

Ministry of Health of Belarus Republic
Vitebsk State Medical University

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**PRACTICAL BOOK ON
MEDICAL BIOLOGY**

*for foreign students of higher educational
establishments on a medical speciality*



Vitebsk,
Vitebsk State Medical University Press
2006

57(075)

УДК [575 + 61] - 076.5

ББК 28+5(я73)

Б 42

Рецензент:

заведующий кафедрой патологической физиологии УО "Витебский государственный медицинский университет", доктор медицинских наук, профессор В.И. Шсбеко

Бекиш, В.Я.

Б 42 Practical book on Medical Biology: for foreign students of higher educational establishments on a medical speciality (Практикум по медицинской биологии для зарубежных студентов высших учебных учреждений по специальности "лечебное дело"): Учебное пособие/ В.Я. Бекиш., Ю.Т. Никулин., – Витебск: ВГМУ, 2006. – 157 с.

ISBN 985-447-240-X

In this practical book, the main divisions and aims of biology are described accordingly to life organization levels (molecular-genetic, cellular, ontogenetic, population-species, biospherical-biogeocenotic). The questions of human reproduction, bioethical aspects of genetics, tissue and organs transplantation, ability to have poison by living beings as ecological phenomena are considered. The material of practical book is backed by contemporary findings of medical-biological sciences. The practical book contain the 37 classes. Each class includes: introduction in theme; the purpose of class; questions, which the student should work during preparation on a theme; the literature, which the student should study; the description of laboratory work.

The practical book corresponds with typical educational plan and program, proved by Ministry of Health care of republic of Belarus. It is designed for students of higher medical educational establishments on a medical speciality.

Печатается по решению лечебного совета УО "ВГМУ" (протокол № 7 от «20» сентября 2006 г.).

302293

УДК [575 + 61] - 076.5

ББК 28+5(я73)

пр. 20/0

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MOLECULAR-GENETIC LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS №1.

ESSENCE OF LIFE. MOLECULAR-GENETIC LEVEL OF LIVING SYSTEMS ORGANIZATION.

The biology - is a science, which studies life as a special form of matter being having its own laws of existence and development. The subject of biology study is live organisms and their natural communities. The fundamental features of life are: discretion and integrity, structural organization, substance and energy exchange, reproduction, heredity and diversity, growth and development, irritability, internal regulation and homeostasis.

Modern biology study life processes on different levels. These levels are called life organization levels. There is a list of them: molecular-genetic, cellular, ontogenetic, population-species, biospherical-biogeocenotic levels.

The studying of life is beginning with the studying of molecular-genetic level. Elementary structures of this level are central regulating systems - codes of hereditary information, transmitted from generation to generation. Elementary events are codon reproducing and protein synthesis on a gene matrix. DNA reduplication preserves genetic information, placed in genes, for next generation.

The studying of molecular-genetic life organization is connected with the studying of structure and functions of nucleic acids. Nucleic acids are macromolecules. Nucleic acid exists in two forms: desoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA - is the storage of genetic information. It is in the nucleus chromosomes, in the mitochondria, in the chloroplasts of eukaryotic cells, in prokaryotic cells, in many viruses. RNA serves for transmitting and realization of hereditary information in prokaryotic and eukaryotic cells. In many viruses RNA work as a primary storage of hereditary information. Nucleic acids are composed from nucleotide subunits. The nucleotide subunit is composed of three elements: an organic base, a phosphate group, a 5-carbon sugar. The base is bound to first carbon atom in the sugar and phosphate group is bound to fifth carbon atom in the sugar. Third atom of sugar always has a hydroxyl (-OH) group.

Analyzing DNA of different origin, E. Chargaff in 1949-1955 concluded principles of DNA composition. Chargaff results are commonly referred to as Chargaff rules:

1. The proportion of A always equals that of T and C similarly equal to G; $A=T$, $G=C$.
2. From the above rule, it follows that there is always an equal proportion of purines (A and G) and pyrimidines (C and T).
3. The number of bases with 6-aminogroups equal to 6-ketogroups ($A+C=G+T$).
4. The ratio of such bases as $A+T/G+C$ is species-specific value.

The main principles of DNA structure was formulated by J. Watson, F. Crick in following statements:

1. Each DNA molecule consists of two long antiparallel polynucleotide chains, making double helix. The antiparallelism of polynucleotide chains is provided by linkage of 5' end of one chain to 3' end of the other and overwise.
2. Each nucleoside is in the plane, which has a right angle with helix axis.
3. Two chains are bounded to each other with help of hydrogen bonds between bases.
4. The pair's linkage is very specific. There is only two possible pair A: T and G:C.
5. The sequence of pairs in one chain may vary in wide range but the sequence of pairs in the second chain has to be complementary to it. Thus, the pair sequence in one chain defines the complementary sequence in the other chain.

The genetic information is coded in DNA. The genetic code has such postulates:

1. The genetic code has triplet structure. The triplet of mRNA is called codon.
2. In the genetic code in most cases, one amino acid corresponds to several codons of mRNA. In a codon for one amino acid, the first two nucleotides are the same, the third varying.
3. The nucleotide sequence is recognized only in one direction, triplet by triplet.
4. AUG - is a start codon.
5. UAG, UAA, UGA - are stop codons.
6. The genetic code is universal for all organisms.

Purposes of class: 1. To know levels of living things organization, particularities of genetic material organization in viruses, prokaryotes and eukaryotes. 2. To be able to solve situational problems on DNA replication transcription, and Chargaff's rules. 3. To be acquainted with chair of medical biology and general genetics.

Questions:

1. Essence of life. Fundamental properties of living things. Biological systems, levels of their organization.
2. DNA structure. Chargaff's rules. DNA model. DNA replication
3. RNA structure. RNA types. RNA synthesis.
4. Genetic material organization in viruses, prokaryotes and eukaryotes. Levels of chromatin folding.
5. Euchromatin and heterochromatin. DNA spacers, excessive genes, repeated sequences of nucleotides.
6. Genetic code, its characteristics.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of educational establishments. Vitebsk: VSMU press, 2003 – p. 5-22.

Laboratory work:

I. Solve the tasks on the DNA replication.

№1. Part of one DNA strand has the following sequence of nucleotides: TTAGCATGACGTGTC. Indicate the sequence of nucleotides in the second strand.

№2. One DNA strand has the following sequence of nucleotides: AGGCATCATAGCCGA. What structure does the second DNA strand have?

II. Solve the tasks on the transcription.

№3. One of DNA strands with sequence of nucleotides ATTGCTCAA is used as matrix for m- RNA synthesis. What nucleotide sequence will m-RNA have.

№4. Determine nucleotide sequence of the m-RNA part, which was formed on the gene fragment with following nucleotide sequence: ATTCACGATCCTTCTAGGAGG.

III. Solve the tasks on the Chargaff's rules.

№5. There are 18% cytosine nucleotides in DNA molecule. Determine: how many other nucleotides are contained in DNA molecule (percentage).

№ 6. There are 950 cytosine nucleotides in the certain part of DNA molecule. Their amount corresponds to 20%. How many other nucleotides does this part of DNA molecule contain?

№ 7. Some investigations revealed that guanine percentage is 34 % of total m-RNA nitrogenous bases amount, uracil – 18%, cytosine – 28%, adenine – 20%. Determine percentage composition of nitrogenous bases in double strand DNA molecule, which corresponds to this m-RNA.

IV. Study micropreparation (with drawing):

“Polytenic chromosomes of insect’s salivary gland” (280x). Chromosomes are tape shaped. They consist of dark and light bands of different width. Dark parts of the chromosomes correspond to heterochromatin, light – to euchromatine.

CELLULAR LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS № 2.

A CELL AS ELEMENTARY UNIT OF LIVING THINGS. METHODS OF CELL STUDY.

Elementary structure of cellular level is a cell. Elementary event is cell division and cell development. On this level all organisms look kind of similar. The genetic information is realized in particular proteins on this level too. Protists cellular level coincides with organism level.

The non-cellular life forms are viruses and bacteriophages. The most part of life cellular organism is a prokaryotes and eukaryotes. The prokaryotes are bacteria and dark blue-green seaweed. The eukaryotes are fungi, plants and animals kingdoms.

The division of biology that study cell structure and functions is called cytology. The basic method of cells study is a microscopic method with microscope use.

Light microscope structure.

Main method of cell study is microscopy. It is founded on examination of magnified specimen image. The most often used device for this aim is light microscope. In it light beams passing across specimen are brought to focus by set of glass lenses and resulting image is then viewed by human eye.

The base characteristics of microscopy are magnification and resolution. Magnification shows how many times linear size of image exceeds linear size of specimen. Useful magnification of modern light microscope may be 2500x («x» means «times»).

Limit of resolution is minimum distance between two points of specimen before they are seen as one point. Light microscope can resolve to $0,2\ \mu$, while electron microscope can resolve to $0,0001\ \mu$.

Formula of light microscope resolution limit (d) calculation is: $d = 0,61 \cdot \lambda / NA$, where λ – wavelength, NA – numerical aperture

Formula for numerical aperture calculation is: $NA = n \cdot \sin \alpha$, where n – index of refraction, α – angle between optical axis of objective and most deviated light beam that still passes into objective lens.

Resolving power equals $1/d$.

Microscope consists of three parts: optical, mechanical and light. The main part is optical. In modern microscopes this part includes sets of magnifying lenses (objective lenses and ocular ones). Ocular lenses usually can give magnification 7x, 10x, and 15x. Objective lenses can give magnification 8x, 40x, and 90x.

General magnification of optical device is product of ocular magnification and objective one.

Mechanical part consists of base, arm, eye tube, objective turret (nosepiece), specimen stage (platform on which slide is placed) with slide holder and stage manipulators, coarse focus adjustment knob, fine focus adjustment knob and condenser focus knob.

Light part consists of light source (in some microscopes it is presented by plane-concave mirror), iris diaphragm (it controls amount of light beams that enter objective lens), condenser lens (it condenses light).

Rules of work with microscope at small magnification (objective 8x).

1. Take microscope from the cabinet placing one hand under base and another one on arm of microscope. Check condition of your microscope. Wipe ocular lenses, objective ones and mirror by napkin.
2. Place microscope in front of you at distance of palm width from table border.
3. Rotate condenser focusing knob to move condenser to its highest position. Open diaphragm.
4. Rotate objective turret to move 8x objective into work position (vertically with click of fixing spring).
5. Manipulate by coarse focus adjustment knob and dispose objective 8x at distance 1cm from specimen stage.
6. See in eyepiece and turn concave surface of mirror to light source. Field of vision must be lighted brightly and evenly.

After this, microscope can't be removed!

7. Take specimen slide. Find face surface of slide (where is cover glass). Determine position of specimen. Place slide on the stage and ensure that it is locked in place with help of slide holder. Rotate stage manipulators until specimen is directly under objective 8x.
8. Observing from side rotate coarse focus adjustment knob until distance between slide and objective 8x is 0,5 cm.
9. See in eyepiece (ocular) and lift the objective with help of coarse focus adjustment knob until image appearance.
10. Rotate stage manipulators and place the interesting part of specimen in the centre of vision field. Study image.
11. After completion of work lift the objective 8x until distance 2-3 cm. Remove slide from specimen stage and put it into the box.
12. Place napkin on specimen stage, put down objective 8x until distance 0,5 cm from stage. Return microscope to cabinet placing one hand under base and an other one on the arm of microscope.

Rules of work with microscope at large magnification (objective 40x).

1. If you are going to use objective 40x, you have to repeat all steps of work with the objective 8x (points 1-10).

2. After adjusting focus at objective 8x place the interesting part of specimen with help of stage manipulators in the vision field centre (it is called centralization of specimen)

3. Lift the objective 8x until distance 2-3 cm with help of coarse focus adjustment knob and rotate objective turret (nosepiece) to next higher magnification (objective 40x).

4. Observing from side rotate coarse focus adjustment knob until distance between slide and objective 40x is 1 mm.

5. See in eyepiece (ocular) and lift the objective 40x with help of coarse focus adjustment knob until image appearance.

6. Manipulate by fine focus adjustment knob to obtain sharpest image. This knob is not allowed to rotate more than a half of revolution.

7. Study image.

8. After completion of work lift the objective 40x until distance 2-3 cm. Remove slide from specimen stage and put it into the box.

Rotate objective turret and replace objective 40x by objective 8x. Place napkin on specimen stage, put down objective 8x until distance 0,5 cm from stage. Return microscope to the cabinet.

Rules of work with microscope using oil immersion (objective 90x).

1. Before work with objective 90x repeat all steps of work with objective 8x and then 40x.

Examine specimen at small and then large magnification.

2. After centralization of specimen lift the objective 40x until distance 2-3 cm above slide by coarse focus adjustment knob.

3. Place small drop of immersion oil on the cover glass. Rotate objective turret (nosepiece) to objective 90x.

4. Observing from side, rotate coarse focus adjustment knob and immerse lens of objective 90x into oil almost until slide.

5. See in eyepiece (ocular) and slowly lift the objective 90x with help of coarse focus adjustment knob until image appearance.

6. Manipulate by fine focus adjustment knob to obtain sharpest image.

7. Study image.

8. After completion of work lift the objective 90x until distance 2-3 cm above slide. Remove slide. Immediately after using oil remove any residual oil from slide and then from lens of 90x objective by filter paper and wipe them by napkin. Put slide into the box.

9. Rotate objective turret and replace objective 90x by objective 8x. Place napkin on specimen stage, put down objective 8x until distance 0,5 cm from stage by coarse focus adjustment knob. Return microscope to the cabinet.

Purposes of class: 1. To know principles of modern cell theory, light microscope structure and rules of work with it. 2. To be able to work with microscope. 3. To be acquainted with main methods of cell study and various shapes of cells and nuclei.

Questions:

1. Cytology as a science, its value to biology and medicine.
2. Cell theory, main stages of its development (role of R. Hooke, M. Shleiden, T. Schwann, R. Virchow and other cytologists).
3. Modern state of cell theory.
4. Light microscope structure.
5. Rules of work with microscope.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of educational establishments. Vitebsk: VSMU press, 2003 – p. 23-24.

Laboratory work

I. Study the following micropreparations (with drawing):

- “Cells of onion epidermis” (56x);
- “Frog blood” (280x);
- “Human blood” (630x).

II. Study the following micropreparations (without drawing):

- “Nervous cells of horse eye retina” (280x);
- “Ciliary epithelium of clam mantle” (280x).

CLASS № 3. CELL BIOLOGY

All life matter is represented by monocellular organisms and multicellular organisms. The structural elements of eukaryotic cell are cell wall, cytoplasm and nucleus.

The cell membrane separates protoplasm of a cell from outside environment and at the same time, it regulates ions and substance passing inside and outside of the cell. The cell membrane consists from three layers (outside protein layer, phospholipids bilayer and inside protein layer). In phospholipids bilayer the hydrophobic nonpolar surfaces look toward each other, and polar hydrophilic surfaces look outside of membrane. There are proteins incorporated into membrane. Beside that, an animal cell has glycocalyx outside of phospholipids bilayer, presented by glycolipids and glycoproteins. A plant cell has cell wall, which is made of cellulose. The inner cell membranes, which form organelles, have a same structural principle, without glycocalyx. The cortical layer of cytoplasm lies close to inner cell membrane surface. It has a lot of microtubules and microfilaments, containing contractive proteins.

The plasmalemma carry out the following functions: separation, defense, transportation, regulation of chemical balance inside of the cell. In the plasmalemma are receptors, which are able to recognize biological active substances. With help of receptors a cell can percept outside signals and react to changes in environment or in organism state. In the plasmalemma are special proteins - aquaporins, which are transported water in cell and out cell.

The organelles are stable, highly differentiated cytoplasm bodies, carrying out certain functions. It can be distinguished organelles of special and general purpose. Organelles of general purpose are in all cell types (endoplasmic reticulum, ribosomes, complex Golgi, lysosomes, mitochondria, centrosome, microtubules, microfilaments). The organelles of special purpose are in certain cell types (myofibrils, neurofilaments, villi, cilia, flagella). According to its structure, organelles are divided to organelles derived from membranes (lysosomes, complex Golgi, endoplasmic reticulum) and non-membrane organelles (ribosomes, centrosome, microtubules and microfilaments).

The nucleus is a constant component of eukaryotic cells. There are two different nuclear states. One is mitotic, another is interphase. The nucleus consists of karyolemma (nuclear envelope), nucleoplasm, nucleolus and chromatin. The function of nuclear envelope is separation of eukaryotic cell hereditary information from cytoplasm and regulation of nuclear/cytoplasmic relations.

Purposes of class: 1. To know structure and functions of eukaryotic cell components. 2. To be able to find cellular organelles and inclusions in a slides. 3. To be acquainted with modern methods of cell study.

Questions:

1. Structural parts of a cell.
2. Cell wall. Cytoplasmic membrane, particularities of its structure and functions.
3. Structure of cytoplasm:
 - structural organization and properties of cytoplasm matrix;
 - organelles, their morphological and functional characteristics;
 - cytoplasmic inclusions, their classification and significance.
4. Structure of cell nucleus. Nuclear-cytoplasmic ratio as indicator of cell functional condition.
5. Morpho-functional characteristics of chromosomes. Types and rules of chromosomes.
6. Karyotype. Ideogram. Characteristics of human karyotype. Denver and Paris classification of human chromosomes.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of educational establishments. Vitebsk: VSMU press, 2003 – p. 24-37.

Laboratory work

I. Study the following micropreparations (with drawing):

- “Golgi complex in nervous cells of cat spinal ganglion” (400x);
- “Mitochondria in the epithelial cells of *Ascaris* intestine” (400x);
- “Centrosomes in cloven *Ascaris* eggs” (400x);
- “Fat inclusions in axolotl liver cells” (400x).

II. Study the following micropreparations (without drawing):

- “Human karyotype” (900x).

III. Study the electronic microscopic photographs of cell components:

- “Cell membrane ultrastructure”;
- “Cell nucleus”;
- “Lysosomes of the mice renal tubule cell”;
- “Mitochondria in the pancreatic cell”;
- “Centrosome of cell in mitosis condition”;
- “Rough endoplasmic reticulum in the mice pancreatic cell”;
- “Golgi complex in the animal cell”.

IV. Analysis of human karyotype according to individual assignment.

CLASS №4.

CELL AS OPEN SELF-REGULATING SYSTEM

A cell is an open self-regulating system, which has an information, energy and substance flow. On a level of organism and on a level of a cell it may be distinguished external and internal substance exchange. An external exchange in organism - is exchange with external environment that means incoming of food substances and outcoming of waste substances. An internal exchange in organism occurs by assimilation and dissimilation. Accordinary with assimilation type organisms may be divided on heterotrophic, mixotrophic and autotrophic, accordinary with dissimilation type organisms may be divided on aerobic and anaerobic.

Energy is defined as the ability to bring about change, or, more generally, as the capacity to do work. Accordinary to exchange type with environment living systems may be divided on: isolated - without any exchange, adiabatic - there is no substance exchange, but there is energy one, excluding heat energy, closed -there is no substance exchange, but there is energy one in any form, open - any exchange is possible. The energy flow of organism is presented by cellular energy producing processes such as photosynthesis, chemosynthesis, fermentation and respiration.

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In the heterotrophic organism cells, the energy flow is provided by respiration and fermentation processes. During fermentation, products dissimilate to organic substance still having a lot of energy in its bonds. So, that is why the energy outcome from fermentation is small. This process occurs in hyaloplasm. The major role in energy exchange in heterotrophic organisms is respiration. With help of this process such low energy substance as glucose, fatty acids; amino acids are dissimilated to carbon dioxide. The energy liberating from oxidation of these substances is used for synthesis of ATP.

Each cell as each organism has an information exchange (information flow). Cells and organisms receive information about their environment - about light, food, sexual partner, enemy etc. (external information). The other information flow always outcome from organism. The organism serves as a transmitter of these signals (internal information). The information can't be defined neither as matter nor as energy. But material or energy transmitters carry it. During hormone regulation hormone can get to any part of an organism but only some of them are able to accept it. For example, thyrotropic hormone of anterior pituitary acts only on thyroid gland. During nervous regulation, the information parameter is impulse rate (number of impulses per time unit). A cell accepts external information flow from intercellular matrix with help of receptors on a cell surface.

Purposes of class: 1. To know modern views concerning a cell as open self-regulating system. 2. To be able to study permeability of cell membrane in the experiment. 3. To be acquainted with examples of phagocytosis in animal cells

Questions:

1. Cell as open system.
2. Membrane transport of substances. Passive transport. Active transport. Endocytosis and exocytosis.
3. Organization of energy flow in a cell during photosynthesis, fermentation and respiration processes.
4. Flow of information in a cell.
5. Flow of substances in a cell during protein biosynthesis.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003 – p. 37-44.

Laboratory work

I. Study influence of iso -, hypo – and hypertonic solutions on human blood erythrocytes.

Equipment: microscope, specimen glass, cover glass 18x18 mm, pipette, distilled water, 0,2% and 2% sodium chloride solutions, human blood.

Place drop of human blood on clear specimen glass, cover it by cover glass. Examine specimen at large magnification. Pay attention to round shape of erythrocytes.

Prepare temporary specimen of human blood with sodium chloride isotonic solution (0,9%) drop adding. Examine specimen at large magnification (280x) and draw its image in the table. Notice that there are no any changes in erythrocytes.

Table. Influence of iso –, hypo – and hypertonic solutions of sodium chloride on the human blood erythrocytes

Concentration of NaCl solutions	Character of solution	Picture of specimen	Conclusions
0,9%			
0,2%			
Distilled water			
2,0%			

Prepare temporary specimen of human blood with sodium chloride hypotonic solution (0,2%) drop adding. Water will tend to diffuse into the erythrocytes. Cells will swell because of difference in osmotic pressure between erythrocytes and environment. Examine specimen at large magnification (280x) and draw its image.

Prepare temporary specimen of human blood with distilled water drop adding. Hemolysis will occur (erythrocytes will burst because of great difference in osmotic pressure between them and water). Examine specimen at large magnification (280x) and draw its image.

Prepare temporary specimen of human blood with sodium chloride hypertonic solution (2%) drop adding. Examine specimen at large magnification (280x) and draw its image. Notice that cells will shrink because water diffuses out of the erythrocytes.

Summarize data of experiment in the table.

II. Study the following micropreparations (without drawing):

- “Accumulation of stain by rat subcutaneous fat tissue histiocytes” (630x);
- “Accumulation of stain by rat renal convoluted tubules cells” (630x).

CLASS №5. CELL PHYSIOLOGY

One of the main biological properties of the cell as an elementary life system is its ability to self-reproduce. Cell reproduction provides organism growth, development and regeneration. The time between cell formation by mother cell division and its own division or death is called cell cycle. For cell of an undividing cell populations the cell cycle is time between cell formation by mother cell division and its own death. The mitotic cycle is obvious component of cell cycle. The mitotic cycle is a time between two cell divisions and all processes that occur during this time. The mitotic cycle of growing population may be divided to two big periods: the period between divisions - an interphase, when cell grow, perform its function, and get prepare to divide; and cell division - mitosis.

There are two types of cell divisions: indirect division (mitosis) and direct division (amitosis). The mitosis consists of mitosis itself, meiosis, endomitosis and polyteny. The amitosis is divided by shape (equal, non-equal, multiply, without cytokinesis) and by type (generative, reactive, degenerative).

The mitosis (from Greek "mitos" - thread) - is unique type of animal and plant cell division, during which cell pass a range following changes leading to two daughter cell formation with diploid chromosome number and full range of genes, which are necessary for all individual hereditary properties development. The mitosis is subdivided into five phases: prophase, prometaphase, metaphase, anaphase and telophase.

This type of division appeared as a special mitosis form providing sexual reproduction of organisms. As meiosis result, 4 haploid cells are formed from one somatic cell with diploid chromosome number. The meiosis has two following divisions: the first - reducing division, which decreases chromosome number in half (meiosis I), the second - equalizing division when a cell save their haploid chromosomes set (meiosis II). The most complicate is meiosis I. It has elongated prophase consisting of five stages (leptonemmm, zygonemmm, pahynemmm, diptonemmm, diakinesis).

Purposes of class: 1. To know modes of the cell reproduction, mechanisms of cell division regulation, medical aspects of cells proliferation. 2. To be able to determine mitosis and amitosis stages in the slides. 3. To be acquainted with types and forms of amitosis.

Questions:

1. Cell cycle, its characteristics. Cytogenetical characteristics of a cell in interphase periods.
2. Cell division, its forms and kinds.
3. Mitosis:
 - mitosis itself, its phases, genetic material distribution dynamics, biological value.
 - meiosis, its phases, their cytological and cytogenetical characteristics.
 - endomitosis, polyteny, their mechanisms, biological value.
4. Amitosis, its kinds and forms, biological value.
5. Cell proliferation. Problem of cell proliferation in medicine.
6. Neuro-endocrine mechanisms of cell division regulation.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003 – p. 44-52.

Laboratory work

I. Study the following micropreparations (with drawing):

- “Mitosis in onion root cells” (280x);

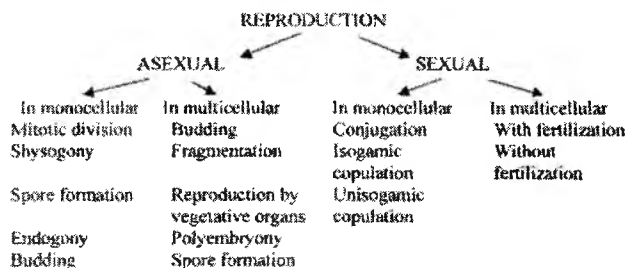
- “Mitosis in *Ascaris* uterus cells” (280x);
- “Amitosis in mice urinary bladder epithelium cells” (280x).

ONTOGENETIC LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS № 6. ORGANISMS REPRODUCTION

The ability to reproduce itself is one of the main features of life systems. On molecular level, reproduction process is determined by nucleic acids duplication ability. On ontogenetic level, self reproduction is performed in different forms: from simple division of protists to sexual reproduction of animals and plants, which is very complicate process in structural and functional aspects.

The reproduction – is ability of organisms to produce new organisms similar to them; and ability of organism to produce offsprings. One's being is supported by cell reproduction; and species being is supported by organism's reproduction. The reproduction is necessary condition of species being and generation's continuity in it. Although, the reproduction ways in worlds of plants and animals are very diverse, but they may be divided into two general types: asexual and sexual.



The asexual reproduction is a reproduction in which only one parent organism takes part. As result of its division or budding one or several new organisms are formed. These organisms are identical in genotype to parent organism. During asexual reproduction, the

somatic cell sets a new organism. There is no special reproductive cells formation.

The sexual reproduction means a development of offspring from fertilized ovicell - zygote, i.e. fused male and female sex cells. While sexual reproduction the continuity between generations is performed by special sex cells - gametes (from Greek "gamos" - marriage). Such cells have a haploid chromosome set and they are formed in meiosis. These cells are spermatozoa and ova.

The sexual reproduction now dominates in animal and plant world. It has some advantages over asexual reproduction. A higher reproduction coefficient is reached, i.e. it gives more new organism germs. A full renewing of genome occurs. It happens because of mother and father genetic information fusion. Such process is a permanent source of hereditary diversity. It extends an adaptation ability of species in abiotic and biotic conditions and provides a success in survival competition.

The basis of sexual reproduction is sexual process. The essence of it is a fusion of genetic material of parents to genetic material of offspring.

Purposes of class: 1. To know principles of asexual and sexual reproduction, particularities of sexual reproduction in multicellular organisms. 2. To be able to determine types of ova, phases of fertilization in the specimen slides. 3. To be acquainted with biological essence of sexual reproduction irregular types.

Questions:

1. Reproduction – universal property of all living things. Evolution of reproduction types.

2. Asexual reproduction, its modes in unicellular and multicellular organisms

3. Sexual reproduction, its advantages over asexual one. Modes of sexual reproduction, their characteristics.

4. Particularities of sexual reproduction in multicellular animals:

- principles of oogenesis and spermatogenesis in mammals;
- morphological and functional features of female and male gametes in mammals;
- insemination (external and internal);

– fertilization, its phases.

5. Irregular types of sexual reproduction: parthenogenesis, gynogenesis and androgenesis.

6. The hermafroditism. The formation of sexual dimorphism while evolution.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003 – p. 53-64.

Laboratory work

I. Study the following micropreparations (without drawing):

- “Clam ovum” (280x);
- “Guinea pig sperms” (280x);
- “Fertilization of *Ascaris* ovum” (280x);
- “Syncaryon in *Ascaris* ovum (280x);
- “Meiosis in *Ascaris* oogenesis” (280x);
- “Mold fungus *Mukor*” (56x);
- “Frog ova “(56x);
- “Cock sperms” (280x).

CLASS № 7.

PARTICULARITIES OF HUMAN REPRODUCTION

The division of mankind into two sexes assumes every individual to have full correspondence of anatomical body plan, structure of sexual organs, body's proportions (growth, shoulder/pelvis width ratio, distribution of adipose tissue and so on), sexual realization (feeling of self as representative of definite sex), and at least adequate direction of sexual drive and appropriate stereotypes of sexual behavior.

The formation of this system starts from genetic sex determination by chromosomes set. The genetic sex determines gonad (or genuine) sex, identified by main sign of sex - histological structure of sexual gland. It is genuine because it allows to determine gamete sex, i.e. ability of sexual gland to produce spermatozoa or ova. Gonads show an individual role in reproduction process. Also gonad sex determines hormonal sex - the ability of sexual gland to produce specific sex

hormones (during embryonic development only testis are hormone active, whereas in puberty both ovarium and testis are hormone active). Then, the level and dominating directions of hormonal action determine morphological (or somatic) sex (phenotype). Morphological sex means features of structure and development of internal and external sexual organs, and also secondary sexual characteristics. It is important to note that a term "sex" is composed from many related to each other biological, social and psychological components.

Sex – is a union of organism's signs and properties providing participating in reproduction and hereditary information transmission through making gametes.

The biological sex differentiation is programmed by genetic sex chromosome set in zygote after gamete nucleuses fusion.

It was pointed above that embryonic gonad is bisexual. Formation of primary gonads occurs on 5th week of embryonic development. The genetic sex is determined by sex chromosome (X or Y) of sperm. The X chromosome has a gene of testicular feminization (X^{tfm}), normal allele of which is responsible for receptor synthesis for androgens. Since, male and female organism has at least one X chromosome. That means that both sexes have such receptor. Y chromosome has a gene, which is responsible for synthesis H-Y antigens, which stimulate differentiation of sexual folds' cells to semeniferous tubules and interstitial cell. If individual has genotype $X^{tfm} X^{tfm}$, the ovarium will be formed from primary gonad cortex. If individual has genotype $X^{tfm} Yh-Y$, the testis will be formed from primary gonad medulla.

At 10th week of development the sex of embryo may be determined by two criteria: sex chromosome set and histological structure of sex glands. The sex of mature gonad (gonad's sex) may be determined by generative elements state: primary follicles with oocyte I in ovariums and semeniferous tubules with spermatozoa in testis.

A hormonal gonad function is producing sex hormone in their intermediate tissues (teca cell in ovarium and Leidig cell in testis). Both ovarium and testis produce main sex hormones: testosterone, estrogen, progesterone, but in different ratio. Ovariums mostly produce estrogens and after ovulation progesterone. Testis mostly produces testosterone. The typical for ovarium and testis features of sex steroid biosynthesis form hormonal sex. It is sexual steroid ratio

and their properties, characterizing each sex. Testosterone, liberating into embryo blood, binds with androgen receptors in a target cell of potential reproductive system. Then complex testosterone-receptor passes to a nucleus, where it changes an activity of genes responsible for tissue growth and development. Testosterone stimulates development of tissues, which give rise only for male reproductive system. That why, male is developed from embryo with sex chromosome set - XY.

Tissues of potential female reproductive system are not activated and they don't develop. In an embryo with sex chromosome set XX the absence of testosterone allows reproductive system to develop female pattern. On a 10-12th week of embryonic development the internal sex organs are formed. Until differentiation period, both male and female embryo has a rests of pronephros urethra, which are a precursors of sexual organs of both sexes.

So called Muller's canals are precursors of female sex organs - uterine tubes, uterus, and upper part of vagina. So called Wolfs ducts are precursors of male reproductive organs - epididymis, vas deferens, seminal vesicles.

After 12th week of development in case of having satisfactory concentration of testosterone, there is masculinisation of external sex organs in a male embryo. It is done in 20th week. There is atrophy of vagina appendix, formation of scrotum suture (scrotum formation), enlargement corpus cavernosa of penis and formation of cavernose part of urethra.

In puberty, the definite level of estrogens provides formation of female sexual characteristics - feminization (female body constitution, mammal glands formation, hymen, vagina and uterus enlargement). Androgens provide male skeleton type, good muscular development, development of larynx cartilages, voice muta don, scrotum and penis enlargement, male type of hair distribution. The synchronization of ovarian cycle (follicule development, ovulation, corpus luteum formation) and pituitary hormone regulation setting also occurs in puberty. Males have stable pituitary regulation.

Purposes of class: 1. To know biological particularities of human reproduction, mechanisms of sex dimorphism formation and of hermaphroditism development. 2. To be able to determine

spermatogenesis and ovogenesis stages in slides. 3. To be acquainted with ethic and legal aspects of intervention in human reproduction.

Questions:

1. Biological mechanisms of sex determination in a human. Sexual dimorphism: genetical, gonad, gametical, hormonal, morphological, civil and behavioural aspects.
2. Sexual traits differentiation during human individual development. Significance of the testicular feminization gene and of the gene which is responsible for HY- antigene synthesis.
3. Particularities of a human oogenesis, its hormonal regulation.
4. Features of a human spermatogenesis, its hormonal regulation.
5. Particularities of human fertilization, influence of season rhythms and social factors on this process.
6. Hermaphroditism (true and false). Disorders of a sexual self – consciousness. A transsexualism. A transvestism.
7. Modern genesial strategy: artificial insemination, in vitro fertilization, embryo placement into an uterus, “substitutive motherhood” etc.
8. Ethic and legal aspects of intervention in human reproduction.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003 – p. 65-75.

Laboratory work

I. Study the following micropreparations (with drawing):

- “Cross section of mammal testis” (56x and 280x);
- “Cross section of mammal ovary” (56x and 280x);
- “Human sperms” (280x).

CLASS № 8.
PRINCIPLES OF CYTOGENETICS
(summing-up class).

Purposes of class: 1. To estimate degree of program material on molecular-genetic, cellular and ontogenetic levels of living matter organization, organisms reproduction principles, particularities of human reproduction mastering. 2. To be able to solve problems on encoding and decoding of genetic information.

Questions:

1. Essence of life. Fundamental properties of living things. Biological systems, levels of their organization.
2. Genetic material organization in viruses, prokaryotes and eukaryotes.
3. DNA structure. Chargaff's rules. DNA model. DNA replication.
4. RNA, its types and structure. RNA synthesis.
5. Gene as a fragment of genomic nucleic acid. DNA spacers, repeated sequences of nucleotides, extragenic genes.
6. Genetic code, its characteristics.
7. Eukaryotic chromosomes molecular organization.
8. Euchromatin and heterochromatin.
9. Cytology as a science, its value to biology and medicine.
10. Cell theory, main stages of its development (role of R. Hooke, M. Schleiden, T. Schwann, R. Virchow). Modern state of cell theory.
11. Cell as elementary structural and functional unit of living things.
12. Particularities of prokaryotic and eukaryotic cell structure.
13. Methods of cell study. Light microscope structure. Rules of work with microscope.
14. Structural parts of a cell.
15. Cell wall. Cytoplasmic membrane, particularities of its structure and functions.
16. Structure of cytoplasm:
 - structural organization and properties of cytoplasm matrix;
 - organelles, their morphological and functional characteristics;

– cytoplasm inclusions, their classification and significance in a cell.

17. Structure of a cell nucleus. Nucleus / cytoplasm index as an indicator of cell functional condition.

18. Morpho-functional characteristics of a chromosomes. Types and rules of chromosomes.

19. Karyotype. Ideogram. Characteristics of human karyotype. Denver and Paris classification of human chromosomes.

20. Cell as open system. Substances exchange in a cell.

21. Membrane transport of substances. Passive and active transport. Endocytosis and exocytosis.

22. Organization of energy flow in a cell during photosynthesis, fermentation and respiration processes.

23. Information flow in a cell.

24. Substances and information flows in a cell during protein biosynthesis.

25. Cell cycle, its periods . Cytogenetical characteristics of a cell in interphase periods.

26. Cell division, its types and kinds.

27. Mitosis:

– mitosis itself, its phases, genetic material distribution dynamics, biological value;

– meiosis, its phases, their cytological and cytogenetical characteristics;

– endomitosis, polyteny, their mechanisms, biological value.

28. Amitosis, its kinds and forms, biological value.

29. Cells proliferation. Problem of cellular proliferation in a medicine.

30. Mechanisms of cell division regulation.

31. Reproduction – universal property of all living things. Evolution of reproduction types.

32. Asexual reproduction, its modes. Sexual reproduction, its types. Advantages of sexual reproduction over asexual one.

33. Particularities of sexual reproduction in multicellular animals:

– principles of spermatogenesis and oogenesis in mammals;

– morphological and functional properties of mature gametes in mammals;

– insemination (external and internal);

– fertilization, its phases.

34. Irregular types of sexual reproduction: parthenogenesis, gynogenesis and androgenesis.

35. Sex determination in a human. Sex dimorphism: genetical, gonad, gametical, hormonal, morphological, civil and behavioural aspects.

36. Sex signs differentiation during individual development of a human. Significance of the testicular feminization gene and of the gene which is responsible for HY- antigen synthesis.

37. Particularities of oogenesis in a human, its hormonal regulation.

38. Spermatogenesis in a human, its hormonal regulation.

39. Morphological and functional particularities of human mature gametes.

40. Particularities of human fertilization, influence of season rhythms, stress, social factors on this process.

41. Hermaphroditism in a human (true and false). Disorders of a sexual self – consciousness: a transsexualism, a transvestism.

42. Modern genetical strategy: artificial insemination, in vitro fertilization, substitutive motherhood etc.

43. Ethic and legal aspects of intervention in human reproduction.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 5-75.

Laboratory work:

I. Solve the problems on transcription:

№8. One of DNA strands with sequence of nucleotides ATTTCTCAA is used as matrix for m-RNA synthesis. What nucleotides sequence will m-RNA have?

№9. Determine nucleotide sequence of the m-RNA part which was formed on the part of the gene with following nucleotide sequence: ATTCACGATCCTTCGAGGAGT.

№10. Fragment of DNA strand has following sequence of nucleotides AAAGATACACACATATTTCTGTTACTA. Determine

structure of m-RNA molecule, which is formed in transcription process on this part of DNA molecule.

№11. Part of DNA strand, which is used for m-RNA formation has following nucleotide sequence: AACAACTTAGTTGTTAGAGTGACAGTT. Determine what free nucleotides will be used for m-RNA formation on this part of DNA molecule.

№12. Formed part of m-RNA molecule has following composition of nucleotides: GCGACAUUUUCGCGUAGUAGUAGAAUU. What will DNA nucleotides encode this m-RNA part and in what sequence will they situate?

№13. Part of one DNA strand consists of following nucleotide sequence: AGGGAATATACCATACGAGTAATTTTT. Determine, what will codones be in m-RNA encoded on this DNA part and in what sequence will they situate.

II. Solve the problems on translation:

№14. Determine amino acid sequence of polypeptide, which is controlled by m-RNA with following nucleotide sequence: CCUCCCCACCG.

№15. Fragment of human adrenocorticotrophic hormone produced by anterior lobe of pituitary gland has following structure: Ser-Tyr-Ser-Met. Determine set of t-RNA anticodons which take part in biosynthesis of this ACTH fragment.

№16. Part of gene encoding protein consists of following nucleotides: AACGACTATCACTATACCAACGAA. Determine composition and order amino acids in polypeptide chain which is encoded by this part of gene.

№17. Part of gene encoding one of hemoglobin polypeptide chains consists of following nucleotides: ACCATTGACCATGAA. Determine sequence of amino acids in this polypeptide chain.

III. Solve the problems on determination of DNA structure according to protein molecule structure:

№18. Fragment of protein (myoglobin) molecule consists of amino acids, disposed in following order: Val-Ala-Glu-Tyr-Ser-Gln. Determine structure of DNA molecule part encoding this amino acid sequence.

№19. Fragment of insulin polypeptide chain A includes 20 amino acids: Gly-Ile-Val-Gln-Gly-Cys-Cys-Ser-Val-Cys-Ser-Leu-

Tyr-Gly-Leu-Gln-Asn-Tyr-Cys-Asn. Determine structure of DNA molecule part encoding this polypeptide chain.

№20. Initial part of E. coli bacterium polypeptide chain consists of 10 amino acids disposed in following order: Met-Gly-Arg-Tyr-Gln-Ser-Leu-Phe-Ala-Gly. What is sequence of nucleotides in DNA part encoding this polypeptide chain?

№21. Beginning chain of one hystone H3 fraction obtained from cattle thymus has following amino acid sequence: Ala-Arg-Tre-Lys. What nucleotide structure has initial fragment of m-RNA and corresponding it double-stranded DNA?

CLASS № 9.

GENETICS AS A SCIENCE ABOUT INHERITANCE AND VARIATION PRINCIPLES. GENE LEVEL OF HEREDITARY MATERIAL ORGANIZATION IN PRO- AND EUKARYOTES.

Genetics is a science about principles of heredity and diversity of organisms and about methods to direct them. The term "genetics" was suggested by English scientists W. Batson (from Greek 'geneticos' – related with birth).

Heredity – is an organism's property to transmit their traits and development features in line of following generations. Because of heredity, many species having been preserved unchanged during hundreds millions years (opossum, latimeria, gatteria). In sexual reproduction, a material basement of heredity is sperms and ovum, in asexual reproduction – somatic cells.

Herediting is principles of hereditary traits transmitting process from one organism generation to another while reproduction. During sexual reproduction, herediting is performed through the sex cells, during asexual through the somatic cell division. The analysis of herediting principles is an important method to study heredity patterns.

The genotype is integrity of all organism genes.

The phenotype is integrity of all organism traits. It must be concerned that terms genotype and phenotype commonly are used in a narrow meaning. They may be related with such traits, which are

interested for researcher at this moment. For example – white blue, dark or brown eyes in human.

The variation it is a variety of individual or group traits and properties. The variation is a reflection of unstable preserving of individual hereditary information. It includes a gene changing and gene combining and changes in gene expression throughout individual development.

The genetics studies heredity and variation in four aspects.

Firstly, it studies a problem of genetic information storage. It makes clear the material place of genetic information storage and the ways of genetic information coding.

Secondary, it studies a problem of genetic information transmitting and principles of that transmitting from cell to cell, from generation to generation.

Thirdly, it analyzes a problem of genetic information realization. It studies how genetic information may be realized in definite traits of developing organism, in correspondence with external environment impacts.

Fourthly, it considers the problem of genetic information changing. It discovers the types and reasons of changing and mechanisms of its appearance.

Molecular genetics, we may distinguish such levels of hereditary information organization as gene, chromosome and genome in pro- and eukaryotes.

The gene is a region of genomic nucleic acid, which is characterized by specific nucleotide sequence and which presents function unit different from other genes.

The prokaryotic gene to consist of unseparated DNA region. The eukaryotic have some fragments. These fragments may be exons (having useful information) and introns (without it). Introns are removed during gene expression (process of realization genetic information).

Purposes of class: 1. To know particularities of hereditary material organization and mechanisms of gene expression regulation in pro- and eukaryotes. 2. To be able to solve problems on molecular genetics. 3. To be acquainted with achievements of gene engineering and biotechnology.

Questions:

1. Genetics as a science and a subject. Purposes and methods of genetics. Genetics development stages.

2. Main definitions of genetics (heredity, inheritance, variation, gene, allelic genes, homozygote, heterozygote, hemizygote, dominant genes and recessives ones, genotype, genome, phenotype, gene pool).

3. Hereditary material organization levels in prokaryotes and eucaryotes.

4. Gene level of hereditary material organization in prokaryotes:

- notion about gene structure;
- hypothesis of G. Beadle and E. Tatum “one gene – one enzyme”, its modern reading;
- genes classification (structural and acceptors);
- gene expression during protein biosynthesis (hypothesis of F. Jacob and J. Monod).

5. Gene level of hereditary material organization in eukaryotes:

- mosaic gene structure, processing and splicing phenomena;
- particularities of gene expression regulation, role of steroid hormones in it.

6. Gene theory, its statements.

7. Multidimensional organization of proteins as structural basis of interallelic and intergene interactions while human hemoglobins synthesis.

8. Gene engineering, its purposes and methods. Obtaining of genetic material. Inserting of genetic material into the cells- recipients and setting of genes to genetic cell apparatus. The bioethical aspects of gene engineering.

9. Biotechnology, its value to medicine and pharmacy.

Literature:

Bekish O.- Y. L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 76-88.

Laboratory work:

I. Solve the problems on molecular genetics.

№22. Part of DNA molecule encoding polypeptide part has following structure: ACCATAGTCCAAGGA. Determine amino acid sequence of polypeptide.

№23. At one of Fanconi syndrome form (bone tissue formation disorder) patient excretes with urine amino acids which correspond to following codons of m-RNA: AAA, CGU, GUU, UUA, UGU, and UAU. Determine what amino acids are excreted with urine at Fanconi syndrome.

№24. The human suffering from cystinuria excretes with urine amino acids which correspond to following m-RNA codons: UCU, UGU, GCU, CCU, CAG, CGU, AAA. Alanin, Serin, Glutamic acid and Glycine are revealed in healthy human urine. What amino acids does human with cystinuria excrete? Write down the codons which correspond to amino acids of healthy human urine.

№25. In ribonuclease molecule one of polypeptides has following amino acids: Lys-Asp-Gly-Thre-Asp-Glu-Cys. Determine the nucleotide structure of m-RNA controlling synthesis of this polypeptide.

№26. Polypeptide consists of following amino acids: Valine – Alanine – Glycine – Lysine – Tryptophan – Valine – Serine – Glutamic acid. Determine structure of DNA part encoding this polypeptide.

№27. Polypeptide consists of following aminoacids: Alanine – Glycine – Lysine – Metionine – Tyrosine. Determine structure of DNA part encoding this polypeptide chain.

№28. Initial part of insulin B chain is presented by 10 aminoacids: Phenylalanine - Valine – Aspartic acid – Glutamine – Histidine – Leucine – Cysteine – Glycine –Serine – Histidine. Determine quantitative ratio Adenine + Thymine and Guanine + Cytosine in DNA strand encoding this insulin part.

№29. It is known that distance between two neighboring nucleotides in coiled DNA molecule measured along coil axis equals 0,34 nm. What length have structural genes determining structure of normal hemoglobin molecule including 287 amino acids? What length has part of DNA molecule, encoding cattle insulin if it is known that cattle insulin molecule has 51 amino acids and distance between two neighboring nucleotides in DNA equals 0,34 nm.

CLASS № 10.

CHROMOSOME AND GENOME LEVELS OF HEREDITARY MATERIAL ORGANIZATION IN PROKARYOTES AND EUKARYOTES

The chromosome level of hereditary material organization is characterized by chromosome structure. The chromosome of non cellular live forms is presented in a form of naked DNA chain (or RNA chain in some viruses). The chromosome of the prokaryotes is a naked circular DNA molecule without proteins. The chromosome of the eukaryotes is a complex of DNA with histon, nonhiston proteins and methal ions.

A large contribution to sex genetics studying was made by American scientist C. Mac-Klang in 1901-1902. He proved that the X-chromosome determines the sex of the Protentor bug. In 1959, female organisms with the chromosome set "XO" were discovered. It was concluded that the Y-chromosome determined male sex. The organism containing same sex chromosomes is called homogametic. The organism containing different sex chromosomes is called heterogametic. The sex of future child depends on sex chromosome combination in the zygote. There are four variants of chromosome sex determination in animals by female homogamete or heterogamete. The female homogameting may have following variants: XX, XY (in mammalian and humans) and XX, XO (in bugs). The female heterogameting may have following variants: ZW, ZZ (in butterflies) and ZO, ZZ (in birds). The sex is determined by heterogametic organism.

But sex may be determined also by a chromosome balance, so called "sex index". Balance sex theory was suggested by K. Bridgess and R. Goldshtein in 1911. They sated that male and female sex of Drosophilla is determined by ratio of sex chromosomes to autosomes, instead of sex chromosomes combination. The genes of female organism are mostly located in X-chromosomes, whereas male organism genes are mostly located in autosomes. If ratio is $X:A=1$, it is female organism. If ratio is $X:2A=0.5$, it is male organism. If it is intermediate ratio (from 1 to 0.5), it is intersex organism. Increased ratio ($3X:2A= 1.5$) leads to overmatured female formation. Decreased ratio ($X:3A=0.33$) leads to overmatured male formation.

The balance sex theory may be used in humans. The normal female sex chromosomes to autosomes balance is XX:44A. If such balance is XO:44A, which is observed in patients with Shereshevsky-Terner syndrome, the ovary, uterus tubes, uterus underdevelopment is founded. If patients have three X-chromosomes (XXX:44A), the secondary sex signs expression may be broke. Normal male sex chromosomes to autosomes balance is XY:44A. The patients with Klinefelter syndrome (XXY:44A) have unexpressed secondary sex signs, gynecomasty, and failed spermatogenesis.

The genome - is an assemblage of all haploid chromosome set genes of definite species. The genome level of hereditary material organization has specific features in prokaryotes and eukaryotes.

The virus genomic nucleic acid is consisted of structural genes only, in the bacterial genome most of the genes are unique. That means they are in chromosome only in one copy. Only exclusion is genes, which encode rRNA and tRNA. These genes are repeated in bacterial genome several times. It is interesting to note a discrepancy between nucleotide number and gene number in bacteria genome. It was stated that DNA of *E. coli* contain 3,8 millions of nucleotide pairs. At the same time, it was found around 1000 structural genes in *E. coli*. Such genes contain only about 1,5 millions of nucleotide pairs.

It is clear that only way is to suggest that the rest of nucleotides are in DNA regions with undiscovered function. The DNA spiralization in prokaryotes is less than in eukaryotes.

The eukaryotes genome has more complicate organization. It contains larger numbers of genes, and larger amounts of DNA in the chromosomes. It has a complicated gene activity controlling system which is related with cells and tissue differentiation in ontogenesis. The more complicated in evolutionary plan an organism is the larger amount of DNA it contains. Eukaryotes also have excessive genes. So the human genome contains 3 billions nucleotide pairs, which is enough to make more than 2 millions structural genes. Conversely, different assessments of the human genome have from 50000 to 100000 structural genes. This is in 20-40 times less than possible. More than half of the genome consists of unique genes, which are not repeated. The bull calf has 55% of such genes, human 64%, *drosophila* 70%.

Purposes of class: 1. To know characteristics of chromosome and genome levels of hereditary material organization in prokaryotes and eukaryotes. 2. To be able to solve the problems on sex-linked inheritance, on gene linkage, on determination of distance between genes in a chromosome. 3. To be acquainted with ethic aspects of human genome study.

Questions:

1. Chromosome level of hereditary material organization:
 - the role of sex chromosomes in sex determination;
 - significance of autosomes and sex chromosomes balance in sex determination;
 - sex-linked inheritance in a human;
 - chromosomes as gene linkage groups, complete and incomplete linkage. Morgan's rule. Gene linkage groups in a human;
 - chromosome mapping, its methods;
 - the main statements of chromosome theory of inheritance.
2. Genomic level of hereditary material organization:
 - particularities of prokaryote genome;
 - particularities of eukaryote genome;
 - Human Genome Project; ethic aspects of human genome study.
3. Cytoplasmic inheritance. Cell genetic apparatus.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003. – p. 89-101.

Laboratory work.

I. Solve the problems on sex-linked inheritance:

№30. The classical hemophylia is inherited as the recessive character linked with X-chromosome. The man with hemophylia marries the healthy woman. They have normal daughters and sons, which marry healthy persons. Will hemophylia be revealed among grandchildren and what is probability of it in daughter's and son's families?

№31. The man with hemophylia marries the normal woman who has father suffering from hemophylia. Determine probability of healthy children birth in this family.

№32. In a human recessive gene causing one form of color blindness (daltonism) is located in X-chromosome. The girl having normal vision (her father suffered from color blindness) marries the normal man (his father also suffered from color blindness). What vision may be expected in the children in this family?

II. Solve the problems on gametes formation in gene linkage:

№33. There are dominant genes of brown eyes and myopia in a human which are located on the same pair of autosomes. How many and what types of gametes do the man and the woman produce being heterozygous by these genes?

№34. In a human in the same autosome both dominant genes of blue sclera and of color-blindness are located. How many and what types of gametes will the man $\frac{AB}{ab}$ and the woman $\frac{Ab}{aB}$ produce?

III. Solve the problems on phenotype and genotype determination in gene linkage:

№35. In the x-chromosome of a human the recessive gene h of hemophyilia and recessive gene c of daltonism are located. The girl has the father who suffers from daltonism, and healthy mother who is heterozygous on gene of hemophyilia. She marries the healthy man. What sons may be born in result of noncrossing-over and crossing-over gametes development?

№36. In a human hemophyilia and daltonism are caused by linked with x-chromosome recessive genes h and c . The woman has six sons: two from them suffer from daltonism but have a normal blood clotting, three suffers from both daltonism and hemophyilia. What is genotype of the mother?

IV. Solve the problem on determination of distance between genes in a chromosome :

№37. In a human recessive gene c is responsible for color blindness and recessive gene d is responsible for muscular Dushene dystrophy. Both diseases are inherited as sex-linked sings. According to certain pedigree the following data have been obtained: the healthy woman with normal vision (her father suffered from muscular dystrophy and her mother suffered from color blindness) marries the healthy man with normal color vision. In this family 8 sons and 3 daughters were born. From them 3 daughters and 1 son were healthy completely. 3 sons had muscular dystrophy only, 3 sons suffered from

color blindness only and 1 son had both diseases. Indicate distance between genes c and d.

V. Solve the problems on gene linkage:

№38. In a human the locus of Rh factor is linked with locus determining the shape of erythrocytes and is from it on the distance of 3 centimorgans (K. Stern, 1965). Both rhesus - positivity and oval shape of erythrocytes are determined by dominant autosomal genes. One of the parents is heterozygote by both characters. Thus he has inherited rhesus - positivity from the mother and oval shape of erythrocytes – from the father. The second one is rhesus negative and has normal erythrocytes. Define percentage of probable genotypes and phenotypes of children in this family.

№39. The classical hemophylia and daltonism are inherited as recessive characters linked with X-chromosome. The distance between genes is determined in 10 centimorgans. The woman whose mother suffers from daltonism, and father – from hemophylia marries the man suffering from both diseases. Define probability of children with both anomalies birth in this family.

CLASS № 11.

PRINCIPLES OF MONOGENIC AND POLYGENIC INHERITANCE. PHENOTYPE FORMATION AS RESULT OF GENETIC AND ENVIRONMENTAL FACTORS INTERACTION.

Inheritance – is the way of hereditary information transmitting from generation to generation through gametes in sexual reproducing and through somatic cells in asexual reproducing.

If a trait expression is controlled by only one gene, it is monogenic inheritance. If a trait expression is controlled by several genes, it is polygenic inheritance. Since gene may be placed in autosomes or in sexual chromosomes. Accordingly, it may be distinguished two variants of inheritance – autosomal, and linked with X-chromosome or Y-chromosome. And also due to character of gene expression it can be distinguished dominant and recessive inheritance.

Formation of phenotype is a complicated process, which takes a time. The phenotype – is the observable expression of trait (affecting

an individual's structure, physiology or behavior) that results from the biological activity of the DNA molecules. It is the realized expression of genotype. Genes provide only a possibility of traits expression. It depends on genetic factors, environmental factors, and individual development and so on. That means that formation of phenotype is under direction of many factors.

Among genetic factors affecting phenotype formation are interactions of genes from one allele (dominance, recessing, incomplete dominance, codominance, superdominance) and from different alleles (dominant and recessive epistasis, hypostasis, complementarity), from many alleles, pleiotropic gene action, gene dose.

Purposes of class: 1. To know: types and kinds of inheritance; essence of Mendel's laws at monohybrid and polyhybrid cross; types of allelic and nonallelic genes interactions; particularities of quantitative and qualitative gene expression; multifactorial principle of phenotype formation. 2. To be able to solve problems on interaction of allelic and nonallelic genes, on multiple alleles, on gene penetrance. 3. To be acquainted with statistical pattern of inheritance principles.

Questions:

1. Inheritance, its types and kinds.
2. Hybridologic analysis, its essence.
3. Monogenic inheritance:
 - principles of inheritance at monohybrid cross (the law of dominance, the law of segregation, the rule of "gametes purity");
 - principles of inheritance at dihybrid and polyhybrid cross (the law of an independent assortment); Punnett square; phenotypic radical;
 - conditions of G. Mendel's laws manifestation; statistical pattern of mendelian traits inheritance;
 - mendelian traits in a human.
4. Polygenic inheritance, conditions of its display. Notion about gene dose.
5. Value of genetic factors in phenotype formation:
 - interactions among allelic genes (complete dominance, incomplete dominance, codominance, superdominance);

- interactions among nonallelic genes (dominant and recessive epistasis, complementarity);
 - multiple alleles, inheritance of ABO system blood groups in a human;
 - primary and secondary pleiotropy, genocopies.
6. Influence of environmental factors on realization of a genotype to a phenotype; variable expressivity; incomplete penetrance; phenocopies.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003. – p. 102-110.

Laboratory work.

I. Solve the problems on monohybrid cross.

№40. In a human dominant gene **A** determines achondroplasia - dwarfism due to lower limbs skeleton sharp shorting. Its recessive allele - the gene **a** - determines a normal structure of a skeleton.

The woman having a normal structure of a skeleton has married the man who is heterozygous by achondroplasia gene. What is probability of the child with achondroplasia birth?

The woman with a normal structure of a skeleton has married the man who is homozygous by achondroplasia gene. What is probability that their child will suffer from achondroplasia?

№41. In a human the gene **s** determines congenital surdomutism. Normal hearing and speech are inherited as dominant traits. Healthy woman has married the healthy man. It is known, that in each of them one of parents was surdomute. What is probability of surdomute child birth?

II. Solve the problems on dihybrid and polyhybrid cross.

№42. In a human brown color of eyes dominates over blue one, and ability to use the right hand dominates over ability to use the left hand. Genes of both traits are located in different chromosome pairs.

The brown-eyed right-handed woman married the blue-eyed left-handed man. Determine possible phenotype of the children in case if this woman is homozygous by both traits and in case if she is heterozygous?

№43. In a human myopia dominates over normal sight, and brown eyes dominate over blue ones. The child of brown-eyed parents suffering from myopia has blue eyes and normal sight. Determine genotypes of all three members of this family.

In the blue-eyed woman suffering from myopia who has married the brown-eyed man possessing normal sight, the brown-eyed child suffering from myopia was born. Whether is it possible to determine genotypes of the parents?

№44. Height of a human is determined by three pairs of unlinked polygenes which cooperate with each other. In a population most dwarfish people have only recessive alleles of these genes and height of 150 cm, the tallest individuals possess only dominant genes and height of 180 cm. The dwarfish woman has married the man of middle height. They have three children who are 165 cm, 155 cm and 150 cm height. Determine the genotypes of the parents and their height.

III. Solve the problems on dominance and recessivity.

№45. Myopia is inherited as dominant trait. Determine probability of children with this anomaly birth in the family where father is heterozygous and mother does not suffer myopia.

№46. The late degeneration of a cornea (it develops after 50 years) is inherited as dominant autosomal trait. Define probability of disease manifestation in the family about which it is known that the grandmother and the grandfather of wife and all their relatives who have lived till 70 years suffered from this anomaly and that father's relatives were healthy.

№47. Absence of small molars is inherited as dominant autosomal trait. What is probability of children with this anomaly birth in the family where both parents are heterozygous by the analyzed trait?

IV. Solve the problems on incomplete dominance.

№48. Acatalasia is caused by rare autosomal recessive gene. In heterozygotes activity of catalase enzyme is a little bit lowered.

In both parents and in their single son catalase activity is below norm. Define probability of the child without this anomaly birth.

Define probable phenotypes of the children in family where one of parents suffers from acatalasia and another one has only lowered activity of catalase.

№49. The rare gene **a** causes hereditary anophthalmia in a human and its allelic gene **A** determines normal development of eyes; in heterozygotes eyeballs are partially reduced.

The man who is heterozygous concerning gene **A** has married the woman with normal eyes. What will segregation be in the offspring?

V. Solve the problems on multiple alleles.

№50. In a human **O(I)** blood group is determined by recessive gene **I^o**, **A(II)** one – by gene **I^A**, **B(III)** one – by gene **I^B**, **AB(IV)** one – by both genes **I^A** and **I^B** together.

Parents have **II** and **III** blood groups. What blood groups will their children inherit?

Mother with **II** blood group has the child with **I** one. Determine father's possible blood group.

Mother has **I** blood group and father – **IV** one. Whether children can inherit blood group of some parent?

Boy has **I** blood group and his sister – **IV** one. Determine blood groups of their parents.

VI. Solve the problems on pleiotropic gene action.

№51. The dominant gene of brachidactylia in homozygous condition results in individual's death. Heterozygotes are viable. Determine probability of viable children birth in heterozygous parents.

№52. Sickle cell anemia is inherited as not completely dominant autosomal trait. Homozygous individuals usually die before puberty, heterozygous ones are viable and do not suffer from malaria.

What is probability of resistant to malaria children birth in the family where one of the parents is heterozygous by sickle cell anemia gene and another one is normal by both alleles?

What is probability of children birth who are unstable to malaria in the family where both parents are resistant to this disease.

VII. Solve the problems on gene penetrance.

№53. The gout is determined by dominant autosomal gene. Its penetrance in a men is 20 % and in a women it equals 0 %.

What is probability of gout manifestation in the family of heterozygous parents?

What is probability of a gout manifestation in the family where one of parents is heterozygous and another one is normal according to analyzed sign?

VIII. Solve the problem on complementarity.

№54. Deafness can be caused by different recessive genes **d** and **e** which are located in different pairs of chromosomes. Normal alleles of these genes are **D** and **E**. The surdomute man with genotype **ddEE** has married the deaf woman **DDee**. What hearing will their children have? What is probability of the deaf child birth in the parents suffering from the same kind of deafness?

CLASS №12.

PHENOTYPIC VARIATION: ONTOGENETIC AND MODIFICATIONAL.

Variation is the ability of organism to change their traits, getting new ones or losing old ones in process of individual development.

The reason of variation may be variety of genotypes or variety of environmental condition determining trait expression. Diversity provides traits and properties variety in different individuals.

There are two variants of variation: genotypic and phenotypic. The genotypic (hereditary) variation can be combinative and mutational. The phenotypic diversity can be ontogenetic and modificational.

The phenotypic variation shows phenotype changes under environmental condition, which not affect genotype, but level of its expression is determined by genotype.

The modificational variation describes the individual's changes caused by environmental factors. To understand the relative impact of genotype and the environment in phenotype formation we need to investigate modification appearing under some environmental conditions. The examples of modificational variation are skin pigmentation of ultraviolet light, weight varying due to diet imbalance, effects of low vitamin intake.

The modification variation reaction is understandable and has only one direction to change. That means that the same environmental effect causes the same organism reaction in organisms. This is a main difference from mutations, which have strict direction in changes. Each mutagen may cause different effects and different mutagens may cause the same mutation. The most common modification in mammals and humans are modifications related to weight varying due to diet

misbalance. The level of modification expression corresponds with intensity and duration of environmental effect. The mutations, especially genetic ones, don't follow such pattern. The level of phenotype changes in genetic mutation don't correspond with intensity and duration of environmental effect.

The ontogenetic variation is variation showing normal development changes in organism or its cells during individual development. The main difference from genotypic variation is that organisms have the same genotype throughout all individual development.

From a variety of mechanisms controlling ontogenetic variation the main are the following: different gene activity; different activity of endocrine glands; different relation between processes of growth and differentiation in different periods of life.

The examples of ontogenetic diversity are milk-teeth exchange, development of secondary sex signs, grey hair, loosening of skin elastics in aging, the increased rate of bone fractures in elderly and over.

Ontogenetic diversity plays a definite role in the development of some hereditary diseases. A range of hereditary defects appears in embryo (polydactylia, syndactylia, achondrodisplasia, amavrotic idiocy Tei-Saks). Some are developed in childhood or puberty. And very few are developed in elderly. For example, family Friedreich's ataxia are developed in child 6-12 years of age, cerebellum ataxia are developed in young men 20-30 years of age, alcaptonuria – around 30 years of age, diabetes mellitus type II – 40 years of age, gout – after 40 years of age and only in men.

Purposes of class: 1. To know characteristics of ontogenetic and modificational variation. 2. To be able carry out statistic procedure at modifications study. 3. To be acquainted with role of development, training and education in humans' traits manifestation.

Questions:

1. Variation, its types and kinds.
2. Ontogenetic variation, its mechanisms.
3. Role of ontogenetic variation in human hereditary diseases manifestation.
4. Modifications, their characteristics. Reaction norm.

4. Statistic methods of modifications study (variation series, average, standard deviation, standard error, distribution curve).

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 111–113.

Laboratory work.

I. Statistic and graphic characterization of height distribution in human population.

Equipment: ruler, microcomputer, individual assignment.

Work order.

For processing of experimental data in modifications study variation series (frequency polygon) is constructed. Numerical meaning of quantitative trait is called variant. A variants are situated in increasing order.

Construct variation series (frequency polygon) according to following scheme:

I	155- 159	160- 164	165- 169	170- 174	175- 179	180- 184	185- 189	190- 194	195- 199	200- 204	205- 209
x_i	157	162	167	172	177	182	187	192	197	202	207
n_i											

where I – interval of height, x_i – variant (mean of height to given interval), n_i – variant frequency - number of random variables in each interval (number of individuals in given height interval).

Use data of variation series for variation distribution curve construction. Draw distribution curve in following coordinate system: x_{axis} – variant (x_i – human height), y_{axis} – variant frequency (n_i).

Count average (mean) according to following formula:

$$\bar{x} = \frac{\sum (x_i n_i)}{n}$$

where \bar{x} – average (mean), x_i – variant, n_i – variant frequency, Σ – sign of sum, n-volume of samples (total number of persons in variation series) which equals: $n = \sum n_i$.

Count standard deviation (S) according to following formula:

$$S = \sqrt{\frac{\sum n_i (x_i - \bar{x})^2}{n - 1}}.$$

Count standard error of average ($S_{\bar{x}}$) according to following formula:

$$S_{\bar{x}} = \frac{S}{\sqrt{n}} = \sqrt{\frac{\sum n_i (x_i - \bar{x})^2}{n(n-1)}}.$$

CLASS №13.

GENOTYPIC VARIATION: COMBINATIVE AND MUTATIONAL. MUTAGENESIS.

The variation, which involves changes in genotype due to mutations or gene combinations, is called genotypic variation. It may be of two types: mutational and combinative.

The combinative variation is the formation of new allele combinations due to crossing over in meiosis and gene recombination. New gene combinations and interaction between them may cause new trait formation.

The combinative variation has three main mechanisms:

1. Crossingover in prophase of meiosis.
2. Independent divergence of chromosome in anaphase of meiosis

I.

3. Independent fertilization by some sperm and ovum.

Combinative variation is inherited according to Mendel's Laws. On gene expression in combinative diversity, the following factors may have some influence such as interaction of allelic and non-allelic genes: pleiotropic gene action, gene linkage, gene expressivity, penetrance, and so on. This wide traits variety is provided by combinative diversity.

The variation with rapid, strong changes of trait is called mutational.

Mutations – are occasional, stable changes of genetic cell apparatus. They may include changing allelic gene position, changing of gene structure, changing in chromosome number and state, changing of cytoplasmic DNA containing structures.

All mutations are divided on groups. The mutation classification helps to study and describe them. It is made according mutation causing factors and cells subjected to mutation.

The classification of mutation.

Classifying factor	Mutations' names
According mutated cells	1. Generative 2. Somatic
According genotype change	1. Gene or point mutations 2. Chromosome aberrations (deletions, deficiency, duplications, inversions) 3. Interchromosome translocations 4. Genome mutations (polyploidy and aneuploidy). 5. Cytoplasmic mutations
According adaptive significance	1. Useful 2. Harmful (lethal and semilethal) 3. Neutral
According reason of mutation	1. Spontaneous 2. Induced

Purposes of class: 1. To know mechanisms and value of recombinations, main statements of mutational theory, characteristics of mutations, influence of mutagens on human organism, genetic danger of environment pollution. 2. To be able to solve the problems on combinative and mutational variation. 3. To be acquainted with genetic mathetrial repair types and with role of repair disorders in hereditary diseases development.

Questions:

1. Combinative variation, its value to genetic variety.
2. Mutations and mutational theory. Classification of mutations.
3. Characteristics of generative and somatic mutations.
4. Gene mutations, chromosome ones, interchromosome ones, genome ones and cytoplasmic ones.
5. Characterization of mutations according to their adaptive significance.
6. Spontaneous mutations, mechanisms of their formation.

7. Induced mutations. Physical, chemical and biological mutagens, mechanisms of their action.

8. Genetic material repair. Photoreactivation. Excision repair. Postreplicative repair.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003. – p.83-84, p. 113-121.

Laboratory work:

I. Solve the problems on combinative variation in a human:

№55. In the surdomute (it is supposed that surdomutism is inherited) blue-eyed man all children have brown eyes and normal hearing and speech. What is mother's genotype if surdomute child was born?

№56. The red-haired (dominant sign) man without freckles and the brown-haired woman with freckles (dominant sign) have five children. Determine probability of red-haired children with freckles and brown-haired children without freckles birth in these parents.

№57. In a human syndactylia and glaucoma are determined by autosomal dominant genes located in different pairs of chromosomes. The woman suffered from glaucoma has married the man with syndactylia. Woman's mother suffered glaucoma, but father hadn't this disease. Man's mother suffered syndactylia but all father's relatives hadn't this disease. Determine probability of child with both diseases birth.

№58. In a human surdomutism is inherited as autosomal recessive trait and gout – as dominant one. Both genes are situated in different pairs of chromosomes. Determine probability of surdomute child with predisposition to gout birth in the surdomute gout-free mother and the man with normal hearing and speech but suffering from gout.

II. Solve the problems on gene mutations:

№59. What will changes in the protein molecule structure be if 5-th and 13-th nucleotides at the left are removed from coding this protein DNA part including following nucleotide sequence AATACATTAAAGTC?

№60. What will changes in protein molecule structure be if in DNA molecule coding this part of protein and having following nucleotide sequence TAACAAAGAACAAAA cytosine has been inserted between 10-th and 11-th nucleotides, thymine has been inserted between 13-th and 14-th nucleotides and adenine has been added in the end of DNA molecule strain?

№61. DNA molecule part coding polypeptide has following sequence of nitrogenous bases: AAAACCAAAATACTTATACAA. During replication third at left adenine have been lost. Determine structure of polypeptide chain encoded by this DNA part in norm and after adenine loss.

CLASS №14.

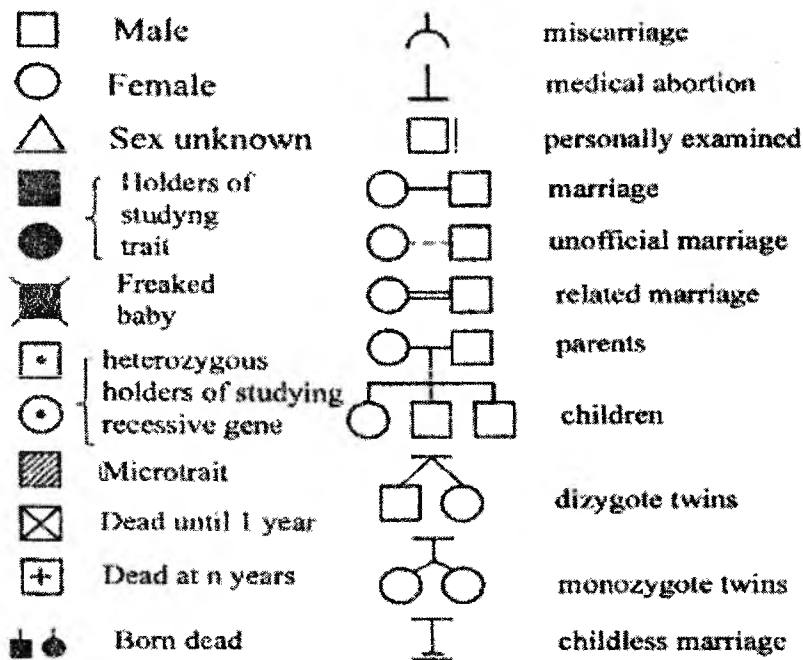
METHODS OF ANTHROPOGENETICS: PEDIGREE ANALYSIS, TWIN'S, STATISTICAL AND DERMATOGLYPHICAL

It is hard to study human genetics. The main difficulties are failure of large number of chromosomes and gene linkage groups, directed breeding, late puberty, small number of offsprings, long life expectancy, development of some hereditary diseases in ontogenesis. The negative moment is also social segregation, which retards realization of human abilities. In spite all difficulties listed above, some success was achieved in this field. Many traits were mapped and described. But features of mental and creative activity are so complicate and depend on many factors, including social, that it is hard to analyze them. But it is stated that they have hereditary nature.

Human genetics studies traits inheritance in human. To study such inheritance, it was discovered and was successfully applied several methods. Nevertheless, none from them is universal.

The method's idea was suggested by F. Galton. To study how a human traits are inherited, investigators look at the results of crosses that have already been made - they studied family histories, called pedigree. This methods may be applied if it is known direct parents of individual which is studied (he is called proband) or if it is known children of such individual. To make pedigree specific signs are used (Pic. 1). They firstly were suggested by G. Ust in 1931.

We analyze pedigree to determine pattern of inheritance. The pedigree analysis allows determining heterozygous state of defected gene and probability to have child with hereditary defect. The method is used for determining hereditary diseases in genetic counseling.



Pic. 1. The genetic symbols for pedigree (by G.Ust, 1931 with changes).

There are several patterns of inheritance.

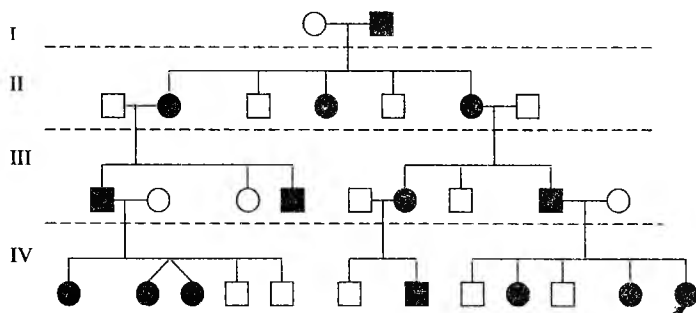
In the autosomal dominant pattern of inheritance, the mutated trait appears in heterozygous state in individuals of both sexes. The trait occurs in horizontal and vertical lines of pedigree as well. The child may be affected, if anyone from parents is affected too. However, it is important to remember about incomplete penetrance of dominant gene. Some diseases develop only after achieving particular age. For instance, Hantington's chorea appears only in individual over

35 years of age. The sparkles, brachidactilia, cataract, are inherited according the autosomal dominant pattern of inheritance.

In the autosomal recessive pattern of inheritance, the mutated trait appears only in homozygous state in individuals of both sexes. If parents are healthy, but they are heterozygotes, we can expect that 25% of offsprings will have disease. The trait occurs in horizontal line of pedigree not in every generation. If parents are both recessive for trait, all offsprings will have such trait. The examples are albinism, phenyketonuria, diabetes mellitus.

In the X-chromosome linked dominant pattern of inheritance, the mutated trait appears in individuals of both sexes (Pic. 2). The trait occurs in horizontal and vertical lines of pedigree as well. Inbreeding increases probability of ill childbirth. Female express such trait more often, because they may get trait from mother and father as well. The follicular keratosis, pigment dermatosis are inherited according X-linked dominant pattern of inheritance.

In the X-chromosome linked recessive pattern of inheritance, the mutated trait appears mainly in males. In a family, there are half of males suffered from disease and half of females having gene in heterozygous state. If the male have such trait, he inherited it from mother line of pedigree. The most common diseases having such pattern of inheritance are hemophilia A, muscular Duchenne dystrophy, daltonism.



Pic. 2 Pedigree of family with specific form of rachitis (X-chromosome linked dominant pattern).

In the Y-chromosome linked pattern of inheritance, the mutated trait appears only in males. The syndactylia, hypertrichosis of cochlea are inherited according to such pattern. The ability to develop male gonads is a holandric trait, located in Y-chromosome.

Purposes of class: 1. To know essence and value of pedigree analysis, of twin's methods, of population statistic one, of dermatoglyphic one of human genetics. 2. To be able to construct and analyze a pedigree, to carry out dermatoglyphic analysis, to calculate coefficients of heredity and environment influence on human traits formation. 3. To be acquainted with social factors role in realization of genotype to phenotype.

Questions:

1. Human as specific object of genetic analysis.
2. Methods of human genetics:
 - pedigree analysis, its potential;
 - twin's method, its value for human predisposition to hereditary diseases study;
 - population statistic method, its potential in practical health care;
 - dermatoglyphic method as mode of individual human variation study, its application in hereditary diseases diagnosis and in criminalistics practice.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003. – p. 122-124, 126-130.

Laboratory work:

I. Solve the problems on pedigree construction and analysis.

№ 62. Construct family pedigree with case of diabetes mellitus. Healthy husband and wife (cousins) have child with diabetes mellitus. Husband's mother and wife's father (siblings) are healthy, husband's brother, two wife's sisters their common uncle and grandmother are healthy. Grandfather was ill. All husband's relatives on father's line (two uncles, cousins, grandfather and grandmother) and all wife's

relatives on mother's line (aunt, cousin, grandfather and grandmother) are healthy. Determine pattern of disease inheritance and indicate those family's members who are heterozygotes by diabetes mellitus gene.

№63. Construct family pedigree concerning schizophrenia. Proband – woman with schizophrenia. Her brother, sister and father are healthy. There are following relatives on father's line: uncle with schizophrenia and two healthy aunts. One of aunts have three healthy children, another one has healthy son. Grandfather and grandmother (on father's line) are healthy; grandmother's sister was ill. Proband's mother, uncle, grandfather and grandmother (on mother's line) are healthy; uncle has two healthy children. Determine pattern of disease inheritance and indicate genotypes where is it possible.

№64. Construct family pedigree in relation to rare disease – epiloia which is determined by genes with lethal effect. Majority of persons with epiloia (pathological skin growth, mental retardation, epilepsy, tumor of heart and kidneys) die before puberty. But due to low gene expressivity some of patients survive and produce offspring.

Proband – woman with epiloia in marriage with healthy man had three children: healthy son and healthy daughter and ill daughter, which had five children: two healthy sons, two healthy daughters and one daughter with epiloia. It was revealed that this ill woman (proband's daughter) had two dead born children. Determine what gene (dominant or recessive) is responsible for this disease.

№65. Construct family pedigree concerning brachydactylia and determine pattern of this sign inheritance and genotypes of persons indicated in pedigree.

Proband – woman with brachydactylia has three healthy brothers and one healthy sister. Proband's father suffers from brachydactylia. On father's line uncle and one of aunts suffer from brachydactylia, another aunt has normal hand. Uncle has seven children with brachydactylia (three sons and four daughters) and one son and two daughters with normal hand. Grandmother (on father's line) suffered from brachydactylia and all relatives on mother's line were normal.

II. Solve the problems on coefficients of heredity (H) and of environment influence (E) calculation.

№66. Count coefficient of heredity (H) and coefficient of environment influence (E) according to Holtzinger's formula.

$$H = (CMZ - CDZ/100 - CDZ) \times 100 \quad E = 100 - H$$

Disease	Percentage of concordant twins pairs (C)	
	MZ	DZ
Measles	98	94
Parotitis	82	74
Tuberculosis	67	23
Diabetes mellitus	65	18
Epilepsy	67	3
Schizophrenia	69	10
Inborn dislocation of thigh	41	3
Cleft lip	33	5
Club-foot	32	3

CLASS №15.

METHODS OF ANTHROPOGENETICS: CYTOGENETIC, ONTOGENETIC, IMMUNOLOGICAL, BIOCHEMICAL, MOLECULAR-GENETIC, SOMATIC CELLS HYBRIDIZATION

The cytogenetic method is usually called cytological analysis of human karyotype in normal and pathological conditions. The term "cytogenetic" can be used, only if cytological analysis is combined with pedigree analysis and it is possible to link cytological pictures with phenotype effect. It is based on chromosome microscoping. Chromosomes are studied in metaphase of mitosis in fibroblasts and lymphocytes, which are cultivated in artificial conditions. The luminescent microscoping also may be used. In this case, we need to stain chromosomes by fluorochrom. Chromosomes are classified according Denver classification. This method allows determining

diseases related with changes in chromosome set and shape. It is also used for chromosome mapping.

The method is kind of complicated. The lymphocytes grow in an artificial culture. They are stimulated to division by phytohemagglutinin. In metaphase, spindle proteins are destroyed by colchicin. After that, chromosomes are available for observation for long time.

In 1969 T. Caspersen discovered the method of different chromosome staining. It made possible to distinguish chromosomes according to their segments staining. The aneuploidy, chromosome aberrations (deletions, deficiency, duplications, inversions, translocations), interchromosome translocations may be revealed with help of this method.

If there are defects in sex chromosome set, we can determine them easily. For such purpose evaluation of sex chromatin in somatic cells are used. The most common material for that is buccal epithelium (the epithelium of internal surface of a cheek).

Sex chromatin (Barr's body) – is condensed second X-chromosome in female cells. It is inactivated on 16 day of embryogenesis. It looks like heterochromatin body nearby nucleus membrane. It is revealed on preparations stained by aceto-orsein. Normally, Barr's bodies are determined in 20-40% of female cells and in 1-3% of male cells. Number of X-chromosomes is calculated according such formula: Barr's bodies' number plus one. For example, if woman has one Barr's body that means she has two X-chromosomes (1+1); if there is no Barr body in female cell that means she has one X-chromosome (0+1); if man hasn't Barr's body that means he has sex chromosomes set like that - XY (0+1).

In somatic cells, in particular in buccal epithelium, it is possible to determine Y-chromatin. Slides need to be stained by akrychin followed by ultraviolet microscoping. Y-chromatin is intensively stained body in a nucleus, usually near nucleolus. Normally, Y-chromatin is determined in 20-40% of male cells.

The express-methods for sex chromatin determining are used for hereditary, related with changing in sex chromosome set, diseases diagnostic, sex determining in hermaphrodites, transsexuals, and in forensic medicine.

All methods of prenatal diagnostics can be divided to biological and physical.

The physical methods are X-ray examination of embryo, ultrasonic examination, fetografia and fetoscopia. X-ray examination gives diagnosis of hereditary defects only in last third of pregnancy. The anencephalia, spinal cord hernia and hydrocephaly are good visible in X-rays. The variant of X-ray examination is fetographia. This is a method when contrast substance is injected to amnion cavity. This method allows diagnosing alimentary canal atresy, urinary system defects. The fetoscopy gives a real visible image of embryo, but it has many side effects and is used very rare. Many defects of nervous system are determined with help ultrasonic examination. Also it helps to evaluate defects of kidney such as polycystosis.

The biological methods are amniocentesis and chorionopexia.

The amniocentesis is performed on 14-16th week of development when amount of amniotic fluid is sufficient and when there is a time to cancel pregnancy. 15-20 ml of amniotic fluid are taken and centrifuged. The supernatant is used for biochemical and immunological methods, whereas cell detritus is used for cytogenetic methods. Now it is possible to determine sex of embryo, all chromosome abnormalities, more than 60 hereditary diseases, intolerance to Rh-antigen, hemoglobinopathy, enzymopathy, immunodeficiency syndromes with help of amniocentesis.

The same investigations are conducted while chorionopexia is performed. This method has several advantages over amniocentesis. It may be performed on earlier stage of development (6-7 week) and it excludes penetration of amniotic space. The material for investigation is chorion particles, taken from cervical canal of pregnant woman.

Purposes of class: 1. To know essence and value of cytogenetic, ontogenetic, immunological, biochemical, molecular-genetic, somatic cells hybridization methods. 2. To be able to determine X-chromatin. 3. To be acquainted with molecular-genetic method potential.

Questions:

1. The cytogenetic method, its usage for human chromosomal diseases diagnosis.

2. The method of sex chromatin determination.
3. The methods of hereditary diseases prenatal diagnosis: amniocentesis, chorionic villus sampling and others.
4. The ontogenetic method as mode of genes differential activity study.
5. The immunological method, its usage for hereditary diseases diagnosis and for tissues histocompatibility determination.
6. The biochemical method as mode of metabolism hereditary disorders diagnosis.
7. The molecular - genetic method and mode of somatic cells hybridization potential.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 125-126,130-135.

Laboratory work:

I. Study the following micropreparations (without drawing):

- “X-chromatin in leukocytes” (400x);
- “Metaphase plate of human karyotype” (400x).

II. Human karyotype analysis according to individual assignment.

Equipment: photographs of human karyotype, scissors, plates for chromosome placement.

Work order:

After individual assignment receipt cut out chromosomes from karyotype photo by scissors after individual assignment receipt. Then chromosomes have to be grouped on the plate according to Denver's classification. Give karyotype characterization. Make conclusion.

III. X-chromatin determination in nuclei of buccal epithelium by acetoorsein method (according to A. R. Sanderson, J. S. Stewart, 1961).

Equipment: microscope, specimen slides, cover glasses of 18x18mm, metallic spatulae, chemical glass eye pipette, pincers, blotting paper, 1% acetoorsein solution.

Work order.

Wash oral cavity by water to remove microorganisms, saliva and slime. Take sample of buccal epithelium cells using spatula edge. Remove obtained white mass on clean specimen slide disturbing it by thin uniform layer. Dry smear at air during 5-10 min. Add one drop of acetoorsein to prepared smear and cover it by cover glass. Surplus of staine may be removed by blotting paper. Time of staining smear lasts 5-10 min. Examine specimen at small magnification of microscope. Find cell group and study it at large magnification.

Nuclei with right shape and thin net of chromatin, with unimpaired and sharpe nuclear envelope are suitable for investigation only. It is unuseful to count nuclei with injured envelope and picnotic nuclei. X-chromatin is looked as big chromocenter of triangle, semilunar or round shape which is placed near nuclear envelope. Exemine 100 nuclei and point out the number of nuclei with one or more bodies of X-chromatin. Normal frequency of X-chromatin in a cell nuclei of females is from 20 to 50 per 100 nuclei (20%-50%). Normal frequency of X-chromatin in a cell nuclei of males is from 0 to 4 per 100 nuclei (0%-4%). In case when this frequency is lower than 15% in females or when it is higher than 4% in males it is necessary to increase number of examined nuclei up to 300-400 and carry out repeated investigation.

CLASS №16.

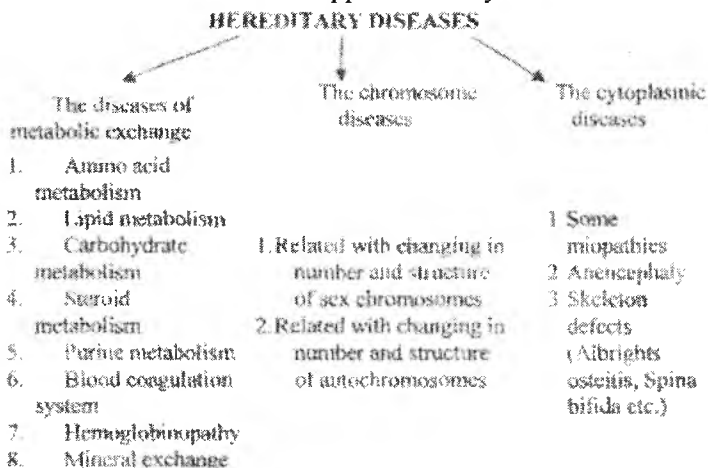
HUMAN HEREDITARY DISEASES

These days, we see a decreasing rate of infectious diseases, but at the same time hereditary disease rate are increasing. More than 3000 prevalently hereditary diseases have been registered. In the world more than 1.5 millions children are born with hereditary diseases each year. Around 10% of them die in the first year of life. In countries with good developed health care, they represent 15-20% of the total number of hospitalized patients.

Levels of damage, of all hereditary diseases can be divided into three groups: diseases of metabolic exchange, chromosomal diseases, and cytoplasmic diseases.

Normally, genes control steps of different metabolic pathways. The gene mutation may cause decreased enzyme activity or even

failure in function. There are many diseases caused by failure of one metabolic step. This group of diseases is called diseases of metabolic exchange. When enzymes can't work at all, the metabolic precursors of reaction controlled by the enzyme are accumulated in the tissue. These accumulated substances suppress activity of surrounded cells.

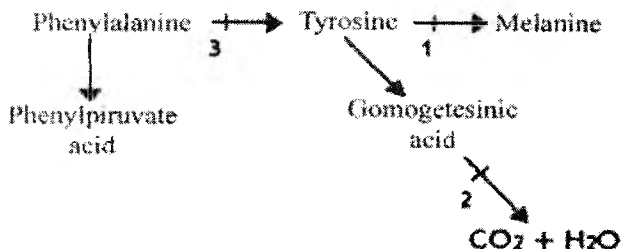


This mechanism occurs in phenylketonuria, galactosemia, and alkaptonuria. On the other side, absence of the metabolite can cause a range of hereditary defects as hereditary cretinism, adrenohenital syndrome and so on. The pathology process also may occur on a level of renal tubules. The accumulated substance can be excreted improperly or not fully. According to imbalanced exchange it can be distinguished following types of metabolic exchange diseases.

Diseases of amino acid exchange. The most common example of this type is phenylalanine misbalance (Pic. 3).

Phenylketonuria - is an autosomal recessive disease. It is caused by deficiency of phenylalanine hydroxylase enzyme. This enzyme converts phenylalanine to tyrosine. When it is blocked, phenylalanine is converted to phenylpyruvate and excreted with the urine. The rate of this disease in Europe is 1:10000. The signs of disease are irritability, convulsions, mental retardation, microcephaly, loss of

pigmentation of skin, hair, and the iris. If newborns suffering from this disease are feed as usual newborns, they express all those signs in few months. But if we give them a diet without phenylalanine, they develop as usual children without any signs of mental retardation. To evaluate phenylketonuria, the 10% FeCl test is used. It gives green color to urine when it is positive. The express-tests are used to evaluate phenylketonuria right after delivery.



Pic. 3. The scheme of human phenylalanine exchange: 1-3 the points of metabolism blocking by mutations (1 - total albinism, 2 - alkaptonuria, 3 - phenylketonuria).

Total albinism - is an autosomal recessive disease. It is caused by a defect of the gene controlling the enzyme, which converts tyrosine to melanin. Thus, melanocytes loose their ability to produce melanin pigment. The signs of the disease are absence of melanin in skin, hair, and eyes. The eyes look of red color because of visible blood capillaries. The rate of this disease is about 1:20000.

Alkaptonuria - is a recessive abnormality, having a rate of about 3-5:1000000. It is caused by a deficiency of homogentistic acid oxidase enzyme. Signs of the disease are special staining of cartilages and arthritis in elderly. There are diagnostic signs such as fast changing in color to dark in urine with added bases and changing in color to red with added Milon's reactive (containing ions of Hg) which prove the presence of tyrosine in the urine.

Purposes of class: 1. To know mechanisms of human hereditary diseases development. 2. To be able to solve the problems on human metabolism disorders inheritance. 3. To be acquainted with genetic counseling potential.

Questions:

1. Human hereditary diseases classification.
2. Human metabolism genetic disorders (disorders of amino acid metabolism, of lipid one, of carbohydrate one, of steroid one, of purine one, of metal ions one, of blood clotting one; hemoglobinopathy).
3. Human chromosomal diseases:
 - autosomal abnormalities;
 - sex chromosome abnormalities.
4. Human mitochondrial diseases.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003. – p. 136-147.

Laboratory work:

I. Solve the problems on amino acid metabolism hereditary diseases.

№67. Phenylketonuria and one of rare forms of Swiss type agammaglobulinemia (it leads to death before 6-th month of age usually) are inherited as autosomal recessive trait. Modern medicine allows to escape severe complications connected with phenylalanine metabolism disorder. What is the probability of healthy children birth in the family if both parents are heterozygous by both pathological gene pairs? Determine the probability of birth of children with phenylketonuria.

№68. One of cystinuria forms is inherited as autosomal recessive character. There is only increased amount of cysteine in urine of heterozygotes, but cysteine stones formation in kidneys of heterozygotes is observed. Determine possible forms of cystinuria expression in children if one of their parents suffers from severe cystinuria with stones formation in kidneys and another one has only increased level of cysteine in urine. Determine possible forms of cystinuria manifestation in children if one of parents suffers from nephrolithiasis (stones in kidneys) and another one is normal by analyzed character.

№69. One of agammaglobulinemia forms is inherited as autosomal recessive character, another one- as recessive X - linked character. Determine the probability of healthy children birth if mother is heterozygous by both genes pairs and father is healthy and has only dominant alleles of analyzed genes.

№70. Proband is healthy woman. She has two healthy brothers and two brothers suffered from alcaptonuria. Proband's mother is healthy and she has two healthy brothers. Proband's father is healthy and he is cousin to his wife. He has healthy brother and sister. Grandmother (on father's line) was ill and she married healthy cousin. The grandmother and grandfather on mother's line were healthy. Grandfather's father and mother were healthy too. Determine the probability of birth of children with alkaptonuria in proband's family if she were married healthy man whose mother had suffered from alkaptonuria.

II. Solve the problem on lipid metabolism disorders.

№71. Familial hypercholesterolemia is inherited as autosomal dominant trait. In heterozygotes this disease expresses only high level of cholesterol in the blood. In homozygotes xantoms (benignant tumors) of the skin tendons and atherosclerosis are developed. Determine possible type of hypercholesterolemia in children in the family where both parents have only high level of cholesterol in the blood. Determine the probability of birth of children with hypercholesterolemia and type of this disease in the family where one of parents has high level of cholesterol, xantoms and atherosclerosis but another one is normal by analyzed sign.

III. Solve the problem on carbohydrate metabolism disorders.

№72. There are two forms of fructoseuria. One of them is clinically asymptomatic, another one leads to retardation of physical and mental development. Both forms are inherited as recessive unlinked signs. One of parents is homozygote by first form of fructoseuria and he is heterozygote by second form. Another of parents is homozygote by second form of fructoseuria, but he is heterozygote by first form. What is the probability of birth of children with clinical (second) form of fructoseuria?

IV. Solve the problem on purine metabolism disorders.

№73. The gout is determined by dominant autosomal gene. Penetrance of this gene in a men is 20 % and in a women it equals zero.

What is the probability of disease manifestation in the family of heterozygous parents?

What is the probability of disease manifestation in the family where one of parents is heterozygous and another one is normal to analyzed trait?

V. Solve the problem on blood clotting disorders .

№74. In a human hemophylia is determined by X-linked gene h.

The mother and the father are healthy. Their child suffers from hemophylia. Who from parents transmitted gene of hemophylia to the child?

The healthy woman (heterozygote by gene of hemophylia) married the healthy man. What is the probability of hemophylia expression in progeny? What do children (sons or daughters) have more risk to hemophylia inherit?

The girl's father suffers from hemophylia, the mother is healthy and hasn't relatives with hemophylia. This girl marries the healthy man. What is the probability of hemophylia expression among their offspring in first and second generations?

What is the probability of birth of child with hemophylia in the healthy man whose brother suffers from hemophylia? What is the probability of such child birth in the healthy woman whose brother suffers from hemophylia?

Father and his son suffer from hemophylia. Mother has normal blood clotting. Is it right to say that son inherited this disease from his father?

CLASS №17.

TRAINING FOR SOLVING GENETIC PROBLEMS

Purposes of class: To consolidate practical skills on solving genetic problems which are related to sex linked inheritance, determination of distance between genes in chromosome, determination of offspring phenotype and genotype at gene linkage, interactions among allelic and nonallelic genes, gene penetrance,

combinative variation, pedigree construction, human genetic metabolism disorders.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 76-147.

Laboratory work:

I. Solve the following problems:

№75. In a human aniridia (absence of iris leading to blindness) depends on dominant autosomal gene and optical atrophy (it leads to another type of blindness) depends on recessive x-linked one.

The man with optical atrophy married the woman with aniridia (her father hasn't aniridia). Determine possible phenotype of their children.

№76. In a human gene causing one of forms of color blindness (daltonism) is located in X-chromosome. Disease is caused by recessive gene.

Woman with normal sight (her father suffered from color blindness) married normal man (his father had color blindness). What sight can be expected in their children?

№77. The man suffering from both daltonism and deafness married the woman with normal sight and hearing. They have deaf son with daltonism and daughter with daltonism and normal hearing. Determine probability of birth of daughter with both abnormalities, if it is known that daltonism and deafness are inherited as recessive signs but deafness is autosomal trait and daltonism is X-linked one.

№78. Hypertrichosis is transmitted by Y chromosome, polydactyly is inherited as dominant autosomal sign. In father with hypertrichosis and mother with polydactyly normal daughter was born. What is probability of next normal child birth?

№79. Hypertrichosis is inherited as Y-linked sign which appears after 17 years old only. One of ichtiosis forms is inherited as recessive X-linked sign. In the family where woman is normal by both traits and husband has hypertrichosis, boy with ichtiosis was born. Determine probability of hypertrichosis inheritance by this boy. Determine probability of birth of children without both abnormalities and their sex.

№80. In human dominant genes of brown eyes and of myopia are situated in different pairs of autosomes. How many and what types of gametes do men and women produce, if they are heterozygotes by both pairs of these genes?

№81. In a human cataract and polydactyly are caused by dominant autosomal genes. Woman inherited cataract from her mother and polydactyly from father. Her husband was normal by both signs. If both indicated signs are closely linked, what signs combination can be expected more likely: cataract and polydactyly simultaneously, absence of both abnormalities, either cataract only or polydactyly only?

№82. Genes L, M and N are linked. It was established in experiment, that distance between genes L and M is 5 centimorgans while distance between genes M and N equals 3 centimorgans. Determine distance between genes L and N.

№83. Family hypercholesterolemia is inherited as autosomal dominant sign. In heterozygotes this disease expresses only high level of cholesterol in the blood. In homozygotes xantomas (benignant tumors) of skin and tendons and atherosclerosis are developed in addition. Determine possible type of hypercholesterolemia in children in the family where both parents have only high level of cholesterol in the blood. Determine probability of children birth with hypercholesterolemia and its severity in the family where one of parents has high level of cholesterol, xantomas and atherosclerosis but another is normal by analyzed sign.

№84. There are two forms of fructosuria. One of them has not clinical symptoms, another leads to retardation of physical and mental development. Both forms are inherited as recessive unlinked signs. One of parents is homozygote by first form of fructosuria but he is heterozygote by second form. Another of parents is homozygote by second form of fructosuria but he is heterozygote by first form of it. What is probability of birth of children with clinical (second) form of fructosuria?

№85. Hemophylia and daltonism are inherited as recessive traits linked with X-chromosome. Distance between these genes is 10 centimorgans. Woman whose father suffers from hemophylia and daltonism simultaneously but mother is healthy and hasn't ill relatives

married the healthy man. Determine probable phenotypes of their children.

№86. In a human brown color of eyes dominates over blue one and ability to use right hand dominates over ability to use left hand. Genes of both signs are situated in different pairs of chromosomes.

The blue-eyed right-handed man married the brown-eyed right-handed woman. They had two children – brown-eyed left-handed child and blue-eyed right-handed one. In second marriage of this man and another brown-eyed right-handed woman nine brown-eyed children were born. All of them were right-handed persons. What genotype does each of these parents have?

Blue-eyed right-handed man (his father was left-handed person) married brown-eyed left-handed woman whose relatives have only brown eyes during several generations. What will offspring be expected in this marriage?

Brown-eyed right-handed man married blue-eyed right-handed woman. Their first child is right-handed and has blue eyes. What will signs be in other children of this marriage?

№87. In a human myopia dominates over normal sight and brown eyes dominate over blue ones.

The blue-eyed man with myopia (his mother has normal sight) married the brown-eyed woman with normal sight. First child from this marriage has brown eyes and myopia, second one – blue eyes and myopia. Determine genotypes of parents and children.

Brown-eyed man with normal sight married the blue-eyed woman with myopia. They have three sons: brown-eyed with normal sight, brown-eyed with myopia and blue-eyed with normal sight. Determine genotypes of parents and children.

№88. Schizophrenia is inherited as dominant autosomal sign. In homozygotes its penetrance is 100%, in heterozygotes – 20%. Determine the probability of children with schizophrenia birth in marriage of two heterozygous parents.

№89. Proband is healthy woman. She has two healthy brothers and two brothers suffering from alkaptonuria. Proband's mother is healthy and she has two healthy brothers. Proband's father suffers from alkaptonuria and he is cousin of his wife. He has healthy brother and sister. Grandmother (by father's line) was ill and she married healthy cousin. Grandmother and grandfather (by mother's line) were

healthy. Grandfather's father and mother are healthy too. Grandfather's mother (by proband mother's line) is sister of proband's grandfather (by father's line). Determine the probability of children with alkaptonuria birth in proband's family, if she will marry the healthy man whose mother had suffered from alkaptonuria.

№90. In human hemophylia is determined by X-linked gene h.

Mother and father are healthy. Their child suffers from hemophylia. Who from parents have transmitted gene of hemophylia to child?

Healthy woman (heterozygote by gene of hemophylia) married healthy man. What is probability of hemophylia inheritance? What children (sons or daughters) have more probability of hemophylia inheritance?

Girl's father suffers from hemophylia, mother is healthy and hasn't relatives with hemophylia. This girl married healthy man. What is probability of hemophylia expression among their offspring in first and second generations?

CLASS №18. PRINCIPLES OF GENETICS (summing-up class).

Purposes of class: 1. To check degree of mastering of program material on genetics. 2. To be able to solve situational problems on monogenic and polygenic inheritance, on gene interactions among allelic and non- allelic gene pairs, on multiple alleles, on pleiotropic gene action, on gene penetrance, on pedigree construction.

Questions:

1. Genetics as a science, its subject. Purposes and methods of genetics. Genetics development stages.
2. Main definitions of genetics (heredity, inheritance, variation gene, allelic genes, homozygote, heterozygote, hemizygote, dominant genes and recessives ones, genotype, genome, phenotype, gene pool).
3. Hereditary material organization levels in procaryotes and eucaryotes.
4. Gene level of hereditary material organization in procaryotes:
 - notion about gene structure;

- hypothesis of G. Beadle and E. Tatum “one gene – one enzyme”, its modern reading;

- genes classification (structural and acceptors);

- gene expression during protein biosynthesis (hypothesis of F. Jacob and J. Monod).

5. Gene level of hereditary material organization in eucaryote:

- mosaic gene structure, processing and splicing phenomena;

- particularities of gene expression regulation, role of steroid hormones in it.

6. Gene theory, its statements.

7. Multidimensional organization of proteins as structural basis of interallelic and intergene interactions while human hemoglobins synthesis.

8. Gene engineering, its purposes and methods. Obtaining of genetic material. Inserting of genetic material into the cells- recipients and setting of genes to genetic cell apparatus. The bioethical aspects of gene engineering.

9. Biotechnology, its value to medicine and pharmacy.

10. Chromosome level of hereditary material organization:

- the role of sex chromosomes in sex determination;

- significance of autosomes and sex chromosomes balance in sex determination;

- sex-linked inheritance in a human;

- chromosomes as gene linkage groups, complete and incomplete linkage. Morgan's rule. Gene linkage groups in a human;

- chromosome mapping, its methods;

- the main statements of chromosome theory of inheritance.

11. Genomic level of hereditary material organization:

- particularities of prokaryote genome;

- particularities of eukaryote genome;

- Human Genome Project; ethic aspects of human genome study.

12. Cytoplasmic inheritance. Cell genetic apparatus.

13. Inheritance, its types and kinds.

14. Hybridologic analysis, its essence.

15. Monogenic inheritance:

- principles of inheritance at monohybrid cross (the law of dominance, the law of segregation, the rule of "gametes purity");

- principles of inheritance at dihybrid and polyhybrid cross (the law of an independent assortment); Punnett square; phenotypic radical;

- conditions of G. Mendel's laws manifestation; statistical pattern of mendelian traits inheritance;

- mendelian traits in a human.

16. Polygenic inheritance , conditions of its display. Notion about gene dose.

17. Value of genetic factors in phenotype formation :

- interactions among allelic genes (complete dominance, incomplete dominance, codominance);

- interactions among nonallelic genes (dominant and recessive epistasis, complementarity);

- multiple alleles, inheritance of ABO system blood groups in a human;

- pleiotropy, genocopies.

18. Influence of environmental factors on realization of a genotype to a phenotype; variable expressivity; incomplete penetrance; phenocopies.

19. Variation, its types and kinds.

20. Ontogenetic variation, its mechanisms.

21. Role of ontogenetic variation in human hereditary diseases manifestation.

22. Modifications , their characteristics. Reaction norm.

23. Statistic methods of modifications study (variation series, average, standard deviation, standard error, distribution curve).

24. Combinative variation (recombinations), its value to genetic variety.

25. Mutations and mutational theory. Classification of mutations.

26. Characteristics of generative and somatic mutations.

27. Gene mutations, chromosome ones, interchromosome ones, genome ones and cytoplasmic ones.

28. Characterization of mutations according to their adaptive significance.

29. Spontaneous mutations, mechanisms of their formation.

30. Induced mutations. Physical, chemical and biological mutagens, mechanisms of their action.

31. Genetic material repair. Photoreactivation. Excision repair. Postreplicative repair.

32. Human as specific object of genetic analysis.

33. Methods of human genetics:

- pedigree analysis, its potential;
- twin's method, its value for human predisposition to hereditary diseases study;

- population statistic method, its potential in practical health care;

- dermatoglyphic method as mode of individual human variation study, its application in hereditary diseases diagnosis and in forensic medicine.

34. The cytogenetic method, its usage for human chromosomal diseases diagnosis.

35. The method of sex chromatin determination.

36. The methods of hereditary diseases prenatal diagnosis: amniocentesis, chorionic villus sampling and others.

37. The ontogenetic method as mode of genes differential activity study.

38. The immunological method, its usage for hereditary diseases diagnosis and for tissues histocompatibility determination.

39. The biochemical method as mode of metabolism hereditary disorders diagnosis.

40. The molecular – genetic method and mode of somatic cells hybridization potential.

41. Human hereditary diseases classification.

42. Human metabolism genetic disorders (disorders of aminoacid metabolism, of lipid one, of carbohydrate one, of steroid one, of purine one, of metal ions one, of blood clotting one; hemoglobinopathy).

43. Human chromosomal diseases:

- autosomal abnormalities;
- sex chromosome abnormalities.

44. Human mitochondrial diseases.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 76-147.

Laboratory work:

I. Solve the situational problems according to individual assignment.

Variant №1.

№91. In a human the gene *s* determines congenital surdomutism. Normal hearing and speech are inherited as dominant traits. Healthy woman married healthy man. It is known that in each of them one of parents was surdomute. What is probability of birth in them the child with surdomutism?

№92. In a human locus of Rh- factor is linked to locus determining the shape of erythrocytes and they are located on the distance 3 centimorgans from each other (K. Stern, 1965). Rhesus - positivity and oval shape of erythrocytes are determined by dominant autosomal genes.

One of parents is heterozygote by both characters. He has inherited rhesus - positivity from one of parents and oval shape of erythrocytes – from another. The second one is rhesus negative and has normal erythrocytes. Determine percentage interrelations of probable genotypes and phenotypes of children in this family.

Variant №2.

№93. Night blindness is hereditary disease. It is determined by dominant gene *N*. Woman with night blindness has married healthy man. All children (6) have inherited this disease. Woman's sister also suffering from night blindness has married healthy man. Three healthy children and one child with night blindness were born in this marriage. What are genotypes of the sisters and their parents if it is known, that both parents had suffered from night blindness?

№94. Sickle cell anemia is inherited as not completely dominant autosomal trait. Homozygous individuals die usually before puberty, heterozygous ones are viable. All humans having this form of hemoglobin do not suffer from malaria.

What is probability of resistant to malaria children birth in the family where one of parents is heterozygous by sickle cell anemia and another has normal genotype?

What is probability of unresistant to malaria, children birth in the family where both parents are resistant to this disease?

Variant №3.

№95. In marriage between healthy cousin brother and cousin sister 5 children were born. Three from them suffered from diabetes insipidus and died in age of 14 years old. What is gene (dominant or recessive) determining this disease? Whether is risk to transfer this disease to next generation in case of marriage of survived children and healthy non-relative persons? With relative ones?

№96. The gout is determined by dominant autosomal gene. Penetrance of this gene in a men is 20 %, and in a women it equals zero.

What is probability of gout expression in offspring of heterozygous parents?

What is probability of gout inheritance by children in the family where one of parents is heterozygous and another is normal by analyzed sign?

Variant №4.

№97. In a human baldness dominates over absence of it in a men and it is recessive in a women. The brown-eyed bald man (his father had no baldness and he was blue-eyed) married the blue-eyed woman (her father and all her brothers were bald). What is probable phenotype of children from this marriage?

№98. According to Swedish geneticists (K. Stern, 1965), some forms of schizophrenia are inherited as dominant autosomal sign. Penetrance of it in homozygotes is equals 100%, and in heterozygotes – it is 20%.

Determine the probability of this disease inheritance by children in family in the which one of parents is heterozygous and another is normal by this sign.

Determine probability of affected children birth in the marriage of two heterozygous partners.

Variant №5.

№99. In blond man with myopia and black-haired woman with normal sight four children were born: black-haired with normal sight, blond with myopia, black-haired with myopia and blond with normal sight. Determine genotypes of parents and of children.

№100. The classical hemophylia and daltonism are inherited as recessive x-linked characters. The distance between these genes is 10 centimorgans. The woman whose mother suffered from daltonism and father – from hemophylia married the man suffering from both diseases. Determine the probability of children birth with both anomalies in this family.

Variant №6.

№101. In the surdomute (it is supposed that surdomutism is inherited) blue-eyed man all children have brown eyes and normal hearing and speech. What would his wife's genotype and phenotype if surdomute child were born?

№102. Deafness can be caused by different recessive genes **d** and **e** laying in different pairs of chromosomes. Normal alleles of these genes are **D** and **E**. The man with surdomutism **ddEE** has married the deaf woman **DDee**. What hearing will their children have? What is the probability of birth of the deaf child in the parents suffering from the same kind of hereditary deafness?

Variant №7.

№103. In a human surdomutism is inherited as autosomal recessive trait and gout – as dominant one. Both genes are situated in different pairs of chromosomes. Determine the probability of birth of surdomute child with predisposition to gout in the surdomute mother without gout and the father with normal hearing and speech suffering from gout.

№104. Construct family pedigree with case of diabetes mellitus. Healthy husband and wife (cousins) have child with diabetes mellitus. Husband's mother and wife's father (siblings), wife's sister, wife's and husband's common uncle and grandmother are healthy. Grandfather was ill. All husband's relatives on father's line (two uncles, cousin, grandfather and grandmother) and all wife's relatives on mother's line (aunt, cousin, grandfather and grandmother) are

healthy. Determine pattern of disease inheritance and indicate those family's members who are heterozygotes by diabetes mellitus gene.

Variant №8.

№105. Myoplegia is inherited as autosomal dominant trait.

Determine probability of birth of children with this anomaly in the family where father is heterozygous, and mother does not suffer from myoplegia.

№106. Construct family pedigree with case of schizophrenia. Proband – woman with schizophrenia. Her brother, sister and father are healthy. On father's line following relatives are known: uncle with schizophrenia and two healthy aunts. One of aunts has healthy son. Grandfather and grandmother (on father's line) are ill. Mother of proband, proband's uncle, grandfather and grandmother (on mother's line) are healthy; uncle has two healthy children. Determine pattern of disease inheritance and indicate genotypes where it is possible.

Variant №9.

№107. The late degeneration of a cornea (develops after 50 years) is inherited as dominant autosomal trait. Determine the probability of disease expression in the family about which it is known that the grandmother and the grandfather of mother and all their relatives who have lived till 70 years suffered from this anomaly and father's all relatives were healthy.

№108. Construct family pedigree with rare disease – epiloya, which is determined by gene with lethal effect. Majority of persons with epiloya (pathological skin growth, mental retardation, epilepsy, tumor of heart and kidneys) die before puberty. When gene expressivity is mild some of patients survive and give offspring.

Proband – woman with epiloya in marriage with healthy man had three children: healthy son and daughter and ill daughter, who had five children: two healthy sons, two healthy daughters and one daughter with epiloya. It was revealed that this ill woman (proband's daughter) had two dead born children. Determine what gene (dominant or recessive) is responsible to this disease.

Variant №10.

№109. Absence of small molars is inherited as dominant autosomal trait.

What is the probability of birth of children with this anomaly in the family where both parents are heterozygous by analyzed trait?

№110. Construct family pedigree on brachydactylia, determine pattern of this sign inheritance and genotypes of persons indicated in pedigree.

Proband – woman with brachydactylia has three healthy brothers and one healthy sister. Proband's father has brachydactylia. On father's line uncle and one of aunts have brachydactylia, another aunt has normal hand. Uncle has seven children with brachydactylia (three sons and four daughters) and one son and two daughters with normal hand. Grandmother (on father's line) had brachydactylia and all relatives on mother's line were normal.

Variant №11.

№111. Anomaly of leukocyte nucleus segmentation is inherited as autosomal incompletely dominant sign. In homozygotes segmentation of nucleus is absent completely, in heterozygotes it is unusual.

Determine pattern of leukocyte nucleus segmentation in children from the family in which one of parents has leukocytes with unusual segmentation of nucleus and another is normal by this sign. Determine pattern of leukocyte nucleus segmentation in children from the family in which one of parents has unsegmentated nuclei of leukocytes and another – normal ones.

№112. Proband is healthy woman. She has two healthy brothers and two brothers suffering from alkaptonuria. Proband's mother is healthy and she has two healthy brothers. Proband's father is healthy and he is cousin of his wife. He has healthy brother and healthy sister. Grandmother on father's line was ill and she married healthy cousin. Grandmother and grandfather on mother's line are healthy. Grandfather's father and mother were healthy too. Determine the probability of birth of children with alkaptonuria in proband's family, if she will marry the healthy man whose mother suffered from alkaptonuria.

Variant №12.

№113. Acatlasia is caused by autosomal recessive rare gene. In heterozygotes activity of catalase enzyme is a little bit lowered.

In both parents and their son catalase activity is below norm. Determine the probability of birth of the next child without this anomaly.

Determine probable phenotypes of children in the family where one of parents suffers from acatalasia and another has only lowered activity of catalase.

№114. In a human recessive gene **c** is responsible for color blindness and recessive gene **d** is responsible for muscular Dushene dystrophy. Both diseases are inherited as sex- linked signs. According to certain pedigree following data have been obtained: healthy woman with normal vision (her father had suffered from muscular dystrophy and her mother had suffered from color blindness) had married healthy man with normal color vision. In this family 8 sons and 3 daughters were born. From them 3 daughters and 1 son were healthy, 3 sons had muscular dystrophy only, 3 sons suffered from color blindness only and 1 son had both diseases. Indicate distance between genes **c** and **d**.

CLASS №19.

EMBRYONIC DEVELOPMENT, MECHANISM OF ITS REGULATION

Ontogenesis or individual development – is a process of organism development from it's origination to death. In sexual reproduction, the life of a new individual starts with zygote formation.

Individual development is encoded in the genotype. The genotype determines where, when, and how genes will work. The ontogenesis is a reflection of species history fixed in genotype.

There are two types of ontogenesis: direct and indirect.

The indirect development. The species having such ontogenesis have several intermediate development stages before maturation. Species may have incomplete and complete metamorphosis.

In incomplete metamorphosis the organism develop in the stages egg – nymphs – imago or adult organism. The juvenile stages are called nymphs and they are morphologically quite similar to imago.

For complete metamorphosis, the organisms develop internally during the juvenile stages and appear externally during only the resting stage the immediately precedes the final molt. The juvenile stages of complete metamorphosis is a egg – larva – pupa – imago or adult organism. The juvenile stages are called larva and pupa and they are morphologically different from imago.

The direct development. The species having such ontogenesis deliver an organism after birth similar to adult organism. This ontogenesis occurs in species whose ova are rich in yolk (fish, birds, reptilians). The exception is the Mammalians. They have ova poor in yolk, but they have direct ontogenesis. It is because the embryo is supplied by the mother organism through the placenta. The embryo has provisional organs such as the amnion, chorion, yolk sack, and allantois. There are two types of direct ontogenesis (nonlarva and interuterine).

Ontogenesis has two periods: embryonic and postembryonic.

The embryonic period starts from zygote formation and terminates by birth. The embryonic development includes the following periods: prozygote, zygote, cleavage, gastrulation, tissue and organ formation. The mammalian embryo is called an embryo before formation of the main tissue stems, and is called a fetus after that.

Purposes of class: 1. To know principles of embryonic development and mechanisms of its regulation, derivatives of embryonic layers, particularities of human embryonic development. 2. To be able to determine stages of embryonic development of vertebrates on the specimen slides. 3. To be acquainted with human teratology achievements.

Questions:

1. Ontogenesis, its types and periods.
2. Embryonic period, its characteristics: zygote stage, cleavage, gastrulation, histogenesis and organogenesis.

3. Extraembryonic membranes, their role in materno – fetal interrelations.

4. Gene control of embryonic development, significance of gene amplification and ooplasmic segregation, omniopotentness (totipotentness), differential gene expression.

5. Interactions between parts of developing organism, embryonic induction.

6. Ontogenesis integrity. Correlations in ontogenesis (genomic, morphogenetic, functional).

7. Particularities of human prenatal development:

- prenatal development of human in primary period, embryonic one and fetal one;
- critical periods of embryonic development;
- influence of environmental factors on embryonic development; teratogenic factors of environment (physical, chemical, biological).

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 148-164.

Laboratory work:

I. Study the following macropreparations in museum:

- “Fly metamorphosis”;
- “Honeybee metamorphosis”;
- “Fish development”;
- “Fish embryo”;
- “Amphibian development”;
- “Bird development”;
- “Rat development”;
- “Embryonic development of a human”.

II. Study the following micropreparations (without drawing):

- “Ascaris’s eggs cleavage” (280x);
- “Frog’s eggs cleavage” (16x);
- “Frog’s blastula” (16x);
- “Frog’s gastrula” (16x);
- “Chicken’s embryonic layers” (56x);

- “Frog’s neurula” (16x);
- “Somits, chorda, neural tube of chicken’s embryo” (16x);
- “Fish’s embryo with yolk sac” (16x);
- “Chicken’s allantois” (16x);
- “Villi of human’s chorion” (32x).

CLASS №20.

POSTEMBRYONIC DEVELOPMENT. AGING AND DEATH OF ORGANISM.

The postnatal ontogenesis is a period between organism's birth and death. It has three periods: prereproductive, reproductive and postreproductive.

The prereproductive period is also called growth period. During this period, the organogenesis and intensive growth take place. In the beginning of this period, the organs have been sufficiently differentiated to allow organism surviving outside of mother's organism. The alimentary canal, respiratory pathways and sense organs start to perform their function right after the birth. Whereas nervous system, circulatory and excretory systems have already started to work in fetus. The individual and species traits are completely formed during prereproductive period. Human prereproductive period is also called juvenile period (from Latin «juvenilis» - young). According to the ontogenesis type, this period occurs differently.

In direct organogenesis, newborns differ from adults only by sizes, proportions and organs differentiation level. The same is in a human. A newborn has skeleton, muscles, central nervous system and internal organs, which need to be developed.

In indirect organogenesis, larvae are subject to metamorphosis. The metamorphosis occurs in cnidarians, annelids, mollusks, arthropods and amphibians.

The reproductive system is differentiated as last one. When it has been differentiated, the reproductive period starts. During this period organism can reproduce itself. It lasts for several days in some species (silkworm), or for many years in others (mammalians).

The next period is postreproductive period or period of aging. Aging is terminal period of ontogenesis.

The terminal period of life is death. Death is unavoidable event. It results from all previous ontogenesis. Death results from many reasons. Accidents may cause preliminary death in any ontogenesis period. The multicellular organisms have death occurring at one way. The metabolism becomes disordered; body becomes dead and it is digested by bacteria.

Purposes of class: 1. To know characteristic of postnatal ontogenesis periods, its control, endocrine glands and vitamins role on growth and development of organism, particularities of human constitutions, biological and social aspects of aging, characteristic of clinical and biological death of organism. 2. To be able to explain predisposition to diseases at human with different constitutional types. 3. To be acquainted with ethical and justice problems of euthanasia.

Questions:

1. Postnatal ontogenesis, its periods.
2. Growth and development of organism. Role of endocrine glands and vitamins in human postnatal ontogenesis. Acceleration.
3. Human constitution. Build types classification according to body shape, its medical aspects.
4. Interaction of social and biological features during prereproductive, reproductive and postreproductive periods. Influence of alcohol, smoking, drugs consumption on growth and organism development.
5. Organism aging (physiological and preliminary). Biological aspects of aging. Hypotheses of aging. Gerontology and geriatry. Role of social factors in aging process.
6. Organism death (clinical and biological). Euthanasia, its ethic and justice aspects.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 165-174.

Laboratory work:

I. Study the following macropreparations in museam:

- “Hypophysis and epiphysis of mammal”;

- “Thyroid gland and parathyroid glands of mammal”;
- “Suprarenal glands of mammal”;
- “Sex glands of mammal”.

II. Study the following micropreparations (with drawing):

- “Thyroid gland at hypofunction condition” (280x);
- “Thyroid gland at hyperfunction condition” (280x);
- “Pancreatic Langergans islands in hypofunction condition” (280x);
- “Pancreatic Langergans islands in hyperfunction condition” (280x).

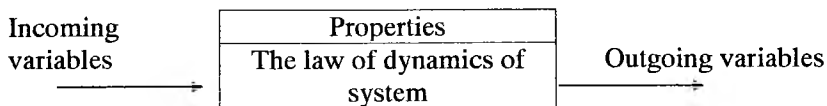
CLASS №21. ONTOGENETIC HOMEOSTASIS, MECHANISMS OF ITS REGULATION

Homeostasis is a maintaining a relatively stable internal physiological environment in organism, involving some form of feedback self-regulation. Homeostasis provides freedom from the influences of unprogrammed disturbances that might upset the delicate balance required to produce complex organized tissues. However, if that influences overlap normal limits for a long time, the organism can adapt to them not only by maintaining stable environment, but also by changing activity of several system to cope with it better. The homeostasis reactions can be directed on maintaining stable internal environment condition, limitation of harmful substances impact, designing the new forms of optimal interactions of organism with environment in changing conditions. That means that term homeostasis is not only maintaining steady state of main functional constants, but also it includes adaptation.

The main components of homeostasis were determined by Clod Bernar and William Cannon (1871-1945) and were updated accordinary new findings later. These components can be classified on three groups:

1. Substances providing cell needs (proteins, fats, carbohydrates, ions, oxygen, hormones).
2. Surrounding factors, affecting cell activity (osmotic pressure, temperature, pH).

3. Mechanisms, providing structural and functional integrity (heredity, diversity, regeneration, immunity).



In biology, the incoming variables can be reasons, stimuli, irritation, whereas outgoing variables can be consequence, effect, reaction and so on. The self-regulation processes are based on biological feedback.

There are positive and negative feedbacks.

The negative feedback decrease influence of incoming signal on outgoing signal.

The positive feedback act controversy; it enhance influence of incoming signal on system response.

The negative feedback helps to keep steady state condition. The positive feedback pushes system away from initial state. However, positive feedback also can work as self-regulating mechanism.

There are three levels of homeostasis: genetic, cellular and systemic.

Gene regulatory mechanisms determinate homeostasis processes, such as protein synthesis, DNA reparation, gene expression and repression, preserving diploid chromosome set in eukaryotes somatic cell nucleus, gene control of expression blood groups ABO, Daffi, Lutheran, Rh-factor, human histocompatibility complex and so on.

From genetic point of view, we can distinguish elementary and systemic homeostasis events. The example of elementary event is human histocompatibility, which prevents transplants rejection. The transplantation is placing of tissue, organ or system of organs from one individual to another. The tissue or organ, which is transplanted, called transplant. The organism from which tissue or organ have been taken is called donor; the organism to which tissue or organ are transplanted is called recipient.

There are autotransplantation, syngenic transplantation, allotransplantation and xenotransplantation.

In autotransplantation, donor and recipient are the same person.

Syngenic transplantation is performed only for monozygote twins. In allotransplantation, donor and recipient are individuals of same species. The successful allotransplantation can be performed only with determining genes of histocompatibility complex. In xenotransplantation, donor and recipient are individuals of different species.

The transplantation immunity determines the success of transplantation. All cells are marked with "self-markers" on their surfaces to prevent the attack of one's own cells by immune system. These are called histocompatibility antigens. The combination of these antigens is unique for each individual as a fingerprint. Only monozygote twins have the same self-makers. The more closely related individual are to one another, the more likely they are to possess some common self-antigens. This is a reason that tissue transplants are more likely to succeed if the donor and recipient are matched with respect to these antigens.

The major human histocompatibility system is a HLA system (Human Leukocyte Antigen system A). This name was given because histocompatibility antigens express and are revealed better on leukocyte surface. The genes, which control this system, are in 6th chromosome and are presented by six locus's A, B, C, D₁, D₂ and R. The structural plan of main histocompatibility system is similar in all animals.

The antigens, which were internationally approved, are named HLA-A1, HLA-A2 and so on. Those, which just have been discovered, are pointed with index W (work).

The antigens are divided into two groups, which are controlled by closely linked genes. The first group antigens are revealed on leukocytes by serum complement-dependent reaction. Therefore, they are called SD-antigens (Serum Defined). The second group antigens are revealed on leukocytes by method of mixed leukocytes cultures. Therefore, they are called LD-antigens (Leukocyte Defined). SD-antigens are controlled by three sublocuses of sixth chromosome: HLA-A, HLA-B, HLA-C. LD-antigens are controlled by sublocus D₁, D₂ and R of sixth chromosome. Each gene, controlling human HLA-antigens, has many alleles. Thus, sublocus HLA-A has 19 alleles, sublocus HLA-B has 20 alleles, sublocus HLA-C has 5 alleles,

sublocus HLA-D has 6 alleles. By this way, it has been revealed about 50 antigens. It is believed that such genetic polymorphism is due to similar origin of some genes from others and due to close relationship of these genes.

Purposes of class: 1. To know general principles of homeostasis; gene, cellular and systemic mechanisms of homeostasis. 2. To be able to solve situational problems on transplantation (on example of blood transfusion).

Questions:

1. Organism as open self-regulated system. Notion about homeostasis. General cybernetic principles of homeostasis. Value of mechanisms of positive and negative feedbacks of organism. Mechanisms of homeostasis regulation.

2. Gene mechanisms of homeostasis in organism live:

- characteristic of transplantation kinds: autotransplantation, syngenic transplantation, allotransplantation (homotransplantations), xenotransplantation (heterotransplantations);

- tissue and species specificity of proteins, their antigenic properties;

- genetic of histocompatibility as manifestation of gene control of homeostasis at tissues and organs transplantation (HLA system, ABO system, Rh-factor);

- immunological mechanisms of tissue incompatibility, means of their getting over; notion about transplantation immunity;

- bioethic aspects of organ and tissue transplantations (Donorship, death determination, commercialization of donorship);

3. Cellular mechanisms of homeostasis:

- tissues and organs regeneration as cellular mechanisms of homeostasis appearance; types of regeneration (physiological and reparative); kinds of cell regeneration (cellular regeneration, cellular and intracellular regeneration, intracellular regeneration); tissues classification according to their ability to regenerate;

- types of reparative regeneration, means of its realization: epimorphosis, morpholaxis, endomorphosis (regenerative hypertrophy), compensatory hypertrophy, regenerative induction;

- particularities of reparative regeneration at mammals and human (intracellular hypertrophy, regenerative one, complete regeneration);
- value of regeneration problem for biology and medicine.
- 4. Systemic mechanisms of homeostasis:
 - role of endocrine and nervous systems in regulation of homeostatic reaction;
 - biological rhythms and homeostasis; medical value of chronobiology;
 - particularities of homeostasis at aging process.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 175-185.

Laboratory work:

I. Solve situational problems on transplantation (at example of blood transfusion).

№116. It is known, that blood of O(I) group can be transfused to all people, blood of A(II) group can be transfused to persons with A(II) or AB(IV) groups, blood of B(III) group – persons with B(III) or AB(IV) groups only, blood of AB(IV) group – persons with AB(IV) group. Can be blood transfusion carried out from mother to her children? At what genotype of parents can be blood of sister transfused to her brother?

№117. Mother has A(II) blood group, child – B(III). Blood group of father is unknown. Whose blood (father's or mother's) can be transfused to child? Can be father's blood transfused without its group determination?

№118. At human presence of Rh-antigen in erythrocytes is determined by dominant gene D. Its allele d determines absence of this antigen. Gene I^0 is recessive in comparison with genes I^A and I^B . Both last alleles are codominant, their combination $I^A I^B$ determines AB(IV) blood group. Genotype of husband $I^A I^B DD$, wife – $I^0 I^0 dd$. Determine particular genotypes of children and determine children that can receive mother's blood or father's blood.

Rhesus-positive woman with A(II) blood group (her father had rhesus-negative O(I) blood) marries man with rhesus-negative O(I)

blood. Determine possible blood group of children and who from them can receive mother's blood.

Husband's genotype – $DdI^A I^B$, wife's genotype – $DdI^B I^B$. What is the probability of rhesus positive child with AB(IV) blood group birth? Whose blood can be transfused to child?

Man with rhesus-negative blood AB(IV) marries woman with rhesus-positive blood B(III). Father of woman had rhesus-negative blood O(I). Family has two children first with rhesus-negative B(III) blood, second with rhesus-positive O(I) blood. Medical finding revealed, that one of them is bastard. According what allelic pair it is established? Whose blood can be transfused to child?

Whose blood can be transfused to children if father has rhesus-positive A(II) blood (one of parents of father had rhesus-negative O(I) blood), mother – rhesus-negative AB(IV) blood?

Investigation of blood of three members of family revealed following results: woman has rhesus-positive AB(IV) blood, man has rhesus-negative O(I) blood, child has rhesus-positive O(I) blood. What conclusion has to be made and why? What blood can be transfused to child?

№119. At human antigens of AB0 blood group situated not only in erythrocytes, but in other body cells too. At one type of people (secretors) water-soluble forms of these antigens stand out with saliva and other fluids, at other type of people (nonsecretors) they absent there. Presence of A and B antigens in saliva is determined by dominant gene Se.

Parents do not produce antigens A and B with saliva, their genotypes: $I^A I^B \text{ sese}$ and $I^0 I^0 \text{ Sese}$. What probability of child births with antigen A in saliva? Whose blood can be transfused to him?

At blood and saliva investigations of four members of family it was determined, that mother has antigens A and B in erythrocytes, but does not concern them in saliva. Father hasn't A and B antigens in erythrocytes and in saliva. In erythrocytes of first child antigen A is revealed, but it is absent in saliva. Second child has B antigen in erythrocytes, but hasn't it in saliva. Determine genotypes of all indicated persons. Whose blood can be transfused to children?

CLASS №22.
COMPARATIVE ANATOMY OF VERTEBRATES' ORGAN
SYSTEMS: INTEGUMENT, SKELETON, DIGESTIVE AND
RESPIRATORY SYSTEMS

Carl Ber was open the law of germs similarity. He is compared stages of germ development of organisms in different species and classes in phylum Chordata. It is reduced to three conclusions.

1. Germs of an animal one type at early stages of development are similar.

2. Germs consistently pass in the development from more general traits such as to more individual. In last turn the traits indicating a belonging of germs to a certain sort, species, and, at last, individual features develop.

3. Germs of the different representatives of one type gradually stand apart from each other.

Carl Ber was not evolutionary scientists and did not connect, open by him the laws of ontogenesis with process of philogenesis. C. Darwin has shown, that the law of germs similarity testifies to a generality of an origin and unity of the initial stages of evolution within the limits in phylum Chordata. Comparing of crayfishes ontogenesis with morphology of their dyed out ancestors, F. Muller has made a conclusion, that nowadays-living crayfishes in the individual development (ontogenesis) repeat a way by their ancestors (philogenesis). In its opinion, the ontogenesis transformations in evolution are carrying out at the expense of addition to it of additional stages. Based on supervision F. Muller a scientist E. Gekkel (1866) has formulated the basic biogenetic law: "Ontogenesis represents brief and fast recurrence of philogenesis". The essence of the law is consists that organism in the individual development repeats separate features of the ancestors. Further to treatment of the law was adder that the brief and fast recurrence philogenesis is observes only at early stages of germ development.

Moduses of ontogenesis modification, which have evolutionary value, is palingenesis, cenogenesis and philembryogenesis.

Palingenesis (grec. *palin* - again, *genesis*- an origin) is an attributes of germs repeating attributes of the remote ancestors (development of horde at vertebrates, nervous tube etc.). The

formation of palingenesis can be move together in time (heterochronia) and in area (heterotopia). The example of heterochronia is an earlier development of nervous system and delay of sexual system formation. The example of heterotopia is a change of place of prekidney, primary and secondary kidneys development.

Cenogenesis (grec. *seainos* - new, *genesis* - origin) is an occurrence in germs of attributes unusual for ancestors. Cenogenesis provide higher probability of a survival of posterity and disappear at the adult organisms. The examples of cenogenesis are a development of provisore organs in germs ground vertebrates (amnion, chorion, allantois).

Philembryogenesis is an evolutionary hereditary morphophysiology of transformation animal organisms. It is determine new directions of philogenesis. It is changes got in process of embryonic development, kept in an adult condition and inherited of offspring. Philembryogenesis explain connection between ontogenesis and philogenesis. The new attributes varying a direction of evolution, can occur at germ at various stages of development: early, average and late.

The scientist A.N. Severcev was allocating three basic ways of changes ontogenesis: anabolia, deviation and archallaxis.

Anabolia is a one of ways of philembryogenesis, at which occurrence of new attributes and the reorganization at final stages of embryonic development. Before occurrence anabolia, the organ or tissue develops as well as at an ancestor. So the kidneys higher vertebrates' develop, passing stages prekidney, primary and secondary kidneys.

Deviation (lat. *deviatio*- rejection) - one of ways of philembryogenesis, at which the rejection in ontogenesis of animal organs of occur at average stages of individual development. From this moment, the development goes on new way, distinct from ancestors. An example is the development horn scales at reptile, which in initial stages of development are similar to a development of plakoid scales at shark fishes and are former at the expense of condensation of epidermis and accumulation under it of a connecting tissue. At average stages of the embryonic development the scales begins to develop on other ways.

At archallaxis (grec. *arche* - a beginning, *allaxis* - change) the rejection in individual development occur at the earliest stages of morphogenesis, resulting to reorganization of all its subsequent stages. For example is a development of a hair. The hair is homologue in development of scales of fishes and reptilian.

The comparative anatomy data allows tracing evolutionary development of the same organ. The comparative anatomy is of big interest not only for biologists, but for doctors too. Human has animal origin. The complex structures, which doctors deal with, have a long history of development. On a base of this knowledge, doctors can correctly understand the ways of hereditary defects formation and reserve regenerative potential of the organ.

The inherited defects of integument in humans are excessive keratinizing of skin, lack of sweat glands, hemangiomes (good-quality vassals' tumors of skin), teleangioextasia (expansion of capillaries), politelia (increase of nipple amount), polymastia (increase of amount of milk glands).

Among inherited defects of spinal column the most common are changing in vertebra number (increasing or decreasing), knitting of vertebra's body and processes, arches disjunction, atlas assimilation, scoliosis.

There are defects of chest development such as ribs underdevelopment, development of cervical ribs, additional ribs, splitting of sternum.

There are defects of limbs development such as Shprengel disease (disturbance of localization of upper limb from neck area on level of 1-2 chest vertebrates or upper localization shoulder-blade), cranial-clavicular disostosis, synostosis of ulna and radius, or tibia and fibula, hemypodia (limb underdevelopment), ectropodia (limbs reduction to bud size), apodia (absent of limb accompanied by pelvis bone underdevelopment), arachnodactilia, brachidactilia, polydactilia, syndactilia, flat-foot, club-foot and so on.

Among skull defect the common are cleft palate, harelip, craniostenosis (preliminary suture closure), microgenia (underdevelopment of lower jaw), micrognathia (underdevelopment of upper jaw), exoencephalia (absence of cranium bones). The teeth development defects are adentia (absence of teethes), diastema (teeth development in unusual place), and bite defects.

The defects of digestive system development are athresy of esophagus, macro and microesophagus, gastropstosis (lower positioning of stomach), Merckell's diverticulum, situs viscerus inversum, neck fistulas.

The human hereditary defects of respiratory system are preserving of gill's slits, athresia of trachea, tracheal-esophagus fistula, agenesis (absence) and hypoplasia (underdevelopment) of lung or its lobe, additional lobes or lung, lungs cyst.

Purposes of class: 1. To know essence of notions "ontogenesis" and "philogenesis", comparative anatomy of integument, skeleton, digestive and respiratory systems of vertebrates. 2. To be able to explain mechanisms of human development defects (integument, skeleton, digestive and respiratory systems). 3. To be acquainted with "palingenesis", "cenogenesis", "philembryogenesis" notions.

Questions:

1. Individual development and historical one. Biogenetic law. Philogenesis as process of ontogenesis evolution.
2. Moduses of ontogenesis modification, which have evolutionary value. Heterochronia, heterotopia, autonomization of ontogenesis. Notion about palingenesis, cenogenesis and philembryogenesis.
3. Comparative anatomy of vertebrate's integument. Human development defects of skin.
4. Comparative anatomy of vertebrate's skeleton. Changes of skeleton during anthropogenesis. Human development defects of skeleton.
5. Comparative anatomy of vertebrate's digestive system. Human development defects of digestive system.
6. Comparative anatomy of vertebrate's respiratory system. Human development defects of respiratory system.

Literature:

Bekish O.- Y. L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 186-191, 194-196.

Laboratory work:

I. Study the following macropreparations in museum:

- “Skull of bony fish”;
- “Skeleton of frog”;
- “Skeleton of grass-snake”;
- “Skeleton of lizard”;
- “Skeleton of mole”;
- “Skeleton of rat”;
- “Child with polydactilia”;
- “Respiratory and digestive organs of perch”;
- “Respiratory and digestive organs of frog”;
- “Internal construction of lizard”;
- “Respiratory and digestive organs of birds”;
- “Lungs of bird”;
- “Respiratory and digestive organs of rat”.

II. Fill in table on comparative characteristic of integument of vertebrates.

Signs	Fishes	Amphibians	Reptiles	Birds	Mammals
Characteristic of epithelium					
Ratio of epidermis and derma					
Presence of glands, their characteristic					
Derivates of epidermis					
Main directions of integument evolution	1. 2. 3. 4.				

III. Fill in table on comparative characteristic of skeleton of vertebrates.

Signs	Fishes	Amphibians	Reptiles	Birds	Mammals
Axial skeleton, its structure					
Parts of spinal column					
Organs of movement					
Skeleton of girdle and limb					
Skeleton of lower girdle and limb					
Visceral skeleton, its modifications					
Main directions of axial skeleton evolution	1. 2.				
Main directions of skull evolution	1. 2. 3. 4.				

CLASS №23.

COMPARATIVE ANATOMY OF VERTEBRATES' ORGAN SYSTEMS: CIRCULATORY, NERVOUS, EXCRETORY AND REPRODUCTIVE SYSTEMS

The circulatory system of vertebrates has similar organization as the circulatory system of lower chordates and even annelids. It consists of ventral and dorsal vessels, which have anastomosis in the intestine wall and body's wall.

The main tendencies in circulatory system development are following: separation of heart, vessel differentiation to blood and lymphatic vessels, formation of double circulatory system, development of structures which separate arterial and venous circulation.

The main tendencies in circulatory system evolution are following: differentiation of heart on parts, divide of blood on arterial and venous, development of second ring of circulatory, differentiation of vessels on arteries and veins, division of lymphatic system from blood system.

There are many abnormalities of circulatory system development in human. The most common are heart septa defects that result in formation of three chambers or two chamber heart.

Among vessels abnormalities, the most important are deviation of aorta formation and big vessel formation that are derivatives of gill's arches. The most common is failure of Botalli duct obliteration. Sometimes, there is no reduction of right fourth arterial arch. It results in formation of two aortal arches and so called "arterial circle". It becomes narrower with age and requires surgery. In normal human embryogenesis, there is only one trunk leaving ventricles, which further is divided into aorta and pulmonary artery. In 2.1% of cases such division hasn't been performed. It results in body's supply by mixed blood. The transposition of aorta and pulmonary artery can occur if that septa have been placed improperly. In this case aorta leaves right ventricle, whereas pulmonary artery - right. One of the most severe heart defects of human is Fallo triad (pulmonary artery stenosis, defect in interventricular septa, hypertrophy of right ventricle). It also can be accompanied by aorta dextraposition, and called Fallo tetrad. Fallo pentad also includes defect of interauricular septa.

The brains of vertebrates have three principal divisions: the hindbrain, the midbrain, and the forebrain. Each part of the brain was developed from separated bud.

The forebrain bud (prosencephalon) divides into two parts. The anterior part forms anterior part of brain or telencephalon, which in most of vertebrates differentiates to big hemispheres. The posterior part of forebrain bud gives rise to diencephalon. The midbrain bud gives rise to mesencephalon. The hindbrain bud also divides into two parts.

The anterior part of it gives rise to cerebellum or metencephalon. Whereas posterior part differentiates to myelencephalon or medulla oblongata which extends to spinal cord.

During brain development, the internal cavities of brains are formed. They are called brain ventricles. The cavity of telencephalon is two lateral ventricles. The cavity of diencephalon is third ventricle.

The cavity of medulla oblongata is fourth ventricle. The cavity in the mesencephalon is Silvii's aqueduct.

Thus, the vertebrate's brain consists of 5 divisions. They are placed in same sequence. But the degree of their development differs within vertebrata subphylum. All these differences are due to phylogenesis. There are three types of brain: ichtiopsydic (from greek "ichtios" - fish), sauropsydic (from Greek "sauros" -pangolin), and mammalians.

The main tendencies in brain evolution are following: change of anterior nervous tube enlargement on brain, differentiation of brain on parts and development of brain, change of localization of nervous centre from median brain in basis of telencephalon and after that in cortex of telencephalon, appearance of archicortex and change it on neocortex, increase of brain value, appearance of cortex bend, increase of number of cranial nerves pairs of the brain.

The defect of back brain development is rahishis (platinevria) absence of close of nervous tube. The defects of human brain development are anencephaly (underdevelopment of forebrain), microcephalia (general underdevelopment of brain), hydrocephaly (excess of cerebrospinal fluid), underdevelopment of brain lobes, cranial hernias.

The defects of human excretory system development are aplasia (absence), hypoplasia (underdevelopment) and distopy (mislocalization) of kidney; doubling of kidneys, joining of kidneys; hydroureter (extension and fluid excess in ureter); ureter mouth ectopy (abnormal localization); entering uterus to urethra, aplasia and doubling of urine bladder; diverticulum and cysts of urine bladder; opening of urethra on upper (epispadia) and lower (hypospadia) surface of penis; doubling, stenosis and diverticulum of urethra.

The defects of reproduction system development in women are double uterus with one or two vaginas, two-horn and one-horn uterus, athresia of vagina, agenesis and hypoplasia of ovariums, hermaphroditism. The men can develop anarchism (absence of testis), cryptorchism (testis positioning out of scrotum), phymosis (narrowing of foreskin), absence or doubling of prostate and penis, testis ectopy, hydrocoele.

Purposes of class: 1. To know comparative anatomy of circulatory, nervous, excretory and reproductive systems of vertebrates'. 2. To be able to explain mechanisms of human development defects (circulatory, nervous, excretory and reproductive systems). 3. To be acquainted with main morphological appearance of development defects of indicated systems at human.

Questions:

1. Comparative anatomy of vertebrates' circulatory system. Pulmonary and systemic circulations formation, transformation of aorta archs, heart development. Ontophylogenetic mechanisms of human development defects of heart and main blood vessels.

2. Comparative anatomy of vertebrates' nervous system. Particularities of ichtiopsydic, zauropsydic, mammalian brains of vertebrates'. Human development defects of brain.

3. Comparative anatomy of vertebrates' excretory system. Ontophylogenetic mechanisms of human development defects of excretory system.

4. Comparative anatomy of vertebrates' reproductive system. Ontophylogenetic mechanisms of human development defects of excretory system.

Literature:

Bekish O.- Y. L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 191-194, 196-204.

Laboratory work:

I. Study macropreparations in museum:

- “Arterial system of fish”;
- “Arterial system of frog”;
- “Arterial system of turtle”;
- “Arterial system of grass-snake”;
- “Arterial system of lizard”;
- “Circulatory system of bird”;
- “Arterial system of rat”;
- “Human heart”;
- “Heart, frontal section”;

- “Nervous system of frog”;
- “Nervous system of bird”;
- “Nervous system of rat”;
- “Brain of cat”;
- “Brain of dog”;
- “Child with anencephaly”;
- “Excretory and reproductive systems of fish”;
- “Excretory and reproductive systems of frog”;
- “Excretory and reproductive systems of bird”;
- “Excretory and reproductive systems of cat”;
- “Kidney of walrus”;
- “Kidney of human”;
- “Thyroid and parathyroid glands of dog”;
- “Larynx and thyroid gland”; “Hypophysis and epiphysis of mammal”.

II. Fill in table on comparative characteristic of circulatory system of vertebrates.

Signs	Fishes	Amphibians	Reptiles	Birds	Mammals
Number of chambers in heart					
Character of blood in heart chambers					
Number of circulation, their main vessels					
Liver and kidneys portal systems					
Arterial arches, their transformation					
Main directions of circulatory system evolution	1. 2. 3. 4.				

III. Fill in table on comparative characteristic of brain of vertebrates.

Signs	Fishes	Amphibians	Reptiles	Birds	Mammals
Type of brain					
Localization of highest centers of nervous regulation					
Degree of brain parts development					
Presence of brain cortex and its characteristic					
Number of cranial nerves pairs					
Main directions of brain parts evolution	1. 2. 3. 4. 5. 6.				

POPULATION-SPECIES LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS №24.

STRUCTURE OF HUMAN POPULATIONS

All species are presented in the nature by their populations. The population is a real thing, the same as cell, individual and biosphere is.

A population consists of the individuals of given species that occur together at one place and during long time (large number of generations). Population is separated from other populations by one or another kind of isolation. Within a population the particular level of panmixing occurs. Panmixing is ability to mate with any individual in population. If there are some limitations of free mating in population, such population is called non-panmixing.

A population is an elementary evolutionary unit. Species, group of populations have their own evolutionary fate, but they aren't

elementary evolutionary units. The population is a whole structure in ecological, genetic and morphophysiological aspect. Individuals, families can't be elementary evolutionary units. Individuals are not subject to evolution. Only groups of individuals are able to do so. And the population is a smallest group which is subject to evolution.

The population has ecological and genetical characteristics as well. The main ecological characteristics are the following: size of population, number of individuals, area of living, age and sex structure, population dynamics. Genetically, population has to be divided equally to same sex groups. But individuals of different sex have different ability to survive. Therefore, the secondary and thirdly sex distribution in population differ from genetical one. In human population, the secondary distribution right after birth is 100 girls on 106 boys. But in the age group 16-18 years, it becomes equal because of higher boy's mortality. In the age group 50 years, the distribution is following: 85 men to 100 women; in 80 years, 50 men to 100 women.

Each individual, having general species characteristics, have its own traits and genetical features. All genetical information of population (that means full gene set of all individuals) is called population genefond. Of course, the main principles of inheriting are used to study population genetics, such as Mendel's Laws of heredity, independent assortment of gametes while fertilization and so on. The first to evolve studying of population genetics was V. Yoganen (1903). He described the effect of selection in genotype mixture. At the same time, he showed that the selection doesn't work in clear lines (among offsprings of one self-reproducing individual). The differences between individuals in population may be due to their genotype differences as well as influences of external environment. The differences between individuals in the line are only due to influences of external environment.

The works of S.S. Chetverikov were in great importance. He was first to design methods of genetic analysis of population and to assume concept about genetical structure of population. He showed that all evolutionary events occur in population, which is rich in mutations.

At the same time in population, there are individuals with dominant and recessive traits. The question appears: why recessive genes are not replaced by dominant genes? For example, if "brown

eyes" is dominant trait (A), why the number of individuals with blue eyes (a) doesn't decrease? The solution to the puzzle of why genetic variation persists was developed independently and published almost simultaneously in 1908 by G.H. Hardy, an English mathematician, and G. Weinberg, a German physician. They pointed out that in the large population in which there is random mating and in the absence of the forces that change the proportion of the alleles in the given locus, the original proportion of genotypes will remain constant from generation to generation. Dominant alleles do not in fact replace recessive ones. Because their proportion does not change, the genotypes are said to be in Hardy-Weinberg equilibrium.

In algebraic terms, the Hardy-Weinberg principle is written as an equation. Its form is what is known as binomial expansion. For dominant gene "A", the concentration is pointed by "p", whereas for recessive gene "a", the concentration is pointed by "q". The resulting equation looks like this.

$$p^2 AA + 2 pq Aa + q^2 aa$$

Where p is frequency of one allele and q is frequency of another. Because there are only two alleles, p and q must equal 1. Thus, the Hardy-Weinberg rule states that in a large population mating at the random and in the absence of the forces that would change the proportion of the different alleles in the given locus, the process of sexual reproduction (meiosis and fertilization) alone will not change their proportions.

This rule can work only in appropriate conditions such as:

1. The population should be very large.
2. All individuals have to mate independently and randomly.
3. The homozygous and heterozygous individuals have to have same survival rate, same ability to reproduction, and not subject to selection.
4. The mutations (direct and reverse) have to occur at the same rate.

The allele distribution is based on allele frequency in population. If we know frequency of recessive gene, we can calculate the frequency of dominant gene according the Hardy-Weinberg rule. Conversely, if we know frequency of dominant gene, we can calculate frequency of recessive one, frequency of heterozygotes and so on.

The Hardy-Weinberg rule can be named as law of equality of gene frequencies in panmixing populations. This equality preserves until any factor will change allele frequency. The new breeding, which occurs in population with changed frequencies of alleles, is called stabilizing breeding.

The population structure of humankind is very diverse. It was divided into many particular populations. Therefore, the humankind isn't great panmixing population. It is a mixture of many very different populations. Among them, it can be as open population, where people can mate with representatives of other populations as closed populations, where people can mate only inside of the population. All of them have a very different rate of reproduction. There are dems and isolates.

The dem (from Greek "demos" - people) – is local relatively isolated group of close relatives with random mating. It stable can exist during life of several generations. The particular dems of population can differ one from another by several traits. They have higher level of panmixing in compare with population.

The isolates - are populations or groups of populations, which are isolated from other populations of the same species. They have very limited exchange of individuals. The example is parses. It is a tribe of peoples, who worship to fire. They lived in 12th century in the Baku region. Then, they were forced by Muslims to migrate to India. They still believe in Fire God and allow marriages only between close relatives.

Dems and isolates have very low population income. The rate of marriages between close relatives is around 80-90%. It facilitates expression of rare pathological genes, which have been preserved in heterozygous state. These genes become homozygous and cause hereditary diseases. These races are becoming extinct.

Purposes of class: 1. To know ecological and genetic characteristics of population; particularities of humankind population structure; essence of Hardy-Weinberg law and conditions of its employment for human populations; influence of elementary evolutionary factors on human populations; genetic polymorphism of human populations. 2. To be able to count alleles and genotypes

frequency in populations. 3. To be acquainted with frequency of hereditary diseases in human populations.

Questions:

1. Population structure of species. Ecological and genetic characteristics of population. Gene pool (gene fond) of population. Hardy-Weinberg law, conditions of its appearance.

2. Particularities of humankind population structure. Deme. Isolates. Particularities of isolate gene pool (gene fond). Employment of Hardy-Weinberg law for frequency calculation of heterozygotes in human populations.

3. Influence of elementary evolutionary factors on human populations: mutational process, isolation, genetic drift, natural selection, selection and counterselection, selection against homozygotes and heterozygotes.

4. Genetic polymorphism of human populations, its classification according to character of genetic changes (gene, chromosomal, genomic), classification according to adaptive value (transitional, neutral, balanced). Biological and social aspects of genetic polymorphism.

5. Genetic aspects of human predisposition to somatic diseases.

6. Genetic load, its kinds (mutational, balanced, substitution), biological essence and medical value.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 205–212.

Laboratory work:

I. Study inheritance on model panmictic population at certain frequency of gametes.

Equipment: 1. Model of population – sacs with white squares (symbols of gametes with recessive gene allele a) and green squares (symbols of gametes with dominant gene allele A). Each sac contains 100 squares in certain ratio. 2. Microcalculator.

Work order:

Assignment is carried out by group with two students. It obtains two sacs. Each contains 100 “gametes”: one includes “ovicell”, another – “sperms”. One student takes out one square from one sac “ovicell”, and other square from other sac “sperms”. Another student writes combination of “gametes” (“zygote”). Results are entered into table according to envelope rule.


Experimental frequency of genotypes in model panmictic population.

Color of square	Green Green	Green White	White White
Genotype	AA	Aa	aa
Number			

After each determining squares are returned into their sacs and are mixed. This procedure is repeated 100 times.

Theoretical ratio of genotypes may be counted in table:

Calculation of theoretical frequencies of genotypes in panmictic population.

	pA	qa
pA	p^2AA	pqAa
qa	pqAa	q^2aa

For absolute amount expression of results this data must be multiplied on 100. Record experimentally obtained data and theoretically expected data in table:

Calculation χ^2

Indexes	Number of genotypes			
	AA	Aa	aa	Total
Experimental data (O)				
Theoretical data (E)				
Deviation (d) (d=O-E)				
d^2				

Compare experimental data and theoretical data by χ^2 method.

$$\chi^2 = \sum \frac{d^2}{E}$$

Determine degree of reliability of obtained results with help of table:

Probabilities p for χ^2 .

K	p=0,05	p=0,02
1	3,841	5,412
2	5,991	7,824
3	7,815	9,837
4	9,488	11,668
5	11,070	13,388
6	12,592	15,033
7	14,067	16,622

Make summary about degree of experimental and theoretical reliability at K=2.

II. Determine phenotypes of students' accordinary their ability to feel bitter taste of phenylthiocarbamide.

Equipment: strips of filter paper with size 0,5x4,0 sm, pincers, chemical glass, solutions of phenylthiocarbamide in increasing concentrations: №1 – 0,013%, №2 – 0,13%, №3 – 0,26%, №4 – 0,39%, №5 – 0,52%, №6 – 0,65%, №7 – 0,78%, №8 – 0,91%, №9 – 1,04%, №10 – 1,17%.

Work order:

You have to keep in your mind that ability to feel phenylthiocarbamide is dominant sign (T). Each student checks himself for ability to feel bitter taste of phenylthiocarbamide and determines susceptibility. For this purpose it is necessary consequently put strip of filter paper with phenylthiocarbamide solution to tongue, beginning from solution №1 and so on.

After determination mouth is washed by water. At base obtained data construct variation range.

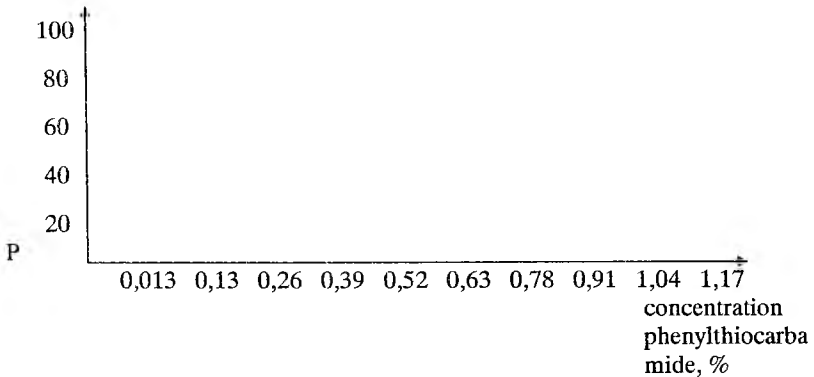
Concentration of phenylthiocarbamide	0,013	0,13	0,26	0,39	0,52	0,65	0,78	0,91	1,04	1,17	tt
n											
%											

% - percentage from general number of students.

Calculate number of students that feel phenylthiocarbamide (TT, Tt) and number of students that can't feel its bitter taste (tt).

At base of determination of susceptibility to phenylthiocarbamide construct variation curve of person frequency with to phenylthiocarbamide.

students, %



Accordingary Hardy-Weinberg low determine frequency of heterozygotes, dominant homozygotes and their absolute number.

$pT + qt = 1$ where:

pT is concentration (frequency) of dominant allele T;

qt is concentration (frequency) of recessive allele t.

$p^2TT + 2pqTt + q^2tt = 1$ where:

p^2TT is frequency of dominant homozygotes;

q^2tt is frequency of recessive homozygotes;

$2pqTt$ is frequency of heterozygotes.

We know frequency of recessive homozygotes q^2tt from experiment.

Frequency of recessive allele qt is equal:

$$qt = \sqrt{q^2tt}$$

Frequency of dominant allele pT is equal:

$$pT = 1 - qt$$

Then, count frequency of dominant homozygotes p^2TT .

Frequency of heterozygotes will be equal $2pqTt$.

Absolute number of recessive homozygotes and their percentage is indicated in table (tt).

Absolute number of dominant homozygotes and heterozygotes are equal:

$$p^2TT \times \sum n \text{ and } 2pqTt \times \sum n, \text{ respectively}$$

Percentage of them:

$$p^2TT * 100\% \text{ and } 2pqTt * 100\%$$

Make summary about numbers of students with dominant, recessive homozygote and heterozygote genotypes.

BIOSPHERAL-BIOGEOCENOTIC LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS № 25.

PRINCIPLES OF HUMAN ECOLOGY. ANTROPOECOLOGY.

Life on Earth cannot exist in a form of separate populations. It exists as community of organisms of different species, where all species related to each other. Ecology studies these relations on a biospherical life organization level. The term "ecology" was suggested by A.Gekkel in 1866. However, as independent science, ecology was founded at the beginning of 20th century.

Ecology – is a science, which studies a close network of relationships between organisms' communities and environment, a structure, dynamics and historical development of communities – ecosystems, biogeocenoses and biosphere. Ecology is a system of biological disciplines, which study life on higher organization levels. That means that ecology studies relationships of populations and species within species and relationships of them with environment. Ecology studies the influence of communities on their environment too. Ecology has to regulate using of natural resources, to forecast weather changes, to prevent biosphere damage by human, to safe human environment. The subject of ecological study is physiology and behavior of individuals in natural environment (autoecology), of organisms population (demecology), birth rate, mortality, migration, relationships within species, interspecies relationships, and energy and substance cycles (synecology).

There are five stages of ecology development.

The first stage – background of ecology as sciences. It proceeded from a deep antiquity up to the end XVIII of century and was characterized by occurrence of ecological knowledge in zoological and botanical geography. In the works of Aristotle and Feofrast, ancient Roman, Indian and Chinese scientists the animals and the plants frequently were considered in connection with environmental factors. In this period the works of greatest scientific K. Linnei had the importance. He has formulated a hypothesis of a constancy of species, given bases of scientific system of animals and plants, entered the binary nomenclature, recognize formation of versions under influence of existence conditions.

The second stage – creation of ecological directions in botanical and zoological geography. The is period covers first half XIX century. The greatest importance had the works French scientist G.B. Lamark, which described influence alive organisms on geological processes, given concept of "biosphere". In the book "Philosophy of zoology" G.B. Lamark for the first time formulated the complete evolutionary concept, entered principles of gradation, shown influence of the environment factors on organisms, but he has failed to explain principles of organisms adaptation by environment area, incorrectly specified the evolutionary factors.

The third stage – formation of plants and animal ecology as sciences about adaptations of organism on Darwinism base. This is period covers time from second half XIX of century till 20 years XX of century. In the book "An origin of species by natural selection" (1859) Ch. Darwin has given the materialistic theory of historical development of organisms. On a basis of Darwinism were developed genetics and ecology. The German biologist Gekkel in 1866 has named a science studying the relations of organism with inorganic and organic environment, as "ecology". In 1877 scientist K. Mebius has entered concept about biocenosis. In this connection the ecology was ceased to be only ecology of similar organism (autoecology), in it develop a new direction – ecology of communities (synecology, or biocenology).

The fourth stage is state of ecology as common biology science that interconnected to protection of a nature. It is the period with 20 till 60 years XX century. The large importance for development of

ecology had the works of the Russian geochemist V.I. Vernadski. In the doctrine, created by him about biosphere the basic properties alive organism, their interaction with a lifeless nature were considered. Influence alive on abiotic environment for the first time was shown, the definition of noosphere is given which the scientist considered as a maximum stage of biosphere development. In 1935 English botanist A.Tensli entered concept "ecosystem" as set of alive and dead elements of a nature. In 1940 the Russian scientist V.N. Sukachev developed representation about biogeocenosis, opening all completeness of interactions both interdependence of alive essences and elements of a lifeless nature in biosphere. The ecology in this period considered alive in his interrelations with environment at levels of one organism (autoecology), population (demecology), species (speciesecology), biocenosis (synecology) and ecosystem (biogeocenology).

The fifth stage - development of global ecology and antropoecology. It is the modern period which has begun since 60 years XX of century.

The closest relations occur between individuals, which inhabit the particular region of environment with similar conditions. Such regions were called biotopes (from Greek "bios" - life, "topos" - place). The community of organisms that inhabit biotope for a long time is called biocenosis. Biocenosis can include thousand species, but majority of them play a minor role in it. Several main species regulate life in it. In land biocenosis, the regulating factor is plants.

Biocenosis and biotope taken together make biogeocenosis. Biogeocenosis is limited in territory, internally similar system of functionally related organisms and nonliving environment, which has particular energy state, type and rate of substance and information exchange (V.Sukachev, 1940). The main part of biogeocenosis is biocenosis.

Concerning close relationships of biocenosis with abiotic environment, A. Tensley suggested the term "ecosystem" in 1935.

Ecosystem – is complex association of plants, animals, fungi, and microorganisms that interact with their nonliving environment in such a way as to regulate a flow of energy through them and the cycling of nutrients within them. Ecosystems have no limited volume. It can exist in the water drop and ocean as well.

The biggest ecosystem is biosphere. It includes all life creatures of Earth, which interact with physical environment of Earth. This system takes energy of the sun and maintains stable equilibrium. The term "biosphere" was suggested by Austrian geologist E. Zuss (1875) considering one Earth layer.

Further development of concept about biosphere is connected with name of Russian scientists V.I.Vernadsky. He used this term firstly in 1911. He suggested that biosphere contains four main components: living substance - all living organisms; biogenic substance - all substance which is made by living organisms (atmospheric gases, bituminous coal, lime and so on); stagnant substance - is made without organisms (volcano, meteors); biostagnant substance - is result of collaboration of organisms and abiogenic processes (wind, water and so on). The terms "living substance" and "stagnant substance" which were used by him are not very successful. They are reflection of initial author's view on processes of life development and evolution. Now following terms are in use: community of organisms, living shell of earth, life film, and Earth biomass. In spite of "stagnant substance" the following terms are used: mineral elements, inorganic substance, abiogenic substance. The higher border of biosphere is about 15-20 kilometers over land surface. The lower border is limited by organic sedimentations on the oceans bottom (more than 10 kilometers of depth).

In a history of evolution of biosphere allocate six stages.

The first stage – development of life in water environment which has resulted during evolution in occurrence of plants and animals. The second stage - formation of organisms as characteristic alive environment of life of the parasites and symbionts at the inhabitants of water. The third stage - output of organisms on land and formation air and biocosnoi environments. The fourth stage - occurrence of life birth, that has made organism as environment of life not only interspecies, but also inspecies by the phenomenon. The fifth stage - occurrence of the man and formation of a human community. The sixth stage - transition of biosphere in noosphere.

Purposes of class: 1. To know: aims and problems of anthropoecology, characteristic of community, biogeocenosis, ecosystem, biosphere; ecological diversity and human adaptive types;

biological and social aspects of human adaptation to environmental conditions. 2. To be able to solve situational problems on anthropoecology. 3. To be acquainted with aims and problems of valeology.

Questions:

1. Ecology as science, its aims and problems.
2. Biological systems, studied by ecology: communities, biogeocenosis, ecosystems, biosphere. Noosphere. Influence of humans on biosphere.
3. Anthropoecology as science, its aims and problems. Levels of human ecological relations (individual, population, global).
4. Ecological differentiation of humans on adaptive types and their morphophysiologic characteristics.
5. Biological and social aspects of human adaptation to life conditions.
6. Human health and life supporting system as categories of anthropoecology. Problem "predisease – disease – compensation" as possible human organism stays. Factors of health.
7. Valeology as science about human health.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 213-221.

Laboratory work:

I. Solve situational problems on anthropoecology:

№120. Square of Earth is equal to 149 millions km^2 , mankind is equal to 5,4 billions of people in 1985. Humankind habitats different ecosystems irregularly. Tropical forests occupy 15 % of terrestrial square, where lived 28 % of peoples. Grasslands and savannas square occupy 21 % of Earth. Here lived 12 % of peoples. Square of deserts is equal 18 %, where lived 4 % of peoples. Taiga occupies 10 % of Earth, its people – 1%. Mountains regions presents 12% Earth surface. At this territory lived 12 % of peoples. Deciduous forests occupy 7 % of Earth, where lived 42 % of peoples. Polar lands and tundra occupies 17 % of earth. Here lived 1 % of peoples.

Calculate relative density of people for indicated zones. Results have to be reflected in table.

№	Habitat environment	Square in millions km ²	People millions	People density (per km ²)
1.	Tropical forests			
2.	Grasslands and savannas			
3.	Deserts			
4.	Taiga			
5.	Mountains regions			
6.	Temperate deciduous forests			
7.	Polar lands and tundra			

Explain causes of different relative density in different ecosystems.

№121. Give comparative characteristics changes of biochemical indexes of human blood during adaptive processes to far North conditions.

Time of life on North	General protein, %	Glucose of blood, mg%	Lipids, mg%	11-OKS, mcg%
1-2 month	7,89	82	701	25,1
6 month	8,08	65	699	22,0
1 year	8,00	73	659	24,7
1,5 year	8,32	72	666	24,8
2 year	8,20	91	652	24,8
Novosibirsk peoples	8,56	92	476	19,8

№122. Give comparative characteristics of indexes of oxygen blood balance at humans during adaptation processes to far North conditions with yearly and seasonal rhythms account.

Time at far North	Oxygen saturation of blood, %		
	arteria	vena	arteriovenous difference
1. Control group	93,1	50,3	42,8
2. Up to 1 month, winter	92,5	66,0	26,5
3. Up to 1 year, winter	91,6	50,3	41,3
4. Up to 1 year, spring	93,1	45,2	47,9
5. Up to 2 year, spring	94,7	52,0	42,7
6. Up to 2 year, spring	93,8	33,2	60,6

Explain particularities of organism adaptation in North conditions.

№123. Give comparative analysis of indexes of circulatory system functional condition in dependence from time of living at far North.

Time of live	Heart beating frequency, min^{-1}	Average Arterial pressure, mm Hg	Systolic volume, ml	Minute volume of blood circulation, l	Hemoglobin, g%
1-6 month	68,9	86,7	72,2	4,977	15,18
7-12 month	67,4	85,9	73,9	5,136	15,41
13-24 month	66,6	86,0	71,8	4,895	15,26
25-36 month	65,5	89,0	69,1	4,737	15,59
4 years	65,8	91,6	68,7	4,741	15,66
5-9 years	65,6	95,0	60,1	4,060	15,56
10 and more years	65,4	96,0	57,8	3,933	16,06
First generation of posterity	65,3	100,6	60,1	3,952	15,34
Far North people	63,4	88,5	60,9	4,004	14,5
Novosibirsk people	63,7	84,5	66,0	4,436	13,86

Explain phase character of human adaptation to North condition.

№124. Give analysis and determine correlation level between expression of emotional exertion and of emotional stability with indexes of Arterial blood pressure.

Psychoemotional exertion	Arterial blood pressure, mm Hg	Emotional stability	Arterial blood pressure, mm Hg
High	138,5	Low	140,3
Middle	131,2	Middle	132,1
Low	134,0	High	127,5

CLASS № 26.**ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM SARCOMASTIGOPHORA, CLASSES ZOOMASTIGOTA AND SARCODINA**

Parasitism - is kind of symbiosis when one organism (parasite) uses another (host) as a source of food and place for living. It is harmful for host, but in most cases, it is not lethal. There are many forms of parasitism. There are facultative and obligatory; temporal and permanent; truth and false, ectoparasitism and endoparasitism.

Parasitism is studied by parasitology. Parasitology is a division of biology that studies parasites, their biology and ecology, their relationships with host and environment, diseases caused by them, and methods of treatment of parasitological diseases. Parasitology as a science concerns many questions of general biology. It also studies the formation of morphological and functional adjustments of parasites to their life and origin of these adjustments. Parasitology is very important in studying human, animal, and plant diseases that are caused by parasites. Accordingly, there is medical parasitology, veterinary parasitology, and phytoparasitology.

Medical parasitology studies the biology and ecology of human parasites, diseases caused by them, methods of diagnostics, treatment, and prevention of these diseases. It includes medical protozoology, helminthology and arachnoentomology. Medical protozoology studies pathogenic protozoa, which cause human diseases. Medical helminthology studies flat worms and nematodes, which cause human diseases. Medical arachnoentomology studies arthropods as transmitting agents, natural reservoir and causative organisms. Medical parasitology is used to solve following problems:

- Studying of morphology, biology, ecology, and the systematics of human parasites.
- Discovering the ways how parasites act on the human organism (and overwise) to understand mechanisms of diseases caused by them.
- Suggesting new ways of treatment and preventing of diseases caused by parasites.

To solve these problems, the methods of many other biological disciplines such as anatomy, zoology, cytology, histology, genetics, physiology, ecology, pathology, and hygiene are used.

Parasites are such organisms, which use other organisms as sources of food and environment, giving off completely or partially the function of relationships with environment to their hosts (V.A. Dogel 1947). All parasites are divided into two big subdivisions: ectoparasites and endoparasites. Ectoparasites are animals that live on surface of the body. Mainly they are arthropods. Ectoparasites can be permanent (having all life cycle on a body), like louses, and temporal (which are on surface only during feeding), like mosquitoes. Endoparasites, according to their localization can be classified to intercellular parasites (which live inside of a cell), like *Plasmodium malariae*; tissue parasites (which live in tissues), like *Entamoeba histolytica*, trypanosomes, *Fillaria* and so on; organs parasites (which affect various organs), like *Opistorchis felinus*, and others; and cavity's parasites (which settle different bodies cavities such as pleural cavity, abdominal cavity and so on), like *Taenia solium*, *Ascaris lumbricoideus*, *Enterobius vermicularis* and others. All endoparasites are permanent parasites.

Each parasite should have at least one host. Parasites having only one host are called monoxenic or monohost parasites. For example, *Hymenolepis nana* and *Enterobius vermicularis* live only in human. The majority of monoxenic helminthes need the fertilized ova to be evacuated to external environment. The parasites that need two or more host during their life cycle called heteroxenic or multihost parasites (*Plasmodium*, *Taenia solium* and others).

All helminthes are divided into geohelminthes, biohelminthes and contact helminthes. Geohelminthes are worm in which development of invasive larva occurs in a soil. Human invasion occurs through unwashed vegetables, fruits (*Ascaris lumbricoideus*, *Trichocephalus trichiurus*) or through the skin while close contact with soil (*Necator americanus*, *Ancylostoma duodenale*). Biohelminthes are parasites obligatory having several host to complete their life cycle (all Trematodes, Cestodes, *Fillaria* and so on). Contact helminthes are parasites that can have their full life cycle in one organism, without leaving an organism (*Hymenolepis nana*, *Enterobius vermicularis*).

The parasite host - is an organism, in which parasites permanently or temporally live and reproduce by a sexual or asexual way. The host changes occur because of different life stages in the parasite. Larval stages are developed in one organism, whereas mature parasites live in

another. There is one more reason to change a host. It is the way of changing generations which are reproduced by a sexual or asexual way.

The host where the parasite becomes mature and performs sexual reproduction is called the definite host. Thus, the human organism is definite host for many cestodes and trematodes.

The host where parasite's larvae live and can perform asexual reproduction is called an intermediate host. The human is an intermediate host for plasmodiums, and *Echinococcus granulosus*.

For some parasites, it is necessary to have two intermediate hosts to complete their life cycle. Second intermediate host called additional host. Thus, *Opisthorhis felinus* have two intermediate hosts: one is mollusk *Bithynia leachi*, additional -some fishes.

The hosts where parasites have optimal life and reproduction are called obligate hosts. Thus, the human is an obligate host for *Ascaris lumbricoideus*, *Ancylostoma duodenale*, and others.

The host where parasite can live, but it is not fully adapted is called the facultative host. For example, a human can be an obligate host for *Diphyllobothrium latum*. However, this cestod can live in fox, but in this case, it has lesser size and lives no longer than two month. So, fox is facultative host for *Diphyllobothrium latum*.

Organisms where parasites reserve for a time without developing are called reservoir host. Reservoir hosts accumulate parasite and facilitate the spread to others. For example, a pike can eat additional host of *Diphyllobothrium latum*. Thus, it accumulates larva of *Diphyllobothrium latum* in its tissues, preserving them for definitive host.

There are different ways for parasites to enter the human body: through mouth, skin, blood, placenta, and so on.

The oral way of invasion is the most common. By eating fruits and vegetables a human can swallow larva of helminthes and cysts of protozoa. In some cases, it can be accompanied by interintestinal and transplacental ways.

Interintestinal ways of invasion takes place when all stages of helminth development occur in the intestine without leaving the organism. This way is typical for *Hymenolepis nana* and *Strongyloides stercoralis*.

Transplacental way means that invasional stages of parasite development can enter the developing embryo through placenta from his mother. It is very common during *Toxoplasma* invasion. It can result in development of inherited toxoplasmosis. It was describe that this way can occur during malaria, visceral leishmaniasis, ancylostomosis.

Transdermal way - is invasion of parasite through undamaged skin. It is typical for shystosomes, fillaria-shaped larva of ancylostoma and others.

The contact way is transmission of parasites directly from affected man to healthy one or through medical instruments, linen and others, which were in use by affected individual. This way is typical for *Trichomonas vaginalis*, louses.

The transmittional way of invasion is performed by sanguivorous insects. There are two variants of this way: *inoculation and contamination*. During *inoculation*, parasite is actively entered the blood of human or animal. It is due to active destruction of integuments by transmitter. During *contamination*, a parasite is placed on the undamaged skin. But human can rub it in because of itching. Both contamination and inoculation can be specific and mechanical. In *specific inoculation*, parasites actively reproduce themselves in transmitter and then they are entered into the host. It occurs during malaria, leishmaniasis and so on. *Mechanical inoculation* can also be called occasional. The parasite stays in the oral cavity without reproducing. It waits for the appropriate moment to enter a host. When a transmitter bites someone, parasites go to the tissues of the bitten animal. Thus, biting flies transmit exciter of anthrax. Specific contamination occurs in those cases when the parasite is reproduced in the intestine of transmitter. Then, it is ejected with feces to the skin, where it is rubbed in by human. It is typical for Provachek' rickettsia and for plague while louse biting. During mechanical contamination, houseflies can transmit cysts of protozoa and helminthes ova on the food staffs.

There is also a transovarial way of invasion. It is very important in nature to preserve parasites in the generation line. Thus, the female can transmit parasites to her offspring through sex cells. Such a way of transmittion is typical for exciter of taiga's encephalitis.

Purposes of class: 1. To know main notions of parasitology, classification of parasites, types of parasite's hosts; classification of parasite diseases, geographical expansion, particularities of morphology, cycles of development, infection pathways of humans, pathogenic influence of important parasites from Zoomastigota and Sarcodina classes on human organism, laboratory diagnosis and prophylaxis of diseases caused by them. 2. To be able to diagnose parasites from Zoomastigota and Sarcodina classes, which can cause human diseases. 3. To be acquainted with main clinical symptoms of trypanosomiasis, leishmaniasis, lambliasis, trichomoniasis and amoebiasis.

Questions:

1. Parasitism as form of ecological relationships in nature, its types. Medical parasitology as part of human anthropoecology, its problems.

2. Characteristic of parasites and of their hosts. Ways of parasite invasion into human body. Life cycles of parasites. Relationships in system "parasite - host". Parasitocenosis.

3. Diseases caused by parasites, their classification. Concept about natural regions of parasite diseases, suggested by E.N. Pavlovsky. Biological bases of human parasite diseases prophylaxis.

4. Protists as exciters of invasion diseases of human and animals. Their characteristic features. Classification.

5. Phylum Sarcomastigophora. Characteristic features of organization.

5.1. Zoomastigota class, the most important parasites (trypanosoma, leishmania, trichomonas, lamblia): geographical expansion, particularities of morphology, cycles of development, invasion ways for human, pathogenic influence; methods of laboratory diagnosis (microscopic, immunological). Preventive measures against diseases, caused by them.

5.2. Sarcodina class, the most important parasites (Entamoeba histolytica; Entamoeba coli; Entamoeba gingivalis, Limax group amoebas): geographical expansion, particularities of morphology, cycles of development, invasion ways for human, pathogenic influence; methods of laboratory diagnosis (microscopic,

immunological). Preventive measures against diseases, caused by them.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 222-240.

Laboratory work:

I. Study the following macropreparations in museam:

– “Ulcers of gut at amoebiasis”.

II. Study micropreparations without drawing:

– “Trypanosoma brucei gambiense” (400x);

– “Leishmania tropica major (promastigota) (400x);

– “Lambliia intestinalis” (630x);

– “Entamoeba histolytica” (630x).

III. Fill in table for pathogenic Zoomastigota characteristics.

Signs	Skin leishmaniasis exciter	Visceral leishmaniasis exciter	African trypanosomiasis exciter	Chagas disease exciter	Lambliasis exciter	Trichomoniasis exciter
Latin name of parasite, localization, sizes						
Epidemiological characteristic of disease						
Source of invasion, vector						
Pathogenic influence on organism						
Methods of diagnosis: - microscopic; - immunological						
Epidemiological chain: - source of invasion (donor); - environment; - vector; - recipient						
Prophylaxis: - individual; - social						

CLASS № 27.

ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM APICOMPLEXA, CLASS SPOROZOA AND IN PHYLUM INFUSORIA, CLASS CILIATA

In the Sporozoa class there are only intercellular parasites having two types of asexual reproduction (schizogonia, sporogonia) and sexual reproduction. Main human parasites are representatives of *Plasmodium*, *Toxoplasma*, *Pneumocyst*, *Cryptosporidium* genera.

The exciters of malaria are referred to *Plasmodium* genus. There are four species in this genus: *Plasmodium vivax* - is exciter of "tertian" malaria; *Plasmodium malariae* - is exciter of "quartan" malaria; *Plasmodium ovale* - is a cause of malaria, which is morphologically similar to *P. malariae*, but has developed periodicity as *P. vivax*; *Plasmodium falciparum* - is exciter of tropical malaria. Human is an intermediate host for *Plasmodium*, whereas mosquito is definite host. All four exciters have similar life cycles. In a human organism the following stages can be seen: asexual reproduction in liver cells (tissue schizogony or exo-erythrocytic schizogony), then development in erythrocytes (erythrocytic schizogony), and formation of gametocytes (immature gametes). Gametogony and sporogony occur in mosquito organism.

The exo-erythrocytic schizogony starts right after mosquito bite. The sporozoites enter the capillary vessels of the skin with salivary juice from the mosquito and, at first, enter the general circulation. After approximately a hour, the injected sporozoites are taken up by the parenchymal liver cells in which they divide and multiply to form liver schizonts containing several hundreds of merozoites and reaching a size of 25 to 40 μm in about 7 days. *P. falciparum* can make more than 30 thousands of merozoites from one schizont. Other species can form about 15 thousands of merozoites from one schizont. Duration of this phase is for *P. vivax* - 8 days, for *P. falciparum* - 5-6 days, for *P. malariae* - 13-16 days, for *P. ovale* - 9 days. The liver cells are ruptured by over population of merozoites. Thus merozoites are liberated from liver cells and enter blood stream.

The erythrocytic schizogony. On the erythrocyte membrane, there are antigens to which tissue merozoites are attached. In this place, erythrocyte membrane engulfs to enable parasite enter erythrocyte.

Merozoite, which has entered erythrocyte, called erythrocytic trophozoite. It has four stages of development:

1. Stage of young trophozoite. It starts 2-3 hours after merozoite entering. Parasite develop vacuole which shift cytoplasm with nucleus to the periphery. Therefore, this stage also called young ring stage.

2. Stage of older trophozoite. The parasite grow in sizes, the nucleus becomes bigger. It expresses pseudopods, which enable it to move. In the erythrocyte cytoplasm, many small granules appear.

3. Stage of young schizont. It continues enlarging in sizes. The granules of red pigment appear in parasite cytoplasm. Vacuole disappears. Nucleus starts to divide into several parts. Chromatin is irregular in shape.

4. Stage of older schizont. The nucleus division is completed. It results in merozoites formation. They are 1.5 μ m in diameter. The pigment granules surround them.

When older schizonts have been formed, they rupture affected erythrocytes and liberate from them. Clinically, it results in fever attacks. It occurs repeatedly in *P.vivax* ("tertian" fever), in *P.ovale* (like "tertian") and in *P.falciparum* (tropica) every 48 hours, in *P.malariae* ("quartan" fever) every 72 hours. Merozoites affect new erythrocytes. The reproduction cycle starts once again. After several days of erythrocytic schizogony onset, part of merozoites transforms to male and female gamonts. From this moment, a man becomes infective. Mature male gamont has light blue cytoplasm and big nucleus diffusely stained. Mature female gamont has dark blue cytoplasm, compact, good stained nucleus. Gamonts have large amount of pigment. Gamonts become mature during three days. Only in *P.falciparum* it takes 9 days. Gamonts of *P.falciparum* are sickle shaped. They can stay in a blood for three weeks. Gamonts of other species disappear earlier.

Gametogony takes place in mosquito's stomach. 15 minutes after swallowing, male gamonts loose erythrocyte shell and form 6-8 active gametes on a periphery of the cell. Gametes can move. They look like flagella. This process was called exflagellation. Female gamonts also present female gametes on a periphery of the cell. Male and female gametes fuse forming zygote. It becomes elongated. It called ookinete. Ookinete penetrate stomach wall and get under basement membrane.

It loses ability to move, forms dense shell. This stage called oocyst. Oocyst is subjected to meiosis division.

Next stage is sporogonia. It is a cell after second meiosis division of oocyst. Nucleus and cytoplasm divides rapidly into many parts. They form more than 10000 daughter cells (sporozoites). Sporozoites reach mosquito's salivary gland with lymph flow, when oocyst shell has been ruptured. Now the mosquito can infect someone. Duration of sporogonia depends on weather conditions and on plasmodium type.

Toxoplasma gondii — is obligate intracellular parasite. It is cause of toxoplasmosis of human and animals. S.Nicolle in 1908 discovered it and classified it as independent genus *Toxoplasma*. Parasite develops with the host change. Final hosts domestic cats and some wild representatives of that family (ocelot, bobcat, and Bengali tiger). Invasion cannot survive in the nature without cats. Intermediate hosts are domestic and wild mice, rats, rabbits, sheep, pigs, cows, some birds and human.

Trophozoites can reproduce itself by both sexual and asexual way. Asexual way is schyzogonia with merozoites formation. Sexual way occurs when part of merozoites transforms into sex cell (micro- and macrogametes). Microgametes and macrogametes fuse forming oocyst (20-100 μm of size). They are surrounded by thick shell. Oocysts are excreted with faeces to the environment, where they can preserve for a long time. When conditions become appropriate, each oocyst forms two sporocyst with four sporozoites in each. Such oocyst becomes invasional. In the intermediate host, the life cycle occurs mostly in a same way. Sporozoites penetrate epithelial cells of intestine. Then, they live and divides in it forming trophozoites. Trophozoites can divide many times. Then, they can travel with blood flow to any tissue of intermediate host. In the tissue, they can form tissue cysts. It is latent invasional form of parasite. They are placed in brain, heart, muscles, and eyes. They can survive for years.

Purposes of class: 1. To know characteristic of Sporozoa and Ciliata classes; geographical expansion, particularities of morphology, development cycles, invasion ways for human, pathogenic influence of malaria plasmodia, toxoplasma, cryptosporidium, pneumocysta, balantidium on human; prophylaxis of diseases caused by them. 2. To be able to diagnose excitors of malaria, toxoplasmosis and

balantidiasis. 3. To be acquainted with main clinical symptoms of malaria, toxoplasmosis, cryptosporidiosis, pneumocystosis, balantidiasis.

Questions:

1. Phylum Apicomplexa. Characteristic features of organization, classification.

1.1. Class Sporozoa, order Coccidia.

1.1.1. *Toxoplasma gondii*: geographical distribution, particularities of morphology, cycle of development, ways of parasite invasion for human, pathogenic action, methods of laboratory diagnosis (microscopic and immunological), preventive measures against toxoplasmosis.

1.1.2. *Cryptosporidium parvum*: geographical distribution, particularities of morphology, cycle of development, ways of parasite invasion for human, pathogenic action, methods of laboratory diagnosis (microscopic), preventive measures against cryptosporidiosis.

1.1.3 *Pneumocystis carinii*: geographical distribution, particularities of morphology, cycle of development, ways of parasite invasion for human, pathogenic action, methods of laboratory diagnosis (microscopic and genetic), preventive measures against pneumocystosis.

1.2. Class Sporozoa, order Haemosporidia.

1.2.1 Malaria plasmodia: geographical distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic action, methods of laboratory diagnosis (microscopic and immunological); differences between malaria plasmodium; preventive measures against malaria.

2. Phylum Infusoria. Characteristic features of organization, classification.

2.1. Class Ciliata. *Balantidium coli*: geographical distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic action, methods of laboratory diagnosis (microscopic); preventive measures against balantidiasis.

Literature:

Bekish O. - Y. L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 240-250.

Laboratory work:

I. Study the following macropreparations in museum:

- “Coccidia in liver”;
- “Ulcers in large intestine mucous coat at balantidiasis”.

II. Study the following micropreparations without drawing:

- “Blood smears from patient suffered tertian malaria” (900x);
- “Toxoplasma gondii” (400x);
- “Balantidium in large intestine mucous coat” (280x).

III. Fill in table for malaria excitors characteristics.

Signs	Plasmodium vivax	Plasmodium malariae	Plasmodium ovale	Plasmodium falciparum
Localization in human organism				
Epidemiological characteristic of parasite				
Epidemiological characteristic of disease.				
Latin name of fever				
Interval between attacks of fever (in hours)				
Stages of parasite revealed in blood smear				
Methods of diagnosis: - microscopic; - immunological				
Epidemiological chain: - source of invasion (donor); - vector; - recipient				
Prophylaxis: - individual; - social.				

CLASS № 28.
ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM
PLATHELMINTHES, CLASS TREMATODA.

Medical helminthology - is a division of medical parasitology that studies parasite worms as exciters of human diseases. Diseases, which are caused by helminthes, called helminthoses. Human can be a host for more than 250 species of worms. More than half of them are flatworm, the rest of them are nematodes.

Today, helminthoses are most spread parasite diseases in a world. Therefore, much attention is paid to them. Accordinary data of WHO Helminthosis Committee (report N227) "...parasite worms in general affect health of whole mankind". Helminthes can live in any tissues and organs of human body. However, intestine is most common place of their living. *Paragonimus westermani* and *Echinococcus granulosus* can inhabit lungs. Almost all trematodes can inhabit liver. Brain can be a place for tapeworm cysts storage. Muscles are the place for *Trichinella spiralis* larvae preserving.

Clinical picture of helminthoses is very complicate. It is due to parasite action on host, as well as, host action on parasite. It is incorrect to discuss helminthoses as only parasite action on host, or only host action on parasite invasion. All clinical signs are the consequences of these interactions. The expression of clinical signs depends on number of parasites affecting the host. However, it is so particular in each case.

Flatworms are very spread in nature. There are more than 7300 species in this phylum. They live in sea, ponds, land. Many of them are parasites.

Flatworms develop from three embryo layers. They have bilateral symmetry of body. Body is flat in dorso-ventral direction. There is no coelom. Internal organs are suspended in loose connective tissue — parenchyma. Musculo-cutaneous sack consists of external layer - tegument (multinucleus unicellular structure) and three muscular layers (longitudinal, cross and oblique).

Many flatworms have gut with only one opening. The gut is branched and it extends throughout the body. It divides into anterior, middle and posterior part. Undigested particles are eliminated through

the mouth. Tapeworms lack digestive system. They adsorb their food directly through their body walls.

Flatworms do have excretory system, which consists of a network of fine tubules that runs throughout the body. Cilia line the hollow centers of the bulblike flame cells, which are located on side branches of the tubules. By doing so, cilia move water with the substances to be excreted into a system of tubules and then to exit pores located between epidermal cells. Flame cells were named because of the flickering movements of the tuft of cilia within them.

Flatworms lack respiratory system. They uptake oxygen through whole body surface.

Flatworms lack circulatory system. However, flatworms have thin bodies and highly branched digestive cavities, which facilitate diffusion of oxygen and food.

Nervous system is presented by two longitudinal nerve cords and two swelling at the anterior end.

Flatworms are hermaphroditic, excluding blood flukes (Schistosomas).

Phylum has three classes: Class Tutbellaria, Class Trematoda and class Cestoidea. Class Tutbellaria has no medical importance. Accordinary epidemiological classification, flatworms are biohelminthes (all Trematodes, Diphylobothrium latum, Tania soleum, Echinococcus granulosus) and contact helminthes (Hymenolepis nana).

Class Trematoda includes parasites only. Body has a leaf-shape. There are strong organs of attachment: sucker, small anchors, hooks covering whole body. They help to attach to the host. They were formed after a long period of adjusting to parasite being. All Trematodes are hermaphroditic. Male reproductive system is presented by two testicles and two sperm ducts, which fusing form one duct. This duct passes through male copulatory organ - cyrrus. Femal reproductive system is presented by ovary and oviducts. Ovicells travel to special chamber of female reproductive system - ootype. During copulation, cyrrus erect and enter vagina of other worm. Sperm cells leave cyrrus entering accepting chamber. Additional structures of female reproductive system are Mellis's bodies. There is also Laurerov chanal, which enter ootype. Their function is not clear.

Flukes - are biohelminthes, having interchange of reproduction strategies, host change and generation alternation. Adult stage (marita) inhabit organism of vertebrates. Its ova need to be placed into water to continue development. First stage larva, called miracidium, leaves the ovum. It can be ingested by snail. Within the snail, it transforms to sporocyst. Within the sporocyst rediae are produced, which are elongated, nonciliated larvae. This larva continues growing within the snail, giving rise to the several individuals of the tadpolelike next larva stage, the cercariae. The cercariae, which are produced within the snail, escape into the water, where they swim about. They look for definite or second intermediate host. If they look for definite host, they can transform to cyst stage - adolecscariae. They are located on the pondweed and can be ingested by animals. Second group looks for second intermediate host. Having found it, they bore into the muscles or under the scales, loose their tails and transforms to metacercariae. Intermediate hosts are usually fishes. Having entered final host, invasional stages of flukes travel throughout the body looking for an organ where they will live until the end.

Purposes of class: 1. To know characteristic of Plathelminthes distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic influence of trematodes on human organism, prophylaxis of diseases, caused by them. 2. To be able to diagnose excitors of fascioliasis, fasciolopsiasis, opisthorchiasis, clonorchiasis, paragonimiasis, dicrocoeliasis, urogenital shistosomiasis, intestinal shistosomiasis, Japanese shistosomiasis. 3. To be acquainted with main clinical symptomatic of trematodoses.

Questions:

1. Plathelminthes phylum, its characteristic and classification.
2. Trematoda class. Adaptations to parasitism. Epidemiologic classification of trematodes.
3. The most important representatives of Trematoda class – excitors of human and animals diseases (liver fluke, giant intestinal fluke, Chinese liver fluke, blood flukes, cat liver flukes, lung fluke, lancet like fluke): geographical distribution, particularities of morphology, development cycles, ways of invasion for human,

methods of laboratory diagnosis (microscopic, immunological), preventive measures against diseases, caused by them.

4. Mechanism of pathogenic influence of trematodes on human organism.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 251-262.

Laboratory work:

I. Study the following macropreparations in museum:

- “Marita of Fasciola hepatica”;
- “Liver fascioliasis”;
- “Marita of Lung fluke”;
- “Marita of Dicrocoelium lanceatum”;
- “Biology of Dicrocoelium lanceatum”;
- “Marita of cat liver fluke”.

II. Study micropreparations (without drawing):

- “Marita of Fasciola hepatica” (16x);
- “Marita of Opisthorchis felinus” (16x);
- “Marita of Lung fluke” (16x);
- “Marita of Schistosoma Mansoni” (16x);
- “Marita of Dicrocoelium lanceatum” (16x);
- “Eggs of Fasciola hepatica” (280x);
- “Eggs of Opisthorchis felinus” (280x);
- “Eggs of Dicrocoelium lanceatum” (280x);
- “Eggs of Schistosoma Mansoni” (280x);
- “Eggs of Schistosoma haematobium in uterus cervical mucous coat” (56x);
- “Metacercaria of Opisthorchis felinus in fish scale” (56x).
- “Cercaria of liver fluke” (56x).

III. Fill in table for characteristic of human pathogenic trematodes.

Sings	Liver fluke	Schistosoma Mansoni	Schistosoma haematobium	Cat liver fluke	Lung fluke
Latine name of parasite, its localization in human organism, sizes					
Epidemiological chain: - source of invasion; - environment; - intermediate host; - definitive host.					
Ways of human invasion					
Stages: - invasion stage; - pathogenic stage.					
Pathogenic influence on human organism					
Methods of diagnosis: - microscopic; - immunological					
Morphologic characteristic of egg (shape, sizes, color)					
Prophylaxis: - individual; - social					

CLASS № 29.

ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM PLATHELMINTHES, CLASS CESTOIDEA

Tapeworms, as flukes, are parasite of vertebrate animals. They have tape-like structure (strobila). The strobila is divided into many proglottids. On the anterior end, there is ahead or scolex with attachment organs (suckers, bothriæ and hooks). Next to the scolex is neck with young, growing segments. In the middle part of the body the segments are hermaphroditic, in the posterior part they are mature with dilated uterus filled with ova. These ova, each surrounded by a shell, emerge from the proglottids through either the pore or the

ruptured body wall, leave their host with the faeces, and are deposited on the leaves, in water or in other places from which they can be picked up by another animal.

Body is covered by tegument, which is morphologically similar to that in flukes, but functionally to the vertebrate's intestine mucosa. It contains antiproteolytic enzyme, which prevent it from digestion in intestine,

Cestodes lack digestive system; they adsorb nutrients through entire body surface.

They lack respiratory system too. Because of oxygen lack environment, metabolic processes are based on simple fermentation.

Excretory system is presented by protonephrids. Main protonephridic trunks are on a both sides of the body.

Nervous system is presented by scolex ganglion and two nervous cords, which extend throughout the body.

Reproductive system is well developed in mature proglottids. It is presented by ovarium, yolk body, vagina, underdeveloped uterus, testicles, ductus deferens, cyrrus. They have cross insemination.

Cycle of development starts from egg passing out of the human with the faeces. It contains embryos, which can start to develop in intermediate host digestive system. It has hooks. It burrows the walls of the intestine and ultimately reaches the muscles, liver, lungs by the way of blood and lymph vessels.

There, it transforms to larva. Larvae of different Cestodes have different structure. There are five types of Cestodes larvae:

1. The cysticercus. It has sphere shape with head pushed inside. Head has suckers. There is fluid within the sphere. The head can come out in some conditions.

2. The cenur - it is a sphere with several pushed inside heads.

3. The cysticercoid - it has a sphere with a head pushed inside and tail coming out of sphere.

4. The echinococcus- it is a big mother sphere with many daughter spheres inside. There are scolexes in the daughter spheres. Sphere's cavity is filled by metabolic parasite wastes.

5. The plerocercoid - it has worm-like shape. On the anterior end, there are two attachment grooves (bothriae).

Entered final host, larva matures with help of digestive enzymes. The head conies out and attaches to the intestine wall. The sphere is

destroyed. Definite hosts can be infected through eating meat of intermediate hosts with larvae. Final hosts, as well as, intermediate hosts are vertebrates.

Diseases, which are caused by tapeworms, are called cestodiasis. They are zoonosis biohelminthoses and contact anthroponosis helminthoses (hymenolepiasis).

Purposes of class: 1. To know characteristic of Cestoidea class; geographical distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic influence of cestodes on human organism, prophylaxis of diseases, caused by them. 2. To be able to diagnose exciters of teniasis, teniarhynchiasis, diphyllbothriasis, echinococciasis, alveolar echinococciasis and hymenolepiasis. 3. To be acquainted with main clinical symptoms of cestodoses studied.

Questions:

1. Cestoidea class, its characteristic. Adaptations to parasitism. Epidemiologic classification of cestodes.

2. The most important representatives of Cestoidea class – exciters of diseases of human and animals (beef tapeworm, pork tapeworm, fish tapeworm, dog tapeworm, *Alveococcus multilocularis*, dwarf tapeworm): geographical distribution, development, invasion ways for human; methods of laboratory diagnosis (macroscopic and microscopic, immunological); measures of individual and social prophylaxis of diseases, caused by them.

3. The larva migrans diseases of human (sparganosis, cystercosis, cenurosis), which caused by representatives of Cestoidea class.

4. Mechanisms of pathogenic influence of cestodes on human organism.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 262-274, 290-291.

Laboratory work:

I. Study the following macropreparations in museum:

- “Adult form of *Taeniarhynchus saginatus*”;
- “Adult form of *Taenia solium*”;
- “Human brain cysticercosis”;
- “Muscles cysticercosis”;
- “Human heart cysticercosis”;
- “Cysticercosis taeniucolis”;
- “Adult form of *Diphyllbothrium latum*”;
- “Liver echinococcosis”;
- “Multilocular hydatid lesion of liver”;
- “Larva of *Diphyllbothrium eurinacei europeii*”;
- “Adult form of *Drepanidotaenia lanceolata*”;
- “Adult form of *Mnieszia expansa*”;
- “Adult form of *Dilipidium caninum*”;
- “Adult form of *Taenia hydatigena*”;
- “Adult form of *Hymenolepis paracompressa*”;
- “Hymenolepiasis of duck intestine”.

II. Study the following micropreparations (without drawing):

- “Scolex of *Taenia solium*” (16x);
- “Scolex of *Taeniarhynchus saginatus*” (16x);
- “Gravid proglottide of *Taenia solium*” (16x);
- “Gravid proglottide of *Taeniarhynchus saginatus*” (16x);
- “Mature proglottide of *Taenia solium*” (16x);
- “Mature proglottide of *Taeniarhynchus saginatus*” (16x);
- “Eggs of teniids” (280x);
- “Adult form of *Echinococcus granulosus*” (16x);
- “Scolexes of *Echinococcus granulosus* from brood capsule” (56x);
- “Cross section of *Diphyllbothrium latum*” (56x);
- “Mature proglottide of *Diphyllbothrium latum*” (16x);
- “Eggs of *Diphyllbothrium latum*” (280x);
- “Adult form of *Hymenolepis nana*” (16x).

III. Fill in table for characteristic of human pathogenic cestodes.

Signs	Beef tapeworm	Pork tapeworm	Fish tapeworm	Dog tapeworm	Dwarf tapeworm
Latin name of parasite, its localization on human organism, sizes					
Epidemiological chain: - source of invasion; - environment; - intermediate host; - definitive host					
Ways of human invasion					
Stages; - invasion stage; - pathogenic stage					
Pathogenic influence on human organism					
Methods of diagnosis: - macroscopic; - microscopic; - immunological					
Characteristic of egg (shape, sizes, shell, color)					
Prophylaxis: - individual; - social					

CLASS № 30.

ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM NEMATHELMINTHES, CLASS NEMATODA GEOHELMINTHES AND CONTACT HELMINTHES (1-st class)

The nematodes, elworms, and roundworms comprise a large phylum, Nematoda, with some 500 thousands recognized species. The members of this phylum are ubiquitous. They live in water, in land, in animals.

Nemathelminthes are bilaterally symmetrical, cylindrical, unsegmented worms. They develop from three embryonic layers. They have primary body cavity, external cuticle with underlying

muscles, organs systems (digestive, excretory, nervous, reproductive), two sexes, terminal part of digestive system with anus.

There are several classes in Nematelminthes phylum. However, only one of them has medical importance. It is Nematoda Class.

The morphology of this Class is similar to whole phylum. They are covered by flexible, thick cuticle, which is molted as they grow. Their muscles constitute a layer beneath the epidermis and extend along the length of the worm, rather than encircling the its body. These longitudinal muscles pull both against the cuticle and against the pseudocoel. Digestive system is made of anterior, middle and posterior intestine. The excretory system is made of protonephridiums. Their number is small. Gases exchange occurs through entire parasite surface. Parasites metabolic processes are based on simple fermentation because of lack of oxygen. Nervous system is presented parapharyngeal nerve circle and nerve cord extended from it. These cords are connected by commissuras. Sense organs are presented by touch feeling cells and by cells perceiving chemicals. Reproductive organs have tubular shape. In female they are coupled, in male aren't. Male reproductive system is presented by testicles and sperm duct that enter terminal intestine. Female reproductive system includes couple of ovaries, couple of oviducts, couple of uteri, and common vagina that opens on the ventral side of the body. All internal organs are in the primary body cavity filled by fluid. It facilitates gases and metabolites exchange and forms hydrostatic skeleton.

Reproduction is only sexual. Fertilized egg starts to develop in uterus. However, larva formation in the geohelminthes can occurs only outside with oxygen access. The biohelminthes deliver living worms. The larva molts several times. In development cycle of majority of Nematodes there is no host interchange.

Accordinary development cycle features, nematodes are divided into geohelminthes (*Ascaris lumbricoideus*, *Trichocephalus trichirus*, *Ancylostoma duodenale*, *Necator americanus*, *Strongyloides stercoralis*), biohelminthes (*Trichinella siralis*, *Dracunculus medinensis*, *Filariidae*, *Wucheria bancrofti* and others) and contact helminthes (*Enterobius vermicularis*).

Purposes of class: 1. To know characteristics of Nematelminthes phylum and Nematoda class: geographical

distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic influence of round worms on human organism and prophylaxis of diseases, caused by them. 2. To be able to diagnose excitors of ascariasis, trichuriasis, ancylostomiasis, strongyloidosis, enterobiasis. 3. To be acquainted with main clinical symptoms of diseases, caused by nematodes.

Questions:

1. Nematelminthes phylum, its general characteristic and classification.

2. Nematoda class, adaptations to parasitism. Epidemiologic classification of nematodes.

3. The most important representatives of Nematoda class (geohelminthes and contact helminthes) – excitors of human diseases (*Ascaris lumbricoides*, *Trichocephalus trichiurus*, *Ancylostoma duodenale*, *Necator americanus*, *Strongyloides stercoralis*, *Enterobius vermicularis*): geographical distribution, particularities of morphology, cycles of development, invasion ways for human, methods of laboratory diagnosis (macroscopic, microscopic, immunological); measures of individual and social prophylaxis of diseases, caused by them.

4. The larva migrans diseases of human (toxocarosis), which caused by representatives of Nematoda class.

5. Mechanisms of pathogenic influence of nematods on human organism.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 274-282, 290-291.

Laboratory work:

I. Study the following macropreparations in museum:

- “Adult form of *Ascaris lumbricoides*”;
- “Adult form of *Toxocara canis*”;
- “Adult form of *Toxocara leonine*”;
- “Internal structure of *Ascaris lumbricoides*”;
- “Liver ascariasis”;

- “Intestinal ascariasis”;
- “Adult form of *Trichocephalus trichiurus*”;
- “Adult form of *Trichocephalus suis*”;
- “Trichocephalosis of large intestine”.

II. Study the following micropreparations (without drawing):

- “Cross section of *Ascaris lumbricoides*” (56x);
- “Female of *Trichocephalus trichiurus*” (16x);
- “Male of *Trichocephalus trichiurus*” (16x);
- “Female of *Enterobius vermicularis*” (16x);
- “Male of *Enterobius vermicularis*” (16x);
- “Eggs of *Ascaris lumbricoides*” (280x);
- “Eggs of *Trichocephalus trichiurus*” (280x);
- “Eggs of *Enterobius vermicularis*” (280x).

IV. Fill in table for characteristic of human pathogenic nematodes (geohelminthes and contact helminthes).

Signs	Large intestinal roundworm	Whipworm	Hookworm	Dwarf thread worm	Pinworm
Latin name of parasite, its localization in human organism, sizes					
Epidemiological chain: - source of invasion - environment - intermediate host - definitive host					
Ways of human invasion					
Stages: - invasion stage - pathogenic stage					
Pathogenic influence on human organism					
Methods of diagnosis: - macroscopic - microscopic - immunological					
Characteristic of egg (shape, sizes, shell, color)					
Prophylaxis: - individual - social					

CLASS №31.
ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM
NEMATHELMINTHES, CLASS NEMATODA.
BIOHELMINTHES (2-nd class).

Purposes of class: 1. To know characteristic of most important nematodes – biohelminthes, their geographical distribution, particularities of morphology, cycles of development, invasion ways for human, pathogenic influence of round worms – biohelminthes on human organism and prophylaxis of diseases, caused by them. 2. To be able to diagnose excitors of trichinosis, dracunculosis and filariasis. 3. To be acquainted with main clinical symptoms of diseases, caused by nematodes – biohelminthes.

Questions:

1. The most important biohelminthes from Nematoda class – excitors of human diseases (*Trichinella spiralis*, *Dracunculus medinensis*, *Brugia malayi*, *Wuchereria bancrofti*, *Onchocerca volvulus*, *Loa loa*, *Mansonella ozzardi*, *Dipetalonema perstans*): geographical distribution, particularities of morphology, development cycles, ways of invasion for human, pathogenic influence on human organism, methods of laboratory diagnosis (macroscopic and microscopic, immunological); measures of individual and of social prophylaxis of diseases, caused by them.

2. Pathogenic influence of parasitic worms on human organism; consumption of nutrients, local damage, stress reaction, changes in immune homeostasis, influence on infection diseases development. Influence of helminthes metabolites on hereditary apparatus of host.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 282-298.

Laboratory work:

I. Study the following macropreparations in museum:

- “Adult form of *Dracunculus medinensis* (female)”;
- “*Filaria* (male and female)”.

II. Study the following micropreparations (with drawing):

- “Larvae of *Trichinella spiralis* in muscles (280x)”;
- “Adult form of *Trichinella spiralis*, female (280x)”;
- “*Microfilaria* of *Wuchereria bancrofti* (280x)”.

III. Fill in table for characteristic of human pathogenic biohelminthes from Nematoda class.

Signs	Trichina worm	Medina worm	Wuchereria	Loa loa	Onchocerca
Latin name of parasite, its localization in human organism, sizes					
Epidemiological chain: - source of invasion - environment - intermediate host - definitive host					
Ways of human invasion					
Stages: - invasion stage - pathogenic stage					
Pathogenic influence on human organism					
Methods of diagnosis: - macroscopic - microscopic - immunological					
Prophylaxis: - individual - social					

CLASS №32.

ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM ARTHROPODA, CLASSES CRUSTACEA AND ARACHNOIDEA

The arachnoentomology is division of medical parasitology, which studies representatives of Arthropoda phylum as ectoparasite, endoparasites and vectors of human disease excitors.

Arthropoda - is most successive phyla of all living animals in term of number of individuals and species, total mass and complete occupation of terrestrial habitats.

Arthropods have the following features of structure: heteronomic segmentation of the body, which is expressed as different structure and functions of different segments; segment fusing into body's parts (head, thorax, abdomen); appearance of segmented limbs; muscle separation and appearance of striated muscles; external chitin skeleton, protecting body from external influences and serving as a place of muscles attachment; mixed coelomic cavity, resulting from fusing of primary and secondary coelomic cavity in embryogenesis; having organs systems (digestive, respiratory, excretory, circulatory, endocrine, reproductive).

The phylum Arthropoda has three subphyla: Branchiata, Chelicerata, Tracheata. In each of them, there is only one class, which is important for medicine - Crustacea, Arachnida, and Insecta.

The Crustaceans are not as important for medicine as Arachnidans and Insects. They can be only intermediate hosts for *Diphyllbothrium latum*, *Dracunculus medinensis*, *Paragonimus westermani*. Therefore, in the name of the division there are names of Arachnidans and Insects only.

Pathogenic influence of arthropoda on human being is due to their value as intermediate hosts of helminthes; human poisoning agents; vectors of diseases; parasites of human being. Arthropoda can transmitte invasion by specific and mechanical inoculation and contamination.

The Arachnidans - are Arthropoda, which were adapted to survive on the land. They have organs of air respiration. Two anterior parts fuse to one - cepha-lothorax. It connected with body by thin stem or fuse with it.

The body is covered by cuticle of chitin and hypoderm, which has cellular structure. The appendages of hypoderm - silk glands and poison gland - are localized in chelicerae base. The Arachnidans have 6 pairs of limbs, from which two anterior pairs (chelicerae and pedipalps) are adapted to catching and pounding of food. The rest four pairs are for locomotion.

The digestive system is adapted to eat fluid food. The pharynx has a function of sucking.

The respiratory system is presented by leaf-shaped lungs, which open outside by stigma (special opening). Lungs of Arachnidans are homologous of Crustacean gills. The tracheae are tubes, which highly branch and come to every organ and tissue where the gases exchange takes place.

The excretory system is presented by modified metanephridia. Many species form special Malpighian tubules, which are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. They excrete dissimilation products to the hindgut.

The circulatory system is open. It is most complicate in scorpions and spiders, which have lung. The principle component of circulatory system is longitudinal vessel, which is called the hearth. The vessels branch off this central vessel and bring blood to the organs. The blood is returned back to the heart by lacunas. The mites have reduced blood vessels and, sometimes, the heart.

The central nervous system of the arthropod is a double chain of segmented ganglia running along the animal ventral surface. This chain gives up peripheral nerves. The forms, having some segments fused, can fuse and nervous segments too. The Arachnidan typical feature is 1-6 pairs of simple ears.

The Arachnidans are animals having two sexes. The female ovarium is in the abdomen, whereas oviducts fuse to the single duct, which open in the anterior part of the abdomen. The male testicles are also in the abdomen and sperm ducts fuse to the single duct, which open on the abdomen surface. The sexual dimorphism is much expressed. Some species deliver living offsprings.

The development can be direct or with metamorphosis.

In the Arachnida Class, the mites (Acari order) have the most important medical value. The Order Acari, the mites, is the largest - in term of number of species - and most diverse of the arachnids. Many of them are sanguivorous. They may parasite on birds, mammalians and human being. They can be vectors of transmis-sive diseases. The important families of Order Acari are Ixodidae, Argasidae, Trombiculidae, Gamasoidae, Sarcoptidae, Demodecidae, and Tyroglyphidae.

Purposes of class: 1. To know characteristic of Arthropoda phylum; particularities of Crustaceans morphology and of Arachnids morphology, their medical value; transmission ways of influence exciters and invasion exciters to human by arthropods. 2. To be able to diagnose ticks – ectoparasites vector of infections diseases exciters, mites – exciters of human diseases. 3. To be acquainted with ticks role in distribution of influence diseases in nature.

Questions:

1. Arthropoda phylum. General characteristic and classification.
2. Pathogenic influence of Arthropods on human organism. Means of infections and invasion diseases exciters transmission to human by Arthropods.
3. Crustacea class, medical value of crustaceans.
4. Arachnida class, its characteristics. The most important orders of Arachnida class which have medical value.
5. Acari order characteristic and its most important families: Sarcoptidae family (*Sarcoptes scabiei*), Demodecidae family (*Demodex folliculorum*), Ixodidae family (*Ixodes ricinus*, *Ixodes persulcatus*, ticks of *Dermacentor* genus), Argasidae family (*Ornithodoros papillipes*), Trombiculidae family, Gamasoidea family, Thyroglyphidae family; their morphological and biological particularities, medical value. Measures used against mites and ticks.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 299-305.

Laboratory work:

I. Study the following macropreparations in museum:

- “Skeleton of crayfish”;
- “Nervous system of crayfish”;
- “Internal structure of crayfish”;
- “Crab”;
- “Shrimp”;
- “Spider”.

II. Study the following micropreparations (with drawing):

- “Dog tick (male and female)” (16x);
- “Tick from Dermacentor genus (male and female)” (16x);
- “Ornithodoros papillipes” (16x);
- “Itch mite” (56x).

CLASS №33.

ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM ARTHROPODA, CLASS INSECTA

The class Insecta is highest invertebrate. They have highest number of species. Their body divides into head, thorax and abdomen. There have sense organs - antennae and eyes - on the head. There is also complicate oral apparatus. Its structure depends on type of the feeding. The thorax has three segments, each of them carry one pair of legs. Beside that, the second and third segments can carry two wings. The abdomen includes 6-12 segments.

The body is covered by cuticle of chitin and hypoderm, which has cellular structure. The appendages of hypoderm are different glands (smelling, vex, molting). The muscles are striated.

The digestive system starts from mouth. It continues by mouth cavity, in which ducts of salivary gland open. The anterior part of the intestine has dilatation, called craw. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are Malpighian tubules and "yellow body" (accumulation kidney). The Malpighian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. They excrete dissimulation products to the hindgut. The dissimulation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The nervous system is a double chain of segmented ganglia running along the animal ventral surface. It starts from suprapharyngeal-paired ganglion. The nerve ganglia of neighbor

segments can fuse. The eyes are compound, but they can be simple too. The organs of balance, taste, smell and, sometimes, hearing are present.

The insects have two sexes. The development occurs by simple or complete metamorphosis.

The medical value of insects is big. It is due to pain from biting, local allergic reactions, possibility of infection of bitten places, transmitting various diseases. The insects can cause crop failure, abolish storages and therefore cause humans starvation.

The Insecta Class includes 34 orders. Among them, the Blattoidea, the Hemiptera, the Anoplura, the Aphaniptera, the Diptera have a medical value.

Purposes of class: 1. To know particularities of morphology, of biology and medical value of representatives from Blattoidea order, Hemiptera order, Anoplura order, Aphaniptera order, Diptera order. 2. To be able to diagnose insects, that have medical value, by microscopic methods. 3. To be acquainted with fight measures against insects, those have medical value.

Questions:

1. Insecta class, its characteristic and classification.
2. Blattoidea order. Particularities of morphology and biology. Medical value of black and red cockroaches.
3. Hemiptera order. Particularities of morphology and biology. Medical value of bed chinch and kissing chinchies.
4. Anoplura order. Particularities of morphology and biology. Medical value of head, body and pubic louses.
5. Aphaniptera order. Particularities of morphology and biology. Medical value of dog, rat flea and human fleas.
6. Diptera order. Particularities of morphology and biology. Medical value of representatives from following families: Culicidae, Phlebotomidae, Simuliidae, Ceratopogonidae, Tabanidae, Muscidae, Sarcophagidae, Gastrophilidae, Hypodermatidae, Oestridae.
7. Measures of fight against insects having medical value.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 306-316.

Laboratory work:

I. Study the following micropreparations (with drawing):

- “*Pediculus humanus capitis*” (16x);
- “*Pulex irritans*” (16x);
- “Heads of *Anopheles* genus mosquitoes female and of *Culex* genus mosquitoes female” (16x);
- “Heads of *Anopheles* genus mosquitoes male and of *Culex* genus mosquitoes male” (16x);
- “Larvae of *Anopheles* genus mosquitoes and of *Culex* genus mosquitoes” (16x);
- “Pupa of *Anopheles* genus mosquitoes and of *Culex* genus mosquitoes” (16x);
- “Leg of *Musca domestica*” (56x).

II. Study the following micropreparations (without drawing):

- “*Phtirus pubes*” (56x);
- “*Cimex lectularius*” (10x);
- “Eggs of *Anopheles* genus mosquitoes and *Culex* genus mosquitoes” (56x).

CLASS №34.

PRINCIPLES OF PARASITOLOGICAL DISEASES

DIAGNOSIS (training class).

Purposes of class: 1. To consolidate knowledge and practical skills for slides with pathogenic protists, parasitic worms and arthropods determination. 2. To be able to diagnose protists, helminthes, ticks, insects, that have medical value, by microscopic methods.

List of micropreparations:

1. “*Trypanosoma brucei gambiense*”;
2. “*Plasmodium vivax* (exciter of tertian malaria)”;
3. “*Toxoplasma gondii*”;

4. "Fasciola hepatica, marita (large liver fluke)";
5. "Eggs of Fasciola hepatica";
6. "Opisthorchis felineus, marita (cat liver fluke)";
7. "Eggs of Opisthorchis felineus";
8. "Scolex of Taeniarhynchus saginatus";
9. "Mature proglottid of Taeniarhynchus saginatus";
10. "Gravid proglottid of Taeniarhynchus saginatus";
11. "Scolex of Taenia solium";
12. "Mature proglottid of Taenia solium";
13. "Eggs of teniids";
14. "Mature proglottid of Diphyllobotrium latum";
15. "Eggs of Diphyllobotrium latum";
16. "Hymenolepis nana";
17. "Cross section of Ascaris lumbricoides";
18. "Eggs of Ascaris lumbricoides";
19. "Trichocephalus trichiurus, female";
20. "Trichocephalus trichiurus, male";
21. "Eggs of Trichocephalus trichiurus";
22. "Enterobius vermicularis, male";
23. "Enterobius vermicularis, female";
24. "Eggs of Enterobius vermicularis";
25. "Larvae of Trichinella spiralis in muscles";
26. "Heads of Anopheles genus mosquitoes male and of Culex genus mosquitoes male";
27. "Heads of Anopheles genus mosquitoes female and of Culex genus mosquitoes female";
28. "Larvae of Anopheles genus mosquitoes and of Culex genus mosquitoes";
29. "Pupa of Anopheles genus mosquitoes and of Culex genus mosquitoes";
30. "Ixodes ricinus (dog tick)";
31. "Dermacentor pictus (female and male)";
32. "Pediculus humanus capitis (head louse)";
33. "Pulex irritans (human flea)";
34. "Cimex lectularius (bed chinch)";
35. "Leg of Musca domestica (house fly);
36. "Ornithodoros papillipes (village tick)".

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 222-316.

CLASS №35.

MEDICAL PROTOZOOLOGY, HELMINTHOLOGY AND ARACHNOENTHOMOLOGY

(summing up class)

Purposes of class: 1. To estimate the degree of mastering program protozoology, helminthology and arachnoenthomology. 2. To be able to diagnose excitors of parasitic diseases from Sarcomastigophora phylum, Apicomplexa phylum, Infusoria phylum, Plathelminthes phylum, Nematelminthes phylum, Arthropoda phylum.

Questions:

1. Parasitism as form of ecological relationships in nature, its types. Medical parasitology as part of human anthropoecology, its problems.

2. Characteristic of parasites and of their hosts. Ways of parasite invasion into human body. Life cycles of parasites. Relationships in system “parasite - host”.

3. Diseases, caused by parasites their classification. Concept about natural regions of parasite diseases, suggested by E.N. Pavlovsky. Biological bases of human parasite diseases prophylaxis.

4. Protists as excitors of invasion diseases of human and animals. Their characteristic features. Classification.

5. Phylum Sarcomastigophora. Classification. Characteristic features of organization. Zoomastigota class, the most important parasites (trypanosoma, leishmania, trichomonas, lamblia): geographical expansion particularities of morphology, cycles of development, invasion ways for human, pathogenic influence; methods of laboratory diagnosis (microscopic, immunological). Preventive measures against diseases, caused by them.

6. Phylum Sarcomastigophora, Sarcodina class, the most important representatives (Entamoeba histolytica; Entamoeba coli; Entamoeba gingivalis): geographical expansion particularities of

morphology, cycles of development, invasion ways for human, pathogenic influence; methods of laboratory diagnosis (microscopic, immunological). Preventive measures against diseases, caused by them.

7. Phylum Apicomplexa. Characteristic features of organization, classification.

Class Sporozoa, order Coccidia (*Toxoplasma gondii*, *Cryptosporidium parvum*, *Pneumocystis carinii*): geographical distribution, particularities of morphology, cycle of development, ways of parasite invasion for human, pathogenic action, methods of laboratory diagnosis (microscopic and immunological). Preventive measures against diseases, caused by them.

Class Sporozoa, order Haemosporidia, Malaria plasmodia: geographical distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic action, methods of laboratory diagnosis (microscopic and immunological); differences between malaria plasmodia; preventive measures against malaria.

8. Phylum Infusoria. Characteristic features of organization. Class Ciliata. *Balantidium coli*: geographical distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic action, methods of laboratory diagnosis (microscopic); preventive measures against balantidiasis.

9. Plathelminthes phylum, its characteristic and its classification. Adaptations to parasitism.

10. Trematoda class. The most important representatives of Trematoda class – exciters of human and animals diseases (liver fluke, giant intestinal fluke, Chinese liver fluke, blood flukes, cat liver flukes, lung fluke, lancet like fluke): geographical distribution, particularities of morphology, development cycles, ways of invasion for human, methods of laboratory diagnosis (microscopic, immunological), preventive measures against diseases, caused by them.

11. Cestoidea class. The most important representatives of Cestoidea class – exciters of diseases of human and animals (beef tapeworm, pork tapeworm, fish tapeworm, dog tapeworm, *Alveococcus multilocularis*, dwarf tapeworm): geographical distribution, development, invasion ways for human; methods of laboratory diagnosis (macroscopic and microscopic, immunological);

measures of individual and social prophylaxis of diseases, caused by them. The larva migrans diseases of human (sparganosis, cystercosis, ctenuriasis), which caused by representatives of Cestoidea class.

12. Nematelminthes phylum, its general characteristic and its classification, adaptations to parasitism.

13. Nematoda class. The most important representatives of Nematoda class (geohelminthes and contact helminthes) – exciters of human diseases (*Ascaris lumbricoides*, *Trichocephalus trichiurus*, *Ancylostoma duodenale*, *Necator americanus*, *Strongyloides stercoralis*, *Enterobius vermicularis*, *Trichinella spiralis*, *Dracunculus medinensis*, *Brugia malayi*, *Wuchereria bancrofti*, *Onchocerca volvulus*, *Loa loa*, *Mansonella ozzardi*, *Dipetalonema perstans*): geographical distribution, particularities of morphology, cycles of development invasion ways for human, methods of laboratory diagnosis (macroscopic and microscopic, immunological); measures of individual and social prophylaxis of diseases, caused by them. The larva migrans diseases of human (toxocarosis), which caused by representatives of Nematoda class.

14. Pathogenic influence of parasitic worms on human organism; consumption of nutrients, local damage, stress reaction, changes in immune homeostasis, influence on infection diseases development. Influence of helminthes metabolites on hereditary apparatus of host.

15. Epidemiologic classification of helminthes.

16. Arthropoda phylum. General characteristic and classification. Pathogenic influence of Arthropods on human organism. Means of infections and invasion diseases exciters transmission to human by Arthropods.

17. Crustacea class, medical value of crustaceans. Arachnida class. Acarina order: Sarcoptidae family (*Sarcoptes scabiei*), Demodecidae family (*Demodex folliculorum*), Ixodidae family (*Ixodes ricinus*, *Ixodes persulcatus*, ticks of *Dermacentor* genus), Argasidae family (*Ornithodoros papillipes*), Trombiculidae family, Gamasoidea family, Thyroglyphidae family; their morphological and biological particularities, medical value. Measures used against mites and ticks.

18. Insecta class: Blattoidea order, Hemiptera order, Anoplura order, Aphaniptera order, Diptera order. Particularities of morphology,

of biology and medical value. Measures of fight against insects having medical value.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 222-316.

Laboratory work:

I. Diagnostic of exciters of parasitic diseases from Sarcomastigophora phylum, Apicomplexa phylum, Infusoria phylum, Plathelminthes phylum, Nemathelminthes phylum, Arthropoda phylum on micropreparations.

CLASS №36.

POISONOUS FUNGI AND POISONOUS PLANTS

There are many species of plants, fungi and animals, which are poisonous. However, ability to have poison is universal event in nature. It is an important mechanism of struggle for existence. Poisons of living organisms are used in ecological relationships between species. The substances, which take part in this relationships giving benefit to organism that produce them, are called allomans. They include poisons of plants (phytotoxins), poisons of fungi (mycotoxines), and poisons of animals (zootoxines).

The ecological view on this problem allows understanding of ecological relationships of organism with poison. It also helps to understand relations between toxin type and features of species being in the nature. In spite of big efforts in zoo- myco- and phytotoxines studying, there are very few toxins, which were studied experimentally. Plants, in compare with animals, use poisons only for defense from animals that can eat them. The traditional view on poisonous plants concerns only plants, which are poisonous for human being. Many of then are medical herbs. However, really, there are many plants, which are poisonous for insects, animals, but they are good for human. Even approximate list of herbs with insecticide

properties includes more than 1000 species. Many of them are not well studied.

The fungi are a distant kingdom of organisms, comprising more than 80000 named species.

Poisoning by poisonous metabolites of fungi occurs by eating, drugs treating (ergot) and folk medicine methods treating (toadstool, death-cup).

Morphologically all fungi are divided into macromycetes and micromycetes. The macromycetes are group of higher fungi with different systematics, whereas micromycetes are the group of all other fungi with microscopical sizes.

In spite of common mention that macromycetes are more poisonous than micromycetes, reality shows that it is incorrect. The micromycetes are more toxic and they can cause severest alimentary poisonings.

Today, plants are considered as poisonous if they produce even in small amounts phytotoxines, which are poisonous for human and animals. However, this definition is relatively conditional. Thus, clover during mild winter (with January isotherm over +5 centigrade) accumulates in young shoots significant amount of cyanogenic glycosides. Thus, clover protects itself from snails, which can eat shoots early in spring. At summer, massive growth makes unimportant small shoots lost by snails. Therefore, there is no need in toxic defense.

Since ancient times, the plant's poisons were used in folk medicine. Modern pharmacologists advise to use them carefully because of side effects, especially when they are overdosed.

There are about 1000 species of poisonous plants. They are mostly Angiosperms. Mainly they are plants of countries with arid climate and highlands. The flora of arid regions includes about 70% of total poisonous plants number.

There are different classifications of poisonous plants based on poison compound or poison action. There are poisonous plants with subdivision extremely poisonous plants and conditionally poisonous plants (they are toxic only in particular living places, after inappropriate storage, affected by fungi or microorganisms). The poisonous plants are crystal tea leduum (*Ledum palustre*), hemlock, May lily of the valley, poison- buttercup, corn poppy and others.

The group of extremely poisonous plants includes black henbane, belladonna, jimson weed, water hemlock, weed-elder, daphne and others.

Phytotoxines can be concentrated in whole plant or in specific organs. Thus, in seed-lobes of many Rosaceae there is amigdaline, which gives a taste of "bitter almond". The amigdaline degrades to prussic acid. The presence of prussic acid preserves young shoot of cherry, almond, prune, peach and apricot from eating by animals. The amigdaline also is in fruits of bird cherry tree, apple tree, cherry-laurel tree, rowan-tree and others.

The seasonal poison accumulation is due to different functioning of different plant organs during year cycle. In the storage underground organs, the maximum amount of poison maintains during winter rest, whereas in shoots the maximum is reached during flowering. Some plants have poisonous immature seed and fruits. However, the majority of fruits are toxic after maturation.

The same plants can be toxic for one species and harmless for other species. Thus, belladonna and jimson weed are very toxic for human being, but they are harmless for rodents, hens and other species. Nevertheless, they are toxic for chickens and ducks. The poisonous fruits of May lily of the valley are not toxic for foxes. The foxes eat them to escape helminthes.

The poisonous plants are common reason of animal and human poisoning. It particularly concerns children, who like to eat "beautiful" fruits, roots, bulbs and shoots. The form of such poisoning is overdosing of herb drugs. The inhalation of poisonous evaporations of several plants (crystal tea ledum) may also cause poisoning. The plants can cause skin irritation, in form of allergic reactions, while direct contact (nettle, spurge, spurge-flax, rue). Sometime poisoning can occur by eating honey contaminated by pollen of poisonous plants (crystal tea ledum, cherry-laurel tree, spurge-flax) or by eating milk and meat of animals, which have ate poisonous plants (buttercup, yew, poppy).

Purposes of class: 1. To know classification of poisonous fungi, of poisonous plants; characteristic of mycotoxines and phytotoxines; clinical symptoms of poisoning by poisonous fungi and plants. 2. To

be able to give characteristic of studied phytotoxines. 3. To be acquainted with prevention measures of poisoning by phytotoxines.

Questions:

1. Ability to produce poisons as universal event in nature.
2. Poisonous micromycetes and macromycetes. Mechanisms of their mycotoxines action on human organism. Clinical symptoms of poisoning by poisonous fungi. Prevention of poisoning.
3. Classification of poisonous plants. Poisonous organs of plants.
4. Main poisonous substances of plants and their mechanisms of action.
5. Poisonous plants. Mechanisms of their phytotoxines action on human organism. Clinical picture of poisoning by poisonous plants. Prevention of poisoning.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 317-330.

Laboratory work:

I. Study herbarium "Poisonous plants".

II. Study the following micropreparations (with drawing):

- "Aspergillus" (56x);
- "Penicillium" (56x).

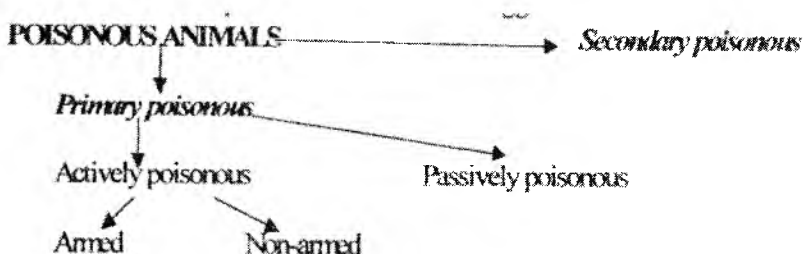
III. Fill in table on main plant poisonous substances characteristic.

№	Groups of toxic substances	Chemical structure	Mechanisms of action
1.	Alkaloids		
2.	Heart (steroid) glycosides - cardenolids; - bufadienolids		
3.	Saponines		
4.	Flavonoids		
5.	Tannins		
6.	Coumarins		
7.	Anthraquinones		
8.	Terpenoids		
9.	Lipids (fats, phospholipids, sterols, waxes) characterize oils		
10.	Organic acids		

CLASS №37. POISONOUS ANIMALS

There are about 5 thousands species of poisonous animals worldwide. They live in water and on the land, as well. They are more often in countries with tropical and subtropical climate. They are relatively poisonous. That means that poison play a specific role in interspecies relationships. It can be poisonous for one species and non-poisonous for another. The poisonous substances can be used to frighten away predators, to hide running away, to lure females.

Accordinary to having special devices for producing and injection of poison, the classification of poisonous animals was suggested.



Primary poisonous are animals who produce poison in special glands or having poisonous metabolites. The ability to have poison is specific sign of the species and occurs in all individuals of the species. The primary poisonous animals are dinoflagellates, cnidarians, some species of spiders, scorpions and others.

Actively poisonous animals have specific apparatus for poison. Armed animals have specific device to wound preys and to inject poison into its internal environment. It is most effective way to poison. Many poisonous cnidarians, mollusks, arthropods, fishes, reptilians are armed poisonous animals. Non-armed animals have no such device. They produce poison by skin (as amphibians do) or by anal glands (as some insects do). They poison preys when they touch their skin. The poison is absorbed from the skin, the effectively it acts.

Passively poisonous animals produce poisons and accumulate them in different organs and tissues, as mollusks, insects and aphibians from Caudata Order.

Secondary poisonous are such animals that can accumulate exogenous poisons. They may be toxic only when they are ate (some mollusks accumulating dinoflagellates poison; insects accumulating poison of poisonous plants).

Passively and secondary poisonous animals are dangerous only if they are feed. The main difference between them is that in passively poisonous animals, the poison preserves continuously throughout the life, whereas in secondary poisonous animals, it appears only sporadically.

It is still not clear, how poisons appeared in animals. It is believed that on early stages of evolution, the poisons are only metabolites, which were excreted into external environment or were accumulated in the body. Then, evolution directed development to appearance of special organs, which produce poison. At first, it was due to increasing of defense properties of ectoderm (cnidarians, amphibians). Then, it was due to development of endocrine and exocrine glands. Thus, Hymenoptera, poisonous apparatus is closely connected with reproductive system, whereas in mollusks and snakes, it is connected with digestive system. At the same time, many fishes preserve poison accumulation in many tissues and organs.

The animals' poisons are natural biologically active substances. They very selectively interact with biological structures. They called zootoxins. The science, which studies them, is called zootoxinology. It borders the following disciplines: molecular biology, zoology, physiology, pharmacology, pathology.

Zootoxinology is ancient science. The emblem of the medicine is cup winded round by snake. It was designed in ancient Greece. In ancient Greece, the healing god Aesculapius and health god Hygia were painted with snakes. The big contribution was made by Avicenna (980-1037), E.N. Pavlovsky (1884-1965), N.A. hologkovsky (1858-1921), F.F. Talysin (1903-1976), S.V. Pigulevsky (1899-1974) and others.

Zootoxins are very different chemically. They may include aliphatic and het-erocyclic compounds, alkaloids, steroids, non-enzymatic polypeptides, and enzymes. They are "genuine toxins", which not exist in recipient organism. Another group of toxins is substances, which exist in recipient organism. They are acetyl-choline, catecholamine, indol derivates, enzymes and their inhibitors.

The toxicity is most important characteristics of toxins. It is ability of chemical substance to induce tissue and organ damage. It may result in failure of main organism functions and death.

Accordingary to physiological effect, the zootoxins are divided into neurotoxins (affecting prevalently nervous system), cytotoxines (damaging tissue cells), hemorrhagines (affecting blood clotting), hemolysins (causing erythrocyte lysis).

There is correlation between chemical nature of poison and structure of poisonous apparatus. Thus, the majority of poisons are mixture of proteins and enzymes (poisons of cnidarians, spiders, scorpions, snakes). They are active only if they were injected parenterally, because they can be digested by digestive enzymes if were taken orally. Therefore, animals with such poisons have specific apparatus to pierce and wound their preys. From the other side, animals with poisons which are active if were taken orally, have no so particular apparatus.

Predators as usually have better poisonous apparatus (snakes, spiders, scorpions). It is due to their life pattern. In general, the poisons of predators are neurotoxins. They are needed to affect nervous system. This makes prey immobile. Animals without specific poisonous apparatus use poisons for defense (frogs, ants).

Poison, which entered the organism, is distributed in the body irregularly. It is due to various membranes (plasma membranes, capillaries walls) and different barriers (hematoencephalic, placental). The speed of membrane diffusion determines speed of poison action. Zootoxins affect organs and systems selectively, that means that they affect target-cells. Zootoxins action may have local and resorptive character.

The clinical picture of poisoning depends on several factors. First is poison chemical composition (prevalence of one component will determine clinical picture). Second is place of poisoning. The more close to CNS organism was bitted, the more toxic action toxin has. Third is season. After molting or winter sleeping, the poison of animals is more toxic. Fourth is psychological state of affected man. Patients with labile nervous system state express more severe picture of poisoning.

Purposes of class: 1. To know classification of poisonous animals; characteristic of zootoxins; clinical symptoms of poisoning by poisonous invertebrates animals and by poisonous vertebrates animals. 2. To be able give characteristic of studied zootoxins. 3. To be acquainted with prevention measures of poisoning by zootoxins.

Questions:

1. Zootoxinology as science: its purposes.
2. Poisons distribution among animals. Classification of poisonous animals.
3. Zootoxins, their physiological and pharmacological characteristics. Factors, that influence on clinical picture of poisoning by zootoxins.
4. Poisonous invertebrates (unicellular, cnidarians, mollusks, arthropods), their zootoxins, mechanisms of action. Prevention of poisoning.
5. Poisonous vertebrates (fishes, amphibians, reptiles), their zootoxins, mechanisms of action. Clinical symptoms of poisoning.
6. Rational using poisonous animals and wildlife protection.

Literature:

Bekish O.-Y.L. Medical biology. Textbook for students of higher educational establishments. Vitebsk: VSMU press, 2003, p. 330–340.

Laboratory work:

I. Study the following macropreparations in museum:

- “Medusa Aurelia”;
- “Karakurt”;
- “Tarantul”;
- “Scorpion”;
- “Scolopendra”;
- “Grey frog”;
- “Caucasian salamander”;
- “Sand efa”;
- “Gurza”;
- “Grass snake”.

II. Fill in table on poisonous snakes characteristic and their poisons characteristic:

Poisonous snakes	Poisonous apparatus	Main component of poison	Clinical signs of poisoning
Opistoglypha - Grass snakes			
Proteroglypha - Aspidae family - Marine snakes family			
Solenoglypha - Adders family - Lachesis family			



Учебное издание
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**ПРАКТИКУМ ПО МЕДИЦИНСКОЙ БИОЛОГИИ ДЛЯ
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Учебное пособие

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Подписано в печать 29.09.06. Формат 64×84, 1/16.
Бумага типографская № 2. Гарнитура Times New Roman. Усл. печ. л. 10,5.
Тираж 200 экз. Заказ № 1150

Издатель и полиграфическое исполнение УО «Витебский государственный
медицинский университет»
ЛИ № 02330/0133209 от 30.04.04.

Отпечатано на ризографе в Витебском государственном медицинском университете.
210602, Витебск, пр. Фрунзе. 27
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