduction, a decrease in their number by half. It leads to a decrease in genetic heterogeneity, since daughter cells do not receive pairs of homologous chromosomes, but only individual partners from these pairs. Thus, they are deprived of allelic genes. But, on the other hand, in meiosis, there is a crossover

- the exchange between homologous chromosomes of certain sites, which serves, in turn, as a known source of the genetic species.

Amitosis is a fairly rare form of cell reproduction. Its peculiarity lies in the fact that the cell divides without interrupting its functions, being, in fact, in interphase. In this case, the chromosomes, being despiralized, are not microscopically detected.

The division of the cell into daughters is performed by the formation of constrictions on the nucleus and nucleus. Cytotomy is not always observed, which leads to the emergence of multinucleated cells. Since replication of chromosomal material does not take place in all cases, cells with nuclei of different ploidy appear.

Mitosis (from the Greek mítos - thread), caryokinesis, - indirect cell division - the most common method of reproduction (reproduction) of cells, which ensures the identical distribution of genetic material between daughter cells and the continuity of chromosomes in a number of cell generations.

Stages of mitosis: profase, metaphase, anaphase and telophase.

In prophase, there is a reorganization of the nucleus with condensation and spiralization of chromosomes, the destruction of the nuclear envelope and the formation of the mitotic apparatus by synthesizing proteins and "assembling" them into a oriented system of the spindle of cell division. Metaphase consists in the movement of chromosomes to the equatorial plane (metakinesis, or prometaphase), the formation of an equatorial plate ("mother star") and the separation of chromatids, or sister chromosomes. Anaphase is the stage of divergence of chromosomes to the poles. Anaphase movement is associated with the elongation of the central filaments of the spindle, which extends the mitotic poles, and with the shortening of the chromosomal microtubules of the mitotic apparatus. The elongation of the central filaments of the spindle occurs either due to the polarization of the "spare" macromolecules that complete the microtubules of the spindle, or due to the dehydration of this structure. The shortening of chromosomal microtubules is provided by the properties of contractile proteins of the mitotic apparatus, capable of contraction without thickening. Telophase consists in the reconstruction of daughter nuclei from chromosomes collected at the poles, the separation of the cell body (cytotomy, cytokinesis) and the final destruction of the mitotic apparatus with the formation of an intermediate body.

The practical part.

1) consider micropreparations and photographs illustrating various forms of cell division;

2) draw all the stages of mitosis of the animal and plant cells, making the appropriate designations. Compare the mitosis of plant and animal cells, indicate the differences;

3) draw the successive stages of amitosis for any of the proposed drugs.

Questions for self-control:

1. What is the most common form of cell division?
2. What is the purpose of interphase preceding cell division?
3. What is the difference between meiosis and mitosis?
4. What is the essence of the crossover, what is its significance?
5. What explains the circadian rhythm of mitoses?

Laboratory work No3 "Cultivation of animal cells"

The theoretical part.

There are two main systems of cell culture.

1. Non-flow cultures - a type of culture in which cells are introduced into a fixed volume of medium. As cells grow, nutrients are used and metabolites accumulate, so the environment must periodically change, which leads to a change in cellular metabolism, also called physiological differentiation. Over time, as a result of the depletion of the environment, cell proliferation stops.

You can increase the life expectancy of non-flowing crops in several ways:

- intermittent (part of the culture is replaced by an equal volume of fresh medium);
- permanent (the volume of culture increases at a constant low rate, and small portions of cells are periodically removed);
- perfusion (there is a constant flow of fresh media into the culture and simultaneous removal of an equal volume of the used (cell-free) medium. Perfusion can be open when the entire medium is removed from the system, and closed when the removed medium passes through an additional vessel, where its pH is restored and aeration is performed, and returned to the culture vessel.

All non-flow crop systems are characterized by the accumulation of waste in one form or another and the impermanence of external conditions.

2. Flow cultures provide true homeostatic conditions without changing the concentration of nutrients and metabolites, as well as the number of cells. Homeostasis is caused by the constant entry of the medium into the culture and the simultaneous removal of an equal volume of the medium with the cells. Such systems are suitable for suspension cultures and monolayer cultures on microcarriers.

There are two major areas in the cultivation of animal cells: monolayer cultures and suspension cultures.

Suspension cultures are preferred in terms of increasing cell yield.

Monolayer crops have a number of advantages:

1. It is easy to carry out a complete replacement of the medium and rinse the cells before adding fresh pit. Environment. This is important in cases where cell growth occurs under some conditions, and the production of the product in other conditions, for example, when transferring cells from a serum medium to a serum-free environment. You can also completely remove unwanted components.

2. Allow to ensure high cell density.

3. Monolayer cultures can be used for any type of cell, which provides the greatest flexibility of research.

5. In some cases, such as the spread of viruses, close cell-to-cell contact is required.

The disadvantages of monolayer crops are:

- requirements of a large space;
- Increasing cost and labor intensity with increasing scale;
- Insufficient monitoring due to sampling difficulties;
- difficulties in determining and controlling pH, oxygen concentration.

It should be noted that the use of microcarriers eliminates these shortcomings. There are many different varieties of this method of cultivation.

Questions for self-control:

1. What are cell cultures?
2. What are organ and tissue cultures (organ cultures)?
3. How is the cultivation in flat vials (mattresses)?
4. How is cultivation in rotating bottles performed?
5. How is the cultivation in the columns on microcarriers performed?

Laboratory work No4 "Cell cloning"

The theoretical part.

Cloning is carried out to isolate stable clones of hybridoma cells. Newly formed hybridoma cells are characterized by high instability associated with the loss of chromosomes. During culture, cells that have lost the ability to produce antibodies may appear, and they may outgrow antibody-forming hypoid cells.

The main methods of cell cloning include cloning by limiting dilution, cloning in semi-liquid agar and cloning with a device - flow cytofluori meter.

Cloning by the method of limiting dilutions. This method is the most common. At the first cloning of the active, i.e. producing antibodies, only a small part of the clones may appear. Re-cloning should always be performed, in which the proportion of positive clones would increase.

For cloning, it is necessary to use the cells of the feeding layer. The same types of cells are used as for the initial growth of hybridomas. It is important to use the selected, as described above, batches of whey and add it in an amount of 15-20%.

Cloning in semi-liquid agar-agar. Semi-liquid agar can be used to clone hybridomas (P. Coffino et al., 1972). Usually, a system consisting of two layers is taken. The lower (hard) layer contains 0.5% agar-agar in the culture medium. It is allowed to harden. Then a second layer is added - soft, containing 0.3% agar-agar, in which the cloned cells are included. When using the cells of the feeding layer, they are seeded in a petri dish prior to pouring the agar-agar, and the culture medium is removed just before the lower layer of agar is added.

To prepare the agar layer, equal parts of the culture medium of double concentration and 0.6% of agar-agar in distilled water are mixed, then placed in a water bath at 43-44 ° C before consumption. The cells are added in a minimal volume and immediately poured into a petri dish, after which it is left for some time at room temperature until the agar hardens.

Cloning with a flow cytofluorimeter. D. Parque et al. (1979) proposed a modification of the flow cytofluorimeter, which allows cloning of individual cells. To do this, prepare fluorescent microbeads made of latex and coat them with antigen. Such balls are adsorbed on antigen-specific hybridoma cells, which allows them to be isolated on this device.

After the positive clones are isolated in one way or another, the cells of these clones are multiplied in sufficient quantities and their samples are frozen.

Questions for self-control:

1. Which culture can be considered pure?

2. What is a cumulative culture?

3. What are the conditions for obtaining a cumulative culture?

4. What are the features of the separation of a pure culture from a separate colony?

5. What are the features of the isolation of a pure culture from a single cell?

V. EDUCATIONAL AND METHODOLOGICAL SUPPORT OF INDEPENDENT WORK OF STUDENTS

Recommendations for independent work of students

The purpose of the independent work of the student is to work meaningfully and independently first with educational material, then with scientific information,

to lay the foundations of self-organization and self-education in order to instill the ability to further continuously improve their professional qualifications.

The process of organizing the independent work of the student includes the following stages:

- preparatory (setting goals, drawing up a program, preparing methodological support, preparing equipment);
- basic (implementation of the program, the use of methods of information retrieval, assimilation, processing, application, transfer of knowledge, fixation of results, self-organization of the work process);
- final (assessment of the significance and analysis of the results, their systematization, assessment of the effectiveness of the program and methods of work, conclusions on the directions of labor optimization).

In the process of independent work, the student acquires the skills of self-organization, self-control, self-government, self-reflection and becomes an active independent subject of educational activity. Independent work of students should have an important impact on the formation of the personality of the future specialist, it is planned by the student independently. Each student independently determines the mode of his work and the measure of work spent on mastering the educational content in each discipline. He performs extracurricular work according to a personal individual plan, depending on his preparation, time and other conditions.

Methodical recommendations for independent work of students

As the material on the subject of the discipline is mastered, it is planned to perform independent work of students on the collection and processing of literary material to expand the field of knowledge in the discipline under study, which allows you to deepen and consolidate specific practical knowledge gained in classroom classes. To study and fully master the program material on the discipline, educational, reference and other literature recommended by this program, as well as specialized periodicals, are used.

When independently preparing for classes, students take notes on the material, independently study the issues on the topics covered, using the educational literature from the proposed list, periodicals, scientific and methodological information, databases of information networks.

Independent work consists of such types of work as the study of material on textbooks, reference books, videos and presentations, as well as other reliable sources of information; preparation for the zechet. To consolidate the material, it is enough, flipping through the notes or reading it, mentally restore the material. If necessary, refer to the recommended educational and reference literature, write

down incomprehensible moments in the questions to understand them in the upcoming lesson.

Preparation for practical exercises. This type of independent work consists of several stages:

1) Repetition of the studied material. For this purpose, lecture notes, recommended basic and additional literature are used;

2) Deepening knowledge on the proposed topics. It is necessary to differentiate the available material in lectures, textbooks in accordance with the points of the plan of the practical lesson. Separately write out unclear questions, terms. It is better to do this in the margins of the lecture notes or textbook. Clarification should be carried out with the help of reference literature (dictionaries, encyclopedic publications, etc.);

3) Drawing up a detailed plan for the speech, or conducting calculations, solving problems, exercises, etc. In preparation for practical exercises, students take notes on the material, prepare answers to the above questions on the topics of practical exercises. In addition to the practical material, students independently study questions on the proposed topics, using educational literature from the proposed list, periodicals, scientific and methodological information, databases of information networks (Internet, etc.).

Requirements for the presentation and design of the results of independent work

There are no special requirements for the provision and design of the results of this independent work.

Control over the implementation of the plan of independent work of students is carried out by the teacher in practical classes by interviewing and by including in the final tasks specified in the lesson from the plan of independent work.

VI. MONITORING THE ACHIEVEMENT OF COURSE OBJECTIVES

No p/n	Supervised sections / topics of the discipline	Achievement indicator code and name	Learning outcomes	Assessment tools	
				current control	Intermediate-accurate certification
1.	Section No1, Purpose, tasks and theoretical foundations of the study of reproduction and differentiation of human cells	PC-2.2 Performs laboratory biological, environmental research using the scientific methodological foundations of fundamental research.	Problems and theoretical foundations of the study of reproduction and differentiation of human cells Itis possible to perform laboratory biological, environmental studies Inaddition to the skills of performing	UO, interview, abstract	Exam, questions 1-25

			research using the scientific methodological foundations of the study of reproduction and differentiation of cells		
2.	Section 2, Life cycle, reproduction and differentiation of cells	PC-2.1 Develops rules and algorithms for the design, implementation of laboratory biological and environmental research.	Itsets out the rules and algorithms for designing, performing laboratory biological and environmental studies. Itis possible to develop projects for life cycle studies, reproduction and differentiation of cells. Has the skills to design and perform research	UO, interview, abstract	Exam 1-54
		PK-2.3 Applies the methodological foundations of design, laboratory biological, environmental research, uses modern equipment and computing complexes in molecular and cellular biology.	Itprovides methodological foundations for the design, implementation of laboratory biological,e-cological studies. Itis possible to perform studies of the life cycle, reproduction and differentiation of cells, using modern equipment and computer complexes. He has the skills to design and perform life cycle studies, reproduction and differentiation of cells, using modern equipment and computer complexes.	UO, interview, abstract	Exam 1-54

VII. LIST OF REFERENCES AND INFORMATION AND METHODOLOGICAL SUPPORT OF THE DISCIPLINE

Main literature

1. Cell therapy for neurodegenerative diseases : monograph / A. V. Revischin, G. V. Pavlova, V. E. Okhotin, K. A. Yakovleva. - Moscow : MPGU, 2017. - 160 p.

- ISBN 978-5-4263-0553-3. - Text : electronic. - URL: https://znanium.com/catalog/product/1316698

2. Proshkina, E. N. Molecular biology: stress-reactions of cells : a textbook for universities / E. N. Proshkina, I. N. Yuraneva, A. A. Moskalev. — Moscow : Izdatelstvo Yurait, 2022. — 101 p. — (Higher education). — ISBN 978-5-534-08502-0. — Text : electronic // Educational platform Yurait [site]. — URL: https://urait.ru/bcode/493641

3. Histology, cytology and embryology : textbook / T.M. Studenikina, T.A. Vylegzhanina, T.I. Ostrovskaya, I.A. Stelmakh ; ed. by T.M. Studenikina. — Moscow : INFRA-M, 2023. — 574 p. — (Higher education: Bachelor's degree). - ISBN 978-5-16-006767-4. - Text : electronic. - URL: https://znanium.com/catalog/product/1916106

4. Ivanishchev, V. V. Molecular biology : textbook / V.V. Ivanishchev. — Moscow : RIOR : INFRA-M, 2019. – (Higher education). — 225 p. — DOI: https://doi.org/10.12737/1731-9. - ISBN 978-5-369-01731-9. - Text : electronic. - URL: https://znanium.com/catalog/product/1019421

5. Fundamentals of Biological Chemistry: Textbook / Gorchakov E.V., Bagamaev B.M., Fedota N.V. - Moscow: StGAU - "Agris", 2017. - 208 p.: ISBN. - Text : electronic. - URL: https://znanium.com/catalog/product/975942

6. Polyakova, T. I. Biologiya celli : uchebnoe posobie / T. I. Polyakova, I. B. Sukhov. — St. Petersburg : Sankt-Peterburgskii medico-sotsial'nyi institut, 2015. — 56 p. — Text : electronic // Digital educational resource IPR SMART : [site]. — URL: https://www.iprbookshop.ru/74246.html

Further reading

1. New biomedical technologies using dietary supplements. Vyp. 2 / Far Eastern Scientific Center for Physiology and Pathology of Respiration of the Siberian Branch of the Russian Academy of Medical Sciences, Research Institute of Medical Climatologyand Rehabilitation Treatment; [ed. E. M. Ivanova]. – Vladivostok 1999. – 127 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:710781&theme=FEFU

2. Biology of stem cells and cell technologies: for medical universities in 2 vol.: v. 1 / M. A. Paltsev, R. S. Akchurin, M. A. Alexandrova [et al.] ; ed. by M. A. Paltsev. – Moscow: Medicine, Shiko, 2009. – 272 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:779352&theme=FEFU

3. Biology of stem cells and cell technologies: for medical universities in 2 vols.: v. 2 / M. A. Paltsev, R. S. Akchurin, M. A. Alexandrova [et al.] ; ed. by M. A. Paltsev. – Moscow: Medicine, Shiko, 2009. – 455 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:779355&theme=FEFU

4. Antitumor potential of hematopoietic stem cells on the model of experimental glioblastoma: abstract of the dissertation for the scientific degreeof candidate of biological sciences: 03.03.04 / P. V. Mishchenko. – Vladivostok, 2015. – 23 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:799674&theme=FEFU

5. Revischin, A.V. Cell therapy for neurodegenerative diseases [Electronic resource]: monograph / A.V. Revischin — Electron. text data. — M.: Moskovskii pedagogicheskii gosudarstvennyi universiteta, 2017. — 160 s. — Mode of access: http://www.iprbookshop.ru/75971.html. — EBS «IPRbooks»

6. Tarantul, V.Z. Genno-cell biotechnology of the XXI century and man / V.Z. Tarantul // Russia and the modern world. – № 1 – 2009. – S. 188-203. http://lib.dvfu.ru:8080/lib/item?id=chamo:641555&theme=FEFU

7. Romanovsky, G.B. Biomedical law in Russia and abroad / G.B. Romanovsky, N.N. Tarusina, A.A. Mokhov [et al.]. – Moscow: Prospekt, 2016. – 364 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:813279&theme=FEFU

8. Chentsov, Y. With. Introduction to Cell Biology: A Textbook for Universities in BiologicalSpecialties / Y. S. Chentsov. – andzd. 4-e, pererab. i dop., ster., perepech. s ed. 2005. – Moscow: Alliance, 2015. – 494 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:776847&theme=FEFU

9. Regenerative potential of mezenchymal stem cells / B. V. Popov. – St. Petersburg: Medkniga «ELBI»,», 2015. – 287 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:803153&theme=FEFU

10. Molekupolar biology of the cell [in 3 t.] : vol. 3 / Bruce Alberts, Alexander Johnson, Julian Lewis [et al.] ; with the problems of J. Wheeleson, T. Hunt; trans. from English A. N. Diakonovoy, A.V. Duby, A. . Svetlova. – Moscow, Izhevsk: Computer Research Institute, Regular and Chaotic Dynamics, 2013. – pp. 1737-2764. http://lib.dvfu.ru:8080/lib/item?id=chamo:772786&theme=FEFU

11. Histology, embryology, cytology : textbook for universities / R. K. Danilov, T. G. Borovaya M.: GEOTAR-Media, 2018 - 518 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:871030&theme=FEFU

12. Molecular biology : textbook / V.V. Ivanishchev. — M. : RIOR : INFRA-M, 2018. – (Higher education). — 225 s. http://lib.dvfu.ru:8080/lib/item?id=Znanium:Znanium-916275&theme=FEFU

13. Visual Medical Biochemistry : [textbook] / J. S. Miller. G. Solvay ; trans. with English A. P. Vabishchevich, O. G. Tereshchenko M.: GEOTAR-Media, 2018 - 160 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:871054&theme=FEFU

14. Molecular biology [Elektronnyi resurs] : uchebnoe posobie / O.V. Krieger [i dr.]. - Electron. dan. — Kemerovo : KemGU, 2017. — 93 s. http://lib.dvfu.ru:8080/lib/item?id=Lan:Lan-103922&theme=FEFU

List of resources of the information and telecommunication network "Internet"

1. Ministry of Health of the Russian Federation – official website: https://www.rosminzdrav.ru/

2. Central Research Institute of Organization and Informatization of Healthcare – official website: http://mednet.ru/

3. Research Institute of Biomedical Chemistry named after V.N. Orekhovich – official site: http://www.ibmc.msk.ru/

VIII.METHODICAL INSTRUCTIONS FOR MASTERING THE DISCIPLINE

Recommendations for planning and organizing the time allotted for the study of the discipline "Reproduction and differentiation of cells":

– study of the lecture notes on the same day after the lecture – 10-15 minutes;

– repetition of the lecture the day before the next lecture – 10-15 minutes;

– study of theoretical material on the recommended literature and notes – 1 hour per week;

– preparation for the practical lesson – 1.5 hours.

The educational process of the student in the discipline "Reproduction and differentiation of cells" is reduced to a sequential study of the topics of classroom classes: lecture and practical. Based on lecture classes, the student proceeds to the implementation of practical ones. In addition, for an in-depth study of a certain topic, the student independently performs a task according to the methodological instructions for CPC.

Mastering the discipline "Reproduction and differentiation of cells" includes several constituent elements of educational activity.

1. Careful reading of the work program of the discipline (helps to holistically see the structure of the studied issues).

2. Study of methodological recommendations for independent work of students.

3. The most important component of the development of the discipline is attending lectures (mandatory) and their note-taking. In-depth development of lecture material is facilitated by preliminary preparation, including reading the previous lecture, working with economic dictionaries, textbooks and scientific materials.

4. Regular preparation for seminars and active work in the classroom, including:

– repetition of the material of the lecture on the topic of the seminar;

– familiarity with the lesson plan and the list of basic and additional literature, with the teacher's recommendations for preparing for the lesson;

– study of scientific information on this topic in various textbooks and scientific materials;

– reading primary sources and proposed additional literature;

– writing out the main terms on the topic, finding their explanation in specialized dictionaries and encyclopedias and maintaining a glossary;

– preparation of notes, the text of the report, if necessary, a plan for answering the main questions of the practical lesson, drawing up schemes, tables;

– visiting the teacher's consultations in order to clarify the complex issues that have arisen in preparation for the lesson, re-passing the control tasks.

5. Preparation for oral interviews, independent and control works.

6. Independent study of topics not presented at lectures. Writing notes on teacher-recommended sources.

7. Preparation for the exam (during the semester), repetition of the material of the entire course of the discipline "Reproduction and differentiation of cells".

If the student does not attend certain classes, for a good reason, the student works out the material in the classroom, while the points for this lesson are not reduced. If the validity of the missed lesson by the student is not documented, in such cases the academic scores are reduced, according to the policy of the discipline. In order to clarify the material on a particular topic, the student can attend the hours of the teacher's consultation, according to the approved schedule of the student . at the end of the course, the student undergoes an intermediate control of knowledge in this discipline in the form of an exam.

Thus, when studying the course "Reproduction and differentiation of cells", you should carefully listen to and take notes on the material presented in classroom classes. For its understanding and qualitative assimilation, the following sequence of actions is recommended:

1. After the end of the training sessions, to consolidate the material, review and think over the text of the lecture listened to, reviewthe examples considered (10-15 minutes).

2. When preparing for the lecture, repeat the text of the previous lecture, think about the next topic (10-15 minutes).

3. During the week, choose the time to work with the recommended literature and to solve problems (1 hour each).

4. When preparing for practical and laboratory classes, repeat the basic concepts on the topic of the lesson, study examples. Solving the problem, - preliminarily understand what theoretical material should be used. Outline a solution plan, try to solve 1 - 2 practical problems on its basis.

The theoretical part of the discipline "Reproduction and differentiation of cells" is revealed in lecture classes, 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.

IX. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

Training sessions on the discipline are held in rooms equipped with appropriate equipment and software.

The list of material and technical and software of the discipline is given in the table.

Logistics and Software Discipline

Name of special premises and premises for independent work	Equipment special premises and rooms for independent work	List of licensed software. Details of the supporting document
Laboratory auditorium equipped with a multimedia complex Vladivostok, Russky Island, Ajax village, 10, aud. M420, area 74,6 m²	Screen with electric drive 236 * 147 cm Trim Screen Line; Projector DLP, 3000 ANSI Lm, WXGA 1280x800, 2000:1 EW330U Mitsubishi; Subsystem of specialized fasteners of equipment CORSA-2007 Tuarex; Video switching subsystem: DVI DXP 44 DVI Pro Extron matrix switch; DVI twisted pair extender DVI 201 Tx/Rx Extron; Subsystem of audio switching and sound amplification; acoustic system for ceiling mounting SI 3CT LP Extron; digital audio processor DMP 44 LC Extron; extension for IPL T CR48 control controller Aqua distiller PE-2205 (5l/h); Analytical scales Acculab ATL-2200d2-I; Laboratory scale Vibra SJ-6200CE (LSE=6200 g/0,1 g); Moisture meter AGS100; Dual-beam spectrophotometer UV-1800 manufactured by Shimadzu; Rotary evaporator Hei-VAP Advantage ML/G3B; Magnetic stirrer PE-6100 (10 pcs); Magnetic stirrer PE-6110 M with heating (5pcs); Electric heating tiles; Infrared spectrophotometer IRAffinity-1S with Fourier; Form for the formation of suppositories for 100 cells; Pharmaceutical refrigerator; Liquid chromatograph LC-20 Prominence with spectrophotometric and refractometric detector; Laboratory centrifuge PE-6926 with a rotor of	-

	10×5 ml, a set of automatic dosers Ecochem, a set of porcelain mortars, manual machines for packing capsules in size "0", "00", "1".	
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	-
Laboratory auditorium Vladivostok, Russky Island, Ajax village, 10, aud. L406, area 30 m²	Aqua distiller PE-2205 (5l/h); mixer; Laboratory scale AGN100; Magnetic stirrer PE-6100 (5 pcs); Magnetic stirrer PE-6110 M with heating (2 pcs); Electric heating tiles; a set of laboratory utensils, a set of porcelain mortars with pistils.	-

X. VALUATION FUNDS

The following assessment tools are used for discipline:

1. Oral aboutpros
2. Peferat

Oral questioning.

Oral questioning allows you to assess the knowledge and logic of the student, the ability to use terminology, speech skills and other communication skills.

The training function is to identify details that for some reason were not sufficiently understood during the training sessions and in preparation for the test.

A survey is a means of control, organized as a special conversation of the teacher with the student on topics related to the discipline being studied, and designed to clarify the amount of knowledge of the student on a certain section, topic, problem, etc.

Essay topics (abstracts, reports, communications)

1. Cellular technologies in the creation of genetic diversity and valuable for the selection of plant forms.
2. Cellular technologies in the creation of genetic diversity and valuable for the selection of animal forms.
3. Cellular technologies in the creation of genetic diversity and valuable for the selection of forms of microorganisms.

4. Somaclonal variants and cell selection.

5. Biotechnologies based on isolated protoplasts.

6. Hybridoma technology and technology for obtaining monoclonal antibodies.

7. Clonal micropropagation of plants for practical purposes: economic aspects.

8. Production of virus-free planting material.

9. Biotechnologies based on nuclear transplantation.

10. Germplasm banks (gene banks) and the problem of biodiversity conservation.

11. Scientific, ethical and economic problems of embryoengineering.

12. Embryo engineering of pets.

13. Biotechnologies based on embryo transplantation.

14. History and prospects of development of cell biotechnologies.

15. Sources of biomass and energy reproduction: possibilities of biotechnology.

16. Approaches and methods in the creation of artificial cells.

17. The phenomenon of premature condensation of chromosomes and its importance for practical selection.

18. Methods of genetic transformation of animals using cell technologies.

19. Methods of genetic transformation of plants using cellular technologies.

20. Genetic variability of plants due to IN VITRO manipulation.

21. Genetic variation of animal cells due to IN VITRO manipulation.

22. Parasexual hybridization: possibilities and limitations.

23. Cryopreservation and storage of the gene pool: methods and approaches.

24. Somatic embryogenesis and its practical use.

25. Organogenesis of plants IN VITRO and technologies based on it.

26. The phenomenon of cell totipotency.

27. Production and use of monoclonal antibodies.

28. Ethical and professional problems in the use of cell biotechnologies.

29. Cellular engineering and problems of obtaining transgenic organisms.

30. Methods and approaches in cell reconstruction.

31. Cell fractionation methods for cell engineering.

32. Cellular biotechnologies and market relations.

33. Problems and approaches in teaching cell biotechnologies.

34. Features of mutagenesis and selection of mutants IN VITRO.

35. Mutagens and their use in cell cultures.

36. Varietyof c a moclonal variants and their practical use.

37. Cultures of anthers and microspores in cell biotechnologies.

38. Obtaining genetically labeled cells and organisms by transferring foreign selective traits.

39. Fusion of protoplasts and transfer of cytoplasmic mutations.

40. Schemes of transfer and introduction of new genes into eukaryotic cells.

41. Clonal reproduction of mammals: technological and ethical problems.

42. Opportunities for human cloning: technological, biological and ethical issues.

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

Assessment tools for intermediate attestation

Intermediate certification of students in the discipline is carried out in accordance with local fefu regulations and is mandatory. The form of reporting on the discipline is an exam.

Methodical instructions for passing the exam

The exam is taken by the leading teacher (associate professor, professor), for whom this type of educational load is assigned in an individual plan. The form of the exam is oral.

The time allowed to the student to prepare for the answer to the exam should be no more than 40 minutes. After this time, the student should be ready to respond.

The presence at the examination of unauthorized persons (except for persons carrying out the inspection) without the permission of the relevant persons (rector or vice-rector for academic affairs, director of the School, head of the OBOR or director of the department) is not allowed. Disabled persons and persons with disabilities who do not have the opportunity to move independently are allowed to take the exam with accompanying persons.

With an intermediate assessment, students are given a grade of "excellent", "good", "satisfactory" or "unsatisfactory". If the student does not appear for the exam, an entry "did not appear" is made in the statement.

Assessment tools for intermediate attestation

Intermediate certification of students in the discipline is carried out in accordance with local fefu regulations and is mandatory. The form of reporting on the discipline is an exam.

Methodical instructions for passing the exam

The exam is taken by the leading teacher (associate professor, professor), for whom this type of educational load is assigned in an individual plan. The form of the exam is oral.

The time allowed to the student to prepare for the answer to the exam should be no more than 40 minutes. After this time, the student should be ready to respond.

The presence at the examination of unauthorized persons (except for persons carrying out the inspection) without the permission of the relevant persons (rector or vice-rector for academic affairs, director of the School, head of the OBOR or director of the department) is not allowed. Disabled persons and persons with disabilities who do not have the opportunity to move independently are allowed to take the exam with accompanying persons.

With an intermediate assessment, students are given a grade of "excellent", "good", "satisfactory" or "unsatisfactory". If the student does not appear for the exam, an entry "did not appear" is made in the statement.

Exam Questions

1. Modern achievements in the field of cell reproduction and differentiation.
2. The place of the discipline "Reproduction and differentiation of human cells" among the sciences of medical and biological profile.
3. The importance of the discipline "Reproduction and differentiation of human cells" in the development of cell technologies.
4. Connection of cytology and cell biology with modernscientific areas: biotechnology, genetic engineering, cell engineering, tissue engineering.
5. Disclose the definition of "Cell reproduction", "Cell differentiation".
6. History of the development of cytology and cell biology. Theories of preformism and epigenesis.
7. Outstanding scientists of cytology of the past and our contemporaries.
8. "Cell Sociology" by R. Virchow.
9. Research methods in cytology and cell biology.
10. Mechanical factors of cell differentiation.
11. Regeneration.
12. Cell differentiation.
13. Methods of studying fixed objects. Advantages and disadvantages.
14. Basic cytological methods of cell staining.
15. Methods of vital study of objects. Advantages and disadvantages.
16. Principle of research in cell culture. Advantages and disadvantages.
17. Cell theory. The current state of the issue. To show the importance of cell theory in biology, medicine and agriculture.
18. The level of somatic mutations.

19. Transcription level.

20. Regulation in the process of splicing and transport of mRNA into the cytoplasm.

21. Broadcast level.

22. Post-broadcast level.

23. Distant interactions.

24. Organogenesis.

25.Obtaining energy in living organisms.

26. Anaerobic glycolysis and oxidative phosphorylation.

27. General principle of cell structure. Define "organelle".

28. Functional systems of the cell.

29. Structure and function of the intermediate exchange system.

30.Morphological and chemical properties of the elementary biological membrane.

31. Structure and function of glycocalyx.

32. Structure and function of the receptor-barrier-transport system of the cell.

33. The main mechanisms of transmembrane transfer of low molecular weight compounds.

34. Transmembrane transfer of high molecular weight compounds.

35. Mechanisms of endocytosis and exocytosis.

36. The importance of clathrin and caveolin in the mechanisms of transmembrane transfer.

37. Growth of the plasma membrane. The cycle of membranes in the cell.

38. Give about the"Intercellular contacts" in the ids of intercellular contacts.

39. Structure and function of the energy supply system of the cell.

40. Morphological features of the structure of mitochondrial membranes.

41. Theory of endosymbiotic origin of mitochondria.

42. Structure and function of the musculoskeletal system of the cell.

43. Structure, function and localization of microfilaments in the cell.

44. Structure and function of derived microfilaments.

45. Function of intermediate filaments.

46. Structure, function and localization of microtubules in the cell.

47. Microtubule organization centers.

48. Structure and function of the system of synthesis and transport of biopolymers.

49. Structure and function of the agranular endoplasmic reticulum.

50. Structure and function of the granular endoplasmic reticulum.

51. Structure and function of the Golgi complex.

52. Understanding the transport of proteins from the Golgi complex (consisting of the three most important streams).

53. Structure and function of the early endosome.

54. To define "Apoptosis". Morphological, biochemical and physiological signs of apoptosis.

Criteria for grading a student on the exam

Evaluation of the test	Requirements for the formed competencies
"Excellent"	The "excellent" grade is given to the student if he has deeply and firmly mastered the program material, exhaustively, consistently, clearly and logically coherently presents it, is able to closely link the theory with practice, freely copes with tasks, questions and other types of application of knowledge, and does not find it difficult to answer when modifying tasks, uses the material of monographic literature in the answer, correctly justifies the decision made, has versatile skills and techniques implementation of practical tasks on the methodology of scientific research.
"Good"	The "good" grade is given to the student if he firmly knows the material, correctly and substantively presents it, avoiding significant inaccuracies in the answer to the question, correctly applies theoretical provisions when solving practical questions and problems, possesses the necessary skills and techniques for their implementation.
"satisfactory"	The grade "satisfactory" is given to the student if he has knowledge only of the basic material, but has not mastered its details, admits inaccuracies, insufficiently correct wording, violations of the logical sequence in the presentation of the program material, has difficulties in performing practical work.
"unsatisfactory"	The grade "unsatisfactory" is given to a student who does not know a significant part of the program material, makes significant mistakes, uncertainly, with great difficulties performs practical work. As a rule, the grade "unsatisfactory" is given to students who cannot continue their studies without additional classes in the relevant discipline.