Ministry of Health of Belarus Republic
Vitebsk State Medical University

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MEDICAL BIOLOGY AND GENERAL GENETICS

PRACTICAL BOOK

Рекомендовано учебно-методическим объединением по высшему медицинскому, фармацевтическому образованию в качестве учебно-методического пособия для студентов учреждений высшего образования, обучающихся по специальности 1-79 01 01 “Лечебное дело”

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In this practical book, the main divisions and aims of biology are described accordinary to life organization levels (molecular-genetic, cellular, ontogenetic, population-species, biospheral-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 contains the 33 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 the Republic of Belarus (2016). It is designed for students of higher medical educational establishments on a medical speciality.

Pictures 30.

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MOLECULAR-GENETIC LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS №1.
ESSENCE OF LIFE. MOLECULAR-GENETIC LEVEL OF LIVING SYSTEMS ORGANIZATION

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 following: 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, biospheral-biogeocenotic levels.

Life study begins with the study 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 tree 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.

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

1. Each DNA molecule consists of two long antiparallel polynucleotide chains, making double helix. The antiparallelity 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 are 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 trip let.

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. 3. To be acquainted with chair of medical biology and general genetics.

Questions:

1. Genetic material organization in viruses, prokaryotes and eukaryotes.

2. DNA structure. J. Watson, F. Crick laws. DNA replication, its types.

3. RNA structure. RNA types. RNA synthesis (primary transcript, processing, splicing).

4. Euchromatin and heterochromatin. DNA spacers, excessive genes, repeated sequences of nucleotides.

5. Genetic code, its characteristics.

6. Molecular organization of eukaryotic chromosomes. The structure of the nucleosome. The value of histone and non-histone proteins, metal ions.

7. Compact DNA structure in the chromosome. Levels of DNA folding:

nucleosome string, chromatin fibril, interphase chromonemm, metaphase chromosome. Euchromatin. Heterochromatin (facultative, constitutive).

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 5–19.

Tests to check level of knowledge

1. Properties of living things:

a) discretion and integrity, structural organization; b) growth and development, irritability and locomotion, heredity and variability; c) homeostasis.

2. Location of DNA in a cell:

a) nucleus; b) mitochondria, plastids; c) centriols.

3. Location of m-RNA in a cell:

a) ribosomes; b) nucleolus; c) cytoplasm matrix.

4. Location of t-RNA in a cell:

a) nucleus; b) nucleolus; c) cytoplasmic reticulum; d) cytoplasmic matrix.

5. Location of r-RNA in a cell:

a) nucleolus; b) ribosomes, c) cytoplasmic reticulum; d) cytoplasmic matrix.

6. Role of DNA in life activity of a cell:

a) the keeper of nuclear and cytoplasmic heredity; b) participation in reactions of matrix synthesis; c) participation in transcription.

7. Role of m-RNA in life activity of a cell:

a) participation in a transcription in a biosynthesis of protein; b) participation in translation in a biosynthesis of protein; c) transport of amino acids; d) formation of protein structure.

8. Role of t-RNA in life activity of a cell:

a) participation in transcription in a biosynthesis of proteins; b) participation in translation in a biosynthesis of proteins; c) transport of amino acids to ribosomes; d) participation in assembly of ribosomes.

9. Role of r-RNA in life activity of a cell:

a) participation in a transcription in a biosynthesis of proteins; b) participation in translation in a biosynthesis of proteins; c) participation in construction of a nucleolus; d) participation in construction of ribosomes.

10. Kinds of DNA replication:

a) conservative; b) semiconservative; c) dispersive; d) postreplicative.

11. What is the genetic code, codon, anticodon?

a) genetic code – triplet of DNA, codon " triplet of m-RNA, anticodon

“ triplet of t-RNA; b) genetic code “ triplet of DNA, codon “ triplet of r-RNA, anticodon “ triplet of t-RNA; c) genetic code “ triplet of m-RNA, codon “ triplet of DNA, anticodon “ triplet of t-RNA.

12. What shows the abundance of a genetic code?

a) one codon codes some amino acids; b) one amino acid is coded with some codons; c) nucleotide sequence is read out only in one direction.

13. Starting codon:

a) AUG; b) UAG; c) AGG; d) UAA.

14. Terminating codons:

a) AUG; b) UAG; c) UAA; d) UGA.

15. Structural components of a nucleosome:

a) non-histon proteins; b) histons H2a, H2b, H3, H4; c) histon H1; d) molecule of DNA.

16. Value of histons in an eucariotic chromosomes:

a) stabilize frame of chromosome; b) activate genes; c) are responsible for DNA replication.

17. Value of non-histon proteins of a eucariotic chromosome:

a) stabilize frame of a chromosome; b) activate genes; c) are responsible for DNA replication and repare; d) are responsible for a transcription.

18. Value of metals ions in a eukaryotic chromosome:

a) stabilize frame of a chromosome; b) activate genes; c) are responsible for DNA replication; d) control density of nucleosomes location in a chromatin fibrils.

19. Levels of DNA packaging in a chromosome:

a) fibril; b) chromonem; c) chromatid; d) nucleosome.

20. The characteristics of a heterochromatin:

a) non-informative and non-transcribed region of chromosome; b) rough decondensed region of chromosome; c) it happens facultative and constitutive.

Laboratory work:

I. Solve the problem 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 problem on the transcription.

№3. One of DNA strands with sequence of nucleotides ATTGCT-CAA 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. Study micropreparation:

“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 hetero-chromatin, light – to euchromatine (Fig. 1).

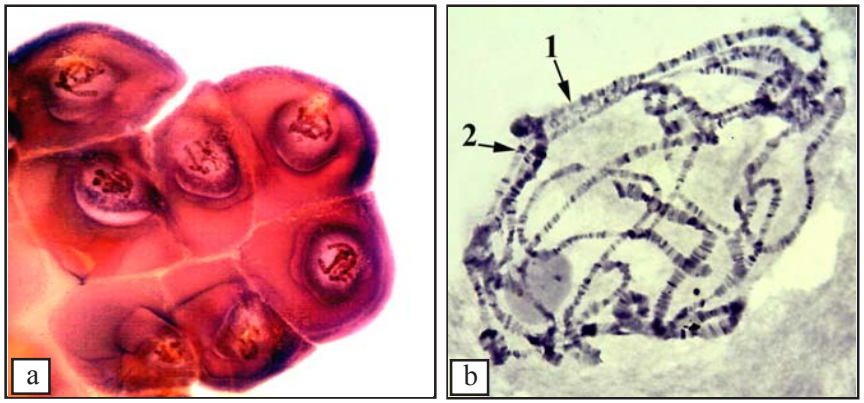


Fig. 1. “Polytenic chromosomes of insects salivary gland”:
1 - euchromatine and 2 - heterochromatin parts of the chromosome.

CELLULAR LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS 1 2.
CELL AS ELEMENTARY UNIT OF LIVING THINGS. METHODS OF CELL STUDY

The elementary structure of cellular level is a cell. The 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 bacteriaphages. 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.

The microscopic method allows studying the structure of the cell with a microscope (light, phase-contrast, luminescent, ultraviolet and electronic). With light microscopy, the object is viewed in the rays of visible light. For this purpose, microscopes are used (Fig. 2).

The histological method is based on the preparation of microscopic slides from native and fixed tissues and organs. The native material is frozen, and a fixed object goes through the stages of compaction, embedding in paraffin or celloidin. Then, sections are made from the material under study, stained and enclosed in Canadian balsam or other transparent media. The classic coloring for the slides is hematoxylin-eosin staining.

The histochemical method is used to determine organic and inorganic substances in cells. The basis of this method is to conduct a chemical reaction on the preparation for the detection of biochemical components of the cytoplasm. Histological and histochemical preparations can be quantitatively processed using morphometry and cytophotometry.

Phase-contrast microscopy is used to study living objects and unstained slides. ***The luminescence microscopy*** is used for study the chemical composition of a cell. The radiation of the ultraviolet region spectrum used with wavelength in 2 times smaller than the length of visible light (wavelength range from 200 nm to 400 nm) at ***ultraviolet microscopy.***

Electron microscopes have the highest resolution and magnification (1.000 times larger than a light microscope). They use electromagnetic

oscillations of a electrons stream with a very small wavelength. Electron microscopy is used for a detailed study of the structural components of the cell.

In addition to these, lyophilization, X-ray diffraction, autoradiography are used to study cells.

Light microscope structure.

Microscopy is a main method of cell study. 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.

Microscope consists of three parts: optical, mechanical and light (Fig. 2).

Optical part. In modern microscopes this part includes sets of magnifying lenses (objective lenses and ocular ones). Ocular lenses (lens system facing the object) usually can give magnification 7x, 10x, and 15x. Objective lenses (the lens system facing the object, it is located in a special device - the "revolver") can give magnification 8x, 40x, and 90x. General magnification of optical device is product of ocular magnification and objective one. For example, with an ocular 10x and an objective 8x, we will have a microscope magnification of 8 x 10 = 80 x.

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

The mirror is inserted into the arc holder, which is fixed with a central pin in the base, which allows the mirror to be turned in any direction towards the light source. Functions of the mirror are direction of light on the slide (object), optimization of an object lighting and lighting control. The mirror has two surfaces (flat and concave). The flat surface of the mirror is used in high light, and the concave - in low light. There is no mirror and in modern microscopes. The light source is an electric lamp built into the base. The light is immediately sent to the condenser. Its brightness is controlled by the lamp voltage knob.

The irise-diaphragm consists of a system of metal plates, which due to the movement of the lever can converge towards the center or diverge from the center. The irise-diaphragm is under the condenser. The function of the irise-diaphragm is the change in the width of the light.

The condenser is a system of lenses that concentrate light rays into a thin stream of parallel rays and direct them to the object of the slide. Its

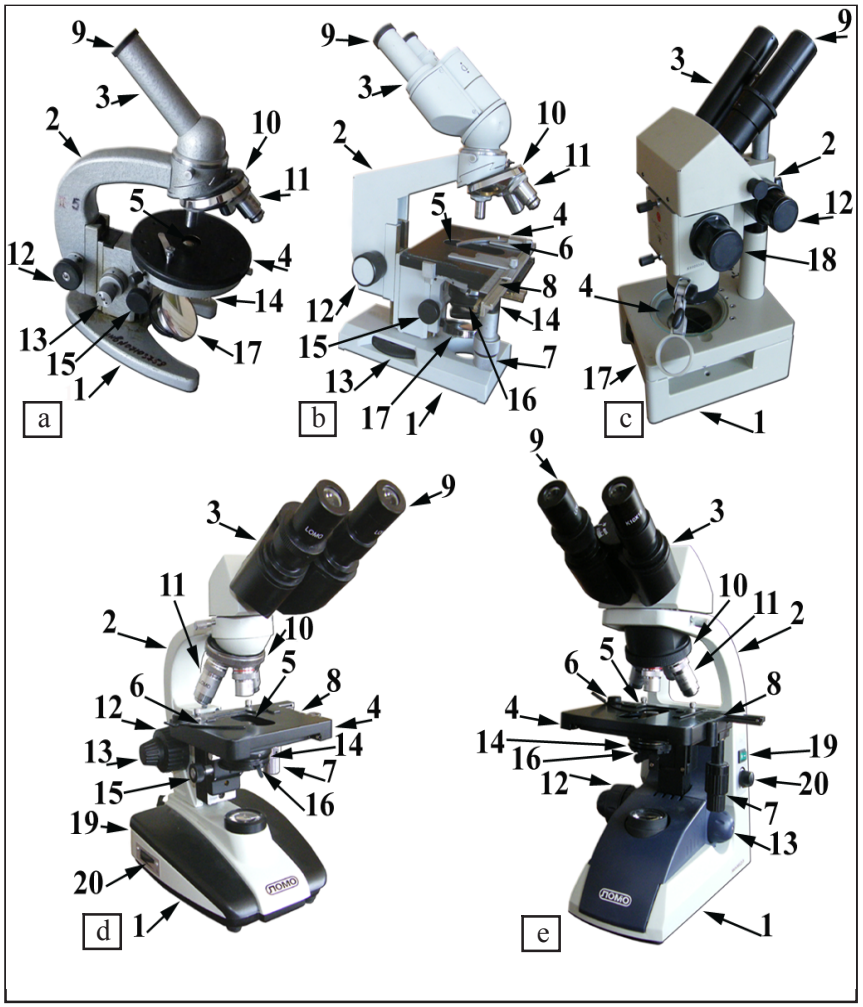


Fig. 2. Light microscopes:
a - microscope MBR - 1; b - microscope R-15; c - microscope MBS - 10; d - microscope Mikmed - 5 (var. 1); e - microscope Mikmed - 5 (var. 2). 1 - base; 2 - tube holder; 3 - tube; 4 - object table; 5 - hole of object table; 6 - terminals (clamps) of micropreparations; 7 - knobs moving the table; 8 - rulers for determining the coordinates (vernier) of the object on the micropreparation; 9 - eyepieces; 10 - revolver; 11 - objective lenses; 12 - macrometer knob; 13 - micrometer knob; 14 - condenser; 15 - condenser knob; 16 - irise-diaphragm; 17 - a mirror; 18 - lens change knob; 19 - lamp power button; 20 - dimmer lamp light.

moves a special knob up or down, which allows you to set the optimal coverage of the slide. The normal position of the condenser is the highest. The lighiting is regulated as well as by light filters in the microscope, which are inserted into a special folding frame, located under the condenser diaphragm. The opaque light filter is used at diffused lighting, blue - at bright light.

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. Sorting knobs are used to center the object on the slide and can be located on the sides of the stage or can be combined in one rod. The microscope base is rectangular or horseshoe shaped. There is a vertical and horizontal ruler on the surface of the base in modern microscopes, which allow determining the coordinates (nonius) of the object on the slide. The objective turret consists of two ball segments connected to each other by a central screw. The upper segment of the ball has one hole that is attached to the tube. The spring is attached to the outer surface of the upper segment in the center. In the lower segment of the ball there are 4 - 6 - 8 holes for screwing in objectives. The lower segment of the ball is rotated until you feel a click and a sense of support. This indicates that the optical axis of objectives and ocolars are the same.

Main characteristics of microscopy are magnification and resolution. The 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»).

The 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 м, while electron microscope can resolve to 0.0001 м.

Formula of light microscope resolution limit (d) calculation is: $d=0.61 \cdot л/NA$, where л – wavelength, NA – numerical aperture

Formula for numerical aperture calculation is: $NA=n \cdot \sin б$, where n – index of refraction, б – angle between optical axis of objective and most deviated light beam that still passes into objective lens. Resolving power equals 1/d.

When working with a light microscope, you should know the rules for working with small, large magnifications and immersion objective.

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 objectives 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!

When working with modern microscopes, the 6th paragraph of the rules is not fulfilled, since the light of the electric lamp is immediately directed to the object after turning it on.

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 the help of course 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 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).

The objective "90x" is used when working with very small and thin objects. The space between the objective and the slide is filled with special immersion oil. It has a refractive index approaching the refractive index of the glass. This leads to the fact that the light rays, without refraction and without changing the direction during the passage of various media, fall into the objective. The immersion objective requires careful handling, since its frontal lens has a short focal length and with rough work you can damage both the objective and the slide.

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. Features of the structure of prokaryotic and eukaryotic cells.
3. Methods for studying cells: histological, histochemical, microscopic (light, luminescent, ultraviolet, phase-contrast, electron microscopy).
4. Light microscope structure. Rules of work with microscope.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p 20.

Tests to check level of knowledge

1. Representatives of prokaryote:
a) viruses; b) bacteriophages; c) bacteria; d) blue-green algas.
2. Representatives of eukaryote:
a) bacteria, blue-green algas; b) plant; c) animal; d) funguses.
3. Construction of a prokaryote chromosome:
a) annular strand DNA; b) strand RNA; c) a nucleoprotein.
4. Construction of a eukaryote chromosome:
a) ring strand DNA; b) desoxyribonucleicprotein with ions of metals; c) DNA and RNA.
5. Quantity of the genes keeping in plasmids of a bacterial cell:
a) 1 - 2; b) 3 - 4; c) 8 - 10.
6. Why the cell is elementary biological unit?
a) a cell is the least structural unit which properties alive are characteristic; b) all living organisms will consist of cells; c) cells of metaphytes specialized on functions form tissues.

7. What are the properties testifying that the cell is an elementary structural unit?
a) body height and development; b) irritability and movement; c) structural organization; d) step-type behaviour and integrity.
8. What are the properties testifying that the cell is an elementary functional unit?
a) heredity and variation; b) body height and development, reproduction; c) irritability and locomotion; d) metabolism and energies; e) homeostasis.
9. What determines that the cell is an elementary genetical unit?
a) metabolism and energies; b) body height and development; c) heredity and variation; d) the cell contains the heredity information which is transferred from generation to generation at devision of cells.
10. The basic methods of studying of cells:
a) histological; b) histochemical; c) microscopical.
11. Opportunities of a histological method:
a) allows to determine the contents of inorganic matters in cells; b) allows to study a survey picture of tissue; c) allows to study structural ingredients of a cell in details.
12. Opportunities of a histochemical method:
a) allows to define the maintenance organic and inorganic matters in cells; b) allows to study structural ingredients of a cell in details; c) to carry out a microsurgery.
13. What microscopy is applied to inheritance of chemical compound of cells?
a) light; b) electron; c) luminescent.
14. What microscopy is used for detailed studying structural ingredients of cells?
a) electron microscopy; b) phase-contrast microscopy; c) luminescent microscopy.
15. What is part of mechanical part of a light microscope?
a) condenser; b) column and support of support; c) radiographic cone, the subject stage with screws and plugs, macro-and micrometer screws; d) the screw of a condenser and a revolver.
16. What is part of a light part of a light microscope?
a) plano-concave mirror, colour-filter; b) the screw of the condenser; c) the condenser; d) irise-diaphragm.
17. That is going in composition of optical part of a light microscope:
a) diaphragm; b) oculars; c) lenses; d) colour-filter.
18. By means of that the diffraction of light in a light microscope is eliminated?
a) irise-diaphragm; b) condenser; c) colour-filter.

19. By means of that it is possible to change illuminating intensity of field of vision in light microscope?

a) plano-concave mirror; b) condenser; c) irise-diaphragm.

20. What is the resolving power of a light microscope?

a) the minimal distance between two points of object which are visible separately; b) product of augmentations of an ocular and lens; c) the numerical aperture of lens.

Laboratory work

I. Study the following micropreparations:

– "Cells of onion epidermis" (56x).

Onion epidermis cells have various sizes, polygonal, with thin, tightly closed walls. The nucleus is well visible. The nucleus is surrounded by cytoplasm and lies in the middle section of the cell. There are vacuoles in the cytoplasm (Fig. 3a).

– "Frog blood" (280x).

Erythrocytes are the majority of blood smear cells. These are oval-shaped cells with an oval nucleus. Leukocytes are located next to erythrocytes. Lymphocytes are visible beside to leukocytes and erythrocytes. These are round cells with a rounded nucleus and blue cytoplasm. Platelets are visible between erythrocytes. These are small oval cells with an oval nucleus that are slightly larger than or equal to the size of an erythrocyte (Fig. 3b). When working with this slide to work out the rules of the object centering when change magnification from 56x to 280x.

– "Human blood" (630x).

Nuclear-free erythrocytes are the majority of cells. The erythrocyte has the shape of a biconcave disc. The erythrocyte cytoplasm is colored pale pink. Leukocytes are visible between erythrocytes. They have a rounded shape, contain a nucleus. Leukocytes are divided into granulocytes (neutrophilic, eosinophilic, basophilic) and agrunolocytes (lymphocytes, monocytes) in size and shape of the nucleus (Fig. 3c).

– "Nervous cells of horse eye retina" (280x);

Nerve cells of vertebrates have a process form. Several processes leave the body of the neuron (Fig. 3d). The cell has an irregular shape. The processes extend in different directions, they can bend in different planes.

– "Ciliary epithelium of clam mantle" (280x).

The monolayer epithelium consists of high cylindrical cells. The free surface of the cells is covered by cilia closely spaced to each other (Fig. 3e).

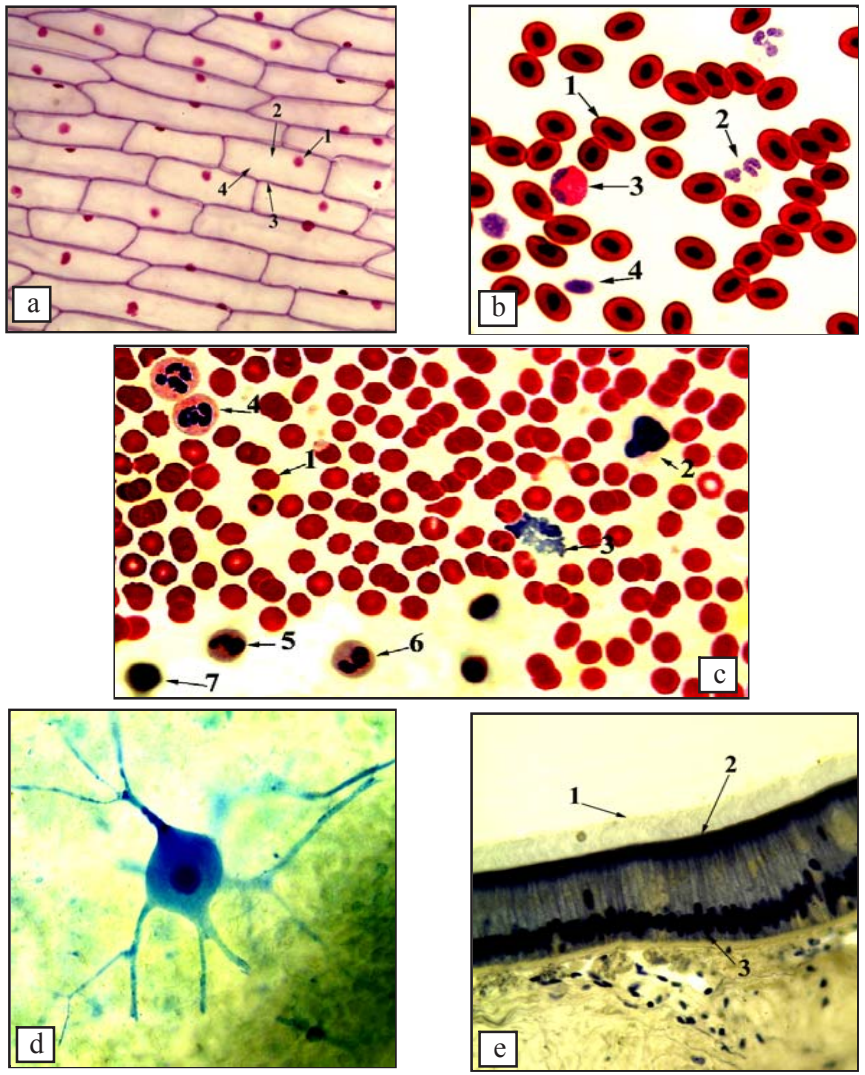


Fig. 3. Plant and animal cells:
a - cells of onion epidermis (1 - nucleus, 2 - cytoplasm, 3 - cell wall, 4 - vacuole); b - frog blood (1 - erythrocyte, 2 - neutrophilic segmented granulocyte, 3 - lymphocyte, 4 - platelet); c - human blood (1 - erythrocyte, 2 - basophil, 3 - platelet, 4 - neutrophil, 5, 6 - monocyte, 7 - lymphocyte); d - nervous cells of horse eye retina; e - ciliary epithelium of clam mantle (1 - cilia, 2 - basal membrane, 3 - nucleus).

CLASS [1] 3.
CELL BIOLOGY

All living 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 plasmalemm carry out the following functions: separation, defense, transportation, regulation of chemical balance inside of the cell. In the plasmolemm 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 plasmolemm are special proteins - aquaporins, which are transported water in cell and out cell.

The organodies 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 an 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, vilia, 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 karyolemm (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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 20–29.

Tests to check level of knowledge

1. Structural components of a cell:
a) cell wall, cytoplasmic matrix, nucleus; b) cell membrane, cytoplasm, nucleus; c) cell wall, cytoplasm, nucleus.
2. Cell organelles of a general purpose:
a) endoplasmic reticulum, ribosomes, Goldi complex; b) microfilaments, tonofibrils; c) centrioles, mitochondria, lysosomes; d) plastids.
3. Cell organelles of a special purpose:
a) myofibrils, neurofibrils; b) cilia, flagella; c) plastids.
4. The organelles of a cell which having membrane structure:
a) centrioles; b) endoplasmic reticulum; c) Golgi complex, lysosomes; d) mitochondria.
5. The organellas of a cell which having non-membrane structure:
a) centrioles; b) ribosome; c) microtubules, microfilaments; d) Golgi complex, lysosomes.
6. Role of endoplasmic reticulum in a cell:

a) synthesis of proteins; b) synthesis of lipids and carbohydrates; c) function of a compartmentalization; d) transport function.

7. Role of lysosomes in a cell:

a) synthesis of lipids; b) hydrolisis of nucleic acids, proteins, lipids, carbohydrates; c) intra-cellular digestion of destroyed components of cytoplasm; d) autolysis of a cell.

8. Role of mitochondria in a cell:

a) keepers of cytoplasmic heredity; b) power stations of a cell; c) takes part in formation of inclusions; d) proteolytic function.

9. Role of Golgi complex in a cell:

a) participates in uniform movement of chromosomes to cell poles; b) formation of lysosomes; c) formation of inclusions; d) excretory and secretory functions.

10. Role of centrioles in a cell:

a) formation of the mitotic spindle; b) formation of lysosomes; c) uniform distribution of chromosomes in a mitosis and a meiosis; d) excretory function.

11. Structural components of a nucleus:

a) cell membrane; b) karyolemm; c) karyoplasm; d) chromatin; e) nucleolus.

12. Types of chromosomes:

a) metacentric; b) submetacentric; c) acrocentric; d) telocentric; e) circular.

13. Rules of chromosomes:

a) rule of chromosome number constancy; b) rule of chromosome pairs; c) rule of chromosome continuity; d) rule of chromosome individuality.

14. Essence of chromosomes continuity rule:

a) triplets of DNA molecule are not overlapped; b) one amino acid is coded with some triplets; c) each chromosome is formed from maternal chromosome in result of cell division.

15. Essence of chromosomes individualitiy rule:

a) each species has specific set of chromosomes; b) each chromosome has the morphological features; c) each chromosome has characteristic gene set.

16. Role of telomeres in chromosomes:

a) participate in division of a cell; b) provide satiation of chromosomes; c) preserve a chromosome as discrete unit; d) interfere with bond of chromosomes or their fragments among themselves.

17. What group of a human karyotype is compounded with the largest metacentric chromosomes (specify numbers of chromosomes)?

a) B (II) - 4-5; b) C (III) - 6-12, X; c) A (I) - 1-3; d) D (IV) - 13-15.

18. What group of a human karyotype is compounded with large submetacentric chromosomes (specify numbers of chromosomes)?

a) B (II) - 4-5; b) C (III) - 6-12, X; c) A (I) - 1-3; d) D (IV) - 13-15.

19. What group of a human karyotype is compounded by middle metacentric and submetacentric chromosomes (specify numbers of chromosomes)?

a) B (II) - 4-5; b) D (IV) - 13-15; c) C (III) - 6-12; d) E (V) - 16-18.

20. Features of Denver classification of human chromosomes:

a) groups of chromosomes are denoted by the Roman digits; b) groups of chromosomes are denoted by capital letters of the Latin alphabet; c) groups of chromosomes are denoted by the Arabian digits.

Laboratory work:

I. Study the following micropreparations:

– "Golgi complex in nervous cells of cat spinal ganglion" (400x).

The black looped network of organoids is visible in cells around the nucleus. It consists of bent threads and cylinders. The nuclei are light, the nucleoli are gray yellow in color (Fig. 4a).

– "Mitochondria in rat intestinal epithelium cells" (400x).

Mitochondria have a round or longitudinal shape with a red-pink color (Fig. 4b).

– "Centrosomes in cloven Ascaris eggs" (400x).

Zygotes are visible at different stages of division. In cells at the stages of a zygote or two blastomeres in the metaphase stage of mitosis, a mitotic apparatus is visible. It consists of long threads running between centrioles and short ones extending from centrioles to chromosomes. Chromosomes are located at the equator of the cell (Fig. 4c).

– "Fat inclusions in axolotl liver cells" (400x).

In the cytoplasm of hepatocytes, black fat droplets with different sizes are localized (Fig. 4d).

– "Human karyotype" (900x).

Find metacentric, submetacentric and acrocentric chromosomes (Fig. 5).

CLASS 1 4.
CELL AS OPEN SELF-REGULATING SYSTEM

The 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

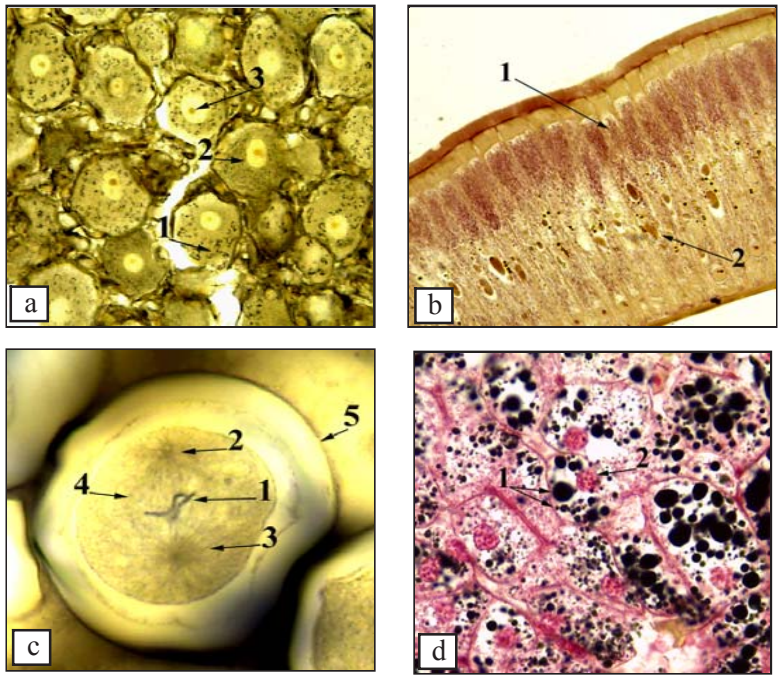


Fig. 4. Organelles and cell inclusions:
a - Golgi complex in nervous cells of cat spinal ganglion (1 - Golgi complex, 2 - nucleus, 3 - nucleolus); b - mitochondria in rat intestinal epithelium cells (1 - mitochondria, 2 - nucleus); c - centrosomes in cloven Ascaris eggs (1 - chromosomes, 2 - centrioles, 3 - radiant crown, 4 - spindle filaments, 5 - egg shell); d - fat inclusions in axolotl liver cells (1 - fat droplets, 2 - nucleus).

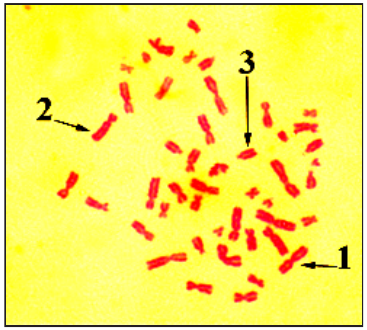


Fig. 5. Human karyotype:
1 - metacentric, 2 - submetacentric, 3 - acrocentric chromosomes.

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. The energy flow of organism is presented by cellular energy producing processes such as photosynthesis, chemosynthesis, fermentation and respiration.

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 not 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. Organization of energy flow in a cell during photosynthesis, fermentation and respiration processes.

3. Flow of internal and external informations in a cell.

4. Flow of substances in a cell during protein biosynthesis.

5. Membrane transport of substances in cell. Passive transport. Active transport. Endocytosis and exocytosis.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 29–35.

Tests to check level of knowledge

1. Kinds of systems in dependence of metabolism and energy:

a) open, closed, isolated, adiabatic; b) open, isolated, adiabatic; c) open and closed.

2. Features of open systems:

a) there is a metabolism and energy exchange; b) there is an exchange of the information, there is no exchange of energy; c) there are metabolism and energy exchange, except thermal are present.

3. Features of adiabatic systems:

a) there is no substance exchange but there is energy one in any form; b) there is no exchange of substance, there is an exchange of energy, except for thermal; c) any exchange is possible.

4. Features of isolated systems:

a) there is neither metabolism and no energy; b) there are metabolism and energy exchange; c) there is no exchange of substance, there is an exchange of energy, except for thermal.

5. Features of closed systems:

a) there is no substance exchange but there is energy one in any form; b) there is no exchange of substance, there is an exchange of energy, except for thermal; c) any exchange is possible.

6. Kinds of active transport of substance through a cell membrane:

a) pino and phagocytosis; b) by proteins-vectors according to gradient of concentration; c) by proteins-vectors against a gradient of concentration; d) like proton and ionic pumps.

7. Kinds of passive transport of substanced across a cell membrane:

a) diffusion; b) by proteins-vectors according to on a gradient of concentration; c) by proteins-vectors against a gradient of concentration; d) across membrane pores.

8. Action of an isotonic solution on erythrocytes of a human blood:

a) changes in erythrocytes does not occur; b) erythrocytes swell; c) erythrocytes shrink.

9. Action of a hypertonic salt solution on erythrocytes of a human blood:

a) changes in erythrocytes does not occur; b) erythrocytes swell; c) erythrocytes shrink.

10. Action of an ideal hypotonic salt solution on erythrocytes of a human blood:

a) changes in erythrocytes does not occur; b) erythrocytes swell; c) erythrocytes shrink.

11. Phases of a phagocytosis:

a) positive chemotaxis macromolecules to a cell membrane; b) adsorption of a macromolecule on a cell membrane; c) entering of macromolecule in a cell, its digestion and undigested particles removing.

12. Kinds of the endocellular mechanism of energy flow of organisms:

a) sun energy; b) photosynthesis, chemosynthesis; c) fermentation, respiration.

13. Features of power supply at fermentation:

a) products of a dissimilation are destroyed not completely; b) the dissimilation leads to organic substances with high-energy; c) output of energy is small.

14. Features of power supply at respiration:

a) low-molecular products of a dissimilation are destroyed to final products; b) the big output of energy; c) products of a dissimilation are destroyed incompletely.

15. Features of external information flow for a cell:

a) it is carried out by means of a brain cortex of a hindbrain and endocrine; b) it is accepted from intersticial fluid by means of cytolemma glands receptors; c) nuclear and cytoplasm DNA takes part.

16. Features of an intracellular information flow:

a) it is coded in nuclear and cytoplasm DNA; b) enzymes, activated amino acids m-RNA, t-RNA takes part; c) proteins-vectors take part; d) the continuity of species characters from generation to generation is provided.

17. Kinds of a plasassimilation describing a flow of a substance:

a) glycolysis; b) photosynthesis; c) chemosynthesis; d) biosynthesis of proteins, fats and carbohydrates.

18. Measure of flow substance:

a) period semirenovation; b) amount of ATP; c) bites; d) time for which a half of certain substance is replaced with new molecules.

19. The processes in light part of photosynthesis:

a) synthesis of organic substance from inorganic; b) photolysis of water; c) producting of free oxygen; d) substances energy accumulation in ATP and NADP-H_2.

20. The processes in dark part of photosynthesis:

a) photolysis of water; b) use of ATP and NADP-H_2 energy; c) synthesis of organic substances from inorganic.

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 adding a drop of sodium chloride isotonic solution (0.9%). Examine specimen at large magnification (280x) and draw its image in the table. Notice that there are no any changes in erythrocytes.

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 adding a drop of sodium chloride hypotonic solution (0.2%). 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 adding a drop of distilled water. 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 adding a drop of sodium chloride hypertonic solution (2%). 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:

– "Accumulation of stain by rat subcutaneous fat tissue histiocytes" (630x).

– "Accumulation of stain by rat renal convoluted tubules cells" (630x).

CLASS [1] 5.
CELL PHYSIOLOGY

The ability to self-reproduce is one of the main biological properties of the cell as an elementary life system. The cell reproduction provides organism growth, development and regeneration. The time between cell formation by mother cell division and it 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 it 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 it 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 citotomy) and by type (generative, reactive, degenerative).

The mitosis 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 (leptonemm, zygonemm, pahynemm, diplonemm, 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. Regulators of the cell cycle (cyclins and cyclin-depends kinases).
7. Cell death (necrosis, apoptosis).

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 35–43.

Tests to check level of knowledge

1. Life cycle of a cell:

a) period since the end of division of initial cell till the end of formed cell division; b) period between cell formation by mother cell division till the end of its own division or death; c) time between cell divisions.

2. Periods of an interphase:

a) presynthetic, synthetic, postsynthetic; b) postmitotic, premitotic; c) synthetic, postsynthetic.

3. The cytogenetic characteristic of a nucleus in G1 - period of an interphase:

a) 2n: 2chr: 4c DNA; b) 2n: 1chr: 2c DNA; c) n: 1chr: 2c DNA.

4. The cytogenetic characteristic of a nucleus in S - period of an interphase:

a) 2n: 2 chr: 4c DNA; b) 2n: 1 chr: 2c DNA; c) n: 2 chr: 2c DNA.

5. The cytogenetic characteristic of a nucleus in G2 - period of an interphase:

a) 2n: 2chr: 4c DNA; b) 2n: 1chr: 2c DNA; c) n: 2chr: 2c DNA.

6. Basic types of a cell division:

a) amitosis; b) mitosis; c) meiosis.

7. Kinds of mitosis:

a) mitosis, meiosis; b) endomitosis, polyteny; c) amitosis.

8. Types of amitosis by shape:

a) generative, degenerative, reactive; b) equal, non-equal, multiple, c) without cytotomy.

9. Kinds of amitosis by type:

a) generative, degenerative, reactive; b) equal, non- equal, multiple, without cytotomy; c) endomitosis, polyteny.

10. What is transported to cell poles in an anaphase of a mitosis?

a) chromosomes; b) chromatids.

11. The cytogenetic characteristic of a cell nucleus in a telophase of a mitosis:

a) 2n: 2chr: 4c DNA; b) 2n: 1chr: 2c DNA; c) n: 2chr: 2c DNA.

12. The biological value of a mitosis:

a) equal distribution of a genetical stuff; b) daughter cells are completely same; c) haploid cells are formed from somatic diploid cells.

13. Stages of a meiosis:

a) meiosis I - interkinesis - meiosis II; b) meiosis I - interphase - meiosis II - death or insemination; c) interphase - meiosis I - interkinesis - meiosis II - death or insemination.

14. Stages of meiosis I prophase:

a) leptonemm, zygonemm, diplonemm, diakinesis, pahynemm; b) zygonemm, pahynemm, leptonemm, diplonemm, diakinesis; c) leptonemm, zygonemm, pahynemm, diplonemm, diakinesis.

15. The basic processes descending to chromosomes in a prophase of meiosis I:

a) spiralization; b) conjugation and a crossin-gover; c) despiralization.

16. The cytogenetic characteristics of a nucleus of the cell which have entered meiosis I:

a) 2n: 1chr: 2c DNA; b) 2n: 2chr: 4c DNA; c) n: 2chr: 2c DNA.

17. What is moved to cell poles in an anaphase of meiosis I?

a) chromosomes; b) chromatids.

18. The cytogenetic characteristic of a nucleus of the cell which have entered meiosis II:

a) 2n: 1chr: 2c DNA; b) 2n: 2chr: 4c DNA; c) n: 2chr: 2c DNA.

19. What is moved to cell poles in an anaphase of meiosis II?

a) chromosomes; b) chromatids.

20. The cytogenetic characteristic of the cells formed after a meiosis II:

a) n: 2chr: 2c DNA; b) n: 1chr: 1c DNA; c) 2n: 1chr: 2c DNA.

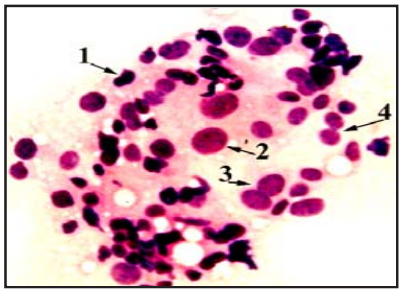


Fig. 6. Amitosis in mice urinary bladder epithelium cells:
1 – division of nucleus; 2 - stage of a dual-nucleus cell; 3 - cytotomy; 4 - stage of two daughter cells.

Fig. 7. Mitosis in onion root cells:
1 - interphase; 2 - prophase; 3 - metaphase; 4 - anaphase; 5 - telophase.

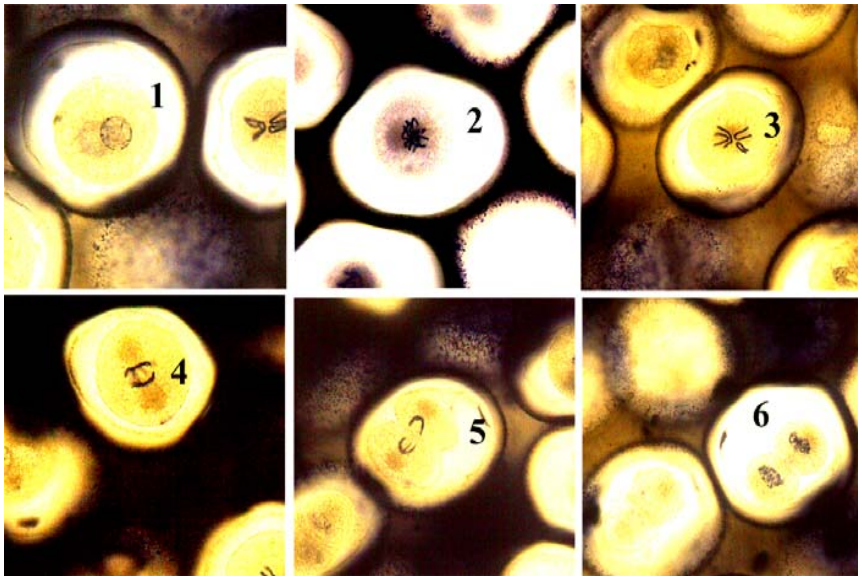


Fig. 8. Mitosis in the eggs of horse roundworm:
1 - interphase; 2 - prophase; 3 - metaphase; 4 - anaphase; 5 - early telophase; 6 - late telophase.

Laboratory work:

I. Study the following micropreparations:

– "Amitosis in mice urinary bladder epithelium cells" (280x).

Cells at different stages of amitosis are visible on micropreparation (Fig. 6).

– "Mitosis in onion root cells" (280x).

There are no centrioles in onion root cells, therefore only chromosomes are visible in them. Cells are at different stages of mitosis (Fig. 7).

– "Mitosis in the eggs of horse roundworm" (280x).

Eggs with shells are visible on the cross section of the uterus roundworm. Inside the egg, cells are located at different stages of mitosis (Fig. 8).

ONTOGENETIC LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS [1] 6. 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, bodys 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 start from genetic sex determination by chromosomes set. The genetic sex determines gonad (or genuine) sex, identificated by main sign of sex - histological structure of sexual gland. It is genuine because it is allows to determine gamete sex, i.d. 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 organisms 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 intersticial cell. If individual has genotype X^{tfm} X^{tfm}, the ovarium will be formed from primary gonad cortex. If individual has genotype X^{tfm} $Y^{h\text{-}Y}$, 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 follicules 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 defferens, seminal vesicles.

After 12th week of development in case of having satisfactory concentration of testosterone, there is musculinisation 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 ovarial 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. Morphological and functional features of mature human gametes.
6. Particularities of human fertilization, influence of season rhythms and social factors on this process.
7. Hermaphroditism (true and false). Disorders of a sexual self – consciousness. Transsexualism. Transvestism.
8. Modern genesial strategy: artificial insemination, in vitro fertilization, embryo placement into an uterus, "substitutive motherhood".
9. Ethic and legal aspects of intervention in human reproduction.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 44–60.

Tests to check level of knowledge

1. Kinds of sex dimorphism at human:

a) chromosomal, gonadal, hormonal; b) genetical, gonadal, gametic; c) hormonal, morphological; d) civil, behavioural.

2. Value of gene Tfm (testicular feminization) of X-chromosome:

a) synthesis of proteins, which differentiate an ovary; b) synthesis of a protein-receptor for testosterone; c) synthesis of H-Y antigen; d) control of fermentative processes.

3. Value of gene H-Y of the Y-chromosome at human:

a) synthesis of a protein-receptor for testosterone; b) synthesis of H-Y antigen monitoring production of testosterone; c) synthesis of H-Y antigen stimulating a differentiation of gonads in spermaries.

4. Term and differentiation of an embryonic gonad at an embryo with genotype X^{tfm} X^{tfm}:

a) 6 weeks of pregnancy, a medulla of embryonic gonads; b) 6 weeks of pregnancy, a bast layer of embryonic gonads; c) 8-9 weeks of pregnancy, a bast layer of embryonic gonads.

5. Term and differentiation of an embryonic gonads at an embryo with a genotype $X^{tfm}Y^{H\text{-}Y}$:

a) 6 weeks of pregnancy, a medulla of embryonic gonads; b) 7-8 weeks of pregnancy, a medulla of embryonic gonads; c) 8-9 weeks of pregnancy, a bast layer of embryonic gonads.

6. The cells of testis producing a testosterone:

a) Leidig cells; b) Sertoli cells; c) spermatocytes I and II of the order; d) spermatozoon.

7. The cells of ovaries producing female sexual hormones:

a) cells of primary follicles; b) teka-cells; c) cells of a yellow body; d) oocytes I and II order.

8. The action of gonadotrophic hormones (FSH and LH) on function of testicals:

a) FSH - on body height and development sperms; b) FSH - production of testosterone; c) LH - on body height and development of sperms; d) LH - production of testosterone.

9. The action of gonadotrophic hormones (FSH and LH) on function of ovaries:

a) FSH - on body height of follicles and an ovulation; b) FSH - on body height of follicles; c) LH - a maturing of follicles and their ovulation; d) LH “ production of estrogens and progesterone.

10. Stages of an ovogenesis in an ovary at a new born girl:

a) 200-400 thousand ovogoniums, oocytes I and II of the order; b) 100-200 thousand ovogoniums, oocytes I and II of the order, ootids; c) 200-400 thousand ovogoniums, oocytes I of the order in a region of growth and a prophase of meiosis I of region of a maturing.

11. The canal of a pronephrous which generative organs of a female fetus are shaped, terms of a differentiation (week of pregnancy):

a) Volfs canal, 10-12 weeks of pregnancy - intrinsic generative organs, 12-20 weeks - outside generative organs; b) Muller canal, 10-12 weeks of pregnancy - intrinsic generative organs, 12-20 weeks - outside generative organs.

12. The canal of a pronephrous which generative organs at a man’s fetus, terms of a differentiation are shaped (week of pregnancy):

a) Volfs canal, 9-18 weeks of pregnancy; b) Volfs canal, 10-12 weeks of pregnancy - intrinsic generative organs, 12-20 weeks - outside generative organs.

13. In what cell the spermatozoa gets at human fertilization:

a) ovum; b) ootid; c) ovocyte I; d) ovocyte II.

14. Ways of penetration of a spermatozoon to a female gamete at human:

a) fermentative; b) through micropele; c) through accepting hillock; d) phagocytal.

15. In what flow of time of a gamete of human preserve ability to fertilization?

a) ootid - 24 hours; b) ootid - 48 hours; c) spermatozoon - till 4 day; d) spermatozoon - 24-48 hours.

16. Minimum quantity of spermatozoons in an ejaculate at which the fertilization is possible:

a) 50 million; b) 100 million; c) 150 million; d) 200 million.

17. Indications to artificial insemination of the woman:

a) azospermia of a husband; b) the small maintenance of spermatozoons in an ejaculate of a semen; c) hereditary disease by the husband; d) an amenorrhea.

18. Indications to an implantation in a uterus of the woman of the embryo cultivated in the tube:

a) high risk of a hereditary pathology; b) obstruction of uterine tubes of the woman; c) desynchronization of a maturing of ovum and ovulation; d) aging of an ovum.

19. Indications to use of substitutive motherhood:

a) hysterectomy of a woman; b) azospermia of a husband; c) underdevelopment of a uterus at the woman; d) desynchronization of a maturing of ovum and ovulation.

20. Ethical aspects of interference in a reproduction of the person:

a) ban of trade by gametes and embryos; b) use of a minimum quantity of ovums at artificial fertilization; c) ban of cultivation of embryos for the scientific purposes; d) commercialization of a substitutive motherhood.

Laboratory work:

I. Study the following micropreparations:

– "Cross section of mammal testis" (56x and 280x).

Spermatogonia are in the peripheral layer and contain small nuclei (Fig.9a). Spermatocytes I have larger and pale nuclei. Spermatocytes II are smaller. Sperm cells are located in the inner layer. In Fig. 9b shows Sertoli cells and Leydig cells.

– "Human sperms" (280x).

Examine the structure of the sperm, pay attention to its shape (Fig. 10).

– "Cross section of mammal ovary" (56x and 280x).

Primordial, maturing and mature follicles are visible on the ovary section at low magnification (Fig. 11a). The mature follicle (Graafov vesicle) contains an oocyte of the first order, surrounded by follicular cells (Fig. 11b). In the oocyte I order visible nucleus, cytoplasm with a small amount of yolk grains. There are theca-cells producing estrogens at the periphery of the Graaf vesicle.

CLASS [1] 7.
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. Genetic material organization in viruses, prokaryotes and eukaryotes.
2. DNA structure. J. Watson, F. Crick laws. DNA replication, its types.
3. RNA structure. RNA types. RNA synthesis (primary transcript, processing, splicing).

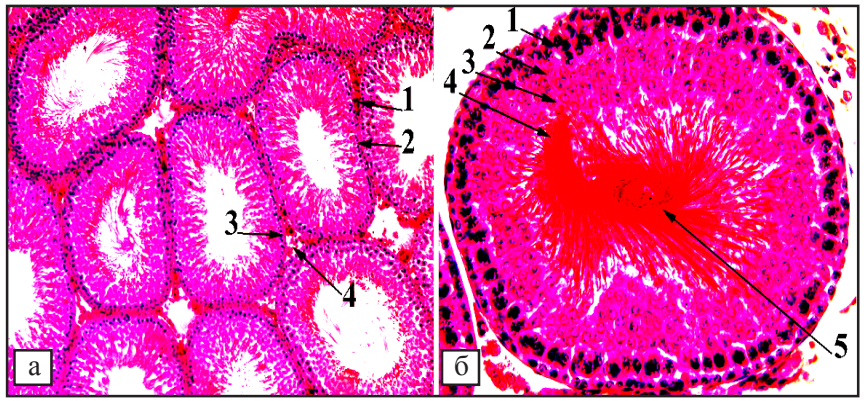


Fig. 9. Cross section of mammal testis:
a - convoluted seminiferous tubules at low magnification (1 - Leydig cells, 2 - Sertoli cells, 3 - sheath of convoluted seminiferous tubule, 4 - inter-canal connective tissue); b - convoluted seminiferous tubules at high magnification (1 - spermatogonia, 2 - spermatocyte I, 3 - spermatocyte II, 4 - spermatoid, 5 - spermatozoa).

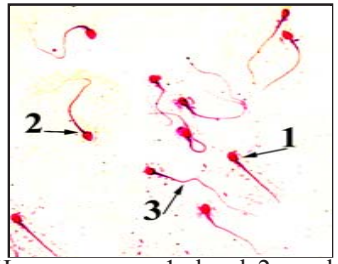


Fig. 10. Human sperms: 1 - head, 2 - neck, 3 tail.

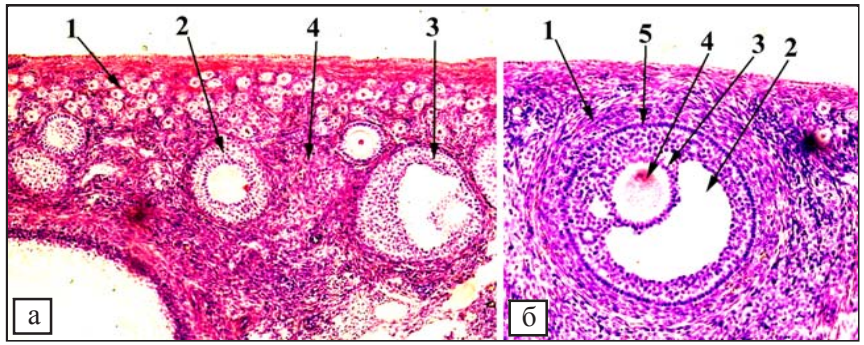


Fig. 11. Cross section of mammal ovary:
a - ovarian section at low magnification (1 - primordial follicle, 2 - mature follicle, 3 - mature follicle, 4 - ovarian stroma); b - Graafov vesicle (1 - wall of the follicle, 2 - cavity of the follicle, 3 - ovary tubercle, 4 - ovocyte I, 5 - theca-cells).

4. Euchromatin and heterochromatin. DNA spacers, excessive genes, repeated sequences of nucleotides.

5. Genetic code, its characteristics.

6. Molecular organization of eukaryotic chromosomes. The structure of the nucleosome. The value of histone and non-histone proteins, metal ions.

7. Compact DNA structure in the chromosome. Levels of DNA folding: nucleosome string, chromatin fibril, interphase chromonemm, metaphase chromosome. Euchromatin. Heterochromatin (facultative, constitutive).

8. Cytology as a science, its value to biology and medicine.

9. Features of the structure of prokaryotic and eukaryotic cells.

10. Methods for studying cells: histological, histochemical, microscopic (light, luminescent, ultraviolet, phase-contrast, electron microscopy).

11. Light microscope structure. Rules of work with microscope.

12. Structural parts of a cell.

13. Cell wall. Cytoplasmic membrane, particularities of its structure and functions.

14. Structure of cytoplasm:

– structural organization and properties of cytoplasm matrix;

– organelles, their morphological and functional characteristics;

– cytoplasmic inclusions, their classification and significance.

15. Structure of cell nucleus. Nuclear-cytoplasmic ratio as indicator of cell functional condition.

16. Morpho-functional characteristics of chromosomes. Types and rules of chromosomes.

17. Karyotype. Ideogram. Characteristics of human karyotype. Denver and Paris classifications of human chromosomes.

18. Cell as open system.

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

20. Flow of internal and external informations in a cell.

21. Flow of substances in a cell during protein biosynthesis.

22. Membrane transport of substances in cell. Passive transport. Active transport. Endocytosis and exocytosis.

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

24. Cell division, its forms and kinds.

25. 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.

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

27. Cell proliferation. Problem of cell proliferation in medicine.

28. Regulators of the cell cycle (cyclins and cyclin-depends kinases).

29. Cell death (necrosis, apoptosis).

30. Biological mechanisms of sex determination in a human. Sexual dimorphism: genetical, gonad, gametical, hormonal, morphological, civil and behavioural aspects.

31. Sexual traits differentiation during human individual development. Significance of the testicular feminization gene and of the gene which is responsible for HY- antigene synthesis.

32. Particularities of a human oogenesis, its hormonal regulation.

33. Features of a human spermatogenesis, its hormonal regulation.

34. Morphological and functional features of mature human gametes.

35. Particularities of human fertilization, influence of season rhythms and social factors on this process.

36. Hermaphroditism (true and false). Disorders of a sexual self – consciousness. Transsexualism. Transvestism.

37. Modern genesial strategy: artificial insemination, in vitro fertilization, embryo placement into an uterus, "substitutive motherhood".

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

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 5–60.

Laboratory work:

I. Solve the problems on transcription:

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

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

№7. 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.

№8. Part of DNA strand, which is used for m-RNA formation has following nucleotide sequence: AACAAACTTAGTTGTTA-

GAGTGACAGTT. Determine what free nucleotides will be used for m-RNA formation on this part of DNA molecule.

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

№10. 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:

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

№12. Fragment of human adrenocorticotropic 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.

№13. 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.

№14. 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:

№15. 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.

№16. 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.

№17. 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?

№18. 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 [1] 8.
GENETICS AS A SCIENCE ABOUT INHERITANCE AND VARIATION PRINCIPLES. GENE LEVEL OF HEREDITARY MATERIAL ORGANIZATION IN PRO- AND EUKARYOTES

The 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).

The heredity is an organisms 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.

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

The genetics studies heredity and diversity 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.

There are following levels of hereditary information organization in pro– and eukaryotes: gene, chromosome and genome.

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 has 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, diversity, 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. Tathum "one gene – one enzyme", its modern reading;
- genes classification (structural and acceptors);
- gene expression during protein byosynthesis (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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 60–75.

Tests to check level of knowledge

1. Features of a constitution of prokaryotes gene:

a) has a mosaic construction; b) has no mosaic construction; c) the operon contains some structural genes.

2. Features of prokaryote gene expression:

a) group repression of genome genes is possible; b) group repression of chromosome genes, genome and regulation of expression by steroid hormones are not possible; c) the genes monitoring one biochemical reaction locate in one place.

3. Features of eukaryote gene construction:

a) has no mosaic constitution; b) operon consists some structural genes; c) has a mosaic constitution, operon includes one structural gene.

4. Features of eukaryotes gene expression:

a) group repression of genes of chromosome and genome are possible; b) expression is regulated by steroid hormones; c) gene monitoring of one biochemical reaction is locate in different parts of genome.

5. The classification of genes:

a) structural; b) synthesis of RNA; c) regulator; d) modifiers.

6. The function of structural genes:

a) contain the information on synthesis t-RNA and r-RNA; b) increase or decrease the speed of biochemical reactions; c) contain the information on structure of protein-repressor; d) contains the information of polypeptide structure.

7. Regulatory genes are:

a) gene-operator; b) modifier; c) regulator gene; d) gene of synthesis RNA.

8. The function of a gene-regulator:

a) increase or decrease the speed of biochemical reactions; b) contains the information on synthesis t-RNA, r-RNA; c) contains the information of enzyme structure; d) contains the information on frame of protein-repressor.

9. The function of modifiers genes:

a) find necessary m-RNA-polymerase; b) passes or quenches transit of the RNA - polymerase to structural genes; c) increase or decrease the speed of biochemical reactions; d) suppress transcription.

10. The function of the gene-operator:

a) contains the information on structure of protein-repressor; b) passes

or quenches transit m-RNA-polymerase to structural genes; c) finds necessary m-RNA-polymerase; d) cap-proteins binding.

11. Polypeptide chains and genic locuses of haemoglobin A:

a) chains 2б, 2y, locuses бA, y2A; b) chains 2б, 2г, locuses бA, гF; c) chains 2б, 2в, locuses бA, вA.

12. Polypeptide chains and genic locuses of haemoglobin A2:

a) chains 2б, 2в, locuses бA, вA; b) chains 2б, 2y, locuses бA, y2A; c) chains 2б, 2г, locuses бA, гF.

13. Polypeptide chains and genic locuses of haemoglobin F:

a) chains 2б, 2г, locuses бA , гF; b) chains 2б , 2в , locuses бA, вA ; c) chains 2б, 2y, locuses бA, y2A.

14. Induction and repression of the gene locuses coding synthesis of haemoglobin after birth of the child:

a) repression of locus гF, expression вA ; b) repression of locus гF , expression yA2; c) repression of locus вA, expression гF.

15. The basic methods of getting of genetic materials used in gene engineering:

a) synthesis of genes in vitro; b) getting of genes from cells and genic frames and their rearrangement or breeding; c) transmission of new genes to genome of other organism; d) construction of cellular chimaera.

16. Stages of designing used in gene engineering:

a) transformation and transduction; b) reception of genetic material; c) introducing of genetically material; d) including of new genes in the cell genetically apparatus and fastening in him.

17. Methods of reception of genetically material:

a) use of a genome of donor cells; b) use a vector; c) artificial synthesis of genes.

18. Methods of inserting of genetic material:

a) transformation, transduction, conjugation; b) hybridization of somatic cells; c) use of cell - donors genome.

19. Methods of incorporation of new genes in the genetically apparatus of a cell:

a) transformation, transduction; b) use of a vector; c) use of cells-donors.

20. Ethical aspects at carrying out of researches on human DNA:

a) researches on recombination DNA of human should be known a commission of experts on gene engineering; b) researches on cloning DNA of human, getting of chimaers and hybrids from a genetically material of human and animals are forbidden; c) transplantation of genes with the therapeutic purpose is allowable only with somatic cells; d) germ cells are used only after proofs of advantage and safety of manipulations with somatic cells; e) are preserved and the genetically data of any human are not

disclosed.

Laboratory work:

I. Solve the problems on molecular genetics.

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

№20. Fanconi syndrome patient (bone tissue formation disorder) 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.

№21. 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.

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

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

№24. Initial part of insulin B chain is presented by 10 amino acids: 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.

№25. It is known that distance between two neighboring nucleotides in coiled DNA molecule measured along coil axis equals 0.34 nm. What lengths 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.

ÑLASS 1 9.
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.

The 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 aiso by a chromosome balance, so called “sex index”. Balance sex theory was suggested by K. Bridgess and R. Goldshtein in 1911. They set 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 Turner syndrome, the ovarium, 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 Kleinfelter syndrome (XXY:44A) have unexpressed secondary sex sings, gynecomasty, and failed spemiatogenesis.

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 l.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 billons nucleotide pairs, which is enough to make more than 2 millions structural genes. Conversely, different assessments of the human genome have from 50.000 to 100.000 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:
- 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;
- 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.
4. Cell genetic apparatus.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 75–84.

Tests to check level of knowledge

1. Chromosomal sex determination when female is homogametic:
a) P: XX x XY; b) P: ZW x ZZ; c) P: XX x XO.
2. Chromosomal sex determination when female is heterogametic:
a) P: XX x XO; b) P: ZW x ZZ; c) P: ZO x ZZ.
3. Influence on human sex formation of change of autosomes and sex chromosome ratio at caryotype XO : 44A (Turner syndrome):
a) underdevelopment of uterus, uterine tubes, ovaries; b) disorders of secondary sexual attributes formation; c) disorders of ovogenesis and menstrual cycle, sterility; d) gynecomastia.
4. Influence on human sex formation of change of autosomes and sex chromosome ratio at caryotype XXX: 44A (additional X-chromosome in woman):
a) underdevelopment of uterus, ovaries; b) disorders of a menstrual cycle; c) disorders of secondary sexual attributes formation.
5. Influence on human sex formation of change of autosomes and sex chromosome ratio at caryotype XXY: 44A (Kleinefelter syndrome):
a) disorders of secondary sex attributes formation; b) underdevelopment of generative organs; c) sclerotic disorders in semeniferous tubules.
6. What is the sex-linked inheritance?
a) the gene which is responsible for an attribute is located in X-chromosome; b) the gene which is responsible for an attribute is located in autosome; c) the gene which is responsible for an attribute is located in Y-chromosome.
7. What is the complete sex-linked inheritance?
a) the gene which is responsible for attribute is located in heterologous locus of a X-chromosome; b) the gene which is responsible for an attribute, is located in heterologous locus of an Y-chromosome; c) the gene which is responsible for attribute, is located in homologous loci of both sex chromosome.
8. What is the partial sex-linked inheritance?
a) the gene which is responsible for attribute is located in nonhomologous locus of X-chromosome; b) the gene which is responsible for attribute is located in homologous loci of X and Y-chromosomes; c) the gene which is responsible for an attribute is located in heterologous locus of an Y-chromosome.
9. What is holandric attributes?
a) the gene which is responsible for attribute, is located in heterologous locus of an Y-chromosome; b) the gene which is responsible for attribute is located in heterologous locus of X-chromosome; c) the genes which are responsible for an attribute are located in homologous loci X and Y-chromosomes.
10. The illnesses with completely sex-linked inheritance:
a) hemophilia C; b) hemophilia A and B; c) daltonism, Dushene muscular dystrophia; d) hemorrhagic diathesis.
11. The illnesses with partially sex-linked illnesses inheritance:
a) Duschene muscular dystrophy; b) pigment retinitis, pigmentosum xeroderma; c) hemorrhage diathesis, total color-blindness; d) syndactylia.
12. Holandric attributes of a human:
a) syndactylia; b) hypertrichosis of ear; c) total color-blindness; d) the exessive keratinization of a skin (ichtiosis).
13. Complete linkage of genes:
a) genes are located in different chromosomes and are free combined with each other; b) genes are located in same chromosome and are inherited together; c) genes are located in same chromosome; the part of them is inherited together, and the part is combined by a crossing-over.
14. Incomplete linkage of genes:
a) genes are located in same chromosome; the part of them is inherited together, and the part is combined by a crossing-over; b) genes are located in one chromosome and are inherited together; c) genes are located in different chromosomes and are free combined with each other.
15. Statements of T. Morgan's rule:
a) the genes posed in same chromosome are inherited together; b) genes in a chromosome occupy a specific locus; c) between homologous chromosomes the exchange of allelic genes is possible; d) linkage degree between genes depends on distance between them.
16. What kind of genes linkage is characteristic in a human?
a) for men - complete linkage, for women - incomplete one; b) for women - complete linkage, for men - incomplete one; c) both for men and women - complete linkage; d) both for men and women - incomplete linkage.

17. Groups of genes linkage in human autosomes:

a) genes of ABO blood groups and of nails and patella defects; b) genes of a Lutheran blood group and genes which are responsible for A and B antigens secretion with saliva: c) genes of polydactylia and eye cataract; d) loci A, B, C, D/Dr of HLA system; e) genes of a daltonism and of Dushene muscular dystrophia.

18. X-linked groups of genes in a human:

a) daltonism and hemophilia; b) hemophilia and Dushene muscular dystrophia; c) Dushene muscular dystrophia and daltonism; d) daltonism and syndactylia.

19. Concept about the cytologic map of chromosomes:

a) the map shows a relative position of genes on a conditional line; b) the map shows a true position of genes in a real chromosome; c) the map shows a true position of genes on a conditional line.

20. Concept about the gene map of chromosomes:

a) the map shows a relative position of genes on a conditional line; b) the map shows a true position of genes in a real chromosome; c) the map shows a relative position of genes in a real chromosome.

Laboratory work.

I. Solve the problems on sex-linked inheritance:

№27. 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?

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

№29. In a human recessive gene causing one form of color blindness (daltonism) is located in X-chromosome. The girl having normal vision (her farther suffered from color blindness) marries the normal man (his farther 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:

№30. 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?

№31. In a human in the same autosome both dominat 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:

№32. In the X-chromosome of a human the recessive gene **h** of hemophylia 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 hemophylia. She marries the healthy man. What sons may be born in result of noncrossing-over and crossing-over gametes development?

№33. In a human hemophylia 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 hemophylia. What is genotype of the mother?

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

№34. 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:

№35. 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. 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.

№36. 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 [1] 10.
PRINCIPLES OF MONOGENIC AND POLYGENIC INHERITANCE. PHENOTYPE FORMATION AS RESULT OF GENETIC AND ENVIRONMENTAL FACTORS INTERACTION

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

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

Genetic factors affecting phenotype formation are following: interactions of genes from one allele (dominance, recessing, incomplete dominance, codominance, superdominance); interactions of genes from different alleles (dominant and recessive epistasis, hypostasis, complementarity); multiple 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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 84–94.

Tests to check level of knowledge

1. Types of inheritance:

a) autosomal; b) sex-linked; c) monogenic; d) polygenic.

2. Kinds of monogenic inheritance:

a) independent; b) autosomal; c) sex-linked; d) linked.

3. Kinds of autosomal inheritance:

a) independent; b) sex-linked; c) linked; d) Y- linked.

4. Kinds of independent inheritance:

a) dominant; b) recessive; c) complete; d) incomplete.

5. Kinds of linked inheritance:

a) dominant; b) recessive; c) complete; d) incomplete.

6. Kinds of sex-linked inheritance:

a) X-linked dominant and recessive; b) Y- linked; c) complete; d) incomplete.

7. Essence of hybridologic analysis:

a) necessary to cross the individuals that distinguished from each other on one, to two or several pairs of alternative attributes; b) necessary to carry out analyzing cross; c) necessary to conduct the exact quantitative count of investigated attributes in a lineage; d) necessary to conduct individual qualitative analysis of inheritance of characters in a lineage.

8. Cause and effect of a hypothesis of "purity of gametes":

a) the cause - meiosis I, consequence - genes in gametes of hybrid individuals not hybrid, and are clean; b) the cause - allelic genes are in identical homologous loci, but different chromosomes, consequence - owing

to meiosis I they get in different gametes; c) the cause - in meiosis I homologous chromosomes miss in different gametes, consequence " not blending of gametes.

9. In what events analyzing cross is carried out?

a) for definition of genotype of an individual with dominant character; b) for definition of a genotype of an individual with a recessive character; c) for definition of gametes types at an individual with dominant an attribute.

10. Phenotypical radical for digeterozygote crosses:

a) (3 : 1)n; b) 9 AB: 3aB: 3Ав: 1ав; c) 9A_B_: 3aaB_: 3A_вв: 1aавв.

11. Conditions of exhibiting of G.Mendel laws:

a) similar formation of gametes of all kinds by hybrids and similar combinations at a fertilization; b) similar vitality of zygotes of all genotypes; c) complete exhibiting of sign irrespective of conditions of organism development; d) presence of account genes in homologous chromosomes at di- and polyhybrid cross.

12. Genetic factors influencing formation of phenotype:

a) dose and field of gene action; b) expressivity and penetrance of gene; c) interaction gene from one and different alleles, multiple alleles; d) pleiotropic gene action.

13. Kinds of a gene interaction from one allele:

a) complete dominance, incomplete dominance, superdominance; b) dominant epistasis; c) complementarity; d) recession; e) codominance.

14. Kinds of a gene interaction from different alleles:

a) codominance; b) dominant and recessive epistasis; c) hypostasis; d) recession; e) complementarity.

15. Essence of an incomplete dominance:

a) recessive gene suppresses the action of dominant gene; b) the dominant gene not completely suppresses the action of recessive gene and shows a mediate sign; c) two genes from one allele determine a new sign.

16. Essence of a superdominance:

a) recessive and dominant genes determine a new sign; b) the sing of dominant gene in heterozygous is more strongly, than in homozygous; c) one dominant gene suppresses action of other dominant gene.

17. Essence of a codominance:

a) two dominant genes from one allele define a signs; b) two dominant genes from different alleles define a new sign; c) the recessive gene from one allele decrease the action of dominant gene from other allele.

18. Essence of a dominant epistasis:

a) dominant gene suppresses action of recessive gene; b) dominant gene from one allele suppresses action of dominant gene from other allele;

c) dominant gene from one allele suppresses action of a recessive gene in homozygous from other allele.

19. Essence of a recessive epistasis:

a) recessive gene from one allele suppresses a recessive gene from other allele; b) recessive gene from one allele suppresses a dominant gene from other allele; c) recessive gene from one allele suppresses action of a dominant gene from other allele.

20. Essence of a complementarity:

a) two dominant genes from one allele determine a new sign; b) the recessive gene from one allele is suppressed by dominant gene from other allele; c) genes from different alleles determine a new attribute.

Laboratory work:

I. Solve the problems on monohybrid cross.

№37. 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?

№38. 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.

№39. 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 sings and in case if she is heterozygous?

№40. 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 posessing normal sight, the brown-eyed child suffering from myopia was born. Whether is it possible to determine genotypes of

the parents?

№41. 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 posess 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.

№42. Myoplegia is inherited as dominant trait. Determine probability of children with this anomaliy birth in the family where father is heterozygous and mother does not suffer myoplegia.

№43. 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.

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

IV. Solve the problems on incomplete dominance.

№45. 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.

№46. The rare gene a causes hereditary anophtalmia 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.

№47. In a human 0(I) blood group is determined by recessive gene I °, 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.

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

№49. Sickle cell anemia is inherited as not completly 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.

№50. The gout is determined by dominant autosomal gene. Its penetrance in men is 20 % and in 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.

№51. 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 [1] 11
PHENOTYPIC AND GENOTYPIC DIVERSITY

The diversity is the ability of organism to change their traits, getting new ones or loosing old ones in process of individual development. The reason of diversity 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 types of diversity: phenotypic and genotypic. The

phenotypic diversity can be ontogenetic and modificational. The genotypic (hereditary) diversity can be combinative and mutational.

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

The modificational diversity describes the individual's changes caused by environmental factors. Examples of modificational diversity are skin pigmentation of ultraviolet light, weight varying due to diet imbalance, effects of low vitamin intake.

The ontogenetic diversity 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 diversity 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, loosing of skin elastics in aging, the increased rate of bone fractures in elderly and over.

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

The combinative diversity 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 diversity has three main mechanisms: crossing-over in prophase of meiosis; independent divergence of chromosome in anaphase of meiosis I; independent fertilization by some sperm and ovum. The combinative diversity is inherited according to Mendel's Laws.

The mutational diversity is variation with rapid, strong changes of trait. 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 is: according mutated cells - generative, somatic; according genotype change - gene or point mutations, chromosome aberrations (deletions, deficiency, duplications, inversions), interchromosome translocations, genome mutations (polyploidy and aneuploidy), cytoplasmic

mutations; according adaptive significance - useful, harmful (lethal and semilethal), neutral; according reason of mutation - spontaneous, induced.

Purposes of class: 1. To know characteristics of ontogenetic and modificational diversity. 2. To be acquainted with role of development, training and education in humans' traits manifestation. 3. 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 diversity. 3. To be acquainted with genetic matherial repair types and with role of repair disorders in hereditary diseases development.

Questions:

1. Diversity, its types and kinds.
2. Ontogenetic diversity, its mechanisms. Role of ontogenetic diversity in human hereditary diseases manifestation.
4. Modificational diversity, their characteristics. Reaction norm.
5. Combinative diversity, its value to genetic variety.
6. Mutations and mutational theory. Classification of mutations.
7. Characteristics of generative and somatic mutations.
8. Gene mutations, chromosome ones, interchromosome ones, genome ones and cytoplasmic ones.
9. Characterization of mutations according to their adaptive significance.
10. Spontaneous mutations, mechanisms of their formation.
11. Induced mutations. Physical, chemical and biological mutagens, mechanisms of their action.
12. Genetic material repair. Photoreactivation. Excision repair. Postreplicative repair.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 94–102.

Tests to check level of knowledge

1. Types of diversity:
a) combinative; b) phenotypic; c) genotypic.
2. Kinds of phenotypic diversity:
a) modificational; b) mutational; c) ontogenetic.
3. Kinds of genotypic diversity:

a) ontogenetic; b) combinative; c) mutational.

4. Basic mechanisms of originating of ontogenetic diversity:

a) different activity of genes in the different age periods; b) different activity of endocrine glands in the different age periods; c) different ratio of growth and differentiation periods in the different age periods.

5. The role of ontogenetic diversity:

a) it provides adaptively of organisms; b) it plays role in hereditary illnesses manifestation; c) it has no definitive pattern.

6. Examples of hereditary illnesses and the malformations originating in embryogenesis:

a) polydactylia, syndactylia; b) cerebellar ataxia; c) diabetes mellitus; d) cranial - clavicular dysostosis.

7. Examples of the hereditary illnesses manifesting in childhood:

a) syndactylia; b) Friedreich's family ataxia; c) gout; d) alcaptonuria.

8. Examples of the hereditary illnesses that manifest thenselve only in adult people:

a) cerebellar ataxia; b) alcaptonyria; c) gout; d) galactosemia.

9. Characteristics of modifications:

a) they are not inherited; b) they are specific and adaptive characters; c) the degree of manifestation depends on force and duration of an external factor action, after modifications disappearance they can disappear; d) they are not definitive and they are useful to organism.

10. Mechanisms of originating combinative diversity:

a) combination of genes at crossingover and fertilization; b) independent movement of chromosomes in meiosis I at gametogenesis; c) independent movement of chromatids in a meiosis II at a gametogenesis.

11. Biological value of combinative diversity:

a) increases of reproduction coefficient; b) genetically material is updated; c) adaptive opportunities of a organism is increase; d) provided the variety of forms of one species.

12. Definition of inbreeding:

a) marriage between relatives; b) marriage between brother and sister; c) marriage between unrelated humans.

13. Closest inbreeding is a marriage:

a) between uncle and niece, between aunt and nephew; b) between unrelated people; c) between parents and kids, between brother and sister.

14. Consequences of inbreeding:

a) separation of a population into separate pure lines; b) translocation of pathological recessive genes in a homozygous state; c) exhibiting of inheritable disease, decrease of vitality, death of individuals.

15. Definition of an outbreeding is a marriage:

a) between relatives; b) between brother and sister; c) between unrelated people which during 4-6 generations do not have common relatives.

16. Consequences of outbreeding:

a) preserves a heterozygosis at offsprings; b) offsprings has regenerating of a genetic material that increases adaptive opportunities of an organism; c) separation of a population into separate pure lines; d) provides variety of forms.

17. Characteristics of mutations:

a) has indefinite character, has no adaptive value with rare exception; b) have specific and adaptive character; c) the degree of expressed not depend on force and duration of action of the factor, do not disappear after the cessation of its action; d) are inherited.

18. Positions of mutation theory G. de Frieze:

a) mutations has indefinite character; b) mutations appear suddenly; new forms are stable; c) the same mutations may appear repeatedly; d) mutations are qualitative changes, but not quantitative, can be useful and harmful.

19. Kinds of mutations on mutating cells:

a) spontaneous; b) somatic; c) genome; d) generative.

20. The characteristic of somatic mutations:

a) descend in somatic cells; b) are transferred generation during sexual reproduction; c) are transferred generation during asexual reproduction; d) the early mutates in embryogenic cells causes the phenotypic mutation on the most part of the body.

Laboratory work:

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

№52. 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?

№53. 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.

№54. 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.

№55. 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:

№56. 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 AATACATTTAAAGTC?

№57. 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, tymin has been inserted between 13-th and 14-th nucleotides and adenine has been added in the end of DNA molecule strain?

№58. 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.

ÑLASS 1 12.
METHODS OF ANTHROPOGENETICS: PEDIGREE ANALYSIS, TWIN'S AND STATISTICAL (FIRST LESSON)

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 pedigree method 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 method 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.

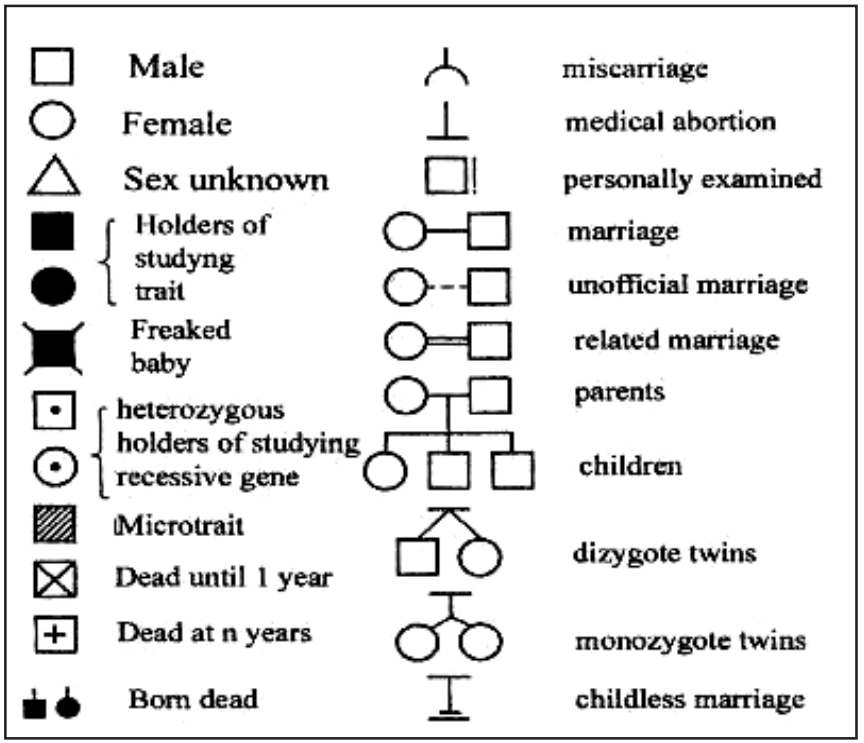


Fig. 12. The genetic symbols for pedigree (by G.Ust, 1931 with changes).

To make pedigree specific signs are used (Fig. 12). They firstly were suggested by G. Ust in 1931.

The pedigree analyzed 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.

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 (Fig. 13). 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.

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

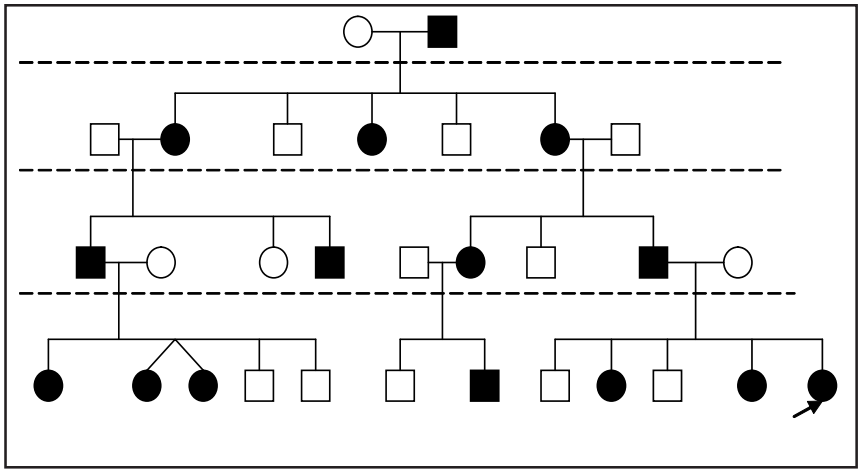


Fig. 13. Pedigree of family with specific form of rachitis (X-chromosome linked dominant pattern).

Purposes of class: 1. To know essence and value of pedigree analysis, twin's, population statistic methods of human genetics. 2. To be able to construct and analyze a pedigree, 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.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 103–105, 107–109.

Tests to check level of knowledge

1. Difficulties connected to studying of human genetics:

a) impossibility to carry out test cross; b) the large set of chromosomes and the big number of genes; c) slow replacement of generations, small number of offspring; d) late maturation and long pregnancy; e) different social conditions of the people.

2. The potency of a pedigree analysis of anthropogenetics:

a) determination of disease character; b) determination of type and variant of inheritance; c) revealing of a heterozygous carriage of a pathological gene; d) in some cases determination of probability of a birth of the child with an hereditary pathology.

3. Characteristics of an autosomal - dominant type of inheritance:

a) the attribute is traced across; b) the attribute is traced across and verticals; c) men and women to the same extent are sick; d) that the child is sick, one of parents should be sick; e) the gene expresses in homo- and heterozygous states.

4. Characteristics of an autosomal - recessive type of inheritance:

a) the attribute is traced across; b) the gene expresses in a homozygous state, the probability of a birth of sick children raises at an inbreeding; c) men are sick, women are carriers of a pathological gene; d) men and women to the same extent are sick; e) the probability of a birth of sick children in healthy heterozygous parents is 25 %.

5. Characteristics of recessive X-linked type inheritance:

a) the attribute is traced across; b) men are sick, women are carriers of a pathological gene; c) the pathological gene is inherited from mother to the son, from father to the daughter; d) men and women to the same extent are sick; e) in case if father is healthy and mother is carrier of pathological gene, a half of sons will be sick and a half of daughters - carriers of a pathological gene.

6. Characteristics of dominant X-linked type of inheritance:

a) the attribute is traced across and verticals; b) men and women to the same extent are sick; c) men are sick and women are heterozygous carriers of a pathological gene; d) the gene expresses in hemizygous state; e) that the child is sick, one of parents should be sick.

7. Opportunities of a twin's method of anthropogenetics:

a) specification of the list of hereditary diseases; b) determination of a role of hereditary factors and environment in illness exhibiting; c) carrying out of well-timed prophylaxis of illness of one of twins at disease manifestation in the second of ones.

8. Opportunities of a population-statistical method of anthropogenetics:

a) determination of heterozygotes number in a population; b) the decision of a question of medical, medicamental and diagnostic maintenance in the population; c) revealing of drift of genes in a population.

Laboratory work:

I. Solve the problems on pedigree construction and analysis.

№ 59. 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.

№60. Construct family pedigree concerning schizophrenia. Proband is a 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.

№61. 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 is a 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.

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

Proband is a 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 brachidactilia (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.

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

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

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

H= (CMZ - CDZ/100 - CDZ)x100 E= 100-H

CLASS [1] 13.
METHODS OF ANTHROPOGENETICS: CYTOGENETIC, BIOCHEMICAL, MOLECULAR-GENETIC, PRENATAL DIAGNOSIS (SECOND LESSON)

The cytogenetic method is a human karyotype analyse in normal and pathological conditions. 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. 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 phytohemaglutinin. In metaphase, spindle proteins are destroyed by colhicin. After that, chromosomes are available for observation for long time.

In 1969 T. Casperson discovered the method of different chromosome staining. It made possible to distinguish chromosomes accordinary their segments staining. The aneuploidity, 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).

The sex chromatin (Barr's body) is condensated 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 acetoorsein. Normally, Barr's bodies are determined in 20-40% of female cells and in 1-3% of male cells. The 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).

It is possible to determine Y-chromatin in somatic cells, in particular in buccal epithelium. 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.

Purposes of class: 1. To know essence and value of cytogenetic, biochemical, molecular-genetic, prenatal diagnosis 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.
4. The biochemical method as mode of metabolism hereditary disoders diagnosis.
5. The molecular - genetic method.
6. The value of anthropogenetics for medicine.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 106–107, 109–112.

Tests to check level of knowledge

1. Opportunities of a cytogenetic method:

a) allows to establish hereditary diseases linked to change of chromosomes number and structure, a translocation; b) to define phylum and variant of inheritance; c) to define hereditary diseases of a metabolism.

2. What cytological and genetic methods lie in the basic of cytogenetic method?

a) cytological - a differential staining, genetic - a karyotyping; b) cytological - histochemical, genetic - cloning; c) cytological - a method of tissues culture, genetic - a karyotyping.

3. Syndrome, caused by a trisomy on 13-th chromosome:

a) syndrome; b) Edward's syndrome; c) Down syndrome; d) Pattaw's syndrome; e) Kleinefelter's syndrome.

4. Syndrome, caused by a trisomy on 18-th chromosome:

a) Kleinefelter's syndrome; b) Down syndrome; c) Edward's syndrome; d) Turner's syndrome; e) Pattaw,s syndrome.

5. Syndrome caused by a monosomy on X-chromosome:

a) Pattaw's syndrome; b) Kleinefelter's syndrome; c) Turner's syndrome; d) Edward's syndrome; e) Down syndrome.

6. Syndrome of additional X-chromosome:

a) Kleinefelter's syndrome; b) Pattaw's syndrome; c) Edward's syndrome; d) Turner's syndrome; e) Down syndrome.

7. Opportunities of the express-method for sex chromatin definition:

a) finding hereditary diseases linked to change of structure of sex chromosomes; b) finding hereditary diseases linked to change of sex chromosomes number; c) sex determination at a hermaphroditism and transsexualism; e) sex determination at judicial examination.

8. Quantity of X-chromatin - positive nucleus in buccal epithelium in norm:

a) at female - 50-60 %, at male - 0 %; b) at female - 60-70 %, at male - 1-2 %; c) at female - 20-40 %, at male - 1-3 %.

9. X-chromatin with high frequency meets:

a) at person of a male; b) at person of a female; c) at Edward's syndrome; d) at Kleinefelter's syndrome; e) at Pattaw's syndrome.

10. The X-chromatin is absent:

a) at person of a female; b) at person of a male; c) at Pattaw's syndrome; d) at Turner's syndrome; e) at Kleinefelter's syndrome.

11. For definition of a X-chromatin research used:

a) epidermis of a skin; b) buccal epithelium; c) level of sexual hormones; d) erythrocytes; e) leucocytes.

12. Opportunities of a biochemical method:

a) finding hereditary diseases of a metabolism; b) finding chromosomal hereditary diseases; c) allows to define phylum and variant of inheritance.

13. What levels of exhibiting of gene action and how hereditary diseases of a metabolism are diagnostic?

a) on molecular - structure and quantity of initial materia; b) on cellular - defective enzymes; c) on ontogenetic - intermediate products of metabolism; d) on histological - antigens.

14. The method of diagnostics of fermentopathy:

a) cytogenetic; b) ontogenetic; c) immunological; d) biochemical; e) genetics of somatic cells.

15. Diagnostics of phenylketonuria at newborn:

a) indicator paper moistened of 3 % solution $FeCl_3$; b) Gatri test; c) addition of 5 % solution Acidic hydrochloric in urine; d) definition of methionine maintenance.

16. Indications to prenatal diagnostics:

a) presence of inheritable disease in family; b) a heterozygosis of both

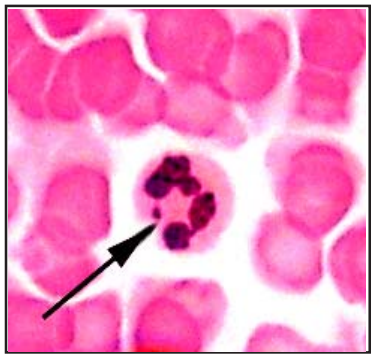


Fig. 14. Sex chromatin in leukocytes.

parents at autosomal-recessive diseases; c) a heterozygous state at mother at X-linked inheritance; d) the age of mother is more than 35 years.

17. The optimal time of carrying out chorionopexia at prenatal diagnostics:

a) 6-7 week of pregnancy; b) 12-13 week of pregnancy; c) 13-14 week of pregnancy; d) 14-16 week of pregnancy.

18. The optimal time of carrying out amniocentesis at prenatal diagnostics:

a) 6-7 week of pregnancy; b) 12-13 week of pregnancy; c) 14-16 week of pregnancy; d) 18-20 week of pregnancy.

19. Opportunities of a molecular-genetic method:

a) finding hereditary diseases of a metabolism; b) definition of changes of structure and function of nucleic acids; c) abjection of genes and injection them in a cell.

20. Method used for mapping of chromosomes of a human:

a) cytogenetic; b) ontogenetic; c) immunological; d) biochemical; e) hybridizations of somatic cells.

Laboratory work:

I. Study the following micropreparations:

– "X-chromatin in leukocytes" (400x) (Fig. 14);

II. X-chromatin determination in nuclei of buccal epithelium by acetoorsein method.

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. Examine 100 nuclei and point out the number of nuclei with one or more bodies of X-chromatin. Normal frequency of X-chromatin in cell nuclei of females is from 20 to 50 per 100 nuclei (20%-50%). Normal frequency of X-chromatin in 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 [1] 14.
HUMAN HEREDITARY DISEASES

More than 3.000 prevalently hereditary diseases have been registered. In the world more than 1.5 millions children are born with hereditary diseases

HEREDITARY DISEASES

The diseases of metabolic exchange	The chromosome diseases	The cytoplasmic diseases
1. Amino acid metabolism		
2. Lipid metabolism		1 Some miopathies
3. Carbohydrate metabolism	1. Related with changing in number and structure of sex chromosomes	2 Anencephaly
4. Steroid metabolism	2. Related with changing in number and structure of autochromosomes	3 Skeleton defects (Albrights osteitis, Spina bifida etc.)
5. Purine metabolism		
6. Blood coagulation system		
7. Hemoglobinopathy		
8. Mineral exchange		

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.

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 aminoacid 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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 106–107, 109–112.

Tests to check level of knowledge

1. Mechanisms of development of gene diseases of a metabolism:
a) mutation of a gene; b) breaking of synthesis or change of enzyme activity; c) action of collecting intermediate products of metabolism.
2. Examples of hereditary diseases of aminoacidic breaking exchange:
a) galactosemia; b) resistant of vitamin D rachitis; c) phenylketonuria; d) alkaptonuria; e) albinism.
3. Causes of phenylketonuria development:
a) deficiency of an enzyme oxidase a homogentistic acid; b) deficiency of an phenylalanindehydrxylase enzyme; c) accumulation in a blood phenylpirovinici acids.
4. Biochemical diagnostics phenylketonuria at neonatal:
a) indicator paper moistened of 3 % solution $FeCl_3$; b) Gatri test.
5. Causes of development alkaptonuria:

a) deficiency or absence of an enzyme oxydase a homogentistic acid; b) absence of an enzyme of a tyrosinase; c) absence of metabolism a homogentistic acid up to end products of disintegration.

6. Examples of hereditary diseases of carbohydrate metabolism:

a) insulindepend diabetes; b) insulinindepend diabetes; c) gout; d) galactosemia, glycogenoses; e) pentosuria.

7. Signs of an adrenogenital syndrom at girls:

a) premature puberty; b) pseudohermaphroditism; c) nanism.

8. Symptoms of adrenogenital syndrome at boy:

a) pseudohermaphroditism; b) premature virilization; c) breaking water and electrolitic exchanges; d) hypertonia; e) nanism.

9. Examples of hereditary disease of breaking of purine and pyrimidine exchanges:

a) disease of Nyman-Pick; b) gout; c) achondroplasia; d) Duchenne muscular dystrophia.

10. Examples of hereditary disease of an exchange of metals:

a) hepatolenticulatis involution; b) Konovalov-Wilson disease; c) hemochromatoses; d) angiohemophilia.

11. Characteristics of Konovalov-Wilson disease:

a) selective accumulation of copper in cells of a liver, nephroses, a nervous tissue, a cornea of an eye; b) increased abjection of copper with urine; c) drop of the contents of copper in a blood; d) breaking of kill in nephroses of amino acids, glucoses, phosphates.

12. Characteristics of hemochromatosis:

a) selective accumulation Ferri lactas in cells of a liver, hemadens, a cardiac muscle; b) the increased contents Ferri lactas in a blood; c) drop of Ferri lactas contents in a blood; d) development of a cirrhosis of the liver, increased xanthopathy.

13. Examples of the hereditary diseases linked to breaking of blood coagulation:

a) talasemia; b) Willebrand disease; c) hemophilia A and B; d) sphingolipidoses; e) hemoglobinopathy S.

14. The basic etiological factor of hemophilia A:

a) defect of the factor IX; b) defect of the factor VIII (antihemophilic globulin); c) defect of the factor of integrity of blood vessels walls.

15. The basic etiological factor of hemophilia B:

a) defect of the factor VIII (antihemophilic globulin); b) defect of the factor VII (proconvertin); c) defect of the factor IX (Kristmas factor).

16. The basic etiological factor of Willebrand disease:

a) defect of the factor VIII (antihemophilic globulin); b) defect of the factor VII; c) defect of the factor IX (Kristmas factor).

17. Examples of hereditary diseases of a lipid exchange:

a) Goshe disease; b) Nyman-Pick disease; c) hyperlipidemia; d) glycogenoses; e) Tay-Sach disease.

18. Examples of inheritable hemoglobinopathies:

a) haemoglobin S anemia; b) talasemia; c) fructosuria; d) hemoglobinopathy D; e) Kyli disease.

19. The mechanism of development of the hereditary diseases caused by change of chromosome number:

a) destruction telomere on the ends of chromosomes; b) breaking of a crossing-over in a gametogenesis; c) breaking of apostatis of chromosomes in a meiosis at a gametogenesis.

20. Examples of autosomal heteroploid diseases of a human:

a) Blume's syndrome; b) Edward's syndrome; c) Pattaw's syndrome; d) Marphan's syndrome; e) Down syndrome.

Laboratory work:

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

№64. Phenylketonuria and one of rare forms of Swiss type agammoglobulinemia (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.

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

№66. One of agammoglobulinemia 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.

№67. 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.

№68. Familiar 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 aterosclerosis 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 desease in the family where one of parents has high level of cholesterol, xantoms and aterosclerosis but another one is normal by analyzed sign.

III. Solve the problem on carbohydrate metabolism disorders.

№69. 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.

№70. 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.

№71. 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 helthy 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 [1] 15. 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, diversity, 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. Tathum "one gene – one enzyme", its modern reading;

– genes classification (structural and acceptors);

– gene expression during protein byosynthesis (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;

– primary and secondary pleiotropy, genocopies.

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

19. Diversity, its types and kinds.

20. Ontogenetic diversity, its mechanisms.

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

22. Modificational diversity, their characteristics. Reaction norm.

23. Combinative diversity, its value to genetic variety.

24. Mutations and mutational theory. Classification of mutations.

25. Characteristics of generative and somatic mutations.

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

27. Characterization of mutations according to their adaptive significance.

28. Spontaneous mutations, mechanisms of their formation.

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

30. Genetic material repair. Photoreactivation. Excision repair. Postreplicative repair.

31. Human as specific object of genetic analysis.

32. 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.

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

34. The method of sex chromatin determination.

35. The methods of hereditary diseases prenatal diagnosis: amniocentesis, chorionic villus sampling.

36. The biochemical method as mode of metabolism hereditary disoders diagnosis.

37. The molecular - genetic method.

38. The value of anthropogenetics for medicine.

39. Human hereditary diseases classification.

40. 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).

41. Human chromosomal diseases:

– autosomal abnormalities;

– sex chromosome abnormalities.

44. Human mitochondrial diseases.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 60–121.

CLASS [1] 16.
EMBRYONIC DEVELOPMENT, MECHANISM OF ITS REGULATION

The ontogenesis or individual development is a process of organism development from it's origination to death.

The individual development is encoded in the genotype. 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 develops in the stages egg – nymphs – imago or adult organism. The juvenile stages are called nymphs. 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 are 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.

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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 121–136.

Tests to check level of knowledge

1. Types and kinds of an ontogenesis:

a) indirect (with a complete and incomplete metamorphosis); b) nonlarval (with a complete metamorphosis); c) direct (nonlarval and intrauterine); d) larval (without metamorphosis).

2. Characteristics of indirect development:

a) low rate of yolk; b) after exit from egg covers specie passes through some stages of development and has some provisional organs; c) high rate of yolk.

3. Characteristics of direct development:

a) character for telo- and isolecithal eggs; b) after exit from egg covers specie do not passes through some stages of development and has no provisional organs; c) after exit from egg covers specie differ from parents and has smaller sizes and undevelopment organs systems.

4. Types and kinds of cleavage:

a) holoblastic (symmetrical and asymmetrical); b) meroblastic (asymmetrical and discoidal); c) holoblastic (superficial and discoidal); d)

meroblastic (superficial and discoidal).

5. Type and kind of cleavage which is characteristic to isolecithal eggs:

a) holoblastic asymmetrical; b) meroblastic superficial; c) holoblastic symmetrical; d) meroblastic discoidal.

6. The type and kind of cleavage which are characteristic to telolecithal eggs with a moderate amount of yolk:

a) holoblastic asymmetrica; b) meroblastic discoidal; c) holoblastic superficial.

7. The type and kind of cleavage which are characteristic to telolecithal eggs with an excessive amount of yolk:

a) meroblastic superficial; b) meroblastic discoidal; c) holoblastic asymmetrical.

8. Type and kind of cleavage which is characteristic to centrolecithal eggs:

a) complete superficial; b) incomplete discoidal; c) incomplete superficial.

9. Type and kind of human zygote cleavage:

a) holoblastic symmetrical; b) holoblastic asymmetrical; c) meroblastic superficial.

10. Types of a gastrulation:

a) invagination, delamination; b) discoidal; c) immigration, epibolia; d) immigration of an ectoderm cells.

11. Constituents of mesoderm:

a) teloblasts; b) mesenchyma; c) mesoblast; d) blastopore.

12. Modes of mesenchyma formation:

a) immigration of cells of an entoderm; b) immigration of cells of an ectoderm; c) delamination; d) epibolia.

13. Paths of the mesoblast formation:

a) immigration of entodermal and ectodermal cells; b) delamination; c) teloblastic mode; d) enterocoelic mode.

14. Ectoderm derivatives:

a) nervous system, sensitive organs receptors, epidermis and its derivatives, dermal glands; b) the reproductive and urinary systems; c) an epithelium of a foregut and hindgut; d) connective tissue.

15. Mesoderm derivatives:

a) the musculoskeletal system, all kinds of a connective tissue; b) circulatory and lymphatic systems; c) sensitive organs; d) the reproductive and urinary systems.

16. Entoderm derivatives:

a) epithelium of a foregut and hindgut; b) epithelium of an middle gut; c) epithelium of the respiratory system; d) digestive glands.

17. Role of yolk sac in a human embryo development:

a) there is practically no value; b) it is reduced and included in umbilical cord; c) it carryes out tpophic function; d) it carries out hemopoietic function while late stages of embriogenesis.

18. Role of allantois in a human embryo development:

a) role of accumulation kidney; b) it is component of umbilical cord; c) it contains umbilical vessels; d) it carries out hemopoietic function.

19. Role of chorion in a human embryo development:

a) specific barrier to microorganisms and number of harmful substances; b) it derivates a chorion-allantois fulfilling the respiratory function; c) it enters into structure of placenta; d) it enters into structure of umbilical cord.

20. Role of amnion and amniotic fluid in a human embryo development:

a) it provides embryogenesis in the water environment; b) it protects a fetus from mechanical damage; c) it takes part in placenta formation; d) it provides mobility of a fetus.

Laboratory work:

I. Study the following macropreparations in museam: "Fly metamorphosis"; "Honeybee metamorphosis"; "Fish development"; "Fish embryo"; "Amphibian development"; "Bird development"; "Rat development"; "Embryonic development of a human".

II. Study the following micropreparations:

– "Ascari eggs cleavage" (280x).

The micropreparation is a cross-section of the uterus pork roundworm. The uterus contains eggs. Zygotes can be seen at different stages of crushing (Fig. 15a).

– "Frog eggs cleavage" (16x).

The micropreparation is a cross-section of the frog crushing egg. Pay attention to the different size of the blastomeres. Small blastomeres are located in the region of the animal pole, and large ones in the region of the vegetative pole (15b).

– "Frog blastula" (16x).

The micropreparation is a cross-section of the blastula. Large blastomeres are clearly visible. Between them is a cavity - blastocoel. The blastoderm is multilayered and consists of identical cells (Fig. 15c).

– "Frog gastrula" (16x).

The micropreparation is a cross-section of the gastrula. Part of the material of the bottom of the gastrula fills the blastopore in the form of a cork. The dorsal lip of the blastopore is well defined and the cavity forming under it - the gastrocoel. The ventral lip of the blastopore is less developed. Remains of the blastocoel are visible between the ectoderm and endoderm (Fig. 15d).

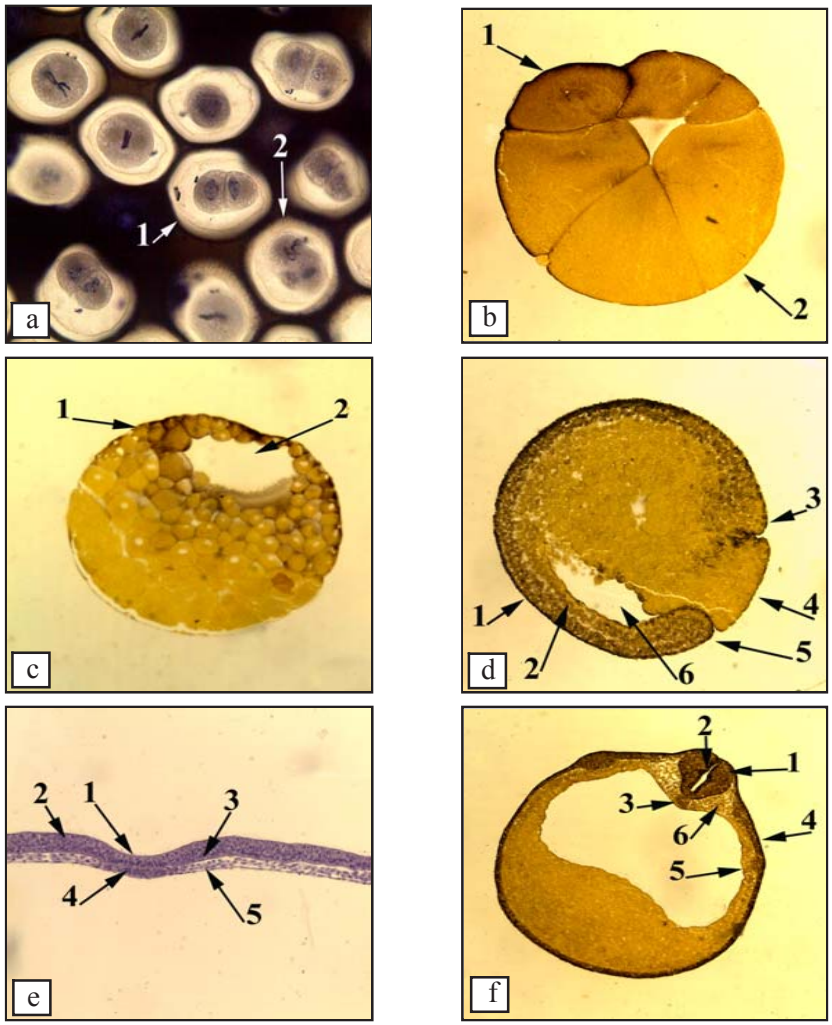


Fig. 15. Stages of embryonic development of organisms:
a - Ascari eggs cleavage (1 - stage of 2 blastomeres and 2 - stage of 4th blastomeres); b - frog eggs cleavage (1 - micro-, 2 - macroblastomeres); c - frog blastula (1 - blastoderm, 2 - blastocell); d - frog gastrula (1 - ectoderm, 2 - endoderm, 3 - dorsal lip of the blastopore, 4 - yolk tube, 5 - ventral lip of the blastopore, 6 - gastrocoel); e - chicken embryonic layers (1 - primary strip, 2 - ectoderm, 3 - basal membrane, 4 - mesoderm, 5 - endoderm); f - frog neurula (1 - neural tube, 2 - neurocell, 3 - chord, 4 - ecto-, 5 - entho-, 6 - mesoderm).

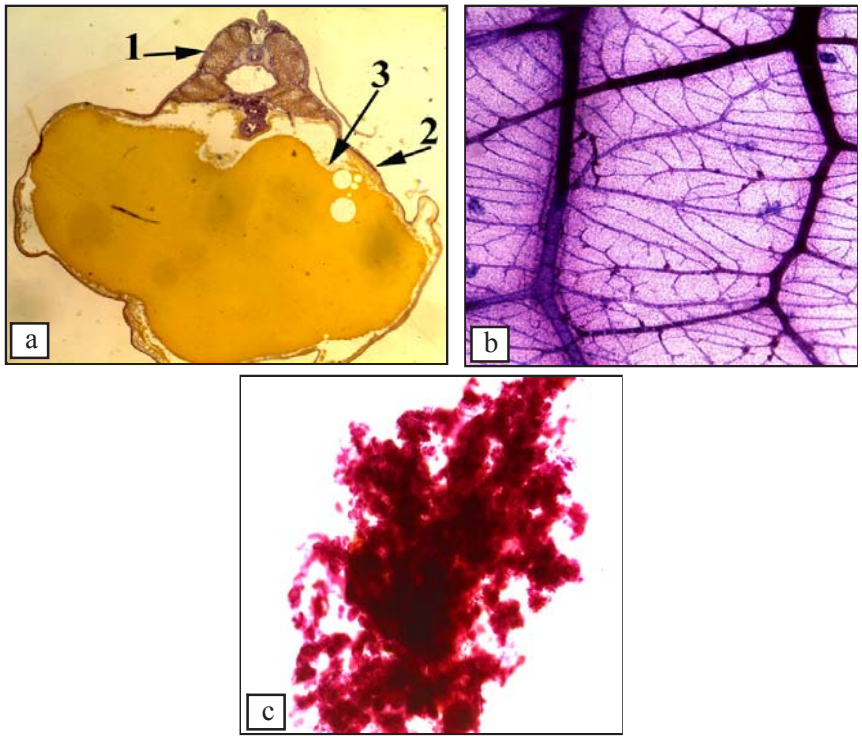


Fig. 16. Germinal membranes of organisms:
a - fish embryo with yolk sac (1 - embryo, 2 - yolk sac, 3 - yolk); b - chicken allantois; c - villi of human chorion.

– "Chicken embryonic layers" (56x).

The embryo is two-layered. The ectoderm is located on the surface. It is denser and thicker than the endoderm. The basement membrane delimited on the lower side of the ectoderm. In the middle part of the slice in the ectoderm a slight depression is visible. The basement membrane is absent. On the sides of the primary strip between the ectoderm and endoderm, loose aggregations of cells are seen, representing a base of the mesoderm (Fig. 15e).

– "Frog neurula" (16x).

The micropreparation is a cross-section of the frog embryo in late development. Full fusion of the edges of the neural tube is visible, which is under the ectoderm. The neural tube contains the canal (neurocell). Contours of the chord are visible with radially located cell nuclei rnder the neural tube. On both sides of these formations are visible somites. The embryo

has a ring-shaped form. The cavity of the gastrula is limited to the yolk cells of the endoderm (Fig. 15f).

– "Fish embryo with yolk sac" (16x).

Find the embryo, yolk sac, yolk (Fig. 16a).

– "Chicken allantois" (16x).

Pay attention to the blood vessels of the allantois (Fig. 16b).

– "Villi of human chorion" (32x).

Pay attention to the structure of the chorionic villi (Fig. 16c).

CLASS [1] 17. 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. The 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. The 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.
3. Role of endocrine glands and vitamins in human postnatal ontogenesis. Acceleration.
4. Human constitution. Build types classification according to body shape, its medical aspects.
5. Interaction of social and biological features during prereproductive, reproductive and postreproductive periods. Influence of alcohol, smoking, drugs consumption on growth and organism development.
6. Organism aging (physiological and preliminary). Biological aspects of aging. Hypotheses of aging. Gerontology and geriatry. Role of social factors in aging process.
7. Organism death (clinical and biological). Euthanasia, its ethic and justice aspects.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 137–146.

Tests to check level of knowledge

1. Stages of postnatal ontogenesis:

a) prozygote, zygote, cleavage, gastrulation, histogeny, organogenesis; b) prereproductive, reproductive, postreproductive; c) juvenile, reproductive, aging.

2. Hypothesis of acceleration:

a) enough noutrishment; b) influence of earth magnetic field; c) high action of electromagnet rays by TV and radio; d) appearance of heterosis.

3. Central endocrine glands of a human:

a) thyroid gland; b) adrenal; c) pancreas; d) pituitary.

4. Peripheral endocrine glands of a human:

a) sex glands; b) pituitary; c) thyroid and parathyroid; d) adrenal, pancreas.

5. Trope hormones of anterior part of pituitary which regulate functions of other glands:

a) somatotropin; b) thyroid-stimulating hormone; c) adrenocorticotropic hormone; d) follicle-stimulating hormone and luteinizing hormone.

6. Usual hormones of anterior part of pituitary:

a) thyroid-stimulating hormone; b) somatotropin; c) vasopressin; d) parathormone.

7. Hormones of intermediate part of pituitary:

a) melanotropin; b) luteinizing hormone; c) mineralocorticoid; d) glucagon.

8. Hormones of posterior part of pituitary:

a) follicle-stimulating hormone; b) vasopressin; c) oxytocin; d) melanotropin.

9. Hormones of thyroid gland:

a) thyroxin; b) threiodthyronin; c) thyroid-stimulating hormone; d) aldosterone.

10. Hormones of parathyroid gland:

a) oxytocin; b) melanotropin; c) parathormone; d) glucagon.

11. Hormones of adrenal cortex:

a) adrenaline; b) aldosterone; c) corticosteroid; d) glucocorticoids.

12. Hormones produced by Langerhans islets:

a) corticosterone; b) glucagone; c) insulin; d) aldosterone.

13. Hormones of sex glands:

a) testosterone; b) estrogenes; c) progesterone; d) gonadotropin.

14. The basic action of somatotropin:

a) stimulation of growth; b) regulation of metabolism; c) regulation of blood pressure; d) regulation of pancreas function.

15. The pathologic condition of organism when synthesis of somatotropin is breaks:

a) nanism and gigantism; b) acromegalia; c) Icenko-Kushingo disease; d) early secondary sexual signs formation.

16. Basic actions of vasopressin:

a) regulation of diuresis; b) decrease of vessel size, regulation of blood pressure; c) regulation of adrenal cortex function; d) stimulation of contractions of uteri mussels.

17. The pathological condition of organism when production of

vasopressin breaks:

a) insulin independ diabet; b) mixedema; c) low of diyresis to anuria; d) tetania.

18. The basic action of oxytocine:

a) regulation of diuresis; b) stimulation of uteri mussels contractions; c) regulate oxidative-restoration processes; d) stimulation of follicles growths.

19. The pathological condition of organism when production of oxytocine breaks:

a) decrease or increase time of birth; b) anuria; c) sterility; d) eunuchoidism.

20. The basic action of thyroid gland hormones:

a) regulation of substances metabolism; b) influence on organism growth and tissue differentiation; c) decrease of vessel size; d) regulates exchange of natrium and kalium.

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:

– "Thyroid gland at hypofunction and hyperfunction conditions" (280x).

On the cross-section of the thyroid gland, follicles formed by a single layer of thyrocytes are visible. The follicles contain a pink colored colloid inside. Follicles in a state of hypofunction have a flat form of thyrocytes. They contain a dense, viscous colloid, painted in a bright pink color. The follicles of the thyroid gland in the state of hyperfunction are formed by prismatic thyrocytes and are filled with a light, foamy colloid of light pink color.

– "Pancreatic Langergans islands in hypofunction and hyperfunction conditions" (280x);

In the pancreas micropreparation, the exocrine part of the organ is visible, consisting of the acini of dark blue color and the endocrine part, represented by the islets of Langerhans with blue color. The hypofunction is characterized by a small number of islets consisting of 3-8 cells (microgresia). The endocrine hyperfunction is characterized by hypertrophy and islet hyperplasia (macrognezia).

CLASS [1] 18.
ONTOGENETIC HOMEOSTASIS, MECHANISMS OF ITS REGULATION

The homeostasis is a maintaining a relatively stable internal physiological environment in organism, involving some form of feedback self-regulation. The 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 is 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 loci A, B, C, D (DP, DQ, DR sites). The structural plan of main histocompatibility system is similar in all animals.

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, AB0 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, preservation of organs and tissues, 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 accordinary 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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 147–160.

Tests to check level of knowledge

1. Types of relationships between incoming and outcoming variables in the law of alive system behaviour:

a) direct; b) positive feedback; c) negative feedback; d) homeostatic.

2. Examples of gene mechanisms of a homeostasis:

a) tissue regeneration; b) DNA repair; c) gene expression and repression; d) gene control of blood systems antigens synthesis.

3. System of human histocompability:

a) HLA; b) LD; c) SD.

4. Types of a transplantation which are most frequently used in a human:

a) syngenic; b) allotransplantation; c) autotransplantation; d) xenotransplantation.

5. Example of cellular mechanisms of a homeostasis:

a) DNA replication; b) keeping of cell as open self-regulating system; c) cellular and intracellular regeneration; d) chromosome aberration.

6. Types of tissues by their ability to proliferation:

a) labile; b) stable; c) static.

7. Labile tissues and organs:

a) osteal tissue; b) friable connective tissue; c) endocrine glands, kidneys, lungs; d) epithelium of a gastrointestinal path, respiratory and urinary paths; e) epidermis, endothelium of vessels, epithelium of peritoneum, hemopoietic system.

8. Type of restoring in labile tissues:

a) only intracellular; b) both intracellular and cellular; c) only cellular; d) intercellular.

9. Stable tissues and organs:

a) lungs, kidneys; b) glands, kidneys; c) muscular tissues (except myocardium); d) epithelium of a gastrointestinal path.

10. Type of regeneration in stable tissues:

a) only intracellular; b) both intracellular and cellular; c) only cellular; d) only intercellular.

11. Static tissues and organs:

a) myocardium; b) ganglion tissue of the central nervous system; c) striated muscles.

12. Type of regeneration in static tissues:

a) only intracellular; b) both intracellular and cellular; c) only cellular; d) only intercellular.

13. Forms of reparative regeneration of a human:

a) full regeneration; b) regeneration hypertrophia; c) intracellular compensatory hypertrophy; d) epimorphosis.

14. How does intracellular compensatory hypertrophia realize?

a) increase of cells number; b) increase volume of cells.

15. Ways of reparative restoring:

a) epimorphosis, endomorphosis; b) regenerative hypertrophy; c) regenerative induction; d) morpholaxis.

16. Essence of epimorphosis:

a) on a place of damage a scar is formed, the restoring is provided by hypertrophy or hyperplasia of cells; b) the restoring starts from surface of wound; c) the restoring is provided by redifferentiating of intermediate cells.

17. Essence of endomorphosis:

a) the restoring starts from surface of wound; b) regeneration is going with the help of differentiation of intermediate cells; c) on a place of damage a scar is formed, the restoring is provided by hypertrophy or hyperplasia of cells.

18. Essence of morpholaxis:

a) the restoring is activated by metabolites of necrotic tissues; b) the restoring is provided by redifferentiating of alive cells after wound; c) the restoring begins from wound surface.

19. Essence of regenerative induction:

a) regeneration starts from wound surface; b) the regeneration is provided by redifferentiating of intermediate cells; c) the regeneration is activated by metabolites of necrotic cells.

20. Systems mechanisms of homeostasis regulation:

a) by nervous system; b) by immune system; c) by endocrine system.

Laboratory work:

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

№72. It is known, that blood of 0(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?

№73. 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?

№74. At human presence of Rh-antigen in erythrocytes is determined by dominant gene D. Its allele d determines absence of this antigen. Gene I0 is recessive in comparison with genes I^A and I^B. Both last alleles are codominant, their combination I^AI^B determines AB(IV) blood group. Genotype of husband I^AI^BDD, wife – I^0I^0dd. 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 0(I) blood) marries man with rhesus-negative 0(I) blood. Determine possible blood group of children and who from them can receive mother's blood.

Husband's genotype – DdI^AI^B, wife's genotype – DdI^BI^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 0(I). Family has two children first with rhesus-negative B(III) blood, second with rhesus-positive 0(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 0(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 0(I) blood, child has rhesus-positive 0(I) blood. What conclusion has to be made and why? What blood can be transfused to child?

№75. 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^AI^Bsese and I^0I^0Sese. 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 [1] 19. COMPARATIVE ANATOMY OF VERTEBRATES ORGAN SYSTEMS

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), micrognatia (underdevelopment of upper jaw), exoencephalia (absence ofcranium 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, gastroptosis (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, agenesia (absence) and hypoplasia (underdevelopment) of lung or its lobe, additional lobes or lung, lungs cyst.

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

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 derivates 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 place improperly. In this case aorta leave right ventricle, whereas pulmonary artery - right. One of 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 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, agenesia 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 integument, skeleton, digestive, respiratory, circulatory, nervous, excretory and reproductive systems of vertebrates. 2. To be able to explain mechanisms of human development defects (integument, skeleton, digestive, respiratory, circulatory, nervous, excretory and reproductive systems). 3. To be acquainted with main morphological appearance of development defects of indicated systems at human.

Questions:

1. The value of knowledge about the comparative anatomy of vertebrates in the training of a doctor.

2. Comparative anatomy of vertebrate's integument. Human development defects of skin.

3. Comparative anatomy of vertebrate's skeleton. Changes of skeleton during anthropogenesis. Human development defects of skeleton.

4. Comparative anatomy of vertebrate's digestive system. Human development defects of digestive system.

5. Comparative anatomy of vertebrate's respiratory system. Human development defects of respiratory system.

6. 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.

7. Comparative anatomy of vertebrates' nervous system. Human development defects of nervous system.

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

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

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 160–171.

Tests to check level of knowledge

1. Evolutionary directions of vertebrate's integument:

a) change of mucous epithelia to dry keratinized epidermis; b) predominance epithelium to corium; c) predominance corium to epithelium; d) differentiation of glands; e) appearance of skin appendage.

2. Examples of skin defect of a human:

a) hemipodia; b) ichthyosis; c) hemangioms; d) teleangiectosia; e) microgenia.

3. Evolutional directions of axial skeleton changing in vertebrates:

a) reduction of gill; b) change of cartilaginous skeleton to bony-cartilaginous and to bony skeleton; c) differentiation of vertebrae into segments; d) transformation of visceral skeleton arches.

4. Evolutional directions of cranium in vertebrates:

a) transformation of arches of visceral skeleton; b) formation of jaws apparatus; c) differentiation of teethes; d) prevalence cranium part on facial part.

5. Skull defects are:

a) extropodia, apodia; b) atlas assimilation; c) increasing or decreasing number of vertebrae; d) knitting body or processes of vertebrae; e) scoliosis.

6. Defects of rib cage shape development:

a) adentia, diastema; b) underdevelopment or additional ribs; c) cervical ribs; d) splitting of sternum; e) hemypodia.

7. Examples of skull defect development of a human:

a) cranial-clavicular disostosis, synostosis of osts; b) hemypodia, apodia; c) acrocephalia; d) arachnodactylia, polydactylia, syndactylia, flat-foot, club-foot; e) atlas assimilation.

8. Examples of cranium defect of a human:

a) cleft palate, harelip; b) craniostenosis, acrocephalia; c) microgenia, micrognatia; d) gemipodia, extropodia.

9. Evolutional directions of respiratory system in vertebrates:

a) changing of gill breathing to skin-lung breathing and to lung breathing; b) appearance and differentiation of respiratory ways; c) appearance of agenesia; d) increase respiratory surface.

10. Examples of human defects development of respiratory system:

a) preserving of gill's slits; b) Hirshprung disease; c) athresia of trachea, tracheal-esophagus fistula; d) absence or underdevelopment of lung or its lob.

11. Evolutionary directions of digestive system at vertebrates:

a) development of athresy, aplasia; b) alimentary canal differentiation separation of digestive glands; c) perfection of jaw apparatus; d) teeth differentiation; e) increase of surface absorb.

12. Examples of digestive system defect development of a human:

a) adentia, dyastema; b) micro- and macroesophagus; c) Merckells diverticulum; d) situs viscerus inversum.

13. Main directions of the circulatory system evolution:

a) differentiation of heart into chambers and separation arterial and venous blood from each other; b) transposition of aorta; c) appearance of the second pulmonary circle of circulation; d) differentiation of vessels into arteries and veins; e) isolation of the lymphatic system from the circulatory one.

14. Examples of the circulatory system development defects in the man:

a) Tolochinov-Roze disease; b) Fallot's triad, tetrad and pentalogy; c) situs viscerus inversum totalis; d) failure of Botallo duct obliteration; e)

right or two aortic arches, transposition of aorta and pulmonary artery.

15. Defects of developments which are included in Fallot's triad:

a) transposition of aorta and pulmonary artery; b) stenosis of a pulmonary artery; c) hypertrophy of left ventricle; d) hypertrophy of a right ventricle; e) defect of interventricular septum.

16. Defects of development which Fallot's tetrad includs:

a) defect of interventicular septum; b) stenosis of pulmonary artery; c) hypertrophy of right ventricle; d) transposition of aorta and pulmonary artery; e) dextraposition of aorta.

17. Fallot's pentalogy includes:

a) defects of interatrial and interventricular septa; b) dextraposition of aorta; c) failure of mitral vavle; d) stenosis of pulmonary artery; e) hypertrophy of right ventricle.

18. Main directions of vertebrates brain evolution:

a) transformation of widening of nervous tube anterior end into the brain; b) differentiating of the brain into divisions and development of brain ventricles; c) offset of main centre of nervous activity regulation from midbrain to the brain bottom and then to the cortex of forebrain; d) change of archicortex to neocortex; e) increase of brain size and of cortex surface, increase of cerebral nerves number.

19. Examples of the nervous system defects development in a human:

a) hydrocephaly; b) hemipodia, apodia; c) anencephaly, microcephaly;. d) spinal hernia.

20. Main directions of excretory system evolution in vertebrates:

a) turning of pelvic kidney into truncal one; b) change of pronephrous, primary and secondary kidneys functioning; c) formation of connection between excretory system and circulatory one; d) increase of nephrons number, lengthening of renal convoluted tubules.

Laboratory work:

I. Study the following macropreparations in museam: "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"; "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 integument of vertebrates.

Signs	Fishes	Amphibians	Reptiles	Birds
Characteristic of epithelium				
Ratio of epider-mis 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 circulatory system of vertebrates.

Signs	Fishes	Amphibians	Reptiles	Birds
Number of chambers in heart				
Character of blood in heart chambers				
Number of circula-tion, their main vessels				
Liver and kidneys portal systems				
Arterial arches, their transformation				
Main directions of circulatory system evolution				

POPULATION-SPECIES LEVEL OF ORGANIZATION OF LIVING SYSTEMS

CLASS [1] 20.
STRUCTURE OF HUMAN POPULATIONS

All species are presented in the nature by their populations. The population consists of the individuals of given species that occur together at one place and during long time (large number of generations). The population is separated from other populations by one or another kind of isolation. A population is an elementary evolutionary unit. 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.

Purposes of class: 1. To know ecological and genetic characteristics of population; particularities of humankind population structure; essence of Hardy-Weinberg low and conditions of it 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 low, conditions of its appearance.
2. Particularities of humankind population structure. Dems. Isolates. Particularities of isolate gene pool (gene fond). Employment of Hardy-Weinberg low 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 contrselection, selection against homozygotes and heterozygotes.
4. Genetic polymorphism of human populations, its classification accordinary character of genetic changes (gene, chromosomal, genomic), classification accordinary 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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 172–180.

Tests to check level of knowledge

1. Ecological characteristics of human population:
a) size of population, number of individuals; b) area of living; c) age and sex structure; d) isolation.
2. Genetic characteristics of human population:
a) genetic drift; b) genetic load; c) genofond.
3. Characteristics of dems:
a) consists of less of 5.000 individuals; b) consists of less than 100 individuals; c) essence during 1-2 generations isolated from other groups; d) through 1-2 generations units with other groups.
4. Characteristics of isolates:
a) consists of less than 5.000 individuals; b) consists of less than 100 individuals; c) isolated from other populations; d) have very limited exchange of individuals.
5. Results of dem and isolate existence:
a) transference of pathological recessive genes in homozygous state and appearance of hereditary disease; b) decrease of viability and die out of population; c) appearance of genetic drift through some generations.
6. Opportunities of Hardy-Weinberg low using:
a) definition of concentration by some genes in population; b) definition of gene drift; c) definition of pathological gene frequent in heterozygote.
7. Elementary evolutional factors influence on human population:
a) natural selection; b) mutational process, genetic drift; c) population rays; d) isolations.
8. Example of selection action against homozygotes and favor of heterozygotes:
a) rhesus-conflict; b) sickle cell anemia; c) brachydactilia.
9. Groups of polymorphism according of character of hereditary material:
a) neutral; b) genes; c) chromosomal; d) genomic.
10. Types of polymorphism by its nature:
a) transitional; b) neutral; c) balanced; d) substitutional.
11. Examples of gene polymorphism of a human:

a) genes of rhesus-factor and oval form of erythrocytes; b) genes of blood groups on ABO system, Luteran; c) plural alleles of A, B, C, DR genes of HLA system.

12. Examples of chromosomal polymorphism of a human:

a) «cats cry» syndrome; b) Orbeli syndrome; c) Chirschchorn syndrome; d) translocation from 21-th pair to 13, 14, 15, 22-th.

13. Examples of genomic polymorphism of the human:

a) Orbeli syndrome; b) Smith syndrome, Pattaw's syndrome; c) Kleinefelter's syndrome; d) Turner's syndrome, additional X- chromosome.

14. The essence of transitional polymorphism:

a) gene in new condition replaces initial one; b) with the help of natural selection population will be monomorphic by new allele; c) consists of two or some more alleles.

15. The essence of neutral polymorphism:

a) close to chromosomal mutations; b) spontaneous changing of gene frequencies occurs; c) in changed environment one gene changes to new one.

16. The essence of balanced polymorphism:

a) close to chromosomal aberrations; b) appears in result of gene load; c) selection acts in different directions on homozygotes and heterozygotes.

17. The genetic load is:

a) relatively decrease viability of population in comparison with normal genotype; b) includes lethal and sublethal mutations; c) high quantity of hereditary diseases in humankind populations.

18. The essence of mutational genetic load:

a) result of repeated mutations; b) result of genetic drift; c) stay by natural selection.

19. The essence of balanced load:

a) spontaneous changing of gene frequencies occurs; b) appears with the help of selection on homozygotes and heterozygotes; c) has two or more alleles.

20. The essence of substitutional genetic load:

a) normal allele in new conditions becomes negative; b) have selection against homozygotes; c) close to chromosomal aberrations.

Laboratory work:

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

Equipment: strips of filter paper with size 0.5x4.0 cm, 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.

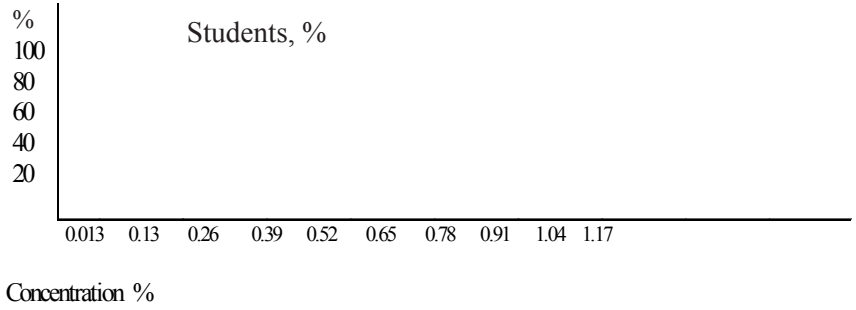
After determination mouth is washed by water. At base obtained data construct variation range.

Concen-tration	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.



Accordinary 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: $p^2TT \times \sum n$ and $2pqTt \times \sum n$, respectively

Percentage of them:

$p^2TT * 100\%$ 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 [1] 21. FUNDAMENTALS OF HUMAN ECOLOGY. ANTROPOECOLOGY

The term "ecology" was suggested by A.Gekkel in 1866. However, as independent science, ecology was founded at the beginning of 20th century.

The 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. The 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. The ecology studies the influence of communities on their environment too. The 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).

Purposes of class: 1. To know: aims and problems of anthropoecology; ecological diversity and human adaptive types; biological and social aspects of human adaptation to environmental conditions. 2. To be acquainted with aims and problems of valeology.

Questions:

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

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 181–188.

Tests to check level of knowledge

1. The ecology studies:

a) physiology and behaviour of separate organisms in natural conditions; b) birth rate, mortality one, migration one; c) the interspecpecific relationships; d) flow of energy, turnover of substances.

2. The anthropoecology studies:

a) principles of the human populations interaction with factors of environment; b) principles of the human populations development; c) possibilities to save health of the people; d) possibilities to perfect physical and mental abilities of the people.

3. Levels of ecological interactions of a human:

a) individual; b) biosphere; c) group; d) global.

4. Adaptive types of a human:

a) negroids, caucasians, asians; b) americans, australians; c) arctic, tropical, of temperate climate; d) high-mountainous, deserted.

5. Features of the arctic adaptive type of a human:

a) good development of the musculoskeletal system, enlarged size of thocacic cavity; b) reduced amount of cholesterol in the blood; c) high levels of haemoglobin, proteins and cholesterol in the blood; d) increased

amount of mineral substances in the bones; e) increased ability to oxygenate lipids.

6. Features of the tropical adaptive type of a human:

a) high levels of proteins and cholesterol in the blood; b) reduced mass of the body; c) long extremities, diminished size of thoracic cavity; d) intensive rate of sweating; e) intensive rate of metabolism, hypocholesterolemia.

7. Features of the temperate climat adaptive type of a human:

a) hypercholesterolemia, hypoglobulinemia; b) the musculorskeletal system is advanced; c) reduced amount of mineral substances in the bones; d) it is intermediate type between arctic and tropical types; e) it is intermediate type between arctic and mountainous types.

8. Features of the high-mountainous adaptive type of a human:

a) increased rate of metabolism; b) increased number of erythrocytes and haemoglobin level, ease of haemoglobin oxygenation; c) enlarged size of thoracic cavity; d) reduced rate of metabolism; e) hypercholesterolemia.

9. Features of the deserted adaptive type of a human:

a) increased rate of metabolism; b) increased haemoglobin level; c) increased process of dehydration; d) reduced amount of mineral substances in the bones; e) hypoglobulinemia.

10. States of human organism vital activity:

a) physiological; b) of stress condition; c) of adapting; d) of pathology.

11. Levels of human adaptive processes:

a) individual; b) population; c) species; d) global.

12. Main factors of health care:

a) rational style of life; b) liquidation of harmful habits; c) physiologically balanced diet; d) active movement and fitness.

Laboratory work:

I. Solve situational problems on anthropoecology:

№76. Square of Earth is equal to 149 millions km^2, mankind is equal to 5.4 billions of people. 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 km2	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.

№77. 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

CLASS [1] 22.
ONTOGENESIS. THE MAIN ASPECTS OF POPULATION GENETICS AND ANTROPOECOLOGY
(summing up class)

Purposes of class: 1. To know the main stages of the ontogeny of vertebrates and humans, the basis of the laws of population genetics and human ecology. To be able to explain the mechanisms of occurrence of malformations in humans. 3. Familiarize yourself with the concepts of "health - preillness - illness - compensation" and with the concept of valeology as a science of human health.

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).

8. Postnatal ontogenesis, its periods.

9. Growth and development of organism.

10. Role of endocrine glands and vitamins in human postnatal ontogenesis. Acceleration.

11. Human constitution. Build types classification according to body shape, its medical aspects.

12. Interaction of social and biological features during prereproductive, reproductive and postreproductive periods. Influence of alcohol, smoking, drugs consumption on growth and organism development.

13. Organism aging (physiological and preliminary). Biological aspects of aging. Hypotheses of aging. Gerontology and geriatry. Role of social factors in aging process.

14. Organism death (clinical and biological). Euthanasia, its ethic and justice aspects.

15. 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.

16. 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, AB0 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, preservation of organs and tissues, commercialization of donorship);

17. 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 accordinary 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.

18. 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.

19. The value of knowledge about the comparative anatomy of vertebrates in the training of a doctor.

20. Comparative anatomy of vertebrate's integument. Human development defects of skin.

21. Comparative anatomy of vertebrate's skeleton. Changes of skeleton during anthropogenesis. Human development defects of skeleton.

22. Comparative anatomy of vertebrate's digestive system. Human development defects of digestive system.

23. Comparative anatomy of vertebrate's respiratory system. Human development defects of respiratory system.

24. 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.

25. Comparative anatomy of vertebrates' nervous system. Human development defects of nervous system.

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

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

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

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

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

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

32. Genetic aspects of human predisposition to somatic diseases.

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

34. Ecology as science, its aims and problems.

35. Anthropoecology as science, its aims and problems. Levels of human ecological relations (individual, population, global).

36. Ecological differentiation of humans on adaptive types and their morphophysiologic characteristics.

37. Biological and social aspects of human adaptation to life conditions.

38. Human health and life supporting system as categories of anthropoecology. Problem "predisease – disease – compensation" as possible human organism stays. Factors of health.

39. Valeology as science about human health.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 121–188.

CLASS [1] 23.
ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM SARCOMASTIGOPHORA, CLASSES ZOOMASTIGOTA AND SARCODINA

The 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, ectoparassitism and endoparasitism.

The parasitism is studied by parasitology. The 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. The 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. The 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.

The 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, helmintology and arachnoenthomology. The medical protozoology studies pathogenic protozoa, which cause human diseases. The medical helmintology studies flat worms and nematodes, which cause human diseases. The medical arachnoenthomology studies arthropods as transmitting agents, natural reservoir and causative organisms. The 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. 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. Ectoparaistes can be permanent (having all life cycle on a body), like louses and temporal (which are on surface only during feeding), like mosquitoes. Endoparasites, accordinary their localization can be classified to intercellular parasites (which live inside of a cell), like plasmodium malariae; tissue parasites (which live in tissues), like Enthamoeba histolytica, trypanosomes, fillariaand so on; organs parasites (which affect various organs), like Opistorhus fellineus, and others; and cavity's parasites (which settle different bodies cavities such as pleural cavity, abdominal cavity an so on), like Taenia soleum, Ascaris lumbricoideus, Enterobius vermicularis and others. All endoparisites 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 soleum 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 occur through unwashed vegetables, fruits (Ascaris lumbricoideus, Trichocephlus 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, Cestoides, Fillaria, etc.). Contact hemlinthes 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 where 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. The second intermediate host called additional

host. Thus, Opisthorhis felineus have two intermediate hosts: one is snail Bithynia leachi, additional is 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 and 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 transmittion 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 Trichmonas 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): 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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 188–209.

Tests to check level of knowledge

1. Examples of intercellular parasites:

a) Trichomonas vaginalis; b) Lamblia intestinalis; c) Leishmania tropica, L. donovani; d) Trypanosoma cruzi; e) Trypanosoma brucei gambience.

2. Examples of tissue parasites:

a) Trypanosoma brusei gambiense, T. crusi; b) Entamoeba histolytica; c) Trichomonas hominis; d) Trichomonas vaginalis.

3. Examples of interorgans parasites:

a) Trichomonas hominis; b) Balantidium coli; c) Fasciola hepatica; d) Opistorchis felineus; e) Onchocerca volvulus.

4. Examples of cavity's parasites:

a) Lamblia intestinalis; b) Entamoeba histolytica; c) Trichomonas hominis; d) Leishmania tropica.

5. Examples of monoxenic parasites:

a) Trichomonas hominis; b) Leishmania donovani; c) Trypanosoma cruzi; d) Entamoeba histolytica; e) Lamblia intestinalis.

6. The localization of Leishmania tropica in human organism:

a) cells of liver, spleen; b) cells of skin; c) blood, lymph; d) cavum of intestine.

7. The pathogenic influence of the Leishmania tropica on the human's body:

a) destroyment of hepatocytes; b) defeat of lymphatic nodes and vessels; c) defeat of skin and ulcer appearance; d) damage of intestine walls.

8. Methods of Leischmania tropica diagnostics:

a) light microscoping of material taken from ulcers; b) part of material is streaked onto plates with NNN-agar; c) immunological reactions.

9. The localization of Leishmania donovani in human organism:

a) liver cells, spleen, lymphatic node; b) cells of red bone marrow; c) blood, spinal fluid; d) skin cells.

10. The pathological influence of Leishmania donovani on human organism:

a) breach of structure and function of red bone marrow cells, liver, spleen, lymphatic nodes; b) ulcer defeat of skin; c) inflammatory process in brain.

11. Methods of visceral Leishmania laboratory diagnostics:

a) method of native smear, flotation; b) finding amastigotes in the red brain cells, lymph nodes; c) crop on NNN – agar; d) immunological reactions.

12. To prevent visceral and cutaneus leishmaniasis need:

a) revealing and treatment of ill people, kill vectors; b) destruction of tse-tse fly of genus Glossina in their birth places; c) destruction of mosquito of genus Phlebothomus in their birth places; d) prevent mosquitos bites.

13. The localization of Trypanosoma brucei gambiense in human body:

a) cells of liver, spleen; b) blood, lymph, spinal fluid; c) tissues of spinal and head brain; d) cardiac muscle.

14. The pathogenic influence of Trypanosoma brucei gambience on human organism:

a) inflammatory and degenerate changes in brain, liver; b) changes in walls of blood vessels; c) megacolon; d) allergic reactions.

15. Methods of laboratory diagnostics of sleeping sickness:

a) flotation method; b) crop on NNN – agar; c) finding parasite in blood slide, thin drop; d) immunological reactions.

16. The localization of Trypanosoma cruzi in human organism:

a) cells of adrenal glands; b) blood, lymph, spinal fluid; c) seroze cavity; d) cardium mussels.

17. The pathogenic influence of Trypanosoma cruzi on human:

a) defeat of skin, cellular tissue, lymphatic nodes; b) defeat of heart; c) defeat of kidney and sex organs; d) allergic reactions.

18. Methods of Chagas,s disease diagnostics:

a) microscoping of peripheral blood to find parasite, thin drop, take material of spinal fluid, spleen; b) xenodiagnostics with Triatoma chinches; c) immunological method reaction of complement binding, intraskin sample.

19. To prevent sleeping sickness and Chagas,s disease need:

a) revealing and treatment of ill people, kill vectors; b) destruction of tse-tse fly of genus Glossina in their birth places; c) destruction of mosquito of genus Phlebothomus in their birth places; d) prevent mosquitos bites.

20. The localization of Lamblia intestinalis in human organism:

a) cells of liver, spleen; b) blood, lymph; c) duodenum; d) bile cyst.

21. The pathogenic influence of Lamblia intestinalis on human organism:

a) mechanical damage of duodenum walls; b) dyspepsia, damage of absorption, motor, secretory functions of a intestine; c) damage of liver function; d) allergic reactions.

22. Methods of lambliosis laboratory diagnostics:

a) method of native smear, flotation, cyst concentration; b) microscoping of duodenal fluid and faeces for trophosoits and cysts; c) immunological methods.

23. Prevent measures of lambliosis:

a) finding and kill ill animals; b) treat of ill people; c) use severage and wc; don't use fresh stool for ground agriculture; d) washing vegetables, berry's; wash hands after work with soil, don't use water from natural lakes.

24. The localization of Trichomonas vaginalis in human organism:

a) vagina and cervix of the uterus; b) adrenal body; c) duodenum; d) cardium muscle.

25. The pathogenic influence of Trichomonas vaginalis on human organism:

a) affection of adrenal glands; b) affection mucous membrane of urogenital organs; c) defeat fibre of duodenum; d) appearance of myocarditis.

26. Methods of trichomoniasis laboratory diagnostics:

a) finding cysts in smear of urogenital ways; b) finding of vegetative forms in smear of urogenetal ways in male – from centrifugate of urine and sperm; c) immunological reactions; d) intraskin sample.

27. Preventive measures of Trichomonas vaginalis:

a) revealing and kill ill animals; b) revealing and treatment of ill people; c) kill flies and cockroackes; d) educational programs concening safe sex.

28. The localization of Entamoeba histolytica in human organism:

a) small intestine; b) large intestine; c) gall-bladder; d) pancreas.

29. The pathogenic influence of Entamoeba hystolytica on human organism:

a) affection mucous cover of large intestine appearance of ulcer; b) perforation of intestine and development of peritonitis; c) hematogenic dissemination of amoeba and development of extraintestinalis amoeba and abscesses.

30. Methods of amoebiasis laboratory diagnostics:

a) method of native smear; b) finding in fresh faeces, phlegm of tissue, big, small vegetative forms and cysts; c) finding tissue and big vegetative forms in scrape of ulcer; d) immunological reactions.

31. Prevent measures of amoebiasis:

a) finding and treat ill people; b) use severage and wc; don't use fresh stool for ground agriculture; c) kill flies and cockroackes; d) washing vegetables, berry's; wash hands after work with soil.

Laboratory work:

I. Study the following macropreparations in museam: "Ulcers of gut at amoebiasis".

II. Study the following micropreparations:

– "Trypanosoma brucei gambiense" (400x).

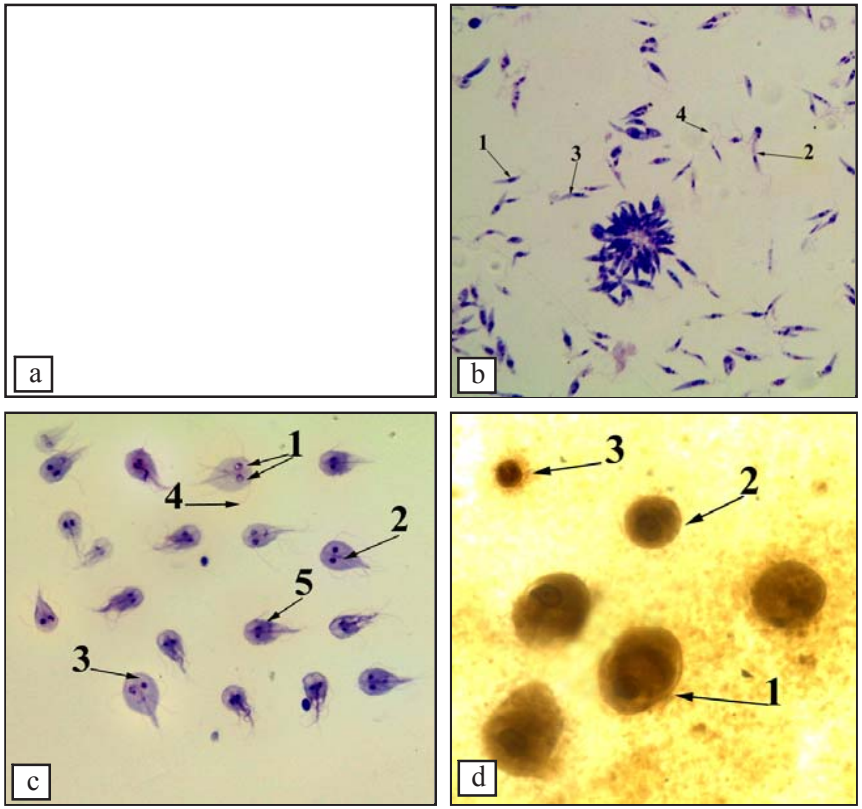


Fig. 17. Pathogenic representatives of the phylum Sarcomastigophora:
a - Trypanosoma brucei gambiense (1 - cytoplasm, 2 - nucleus, 3 - flagellum, 4 - undulating membrane); b - "Leishmania tropica major (promastigota)" (1 - nucleus, 2 - pellicle, 3 - cytoplasm, 4 - flagellum); c - Lamblia intestinalis (1 - nucleus, 2 axiostil, 3 - suction disc, 4 - flagella, 5 - pellicle); d - Entamoeba histolytica (1 - large vegetative form, 2 - small form, 3 - parasite cysts).

The micropreparation is a blood smear of a patient with African trypanosomiasis. Parasites are located between the blood cells. Parasites have an elongated shape, painted in blue-violet color. The nucleus is seen in the middle part of the trypanosome body. The nucleus is a large oblong, reddish-purple color. The blepharoplast is located at the back end of the body in the form of a purple dot. The flagellum departs from blefaroplast. The undulating membrane is visible between the flagellum and the body in large parasites (Fig. 17a).

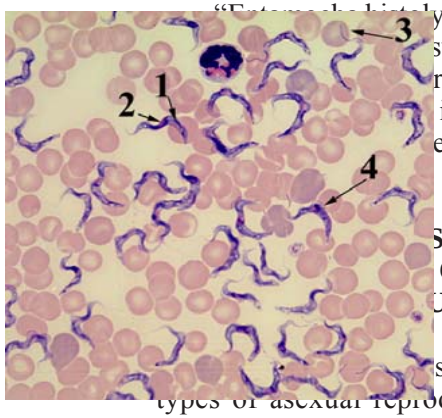
– "Leishmania tropica major (promastigota)" (400x).

- Parasites are seen elongated in length. The cytoplasm of the cell is colored pale pink. The nucleus is located in the center of a blue-violet cell (Fig. 17b).

– "Lamblia intestinalis" (630x).

The micropreparation is prepared from the duodenal contents of the patient with giardiasis. The shape of the body of the parasite is pear-shaped, with a front wide, rounded end and a narrow rear pointed. The suction disc is located at the front end on the ventral side. Two symmetrically located nuclei are visible in the cytoplasm. Two thin parallel threads (aksostyli) are located inside the body from front to back. They start from the basal grains, located in front of the nuclei. 4 pairs of flagella depart from the basal grains (Fig. 17c).

– "Entamoeba histolytica" (630x).



sue) and small luminal forms of the parasite can be ration. Darkly colored rounded erythrocytes are in many amoebas. Cysts have the round shape and ei (Fig. 17d).

CLASS [1] 24. SPECTS OF PARASITISM IN PHYLUM CLASS SPOROZOA AND IN PHYLUM USORIA, CLASS CILIATA

s there are ony intercellular parasites having two types of asexual reproduction (schizogonia, sporogonia) and sexual reproduction. Main human parasites are representatives of Plasmidium, Toxoplasma, Pneumocyst, Cryptosporidium families.

The exciters of malaria are referred to Plasmodium familie. There are four species in this genus: Plasmodium vivax is exciter of "tertian" malaria; P. malariae is exciter of "quartan" malaria; P. ovale is a cause of malaria, which the morphologically similar to P. malariae, but has developed periodicity as P.vivax; P. 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 schyzogony), than development in erythrocytes (erythrocytic schyzogony), and formation of gametocytes (immature gametes). Gametogony and sporogony occur in mosquito organism.

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 familie 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.

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 exciters 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 and immunological), 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 immunological), 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 and immunological); preventive measures against balantidiasis.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 209–224.

Tests to check level of knowledge

1. Epidemiological characteristics of malaria originators:

a) true, obligate, permanent parasites; b) monoxenous, intracellular parasites; c) heteroxenous, intratissue and luminal parasites; d) heteroxenous, intratissue and intracellular parasites.

2. Systematic classification of malaria originators:

a) ph. Sarcomastigophora, cl. Zoomastigota, sp. Plasmodium vivax, Pl. ovale, Pl. malariae; b) ph. Protozoa, cl. Sporozoa, sp. Plasmodium vivax, Pl. ovale, Pl. malariae; c) ph. Apicomplexa, cl. Sporozoa, sp. Plasmodium vivax, Pl. ovale, Pl. malariae, Pl. falciparum; d) ph. Ciliophora, cl. Sporozoa, sp. Plasmodium vivax, Pl. ovale, Pl. malariae.

3. Type of fever caused by Pl. vivax:

a) tropica; b) malaria; c) terciana.

4. Type of fever caused by Pl. ovale:

a) terciana; b) type of; c) quartana.

5. Type of fever caused by Pl. malariae:

a) malaria; b) tertiana; c) quartana.

6. Type of fever caused by Pl. falciparum:

a) tropica; b) quartana; c) tertiana.

7. Location of malarial parasites in organism of a human:

a) hepatic cells; b) blood plasma, erythrocytes; c) celebrospinal fluid; d) lymph.

8. Pathogenic action of malarial parasites:

a) destroy hepatocytes and erythrocytes; b) violate the immune status; c) damage intestine; d) cause hepatolienal syndrome.

9. Methods of laboratory diagnosis of malaria:

a) detection of parasites in thin and thick smear of blood; b) intracutaneous test with malarial antigens; c) indirect imunofluorescence, indirect hemagglutination tests.

10. Personal measures of malaria phophylaxis:

a) revealing and treatment of the patients; b) control for donor's blood; c) mosquitoes eradication; d) preventive course of treatment.

11. Systematic classification of Toxoplasma:

a) ph. Protozoa, cl. Coccidia, sp. Toxoplasma gondii; b) ph. Sporozoa, cl. Coccidia, sp. Toxoplasma gondii; c) ph. Apicomplexa, cl. Sporozoa, od. Coccidia, sp. Toxoplasma gondii; d) ph. Coccidia, cl. Sporozoa, sp. Toxoplasma gondii.

12. Epidemiological characteristics of Toxoplasma gondii:

a) facultative, heteroxenous, intracellular parasite; b) obligate, permanent, heteroxenous, intracellular parasite; c) obligate, temporary, monoxenous, intratissue parasite; d) obligate, permanent, heteroxenous, intradermal parasite.

13. Toxoplasma location in the human organism:

a) cells of small intestine epithelium; b) hepatic cells; c) red blood cells; d) myocardium, sceletal muscles, eyes.

14. Toxoplasma pathogenic action:

a) damages of large intestine epithelium ; b) may affect nervous system; c) may cause myocarditis; d) causes lymphadenopathy.

15. Methods of toxoplasmosis laboratory diagnosis:

a) culture of blood microscopy; b) complement fixation test; c) polymerized chain reaction - PCR; d) ELISA; e) indirect hemagglutination, indirect fluorescent antibody tests.

16. Social measures of toxoplasmosis prophylaxis:

a) revealing and treatment of the ill people; b) inspection of the pregnant women for toxoplasmosis; c) careful washing of the hands after contact with cats; d) avoid contamination of environment by cat faeces.

17. Systematic classification of balantidium:

a) ph. Sarcomastigophora, cl. Infusoria, sp. Balantidium coli; b) ph. Apicomplexa, cl. Ciliata, sp. Balantidium coli; c) ph. Protozoa, cl. Infusoria, sp. Balantidium coli; d) ph. Infusoria, cl. Ciliata, sp. Balantidium coli.

18. Epidemiological characteristics of Balantidium coli:

a) true, obligate, permanent, heteroxenous, intratissue and intracavitum parasite; b) true, obligate, permanent, intratissue parasite; c) true, obligate, permanent, intracellular parasite; d) true, obligate, permanent, intracutaneous parasite.

19. Balantidium location in the human organism:

a) small intestine; b) duodenum; c) large intestine; d) lymph.

20. Source of invasion in balantidiasis:

a) dog, jackal; b) pig, ill man; c) rodents; d) cattle.

21. Methods of balantidiasis laboratory diagnosis:

a) microscopy of faeces for trophozoites; b) microscopy of faeces for cysts; c) microscopy of sputum; d) microscopy of blood thick drop.

22. Social measures of balantidiasis prophylaxis:

a) revealing and treatment of the ill people and pigs; b) keeping of the meat preparation technology; c) keeping of personal hygiene rules; d) health education of a human, especially pig farmers.

23. Methods of pneumocystosis diagnosis:

a) microscopy of blood; b) microscopy of the bronchial lavage; c) ELISA; d) microscopy of sputum.

24. Location of Cryptosporidium parvum in organism of a human:

a) lungs; b) liver; c) blood; d) intestine.

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:

– "Blood smears from patient suffered tertian malaria" (900x).

The micropreparation is painted according to Romanovsky-Giemsa. The all stages of erythrocytic schizogony can find. The stage of early trophozoite is a ring-shaped form of the parasite, which forms 2-3 hours after penetration of merozoite into the erythrocyte. The vacuol is in the center. The circumference of the cytoplasm with the nucleus is located on the periphery. The nucleus and cytoplasm of the parasite gradually grows in size, the central vacuole shrinks and grains of the malarial pigment (a product of hemoglobin metabolism) appear in the stage of developing trophozoite. The parasite grows in size, the nucleus becomes large, amoeba-like outgrowths appear in the cytoplasm, the parasite is capable of movement in the late trophozoite stage. Grit appears in the cytoplasm of the erythrocyte. The parasite grows in size, the vacuole disappears in it, lumps of brown pigment appear in the cytoplasm of the parasite, the nucleus begins to divide into the early schizon stage. The erythrocyte increases in volume. The stage of the late schizon is a large parasite, it ends the division of the nucleus and cytoplasm into parts; daughter merozoite cells are formed (from 14 to 22), in between a bunch of pigments gather in a heap. The male gamont is a rounded cell with a pale blue cytoplasma color and a large diffusely colored nucleus located in the center of the cytoplasm. There is granularity in the cytoplasm of the parasite, as in the cytoplasm of the erythrocyte. The

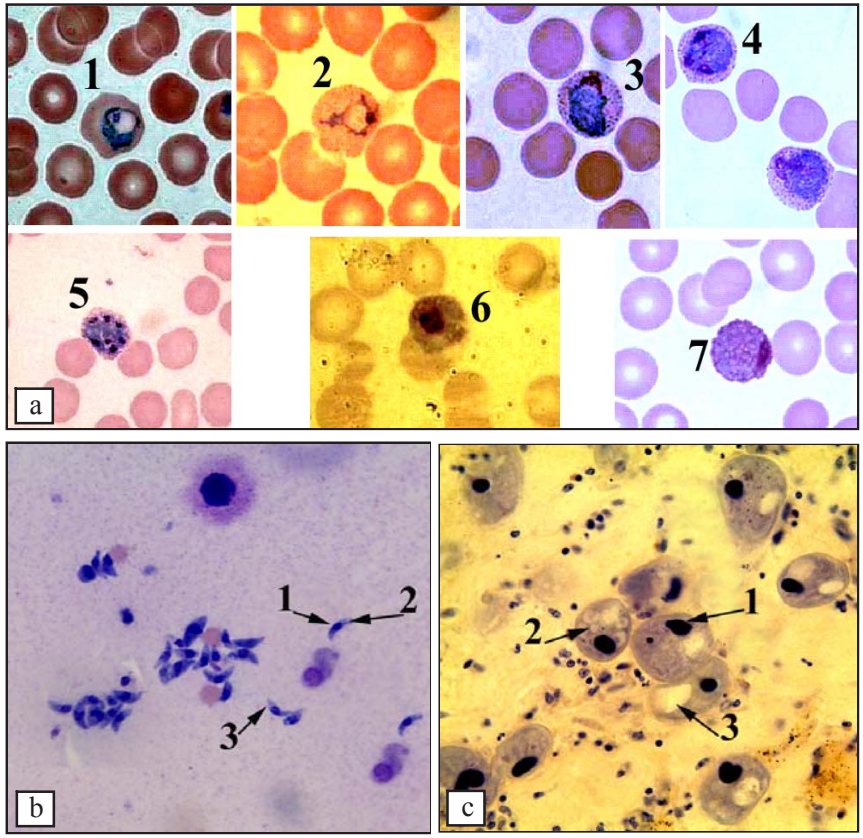


Fig. 18. Pathogenic protists from phylums Apicomplexa and Infusoria:
a - blood smears from patient suffered tertian malaria (1 - early trophozoite, 2 - developing trophozoit, 3 - mature trophozoit, 4 - early schizonte, 5 - late schizonte, 6 - female gamont, 7 - male gamont); b - Toxoplasma gondii (1 - nucleus, 2 - cytoplasm, 3 - pellicle); c - Balantidium in large intestine mucous coat (1 - macronucleus, 2 - vacuole, 3 - cytoplasm).

female gamont resembles that of a male, but its nucleus is smaller and located at the edge of the cytoplasm (Fig. 18a).

– "Toxoplasma gondii" (400x).

Parasites have a crescent shape. One end of the body is pointed, and the other is somewhat rounded. The nucleus is relatively large, it is colored ruby-red and the cytoplasm is blue. The nucleus is located in the center of the parasite and occupies 1 / 4-1 / 3 part of the body (Fig. 18b).

– "Balantidium in large intestine mucous coat" (280x).

Large parasites have an oval shape in the mucous villi. Large vegetative bean-shaped core and vacuole are visible well. The cytoplasm is colored pale pink (Fig. 18c).

CLASS [1] 25.
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.

Flatworms are very spread in nature. There are more than 7.300 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 is suspended in loose connective tissue - parenchyma. The musculo-cutaneus 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. The 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.

The 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, Diphyllobothrium latum, Tania soleum, Echinococcus granulosus) and contact helminthes (Hymenolepis nana).

The 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. The 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 - adolescariae. 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 phylum, particularities of morphology, development cycles, invasion ways for human, pathogenic influence of trematodes on human organism, prevention of diseases, caused by them. 2. To be able to diagnose exciters of fascioliasis, opisthorchiasis, paragonimiasis, 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 - exciters of human and animals diseases (liver fluke, cat fluke, lung fluke, blood flukes): 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.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 224–234.

Tests to check level of knowledge

1. The localization of Fasciola hepatica in human organism:
a) duodenum; b) large intestine; c) bile duct of liver; d) pancreas.
2. The pathogenic influence of Fasciola hepatica on human organism:
a) development of allergic reactions; b) mechanical and pressing action on liver parenchyma; c) obstruction of bile duct and development of icterus; d) development of hepatopancreatic syndrome.
3. Methods of fasciolesis laboratory diagnostics:
a) method of native smear; b) finding eggs in faece and duodenum fluid; c) flotation method; d) immunologic reactions.
4. Morphological characteristics of Fasciola hepatica eggs:
a) size 23-34 by 10-12 мм, asymmetric, brown with operculum on one pole; b) size 125-150 by 62-81 мм, oval, yellow, with operculum on one pole; c) size 120 by 50 мм, oval, yellow spine on the pole.
5. Measures of fasciolesis prevention:
a) revealing and treatment of the patients, kill ill animals and mollusks; b) use severage and wc; c) do not pasture cattle on field near reservoir; d) do not use water from natural lakes, do not use it to water and washing vegetables, berry's.
6. The localization of Opisthorchis felineus in human organism:
a) lungs and bronchi; b) liver and pancreas; c) bile duct, bile cyst; d) small intestine.
7. The pathogenic influence of Opistorchis felineus on human organism:
a) mechanical and pressing action on liver parenchyma and pancreas;

b) development of hepatopancreatic syndrome; c) development of allergic reactions; d) development of pneumonia.

8. Methods of laboratory diagnostics of opistorchosis:

a) method of deposit; b) finding eggs in rectum mucus; c) finding eggs in faece and duodenum; d) immunologic reactions.

9. Morphological characteristics of Opisthorchis felineus eggs:

a) size 23-34 by 10-12 мm, asymmetric, yellow, with operculum on one pole; b) size 80-118 by 48-60 мm, oval, yellow, on flat pole an operculum; c) size 40-50 by 15-20 мm, asymmetric, brown, with operculum on one pole.

10. Measures of opistorchosis prevention:

a) revealing and treatment of the patients, kill ill animals and mollusks; b) use severage and wc; c) measures for improvement of sanitary-hygienic condition of human life; d) don't eat no fully cooking fish.

11. The localization of Paragonimus ringeri, P. westermani in a human organism:

a) bile duct, bile cyst; b) liver; c) pancreas; d) lungs and bronchi.

12. The pathogenic influence of lung fluke on human organism:

a) development of allergic reactions; b) mechanical and pressing action on lung parenchyma; c) development of icterus; d) form cysts which going to bronchopneumonia, bronchoectasis, pneumosclerosis, lung abscesses.

13. Methods of laboratory diagnostics of paragonimosis:

a) method of native smear; b) finding eggs in faece; c) finding eggs in bronchial fluid; d) immunologic reactions.

14. Measures of paragonimosis prevention:

a) revealing and treatment of the patients, kill ill animals and mollusks; b) use severage and wc; c) observe technology of dish preparation from crayfish and crab; d) do not use in food bad thermal cooked crayfish and crab.

15. The localization of Schistosoma haematobium in human organism:

a) mesenteric veins; b) portal veins of liver; c) haemorroidae veins; d) urinary veins.

16. The pathogenic influence of Schistosoma haematobium on human organism:

a) development of allergic reactions; b) mechanical damage mucous membranes of urogenetal system, walls of blood vessels; c) breach of blood stream, arteriitis, splenomegalia; d) atrophia, ulceration, fibrosis, calcinacia of mucous cover of urinary bladder.

17. Methods of laboratory diagnostics of urogenetal schistosomiasis:

a) method of native smear and deposit; b) finding eggs in urine; c) cystoscopia with biopsy the tissue of urinary bladder; d) immunologic reactions.

18. Morphological characteristics of Schistosoma haematobium eggs:

a) size 120-160 by 50-70 мm, oblong, oval, yellow, spine on the pole; b) size 125-150 by 62-81 мm, oval, yellow, with operculum; c) size 23-34 by 10-12 мm, asymmetric, yellow, with operculum on one pole.

19. Measures of urogenetal schistosomiasis prevention:

a) revealing and treatment of the patients, kill ill animals and mollusks; b) use severage and wc; c) measures for improvement of sanitary-hygienic condition of human life; d) don't swim in reservoir where mollusks live.

20. The localization of Schistosoma mansoni in human organism:

a) small intestine; b) mesenteric veins; c) haemorrhoidal veins; d) portal veins of liver.

21. The pathogenic influence of Schistosoma mansoni, S. japonicum on human organism:

a) mechanical damage of skin, mucous cover, intestine, walls of blood vessels; b) development of allergic reactions; c) breach of circulation, arteritis, splenomegalia; d) atrophia, ulceration, fibrosis, calcinacium mucous cover of intestine.

22. Methods of laboratory diagnostics of intestinal schistosomiasis:

a) method of native smear and deposition; b) finding eggs in faece, rectal mucous, in bioptat of rectal mucous; c) finding eggs in phlegm; d) immunological reactions.

23. Morphological characteristics of Schistosoma mansoni eggs:

a) size 70-100 by 50-65 мm, oval, on lateral surface closer to pole small knob; b) size 80-118 by 48-60 мm, oval, yellow, an operculum on flat pole; c) size 130-180 by 60-80 мm, oval, asymmetric, lateral situated big sharp to pole spine.

24. Measures of Schistosoma mansoni, S. japonicum prevention:

a) revealing and treatment of the patients, kill ill animals and mollusks; b) use severage and wc; c) measures for improvement of sanitary-hygienic condition of human life; d) don't swim in reservoir where mollusks live.

Laboratory work:

I. Study the following macropreparations in museum: "Marita of Fasciola hepatica"; "Liver fascioliasis"; "Marita of Lung fluke; "Marita of cat liver fluke".

II. Study the following micropreparations:

– "Marita of Fasciola hepatica" (16x).

The parasite has a length of 3-5 cm, width - 1-1.5 cm. The body of the parasite is flat, in front of the expanded with a conical protrusion. The body gradually tapers towards the rear end. The oral sucker is located at the front end of the body. The abdominal sucker is behind the oral sucker. The

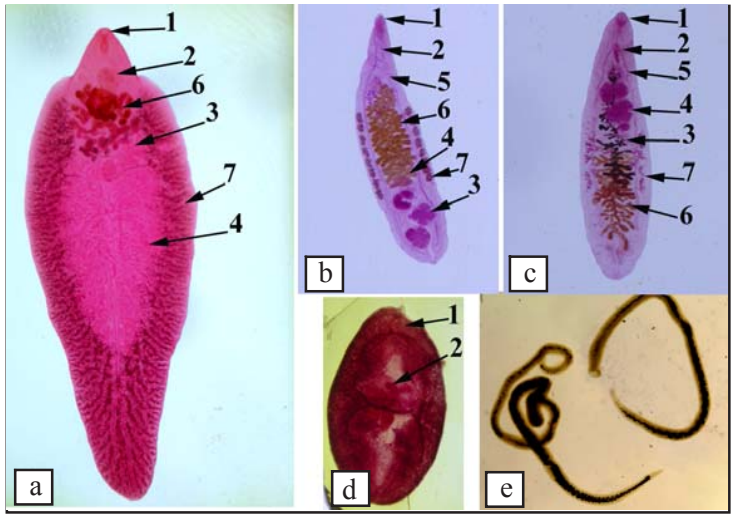


Fig. 19. Marits of mammals trematodes:
a - liver fluke; b - cat fluke; c - lanceolate fluke; d - pulmonary fluke; e - male (above) and female (below) of Schistosome Mansoni (1, 2 - oral and abdominal suckers, 3 - testicles, 4 - ovaries, 5 - intestinal branch, 6 - uterus, 7 - yolks).

uterus is located behind the abdominal sucker in the form of a crimped tube. The ovary is located next to the uterus. Testicles locate in the central part of the parasite's body (Fig. 19a).

– "Marita of Opisthorchis felineus" (16x).

The parasite is 10-12 mm long. The body is elongated. At the anterior end, the oral sucker, the pharynx, the short esophagus and the two branches of the intestine, running parallel to the sides of the body to the posterior end, are clearly visible. The abdominal sucker is located in the anterior third of the body; behind it is the uterus, ovaries and testicles (Fig. 19b).

– "Marita of Lung fluke" (16x).

The parasite has a length of 1.5 cm. It has a characteristic ovoid shape. The oral sucker is located at the front end of the body, and the abdominal - almost in the middle of the body. The multi-lobed ovary and uterus are located in the middle part of the body, behind the abdominal sucker (Fig. 19d).

– "Marita of Schistosoma Mansoni" (16x).

The parasite is dioecious. The male body is wider and shorter (6-13 mm) than the female (7-17 mm). On the ventral side of the male there is a groove (gynecophoric canal) in which the female lies (Fig. 19e).

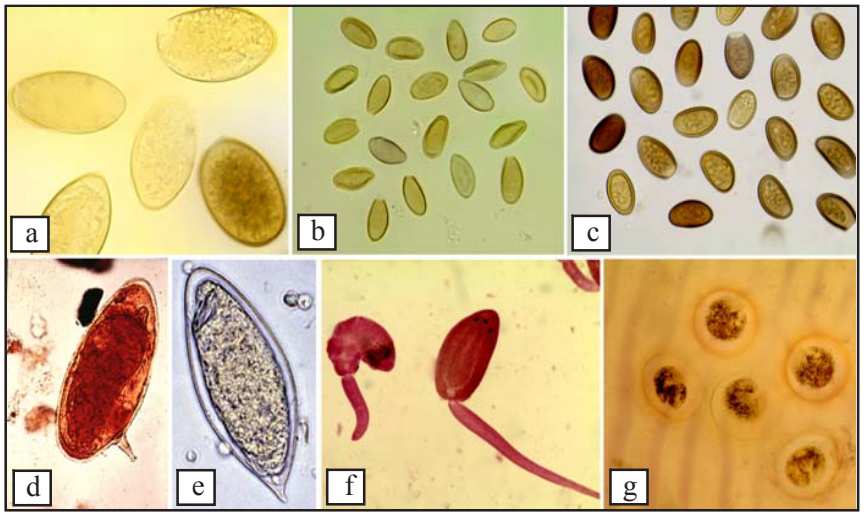


Fig. 20. Eggs and larvae of mammal trematodes:
a - eggs of Fasciola hepatica; b - eggs of Opisthorchis felineus; c - eggs of a lanceolate fluke; d - eggs of Schistosoma Mansoni; e - eggs of Schistosoma haematobium in uterus cervical mucous coat; f - cercaria of liver fluke; g - metacercaria of Opisthorchis felineus in fish scale.

– "Eggs of Fasciola hepatica" (280x).

Eggs are large, yellow-brown, oval-shaped. Cover is easily visible at one of the poles. The size of the egg is 125-150x62-81 мм (Fig. 20a).

– "Eggs of Opisthorchis felineus" (280x).

Eggs are oval, yellowish in color. There is a cover at the front end. These are the smallest eggs, whose sizes are 26-30x10-15 мм (Fig. 20b).

– "Eggs of Schistosoma Mansoni" (280x);

The egg has a yellowish-brown shell with a spike on the side. The egg is elongated in length, sizes 144-175x45-68 μm (Fig. 20d).

– "Eggs of Schistosoma haematobium in uterus cervical mucous coat" (56x).

Pay attention to the shape of the egg, the location of the spike on its vegetative pole (Fig. 20e).

– "Cercaria of liver fluke" (56x). Find the head and tail sections of the cercaria (Fig. 20f).

– "Metacercaria of Opisthorchis felineus in fish scale" (56x). (Fig. 20 g).

CLASS [1] 26.
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, bothriae 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.

The 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.

The excretory system is presented by protonephrids. Main protonephridic trunks are on a both sides of the body.

The nervous system is presented by scolex ganglion and two nervous cords, which extend throughout the body.

The 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.

The 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 cestodiases. 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, prevention of diseases, caused by them. 2. To be able to diagnose exciters of teniasis, teniarhynchiasis, diphyllobothriasis, 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, dwarf tapeworm): geographical distribution, development, invasion ways for human; methods of laboratory diagnosis (macroscopic and microscopic, immunological); measures of individual and social prevention of diseases, caused by them.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 234–242.

Tests to check level of knowledge

1. Taeniids location in a human organism:

a) liver, pancreas; b) bile ducts; c) small and large intestine; d) larva in eye, hurt, muscles.

2. Features of T. saginatus gravid segment structure:

a) it contains only uterus with 7-12 pairs of fateral branches; b) ovary has 3 lobes; c) it contains only uterus with 17-35 pairs of lateral branches; d) ovary has 2 lobes.

3. Features of T. solium gravid segment structure:

a) it contains only uterus with 7-12 pairs of lateral branches; b) ovary has 3 lobes; c) ovary has 2 lobes; d) male reproductive organs are reduced.

4. Features of T. saginatus mature segment structure:

a) the ovary has 3 lobes; b) it contains only uterus with 17-35 pairs of lateral branches; c) the ovary has 2 lobes; d) it contains only uterus with 7-12 pairs of lateral branches.

5. Features of T. solium mature segment structure:

a) the ovary has 3 lobes; b) it contains only uterus with 17-35 pairs of lateral branches; c) the ovary has 2 lobes; d) it contains only uterus with 7-12 pairs of lateral branches.

6. Pathogenesis of taeniids:

a) damage of a intestine mucosa; b) intestinal mechanoreceptors irritation; c) allergic reactions development; d) nutrients loss.

7. Methods of taeniids diagnosis:

a) immunological methods; b) detection of gravid and mature segments in faeces; c) eggs detection in duodenal juice; d) microscopically detection of the eggs in sputum.

8. Characteristics of taeniids eggs:

a) sizes 28-44 x 28-36 мм, spherical, colorless, with thick shell; b) sizes 125-150 x 62-81 мм, oval, yellow, with operculum on one of poles; c) sizes 130-180 x 60-80 мм, lengthened, yellowish, with large spine.

9. Personal measures of taeniids prevention:

a) avoid consumption of suspicious and non-inspected meat; b) consume only well-cooked meat; c) maintain personal hygiene; d) effective treatment for affected persons.

10. The location of Diphyllobothrium latum in a human organism:

a) small intestine; b) large intestine; c) skeletal muscles; d) liver, pancreas.

11. Features of fish worm gravid segment:

a) it contains only uterus with 17-35 pairs of lateral branches; b) it is wide and contains rosette-like uterus; c) it contains ovary with 3 lobes; d) it contains ovary with 2 lobes.

12. Pathogenesis of fish worm:

a) weight loss; b) gastro-intestinal disturbances; c) anemia development; d) vitamin B_{12} deficiency.

13. Methods of diphyllobotriasis diagnosis:

a) macroscopic identification of proglottides in faeces; b) microscopic demonstration of eggs in duodenal juce; c) microscopic identification of

eggs in faeces; d) microscopically detection of the eggs in urine.

14. Characteristics of fishworm eggs:

a) sizes 28-44 x 28-34 мм, spherical, colourless, with thick shell; b) sizes 70-83 x 50-54 мм, oval, yellow, on one of poles operculum is located; c) sizes 125-150 x 62-81 мм, oval, yellow, with operculum.

15. Personal measures of diphyllobotriasis prevention:

a) revealing and treatment of ill people and animals; b) cyclopes eradication; c) rules of personal hygiene keeping; d) the fish should be cooked thoroughly before meal.

16. The location of Echinococcus granulosus in organism of a human:

a) intestine; b) liver, lungs; c) brain; d) tubular bones.

17. The pathogenic influence of Echinococcus granulosus on a human organism:

a) damage of intestine mucosa; b) dystrophy and atrophy of inner organs parenchyma; c) allergic reactions; d) vessels obliteration.

18. Methods of laboratory diagnosis of echihococcosis:

a) microscopically detection of eggs in faeces; b) intracutaneous Casoni's test; c) hemagglutination test, IFA test; d) ELISA.

19. Characteristics of echinococcus eggs:

a) sizes 40 x 35 мм, oval, dark yellow, with thick shell; b) sizes 28-44 x 28-34 мм, spherical, colourless, with thick shell; c) sizes 23-34 x 10-19 мм, asymmetric, yellow, with operculum on one of poles.

20. Personal measures of echinococcosis prevention:

a) destruction of stray dogs; b) keeping of personal hygiene rules after contact with dog; c) preventive worm treatment of pets; d) do not allow domesticated dogs to do out and eat carcasses of dead animals.

21. The localization of Hymenolepis nana in a human organism:

a) intestine; b) liver; c) brain, tubular bones; d) lungs.

22. The pathogenic influence of Hymenolepis nana on a human organism:

a) destruction of intestine mucosa, development of necrotic processes in intestine; b) development of allergic reactions; c) development of jaundice; d) development of bronchitis and pneumonitis.

23. Methods of hymenolepiasis laboratory diagnosis:

a) eggs determination in urine; b) immunological methods; c) detection of segments in faeces; d) faeces examination for the eggs.

24. Characteristics of dwarf tapeworm eggs:

a) sizes 23-34 x 10-19 мм, dissymmetric, yellow, with operculum on one of poles; b) sizes 45 x 37 мм, oval, with the thick transparent and colourless shell; c) sizes 70-100 x 50-65 мм, oval, yellow, with the transparent shell, posess spine.

25. Measures of hymenolepiasis social prevention:

a) revealing and treatment of the patients; b) careful wet sweeping of children's rooms, sterilization of toys; c) regular inspections in children's collectives for detection of affected persons; d) keeping of personal hygiene rules.

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 Diphyllobothrium latum"; "Liver echinococciasis"; "Multilocular hydatid lesion of liver"; "Larva of Diphyllobothrium eurinacei europei"; "Adult form of Drepanidotaenia lanceolata"; "Adult form of Mniesia 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:

– "Scolexs of Taenia solium and Taeniarhynchus saginatus" (16x).

The head of the pork tapeworm is about 1 mm in size. It has four suckers and, on the proboscis, a crown of one row of hooks of two sizes (Fig. 21a). The head of bovine tapeworm is about 1.5-2 mm in size. It has four muscle suckers and a rudimentary proboscis whithout hooks (Fig. 21d).

– "Gravid proglottides of Taenia solium and Taeniarhynchus saginatus" (16x).

The gravid proglottides of the pork tapeworm have three lobes of the ovary (Fig. 21b). The gravid proglottides of the bovine tapeworm is similar to the previous one, but differs in that the ovary contains only two lobes (Fig. 21e).

– "Mature proglottide of Taenia solium and Taeniarhynchus saginatus" (16x).

The mature proglotid of the pork tapeworm is twice as long as its width. There is only one branched uterus with 8-12 lateral branches. The uterus with invasive eggs does not have an outflow (Fig. 21c). The length of the mature proglotid of a bovine tapeworm is much greater than the width. The uterus with eggs has 17-32 lateral branches (Fig. 21f).

– "Eggs of teniids" (280x).

Eggs are rounded, with three shells. The size of the egg is 28-44 x 28-38 мм (Fig. 22a).

– "Eggs of Diphyllobothrium latum" (280x).

The eggs are oval-shaped, yellow-brown in color, and there is a cover

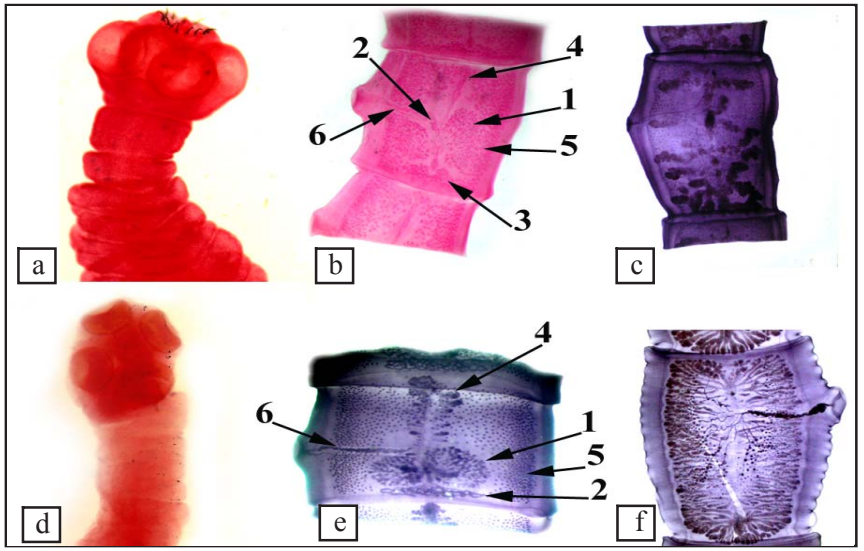


Fig. 21. Morphological features of pork and bovine tapeworms:
a, d - scolexs of tapeworms; b, e - gravid proglottides of tapeworms (1 - ovary, 2 - additional third lobe of the ovary, 3 - yolks, 4 - uterus, 5 - testicles, 6 - seminal duct); c, f - mature proglottides.

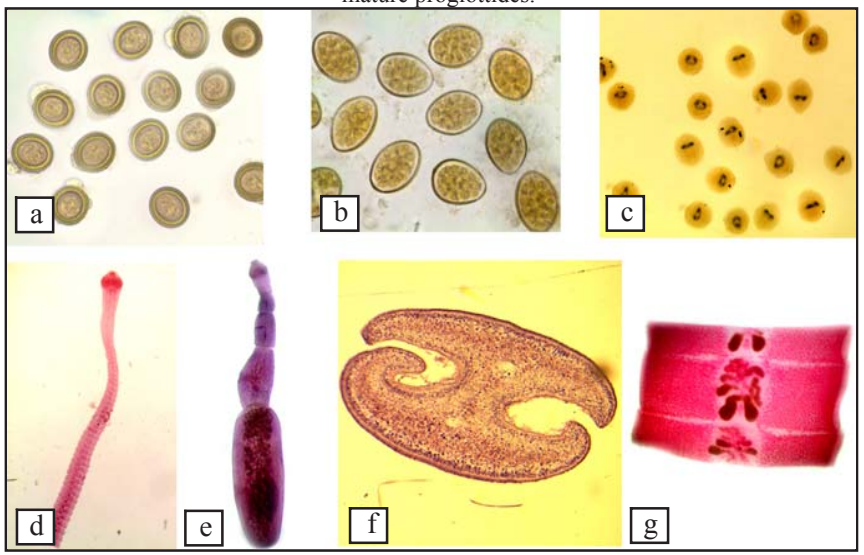


Fig. 22. Morphological features of cestodes:
a - eggs of teniid (pork and bovine tapeworms); b - eggs of fish tapeworm; c - scolexes of Echinococcus granulosus from brood capsule; d - dwarf tapeworm; e - echinococcus; f - cross section of Diphyllobothrium latum; g - mature proglottide of Diphyllobothrium latum.

on one of the poles. The size of the egg is 70-83 x 50-54 μm (Fig. 22b).

– "Scolexes of Echinococcus granulosus from brood capsule" (56x).

Larval scolex of oval shape with the size of 143-159 x 98-123 μm. There is a halo of hooks on the scolex (Fig. 22c).

– "Adult form of Hymenolepis nana" (16x).

Find scolex, suckers, whisk hooks, strobiles, proglottids (Fig. 22d).

– "Adult form of Echinococcus granulosus" (16x).

Find the scolex, suckers, whip of hooks, strobe, proglottids (Fig. 22e).

– "Cross section of Diphyllobothrium latum" (56x).

Find bothria (Fig. 22f).

– "Mature proglottide of Diphyllobothrium latum" (16x);

Pay attention to the shape of the segment and the rosette uterus (Fig. 22g).

CLASS [1] 27. ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM NEMATHELMINTHES, CLASS NEMATODA

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 Nemathelminthes 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 longitudinate muscles pull both against the cuticle and against the pseudocoel. The digestive system is made of an 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. The nervous system is presented parapharyngeal nerve circle and nerve cord extended from it. These cords are connected by commisuras. Sense organs are presented by touch feeling cells and by cells percepting chemicals. Reproductive organs have tubular shape. In female they are coupled. The male reproductive system is presented by testicles and sperm duct that enter terminal intestine. The 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.

The 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, Toxocara canis, Strongyloides stercoralis), biohelminthes (Trichinella spiralis, dirofilaria) and contact helminthes (Enterobius vermicularis).

Purposes of class: 1. To know characteristics of Nemathelminthes phylum and Nematoda class: geographical distribution, particularities of morphology, development cycles, invasion ways for human, pathogenic influence of round worms on human organism and prevention of diseases, caused by them. 2. To be able to diagnose exciters of ascariasis, trichuriasis, toxocarosis, strongyloidosis, enterobiasis, trichinosis, dirofilariasis. 3. To be acquainted with main clinical symptoms of diseases, caused by nematodes.

Questions:

1. Nemathelminthes phylum, its general characteristic and classification.
2. Nematoda class, adaptations to parasitism. Epidemiologic classification of nematodes.
3. The most important representatives of Nematoda class exciters of human diseases (Ascaris lumbricoides, Trichocephalus trichiurus, Strongyloides stercoralis, Toxocara canis, Enterobius vermicularis, Trichinella spiralis, dirofilariasis): 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.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 243–255.

Tests to check level of knowledge

1. The localization of Ascaris lumbricoides in a human organism:

a) large intestine; b) small intestine; c) serous cavities; d) skeleton

muscles.

2. The pathogenic influence of Ascaris lumbricoides on human organism:

a) atrophy and dystrophy changes in liver, lungs; b) breach of digestive function; c) avitaminosis, decrease of host nutrition; d) development of allergic and stress reactions.

3. Methods of laboratory diagnostics of ascariasis:

a) method of native smear and flotation; b) finding imaginal forms in faeces and eggs; c) finding larvae in sputum; d) immunological reactions.

4. Characteristics of Ascaris lumbricoides eggs:

a) size 125-150 by 62-81 мм, oval, yellow, with cover; b) size 40 by 35 мм, oval, dark-yellow, with cover; c) size 50-70 by 40-50 мм, oval, with thick, multilayer membrane, trabecular.

5. Measures of ascariasis prevention:

a) revealing and treatment of the patients; b) kill ill animals; c) use severage and wc; don't use fresh stool for ground agriculture; d) kill flies and cockroaches; e) washing vegetables, berry's; wash hands after work with soil.

6. The localization of Trichocephalus trichiurus in human organism:

a) small intestine; b) large intestine; c) the beginning part of large intestine; d) larva – in liver, lungs.

7. The pathogenic influence of Trichocephalus trichiurus on a human organism:

a) breach of digestive function; b) development of B_{12}- deficit anaemia; c) damage of mucous, development of haemorrhage, erosion, ulcer; d) development of allergic and stress reactions.

8. Methods of Trichocephalus trichiurus laboratory diagnostics:

a) finding imaginal forms in faece; b) finding eggs in faece; c) immunological reactions.

9. Characteristics of Trichocephalus eggs:

a) size 70-83 by 50-54 мм, oval, yellow, on one pole – cover on other - bump; b) size 50-54 by 22-23 мм, tublike form, yellow, with limpid thick membrane, with cavities on poles; c) size 45 by 35 мм, oval, with thick and colourless membrane.

10. Measures of Trichocephalus trichiurus prevention:

a) kill ill animals; b) revealing and treatment of the patients; c) use severage and wc; do not use fresh faece for ground agriculture; d) kill flies and cockroaches; e) washing vegetables, berry's; wash hands after work with soil.

11. The localization of Strongyloides stercoralis in human organism:

a) the beginning part of large intestine; b) proximal parts of small intestine; c) small intestine; d) lower part of large intestine.

12. The pathogenic influence of Strongyloides stercoralis on human organism:

a) development of allergic reactions; b) development of haemorrhages, erosions, ulcers in gaster, intestine; c) damages of lungs, liver, pancreas, myocardium; d) discenensia of bile cyst and its ducts.

13. Methods of laboratory diagnostics of strongyloidosis:

a) finding eggs in fresh faece; b) finding rhabditiform larvae in faece and duodenal fluid; c) Berman, Schylman methods; d) immunological reactions.

14. Characteristics of Strongyloides stercotalis eggs:

a) size 50-60 by 20-30 мм, asymmetric with one side curved outside and the other flat; b) size 50-70 by 40-50 мм, oval, membrane is multilayer, thick, trabecular; c) size 5,8 by 3-3,4 мм, oval, yellow.

15. Measures of strongyloidosis prevention:

a) revealing and treatment of the ill patients; b) inspection of new workers in mine, on tea plantations, citrus plants, rice field; c) use severage and wc; do not use fresh stool for ground agriculture; d) washing vegetables, berry's; wash hands after work with soil.

16. The localization of Enterobius vermicularis in a human organism:

a) the beginning part of small intestine; b) lower part of small intestine; c) the beginning part of large intestine; d) lower part of large intestine.

17. The pathogenic influence of Enterobius vermicularis on human organism:

a) development of allergic and stress reactions; b) damage of intestine mucous, catarrhal changes; c) appendicitis, development of vaginitis; d) exematic damages of skin of perianal area.

18. Methods of laboratory diagnostics of enterobiosis:

a) finding in faeces imaginal forms; b) finding eggs in perianal area; c) method of native smear and flotation; d) immunological reactions.

19. Characteristics of Enterobius vermicularis eggs:

a) size 50-60 by 20-30 мм, asymmetric with one side curved outside and the other flat; b) size 50-70 by 40-50 мм, oval, membrane is multilayer, thick, trabecular; c) size 50 by 30 мм, oval, yellow.

20. Measures of Enterobius vermicularis prevention:

a) revealing and treatment of the patients; b) prevention inspection of children in kindergartens, schools, workers of food industry; c) moisture cleaning; d) keeping the rules of personal hygiene.

21. The localization of Trichinella spiralis in a human body:

a) mature stage - in intestine; b) mature worms - in bile ducts; c) larval stage - in intestine; d) larval stage - in striated muscles.

22. The pathogenic influence of Trichinella spiralis on a human organism:

a) injury of intestinal mucosa; b) lymphangites; c) muscular dystrophy; d) development of vitamin B_{12}- deficiency anemia.

23. Methods of trichinosis laboratory diagnosis:

a) eggs detection in faeces; b) biopsy of skeletal muscles; c) immunological methods: IFA test, ELISA; d) immunological methods: hemagglutination, complement fixation tests.

24. Measures of trichinosis prevention:

a) rats destruction; b) careful inspection of meat at slaughterhouse; c) proper disposal of the night-soil; d) avoidance of eating raw or imperfectly cooked pig's flesh.

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:

– "Cross section of Ascaris lumbricoides" (56x).

The parasite on the cross-section has a rounded shape. Outside the body is covered with a cuticle, under which lie the longitudinal muscles surrounding the primary body cavity. In the cavity are located the intestine, formed by a single layer of epithelial cells, numerous sections of the ovaries and two transverse sections of the uterus. On the sides of the dermal-muscular sac are the dorsal and ventral nerve trunks and the lateral channels of the protonephridia (Fig. 23a).

– "Female and male of Enterobius vermicularis" (16x).

The pinworm is a small white worm. The length of females is about 10 mm, males - 2-5 mm. The rear end of the male is spirally twisted (Fig. 23b).

– "Female and male of Trichocephalus trichiurus" (16x).

The whipworm is 3-5 cm long. The head end is much thinner than the back and filiform elongated. The rear end of the male is spirally twisted (Fig. 23c, d).

– "Eggs of Ascaris lumbricoides" (280x).

Eggs can be fertilized and unfertilized. The fertilized egg is oval in shape with a thick multi-layered shell (Fig. 27a). The outer shell is hilly, yellow-brown in color. Inside the egg, a spherical blastomere occupies a central position. The size of the egg is 50-70 x 40-50 мм. An unfertilized egg is elongated. The egg is filled with yolk cells. The size of the egg is 50–100 x

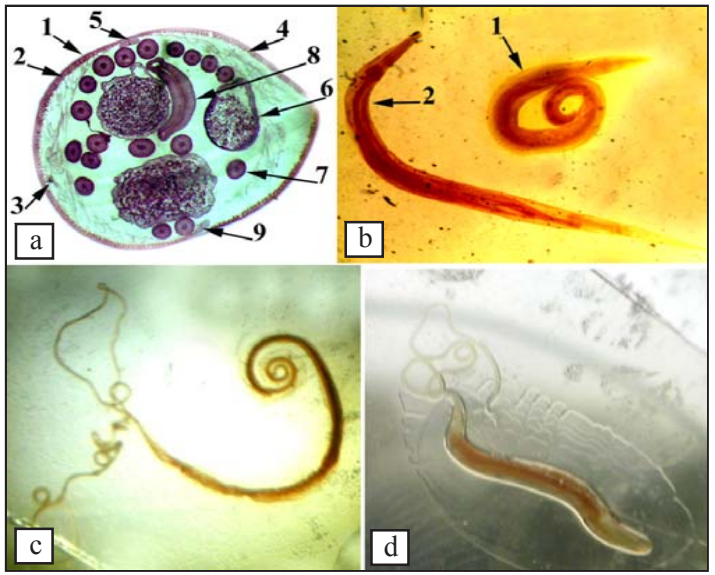


Fig. 23. Mature forms of nematodes:
a - cross-section of A. lumbricoides (1 - cuticle; 2 - hypoderm; 3 - channel of the excretory system; 4 - muscles; 5, 9 - nerve trunks; 6 - uterus; 7 - ovary; 8 - intestine); b - male (1) and female (2) pinworms; c - male of T. trichiurus; d - female of T. trichiurus.

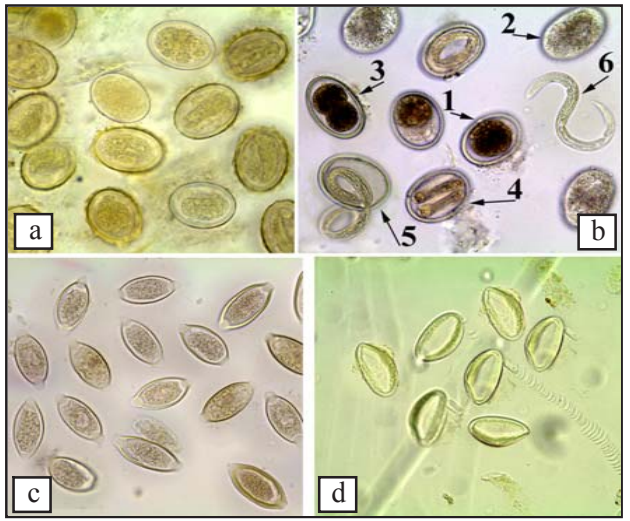


Fig. 24. Nematode eggs:
a - eggs of A. lumbricoides; b - ascaris eggs at different stages of maturation (1 - fertilized, 2 - unfertilized; 3 - stage of two blastomeres, 4 - mature, 5 - release of the larva from the egg, 6 - larva of the roundworm); c - eggs of T. trichiurus; d - eggs of pinworm.

40-50 μm (Fig. 24b).

– "Eggs of Trichocephalus trichiurus" (280x).

The egg is barrel-shaped, with a thick shell of yellow-brown color. At the poles cork formation. Inside the egg is filled with fine-grained contents. The size of the egg is 50-54 x 22-23 μm (Fig. 24c).

– "Eggs of Enterobius vermicularis" (280x).

Eggs have oval asymmetric shape. One side is convex, the other is flattened. The shell is smooth, multi-layered, colorless. Inside the egg is an embryo at different stages of development. The size of the egg is 50-60 x 20-30 μm (Fig. 24d).

– "Adult form of Trichinella spiralis, female (280x)".

The parasite reaches a length of 2.6-3.6 mm. at a thickness of up to 30 мм (Fig. 25a).

– "Larvae of Trichinella spiralis in muscles (280x)".

The micropreparation is a section of the muscle tissue of a patient with trichinosis. Among muscle fibers with inflammatory infiltration, trichinella larvae are seen in capsules (Fig. 25b).

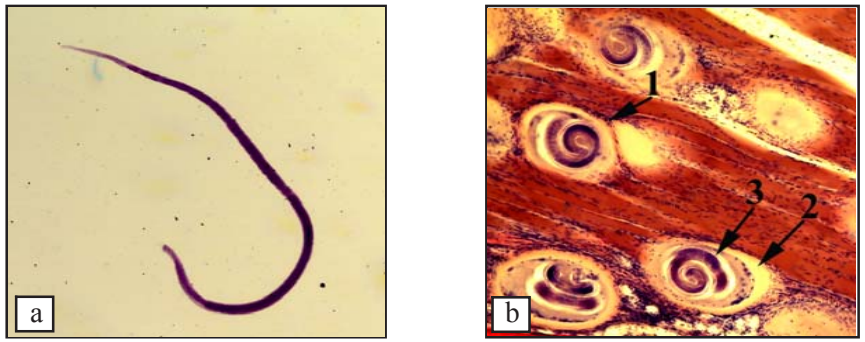


Fig. 25. Morphological features of nematodes:
a - female trichinae; b - trichinae larvae in muscles (1 - leukocyte tissue infiltration, 2 - capsule around the larva, 3 - folded larva).

CLASS [1] 28. ECOLOGICAL ASPECTS OF PARASITISM IN PHYLUM ARTHROPODA, CLASSES CRUSTACEA AND ARACHNOIDEA

The arachnoenthomology is division of medical parasitology, which studies representatives of Arthropoda phylum as ectoparasite, endoparasites and vectors of human disease exciters.

Arthropoda is most successive phylum of all living animals in term of number of individuals and species.

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 Diphyllobothrium latum, Dracunculus medinensis, Paragonimus westermani. Therefore, in the name of the division there are names of Arachnidans and Insects only.

The 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 (cephalothorax). 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 are silk glands and poison gland. It is 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 openning). 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 modificated metanephridia. Many species form special Malpigian 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 longitudinate 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. They may parasite on birds, mammalians and human being. They can be vectors of transmissive diseases. The important families of Order Acari are Ixodidae, 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), Thyroglyphidae family; their morphological and biological particularities, medical value. Measures used against mites and ticks.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 255–261.

Tests to check level of knowledge

1. The medical value of lower Crustaceans:

a) vectors of tularemia, encephalitis; b) intermediate hosts for Diphyllobothrium latum, Dracunculus medinensis; c) intermediate hosts for Paragonimus westermani.

2. Ways of invasion human by arachnoidea:

a) through undamaged skin; b) inoculation; c) contamination; d) transovarial.

3. Examples of vector of infectional disease like specific inoculation:

a) Ixodes ricinus - vector for West-European encephalitis virus, tularemia; b) Sarcoptes scabiei - vector of scabies; c) Glossina palpalis - vector of Trypanosoma gambience.

4. Examples of vector of invasion diseases the specific contamination way:

a) mosquitoes of Phlebotomus genus – Leishmania tropica; b) bugs of Reduviidae family – Trypanosoma cruzi; c) Dermacentor pictus – agent of taiga encephalitis virus and tularemia.

5. Morphological features of Ixodidae family:

a) have shield on the dorsal surface, eyes; b) the oral apparatus is visible from dorsal side, hooklets and suckering pillows; c) the body·s sides are scalloped; d) red colour of the body.

6. The medical value of Ixodes ricinus:

a) temporal ectoparasite; b) vector of taiga encephalitis virus; c) vector of Omsks hemorrhagic fever virus, tularemia; d) vector of West-European encephalitis virus, chronic migrate erythema, tularemia.

7. The medical value of Ixodes persulcatus:

a) temporal ectoparasite; b) vector of taiga encephalitis virus; c) vector of tularemia, brycellosis.

8. The medical value of Dermacentor pictus:

a) vector of taiga encephalitis virus; b) vector of Omsks hemorrhagic fever virus, spotted Rocky Mountains fever virus; c) temporal ectoparasite.

9. The localization of Sarcoptes scabiei in human organism:

a) cavities and ducts of sebaceous glands; b) hair follicles; c) border of horn and malpige layers of a skin of fingers intervals, inguinal area, bottom of a stomach.

10. The pathogenic influence of Sarcoptes scabiei on human organism:

a) obstruction of hair follicle, disturb functions of sebaceous gland; b) pus pimple; c) destroyment of skin integrity, rash appearance with itch; d) development of pyodermit.

11. Methods of scabies laboratory diagnostics:

a) finding mite in pimple contents and from pus pimple; b) finding mite in scrapes of skin from pus pimple; c) immunologic reactions.

12. Measures of scabies prevention:

a) revealing and treat ill people; b) kill ill animals; c) sanitary control over hostels; d) do not use somebody's else clothes.

13. The medical value of Demodecidae family:

a) agent of trombidiosis; b) agent of demodecosis; c) vector of European encephalitis, chronic migrative erythema; d) spoil of food.

14. Places of Demodecidae mites parasite:

a) epidermis of skin; b) hair follicles; c) cavity and ducts of oil glands; d) sweat glands.

15. Morphological features of Demodecidae family:

a) have dorsal shield, oral apparatus is visible from ventral side; b) worm-like body; c) thin short limbs with small hooks; d) edge of the body has wide rant.

16. Laboratory diagnostics of demodecosis:

a) microscoping of pus contents in drop of 50% glycerin solution; b) microscoping of muscle byoptat; c) immunologic reactions.

17. Measures of demodecosis prevention:

a) revealing and treat ill people; b) kill ill animals; c) sanitary control over hostels; d) do not use somebody's else clothes.

18. The medical value of Tyroglyphidae family:

a) spoil of food; b) vector of tularemia, brycellosis; c) the food infected by such mites can cause irritation in digestive tract and it can be allergic.

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:

– "Dog tick (male and female)" (16x).

The tick has an oval body, on the dorsal side there is a shield, which in

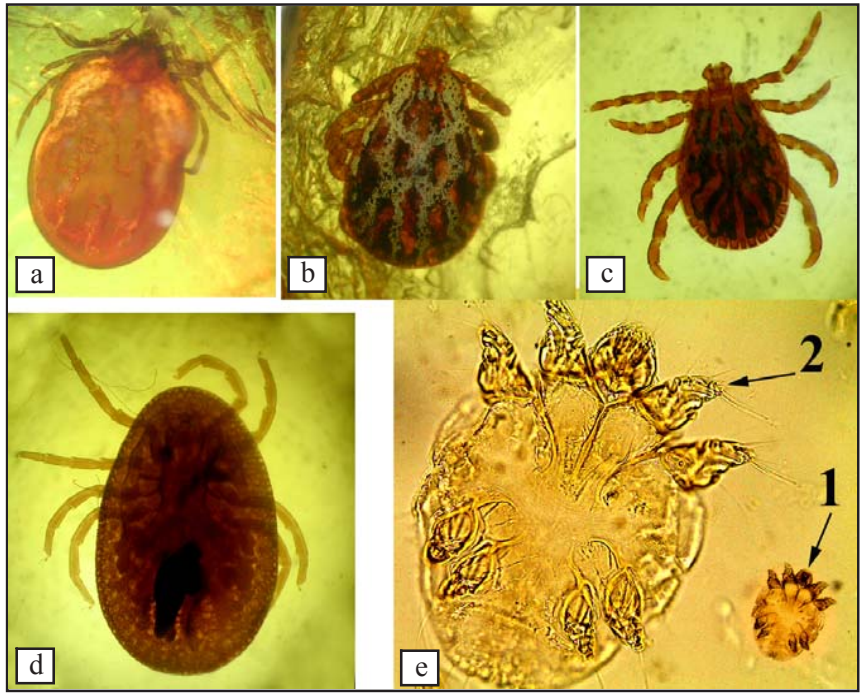


Fig. 26. Mites - parasites of mammals:
a - dog tick; b, c - male and female tick dermacentor; g - village mite;
d - scabby itch (1 - increase 56x, 2 - increase 280 x).

males covers the entire dorsal side, and in females only the front part. The body of the male is covered with chitinous plates from the ventral side, which the females do not have. There are four pairs of articulated limbs in adult ticks (Fig. 26a).

– "Tick from Dermacentor genus (male and female)" (16x).

The tick shield of the dermacentor is decorated with an enamel pattern. In males, it covers the entire surface of the body from the dorsal side, and in females it covers only the anterior third (Fig. 26 b, c).

– "Itch mite" (56x).

The body of the tick is oval, folded, bears on itself a number of scales and long bristles directed backwards. Limbs shortened six-segmented. Females are larger than males (Fig. 26d).

CLASS [1] 29.
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 Malpigian tubules and "yellow body" (accumulation kidney). The Malpigian tubules 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 dissimilation 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 bitted 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, those 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 cockroachs.
3. Hemiptera order. Particularities of morphology and biology. Medical value of bed chinch and kissing chinches.
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, Muscidae.
7. Measures of fight against insects having medical value.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 262–270.

Tests to check level of knowledge

1. Morphological features of Pediculus humanus capitis:

a) deep clippings on edges of the body; b) the expressed pigment spots on edges of abdomen; c) size: 2-4 mm; d) size: 5-7 mm.

2. Morphological features of Pediculus humanus humanus:

a) deep clippings on edges of the body; b) flattened clippings on edges of the body; c) size: 2.1-4.8 mm; d) size: 2-4 mm.

3. The medical value of head and body lice:

a) originators of phthiriasis; b) vectors of brucelliasis and tularemia; c) originators of pediculosis; d) vectors of typhoid.

4. Morphological features of Phthirus pubis:

a) size: 4-5 mm; b) size: 1-2 mm; c) trapezoid shape of body which is supplied with long hair on abdomen edges; d) it has not proboscis.

5. The medical value of Phthirus pubis:

a) temporary ectoparasite; b) the originator of pediculosis; c) the

originator of phtiriasis; d) vector for spotted fever and relapsing fever.

6. The medical value of Cimex lectularius:

a) specific vector for Trypanosoma cruzi; b) temporary ectoparasite; c) mechanical vector for typhoid, cholera; d) mechanical vector for eggs of helminthes and cysts of protozoa.

7. The medical value of kissing bugs:

a) specific vectors for Trypanosoma cruzi; b) specific vectors for Trypanosoma gambiense; c) vectors for tularemia and brucelliasis; d) temporary ectoparasites.

8. The medical value of cockroaches:

a) permanent ectoparasites; b) mechanical vectors for typhoid, cholera, dysentery; c) mechanical vectors for protozoa's cysts and helminthes eggs; d) specific vectors for typhoid infection.

9. The medical value of fleas:

a) temporary ectoparasites; b) vectors for plague, brucelliasis, murine typhus; c) vectors for cholera, abdominal typhoid; d) vectors for classic typhus, flood typhus.

10. Morphological features of Anopheles mosquitoes male:

a) it possesses pilose hair in the antennae, mandibular palps length is 1/3 - 1/4 of proboscis length; b) it possesses pilose hair in the antennae, length of palps and length of proboscis are equal; c) it possesses plumose hair in the antennae, anterior segment of palps is thicken.

11. Morphological features of the Culex mosquitoes male:

a) it possesses pilose hair in the antennae; b) it possesses plumose hair in the antennae, anterior segment of palps is thicken; c) it possesses pilose hair in the antennae, length of palps and proboscis length are equal; d) it possesses plumose hair in the antennae, palps are longer than proboscis.

12. Morphological features of the Anopheles mosquitoes female:

a) it possesses plumose hair in the antennae, mandibular palps length and proboscis length are equal; b) it possesses pilose hair in the antennae, palps length and proboscis length are equal; c) it possesses plumose hair in the antennae, anterior segment of palps is thicken.

13. Morphological features of Culex mosquitoes female:

a) it possesses pilose hair in the antennae, mandibular palps length is 1/3 - 1/4 of proboscis length; b) it possesses pilose hair in the antennae, palps length and proboscis length are equal; c) it possesses plumose hair in the antennae, palps length and proboscis length are equal.

14. Features of Culex and Aedes mosquitoes larva:

a) there is respiratory siphon in the porterior but one body's segment; b) respiratory siphon is conical; c) respiratory siphon is absent; d) it lies vertically to the surface of water.

15. Features of Anopheles mosquito's larvae:

a) respiratory siphons have cylindrical shape; b) respiratory siphons are absent; c) stigmas are located on posterior but one segment of the body; d) they lie parallelly to the surface of water.

16. Features of Anopheles mosquitoes pupae:

a) respiratory tubes are absent; b) respiratory tubes are cylindrical; c) respiratory tubes are conical; d) they have siphon on the posterior but one segment of the body.

17. Features of Culex mosquito's pupae:

a) stigmas are located on the posterior but one body's segment; b) respiratory tubes are cylindrically shaped; c) respiratory tubes are conically shaped; c) they have not respiratory tubes.

18. The medical value of Culex and Aedes mosquitoes:

a) vectors and definitive hosts for malarial parasite; b) vectors and intermediate hosts for filaria; c) vectors for yellow fever; d) vectors for West Nile encephalitis, temporary ectoparasites.

19. The medical value of Anopheles mosquitoes:

a) vectors and definitive hosts for malarial parasite; b) vectors and intermediate hosts for filaria; c) vectors for hill fever, east horse encephalitis; d) temporary ectoparasites.

20. The medical value of sandflies (Phlebotomus):

a) temporary ectorarasites; b) vectors for visceral and dermal leishmaniasis; c) vectors for Japanese encephalitis, tularemia; d) vectors for pappataci fever.

21. The medical value of tse-tse flies:

a) vector for African trypanosomiasis; b) vector for American trypanosomiasis; c) originator of myiasis; d) temporary ectoparasite.

22. The medical value of house flies:

a) temporary ectoparasite; b) mechanical vector for protozoa's cysts and eggs of helminthes; c) mechanical vector for cholera, abdominal typhoid, paratyphoid, dysentery, tuberculosis; d) originator of myiasis.

Laboratory work:

I. Study the following micropreparations:

– "Pediculus humanus capitis" (16x).

The body of a mature louse has size 2-4.5 mm, yello-gray color, divided into head, chest and abdomen. The head is oval-angular in shape, bears on itself a pair of simple eyes, antennae and piercing-sucking oral apparatus. It is not visible from the outside. Non-segmented chest has a trapezoidal shape. Three pairs of short legs with claws attached to the lower surface of the chest. The abdomen is oval or ovoid, consists of segments, the lateral

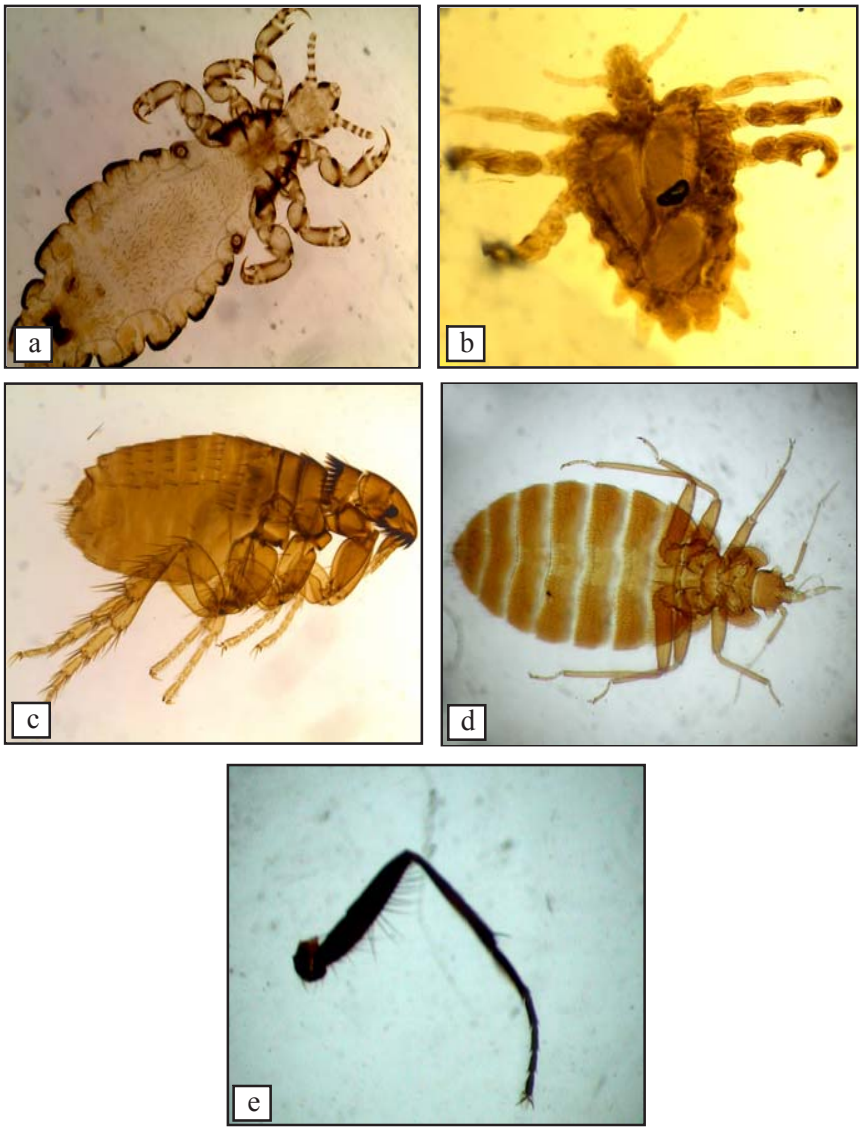


Fig. 27. Morphological features of insects witn medical importance:
a - Pediculus humanus capitis; b - Phtirus pubis; c - Pulex irritans; d - Cimex lectularius;
e - leg of Musca domestica.

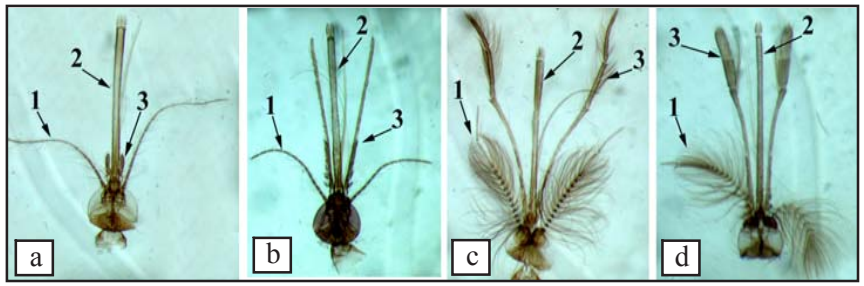


Fig. 28. Heads of females (a, b) and males (c, d) of mosquitoes of the genera Culex (a, c) and Anopheles (b, d):
1 - screeds; 2 - proboscis (lower lip); 3 - mandibular palpi.

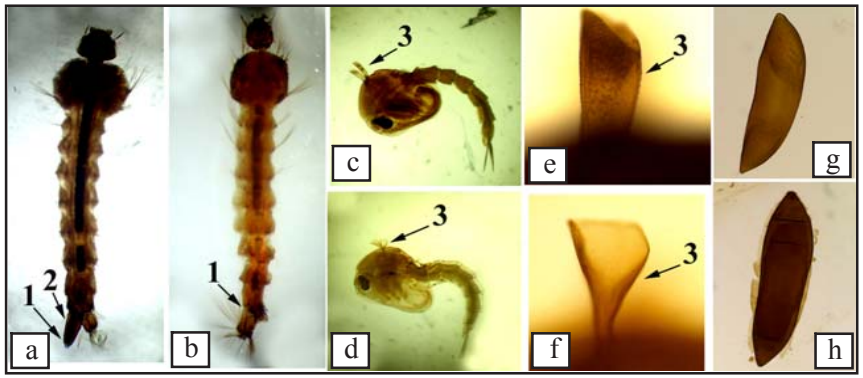


Fig. 29. Larvae, pupae, and eggs of mosquitoes of the genera Culex (a, c, e, g) and Anopheles (b, d, f, h):
1 - respiratory stigma; 2 - breathing siphons; 3 - respiratory tubes.

edges of which form festoons. The posterior end of the abdomen of females is bifurcated, rounded in males (Fig. 27a).

– "Phtirus pubis" (56x) (Fig. 27b).

– "Pulex irritans" (16x).

The body is compressed from the sides, divided into the head, chest and abdomen. Three pairs of legs are attached to the chest segment, the last of which is longer and serves for jumping. The head of a flea carries a piercing-sucking mouth apparatus, a pair of simple eyes and a pair of short antennae. (Fig. 27c).

– "Cimex lectularius" (10x) (Fig. 27d).

– "Leg of Musca domestica" (56x) (Fig. 27e).

– "Heads of Anopheles genus mosquitoes female and of Culex genus mosquitoes female" (16x) (Fig. 28a, b).

– “Heads of Anopheles genus mosquitoes male and of Culex genus mosquitoes male” (16x) (Fig. 28c, d).

– “Larvae of Anopheles genus mosquitoes and of Culex genus mosquitoes” (16x) (Fig. 29a, b).

– “Pupa of Anopheles genus mosquitoes and of Culex genus mosquitoes” (16x) (Fig. 29c, d, e, f).

– “Eggs of Anopheles genus mosquitoes and Culex genus mosquitoes” (56x) (Fig. 29g, h).

CLASS [1] 30.
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:

“Trypanosoma brucei gambience”; “Plasmodium vivax (exciter of tertian malaria)”; “Toxoplasma gondii”; “Fasciola hepatica, marita (large liver fluke)”; “Eggs of Fasciola hepatica”; “Opisthorchis felineus, marita (cat liver fluke)”; “Eggs of Opisthorchis felineus”; “Scolex of Taeniarhynchus saginatus”; “Mature proglottid of Taeniarhynchus saginatus”; “Gravid proglottid of Taeniarhynchus saginatus”; “Scolex of Taenia solium”; “Mature proglottid of Taenia solium”; “Eggs of teniids”; “Mature proglottid of Diphyllobotrium latum”; “Eggs of Diphyllobotrium latum”; “Hymenolepis nana”; “Cross section of Ascaris lumbricoides”; “Eggs of Ascaris lumbricoides”; “Trichocephalus trichiurus, female”; “Trichocephalus trichiurus, male”; “Eggs of Trichocephalus trichiurus”; “Enterobius vermicularis, male”; “Enterobius vermicularis, female”; “Eggs of Enterobius vermicularis”; “Larvae of Trichinella spiralis in muscles”; “Heads of Anopheles genus mosquitoes male and of Culex genus mosquitoes male”; “Heads of Anopheles genus mosquitoes female and of Culex genus mosquitoes female”; “Larvae of Anopheles genus mosquitoes and of Culex genus mosquitoes”; “Pupa of Anopheles genus mosquitoes and of Culex genus mosquitoes”; “Ixodes ricinus (dog tick)”; “Dermacentor pictus (female and male)”; “Pediculus humanus capitis (head louse)”; “Pulex irritans (human flea)”; “Cimex lectularins (bed chinch)”; “Leg of Musca domestica (house fly).

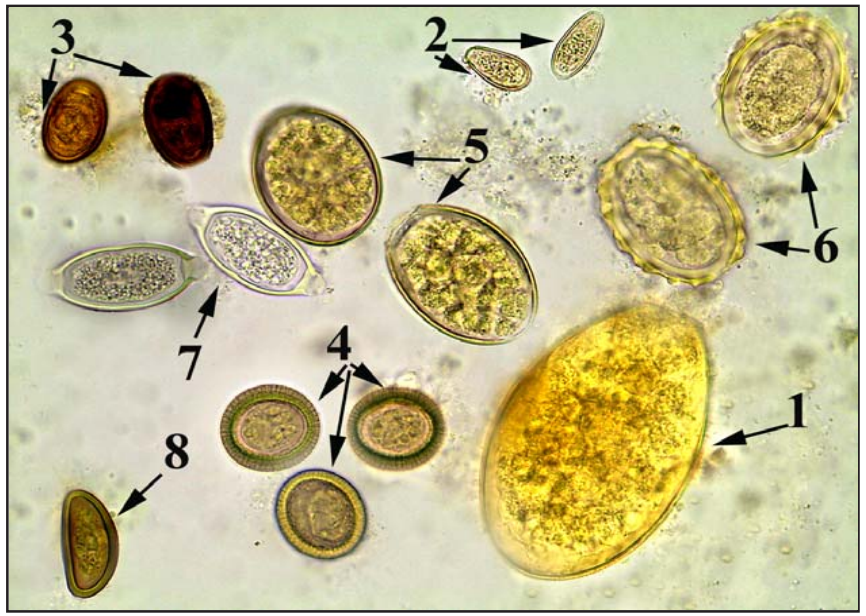


Fig. 30. A mixture of helminth eggs:
1 - egg of hepatic fluke; 2 - eggs of cat fluke; 3 - eggs of a lancet flukes; 4 - eggs of teniid; 5 - eggs of fish tapeworm; 6 - eggs of ascaris; 7 - Trichocephalus trichiurus eggs; 8 - pinworm egg.

Literature:

Bekish V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 197–270.

CLASS [1] 31.
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 exciters of parasitic diseases from Sarcomastigophora phylum, Apicomplexa phylum, Infusoria phylum, Plathelminthes phylum, Nemathelminthes 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 exciters 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): 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, blood flukes, cat fluke, lung 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, 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.

12. Nemathelminthes 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, Toxocara canis, Strongyloides stercoralis, Enterobius vermicularis, Trichinella spiralis, dirofilariasis): geographical distribution, particularities of morphlogy, 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.

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), 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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 188–270.

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 [1] 32.
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 1.000 species. Many of them are not well studied.

The fungi are a distant kingdom of organisms, comprising more than 80.000 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 $+5^0$) accumulates in young shoots significant amount of cyanogenic glycosides. Thus, clover protects itself form snails, which car. 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 off side effects, especially when they are overdosed.

There are about 1.000 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 ledum (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 Rosacaes there is amigdalin, which gives a taste of "bitter almond". The amigdalin degrades to prussic acid. The presence of prussic acid preserves young shoot of cherry, almond, prune, peach and apricot from eating by animals. The amigdalin 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 in 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 particular 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 V.J., Zorina V.V. Medical biology and general genetics. Textbook for students of educational establishments. Vitebsk: VSMU press, 2019. – p. 270–279.

Tests to check level of knowledge

1. Poisons of alloman group:
a) mycotoxines; b) inductors; c) phytotoxins; d) zootoxines.
2. Main toxic substances of mycotoxines and phytotoxins:
a) alkaloids, terpenoids, saponines, flavanoids; b) heart glycosides, tannins, coumarins, anthraquinones; c) neirotoxins, cytotoxins; d) lipids, organic acids.
3. Poisons micromycetes:
a) Paxillus involutus; b) aspergilus; c) fuzarium; d) claviceps.

4. Main toxic substances of aspergilus poison:
a) muscarin; b) phalloidines; c) aflotoxines B_1, B_2, C_1, C_2; d) ergotamine, ergosin.
5. Main symptoms of a human poisoning by aspergilus:
a) loss of appetite, dysfunction of liver and gastro-intestinal system; b) slackness, disorder of movement coordination, paresis; c) oedema, dropsy, hemorrhages; d) death owing to insufficiency of heart-vessels system.
6. Main toxic substances of fuzarium poison:
a) palustrin; b) saponines, flavanoids; c) cycutotoxin; d) sexviterpens.
7. Main symptoms of a human poisoning by fuzarium:
a) vomiting, stomach pain, diarrhea, fatigue and bare walking; b) headache and dizziness; c) disorder of circulatory system; d) convulsions, psychic disorder.
8. Main toxic substances of claviceps poison:
a) sexviterpens; b) cumarin, dicumarin; c) ergotamine, ergosin; г) heart glycosides.
9. Main symptoms of a human poisoning by claviceps:
a) pain and burning sensation in limbs, dry gangrene; b) vomiting, stomach pain, diarrhea, fatigue and bare walking, convulsions; c) renal disorder.
10. Measures of prevention of poisoning by micromycetes:
a) inspection of food-stuffs state; b) elimination of contaminated foodstuffs; c) not use in food afresh or incorrectly stored grain and vegetables.
11. Poisons macromycetes:
a) Paxillus involutus, Gyromitra esculenta; b) toadstool; c) death-cup.
12. Main toxic substances of Paxillus involutus poison:
a) muscarin; b) aflotoxines; c) carcinogenic substances; d) antigens which change of blood components.
13. Main symptoms of a human poisoning by Paxillus involutus:
a) vomiting, stomach pain, diarrhea; b) oedema, dropsy; c) increase of saliva and sweat glands functions; d) anemia.
14. Main toxic substances of toadstool poison:
a) carcinogenic substances; b) amanitines, phalloidines; c) atropine, scopolamine.
15. Main symptoms of a human poisoning by toadstool:
a) indomitable vomiting, stomach pain, diarrhea, thirst, jaundice; b) convulsions, muscles pains; c) haemolise of erythrocytes; d) death owing to insufficiency of heart-vessels and renal systems.
16. Main toxic substances of death-cup poison:
a) muscarin, holine; b) benaine, bufotenin; c) terpenoids.
17. Main symptoms of a human poisoning by death-cup:

a) vomiting, stomach pain, diarrhea; b) drying of mucous; c) increase of body temperature, tachycardia; d) euphoria, hallucinations.

18. Measures of prevention of poisoning by macromycetes:

a) inspection of food-stuffs state, elimination of contaminated foodstuffs; b) do not eat a unknown macromycetes; c) do not use for treatment poison macromycetes.

19. Main toxic substances of Conrallaria majalis poison:

a) colchicines; b) convallarine, heart glycosides; c) soponine; d) aspadiol.

20. Main toxic substances of Hyoscyamus niger poison:

a) ephedrine, colchicines; b) caffeine, papaverine; c) kumarin, dikumarin; d) atropine, hyoscyamine, scopolamine.

21. Main toxic substances of Solanum nigrum poison:

a) atropine, hyoscyamine, scopolamine; b) solanine; c) heart glycosides.

22. Main toxic substances of Cicuta virosa poison:

a) flavonoids; b) kumarin, dikumarin; c) cicutotoxin; d) sangvirin.

23. Main toxic substances of Papaver somniferum poison:

a) steroid glycosides; b) caffeine, codeine, papaverine, tebaine; c) soponine; d) tanins.

24. Main toxic substances of Cannabis saliva poison:

a) steroid glycosides; b) caffeine, codeine, papaverine, tebaine; c) cannabinol, cannabidinol; d) atropine, hyoscyamine, scopolamine.

25. Main toxic substances of Euphorbia waldsteinii poison:

a) euphol, euphorbol; b) caffeine, codeine, papaverine, tebaine; c) diterpenoids, flavonoids.

Laboratory work:

I. Study herbarium "Poisonous plants".

II. Study the following micropreparations: "Aspergillus" (56x); "Penicillium" (56x).

CLASS [1] 33. 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 aimals 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 gopd 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 heterocyclic 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 acetylcholine, 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.

Accordinary 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 parenteraly, 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.

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Tests to check level of knowledge

1. Most dangerous component of animal poison:

a) hemorrhagin; b) hemolysin; c) cytotoxin; d) neurotoxin.

2. Components of animal poisons according to pathophysiological action of them:

a) neurotoxins, cytotoxins; b) acetylcholine, histamine; c) heparin, serotonin; d) hemolysins, hemorrhagins.

3. Dinoflagellates belong to:

a) armed actively poisonous organisms; b) non-armed actively poisonous organisms; c) passively poisonous organisms; d) secondary poisonous organisms.

4. Predominant components of dinoflagellate's poison:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

5. Poisonous jellyfishes belong to:

a) armed actively poisonous animals; b) non-armed actively poisonous animals; c) passively poisonous animals; d) secondary poisonous animals.

6. Most dangerous poisonous jellyfishes:

a) rhysostoma; b) box jelly (Chironex); c) gogronaria; d) Portuguese man -of - war (Physalia).

7. Predominant components of Portuguese man-of-war jellyfish:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

8. Poisonous mollusks belong to:

a) armed actively poisonous animals; b) non-armed actively poisonous animals; c) passively poisonous animals; d) secondary poisonous animals.

9. Predominant components of armed mollusk's (Conus) poison:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

10. Poisonous arachnids belong to:

a) armed actively poisonous animals; b) non-armed actively poisonous animals; c) passively poisonous animals; d) secondary poisonous animals.

11. Predominant components of karakurt and black widow spider's venom:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

12. Predominant components of tarantula's venom:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

13. Predominant components of scorpion's poison:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

14. Poisonous insects belong to:

a) armed actively poisonous animals; b) non-armed actively poisonous animals; c) passively poisonous animals; d) secondary poisonous animals.

15. Most dangerous venomous insects:

a) bumblebee; b) wasp; c) giant hornet; d) fire ant.

16. Poisonous fishes belong to:

a) armed actively poisonous animals; b) non-armed actively poisonous animals; c) passively poisonous animals; d) secondary poisonous animals.

17. Poisonous amphibians belong to:

a) armed actively poisonous animals; b) non-armed actively poisonous animals; c) passively poisonous animals; d) secondary poisonous animals.

18. Predominant components of fugu fish's poison:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

19. Predominant components of sea snake's venom:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

20. Predominant components of rattlesnake's vemon:

a) hemolysin; b) hemorragin; c) neurotoxin; d) cytotoxin; e) dermatotoxin.

Laboratory work:

I. Study the following macropreparations in museum: "Medusa Aurelia"; "Karakurt"; "Tarantul"; "Scorpion"; "Scolopendra"; "Grey frog"; "Caucasian salamander"; "Sand efa"; "Gurza"; "Grass snake".

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ANSWERS ON TESTS

CLASS 1 1. 1 - a, b, c; 2 - a, b; 3 - a, b; 4 - d; 5 - a, b; 6 - a, b, c; 7 - a, b; 8 - b, c; 9 - c, d; 10 - a, b, c; 11 - a; 12 - b; 13 - a; 14 - b, c, d; 15 - b, d; 16 - a, b; 17 - b, c, d; 18 - d; 19 - a, b, c, d; 20 - a, c.

CLASS 1 2. 1 - c, d; 2 - b, c, d; 3 - a; 4 - b; 5 - b; 6 - a, b; 7 - c, d; 8 - b, c, d, e; 9 - c, d; 10 - a, b, c; 11 - b; 12 - a; 13 - c; 14 - a; 15 - b, c, d; 16 - a, c, d; 17 - b, c; 18 - c; 19 - a, b, c; 20 – a.

CLASS 1 3. 1 - c; 2 - a, c, d; 3 - a, b; 4 - b, c, d; 5 - a, b, c; 6 - a, b, c, d; 7 - b, c, d; 8 - a, b; 9 - b, c, d; 10 - a, c; 11 - b, c, d, e; 12 - a, b, c, d; 13 – a, b, c, d; 14 - c; 15 - b, c; 16 - b, c, d; 17 - c; 18 - a; 19 - c; 20 - b.

CLASS 1 4. 1 - a; 2 - a; 3 - b; 4 - a; 5 - a; 6 - a, c, d; 7 - a, b, d; 8 - a; 9 - b; 10 - c; 11 - a, b, c; 12 - b, c; 13 - a, b, c; 14 - a, b; 15 - b; 16 - a, b, d; 17 - b, c, d; 18 - a, d; 19 - b, c, d; 20 - b, c.

CLASS 1 5. 1 - b; 2 - a; 3 - b; 4 - a; 5 - a; 6 - a, b; 7 - a, b; 8 - b, c; 9 - a; 10 - b; 11 - b; 12 - a, b; 13 - c; 14 - c; 15 - a, b; 16 - b; 17 - a; 18 - c; 19 - b; 20 - b.

CLASS 1 6. 1 - b, c, d; 2 - b; 3 - c; 4 - c; 5 - b; 6 - a; 7 - b, c; 8 - a, d; 9 - b, c; 10 - c; 11 - a; 12 - b; 13 - d; 14 - a, c; 15 - a, d; 16 - c; 17 - a, b, c; 18 - a, b, c, d; 19 - a, c; 20 - a, b, c, d.

CLASS 1 8. 1 - b, c; 2 - b, c; 3 - c; 4 - a, b, c; 5 - a, b, c, d; 6 - d; 7 - a, c; 8 - d; 9 - c; 10 - b; 11 - c; 12 - b; 13 - a; 14 - a, b; 15 - a, b, c, d; 16 - b, c, d; 17 - a, c; 18 - a, b; 19 - b; 20 - a, b, c, d, e.

CLASS 1 9. 1 - a, c; 2 - b, c; 3 - a, b, c; 4 - c; 5 - a, c; 6 - a, c; 7 - a; 8 - b; 9 - a; 10 - b, c; 11 - b, c; 12 - a, b, d; 13 - b; 14 - a; 15 - a, d; 16 - d; 17 - a, b, c, d; 18 - c, d; 19 - b; 20 - a.

CLASS 1 10. 1 - c, d; 2 - b, c; 3 - a, c; 4 - a, b; 5 - c, d; 6 - a, b; 7 - a, c, d; 8 - b; 9 - a, c; 10 - c; 11 - a, b, c, d; 12 - a, b, c, d; 13 - a, d, e; 14 - b, c, e; 15 - b; 16 - b; 17 - a; 18 - b, c; 19 - a, c; 20 - c.

CLASS 1 11. 1 - b, c; 2 - a, c; 3 - b, c; 4 - a, b, c; 5 - b; 6 - a, d; 7 - b; 8 - a, b, c; 9 - a, b, c; 10 - a, b; 11 - b, c, d; 12 - a, b; 13 - c; 14 - a, b, c; 15 - c; 16 - a, b, d; 17 - a, c, d; 18 - b, c, d; 19 - b, d; 20 - a, c, d.

CLASS 1 12. 1 - a, b, c, d, e; 2 - a, b, c, d; 3 - b, c, d, e; 4 - a, b, c, e; 5 - a, b, c, e; 6 - a, b, e; 7 - a, b, c; 8 - a, b, c.

CLASS 1 13. 1 - a; 2 - c; 3 - d; 4 - c; 5 - c; 6 - a; 7 - b, c, d, e; 8 - c; 9 - b, d; 10 - b, d; 11 - b, e; 12 - a; 13 - a, b, c; 14 - d; 15 - a, b; 16 - a, b, c, d; 17 - a; 18 - c; 19 - b, c; 20 – e.

CLASS 1 14. 1 - a, b, c; 2 - c, d, e; 3 - b, c; 4 - a, b; 5 - a, c; 6 - a, b, d, e; 7 - b; 8 - b, c, d, e; 9 - b; 10 - b, c; 11 - a, b, c, d; 12 - a, b, d; 13 - b, c; 14 - b; 15 - c; 16 - a, c; 17 - a, b, c, e; 18 - a, b, d, e; 19 - c; 20 - b, c, e.

CLASS 1 16. 1 - a, c; 2 - a, b; 3 - a, b, c; 4 - a, d; 5 - c; 6 - a; 7 - b; 8 - c; 9 - b; 10 - a, c; 11 - b, c; 12 - a, b; 13 - c, d; 14 - a, c; 15 - a, b, d; 16 - b, c, d; 17 - a, b; 18 - b; 19 - a, b, c; 20 - a, b, d.

CLASS 1 17. 1 - b, c; 2 - a, b, c, d; 3 - d; 4 - a, c, d; 5 - b, c, d; 6 - b; 7 - a; 8 - b, c; 9 - a, b; 10 - c; 11 - a, b, c, d; 12 - b, c; 13 - a, b, c; 14 - a, b; 15 - a, b; 16 - a, b; 17 - a, c; 18 - b; 19 - a; 20 - a, b.

CLASS 1 18. 1 - a, b, c; 2 - b, c, d; 3 - a; 4 - a, b, c; 5 - b, c; 6 - a, b, c; 7 - a, b, d, e; 8 - c; 9 - a, b, c; 10 - b; 11 - a, b; 12 - a; 13 - a, b, c; 14 - a; 15 - a, b, c, d; 16 - b; 17 - b; 18 - b; 19 - c; 20 - a, b, c.

CLASS 1 19. 1 - a, c, d, e; 2 - b, c, d; 3 - b, c; 4 - a, b, c, d; 5 - b, c, d, e; 6 - b, c, d; 7 - a, b, d; 8 - a, b, c; 9 - a, b, d; 10 - a, c, d; 11 - b, c, d, e; 12 - b, c, d; 13 - a, c, d, e; 14 - a, b, c, d, e; 15 - b, d, e; 16 - a, b, c, e; 17 - a, b, d, e; 18 - a, b, c, d, e; 19 - a, c, d; 20 - b, c, d.

CLASS 1 20. 1 - a, b, c; 2 - c; 3 - b, c, d; 4 - a, c, d; 5 - a, b, c; 6 - a, c; 7 - a, b, c, d; 8 - b, c; 9 - b, c, d; 10 - a, b, c; 11 - b, c; 12 - a, b, c, d; 13 - b, c, d; 14 - a, b; 15 - b; 16 - c; 17 - a, b, c; 18 - a, c; 19 - b; 20 – a.

CLASS 1 21. 1 - a, b, c, d; 2 - a, b, c, d; 3 - a, c, d; 4 - c, d; 5 - a, c, d, e; 6 - b, c, d, e; 7 - d; 8 - a, b, c; 9 - a, b, c; 10 - a, b, c, d; 11 - a, b, c; 12 - a, b, c, d.

CLASS 1 23. 1 - c, d; 2 - a, b, d; 3 - c, d, e; 4 - a, b, c; 5 - a, d, e; 6 - b; 7 - b, c; 8 - a, b, c; 9 - a, b; 10 - a; 11 - b, c, d; 12 - a, c, d; 13 - b, c; 14 - a, b; 15 - c, d; 16 - a, b, d; 17 - a, b, d; 18 - a, b, c; 19 - a, b, d; 20 - c; 21 - a, b, d; 22 - a, b, c; 23 - b, c, d; 24 - a; 25 - b; 26 - b, c; 27 - b, d; 28 - b; 29 - a, b, c; 30 - a, b, c, d; 31 - a, b, c, d.

CLASS 1 24. 1 - a, d; 2 - c; 3 - c; 4 - b; 5 - c; 6 - a; 7 - a, b; 8 - a, b, d; 9 - a, c; 10 - a, b, c, d; 11 - c; 12 - b; 13 - a, b, c, d; 14 - a, b, c, d; 15 - a, b, c, d, e; 16 - a, b, c, d; 17 - d; 18 - a; 19 - c; 20 - b; 21 - a, b; 22 - a, c, d; 23 - c; 24 - d.

CLASS 1 25. 1 - c; 2 - a, b, c, d; 3 - a, b, c, d; 4 - b; 5 - a, b, c, d; 6 - b, c; 7 - a, b, c; 8 - a, c, d; 9 - a; 10 - a, b, d; 11 - d; 12 - a, b, d; 13 - a, b, c, d; 14 - a, b, c, d; 15 - b, d; 16 - a, b, c, d; 17 - b, c, d; 18 - a; 19 - a, b, c, d; 20 - b, c, d; 21 - a, b, c, d; 22 - a, b, d; 23 - c; 24 - a, b, c, d.

CLASS 1 26. 1 - c, d; 2 - d; 3 - b; 4 - b; 5 - d; 6 - a, b, c, d; 7 - a, b; 8 - a; 9 - a, b, c, d; 10 - a, b; 11 - b; 12 - a, b, c, d; 13 - a, c; 14 - b; 15 - a, b, c, d; 16 - b, c, d; 17 - b, c, d; 18 - b, c, d; 19 - a; 20 - a, b,

c, d; 21 - a; 22 - a, b; 23 - b, d; 24 - a; 25 - a, b, c, d.

CLASS 1 27. 1 - b; 2 - a, b, c, d; 3 - a, b, c, d; 4 - c; 5 - a, c, d, e; 6 - c; 7 - a, c, d; 8 - b, c; 9 - b; 10 - b, c, d, e; 11 - c; 12 - a, b; 13 - a, b, c, d; 14 - c; 15 - a, b, c, d; 16 - b, c; 17 - a, b, c, d; 18 - a, b, d; 19 - a; 20 - a, b, c, d; 21 - a, d; 22 - a, b, c; 23 - b, c, d; 24 - a, b, d.

CLASS 1 28. 1 - b; 2 - b, c, d; 3 - a, c; 4 - b; 5 - a, b, c; 6 - a, d; 7 - a, b; 8 - b, c; 9 - c; 10 - c, d; 11 - b; 12 - a, b, c, d; 13 - b; 14 - b, c; 15 - b, c; 16 - a; 17 - a, c, d; 18 - a, c.

CLASS 1 29. 1 - a, b, c; 2 - b, c; 3 - c, d; 4 - b, c; 5 - c; 6 - b; 7 - a, d; 8 - b, c; 9 - a, b, d; 10 - c; 11 - a; 12 - b; 13 - a; 14 - a, d; 15 - b, c, d; 16 - c; 17 - b; 18 - b, c, d; 19 - a, b, c, d; 20 - a, b, d; 21 - a, d; 22 - b, c.

CLASS 1 32. 1 - a, c, d; 2 - a, b, d; 3 - b, c, d; 4 - c; 5 - a, b, c; 6 - d; 7 - a, b, c; 8 - c; 9 - a, b; 10 - a, b, c; 11 - a, b, c; 12 - a, c, d; 13 - a, c, d; 14 - b; 15 - a, b, d; 16 - a, b; 17 - a, b, c, d; 18 - b, c; 19 - b, c; 20 - d; 21 - b; 22 - c; 23 - b; 24 - c; 25 - a, c.

CLASS 1 33. 1 - d; 2 - a, d; 3 - c; 4 - a, c; 5 - a; 6 - b, d; 7 - c, d, e; 8 - a, d; 9 - c; 10 - a; 11 - b, c; 12 - a, d; 13 - a, b; 14 - a; 15 - c; 16 - a, c, d; 17 - b; 18 - c; 19 - c; 20 - a, b, d.

CONTENT

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