MINISTRY OF HEALTH OF UKRAINE

ODESSA NATIONAL MEDICAL UNIVERSITY

Department of clinical immunology, genetics and medical biology

APPROVED

Vice-rector for research and educational work,

_____ Eduard BURYACHKOVSKY

01 September 2023

METHODOLOGICAL RECOMMENDATIONS

FOR PRACTICAL CLASSES

OF HIGHER EDUCATION STUDENTS IN THE ACADEMIC DISCIPLINE

MEDICAL BIOLOGY

The level of high education: second (magister)
Branch of knowledge: 22 «Health Care»
Speciality: 222 «Medicine»
Educational and professional program: Medicine

Developers:

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Developments are discussed and approved at a methodic meeting of the Department of ClinicalImmunology, Genetics and Medical Biology.

Minutes № 1, 28.08.2023.

Head of the department, professor. Sergiy GONCHARUK

Reviewed and approved at a meeting of the Department of Medical Biology and Chemistry
Minutes № 1 7.09 2023.

Head of the department Gennady Stepanov

Reviewed and approved at a meeting of the Department of Medical Biology and Chemistry
Minutes № ___ _____ 202____.

Head of the department_____

(*signature*) (First Name SURNAME)

Practical class 1. Levels of organization and fundamental characters of living matter. Optical systems in biological researches.

The Purpose of the Lesson. To study the structure of the light microscope. To get the skills of microscoping and preparation of temporary slides. To realize the importance of studying the elementary units of life organization on the each level for understanding underlying basis of health and disease mechanisms.

TOPIC CONTENT

1. Structure of compound optical microscope
2. Usage of optical microscope in low and high magnification
3. Common mistakes in usage of optical microscope
4. Preparation of temporary slides.
5. Levels of organization of living matter. Their importance for understanding of pathological processes.
6. Elementary units and elementary functions of different levels of living matter organization.

TEST QUESTIONS for individual work

	Questions	Answers
1	What are the structural parts of the optical microscope: a ,b, c	
2	Name the main components of mechanical part: a, b, c, d, e, f, g	
3	Name the main components of illuminating part: a, b, c	
4	Name the main components of optical part: a, b	
5	What is the magnification of a)eye-piece lens – a,b,c b)objective lens of low magnification– a c)objective lens of high magnification– a d)objective lens of oil immersion magnification– a	
6	Calculate the total magnification of microscope, if magnification of eye-piece lens is 15x and magnification of objective lens is 8x	
7	List the main levels of biological organization : a, b, c, d, e, f.	

Recommended literature:

1. Medical Biology / Bazhora Yu. I., Bulyk R. Ye., Chesnokova M. M. [et al.]. – 2nd ed. – Vinnytsia: Nova Knyha, 2019. P. 10 – 11
2. Medical biology: manual for practical classes/ Bazhora Yu.I et al. - Odessa: OSMU, 2006. – P.2-7

COMPOUND LIGHT MICROSCOPE (Fig.1.1)

There are **3 main parts** in structure of light microscope **- mechanical, optical and illumination ones.**

1. **Mechanical part** consists of the **base, arm, stage, tube, revolver (nose-piece), coarse adjustment and fine adjustment screws.**
2. **Illumination part** includes **mirror, condenser, diaphragm.** Diaphragm regulates the quantity of entering light.
3. **Optical part** is system of **eyepiece and objective lenses**.

Eyepiece gives **(x7, x10, x15)** magnification. **Objective lenses** can give low **(x8, x10), high (x40) and immersive (x90) magnification** and are attached to the nosepiece.

The **total magnification of the microscope** can be calculating by the following formula: **magnification of eyepiece multiply on magnification of objective lens.**

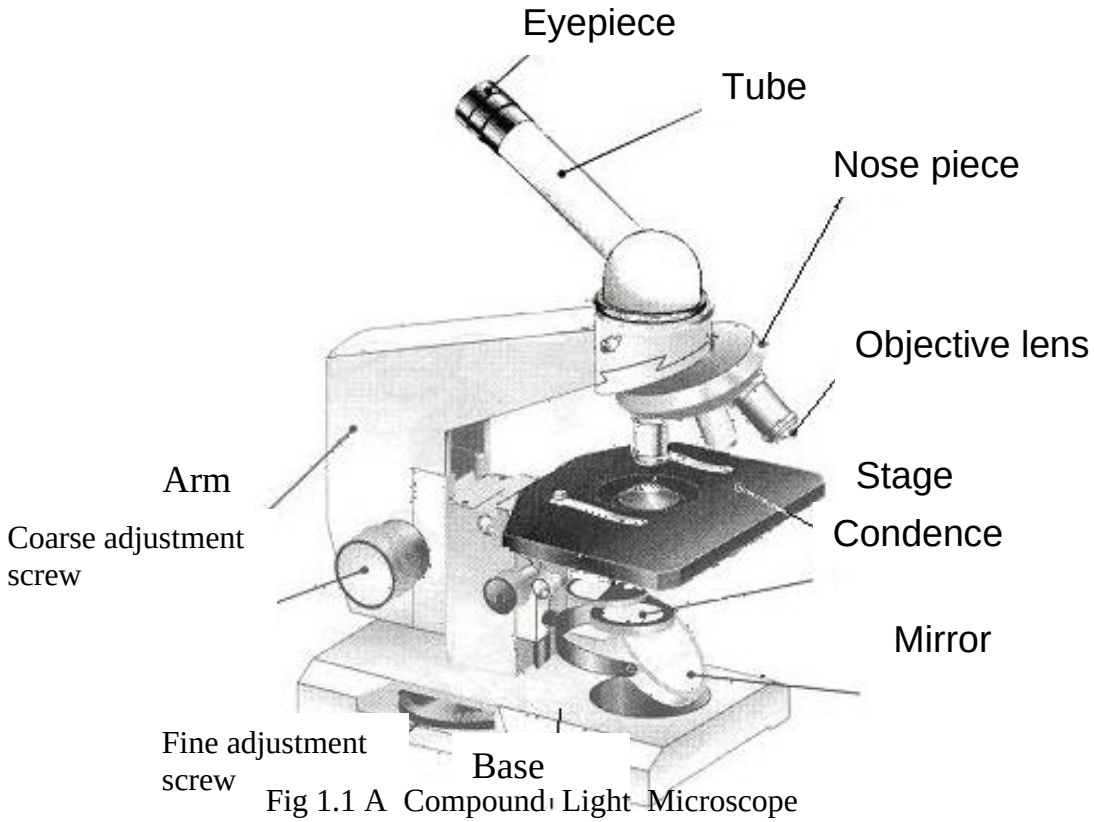


Fig 1.1 A Compound Light Microscope

HOW TO WORK WITH A COMPAUND MICROSCOPE

1. Always use 2 hands to carry a microscope: one on the arm, and one - supporting the base.
2. Take a microscope and place it on your desk at least 10 cm from the edge. Position of the microscope with the arm facing you.
3. Look through the eyepiece. The white circle of the light you see is the field of view. Turn the mirror to catch the light rays until the range becomes bright and even.
4. Place a slide on the stage so that it is central over the stage opening. Always use the lowest power objective lens for bringing specimen into focus, so turn the low power objective into place. Look at the microscope from the side and turn the coarse adjustment so that the low-power objective is close to the stage without touching it (focus distance is about 10 mm).
5. Look through the eyepiece and turn the coarse adjustment to move the low-power objective away from the stage until the objective comes into focus. **Never lower the objective forwards the stage while looking trough the eyepiece.**

6. To shift the magnification lifts the objective lens. Rotate the low-power objective into position and use the coarse adjustment to place it as close to the stage as low as possible (focus distance is less then 1 mm).
7. Look through the eyepiece and turn the coarse adjustment to move the low-power objective away from the stage until the objective comes into focus. Bring specimen into focus by first using coarse adjustment, and then use fine adjustment. **Never lower the objective forwards the stage while looking trough the eyepiece.**

TECHNIQUE FOR PREPEARING A WET MOUNT

1. Place slide on a flat surface.
2. Place a drop of water on the slide. Add the specimen to the drop of water.
3. Hold the cover slip by its sides and lay its bottom edge on the slide close to the specimen, holding the coverslip at a 45^0 angle helps.
4. Slowly lower the coverslip so that is spreads the water out. If you get air bubbles (looking like little black doughnuts), gently press on the coverslip to move them to the edge. If there are dry areas under the coverslip, add a little more water at the edge of the coverslip. Too much water can be dabbed off with a piece of paper towel (filter paper).
5. Place a prepared slide on the stage so that it is central over the stage opening. Study specimen under the lower and high magnification.
6. Take apart the wet mount. Clean the slide and coverslip.

Biology is a science about life. **Characteristics of living matter are:**

Unity of chemical composition; Metabolism; Reproduction; Homeostasis; Response and irritability (sensitivity); Heredity and variation; Growth and development.

Level of organization in living organisms

1. Molecular-genetic level. Its elementary structure is macromolecules (DNA, RNA, proteins). Elementary phenomena of this level are DNA replication, protein biosynthesis. Such medical problem as mutations and it accumulation in populations is studied by a group of sciences as molecular biology, molecular genetics.

2. Cellular level. Its elementary structure is a cell. The cell cycle is an elementary phenomenon. Cellular pathology, tumor growth are studied by cytology, histology.

3. Organismic level. Its elementary structure is the organism, having organ system. Elementary phenomenon of this level is a complex of physiological processes that provides functioning of an organism. Reduced adaptive capabilities of organisms are studied at this level by histology, anatomy, morphology, physiology, medical genetics.

4. Population and species level. Its elementary structure is a population. Evolution of species on the basis of natural selection is an elementary phenomenon. Decreasing of demographic data of population is studied by population genetics and ecology.

5. Biogeocenotic. . Its elementary structure is populations of different kinds and environmental factors. Biochemical cycling of matter and energy flow, life-sustaining are elementary phenomena. Violation of dynamic equilibrium between living organisms and the abiotic environment is studied by biocenology and ecology at this level.

6. Biospheric. Its elementary structure is biogeocenosis and anthropogenic factors. Biological global cycling of matter and energy is elementary phenomenon. The negative effects of human biogeochemical activity on the biosphere are studied by ecology.

Practical work. OPTICAL SYSTEMS IN BIOLOGICAL STUDIES.

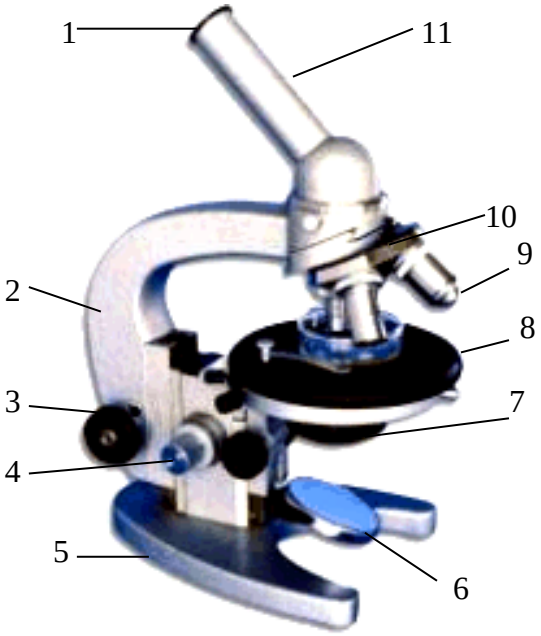
TASK 1. Study how to work with the light microscope:

- While starting the procedure the eyepiece and the mirror are to be clean with a smooth cloth and so should be done after the end of the work.
- The studying of the slide is to be started with low magnification.

- To light the range of view turn the mirror to catch the light rays until range of view becomes throughout clear and lightened.
- Put the preparation slide on to the stage by cover slip up.
- By the control of vision lower the objective lens using coarse adjustment screw. Distance between lens and slide should be about 5 mm. After this lift the lens slowly looking in the eye-piece until your see the subject of studying.
- Turn the nose-piece to put the high magnification objective lens. By the control of vision lower the objective lens using coarse adjustment screw. Carefully touch the slide with the lens. After this lift the lens slowly looking in the eye-piece until your see the subject of studying.Use fine adjustment screw to get fine image.
- After finishing the work return the low magnification lens to it position.
- Microscopes are carried by right hand holding the handle and the left one supporting the base.
- Never unscrew the objective lenses.

Possible Mistakes:

-Improper illumination of visible area.
-Dusty optics.
-Disposition of slide.
-Water on cover slip and objective lens.



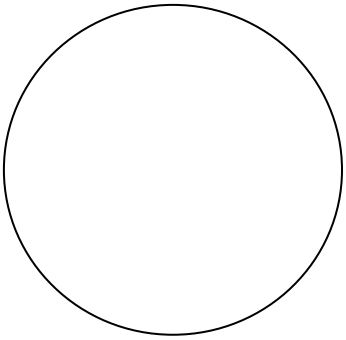
Mark the parts of optical microscope

1- _____
2 - _____
3 - _____
4 -_____
5 - _____
6-_____
7- _____
8-_____
9- _____
10-_____
11-_____

TASK 2. Make a temporary slide of cotton fibers.

1. Drop water on the slide.
2. Put some cotton fibres in the drop of water on the slide.
3. First put one edge of the cover slip in the water drop and then slowly put it down to avoid air bubbles under the cover-slip.
4. Soak the excess of water with filter paper if needed.

TASK 3. Study the slide of cotton fibers under small and high magnification, sketch it, and point out a general magnification of the microscope.



1. Cotton fibers under the low magnification.
Total magnification = ____ (... x ...).

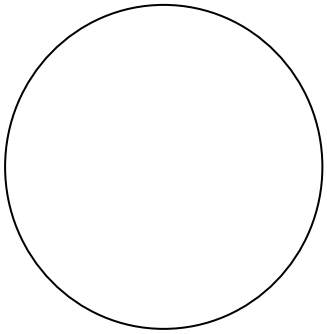


Fig. 2. Cotton fibers under the high magnification.
Total magnification = ____ (... x ...)

TASK 4. Fill a table of levels of organization of living matter.

Hierarchical level	*Elementary unit*	*Elementary function*	*Science studying this level*	*Importance for medicine*
Molecular-genetic				
cellular				
Organism				
Population - species				
Biogeocenotic				
Biospheric (global)				

TASK 5. Compare the various characteristics of life between that of a rabbit and stalactites in a cave by marking "+" if it could occur and "-" if it cannot occur.

Characteristic of life	Rabbit	Stalactites in a Cave
Exchange of the material and energy with the environment		
Homeostatic		
Respond to stimuli		
Reproduce		
Grow and develop		
Adaptation		

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. The term "Biology" for the study of living things was introduced by
   A. Aristotle
   B. B. Morgan
   C. J.B. Lamarck and Treviranus
   D. Purkinje
   E. Leeuwenhoek
2. The levels of biological organization in microsystem:
   A. Molecular, subcellular, cellular
   B. Cellular, tissue
   C. Organ, organism
   D. Subcellular, tissue
   E. Tissue, organ, organism

3. Name the levels of biological organization in mesosystem:
   A. Molecular, subcellular, cellular
   B. Subcellular, cellular, tissue
   C. Organism, population-species
   D. Tissue, organ, organism
   E. Population- species, biocenosis, biosphere
4. Name the levels of biological organization in macrosystem:
   A. Molecular, subcellular, cellular
   B. Subcellular, cellular, tissue
   C. Organism, population-species
   D. Tissue, organ, organism
   E. Population- species, biocenosis, biosphere
5. Main parts of optical microscope includes:
   A. Mechanical
   B. Mechanical and optical
   C. Optical
   D. Mechanical, optical and illuminating
   E. Illuminating
6. Mechanical part of optical microscope includes:
   A. Base
   B. Tube
   C. Nose-piece (revolver)
   D. Coarse and fine adjustment screws
   E. All of the above
7. Illuminating part of optical microscope includes:
   A. Mirror, base, arm
   B. Condenser, diaphragm, tube
   C. Diaphragm, tube, arm
   D. Mirror, condenser, diaphragm
   E. Mirror, condenser, revolver (nose-piece)
8. Optical part of optical microscope includes
   A. Eye piece lenses
   B. Eye piece lenses and diaphragm
   C. Objective and eye piece lenses
   D. Objective lenses and stage
   E. Condenser, eye piece and objective lenses

9. Eye piece occupies a superior position on a tube and gives magnification
   A. 7×, 40×, 15×
   B. 8×, 10×, 15×
   C. 10×, 40×, 90×
   D. 7×, 10×, 15×
   E. 8×, 40×, 90×

10. Objective lenses are attached to nose piece and give magnification
   A. 7×, 10×, 40×
   B. 8×, 40×, 90×
   C. 10×, 40×, 90×
   D. 7×, 10×, 15×
   E. 7×, 40×, 90×

11. Calculate the total magnification of microscope if eye piece gives 10× magnification and objective lens gives 40× magnification
   A. 10×
   B. 40×
   C. 50×
   D. 200×
   E. 400×

12. Resolving power of human eye is
   A. 50 mμ
   B.100mμ
   C. 150 mμ
   D. 200 mμ
   E. 250 mμ

13. Main possible mistakes during the microscoping are:
   A. Improper illumination ofrange of view
   B. Dusty optics
   C. Disposition of the slide
   D. Water on the cover slip and objective lens
   E. All of the above

14. The ability to move is an example of
   A. Homeostasis
   B. Reproduction
   C. Growth and development
   D. Adaptation
   E. Response to stimuli

15. The amount of sugar in our blood is always maintain 3.5 – 6.1 mmol/l. It is an example of
   A. Homeostasis
   B. Reproduction
   C. Growth and development
   D. Adaptation
   E. Response to stimuli

16. Organs such as the heart are composed of _____, which is the next lower level of biological organization
   A. Tissue
   B. Organ system
   C. Cells
   D. Atoms
   E. Molecules

17. The next higher level of biological organization above the cell is
   A. Organ
   B. Tissue
   C. Organ system
   D. Molecule
   E. Atom

18. Which sequence is correct regarding increasing complexity?
   A. Atoms, molecules, cells, organs, tissues
   B. Molecules, atoms, cells, organs, tissues
   C. Atoms, molecules, cells, tissues, organs
D. Atoms, molecules, tissues, organs, cells
E. Atoms, molecules, organs, tissues, cells.

A topic of the following class: Morphology of the eukaryotic cell. Structural components of cytoplasm

Practical class 2. Morphology of the eukaryotic cell. Structural components of cytoplasm

The Purpose of the Lesson: To study the morphology of the cell as elementary life unit. To get an association between structure and functioning of eukaryotic cell as basis for studying of other morphological and medical disciplines. To understand importance of organelles studying in medicine.

TOPIC CONTENT

1. Cellular and non-cellular forms of life.
2. Prokaryotes and eukaryotes.
3. Principle differences in morphology of animal and plant cell
4. Importance of scientific works of R. Hooke, A. Leeuwenhoek, M. Malpighi, R. Brown, J. Purkinje, M.Schleiden, T. Schwann in development of the cell theory.
5. Modern postulates of the cell theory.
6. Structure and function of the main structural components of the cytoplasm: hyaloplasm (cytosol), cell organelles, inclusions, nucleus.
7. Classification of cell organelles: general function organelles (double-membranous, single-membranous, non-membranous) and special function organelles.

TEST QUESTIONS for individual work

	Questions	Answers
1	Cell was discovered by … in ….. year	
2	Cell theory was formulated by … in …..year	
3	List cell organelles of – general function: a,b,c,d,e,f – special function: a,b,c,d	
4	Name the primary functions of 1) lysosomes: a,b,c,d,e 2) mitochondria: a,b 3) smooth endoplasmic reticulum: a,b,c, 4)rough endoplasmic reticulum: a,b 5) ribosomes: a	
6	6) Golgi complex: a, b, c, d 7) centrioles: a	
7	Proteins that are produced for inner cell needs are synthesized in … Proteins that are exported from the cells are synthesized in ….	
8	Dysfunction of which organelles leads to the “storage disorders”?	

9	Name the organelles that provide main processes of 1)synthesis of organic substances: a, b,c 2) disintegration of organic substances: a, b	

There are two types of the cell

- **Prokaryotic cell.** This is bacterial cell. It has no nucleus and membranous organelles.
- **Eukariotic cell.** This is cell of animals, plants and fungi. Eukaryotic cell has nucleus and membranous organelles.

Eukaryotic cell

Eukaryotic cell has

1) **membrane**
2) **cytoplasm**
3) **nucleus**

Cytoplasm

Cytoplasm has:

1) hyaloplasm or cytoplasmic matrix. It is a fluid portion of cytoplasm.

It contains **water, proteins, sugars, amino acids, and ions and other important substances.**

2) cytoskeleton. It is a network of protein filaments. It determines cell shape and enables movement. Main components are microfilaments (actin protein), microtubules (tubulin protein), and intermediate filaments

3) inclusions. These are temporary cytoplasm components like fat droplets, glycogen granules and others.

4) Cell organelles. These are permanent structural components of the cytoplasm with certain structure and function.

Cell organelles

I. Organelles with double membrane.

1. Mitochondria are the energy organelles of the cell. Each mitochondrion has an outer and inner membrane. The inner membrane forms **cristae**. The interior spaces of the mitochondrion is filled with a **matrix**. Matrix contains circular DNA molecules and ribosomes.

The function of mitochondria is

- production of energy (ATP). It occurs as a result of oxidation of organic substances (mitochondria use O_2)
- cytoplasmic inheritance. As it has DNA, it transfere some hereditary characters for next generation
- synthesis of some mitochondrial proteins

II Organelles with single membrane

1. Endoplasmic reticulum (**ER**) is an membranous system of cell. It has tubules and sacs. There are two types of endoplasmic reticulum:

a) **rough endoplasmic reticulum**. It has ribosomes. Function of the rough ER is synthesis and transport of proteins Proteins from rough ER go to the Golgi complex.

b) smooth endoplasmic reticulum. Function of the smooth ER is synthesis and transport of lipids and carbohydrates. In liver cells the smooth ER contains enzymes that detoxify toxic substances.

2. Golgi complex is a set of flattened sacs, tubules and vesicles. Functions of Golgi complex are

- to accumulate, pack and release proteins and lipids produced in the cell.
- to form complex organic substances (for example, glycoproteins).
- to produce lysosomes.

3. Lysosomes are vesicles with digestive enzymes. Functions of lysosomes are

A. intracellular digestion of food substances

B. breakage of macromolecules, accumulated in the cell (for example glycogen)

C. digestion of aged or damaged organelles.

If lysosomes rupture and release their enzymes into the cytoplasm, it causes digesting the whole cell (autolysis

4. Peroxisomes are vesicles with different enzymes. Function of peroxisomeis metabolism of fatty acids and detoxication of peroxides (H_2O_2)

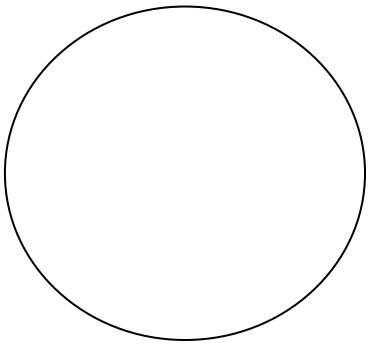
III Organelles without membrane

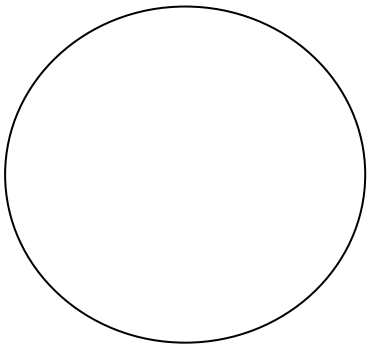
1. Ribosomes has two subunits – a large subunit and a small subunit. Each subunit consists of proteins and rRNA. Function of ribosomes is protein synthesis.

In eukaryotic cells ribosomes are formed in the nucleolus.

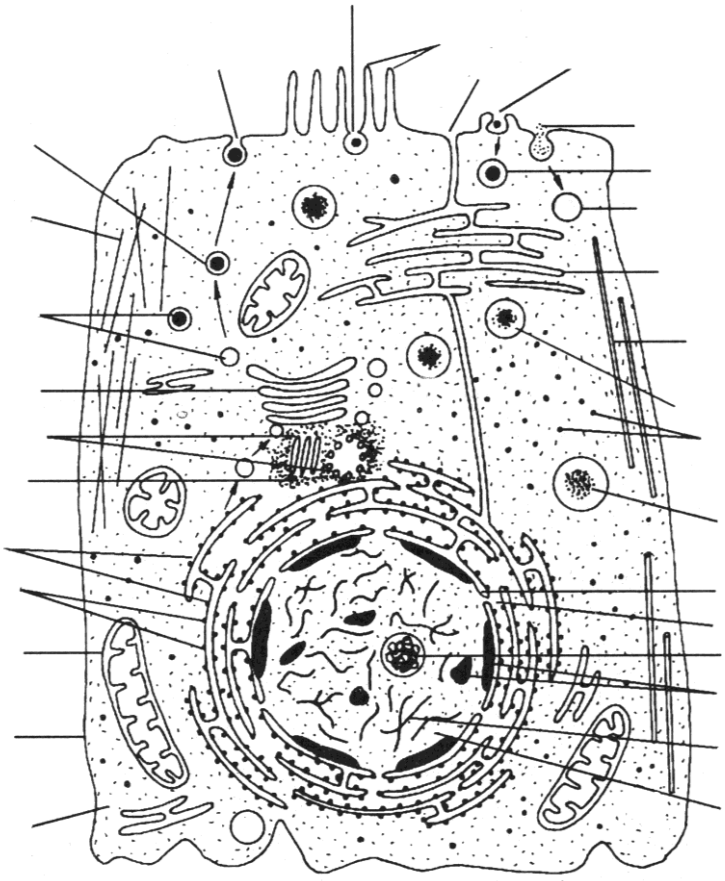
2. Centrosome (Centrioles) are two cylindrical structures that lie at right angles to one another near the nucleus. Each centriole is composed of nine triplets of proteins fibers (tubulins). The centrioles are important in cell division. They organize formation of spindle fibers, which move the chromosomes.

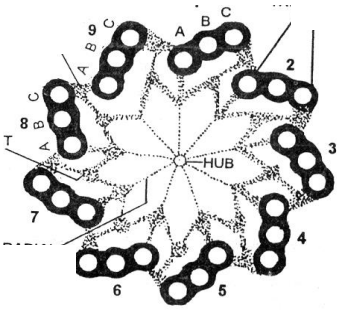
TASK 1. Study under a microscope samples of A) human blood; B) blood of a frog . Sketch the erythrocytes.

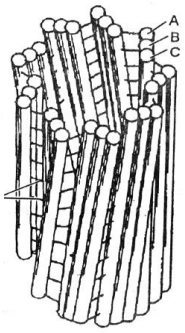
A. 

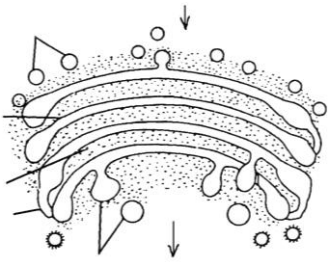
B. 

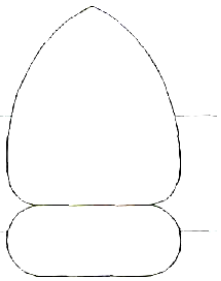
TASK 2. Study a scheme of eukaryotic cell. Point out structural components.

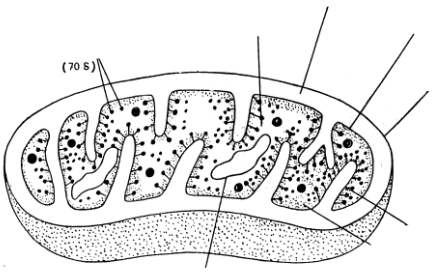












TASK 3. Fill the table

Organelle	Structural components	Function
Mitochondrion EPC a) smooth b) rough Golgi complex Lysosome Peroxysome		

Ribosome Centrioles		

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. The cell theory was enunciated by
   A. Robert Hooke
   B. Anton Van Leeuwenhoek
   C. I. Metchnikoff
   D. T. Schwann
   E. R.Brown
2. The prokaryotic cells differ from eukariotic cells in structure and way of division. Their typical features are
   A. Presence of cell membrane
   B. Absence of nucleus
   C. Absence of membrane-limited organelles
   D. Presence of ribosomes
   E. All of the above
3. The eukaryotic cells differ from prokariotic cells in structure and way of division. Specific feature of eukaryotic cell is
   A. Single circular double strand of DNA
   B. Absence of linear chromosomes
   C. Cell membrane
   D. Absence of membrane –limited organelles
   E. Nuclear membrane around the nuclear material
4. The latest model about the molecular structure of biomembrane is
   A. Fluid mosaic model
   B. Sandwich model hypothesis
   C. Lipid model
   D. Protein model
   E. Unit membrane hypothesis
5. It has been cleared that animal and human cells have specific outer coating - glycocalyx. It consist of
   A. Lipids
   B. Carbohydrate-rich molecules
   C. Proteins
   D. Glycogen
   E. Nucleic acids
6. Some human disorders is a result of dysfunction and structural defects of cell membranes. Which property of cell membrane is most important in cell metabolism
   A. Plasmolysis
   B. Semi permeability
   C. Presence of micrivilli
   D. Structural function
   E. Cell communication
7. In laboratory experiment leukocyte culture was mixed with staphylococci. Neutrophile leukocytes engulfed and digested bacterial cells. This process is termed
   A. Pinocytosis
   B. Diffusion
   C. Metagenes
   D. Phagocytosis
   E. Copulation
8. Cells of most organisms have organelles of special and general function. Example of latter is
   A. Endoplasmic reticulum
   B. Ribosomes
   C. Lysosomes
   D. Mitochondria
   E. All of the above
9. There are two types of endoplasmic reticulum: smooth and rough. Which function is common for both?
   A. Protein biosynthesis
   B. Biosynthesis of carbohydrates
   C. Lipid biosynthesis
   D. Synthesis of glycogen
   E. Transport
10. Electron photomicrograph of the cell shows a network of internal membranes studded with ribosomes. This is
   A. Golgi complex
   B. Smooth endoplasmic reticulum
   C. Rough endoplasmic reticulum
   D. Microtubules
   E. Mitochondria
11. Electron photomicrograph of the cell shows a network of internal membranes which manufacture and transport lipids and carbohydrates. This is
   A. Golgi complex
   B. Smooth endoplasmic reticulum
   C. Rough endoplasmic reticulum
   D. Microtubules
   E. Mitochondria
12. Electron photomicrograph of the cell shows a network of internal membranes studded with ribosomes. The function of ribosomes is
   A. Protein biosynthesis
   B. Lipid biosynthesis
   C. Transport
   D.Biosynthesis of carbohydrates
   E. Synthesis of DNA
13. Ribosomes consist of protein and rRNA. What is the place of biogenesis of ribosomes
   A. Golgi complex
   B. Smooth endoplasmic reticulum
   C. Rough endoplasmic reticulum
   D. Microtubules

E. Nucleolus

14. Tissue sample of the patient with benign tumor was studied under the electron microscope. A lot of small (15 –20 nm) spherical bodies, consisting of two unequal subunits were detected. These are

A. Golgi complex
B. Smooth endoplasmic reticulum
C. Ribosomes
D. Microtubules
E. Mitochondria

15. Small round organelles measures 0.2 – 1.0 μm and participates in intracellular digestion. They originates from Golgi complex and are divided into groups under different contents and function. Destruction of these organelles result in autolysis. Name the organelle

A. Rough endoplasmic reticulum
B. Lysosomes
C. Centrioles
D. Ribosomes
E. Mitochondria

16. While studying human cell culture under the light microscope one saw production of small vesicles by Golgi complex cistern. Biochemical analysis showed digestive enzymes in its contents. Which cell organelle were formed?

A. Centriole
B. Lysosome
C. Plastid
D. Ribosome
E. Mitochondrion

17. Lysosomes are the small sacs containing proteases, nucleases, lipases and other enzymes. What is the function of lysosomes?

A. Protein biosynthesis
B. Synthesis of lipids
C. Synthesis of carbohydrates
D. Synthesis of glycogen
E. Intracellular digestion

18. Different cell organelles have different enzymes because of different functions. Which organelle contain digestive enzymes only?

A. Golgi complex
B. Smooth endoplasmic reticulum
C. Rough endoplasmic reticulum
D. Lysosome
E. Mitochondrion

19. One saw destroying of round cell organelles followed by cell destruction after ultraviolet irradiation. What are these organelles ?

A. Golgi complex
B. Lysosomes
C. Rough endoplasmic reticulum
D. Ribosomes
E. Mitochondria

20. Some human disorders are characterized by destruction of lysosomes in the cells. It leads to the

A. Dysfunction of mitosis
B. Abnormal translation
C. Abnormal transcription
D. Accumulation of certain biochemical compounds
E. Autolysis

21. In electron micrograph are seen oval and round organelles with double wall. Outer membrane is smooth, inner membrane folded into cristae; contain enzyme ATPase synthetase. These are

A. Golgi complex
F. Lysosomes
B. Centrioles
E. Ribosomes
G. Mitochondria

22. As a rule DNA in eukariotyc cells is in chromosomes. Some cell organelles contain DNA also. These are

A. Lysosomes
B. Golgi complex
C. Endoplasmic reticulum
D. Ribosomes
E. Mitochondria

23. There are semi autonomic organelle, historical origin of which is explained by symbiotic theory. These organelles are

A. Nucleus
B. Mitochondria
C. Golgi complex
D. Endoplasmic reticulum
E. Lysosomes

24. Mitochondria are semi autonomic organelles. They contain hereditary information, which is present in

A. Chromosomes
B. Ribosomes
C. Inner membrane
D. Circular DNA
E. Outer membrane

25. Mitochondria are double membrane organelles; lysosomes, complex Golgi are single membrane organelles. Which organelles are nonmembranous?

A. Ribosomes
B. Smooth endoplasmic reticulum
C. Rough endoplasmic reticulum
D. Platsids
E. Digestive vacuoles

26. It is known that DNA is present in some organelles. These are

A. Lysosomes
B. Golgi complex
C. Ribosomes
D. Endoplasmic reticulum
E. Mitochondria

27. Organic substances breaks down into simple molecules during the cell respiration. This process is accompanied by ATP biosynthesis. It takes place in

A. Lysosomes
B. Ribosomes
C. Mitochondria
D. Golgi complex
E. Endoplasmic reticulum

28. Cell organelles which are able to self renewing were separated by centrifugation. Biochemical analysis showed high level of ATPase synthetase. These organelles are

A. Golgi complex
B. Ribosomes
C. Endoplasmic reticulum
D. Microtubules
E. Mitochondria

29. One of the cell organelles provides accumulation and secretion of organic substances, have structural and some other functions. That is why it well expressed in secretor cells. This is
A. Mitochondria
B. Golgi complex
C. Lysosomes
D. Ribosomes
E. Endoplasmic reticulum

30. Golgi complex consists of clusters of tubules, vesicles, and flattened sacs or cisternae. It produces
A. Chromosomes
B. Ribosomes
C. Primary lysosomes
D. Secondary lysosomes
E. Mitochondria

31. Cell center (centiole) was removed from the cell by micromanipulator. Which cell process is destroyed?
A. Protein biosynthesis
B. Cell respiration
C. Carbohydrates metabolism
D. Cell division
E. Fat metabolism

32. Electron micrograph of the cell shows cell organelle, which is situated near the nucleus and composed of microtubules and cisternae. It is known that lysomes arise from it. This organelle is
A. Golgi complex
B. Smooth endoplasmic reticulum
C. Rough endoplasmic reticulum
D. Microtubules
E. Mitochondria

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Biological membranes. Transport across the cell membrane. Structural components of cytoplasm.

Practical class 3. Biological membranes. Transport across the cell membrane. Structural components of cytoplasm.

The Purpose of the Lesson: To study the importance of biological membranes and transport across the membranes for activities of the cells

TOPIC CONTENT

1. Modern model of plasma membrane organization.
2. Chemical composition of plasma membrane.
3. Structure and function of glycocalyx.
4. Functions of plasma membranes.
5. Active and passive transport across the plasma membrane.
6. Endocytosis (phagocytosis and pinocytosis). Exocytosis.

TEST QUESTIONS for individual work

№ №	Questions	Answers
1	Name the modern model of cell plasma membrane structure:a	
2	List the organic substances that compose plasma membrane: a,b	
3	What are the main functions of cell membrane? a,b,c,d,e	
4	Name the types of a) passive transport: a,b,c b) active transport: a,b,c,	
5	Which kind of transport requires ATP energy?	
6	Through which membrane components and by which mechanisms passes • water • water-soluble substances • fat-soluble substances • glucose • amino acids • ions	
7	What is • pinocytosis • phagocytosis • exocytosis	

Recommended literature:

- Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 27 – 31.

The cell membrane or plasma membrane is described according to the fluid mosaic model.

Chemical composition: phospholiopids, proteins and cholesterol.

Organization of cell membrane.
Membrane consists of two layers of phospholipids. The hydrophilic (water-soluble) heads of phospolipids are toward the water. The hydrophobic (insoluble) tails are toward each other. Proteins are on the surface of the lipids or cross the phospolipid layer.
On the outer surface some lipids and proteins combine with carbohydrates (glycolipids and glycoproteids). Glycolipids and glycoproteids form glycocalyx.

Functions of membrane
A. isolates the cytoplasm from the exterior environment;
B. regulates the transport of molecules into and out of the cell;
C. allows communication with other cells;
D. reception of the signals from outer environment .

Transport across the cell membrane
Cell membrane is selectively permeable. Selectively permeability means that some molecules are allowed to pass through the cell membrane while other cannot.

There are two types of transport:
1) Passive transport is transport without energy use. It occurs from area with high concentration to low concentration (down the concentration gradients).
2) Active transport is the transport, that takes energy. It occurs against the concentration gradients.

Passive transport
– Simple diffusion – the movement of particles from an area where their concentration is high to an area that has low concentration. It is transport of ions, gases (O_2, CO_2), fat-soluble molecules (cholesterol, Vitamin D)
– Osmosis – diffusion of water
– Facilitated diffusion - passage of molecules through transmembrane transport proteins. It is transport of amino acids, glucose, some ions

Active transport
D. It requires energy in the form of ATP.
E. Ion pomps (active transport). It is special transport protein of the cell membrane, that supplies energy for transport of ions against a chemical gradient. Example is the sodium pump for the transfer of sodium and potassium ions across a cell membrane.

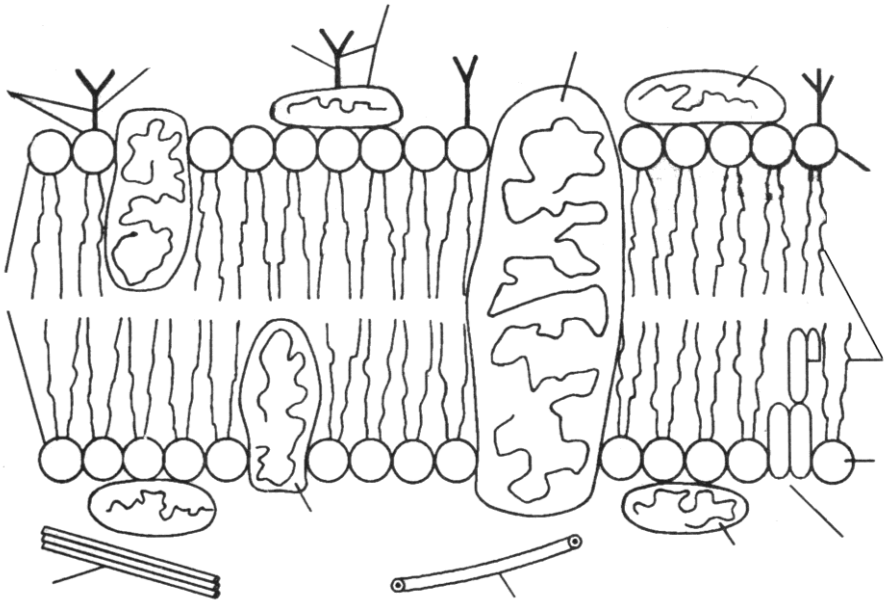
F. Endocytosis. It is a process by which cell get large molecules from outside.
a) phagocytosis is the engulfment of the solid particles. Example is phagocytosis of bacteria by leukocytes.

b) pinocytosis is the engulfment of the liquid (solution of macromolecules)

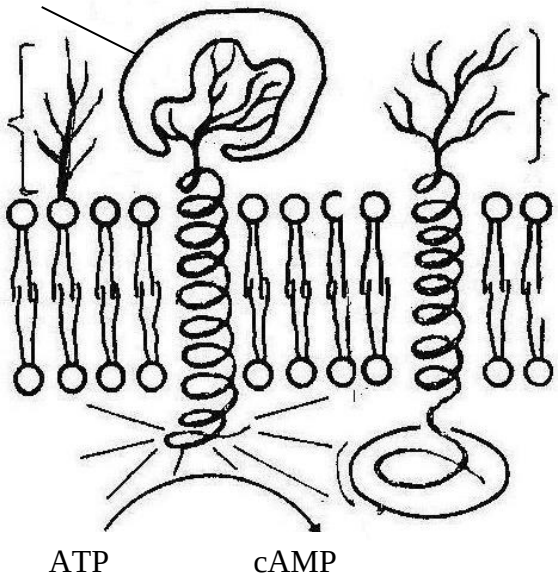
Exocytosis. It is a process by which cell excrete large molecules to outside.

Practical work. **CELL MEMBRANES. TRASPORT ACROSS BIOMEMBRANE**

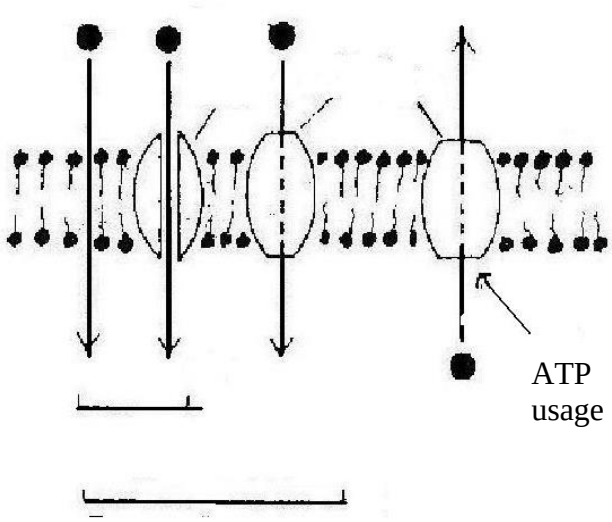
TASK 1. Study fluid mosaic model of plasma membrane. Label hydrophilic heads, hydrophobic tails, proteins (integral, semi integral and peripheral), glycoproteids.



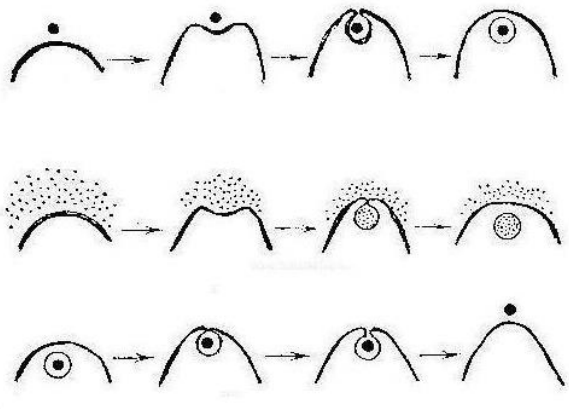
TASK 2. Study receptor function of glycocalyx. Label glycopipids, glycoproteids, hormone.



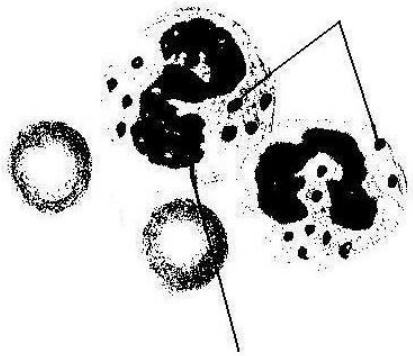
TASK 3. Study scheme of transport across the plasma membrane. Label simple and facilitated diffusion, active transport. Give the examples of substances that enter the cell by each way.



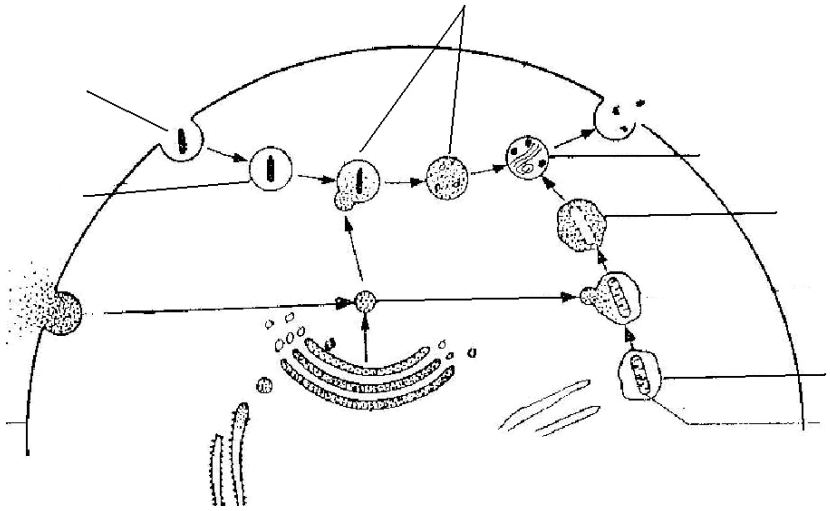
TASK 4. Study the mechanisms of endo- and exocytosis. Label phago-, pino- and exocytosis. Write down the substances that pass across cell membrane by each mechanism



TASK 5. Study a blood smear under the light microscope. Mark leukocytes, erythrocytes and engulfed bacterial cells.



TASK 6. Study the scheme of hetero-, auto and exocytosis. Mark Golgi complex, lysosomes, phagolysosomes, autophagosomes, residual bodies, exocytosis.



TASK 7. Compare passive and active transport across plasma membrane

Characteristic	Passive transport	Active transport
1. Concentration gradient 2. Energy requirement 3. Shape of protein (if protein is involved) 4. Types of transport		

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. The latest model about the molecular structure of biomembrane is
   A. Fluid mosaic model;
   B. Sandwich model hypothesis;
   C. Lipid model;
   D. Protein model;
   E. Unit membrane hypothesis.

2. It has been cleared that animal and human cells have specific outer coating - glycocalyx. It consist of
   A. Lipids;
   B. Carbohydrate-rich molecules;
   C. Proteins;
   D. Glycogen;
   E. Nucleic acids.

3. In laboratory experiment leukocyte culture was mixed with staphylococci. Neutrophile leukocytes engulfed and digested bacterial cells. This process is termed
   A. Pinocytosis;
   B. Diffusion;
   C. Exocytosis;
   D. Phagocytosis;
   E. Copulation.

4. The concentration of calcium in a cell is 0.3%. The concentration of calcium in the surrounding fluid is 0.1%. How could the cell obtain more calcium?
A. Passive transport;
B. Diffusion;
C. Active transport;
D. Osmosis;
E. Any of the above.

5. Red blood cells were immersed in a hypotonic solution. The cells gained water, swelled and lysed. What transport mechanism works in this case?
A. Electro diffusion;
B. Exocytosis;
C. Osmosis;
D. Phagocytosis;
E. Facilitated diffusion.

6. Phagocytosis provides feeding in some protozoan like amoeba. In which human cells this mechanism is not the way of nutrition but provides defense of an organism?
A. Erythrocytes;
B. Leukocytes;
C. Epithelium of digestive tract;
D. Epithelium of respiratory tract;
E. Epithelium of excretory tract.

7. Electron micrograph of a cell shows that cell membrane consists of lipids and proteins. Some proteins are peripheral, some are semi-integral and some are integral. Through which of membrane components transport of ions takes place?
A. Lipids;
B. Peripheral proteins;
C. Glycoproteins;
D. Glycolipids;
E. Integral proteins.

8. Electron micrograph of a pancreatic cell shows well developed Golgi complex and lot of secretory vesicles. Some vesicles are secreted outside by mechanism of
A. Diffusion;
B. Phagocytosis;
C. Exocytosis;
D. Ion pomp;
E. Osmosis.

9. Plasma membrane was partially destroyed by action of ultraviolet rays. Which cell organelle will provide its restoration?
A. Lysosome;
B. Mitochondrion;
C. Golgi complex;
D. Smooth endoplasmic reticulum;
E. Centriole.

10. Electron micrograph of a cell shows outer membrane coating – glycocalix, which consists of carbohydrates covalently bonded to membrane proteins and lipids. The main function of this structural component is
A. Structural;
B. Protective;
C. Passive transport;
D. Receptor;
E. Phagocytosis.

11. Pediatrician examined the patient with rickets and administered vitamin D. This vitamin enters the cells by
A. Active transport;
B. Osmosis;
C. Diffusion through the lipids;
D. Diffusion through the proteins;
E. Phagocytosis.

12. Intravenous injection of glucose is indicated in treatment of different disorders. How does this substance pass through the cellular membranes?
A. Active transport;
B. Osmosis;
C. Diffusion trough the lipids;
D. Fagocytosis;
E. Facilitated diffusion.

13. Movement of materials across a membrane against electrochemical gradient occurs by
A. Active transport;
B. Osmosis;
C. Facilitated diffusion;
D. Diffusion;
E. All of these.

14. Cell recognition and adhesion is facilitated by certain components of cell membrane. These components are generally
A. Proteins and lipids;
B. Glycoproteins and glycolipids;

C. Lipids only;
D. Proteins only.

15. Fluid mosaic model of cell membrane states that it has lipid bilayer with
A. Proteins on both the surfaces;
B. Proteins on the outer surface only;
C. Proteins embedded in it only;
D. Some proteins embedded and some on the surface;
E. Membrane consists of proteins only.

16. If a solution outside a cell is made more concentrated, so the cell loses water to its environment and shrinks, the external solution is said to be
A. Hypotonic;
B. Isotonic;
C. Hypertonic;
D. In equilibrium.

17. The thyroid gland contains a high concentration of iodine This is an example of
A. Passive transport;
B. Active transport;
C. Facilitated diffusion;
D. Endocytosis;
E. Osmosis.

18. Which of the following is actively transported across cell membrane?
A. Carbon dioxide;
B. Oxygen;
C. Water;
D. Amino acids;
E. Sodium ions.

19.Golgi complex exports substances from a cell due to the fusion of the membrane saccule with the cell membrane. The saccule content flows off. What process is it?
A. Exocytosis;
B. Active transport;
C. Facilitated diffusion;
D. Endocytosis;
E. All answers are false.

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Nucleus. Chromosomes morphology. Human karyotype

Practical class 4. Nucleus. Chromosomes morphology. Human karyotype

The Purpose of the Lesson: To study the morphological characteristics of the chromosomes. To characterize normal human karyotype and importance of its studying for the diagnosis of hereditary disorders.

TOPIC CONTENT

1. Chemical composition of the chromosomes.
2. The levels of chromatin condensation.
3. Notion of the euchromatin and heterochromatin
4. The autosomes and heterosomes (sex chromosomes). Homologous and non-homologous chromosomes.
5. Shape of the metaphase chromosome.
6. Karyotype and ideogram. Characteristics of the normal human karyotype.
7. International classification of the chromosomes.
8. The rules of the chromosomes.

TEST QUESTIONS for individual work

№ №	Questions	Answers
1	Name the main components of the nucleus: a,b,c,d	
2	What are the main functions of the nucleus?(a,b,c)	
3	Where does the nucleolus form?	
4	What is the function of the nucleolus?	
5	What is the chemical composition of the chromosomes? (a,b,c)	
6	What are the functions of histones and non-histone proteins?(a,b)	
7	Which kind of chromatin (euchromatin, heterochromatin) posesses active genes?	
8	What is the state of chromosomes (condensed, decondensed) during the interphase(a); metaphase of mitosis(b)	
9	When and where the first international classification of chromosomes has been adopted?	
10	Classification of the human chromosomes is based on: a,b,c	
11	What are the shapes of human metaphase chromosomes: a, b, c (normal),d (pathological)?	
12	Give the definition of: a) metaphase plate b) karyotype c) ideogram	
13	Human karyotype in studied in practical medicine for….	
14	Which cells are taken for karyotyping? a,b,c	
15	How many autosomes (a) and sex chromosomes (b) are in normal human karyotype?	
16	The length of the chromosomes is measured in ….	
17	Which human chromosome is the largest (a) and the smallest (b) in size?	
18	Name the rules of the chromosomes (a,b,c,d)	

1. **Recommended literature:** Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 37 – 45.

Functions of a nucleus

- it contains hereditary information
- it regulates all activities of cell

Structure of the nucleus

The **nucleus** has

1) nuclear envelope (nuclear membrane);
2) nucleoplasm.
3) chromosomes.
4) nucleolus.

1. T**he nuclear envelope** separates the nucleoplasm from the cytoplasm. It is double membrane perforated with large pores.
2. N**ucleoplasm** is a liquid that consists of different types of RNA, nucleotides, enzymes, ATP, lipids and ions such as phosphorus, potassium, sodium, calcium and magnesium.
3. **Nucleolus** is composed of DNA, RNA and proteins. Function of nucleolus is the formation of ribosomes.
4. **Chromosomes.** Chromosome is composed of a single DNA double helix molecule and proteins (basic histone proteins and non-histone proteins). Chromosomes contain hereditary (genetic) information

Chromosomes

During the interphase chromosomes are dispersed (decondensed). They look like long **chromatin threads.**

The condensation of chromatin during the interphase differs. Less condensed portions of chromatin are light. It is **euchromatin**. It is genetically active. More condensed portions of chromatin are dark. It is **heterochromatin.** It is genetically inert.

During the cell division chromosomes are highly condensed. The look like X-shaped bodies. During the metaphase level of condensation is maximal.**Morphology of metaphase chromosome.**

Metaphase chromosome consists of two **sister chromatids** (future daughter chromosomes). Chromatids attach to each other at the site of **primary constriction** or **centromere**. The microtubules of the spindle fibers atteches to the centromere.

The centromere divides the chromosome into two parts, each part is called **ar**m.

The tips of the chromosomes are called **telomeres**.

Some chromosomes have **secondary constriction or nucleolar organizer region.** It has genes for rRNA and participates in the formation of nucleolus during interphase. The terminal part of the chromosome beyond secondary constriction is called **satellite.** The chromosomes with satellite are known as sat-chromosomes.

Shapes of the chromosomes

The position of centromere determines shape of metaphase chromosome.

1. **Metacentric** have centromere in the middle of chromosome so that the two arms are equal.
2. **Submetacentric** are chromosomes with slightly unequal arms.
3. **Acrocentric** are chromosomes with one small and one large arm.
4. **Telocentric** are chromosomes with one arm. In humans telocentric chromosomes are absent.

Karyotype

Karyotype is diploid (double) set of the chromosomes. It is characterized by the number, size and shape of the chromosomes.

There are **46 (or 23 pairs)** of chromosomes in **human karyotype.** Chromosomes same in man and woman are **autosomes**. There are 44 (22 pairs) of autosomes in humans. Chromosomes that determine sex are **sex chromosomes**. **Man** has **XY** sex chromosomes, **woman** has **XX** sex

chromosomes.

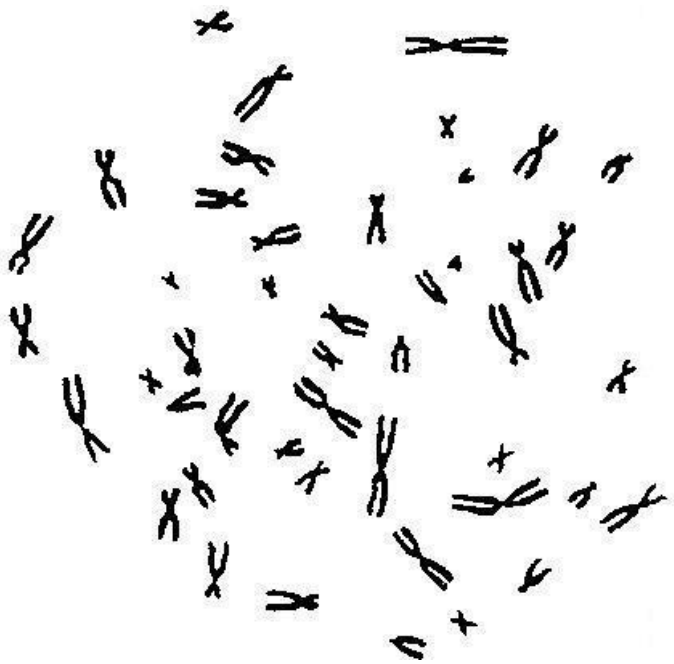
Sperm and egg has haploid set of chromosomes (23 chromosomes)

Karyotyping

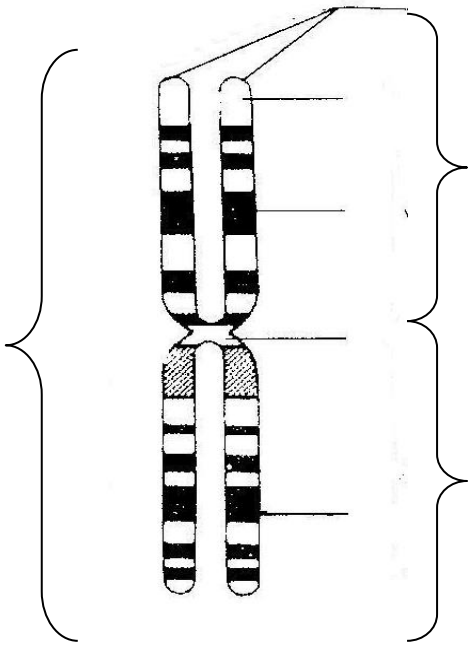
Laboratory investigation of the karyotype is karyotyping. The most commonly used cells are leukocytes (lymphocytes).

Practical work. **MORPHOLOGY OF CHROMOSOMES. HUMAN KARYOTYPE.**

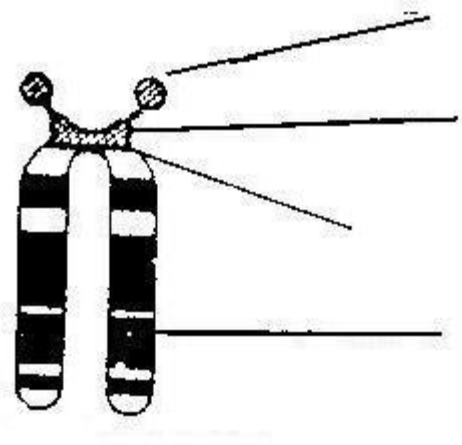
TASK 1. Study the metaphase plate of a man. Mark the chromosomes of metacentric, submetacentric and acrocentric shape.



TASK 2. Study schematic structure of a metacentric chromosome. Label daughter chromatids, centromere, arms, telomeres, euchromatin, heterochromatin.



TASK 3. Study schematic structure of a acrocentric chromosome. Label centromere, long and short arms, secondary constriction, satellite.



TASK 4. Define the types of metaphase chromosomes in human karyotype. Mark each group, characteristic of the group (shape and size) and number of each pair. Detect sex of the person.

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. In somatic cells of most species each chromosome has a pair. How we term the double set of chromosomes, specific for the species?
   A. Genome
   B. Idiogram
   C. Genofond
   D. Karyotype
   E. Genotype

2. Metaphase plate is studied for diagnosis of chromosomal disorders. Which cells are studied usually?
   A. Yellow bone marrow
   B. Red bone marrow
   C. Lymphocytes
   D. Erythrocytes
   E. Epithelial cells

3. Each species is characterized by certain number of chromosomes. This is a rule of
   A. Constant number
   Double number
   B. Individuality
   C. All of the above

4. Some chromosomes have nucleolar organizer region, which is responsible for the formation of nucleolus. These chromosomes are
   A. Telocentric
   B. Submetacentric
   C. Metacentric
   D. Satellite chromosome
   E. Acrocentric

5. Set of the chromosomes of species, which is characterized by certain number and morphology of the chromosomes is
   A. Genotype
   B. Genome
   C. Karyotype
   D. Phenotype
   E. Genofond

6. There are several types of the chromosomes inhuman karyotype. Chromosomes with slightly unequal arms are
   A. Submetacentric
   B. Centromeric
   C. Acrocentric
   D. Metacentric
   E. Telocentric

7. There are three types of the chromosomes in human karyotype. After mutation one of the chromosomes has one arm only. This chromosome is
   A. Metacentric
   B. Submetacentric
   C. Acrocentric
   D. Satellite chromosome
   E. Telocentric

8. There are different types of the chromosomes in photo of metaphase plate. Which of them have equal arms?
   A. Metacentric
   B. Submetacentric
   C. Acrocentric
   D. Telocentric

E. Centromeric

9. Majority of species have diploid set of the chromosomes. This is a rule of
A. Constant number
B. Double number
C. Individuality
All of the above

10. Each species of plants and animals has certain constant number of chromosomes. How many chromosomes are in normal human karyotype?
A. 40
B. 42
C. 44
D. 46
E. 48

11. Which cell structures contain hereditary information?
A. Ribosomes
B. Lysosomes
C. Microtubules
D. Chromosomes
E. Biomembranes

12. By recent technology human chromosomes are differentially stained demonstrating specific banding pattern. Graphic systematic arrangement of the chromosomes according to their size, shape and staining is
A. Genotype
B. Genome
C. Karyotype
D. Genofond
E. Idiogram

13. There are different types of the chromosomes in photo of metaphase plate. Which of them have one long and one very short arm?
A. Metacentric
B. Submetacentric
C. Acrocentric
D. Telocentric
E. Centromeric

14. There are different types of the chromosomes in photo of metaphase plate. Which of them have one arm and terminal position of centromere?
A. Telocentric
B. Submetacentric
C. Acrocentric
D. Metacentric
E. Sat-chromosomes

15. Chemical composition of the chromosomes is
A. Polypeptides
B. Amino acids
C. Glycolipids
D. Glycoproteids
E. Nucleoproteids

16. Each pair of the chromosomes have certain morphological peculiarities. This is a rule of
A. Constant number
B. Double number
C. Individuality
D. All of the above

17. International Denver classification if the chromosomes classify the chromosomes by
A. Shape, size, staining
B. Size, staining, number
C. Shape, staining, number
D. Size, shape, number

18. There are three types of the chromosomes in normal karyotype. Mutation may result in loss one arm of the chromosome. Such chromosome is termed as
A. Metacentric
B. Telocentric
C. Acrocentric
D. Submetacentric
E. Sat-chromosome

19. Method of differential staining causes dark and light banding if the chromosome along its lengths. Dark stained regions are termed
A. Euchromatin
B. Telomeres
C. Centromeres
D. Heterochromatin

20. Chromatin is stained by basic dyes nuclear substance, which consists of
A. DNA
B. mRNA
C. Protein + DNA
D. Protein + mRNA
E. Protein + tRNA

21. Chromosomal parts which are lightly stained and are completely decondensed during the interphase is
A. Euchromatin
B. Telomeres
C. Centromeres
D. Heterochromatin
E. Satellite

22. Each organism inherits chromosome from mother and from father. Such paired chromosomes are
A. Metacentric
B. Acrocentric
C. Homologous
D. Non-homologous
E. Telocentric

23. In males and females the majority of the chromosomes are similar. These are
A. Autosomes
B. Sex chromosomes
C. Heterosomes
D. Homologous
E. Nonhomologous

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following lesson: Molecular basis of heredity. Gene structure in eukariotes.

Practical class 5. Molecular basis of heredity. Gene structure in eukariotes.

The Purpose of the Lesson: To study the characteristics of nucleic acids, structure of genes, classification of eukaryotic and prokaryotic genes for understanding of molecular mechanisms of inheritance.

TOPIC CONTENT

1. Nucleic acids as biological polymers.
2. DNA. Structure, composition of nucleotides, functions.
3. RNA. Structure, composition of nucleotides, functions.
4. Principle of complementarity. Chargaff's rule. The coefficient of DNA specificity.
5. Role of DNA in transmission of hereditary information. Transformation, transduction, conjugation.
6. Organization of eukaryotic genome. Unique, moderately repetitive and highly repetitive sequences.
7. DNA replication. Initiation, elongation, termination.
8. DNA repair. Types of repair.
9. Structural and regulatory genes. Genes for rRNA and tRNA. Mobile genes (transposones).
10. Split genes. Exon-intron organization of eukaryotic genes.

TEST QUESTIONS for individual work

№	Questions	Answers
1	Point out location in a cell of 1) DNA – a,b,c; 2) rRNA-a,b; 3) mRNA – a,b; 4) tRNA- a,b.	
2	Which space organization has 1) DNA molecule; 2) RNA molecule?	
3	What is the chemical composition of 1) DNA nucleotide – a,b,c; 2) RNA nucleotide – a,b,c.	
4	What is the difference between DNA and RNA nucleotide?(a,b)	
5	Where are all the types of RNA formed?	
6	What are the functions of 1)DNA – a,b; 2) tRNA – a; 3) mRNA – a; 4) rRNA – a,b	
7	What are the main functional centers of tRNA molecule? (a,b)	
8	Which components participate in formation of amino-acyl-tRNA complex ?(a,b,c,d)	
9	Replication is….	
10	List main components participating in	
11	DNA replication – a,b,c.	
12	Name main stages of DNA replication – a,b,c.	
13	DNA repair is….	

14 15 16 17	An importance of DNA repair is The main difference in organization of prokaryotic and eukaryotic genes is – (a) Exon is….. Intron is…	

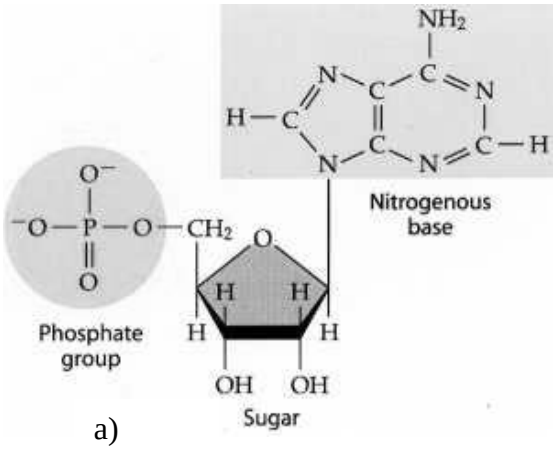
Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 50 – 60.

Nucleic acid

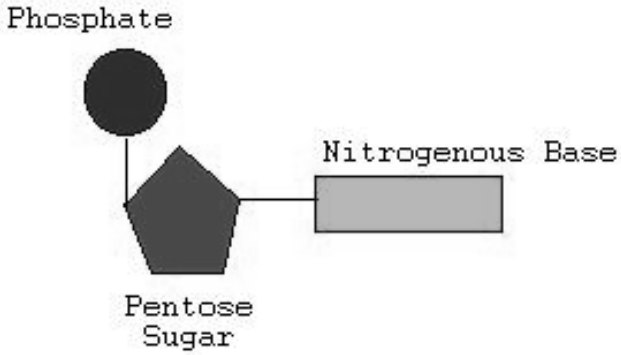
Nucleic acid is a biological polymer, which consists of **nucleotides**.

Each nucleotide consists of 3 components (Fig.1):

- phosphate group,
- pentose sugar
- nitrogenous base.



a)



b)

Fig1. Structure (a) and schematic representation (b) of tne nucıeoıide.

There are two types of nucleic acids:

1) **deoxyribonucleic acid or DNA**
2) **ribonucleic acid or RNA.**

DNA

Function. DNA stores and transfers hereditary information.

Location. DNA is located i**n the nucleus** in the chromosomes.

DNA also occurs in mitochondria as a circular molecule (like in prokaryotes)

Structure. DNA is a biological polymer that consists of nucleotides.

Each deoxyribonucleotide (Fig.2) has:

- phosphate group,
- deoxyribose sugar
- nitrogenous base.

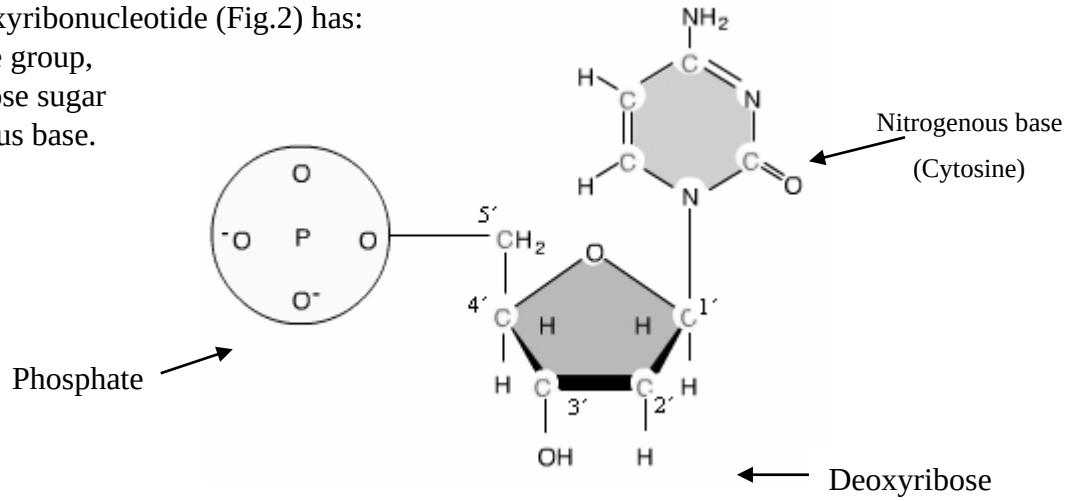


Fig.2. Nucleotide of DNA molecule

The nitrogenous base may be **adenine (A), guanine (G**), **cytosine (C)** and **thymine (T)** (Fig 3). Adenine and guanine are purines, cytosine and thymine are pyrimidines.

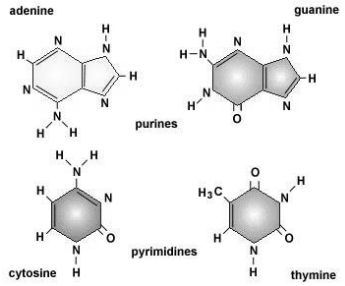
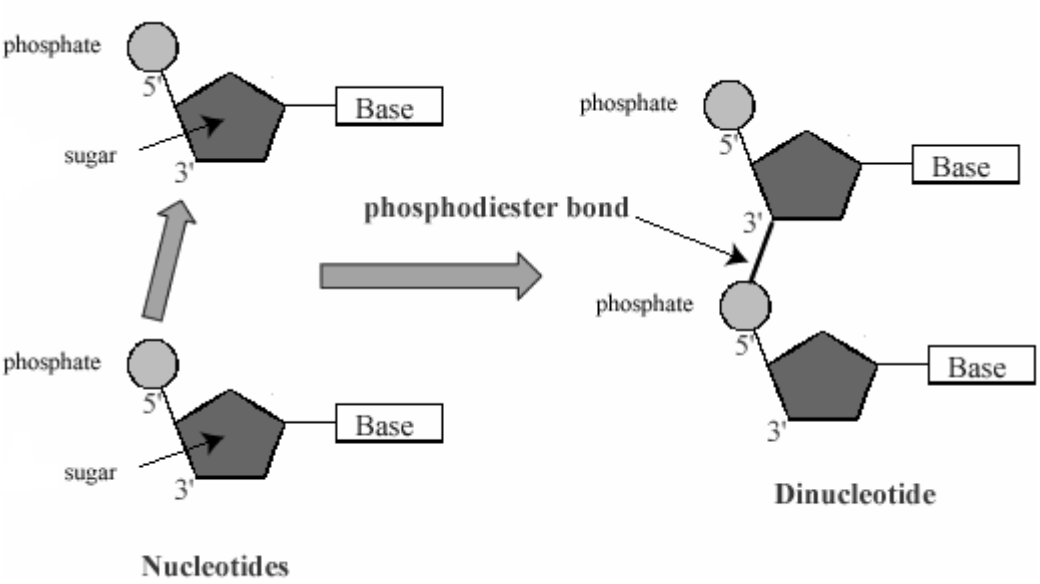


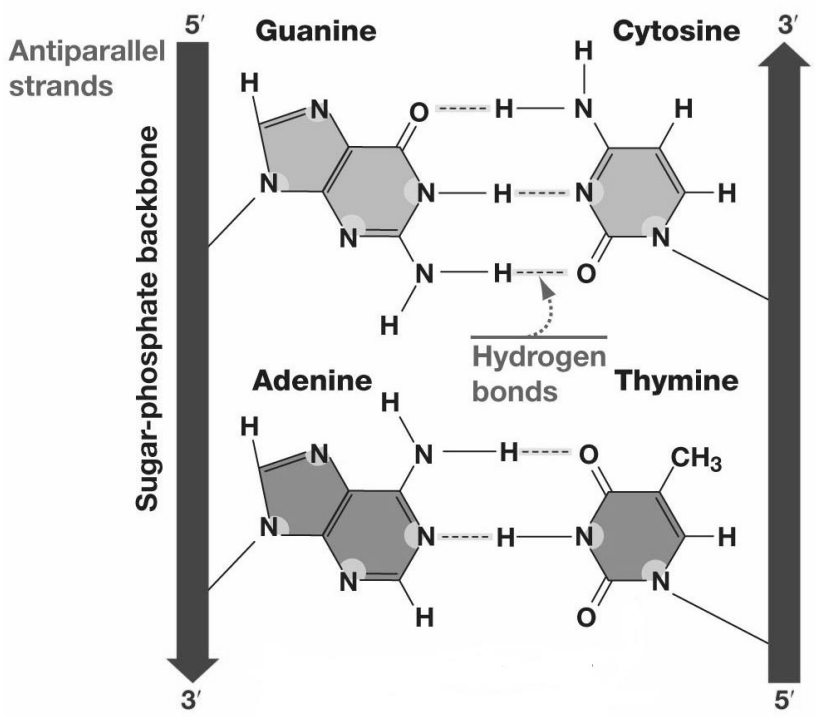
Fig. 3. Nitrogen bases in DNA molecule.

The model of DNA molecule was proposed by Watson and Crick in 1953. The main characteristics of DNA are:

- DNA is **double helix**. It has two polynucleotide strands. The helix is 20 A wide; its one turn is 34 A long and has 10 base pairs.
- The nucleotides of one strand are joined by covalent phosphodiester bonds between deoxyribose of one nucleotide and phosphate of another nucleotide.



- Two strands are held together by hydrogen bonds between nitrogenous bases. Adenine of one chain is always joined to thymine of the other chain by two hydrogen bonds and cytosine is always joined to guanine by 3 hydrogenous bonds. It is principle of **complementarity** of nitrogenous bases.



The Chargaff's rule

The Chargaff's rule states that 1) A = T; C = G;
2) A+G = T+C, so (A+G)/(T+C)=1.
The ratio (A+T)/(G+C) is different in different species. This ratio in humans equals 1.53.

DNA replication

DNA replication is **doubling of DNA molecule**. It is possible because nitrogenouse bases of the strands are complementary to each other. DNA molecule divides into two strands, and new complementary strands are formed.

Replication of DNA occurs in the S (synthetic) period of interphase. In cell division each of daughter cells get one copy of the DNA molecule. Thus hereditary information is transmitted from one generation to another.

DNA repair

DNA repair is correction of mistakes in DNA molecule. Mistakes in one strand are corrected, using second strand as a template.

RNA

RNA is formed in the nucleus on the DNA template

Function. RNA provides synthesis of protein, thus provides the realization of hereditary information.

Location. RNA occurs in nucleus, cytoplasm, ribosomes.

Structure. RNA is a single strand of nucleotides.

Each ribonucleotide has:

A. phosphate,
B. ribose sugar
C. nitrogenous base. The nitrogenous base may be **adenine, guanine** , **cytosine** and

uracil.

The main differences between chemical composition of RNA and DNA are:

- DNA is double strand molecule, but RNA is single strand;
- DNA contains deoxyribose , RNA – ribose;
- DNA contains Thymine, RNA - Uracil.

Types of RNA

There are three main types of RNA

1. Messenger or template (mRNA). It carries genetic information about from DNA to ribosome.
2. Transfer (tRNA). It transport amino acids to the ribosomes. It has anticodon (three nucleotides that complementary to a codon of mRNA) and site for attachmant of amino acid)
3. Ribosomal (rRNA). It forms structural carcass of ribosomes. The rRNA participates in the initiation and termination of protein synthesis

Gene

The unit of hereditary information is **gene**.

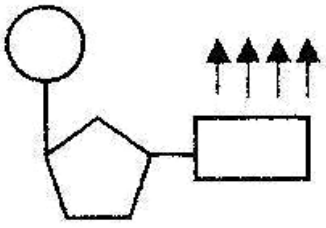
Gene is a fragment of DNA molecule that determines the synthesis of polypeptide, rRNA, tRNA or regulates function of another gene.

Gene has two types of nucleotides sequences:

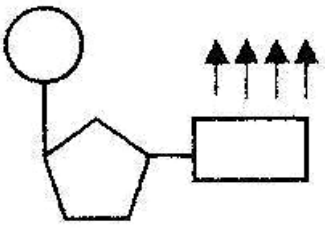
7. **Exons.** Exons code amino acids
8. **Introns.** Introns do not code amino acids

Practical work. **CHARACTERISTIC OF NUCLEIC ACIDS. PROKARYOTIC AND EUKARYOTIC GENE.**

TASK 1. Label the structural components of DNA and RNA nucleotides. Mark the position of the carbon atoms in sugar molecule

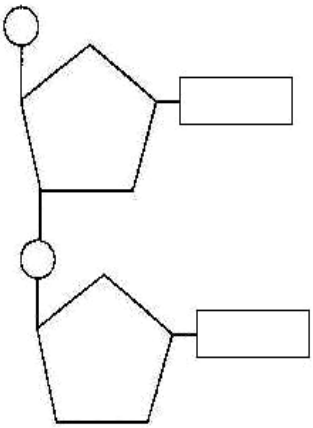


DNA

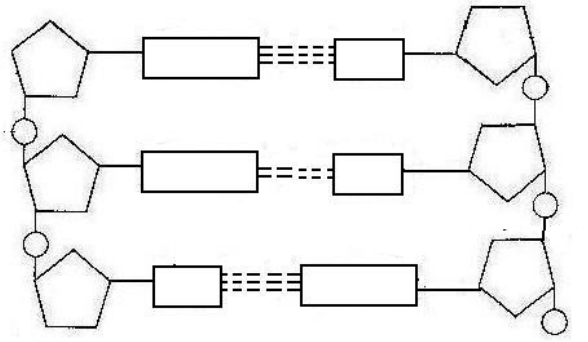


RNA

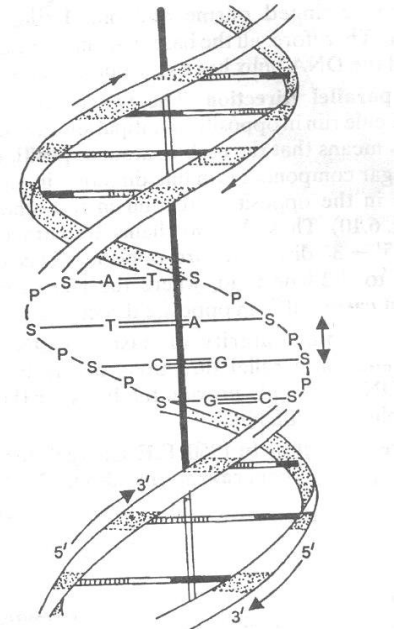
TASK 2. Label a bond between two DNA nucleotides of one chain. Mark the position of the carbon atoms in sugar molecule. Write down type of the bond, mark 5′ and 3′ ends of the chain.



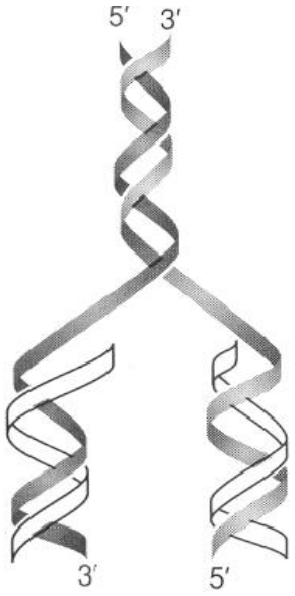
TASK 3. Label bonds between two complementary DNA chains. Mark type of the bond, complementary nitrogenous bases, 5′ and 3′ ends of both chains.



TASK 4. Study the Watson-Crick model of DNA molecule. Mark the diameter of the helix, distance between two neighboring nucleotides,number of nucleotides in single turn, sugar-phosphate backbone, nitrogenous bases, major and minor grooves.



TASK 5. Study the mechanism of DNA replication. Mark the type of DNA replication, parental and daughter strands, 3′ and 5′ ends of daughter strands. Replicate given DNA fragment.



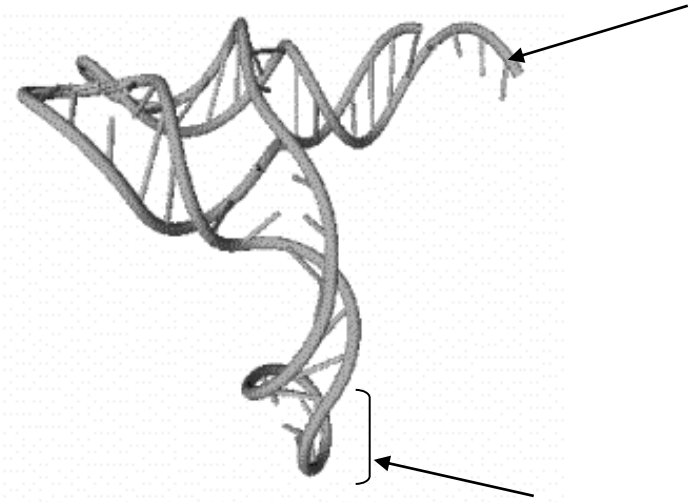
DNA 1	**DNA2**
A-	
C-	
T-	
T-	
C-	
G-	
A-	
G-	
G-	
C-	
A-	
C-	

TASK 6. Give the characteristic of different ways of DNA repair

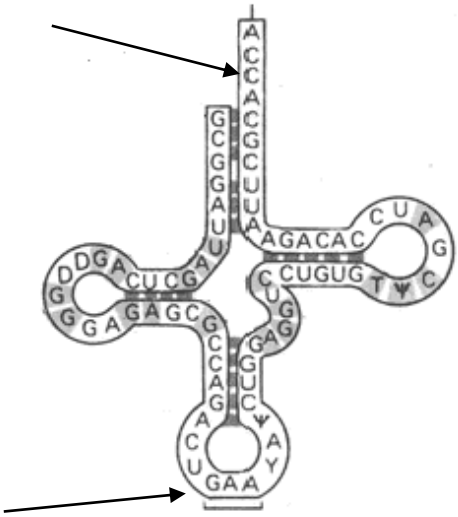
	Light repair	Excision repair
Injuring factor		

Mechanisms

TASK 7. Study the structure of tRNA molecule. Label anticodon and acceptor site.



Three-dimentional model of tRNA



Secondary structure of tRNA

TASK 8. Solve the problems.

1. Define second DNA chain. Calculate content of each type of nucleotides (in %); length and mass of given DNA fragment, (nucleotide length is 0.34 nm, mass is 345); number of deoxyribose and phosphate molecules.	**DNA T-T-A-G-G-C-C-A-C-A-A-A-C-C-G-**
2. Length of DNA fragment is 680 nm. How many a) deoxyribose molecules b) nitrogenous bases are in this fragment? Detect mass of this fragment (c).	
3. There are 250 (20%) Adenine nucleotides in the DNA fragment. How many T, C, and G nucleotides are in this fragment?	
4. Biochemical analyses detected that in mRNA molecule Adenine contents is 22%, Uracil – 12%, Guanine – 26%.	

Define contents of each type of nucleotides in DNA molecule.	

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. The majority of structural genes in eukaryotes consist of expressed sequences (exons) and intervening non-coding sequences (introns). Which molecule is formed on these genes directly after transcription?
   A. Pre-mRNA;
   B. mRNA;
   C. snRNA;
   D. tPNA;
   E. rPNA.
2. DNA is a macromolecular polymer. Its monomer is
   A. Amino acid;
   B. Nitrogenous base;
   C. Polypeptide;
   D. Deoxyribose;
   E. Nucleotide.
3. Structural genes of eukaryotes have exons and introns. Both portions of gene are transcribed but introns removed during the maturation of mRNA. These fragments of genes are
   A. Coding amino acids;
   B. Non-coding;
   C. Spacers;
   D. Promoter;
   E. Terminator.
4. Structural genes of eukaryotes have exons and introns. Both portions of gene are transcribed but mature mRNA consists of exons only. This fragment of genes serves as
   A. Coding amino acids;
   B. Non-coding;
   C. Spacers;
   D. Promoter;
   E. Terminator.
5. Cell contains three types of RNA: mRNA, tRNA, rRNA. Synthesis of all these molecules occur in
   A. Lysosomes;
   B. Ribosomes;
   C. Nucleus;
   D. Smooth ER;
   E. Golgi complex.
6. Which part of DNA carries an information about one protein molecule?
   A. Operon;
   B. Nucleotide;
   C. Gene;
   D. Triplet;
   E. Promotor.
7. There are several types of RNA. Which of them provides transport of amino acids to the ribosome?
   A. rRNA;
   B. mRNA;
   C. tRNA;
   D. snRNA;
   E. pre-mRNA.
8. Which of the RNA molecules is the shortest?
   A. rRNA;
   B. mRNA;
   C. tRNA;
   D. snRNA;
   E. pre-mRNA.
9. The process of DNA unwinding was experimentally blocked experimental studying. Which step of protein biosynthesis will be affected?
   A. Translation;
   B. Transport of amino acids;
   C. Protein modification;
   D. Transcription;
   E. Activation of amino acids.
10. Radioactively labeled uracil was added to the cell culture. Where it will be detected by autoradiography?
   A. In centrosomes
   B. In ribosomes;
   C. In Golgi complex;
   D. In smooth endoplasmic reticulum;
   E. In lysosomes.
11. Eukaryotic gene has following sequence of functional regions: exon-intron-exon. What is the sequence of appropriate pro-mRNA molecule?
   A. exon-intron-exon;
   B. exon-exon-intron;
   C. exon-exon;
   D. exon-exon-exon;
   E. exon-intron.
12. Which process provides transmission of hereditary information to the daughter generations?
   A.DNA repair;
   B. Replication;
   C. Transduction;
   D. Conjugation;
   E. Transformation.
13. One of the biological template reactions is replication. Which molecule is formed during this process?
   A. rRNA;
   B. mRNA;
   C. tRNA;
   D. DNA;
   E. pre-mRNA.
14. Gene is the unit of hereditary information. In which molecule it present in eukaryotes?
   A. tRNA;
   B. DNA;
   C. protein;
   D. amino acid;
   E. mRNA.
15. Special enzyme activated by light restores defects in DNA molecule after UV-irradiation. This process is termed as
   A. Excision repair;

B. Photoreactivation (light repair);
C. Replication;
D. Mutation;
E. Recombination.

16. One type of RNA is characterized by cloverleaf shape and has active centers for interaction with amino acid and mRNA. This type of RNA is
A. rRNA;
B. mRNA;
C. tRNA;
D. snRNA;
E. pre-mRNA.

17. Viruses can transfer fragment of host DNA from one bacterial cell to another, giving it some new properties. This process is termed as
A. Transcription;
B. Translation;
C. Replication;
D. Transformation;
E. Transduction.

18. Gene consists of 4 exons and 3 introns. Mature RNA after processing consists of
A. 4 exons;
B. 2 exons, 2 introns;
C. 1 exon, 1 intron;
D. 3 exons;
E. 4 exons, 3 introns.

19. Both DNA molecules after replication process consist of one maternal and one newly synthesized strands. This mechanism of replication is known as
A. Conservative;
B. Semi-conservative;
C. Analogous;
D. Identical;
E. Dispersed.

20. tRNA molecule has several active centers. Which center recognizes mRNA codon?
A. Codogene;
B. Codon;
C. Anticodon;
D. Nucleotide;
E. Transcripton.

21. mRNA molecule has 200 nitrogenous bases. How many nucleotides does it have?
A. 50;
B. 100;
C. 200;
D. 400;
E. 600.

22. Both DNA and RNA consist of nucleotides. RNA differ from DNA by presence of
A. Adenine;
B. Ribose;
C. Guanine;
D. Cytosine;
E. Phosphate group.

23. All types of RNA are synthesized on DNA template. Enzyme that carries out the transcription is
A. Phosphatase;
B. Lipase;
C. Nuclease;
D. Protease;
E. Polymerase.

24. mRNA molecule has 110 phosphate groups. How many nucleotides does it consist of?
A. 55;
B. 110;
C. 220;
D. 330;
E. 440.

25. Which of the following is a purine?
A. Thymine;
B. Cytosine;
C. Guanine;
D. Uracil.

26. Double helical model of as the structure of DNA molecule was given by
A. Watson and Kornberg;
B. Watson and Crick;
C. Nirenberg and Khorana;
D. Temin and Baltimor;
E. Tchargaff.

27. The number of hydrogen bonds between guanine and cytosine is
A.1;
B.2;
C.3;
D.4;
E. 5.

28. RNA differs from DNA in the replacement of thymine with
A. Thymine;
B. Cytosine;
C. Guanine;
D. Uracil

29. The difference between RNA and DNA is because of
A. Sugar and base;
B. Sugar and phosphate;
C. Phosphate and base;
D. Sugar only;
E. Base only.

30. Nowadays about 50 minor bases have been found in the t-RNA structure besides the main four nitrogenous bases. Choose the minor nitrogenous base:
A. Thymine;
B. Cytosine;
C. Guanine;
D. Dihydrouracil;
D. Uracil

10. Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

11. **A topic of the following lesson**: Organization of information flow in the cell. Stages of protein biosynthesis.

Practical class 6. Organization of information flow in the cell. Stages of protein biosynthesis..

The Purpose of the Lesson: To get notion of genetic code and its properties. To study mechanisms of storage and expression of hereditary information.

TOPIC CONTENT

1. Gene. Genetic code and its main properties.
2. Main stages of protein biosynthesis.
3. Central dogma of molecular biology.
4. Main peculiarities of protein biosynthesis in eukaryotes (transcription, processing, splicing, activation of amino acids, translation, posttranslational modifications).
5. Notion of the regulation of genes expression in prokaryotes.
6. Notion of the regu1ation of genes expression in eukaryotes.
7. The main differences in regulation of gene expression in pro- and eukaryotes.
8. International program ”Human genome project”. Modern notion about human genome

	Questions	Answers
1	What is • a) gene • b) genetic code	
2	List the main properties of genetic code a) b) c) d) e)	
3	Transcription is….	
4	Main stages of transcription are: a, b, c In transcription participate: a, b, c	
5	Which RNA molecule is transcribed on	
6	DNA molecule primarily?	
7	Processing is…	
8	Splicing is…	
9	Activation of amino acids is…	
10	Translation is….	
11	Main active centers of a ribosome are: a, b	
12	Main stages of translation are: a, b, c	
13	In translation participate: a, b, c	
14	Posttranslational modification is…	
15	Posttranslational modification takes place in…	
16	Write down scheme of central dogma of	

	molecular biology	
17	Who and when did propose the scheme of operon regulation in prokaryotes?	
18	Operon is….	
19	Operon includes: a, b, c	
20	Under their functions genes are divided into: a, b	
21	Structural genes specify:a, b, c	
22	Structural genes include 1) informative portions - ... 2) non-coding portions - ...	
23	Which regulatory genes regulate structural genes in operon of prokaryotes? (a, b, c, d)	
24	Inducers are the substances, which induce synthesis of …….	
25	Gene-operator switches on or switches of protein synthesis with the help of .....gene.	
26	Promoter is the site for attachment of enzyme ……..	
27	Terminator is the gene for….	
28	Which protein is specified by the gene-regulator?	
29	The expression of hereditary information of structural genes is suppressed when repressor protein binds to the	
30	If an inducer enters the cell and binds to repressor protein, gene... (a) decomes free and operon …. (b)	

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 59 – 73.

Gene

The unit of hereditary information is **gene**.

Gene is a fragment of DNA molecule that determines the synthesis of polypeptide, rRNA, tRNA or regulates function of another gene.

Gene has two types of nucleotides sequences:

- **Exons.** Exons code amino acids
- **Introns.** Introns do not code amino acids

Realization of hereditary information occurs by protein synthesis.

DNA ⟶ protein ⟶ character

Genetic code

Genetic code is a sequence of nitrogenous bases in DNA which determines the sequence of amino acids in a protein.

Main features of genetic code:

1. Triplet nature - one amino acid is specified by three adjacent nucleotides.
A group of three nucleotides that specify one amino acid is codon or triplet.

2. Degeneracy – most of the amino acids are specified by more than one codon (2-6 triplets).

3. The code is specific – each triplet codes a certain one amino acid.

4. Universality – the genetic code is the same in all living organisms.

5. Three triplets – UAA, UAG, UGA – do not specify any amino acid. These are called nonsense codons. AUG codon (Met) is called starting or initiation codon as it initiates the synthesis of polypeptide.

Protein biosynthesis

Protein synthesis goes on according to the scheme:

$$DNA \xrightarrow{\text{transcription}} mRNA \xrightarrow{\text{translation}} Protein.$$

Protein synthesis includes four steps:

- Transcription
- Activation of amino acids
- Translation
- Posttranslational modification of proteins

1. **Transcription** is synthesis of m-RNA on the DNA template. Transcription takes place in the nucleus. Enzyme, that produce mRNA is RNA-polymerase.
Result of the transcription in eukaryotes is the synthesis of precursor mRNA (pre-mRNA). Pre-mRNA has same sequence of nucleotides as DNA: exons and introns. So, it should undergo processing
Processing is the process of pre-mRNA maturation. It includes **splicing**. During the splicing special RNA cut off the introns and binds exons.
Mature m-RNA consists of exons only and is shorter then pre-mRNA.
Processing takes place in nucleus.

2. **Activation of amino acids.** It is joining of amino acid to tRNA molecule. It requires ATP. Activation of amino acids takes place in cytoplasm.

3. **Translation** is synthesis of polypeptide on the mRNA template. It takes place in ribosomes.
4. Posttranslational modification. The polypeptide folds, and gets its tertiary or quaternary structure. It occurs in endoplasmic reticulum and Golgi complex

REGULATION OF GENE EXPRESSION. OPERON CONCEPT

Control of protein synthesis at transcription level in prokaryotes is explained by operon concept.
Operon is a group of fuctionally related **structural genes** with common **control genes**. Structural genes code proteins. Control (regulatory) genes control the activity of structure genes.

Operon includes:

1. **Regulator gene.** It specify synthesis of repressor protein. It is a protein, which binds to the operator gene and prevent transcription.
2. **Promoter.** It is the DNA segment at which RNA-polymerase starts transcription.
3. **Operator. It** is a DNA segment next to the promoter. It can bind repressor protein.
4. **Structural** genes
5. **Terminator** is the DNA segment at which RNA-polymerase ends transcription.

Example is lactose operon. It includes genes for lactose methabolism. If lactose is absent, repressor protein binds to the operator and prevents the transcription. So enzymes for lactose metabolism are not formed. If lactose is present, it (lactose) binds to the repressor protein and removes it from operator. Free operator allows transcription, so enzymes for lactose utilization are formed.

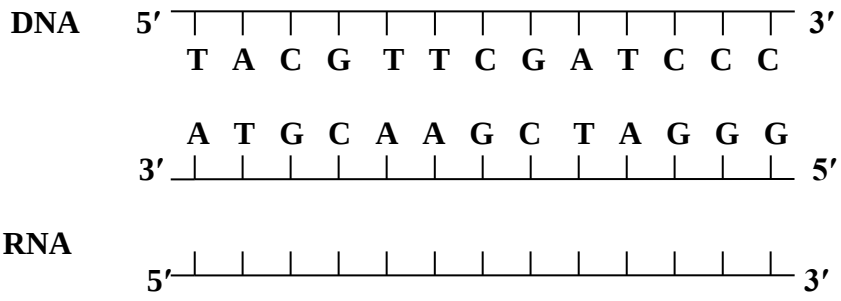
There is no operon organization of genes in prokaryotes.

ORGANIZATION OF INFORMATION FLOW IN THE CELLS.

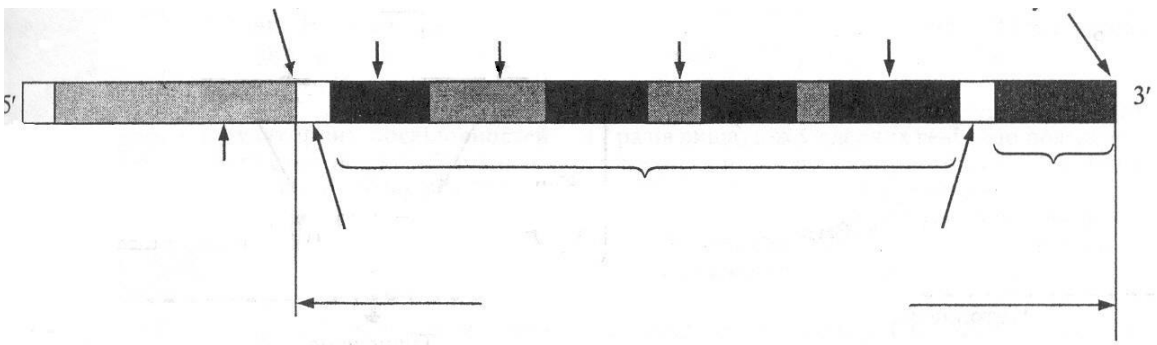
TASK 1. Fill the table

Stage of protein biosynthesis	Process	Where does it take place
1. Transcription		
2. Activation of amino acids (aminoacylation)		
3. Translation E. Initiation F. Elongation G. Termination		
4. Posttranslational modification		

TASK 2. Transcribe following DNA molecule. Label coding and template strands.



TASK 3. Study the structure of eukaryotic gene. Label promoter, terminator, transcribed sequence, translated sequence, leader, trailer, exons and introns.



TASK 4. Study the process of DNA maturation (processing). Label DNA (promoter, leader, trailer), pre-mRNA, processing, splicing, exons and introns. In mRNA molecule label cap, leader, trailer, exons, poly-A tail.

TASK 5. Analyze the process of translation. Label mRNA, subunits of ribosomes, aminoacyl tRNA, free amino acids and tRNA molecules, polypeptide chain. Find initiation, elongation and termination of translation.

TASK 6. Analyze mechanism of translation. Label functional centers of ribosome, describe the processes on each step of translation.

TASK 7. Solve the problems.

1. Fragment of template DNA strand has following sequence of nucleotides. Find sequence of amino acids in polypeptide chain and anti codons of tRNA molecules.	**DNA T-T-A-G-G-C-C-A- A-G-C-T** mRNA protein tRNA
2. Fragment of protein molecule has following sequence of amino acids. What is sequence of nucleotides in DNA? Which amino acids is specified by maximal number of codons- synonyms?	**Protein Tre-Val-Ala-Pro-Leu-Tre** mRNA DNA
3. Fragment of template DMA strand has following sequence. During the replication process 3rd nucleotide was lost. Detect sequence of amino acids, specified by normal DNA fragment and DNA after the mutation.	**Normal DNA AAAACCAAAATACTTATACAAC** mRNA protein **Mutant DNA** mRNA protein

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. There are 100 monomers in protein molecule. How many nucleotides (fragment of double strand DNA) specify this protein?

A. 100
B. 200
C. 300
D. 600
E. 900

2. All amino acids, with the exceptions of methionine and tryptophan are encoded by more than one codon. This feature is referred to as

A. Universality of genetic code
B. Colinearity
C. Degeneracy of genetic code
D. Specificity of genetic code
E. Triplet nature of genetic code

3. Action of some antibiotics on microorganisms is based on the arrest of translation. It means the blockage of synthesis of

A. DNA
B. tRNA
C. rRNA
D. polypeptide chain
E. mRNA

4. Recognizing of mRNA triplets (i.e. deciphering of genetic code) during the translation occurs under the complementary principle by three-nucleotide sequence of rRNA. This sequence is

A. Anticodon

B. Codon
C. Codogene
D. Cystrone
E. Mutone

5. The majority of structural genes in eukaryotes consist of sequences coding the information (exons) and intervening non-coding sequences (introns). Which molecule is formed on these genes directly after transcription?
A. Pre-mRNA
B. mRNA
C. snRNA
D. tPNA
E. rPNA

6. In eukaryotes, pre-mRNA produced directly after transcription should transformed in mature mRNA. This process of maturation is referred to as
A. Translation
B. Processing
C. Splicing
D. Termination
E. Reparation

7. Hemoglobin molecule of adult person (Hb A) is a tetramere protein composed of two α and two β polypeptide chains. Thus it is a protein of following structure
A. Primary
B. Secondary
C. Tertiary
D. Quaternary

8. Monomer of DNA molecule is
A. Amino acid
B. Nitrogenous base
C. Polypeptide
D. Deoxyribose
E. Nucleotide

9. Three triplets (UAA, UAG, UGA) do not specify amino acids. These triplets are termed
A. Introns
B. Codons
C. Anticodons
D. Terminators
E. Exons

10. tRNA molecule has several active centers. What is the name of center that recognizes mRNA codon?
A. Codogene
B. Codon
C. Anticodon
D. Nucleotide
E. Transcripton

11. Ribosome has two active centers: aminoacyl site and peptidyl site. How many nucleotides of mRNA can they bind?
A. 1
B. 2
C. 3
D. 5
E. 6

12. mRNA molecule has 200 nitrogenous bases. How many nucleotides does it have?
A. 50
B. 100
C. 200
D. 400
E. 600

13. Both DNA and RNA consist of nucleotides. RNA differ from DNA by presence of
A. Adenine
B. Ribose
C. Guanine
D. Cytosine
E. Phosphate group

14. All types of RNA are synthesized on DNA template. Enzyme that carries out the transcription is
A. Phosphatase
B. Lipase
C. Nuclease
D. Protease
E. Polimerase

15. Ribosomes synthesize polipeptides (translation). In posttranslation period occurs
A. Replication
B. Processing
C. Splicing
D. Folding
E. Reparation

16. Which cell organelles provides formation of primary protein structure?
A. Ribosomes
B. Golgi complex
C. Lysosomes
D. ER
E. Nucleus

17. Which cell organelles provides formation of secondary and following protein structure?
A. Ribosomes
B. Golgi complex
C. Lysosomes
D. ER
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18. Molecule that is synthesized during the transcription of structural genes of eukaryotes is
A. pre-mRNA
B. mRNA
C. polypeptide chain
D. tRNA
E. rRNA

19. Cell contains three types of RNA: mRNA, tRNA, rRNA. Synthesis of all these molecules occur in
A. lysosomes
B. Ribosomes
C. Nucleus
D. Smooth ER
E. Golgi complex

20. mRNA molecule has 110 phosphate groups. How many nucleotides does it consist of?
A. 55
B. 110
C. 220
D. 330
E. 440

21. The result of transcription of structural genes of eukaryotes is synthesis of immature pre-mRNA. Process of its maturation is termed
A. Translation
B. Processing

C. Splicing
D. Termination
E. Reparation

22. There are 200 amino acids in protein molecule. How many nucleotides are in the gene (double strand DNA) which encode this protein?
A. 200
B. 400
C. 600
D. 900
E. 1200

23. Synthesis of primary protein structure is termed
A. Transcription
B. Translation
C. Replication
D. Termination
E. Reparation

24. Structural genes of eukaryotes has exons and introns. Introns are removed during the maturation of mRNA. This process is termed
A. Processing
B. Splicing
C. Reparation
D. Termination
E. Replication.

25. There are 100 monomers in protein molecule. How many nucleotides (fragment of double strand DNA) specify this protein?
A. 100
B. 200
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B. Translation
C. Replication
D. Termination
E. Reparation

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C. Reparation
D. Termination
E. Replication.

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Cell cycle. Cell division. Regulation of mitotic cycle.

Practical class 7. Cell cycle. Cell division. Reproduction and its forms.

The Purpose of the Lesson: To study the cell cycle, and the peculiarities of organization of cell genetic apparatus during the interphase and each mitotic phase. To get an importance of mitosis in maintaining of genetic stability and meiosis in genetic variability.

TOPIC CONTENT

1. Cell cycle. Mitotic cycle
2. Types of cell division: mitosis, amitosis, endomitosis, polyteny.

3. Characteristics of mitotic phases.
4. Biological significance of mitosis.
5. Mitotic index. Failure of mitosis.
6. Meiosis as a special type of cell division.
7. Characteristics of phases of meiosis.
8. Biological significance of meiosis
9. Principle differences between meiotic and mitotic divisions.

TEST QUESTIONS for individual work

	Questions	Answers
1	Give the definition of cell cycle	
2	What is the difference between cell cycle and mitotic cycle?	
3	Mitotic cycle includes two periods: a, b	
4	Mitosis is	
5	List the phases of mitosis:a,b,c,d.	
6	Cytokinesis is	
7	At which mitotic phase cell division is arrested for karyotype studying?	
8	Give the examples of non-dividing cells in humans(a,b). At which period of interphase do they exist? (c)	
9	What is a mitotic index (MI)? (a)	
10	Give the examples of human cells with the high MI (a, b)	
11	What is biological significance of mitosis?	
12	What is the main difference between mitosis and amitosis?	
13	What is endomitosis?(a) polyteny?(b)	
14	Meiosis is.....	
15	Which kind of human cells divide by meiosis?	
16	The first meiotic division is termed reduction division as ...	
17	The second meiotic division is termed equationa1 division as…	
18	How many daughter cells are formed after mitosis (a) and meiosis(b)	
19	Which set of the chromosomes	

	get daughter cells after mitosis(a), meiosis I (b), meiosis II(c)?	
20	What are the mechanisms of genetic variability of gametes due to the meiosis? (a, b)	
21	What is biological significance of meiosis?	

Fill the table Characteristics of interphase

Stage of the interphase	Main events	Number of chromosomes and chromatids	Number of DNA molecules

Fill the table Characteristics of mitosis

Phase of mitosis	Main events	Number of chromosomes and chromatids	Number of DNA molecules

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 77 – 95.

MITOIC CYCLE.

Mitotic cycle (or cell cycle) is a period from the beginning of one cell division to the beginning of the next one. It includes

A. Interphase

B. Mitotic phase.

INTERPHASE.

Iterphase is period between two cell divisions/ It includes

- **G_1-phase** (post-mitotic or pre-synthetic). Growth, differentiation of the cell, and synthesis of proteins takes place

Set of hereditary information is **2n2c** (**n** – number of chromosomes, **c** – number of chromatids (DNA molecules)

- **S (synthetic) phase**. Synthesis (replication) of DNA molecules occurs. Set of hereditary information is **2n4c**
- **G_2 phase** (post-synthetic or pre-mitotic). Accumulation of energy (ATP) and synthesis of tubulin proteins takes place. Set of hereditary information is **2n4c**

MITOTIC PHASE.

Mitotic cell division occurs during mitotic phase or M phase It has 4 stages**1. PROPHASE. (2n4c)**

Nuclear envelope disappears. The nucleolus disappears.

The chromatids become shortened and thickened.

Centrioles separate and migrate towards the opposite pole of the cell. Spindle fibers appear

2. METAPHASE. (2n4c)

Chromosome are at the equator of the cell.

3. ANAPHASE. (**4n4c**)

The sister chromatids of each chromosome separate and form two daughter chromosomes. The chromosomes migrate towards the opposite poles of the cell.

4. TELOPHASE.

Chromosomes decondence, nuclear membrane and nucleolus appears. Two daughter nuclei are formed. Division of cytoplasm is **CYTOKINESIS**. Set of hereditary information in each daughter cell is **2n2c**

SIGNIFICANCE OF MITOSIS.

In mitosis each daughter cell gets equal hereditary information identical to that of the parent cell. **1 cell 2n4c** ⟹ **2 cells 2n2c**

Endomitosis is duplication of the chromosomes without division of a nucleus. It is formation of a polyploid cell . In human organism it is seen in liver cells

Polytene chromosome forms as a result of repeated replication of DNA in interphase without cell division. It produce giant chromosomes found in the salivary glands of mosquitoes and flies.

The amitosis is direct cell division of interphase nucleus. There is no exact transmission of hereditary information.

Cancer cells can multiply by amitotic division.

MEIOSIS.

Due to the meiosis four haploid cells are formed from the single diploid cell Sperm and egg are formed by meiosis

It occurs in two divisions. Both meiotic divisions include prophase, metaphase, anaphase and telophase.

First Meiotic Division is reductional**.**

Prophase I (2n4c). In prophase I there are synapsis and crossing-over. Synapsis (conjugation) is the pairing of homologous chromosomes. Pairs of homologous chromosomes are bivalents (tetrades).

The crossing-over is mutual exchange of chromatin material (allele genes) between the two homologous chromosomes.

Metaphase I (2n4c).

Bivalents (tetrads) are at the equator of the cell.

Anaphase I.(2n4c)

Homologous chromosomes with its two chromatids move towards the opposite poles of the cell. Because of this daughter cells become haploid.

Telophase I.

Cytokinesis occurs and two haploid cells are formed.

1 cell 2n4c → **2 cells 1n2c**

S-phase (DNA replication) is absent.

Second Meiotic Division is equational**.**

It is the same as mitosis. In anaphase II chromatids move towards the opposite poles of the cell. From 1 cell 1n2c - 2 cells 1n1c are formed.

Result of meiosis

1 cell 2n4c → **4 cells 1n1c**

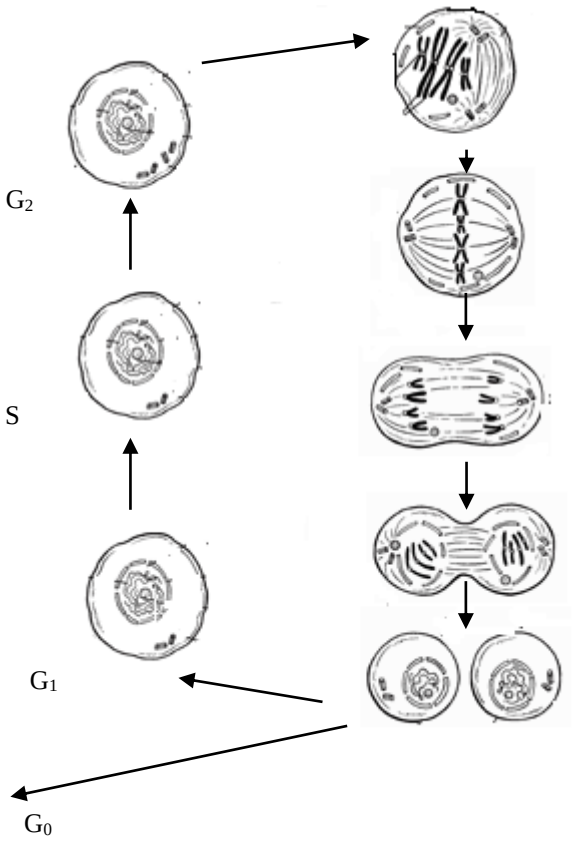
Significance of Meiosis.

1 Number of the chromosomes stay constant from generation to generation in sexual reproduction.

2.Genetic variation. Four daughter cells have different hereditary information

. Practical work. **LIFE CYCLE AND CELL DIVISION. MITOSIS, AMITOSIS, MEIOSIS**

Task1. Label mitotic phases and periods of interphase, number of chromatids in chromosome, number of chromosomes (n), DNA (C).

Number of chromatids n, C	Interphase Mitosis	Number of chromatids n, C
		

Task 2. Fill the table

Interphase period	Main events	Number of chromosomes	Number of DNA

Task 3. Fill the table

Phase of mitosis	Main events	Number of chromatids	Number of chromosomes

Task 4. Study stages of I and II meiotic divisions. Mark stages of prophase I and main events, label bivalents. Write down number of chromosomes (n) and DNA (C) at each phase of meiosis.

Task 5. Compare mitotic and meiotic divisions.

Daughter cells	Mitosis	Meiosis
1. Set of the chromosomes		
2. Hereditary information		
3. Number of daughter cells		

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Active synthesis of proteins, carbohydrates and lipids in the cell takes place in
   A. Anaphase
   B. Interphase
   C. Metaphase
   D. Telophase
   E. Prophase

2. Human somatic cells are diploid (2n), but polyploid cells of red bone marrow (megakaryocytes) may have 64 n chromosomes. What is the mechanism of its forming?
   A. Endomitosis
   B. Polyteny
   C. Mitosis
   D. Amitosis
   E. Meiosis

3. The daughter chromosomes migrates towards opposite poles of the cell in
   A. Metaphase
   Telophase
   Interphase
   B. Anaphase
   C. Prophase

4. Cytokinesis is
   A. Division of the cell nucleus
   B. Synthesis of RNA polymerase
   C. Division of cytoplasm
   D. Separation of daughter chromosomes
   E. Division of mitochondria

5. Electron photomicrograph shows the cell with separating centrioles and forming mitotic spindle. Chromatin threads are situated in cytoplasm. Nuclear envelope and nucleoli are absent. This is typical for
   A. Anaphase
   B. Interphase
   C. Metaphase
   D. Telophase
   E. Prophase

6. Electron photomicrograph shows the cell with chromosomes situated on the equator. What is the stage of cell cycle?
   A. Anaphase
   B. Interphase
   C. Metaphase
   D. Telophase
   E. Prophase

7. Cell has 4n4c set of hereditary information. What is the stage of cell cycle?
   A. Anaphase
   B. Interphase
   C. Metaphase
   D. Telophase
   E. Prophase

8. Replication of DNA occurs in
   A. G_1 phase
   B. Metaphase
   C. G_2 phase
   D. S phase
   E. Prophase

9. Cell cycle includes following stages
   A. Post-mitotic period
   B. Synthetic period
   C. Premitotic period
   D. Mitosis
   E. All of the above

10. Cells in culture multiply by the division into two daughter cells with identical diploid set of the chromosomes. This type of cell division is
   A. Budding
   B. Mitosis
   C. Meiosis
   D. Amitosis
   E. Endomitosis

11. Culture of tumor cells demonstrates rapid cell division by splitting of the nucleus. Formation of spindle fibers and condensation of chromatin are not seen. This type of cell division is
   A. Cytokinesis
   B. Karyokinesis
   C. Mitosis
   D. Amitosis
   E. Endomitosis

12. Electron photomicrograph shows the cell with daughter chromosomes in opposite poles of the cell. This is
   A. Interphase
   B. Prophase
   C. Metaphase
   D. Telophase
   E. Anaphase

13. At which phase of mitosis human cell has 92 single-chromatid chromosomes?
   A. Interphase
   B. Prophase
   C. Metaphase
   D. Telophase
   E. Anaphase

14. DNA replication occurs in
   A. G_1 phase
   B. Metaphase
   C. G_2 phase
   D. S phase
   E. Prophase

15. Cell in mitosis was treated by colchicine. At which stage does colchicine arrest mitosis and what set of hereditary information will have the cell?
   A. Metaphase 4n
   B. Metaphase 2n
   C. Anaphase2n
   D. Anaphase 4n
   E. Telophase 2n

16. Nuclear membrane and nucleoli disappear and chromosomes became distinct in
A. Interphase
B. Prophase
C. Metaphase
D. Telophase
E. Anaphase

17. Set of hereditary information 2n4c is in
A. Interphase
B. Prophase
C. Metaphase
D. Telophase
E. Anaphase

18. Spindle fibers are composed of
A. Tubulin
B. Actin
C. Miosin
D. Glycogen
E. Lipids

19. At which stage of cell cycle we usually study human karyotype for diagnosis of chromosomal disorders?
A. Interphase
B. Prophase
C. Metaphase
D. Telophase
E. Anaphase

20. In culture of liver cells some cells do not continua mitosis after chromosome replication and form nucleus with 4n4c chromosomes. This type of cell division is
A. Cytokinesis
B. Karyokinesis
C. Mitosis
D. Amitosis
E. Endomitosis

21. Chromosomes begin to uncoil and daughter nuclei are formed in
A. Interphase
B. Prophase
C. Metaphase
D. Telophase
E. Anaphase

22. Transcription and processing takes place during
A. Interphase
B. Prophase
C. Metaphase
D. Telophase
E. Anaphase

23. Accumulation of energy and synthesis of tubulins for cell division occurs in
A. G_1 phase
B. Metaphase
C. G_2 phase
D. S phase
E. Prophase

24. In post-mitotic period chromosomes consist of single chromatid. Set of hereditary information in cell during this period is
A. 46 chromosomes 92 DNA
B. 23 chromosomes 46 DNA
C. 46 chromosomes 46 DNA
D. 46 chromosomes 23 DNA
E. 23 chromosomes 92 DNA

25. In salivary gland of drosophila fly are seen giant chromosomes. They are formed by constant replication of DNA without replication of chromosomes. Cell doesn't enter mitosis. This phenomenon is termed
A. Endomitosis
B. Polyteny
C. Mitosis
D. Amitosis
E. Meiosis

26. Chomosomal set 2n2c is seen in
A. Interphase
B. Prophase
C. Metaphase
D. Telophase
E. Anaphase

27. Crossing over is
A. Process of chromosome duplication
B. Exchange of allele genes between homologous chromosomes
C. Type of mutation
D. Exchange of genes between non-homologous chromosomes
E. Reparation of DNA molecule

28. Pairing of homologous chromosomes and crossing over take place in meiosis in
A. Prophase I
B. Prophase II
C. Metaphase I
D. Anaphase I
E. Anaphase II

29. Meiosis is a reduction division. What set of hereditary information has cell after second meiotic division?
A. 1n 2c
B. 1n 1c
C. 2n 1c
D. 2n 4c
E. 2n 2c

30. Prophase I of meiotic division has few substages. In which substage chromosomes appear as long, thin and uncoiled threads?
A. Leptotene
B. Zygotene
C. Pachytene
D. Diplotene
E. Diakinesis

31. Prophase I of meiotic division has few substages. At which stage homologous chromosomes moves apart at the centromere region but are still joined by telomeres?
A. Leptotene
B. Zygotene
C. Pachytene
D. Diplotene
E. Diakinesis

32. Set of hereditary information in cell after I meiotic division is
A. 1n 2c
B. 1n 1c
C. 2n 1c
D. 2n 4c
E. 2n 2c

33. The most complex and longest phase of meiosis is
A. Anaphase I
B. Prophase I
Metaphase I
C. Prophase II
Metaphase II

34. At which stage of meiosis does homologous chromosomes migrate towards the cell poles?
A. Prophase I
B. Metaphase I
C. Anaphase I
D. Metaphase II
E. Anaphase II

35. Meiosis is characterized by pairing of homologous chromosomes – conjugation. Formed bivalents (tetrads) line up at the equator of the cell during the
A. Prophase I
B. Metaphase I
C. Anaphase I
D. Metaphase II
E. Anaphase II

36. Chiasmata are first observed in
A. Leptotene
B. Zygotene
C. Pachytene
D. Diplotene
E. Diakinesis

37. Meiosis has evolutionary significance because it produces
A. Genetically similar daughter cells
B. Four daughter cells
C. Recombinations
D. Eggs and sperms

38. Meiosis is
A) Equational division
B) Reductional division
C) Double division
D) All of these

39. Chiasma represents the site of
A. Synapsis
B. Disjunction
C. Crossing over
D. Terminalization

40. In meiosis the chromatids separate during
A) Prophase I
B) Metaphase I
C) Anaphase I
D) Metaphase II
E) Anaphase II

41. In meiosis, the daughter cells differ from the parent cells as well as among themselves because of
A) Segregation
B) Independent assortment
C) Crossing over
D) All of the above

42. In meiosis crossing over occurs during
A. Prophase I
B. Metaphase I
C. Anaphase I
D. Telophase I

43. In meiosis the chromosome number is reduced to haploid state during
A. Metahase I
B. Metaphase II
C. Anaphase I
D. Anaphase II

10. Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

11. A topic of the following class: Meiosis. Gametogenesis. Fertilization.

Practical class 8. Meiosis. Gametogenesis. Fertilization.

The Purpose of the Lesson. To study human heredity disease concept, its classification. Principles of diagnosis of the heredity pathology. Gene (molecular) diseases, mechanisms of its development and principles of laboratory diagnosis. Gene engineering. Biotechnology. Gene therapy. Population-statistic method. Low of constancy of genetic structure of the population. To practice in usage of Hardy-Wineberg's low for studying of the genetic structure of the population.

TOPIC CONTENT

1. The main forms and sense of sexual and asexual multiplication of organisms.
2. The structure of ovum and spermatozoid.
3. Stages of ovogenesis and spermatogenesis. The most important events of every stage.
4. Principal differences of spermatogenesis and ovogenesis, gamets and somatic cells.
5. The process of fecundation in human. Monospermy.
6. Peculiarities of human reproduction and human biological sociality.

TEST QUESTIONS FOR INDIVIDUAL WORK

	Questions	Answers
1	Gametogenes is … .	

2	What is a name of gametogenesis 1) In male- 2) In female -?	
3	Where does gametogenesis take place 1) In female – a; . 2) In male - a?	
4	What are the periods of gametogenesis in 1) male – a,b,c,d; 2) female - a,b,c?	
5	The period (zone) of formation is present only during …	
6	The period of growth is the most manifested during ...	
7	How many gametes are formed from one 1) primary oocyte – a; 2) primary spermatocyte – a ?	
8	What are the sizes (mcm) of human gametes: 1) ovum (diameter) – a; 2) spermatozoid (length) - a ?	
9	What is a structure of human gametes: 1) ovum - a,b,c; 2) spermatozoid - a,b,c,d.	
10	In which period of human ontogenesis does ovogenesis and spermatogenesis begin and continue?	
11	Fecundation is ...	
12	What are the stages of fecundation?	
13	In which part of female sexual system does fecundation take place?	
14	What is the biological importance of fecundation?	

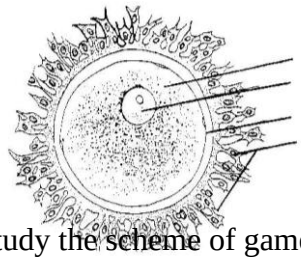
Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 95 – 109.

1. Medical biology: manual for practical classes/ Bazhora Yu.I et al. - Odessa: OSMU, 2006. - pp 144-155

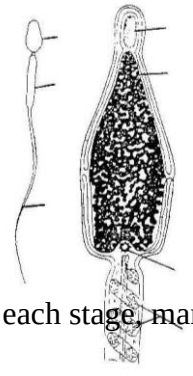
PRACTICAL WORK : Gametogenesis. Fertilization

Task 1. Study the morphology of human gametes. Label main structural components.

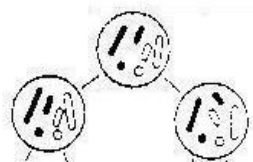
A. Egg



B.Sperm



Task 2. Study the scheme of gametogenesis. Name the cells at each stage, mark chromosomal set and type of the division.



I. Stage _____
N of chromosomes_____

Cells _____ Cells _____

Cells _____ Cells _____

II Stage _____
N of chromosomes_____

Cells _____ Cells _____

III. Stage _____
N of chromosomes_____

Cells _____

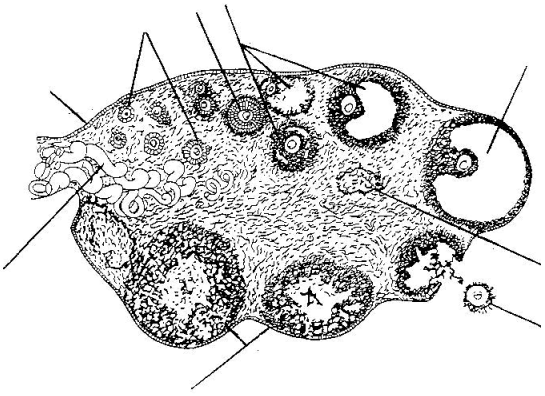
Cells _____ Cells
_____

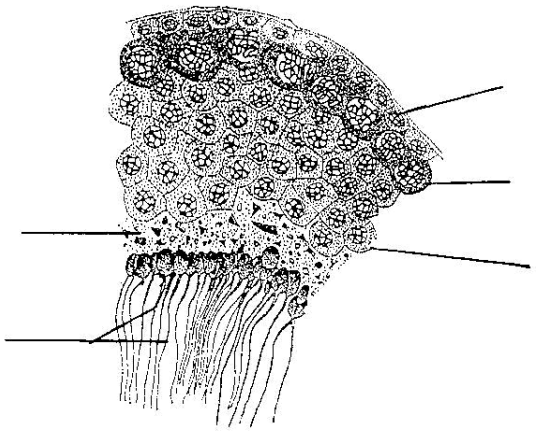
IV Stage _____
N of chromosomes_____
Spermatogenesis occurs in _____ Oogenesis occurs in_____

Task 3. Compare the processes of spermatogenesis and oogenesis

	Oogenesis	Spermatogenesis
When it starts?		
When it stops?		
Which period it takes?		
Pattern of gametocyte division (equal, unequal)		
How mane gametes are formed from one primary gametocyte?		

Task 5. Study under the light microscope morphology of ovary and seminal tubules.
Label surface epithelium, primary follicle, secondary follicle, formation of follicular cavity, mature graafian follicle, atrophic follicle, ovulation, corpus luteum in ovary; spermatogonia, primary and secondary spermatocytes, spermatids and spermatozoons in seminal tubules.





Task 6. Compare the structures of male and female gametes in humans

	Egg	Sperm
Shape		
Size		
N of chromosomes		
Nuclear/cytoplasm index		
Motility		
How long cells keep ability to fertilization		

Task 7. Study the successive stages of fertilization.

I. Distant interaction:

a. _____-_____

By which mechanisms it is provided?

II. Contact interaction:

a. _____-_____

b. _____-_____

c. _____-_____

The result is a _____ formation.

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Formation of egg in humans takes

A. 1 month
B. 28 days
C. 1 – 2 years
D. 5 – 7 years
E. 15 – 20 years

2. In humans, mammals and other chordates sexual reproduction takes place by fusion of large immobile ovum and small motile sperm. This kind of sexual reproduction is

A. Isogamy
B. Schisogony
C. Oogamy
D. Conjugation
E. Polyteny

3. Formation of sperm in humans takes

A. 10 days
B. 30 – 35 days
C. 65 –70 days
D. 6 months
E. 1 year

3. Tissue sample of the ovary shows large cells with paired homologous chromosomes and points of crossing over in some of them. At what period of gametogenesis are the cells?

A. Multiplication
B. Growth
C. Maturation
D. Formation

4. Process of spermogenesis starts at the

A. Third month of the embryonic development
B. 2 –3 year of life
C. 5 – 7th year
D. 12 - 13th year
E. 20th year of life

5. Oocytes in humans start to form at embryonic period, but then meiosis stops for years till fertilization. At which stage of meiosis eggs are stored in the ovaries?

A. Prophase
B. Metaphase
C. Anaphase
D. Telophase
E. Interphase

6. In some organisms ovum can start to develop without fertilization. Such way of reproduction is called

A. Gametogenesis
B. Parthenogenesis
C. Ovogamy
D. Polyteny
E. Copulation

7. Tissue sample of the ovary shows the resting cells that accumulate nutritive substances. At what period of gametogenesis are the cells?

A. Multiplication
B. Growth
C. Maturation
D. Formation

8. Process of ovogenesis starts at the development
A. Third month of the embryonic development
B. 2 –3 year of life
C. 5 – 7th year
D. 12 - 13th year
E. 14 - 16th year of life

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Peculiarities of the prenatal period of ontogenesis and preconditions of congenital defects in humans

Practical class 9. Peculiarities of the prenatal period of ontogenesis and preconditions of congenital defects in humans

The Purpose of the Lesson: To study ontogenesis and its periods. Embryonic period of the development, its stages. Congenital defects, its classification. Regulation of gene function in ontogenesis. Experimental studying of embryonic development. Critical periods of development. Teratogenesis. Teratogenic factors of environment.

TOPIC CONTENT

1. Ontogenesis, its periods
2. Stages of embryogenesis.
3. Embryonic induction. Experiences of D.Gerdon and G.Shpeman.
4. Problems of differentiation.
5. Prenatal period of human development. Peculiarities and critical periods.
6. Classification of congenital malformations in human.

TEST QUESTIONS FOR INDIVIDUAL WORK

№	Questions	Answers
1	What is ontogenesis from embryological point of view _____ _____	
2	What is ontogenesis from genetic point of view _____ _____	
3	What are the periods of ontogenesis? **a**	**b**
4	Embryologic development begins from _____ and finishes _____	
5	What is a type of ovum according to a quantity and a position of a yolk in a cytoplasm? **a**	**c**
	b	**d**
6	The nutrition of an embryo is done by _____	
7	Fill a table	

Stage	Stage of human embryo genesis	It finishes by formation
I		
II		
III		
IV		

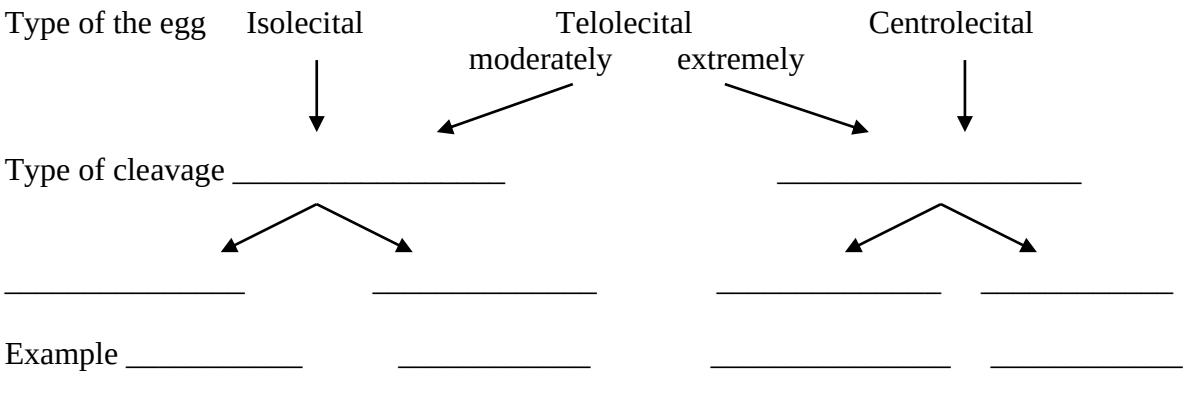
8	Blastula is _____

9	Which type of blastula is formed in human? _____
10	Gastrula is _____
11	What are the types of human embryo gastrulating during the period of Early gastrulating – Late gastrulating –
12	Provisory organs are _____
13	What are the functions of provisory organs? **a** **c** **b** **d**
15	What are the provisory organs of human? **a** **c** **b** **d**
16	Critical periods of embryogenesis are _____ _____
17	What are the critical periods in human embryogenesis? **a** **c** **b** **d**
18	What is an embryo? _____
19	Fetal period continues from _____week till _____
20	Teratology is ……
21	Teratogenesis is ……
22	Teratogenic factors are ……
23	Embryonic induction is .....
24	What are the examples of tissues -inductors? ……

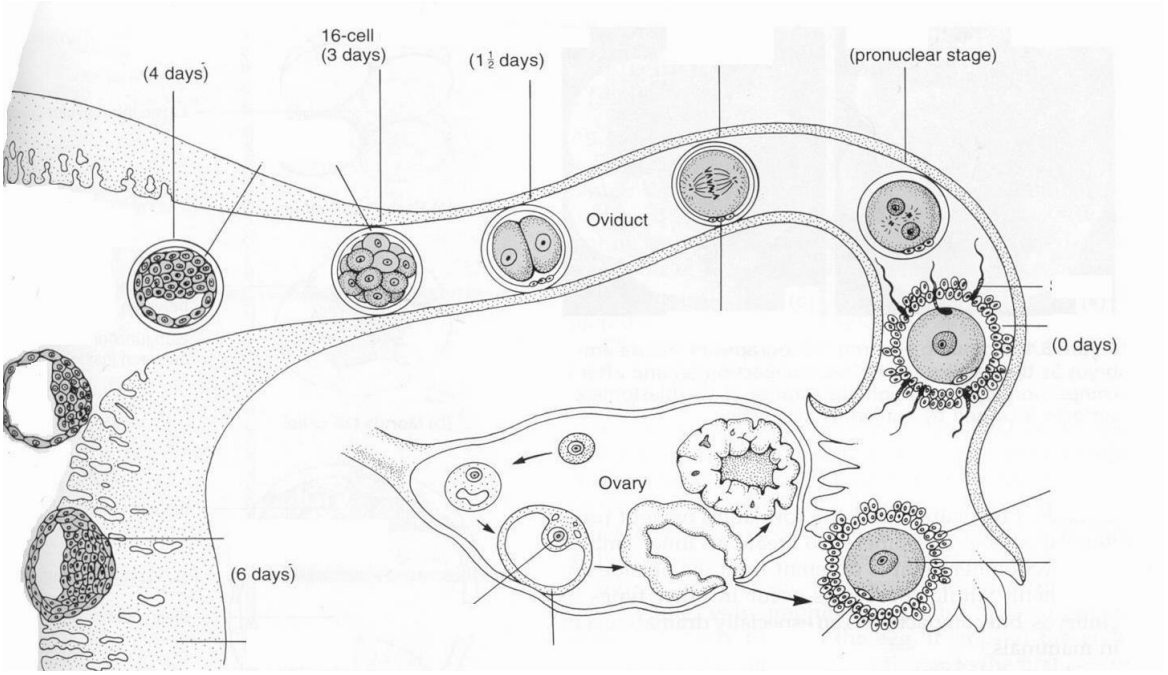
1. **Recommended literature:** Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 156-171.

PRACTICAL WORK.
Embriogenesis.

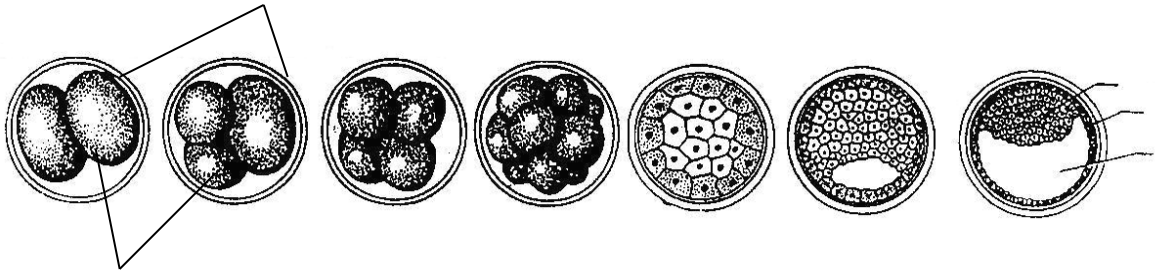
Task1. Write down types of cleavage according to the type of egg. Give the examples.



Task 2. Study the scheme of first week of human development. Label egg, follicule, secondary oocyte, zona pellucida, corona radiata, polar body, fertilization, zygote, cleavage, morula, early blastocyst, implantation.



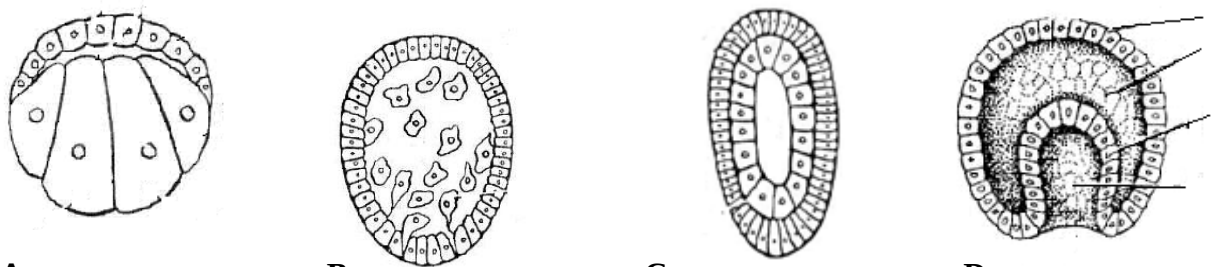
Task 3. Study the cleavage in human zygote. Mark blastomeres, zona pellucida, morula stage, early blastocyst, late blastocyst and its structure (blastocoel, trophoblast, embryoblast).



_____ _____ _____

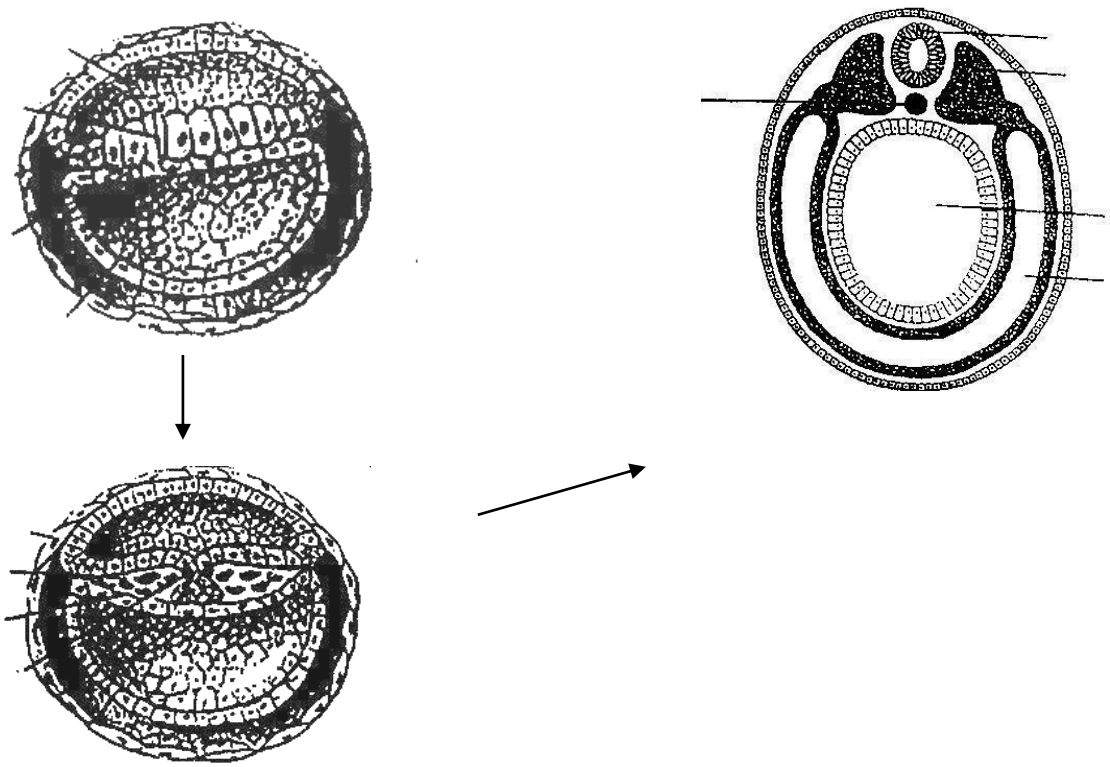
Type of cleavage is _____

Task 4. Study different types of gastrulation. Label ectoderm, entoderm. Gastrocoel, blastocoel.



A_____ **B**_____ **C**_____ **D**_____

Study the structure of early and late human gastrula and neurula.



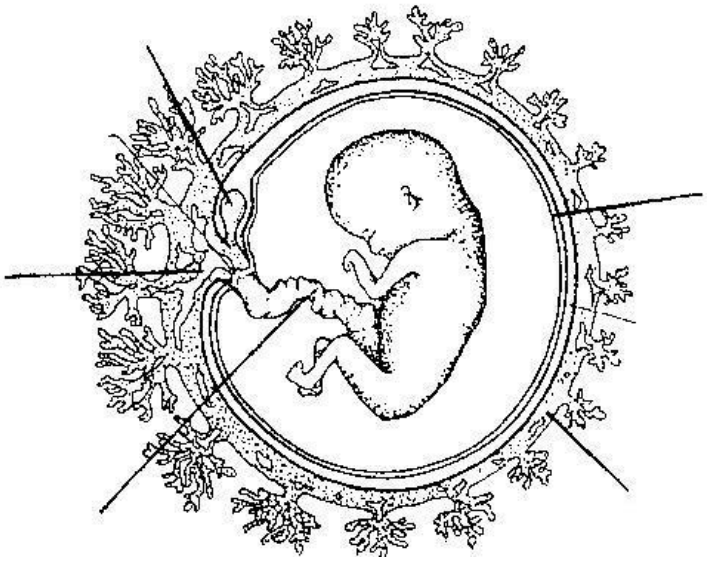
Type of gastrulation in humans_____

Task 5. Write down the derivatives of germ layers in humans.

Ectoderm	Entoderm	Mesoderm
		Dermatome→
		Myotome→
		Sclerotome→
		Nephrotome→
		Gonotome→
		Splanchnotome→
		Mesenchyme→

Task 6. Label the provisory organs of human being. Choose the derivatives of embryoblast and trophoblast.

Embryoblast	Trophoblast



a) b) c) d)	a) b)

Task 7. Give the classification of congenital defects according to the period of formation

Congenital defect	Stage of embryogenesis	Temporal period of formation	Example
Gametopathy			
Blastopathy			
Embryopathy			
Phetopathy			

Task 8. Give the classification and examples of teratogenic factors

Physical	Chemical	Biological

1. **Recommended literature:** Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 156-171.

Embryonic development

Ontogenesis **- individual development of an organism from fertilization to death.**
It is divided into two periods:

- **Embryonic (embryogenesis).** It starts after fertilization and finishes with birth. In man this period is often termed as prenatal.
- **Postembryonic** (in man – postnatal) from birth to death.

I. Fertilization is the fusion of male and female gametes to form diploid zygote. In humans the sex of a chills is determined at the moment of fertilization.

Fertilization in humans takes place in fallopian tubes.

II. Cleavage. It includes the rapid mitotic division of the zygote to form a blastula. Blastrula is an embryo from one layer of the cells and has cavity inside.

These divisions are not accompanied by cell growth, so they subdivide the large zygote into many smaller daughter cells called blastomeres.

Cleavage in human zygote occurs during its passage through the fallopian tube to the uterus. Type of the cleavage is complete, equal, asynchronic. A solid ball that consists of 16 go 32 blastomeres is known as **morula**. Than blastula is formed. Blastula in mammales is blastocyst. It consists from the inner cell mass – **embryoblast,** and outer cell mass or **trophoblast**.

Implantation. Implantation is the attachment of the blastocyst to the uterine wall. It takes place about five to seven days after ovulation.

III. Gastrulation.

Gastrulation is formation of germ layers. There are three germ layers: ectoderm, mesoderm and endoderm. Each germ layer gives rise to specific tissues, organs and organ-systems .

Gastrulation in human is the major event of the third week. It occurs by delamination and migration of the cells.

III.Organogenesis. It includes the formation of specific organ systems from three primary gem layers.

1. Ectoderm gives rise to skin epidermis and epidermal derivatives (glands, hair, nails), nervous system.

2. Mesoderm produces dermis of skin, most muscles, connective tissues, kidneys, gonads, heart, blood and lymph vessels, skeleton.

3. Endoderm forms lungs, digestive system, liver,pancreas.

The nervous system is the first organ system to form. Formation of the neural tube is called neurulation, embryo in this stage – neurula.

After the nineth week all organs are formed and embryo is termed fetus

The term during which the development occur is called the gestation period and is approximately 266 from fertilization.

Embryonic or fetal membranes (provisory organs) include the amnion, yolk sac, allantois and chorion.

The amnion is form an amniotic sac that is filled with amniotic fluid. Amniotic fuid gives space for development and growth; helps to maintain consistent pressure and temperature.

The yolk sack in man contains no nutritive yolk. It produces blood for the embryo and primary germ cells form in the wall of the yolk sac.

The allantois in humans give rise to the fetal umbilical arteries and vien. The umbilical cord contains two umbilical arteries, which carry deoxygenared blood from the embryo toward the placenta, and one umbilical vein, which carryies oxygenated blood from the placenta to the embryo.

The chorion forms placenta **Placenta** is a vascular structure by which fetus is attached to the uterine wall. Placenta supplies fetus with nutrition, provides gas exchange and removing of metabolic products. It also serves as protective barrier and edocrine organ producing steroid hormons.

The **umbilical cord** forms as the yolk sac shrincs and the amnion expands to envelope the tissues on the underside of the embryo.

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1.Placenta is formed in:
1) Reptiles
2) mammals
3) birds
4) none of these

2. Fetus gets nourishment and oxygen through
1) yolk sac
2) allantois
3) placenta
4) amnion

3. Fertilization in human female occurs in the
1) Fallopian tube
2) vagina
3) uterus
4) ovary

4. Mesoderm gives rise to
1) Epidermis
2) liver
3) intestinal lining
4) muscles

5. Morula is enclosed by
1) corona radiate
2) Zona pellucida
3) both of above
4) none of above

6. Ectoderm produces
1)dermis
2) lining of urinary bladder
3) nervous tissue
4) peritoneum

7. Embryo reaches the uterus from the Fallopian tube in about
1)24 hours
2) 2 days
3) 7 days
4) 14 days

8. In human parturition usually takes place… after the last menstrual period
1) 10 months
2) 30 weeks
3) 365 days
4) 40 weeks

9. Germ layers are formed during
1) copulation
2) cleavage
3) gastrulating
4) fertilization

10. At the time of ovulation in the human female, all the following are true except that
1) meiosis I has just been occurred
2) first polocyte has just been expelled
3) Zona pellucida has broken down
4) fertilization is possible

11. Foetal membrane that participates in the formation of placenta in human female is
1) allantois
2) amnion
3) yolk sac
4) chorion

12. Cleavage of the zygote gives rise to
1) blastula
2) morula
3) gastrula
4) foetus

13. Gonads develop from embryonic
1) ectoderm
2) endoderm
3) mesoderm
4) both mesoderm and endoderm

14. Human eggs are
1) alecital
2) mesolecital
3) microlecital
4) macrolecital

15. Blastopore is
1) Opening of neural tube
2) opening of gastrocoel
3) further anterior end of embryo
4) found in blastula

16. Amount of yolk and its distribution are changed in the egg. Which one is affected?
1) pattern of cleavage
2) formation of zygote
3) number of blastomeres
4) fertilization

17. Which one is produced by mesoderm?
1) heart and notochord
2) heart and brain
3) spinal cord and notochord
4) brain and notochord

18. Extra embryonic membranes of the mammalian embryo are derived from
1) inner cell mass
2) formative eggs
3) trophoblast

4) follicle cells

19. Coelom is formed by splitting of
1) mesoderm
2) endoderm
3) ectoderm
4) all the above

20. When do the three germinal layers differentiate?
1) Blastula
2) gastrula
3) cleavage
4) fertilization

21. Which is derived from ectoderm?
1) Epidermis
2) retina
3) spinal cord
4) all the above

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Postnatal period of human ontogenesis.

Practical class 10. Postnatal period of human ontogenesis.

The Purpose of the Lesson: To study postembrionic period of ontogenesis, its periodization. Growth and differentiation in postnatal period.

TOPIC CONTENT

1. Characterize postembryonic period of human ontogenesis.
2. What are the stages of postnatal period of human development?
3. What are the peculiarities of postnatal period of human development according to the biosocial nature?
4. Proportion of processes of growth and differentiation in postnatal period.
5. Old age as normal stage of postnatal period of human ontogenesis.
6. Manifestations of old age processes at different levels of human organization.
7. Modern theories of aging.
8. Gerontology and geriatrics.
9. Clinical and biological death.

TEST QUESTIONS FOR INDIVIDUAL WORK

№	Questions	Answers
1	Postembryonic development of human begins from _____ and finishes_____	
2	What is a type of human development? _____	
3	What are the periods of human postnatal ontogenesis according to the ability for fertilization?	**b**
	a	**c**
4	What is the main criterion of human development? _____	
5	What are the peculiarities of growth according to its duration –	its proportionality –
	a	**a**
	b	**b**
6	Which factors influence the speed of human growth?	**b**
	a	**c**

7	Acceleration is _____ _____
8	What are the possible reasons of acceleration? **a** **c** **b** **d** **e** **f**
9	What are the types of human constitution according to morphological indices? **b** **a** **c**
10	Oncology is a science_____ _____
11	What are the types of tumor growth? **a** **b**
12	What is a classification of tumors according to a type of cells growth and a stage of atypy? **a** **b**
13	What are cancerogenic factors? _____

Recommended iterature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 156-171.

Postembryonic period (in man – postnatal) is the period from birth to death.

There are two principle types of postembryonic development: direct and indirect.

In the direct development nascent body is similar to the adult, but smaller in size. Direct development is possible if egg accumulates enough amount of yolk (reptiles and birds) or embryo gets nutrition directly from maternal organism (mammals). A human being has direct postembryonic development.

In the indirect development the larva, which is not like an adult, hatches of the egg. A metamorphosis – the gradual transformation of the larva into an adult occurs in the postembryonic period. Such type of development is seen in animals with insufficient for direct development amount of yolk in eggs (insects, bony fish, amphibians)

Man has direct postembryonic development

According to the reproduction ability postembryonic period is divided into:

-Pre-reproductive

-Reproductive

-Post-reproductive

Pre-reproductive period

Neonatal – first 10 days (28 days);

-Infancy (up to 1 year);

-Childhood (early childhood 2 – 3 year, first 4 – 7 years, second – 8 – 11 years);

-Juvenile age (♀12 – 15; ♂ 13 – 16);

-Youth (♀16 – 20; ♂ 17 – 21).

Pre-reproductive period is characterized by active growth and differentiation

Growth

1)- Limited (restricted)

- Unlimited (unrestricted)

2)Isometric

- Allometric

3) Even

- Uneven (irregular)

Human growth is limited, allometric, irregular

Reproductive period

Mature:
Mature I (22 – 35 years ♂, 21 – 35 ♀)
Mature II 36 – 55 years (60 ♂)

Postreproductive period

- Middle age (60 – 74 ♂, 55 – 74 y ♀)
- Old age (75 - 90)
- Longivity period – older than 90

PRACTICAL WORK. Postnatal ontogenesis.

Task 1. Give the characteristic of periods of human ontogenesis.

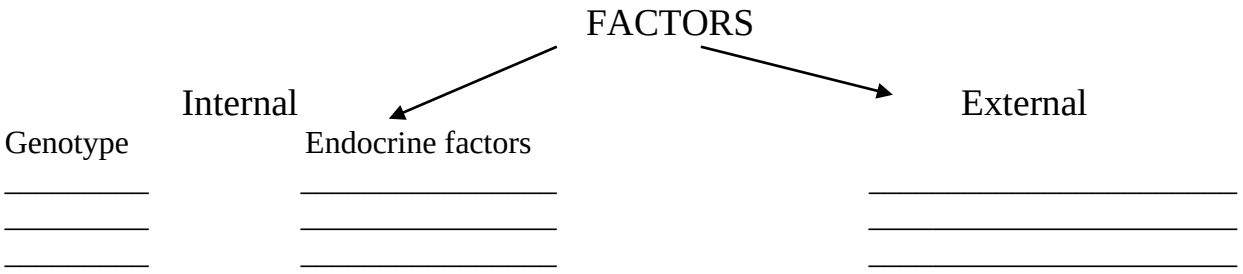
Periods	Limits	Growth spurt	Biological characteristics
Pre-reproductive			
New-borns	♀ ♂		
Infancy	♀ ♂		
Early childhood	♀ ♂		
First childhood	♀ ♂		
Second childhood	♀ ♂		
Juvenile age	♀ ♂		
Adolescence	♀ ♂		
Reproductive			
Mature age I	♀ ♂		
Mature age II	♀ ♂		
Post-reproductive			
Aged	♀ ♂		
Senile	♀		

	♂		
Period of Longevity	♀ ♂		

Task 2 Give the characteristic of critic periods of postnatal ontogenesis.

Period	Limits	Possible reasons
1. Newborns		
2. Puberty		
3. Post-reproductive		

Task 3. Study the factors that influence human growth.



Task 4. Fill the table.

Influence of the pituitary hormones on the human growth and development

Pituitary hormones	Target gland, hormones	Phenotypic manifestation
STH		Hypo function Hyper function
TTH		Hypo function Hyper function
ACTH		Hypo function Hyper function
GTH		Hypo function Hyper function

Task 5 Study the types of abnormal cellular growth. Fill the table

	Expansive	Invasive
Type of the tumor		

Characteristic of the cells		
Influence on the organism		
Examples		

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. A physician collects the patient's history of the post-embryonic period of ontogenesis from birth to puberty. In this case we are talking about:
   A Juvenile period
   B The first period of adulthood
   C Senium
   D The second period of adulthood
   E Advanced age

2. For the purpose of myocardium infarction treatment a patient was injected with embryonal stem cells derived from this patient by means of therapeutic cloning. What transplantation type is it?
   A Isotransplantation
   B Allotransplantation
   C Xenotransplantation
   D Autotransplantation
   E Heterotransplantation

3. A 30-year-old patient has undergone keratoplasty in the transplantation center, cornea has been taken from a donor, who died in a road accident. What kind of transplantation was performed?
   A Autotransplantation
   B Xenotransplantation
   C Explantation
   D Allotransplantation
   E Heterotransplantation

4. Differentiation of B-lymphocytes into plasma cells leads to synthesis of immunoglobulins that ensure specific immune response of the body. Differentiation of B-lymphocytes takes place in following organ of immune system:
   A Thymus
   B Red bone marrow
   C Thyroid gland
   D Tonsils
   E Liver

5. Following exposure to radiation a lot of mutant cells appeared in a patient. Some time later most of them were detected and destroyed by the following cells of the immune system:
   A T-lymphocytes-supressors
   B Plasmoblasts
   C T-lymphocytes-killers
   D B-lymphocyte
   E Stem cells

6. A patient in a transplantation center underwent heart transplantation. The organ was taken from a donor who died in a road accident. Foreign heart can be rejected as a result of development of transplantation immunity. It is usually prevented by means of:
   A Immunosuppressors
   B Chemotherapy
   C Ultrasound
   D Enzymes
   E X-ray therapy

7. Highly injured person gradually died. Please choose the indicator of biological death:
   A Disarray of chemical processes
   B Absence of movements
   C Absence of palpitation
   D Loss of consciousness
   E Autolysis and decay in the cells

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Peculiarities of human genetics. Mono- and dihybrid, polyhybrid crossing. Mendelian characters in human.

Practical class 11. **Peculiarities of human genetics. Mono- and dihybrid, polyhybrid crossing. Mendelian characters in human.**

The Purpose of the Lesson. To study subject and tasks, periods; main terms and notions of genetics. Mendelian characters in human. Principles of hybridological analysis. Monohybrid cross: low of dominance, low of segregation. Low of "gamete purity". Cytological basis of the lows. Test cross and its practical usage. Lethal genes. Deviations from the expected ratio. Di- and polyhybrid cross: low of independent assortment and its cytological basis. Dominant and recessive modes of inheritance of normal and pathological characters. Intermediate inheritance in humans.

TOPIC CONTENT

1. The science of genetics. Medical genetics. Human genetics.
2. Hybridologic method. What about it's using in human genetics?
3. Monohybrid crossing. I and II Mendel's lows.
4. Dihybrid crossing. III Mendel's low.
5. Cytological improvement of the hypothesis of "gametes purity".
6. Test-crossing and its using.
7. What are mendelian characters? Examples

TEST QUESTIONS FOR INDIVIDUAL WORK

№	Questions	Answers
1	Laws of heredity were discovered **by**_____ **in** _____ year	
2	The year of genetics birth is _____ when 3 scientists _____, _____ and _____ rediscovered Mendel's laws.	
3	Inheritance is …	
4	Variation is …	
5	Genotype is …	
6	Phenotype is …	
7	Phenotype depends on:	a) b)
8	Allele genes are …	
9	Alternative (contrasting) characters are …	
10	Homozygote organism is …	
11	Heterozygote organism is …	
12	Dominant gene is …	
13	Recessive gene is …	
14	The hybridization method is characterized by	
	a)	c)
	b)	d)

15	I Mendel's law states…
16	II Mendel's law states… Ratio in genotype is……..in phenotype is……
17	In the case of incomplete dominance ratio in genotype is……. in phenotype is……
18	III Mendel's law states…
19	The law of purity of gametes states …
20	Test cross is…
	It helps to define …
21	Lethal genes are …

1. **Recommended literature:** Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 154-160.

BASIC TERMS OF GENETICS:

Genetics is a science about heredity and variation.

Heredity is the transmission of characters from generation to generetion.
Variation is an ability of organism to change
Genotype is the set of genes in diploid set of chromosomes.
Phenotype is the external and internal features of an organism. Phenotype depends on genotype and environment.
Allele genes are the genes located at the same locus of homologous chromosomes and determining one character.
Alternative characters - contrasting features controlled by allele genes.
Homozygous – organism has same allele genes
Heterozygous - organism has different allele genes
Dominant gene (A) is the allele gene that expresses itself in the homozygous and heterozygous state.
Recessive gene (a) is the allele generation that expresses itself just in the homozygous state.

So, there are **three types of genotype**:
AA – dominant homozygotes
Aa – heterozygotes } Both have dominant phenotype
aa - recessive homozygotes, have recessive phenotype
Example: Brown eyes is a dominant character (**A**) Person with brown eyes might be homozygous (**AA**) or heterozygous (**Aa**). Blue eyes is recessive character. Person with blue yes is always homozygous(**aa**)

LAWS OF HEREDITY

Laws of heredity were discovered by Gregor Mendel in 1865. He studied inheritance of the characters in pea plants. He studied inheritance of one character (**monohybrid cross**)

I Mendel's law is the law of dominance: In crossing between homozygous organisms that differ in one pair of contrasting characters all the hybrids of first generation will manifest just one of the

characters. All hybrids will have same phenotype and genotype.

For example, Mendel crossed pea plants with yellow and green seeds and got all offspring with yellow seeds

Parents - **"P"** (lat . parents).
female is ♀
male is ♂ ;
"x" - crossing
offspring generation - "F"
(from Latin - filia **-children**)

P: ♀ AA x ♂ aa
yellow green
Gamets: A a
F_1: Aa – 100% yellow

Then Mendel crossed the hybrids of first generation (self-pollination of F_1 hybrids) He got plants with yellow and green seeds in 3 to 1 ratio.

II Mendel's law is the law of segregation. The hybrids of F_1 generation produce offspring with 2 contrasting characters in phenotypic ratio 3:1 and genotypic ratio 1:2:1.

F_1: ♀ Aa x ♂ Aa
yellow yellow
G : A,a A,a
F_2: AA , Aa , Aa , aa
yellow yellow yellow green

The F_2 ratio by phenotype is 3:1 (3 yellow : 1 green). Genotype ratio in is 1:2:1 (1 dominant homozygote : 2 heterozygotes : 1 recessive homozygote)

Dihybrid cross is the cross in which inheritance of 2 pairs of contrasting characters is studied simultaneously.

Law of independent assortment is the III Mendel's law. When parents differ in 2 or more pairs of contrasting characters the inheritance of each pair occurs independently, if genes are situated in different pairs of chromosomes.

Mendel cross the plants with **yellow (A) round (B) seeds** with the plant with **green (a) wrinkled (b) seeds.**

P: ♀ AABB x ♂ aabb
yellow, round green, wrinkled
G : AB ab
F1: AaBb
yellow, round
After F_1 self-pollination:
P: ♀ AaBb x ♂ AaBb
yellow, round yellow, round
G : AB, Ab, aB, ab AB, Ab, aB, ab

Punnett square helps in calculation of F_2 ratio**:**

F2 ♂ / ♀	**AB**	**Ab**	**aB**	**ab**
AB	**AABB** yellow round	**AABb** yellow round	**AaBB** yellow round	**AaBb** yellow round
Ab	**AABb** yellow round	**AAbb** yellow wrinkled	**AaBb** yellow round	**Aabb** yellow wrinkled

AB	**AaBB** yellow round	**AaBb** yellow round	**aaBB** green round	**aaBb** green round
ab	**AaBb** yellow round	**Aabb** yellow wrinkled	**aaBb** green round	**aabb** green wrinkled

F_2 phenotypic ratio is **9:3:3:1** in diheterozygous individuals.

So, the phenotype variants are:

9 A_B_ yellow round**;**
3 A_bb yellow wrinkled**;**
3 aa B_ green round**;**
1 aabb green wrinkled**.**

The complete ratio by genotype is: 1AABB: 2AABb: 2AaBB: 4AaBb: lAAbb: 2Aabb: 1aaBB: 2aaBb: 1aabb

The ratio of each character taken separately is 3:1 (12 yellow and 4 green; 12 round and 4 wrinkled), so segregation of each pair of characters occurs independently.

Incomplete dominance.

Mendel's laws do not occur universally. For example, when a **red** flowered 4 o'clock plant (AA) is crossed with **white** flowered plant (aa) the F_1 hybrids are found to have **pink flowers**.

P: ♀ AA x ♂ aa
red white
Gametes: A a
F_1: Aa x Aa
pink pink
Gametes: A;a A;a
F_2: AA , Aa , Aa , aa
red pink pink white

The manifestation of intermediate character in F_1 generation is incomplete dominance. **The ratio by phenotype and genotype in F_2 is the same in case of incomplete dominance (1:2:1).**

The crossing of hybrids with parental forms is used in **the hybridologic analysis**. It's called **the backcross,** offspring are called F_b.

Test cross is the cross of hybrids with the recessive homozygote. It helps to define the genotype of individual with dominant phenotype. If F_1 generation is uniform the genotype of dominant parent is AA; if the ratio is 1:1, the genotype of dominant parent is Aa.

P: ♀ AA x ♂ aa P: ♀ Aa x ♂ aa
F_1: Aa F_1: Aa; aa
100% 50% 50%

Characters following Mendel's laws are termed as Mendelian characters. Example in humans are **brown and blue eyes**

Some hereditary disorders are also Mendelian characters.

dominant disorders are **polydactyly, achondroplasy (dwarfism);**
recessive disorders are albinism, sickle-cell anemia

PRACTICAL WORK. Mono- and dihybrid, polyhybrid crossing. Mendelian characters in human.

TASK 1. Solve following problems.

1. Mother with light hair and father with dark hair have five children with dark hair. Define the genotypes of all family members.

A - _____

a - _____

P ♀ x ♂

G

F_1

Ratio in phenotype is _____

Ratio in genotype is _____

2. Both parents have brown eyes. Two among their five children are with blue eyes. Define the genotypes of all family members.

A - _____

a - _____

P ♀ x ♂

G

F_1

Ratio in phenotype is _____

Ratio in genotype is _____

3. Polydactyly (six fingers) is a dominant character. Man with polydactyly and normal woman has one normal child and one child with polydactyly. Define the genotypes of all family members.

A - _____

a - _____

P ♀ x ♂

G

F_1

Ratio in phenotype is _____

Ratio in genotype is _____

4. Polydactyly (six fingers) is a dominant character. Man with polydactyly and normal woman has four children with polydactyly. Define the genotypes of all family members.

A - _____

a - _____

P ♀ x ♂

G

F_1

Ratio in phenotype is _____

Ratio in genotype is _____

5. Anophtalmos (absence of eyeballs) is a recessive character. Heterozygous individuals have abnormally small eyeballs. Normal man got married to woman with anophtalmos. Detect the phenotype of their **a) children**

A - _____

a - _____

P ♀ x ♂

G

F_1

Ratio in phenotype is _____

Ratio in genotype is _____

b) **grandchildren** if both parents are heterozygous

A - _____

a - _____

F_1 ♀ x ♂

G

F_2

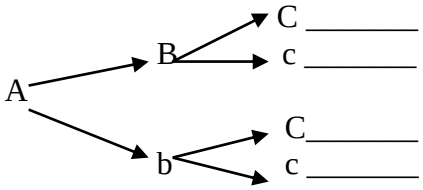
Ratio in phenotype is _____

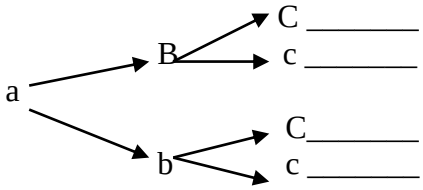
Ratio in genotype is _____

6. Write down the gametes produced by individuals with following genotypes

Genotype	AABB	AaBB	aaBb	AaBb	AABbcc
N of gametes					
Gametes					

7. Write down the gametes produced by individuals with following genotype AaBbCc





Totally _____ types of the gametes

8.

Parents with brown eyes and normal hearing have two deaf children: daughter with brown eyes and son with blue eyes. Define the genotypes of family members. What is the chance to have next child deaf with blue eyes?

A_____ P ♀ x ♂

a _____ G

B_____

b_____

Genotypic and phenotypic ratio

Chance to have next child deaf with blue eyes is _____%

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Man is homozygous with brown eyes, his wife has blue eyes. Their childrens' phenotype is the example of

A. Low of dominance
B. Low of segregation
C. Lw of independent assortment
D. Hypothesis of purity of gametes
E. Linked inheritance

2. Auricle-dental displasia is autosomal dominant disorder, which is characterized by absence of molars and some other defects. There is a normal child in family where mother is healthy and father is ill. What is the risk to have second child with displasia?

A.50%
B. 100%
C. 75%
D. 25%
E. 0%

3. Normal parents have the child with microcephaly, cleft lip and palate. What is the recurrence risk in this family, if disease is of autosomal recessive inheritance?

A.50%
B. 100%
C. 75%
D. 25%
E. 0%

4. One of the ectodermal displasia syndromes is characterized by defects of hair, teeth and bones and is of autosomal dominant pattern of inheritance. What is the chance to have normal children if both parents are ill and heterozygous?

A. 25%
B. 50%
C. 75%
D. 100%
E. 0%

5. Healthy parents have deaf child with albinism (two

recessive characters). What is the genotype of the parents?

A. AABB and AABB
B. AaBb and AABB
C. aaBB and aaBB
D. AaBb and AaBb
E. AABb and AaBb

6. Normal woman and man with aniridia (absence of iris, autosomal dominant character) have five children with aniridia. What is the chance to have normal child in this family?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

7. Albinism is the recessive character. In which marriage risk to have affected child is 50%?

A. AA and aa
B. Aa and aa
C. Aa and Aa
D. Aa and AA
E. AA and AA

8. Healthy couple have child with microcephaly (recessive character). What is the chance to have next child healthy?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

9. Man with achondroplasia (dwarfness) got married with normal woman. What is the chance for child to inherit this desease if father is heterozygous?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

10. Woman has night blindness (dominant character). Her husband and child are healthy. What is the chance to have next child healthy?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

11. One of the couple is normal, another with albinism. They have fraternal twins: normal and with albinism. What is the risk to have affected child in this family?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

12. Anophtalmos (absence of eyeballs) is the recessive character. Heterozygotes have small eyeballs (incomplete dominance). Couple is heterozygoes. What is the chance to have a child with normal eyes?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

13. Father is deaf and has albinism (recessive characters). Mother is healthy and diheterozygous. Which ratio will help to calculate the chances of their children to be healthy?

A. 3 : 1
B. 1 : 1
C. 1 : 1 : 1 : 1
D. 9 : 7
E. 9 : 3 : 3 : 1

14. Parents are healthy heterozygous carriers of recessive genes for diabetes and defect of lenses. What ratio will help to calculate the risk of having affected child?

A. 1 : 1
B. 3 : 1
C. 9 : 3 : 3 : 1
D. 15 : 1
E. 9 : 7

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Multiple alleles. Blood groups genetics.

Practical class 12. Multiple alleles. Blood groups genetics.

The Purpose of the Lesson. To study the mechanisms of multiple alleles, inheritance of blood groups of AB0 antigen system and Rh factor in human.

TOPIC CONTENT

1. Allelic genes. Mechanisms of multiple alleles origin.
2. Inheritance of blood groups of AB0 antigen system in human.
3. The role of blood group definition in clinics, application in forensic medicine.
4. The universal donor and universal recipient.
5. Inheritance of the Rh factor.

6. Development of Rh-conflict (haemolytic disease) in newborns.

TEST QUESTIONS for individual work

№	Questions	Answers	
1	In homologous chromosomes usually are situated _____ allele genes.		
2	In the case of multiple alleles there are _____ allele genes in population.		
3	Multiple alleles are formed as a result of _____.		
4	ABO blood groups are characterized by presence (or absence) of …	a)_____(_____) on the membrane of RBC	
		b)_____ (_____) in blood plasma	
5	Name genes that determine the ABO blood groups proteins:	a) antigens -	
6	How many allele genes specify human ABO blood groups?	- in population …….	
		- in somatic cell …….	
		- in gamete …….	
7	How 0 (I) blood group differs from other ABO blood groups? _____		
8	A person with A (II) blood group has antigen _____ and antibody _____.		
9	Which type of gene interaction is between genes I^A, I^B, i in following genotypes? I^Ai -_____ I^Bi -_____ I^AI^B - _____		
10	Rh-positive blood group is defined by presence of _____ on the membrane of_____		
11	What complications occur if the donor's Rh-positive blood is transfused to a person with Rh-negative blood?_____		
12	Rh-factor is important in following clinical situations:	a)	
		b)	
13	Rh-…….. fetus can be born with erythroblastosis fetalis (haemolytic disease of newborn) if mother is Rh-……		
14	Write the genotypes of a person with	Rh-positive 0 (I) blood	Rh-negative AB (IV) blood

1. **Recommended literature:** Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 161-171.

If there are **more than 2 alleles responsible for a single character in population,** these are **multiple alleles**. Multiple alleles are the result of mutation of a gene. Multiple alleles increases variation

Example in humans is inheritance of ABO system.

ABO BLOOD GROUPS

AB0 antigen system determines the blood groups **- 0(I), A(II), B(III), AB(IV)**.

Each has specific proteins **(antigens)** on erythrocytes and **antibodies** in blood plasma.

Gene I^A specifies antigen A;

gene I^B specifies antigen B;

gene I^O is recessive, it doesn't specify antigen

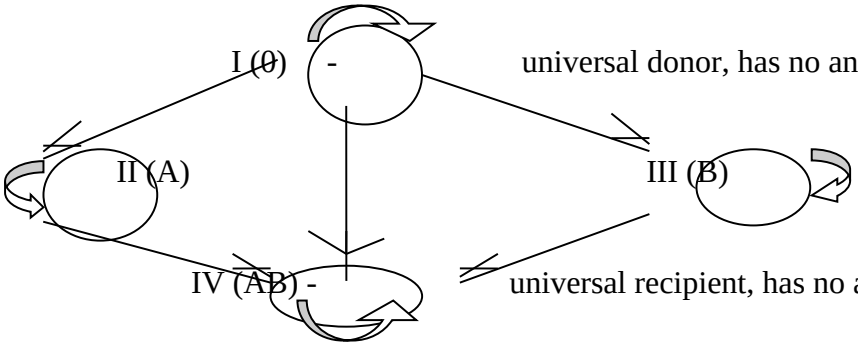
Blood Group	Antigen of erythrocytes	Antibodies of plasma	Gene	Genotype
0(I)	*None*	α,*β*	I^O (recessive)	I^OI^O
A(II)	A	*β*	I^A (dominant)	I^AI^A, I^AI^O
B(III)	B	α	I^B (dominant)	I^BI^B, I^BI^O
AB(IV)	A,B	*None*		I^AI^B

Genes I^A and I^B genes are codominant. Codominance means both the genes are equally dominant and both expressed in the phenotype. Presence of I^A and I^B genes determines presence of **two antigens (A and B) of IV blood group.**

Importance of ABO blood groups in medicine

1. Blood groups are important in blood transfusions. If antigen A meets antibody α or antigen B meets antibody *β,* it causes agglutination of donor erythrocytes. It can cause death.

The theoretical scheme of blood transfusion is:



2. Studying of blood groups inheritance can help in cases of **disputed parentage**. If a child has a blood group, which is not likely to be inherited from parents, child is adopted.

RH-BLOOD GROUPS

Rhesus-factor (Rh-factor) is antigen in human erythrocytes. 85% of Caucasians have it and are Rhesus-positive (Rh+), 15% don't have it and are Rh-negative (Rh -).

Positive Rh-factor is controlled by the dominant gene (D),
negative Rh-factor is controlled by the recessive gene (d).

Blood Group	Antigen of erythrocytes	Antibodies of plasma	Gene	Genotype
Rh+	**+**	**-**	**D**	**DD,Dd**
Rh-	**-**	**-**	**d**	**dd**

Importance of Rh-factor in medicine

- **Transfusion of Rh-positive blood to Rh-negative recipient**. The first transfusion leads to immunization of the recipient and production of anti-Rh antibodies. The second transfusion of Rh-positive blood results in hemolysis of donor erythrocytes and even death of the patient.
- **Pregnancy of Rh-negative women with Rh-positive child**. When women is Rh-negative and man is Rh-positive their children are Rh-positive.

P ♀ dd x ♂DD or P ♀ dd x ♂ Dd
G d D G d D,d

F Dd
Rh +

F Dd, dd
Rh + Rh-

The first pregnancy usually ends with delivering a healthy child. But during the labor erythrocytes of the child get into the maternal blood. Mother's organism start to produce antibodies against Rh+ factor. In the next pregnancy anti-Rh antibodies pass through placenta and destroy Rh+ erythrocytes of the fetus. Hemolysis of erythrocytes leads to jaundice of the newborn, edema, anemia and even death of the child **("erythroblastosis fetalis"**).

PRACTICAL WORK. Multiple alleles. Genetics of blood groups

Task 1. Analyze phenotypic characteristics and inheritance of ABO blood groups. Fill the table

ABO blood group	Antigens (A , B)	Antibodies (α, β)	Determining genes	Genotypes
O (I)				
A (II)				
B (III)				
AB (IV)			-	

Task 2. Solve the problems

2.1 Parents have AB and O blood groups. Will children inherit their ABO blood groups?

P ♀ x ♂

G

F_1

Phenotypes (in %) _____

2.2 Woman with A blood group, whose father has O blood group, marries man with B blood group (his mother has O blood group). Detect blood groups possible in their children

P ♀ x ♂

G

F_1

Phenotypes (in %) _____

2.3 Parents have A and B blood groups. Define the genotypes of the parents if the have six children with following blood groups:

a) all with AB blood groups

P ♀ x ♂

G

F_1

Phenotypes (in %) _____

b) three with AB and three with A

P ♀ x ♂

G

F_1

Phenotypes (in %) _____

c) two with O, three with B and one with AB

P ♀ x ♂

G

F_1

Phenotypes

2.4 Mother has O blood group, child has A group, and suspected father has B one.

A) Is the man biological father of the child?

B) Which ABO blood groups are possible in biological father of the child?

P ♀ x ♂

G

(in %) _____

F_1

Phenotypes (%)_____

Answer

A _____

Answer

B _____

2.5 Two new born boys were not properly registered in obstetric department. Is it possible to define the parentage if boys have A and B blood groups, first couple has O and AB blood groups and second one – A and B blood groups?

1st case P ♀ x ♂

G

F_1

Phenotypes (in %)

2nd case P ♀ x ♂

G

F_1

Phenotypes (in %)

2.6 Solve problem 2.5 if boys have A and B blood groups, first couple has O and AB blood groups and second one – A and O blood groups.

1st case P ♀ x ♂

G

F_1

Phenotypes (in %)

2nd case P ♀ x ♂

G

F_1

Phenotypes (in %)

Task 3. Analyze phenotypic characteristics and inheritance of Rh-factor. Fill the table.

Rh -factor	Antigen	Antibody	Genes	Genotypes
Rh+				
Rh-				

Task 4. Fill the table. In which cases there is a risk of "erythroblastosis fetalis" (haemolytic disease of a newborn)?

A. P ♀ DD x ♂ dd

G

F_1

Phenotypes (in %) _____

B. P ♀ Dd x ♂ dd

G

F_1

Phenotypes (in %) _____

C. P ♀ dd x ♂ DD

G

F_1

Phenotypes (in %) _____

D. P ♀ dd x ♂ Dd

G

F_1

Phenotypes (in %) _____

Task 5 Solve the problems.

5.1. Rh-negative woman with O blood group got married to Rh-positive man with AB blood group. What is the chance to have Rh-negative child with B blood group in this family? At which case there is a risk of "erythroblastosis fetalis"?

P ♀ x ♂

G

F_1

Phenotypes
(in %) _____

5.2. Man having AB Rh- blood group got married to woman having B Rh+ blood group. Woman's father has O Rh- blood group. There are two children in the family having B Rh– and O Rh+ blood groups. Forensic expert detected that one of the children is illegitimate. How we can exclude the paternity?

P ♀ x ♂

G

F_1

Phenotypes
(in %) _____

A child with _____ blood group is illegitimate.

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Woman with Rh-negative B (III) blood has newborn child with AB (IV) blood group and hemolytic disease because of Rh-conflict. What type of ABO and Rh blood group does her husband have?
   A. A(II) Rh (+)
   B. A(II) Rh (–)
   C. AB (IV) Rh (–)
   D. B (III) Rh (-)
   E. B (III) Rh (+)

2. Man with AB (IV) Rh (-) blood has a wife with B (III) Rh (+) blood. Her father has O (I) Rh (-) blood. There are children with B (III) Rh(-) and O (I) Rh (+) blood groups in this family. Forensic expert determined that on child is illegitimate. Which character permits to exclude the paternity?
   A. ABO blood groups
   B. ABO and Rh blood groups
   C. Rh factor
   D. Plasma proteins
   E. Rh factor and plasma protein.

3. Parents has A (II) and B(III) ABO blood groups. What is the chance to have a child with type O (I) blood if they are homozygous?
   A. 0%
   B. 25%
   C. 50%
   D. 75%
   E. 100%

4. Man has type AB (IV) blood, his wife has type 0 (I) blood. What is the chance to have a child with type B (III) blood?
   A. 0%
   B. 25%
   C. 50%
   D. 75%
   E. 100%

5. Children have O(I) and AB (IV) blood types. Their parents should have
   A. O(I) and A(II) blood types
   B. O(I) and B(III) blood types
   C. A(II) and B(III) blood types
   D. A(II) and AB(IV) blood types
   E. AB (IV) and O (I) blood types

6. Parents has A (II) and B (III) ABO blood groups. What is the chance to have a child with type O (I) blood if they are heterozygous?
   A. 0%
   B. 25%
   C. 50%
   D. 75%
   E. 100%

7. Both parents have A (II) and are heterozygous? What is the chance to have a child with type A (II) blood?
   A. 0%
   B. 25%
   C. 50%
   D. 75%
   E. 100%

8. Healthy parents with A (II) and B (III) blood types have child sick with phenylketonuria (recessive character) and O (I) blood type. What is the genotype of this child?
   A. $I^0 I^0$ aa
   B. $I^A I^0$ aa
   C. $I^B I^0$ aa
   D. $I^A I^B$ Aa

E. $I^0 I^0$ AA

9. ABO blood groups are controlled in population by three alleles I^0 , I^A and I^B. I^A and I^B are equally expressed in phenotype when present together. What is the type of interaction of these genes?

A. Complete dominance
B. Incomplete dominance
C. Over-dominance
D. Co-dominance
E. Complementarity

10. ABO blood groups are controlled in population by three alleles I^0, I^A and I^B. What are the genotypes of the parents if their children have all possible ABO blood groups?

A. $I^A I^A$ x $I^0 I^0$
B. $I^A I^A$ x $I^B I^B$
C. $I^A I^O$ x $I^B I^B$
D. $I^A I^O$ x $I^B I^0$
E. $I^A I^O$ x $I^A I^B$

11. ABO blood groups are controlled in population by three alleles I^0 , I^A and I^B. How many allele genes controlling ABO groups are in human somatic cell?

A. 1
B. 2
C. 3
D. 4
E. 5

12. ABO blood groups are controlled in population by three alleles I^0 , I^A and I^B. How many allele genes controlling ABO groups are in human sex cell?

A. 1
B. 2
C. 3
D. 4
E. 5

13. Rh factor inheritance is very important in obstetrics practice. In which situation there is a chance of hemolytic disease of a newborn because of Rh-conflict?

A. First pregnancy of Rh (+) woman with Rh (-) fetus
B. First pregnancy of Rh (-) woman with Rh (+) fetus
C. Second pregnancy of Rh (+) woman with Rh (-) fetus
D. Second pregnancy of Rh (-) woman with Rh (+) fetus
E. Pregnancy of Rh (-) woman with Rh (-) fetus

14. Both parents have A (II) Rh negative blood and are homozygous. What is the chance to have a child with type A (II) Rh negative blood?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

15. Both parents have A (II) Rh negative blood and are homozygous. What is the chance to have a child with type A (II) Rh positive blood?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

16. Both parents have A (II) Rh negative blood and are homozygous. What is the chance to have a child with type B (III) Rh negative blood?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

17. Parents have Rh negative blood and are heterozygous with A (II) and B (III) blood groups. What is the chance to have a child with type AB (IV) Rh-negative blood?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

18. Gene that specifies MN-system blood groups has two allele states. Gene M is considered to be of wild type. Which process provided formation of allelic gene N?

A. Crossing over
B. Mutations
C. DNA replication
D. Gene combination
E. DNA repair

19. A woman with III (B), Rh- blood group born a child with II (A) blood group. The child is diagnosed with hemolytic disease of newborn as a result of rhesus incompatibility. What blood group is the child's father likely to have?

A. II (A), Rh+
B. I (0), Rh+
C. III (B), Rh+
D. I (0), Rh-
E. II (A), Rh-

20. Man has AB (IV) blood group, woman has B (III) blood group. Female's father has I(0) blood group. There are five children in the family. Which genotype has illegitimate child?

A. $I^0 I^0$
B. $I^A I^0$
C. $I^B I^B$
D. $I^A I^B$
E. $I^B I^0$

21. ABO blood groups are controlled in population by three alleles I^0, I^A and I^B. How many alleles control ABO groups in population?

A. 1
B. 2
C. 3
D. 4
E. 5

22. A woman with A (II) Rh-negative blood had a child with B (II) Rh-positive blood. This child was diagnosed with congenital anemia of the newborns. What is the most likely cause of its development?

A. Intrauterine infection
D. Intrauterine intoxication
B. ABO incompatibility
D. Hereditary chromosomal pathology
E. Rhesus incompatibility

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Interaction of allele and non-allele genes. Pleiotropy.

Practical class 13. Interaction of allele and non-allele genes. Pleiotropy.

The Purpose of the Lesson. To study the peculiarities of inheritance based on different types of allelic and non-allelic gene interaction. Pay attention to the numerous deviations from Mendel's laws in different types of gene interaction between one and a few pairs of alleles, as well as the phenomenon of primary and secondary pleiotropy in human.

TOPIC CONTENT

1. The notion of the interaction phenomenon of allelic and non-allelic genes.
2. Complementary gene interaction. Mechanism, manifestation, practical value.
3. The phenomenon of epistasis. Molecular mechanism, manifestation, biological significance.
4. Polymeria (polygeny). Molecular mechanisms, biological and practical importance.
5. Primary and secondary pleiotropy. Molecular mechanism, practical importance.

TEST QUESTIONS for individual work

№	Questions	Answers
1	Interaction of genes is_____ _____	
2	Allele interactions are _____ _____	
3	Non-allele interactions are _____ _____	
4	There are following gene interaction types:	allele genes: a) b) c) d) non-allele genes: a) b) c)
5	Complementary interaction of dominant alleles means …	
6	Write down the F_2 ratio in phenotype in complementary gene interaction:	
7	Examples of complementary gene interaction in human are: a) b) c)	
8	Epistasis is …	
9	Write down the F_2 ratio in phenotype in epistatic gene interaction:	
10	Examples of epistatic gene interaction in human are:	
11	Write down the F_2 ratio in phenotype in epistatic gene interaction:	
12	Polymeria (polygenic interaction) is …	
13	Examples of polygenic gene interaction in human are: a) b) c) d)	

14	Pleiotropy is …	
15	Primary pleiotropy means …	
16	Secondary pleiotropy means …	
17	Examples in human	a) primary pleiotropy b) secondary pleiotropy

1. **Recommended iterature:** Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 172-178.

Gene interaction is interaction between protein products of the genes.

There are:

Allelic interaction is between the allelic genes (**A** and **a)**

complete dominance,
incomplete dominance,
codominance.

Non allelic interaction is between non-allele genes (**A** and **B**)

- Complementarity,
- epistasis
- polygenic traits.

The Allelic Interactions:

Complete dominance is the case when dominant allele completely suppress the manifestation of recessive one. Dominant character is completely present in phenotype. Examples are

- inheritance of eye color: dominant homozygotes (AA) have brown eyes, heterozygotes (Aa) have brown eyes, recessive homozygotes (aa) have blue eyes;
- number of fingers: AA – polydactyly (six fingers), Aa - polydactyly (six fingers), aa - norm (5 fingers).

Incomplete dominance is the case when dominant allele doesn't suppress the manifestation of recessive gene completely. So heterozygotes (Aa) have an intermediate phenotype. Examples are

- sickle-cell anemia: dominant homozygotes (AA) are healthy, recessive homozygotes (aa) have severe disease, heterozygotes (Aa) have mild disease.
- Anophtalmos (congenital absence of the eye balls): dominant homozygotes (AA) have normal eyes, recessive homozygotes (aa) have no eyes, heterozygotes (Aa) have small eyes.

Co-dominance is the case when two allele genes are equally expressed in phenotype. Example is

AB (IV) blood group: Gene I^A determines presence of antigen A, and gene I^B determines presence of antigen B. Person with genotype I^AI^B(AB blood group) has both antigens A and B on the erythrocytes.

The Non-Allelic Gene interactions

1. Complementary interaction means that two non-allele genes produce new character if present together in genotype (complement each other)

gene **A** gives one character gene **B** gives another character
A + B = new character

Examples in humans are:

F. Normal hearing: 2 dominant gene are required for normal hearing. Gene A determines normal cochlea and gene B determines normal acoustic nerve.
G. Human hemoglobin: Hemoglobin molecule consists of 2 α and 2 β chains (totally 4 globules), so 2 genes (for α and β chain) are required for normal molecule.

2. Epistasis is the suppression of one gene by another non-allele gene.

gene **A** gives a character gene **B** suppresses this character, so
A + B = no character

The gene that suppresses another one is called epistatic gene (inhibitor or supressor). The gene which expression is suppressed is termed as hypostatic gene.

3. Polygenic inheritance (polymeria) or quantitative inheritance is a case when several non-allelic genes controls same character. The more dominant genes are present, the more expressed is the character.

GeneA (A_1) gene B(A_2) gene C(A_3) gene D(A_4)
⇩
same (common)character

Such **genes are called polygenic (cumulative) genes** and the **feature they determine is polygenic.** These genes are marked by the same letter with different indices (A_1,A_2,A_3).

Examples in humans are: skin color, height, body weight, intelligence, blood pressure.

Pleiotropy

Pleiotropy is a case when many features depend on one gene.

1 gene
⇩
Many characters

Example in humans is: Marfan disease (arachnodactyly). Gene of the disease controls the connective tissue protein. If protein is abnormal all systems that have this protein are also abnormal: high height, arachnodactyly (spider fingers), congenital heart defects, dislocation of lenses and shortsightedness.

PRACTICAL WORK. Gene interactions. Pleoitropy

TASK 1. Write down different types of allelic genes interactions and give the examples.

Types of <u>allelic (intrallelic)</u> genes interactions

_____ _____ _____ _____

Examples:

_____ _____ _____ _____

TASK 2. Write down different types of non-allelic genes interactions and give the examples.

Types of <u>non-allelic(interallelic)</u> genes interactions

_____ _____ _____

Examples:

_____ _____ _____

TASK 3. Study the **<u>complementary</u>** type of non-allelic genes interactions.

3.1 Analyze the complementary type of non-allelic genes interactions, taking the inheritance of flowers' color in sweat pea plants as an example.

A - _____ B - _____

a - _____ b - _____

P ♀ x ♂

G

F_1

F_1 ratio

in phenotype _____

in genotype _____

Conclusion:

Ratio in phenotype _____ : _____

P (F_1) ♀ x ♂

G x

Using the scheme F_2 ratio:

Expected ratio	Phenotype	Real ratio
9……..	- _____	- __……..
3……..	- _____	- __……..
3……..	- _____	- __……..
1……..	- _____	- __……..

3.1 Solve the problems

Normal hearing depends on complementary action of dominant gene D that influences the development of the cochlea and dominant gene E that controls the development of the acoustic nerve. If any of them is absent, the normal acoustic apparatus isn't formed and a person is deaf. Both parents are deaf but they have five children with normal hearing. Detect the genotypes of all the family members. What is the chance to have a deaf child in this family? What is the expected F_2 phenotypic ratio if children will marry the partners with same genotype?

D - _____ E_____

d - _____ e_____

P ♀ x ♂

G

F_1

P ♀ x ♂

G

F_2 ratio

TASK 4 Study the **<u>epistatic</u>** type of non-allelic genes interactions.

4.1 Analyze the epistasis, taking the inheritance of fowl's feather as an example. Cross white hens with genotypes **CCII** and **ccii.** What is the ratio in F_2 generation?

C_____ I_____

c _____ i_____

P ♀ x ♂

G

F_1

F_1 ratio

in genotype _____

in phenotype _____

P (F_1) ♀ x ♂

G x

Using the scheme F_2 ratio:

Expected ratio	Phenotype	Real ratio
9……..	- _____	- __……..

Conclusion:
Ratio in phenotype _____ : _____

3…….. - _____ - __……..
3…….. - _____ - __……..
1…….. - _____ - __……..

4.2. "Bombay phenomenon" has been discovered by studying the family in which father with O (I) blood group of AB0 antigen system and mother with B (II) group had a girl with O (I) blood group. She married a man with A (II) blood group, they had two daughters of O(I) and AB(IV) blood groups. Determine the probable genotypes of all the three generations of the pedigree. Explain the mechanism of "Bombay phenomenon."

TASK 5 Study the **polymeric (polygenic)** type of non-allelic genes interactions
5.1 Analyze the polymery, taking the inheritance of skin color as an example. Detect possible color of the skin in children of Caucasian and Negro

$A_1A_1A_2A_2$ negro
$A_1A_1A_2a_2$ dark mulatto
$A_1A_1a_2a_2$ mulatto
$A_1a_1a_2a_2$ light mulatto
$a_1a_1a_2a_2$ white

P ♀ $A_1A_1A_2A_2$ x ♂ $a_1a_1a_2a_2$

G

F_1

Conclusion:
Ratio in F_2 phenotype _____ : _____

F_2

♂ gametes / ♀ gametes				

TASK 6 Give the schemes of primary and secondary **pleiotropy** in man

Primary pleiotropy

Gene

Character___ Character___ Character___

Secondary pleiotropy

Gene
↓
Character___
↓
Character___
↓
Character___

Example_____ Example_____

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Deafness is caused by different recessive genes ***a*** and ***b*** situated in different homologous chromosomes. Deaf man with *aaBB* genotype married deaf woman with *AAbb* genotype. They have four children. How many of them are deaf?
   A. Nobody
   B. 1/4
   C. Half
   D. 3/4
   E. All of them
2. Hemoglobin molecule is composed of two α and two β -chains. Genes for this chains are situated in different pairs of homologous chromosomes. What type of interaction is between these genes?
   A. Complementarity
   B. Epistasis
   C. Polymeric interaction
   D. Over-dominance
   E. Complete dominance
3. Newborn child has dislocation of lenses, long and thin fingers, congenital heart defect, high level of oxyproline (amino acid) in urine. These clinical symptoms are typical for
   A. Marfan's syndrome
   B. Phenylketonuria
   C. Hypophosphatemia
   D. Fructosuria
   E. Galactosemia
4. Hereditary deafness is determined by two recessive genes ***d*** and ***e***. For normal hearing both dominant alleles (***D*** and ***E***) are required. Deaf man (*ddEe*) got married deaf woman (*Ddee*). What is the chance to have normal children in this family?
   A. 0
   B. 25%
   C. 50%
   D. 75%
   E. 100%
5. Patient is sick with Marfan's syndrome. This syndrome is an example of following genetic phenomenon:
   A. Complementarity
   B. Epistasis
   C. Polymeric genes
   D. Pleiotropy
   E. Over-dominance
6. There are several types of hereditary glaucoma (high intraocular pressure). One type is determined by dominant gene, another by recessive one. Father is sick and diheterozygous (*AaBb*), mother is homozygous (*aabb*). What is the risk to have affected child in this family?
   A. 0
   B. 25%
   C. 50%
   D. 75%
   E. 100%
7. Hereditary blindness is determined by two non-allele recessive genes ***a*** and ***b***. Parents are blind. They have same type of blindness and are homozygous. What is the risk of blind child in this family.
   A. 0
   B. 25%
   C. 50%
   D. 75%
   E. 100%
8. Biosynthesis of interferon molecule is controlled by two dominant non-allele genes. What type of interaction is between these genes?
   A. Complementarity
   B. Epistasis
   C. Polymeric interaction
   D. Over-dominance
   E. Complete dominance
9. Hereditary deafness is determined by two recessive genes ***d*** and ***e***. For normal hearing both dominant alleles (***D*** and ***E***) are required. Deaf man (*ddEE*) got married with normal woman (*DdEe*). What is the chance to have normal children in this family?
   A. 0
   B. 25%
   C. 50%
   D. 75%
   E. 100%
10. Cystinuria is autosomal recessive disorder, characterized by formation of stones in kidneys. Heterozygous persons have elevated level of cystin in urine. What type of gene interaction is present?
   A. Complete dominance
   B. Incomplete dominance
   C. Complementarity
   D. Epistasis
   E. Co-dominance
11. Rh-positive couple has Rh-negative son. Inheritance of Rh- factor is characterized by
   A. Complete dominance
   B. Incomplete dominance
   C. Complementarity
   D. Epistasis
   E. Co-dominance
12. Hereditary deafness is determined by two recessive genes ***d*** and ***e***. For normal hearing both dominant alleles (***D*** and ***E***) are required. Parents are heterozygous. What phenotypic ratio we can use to calculate the risk in this family
   A. 9:3:3:1
   B. 1:1:1:1
   C. 9:7
   D. 13:3
   E. 15:1
13. For normal hearing two dominant alleles (D and E) are required Gene D controls acoustic nerve, gene E controls cochlea. What type of interaction is between these genes?
   A. Complete dominance
   B. Incomplete dominance
   C. Complementarity
   D. Epistasis

E. Co-dominance

14. Deafness is a recessive character. Deaf parents have six normal children. This example illustrates
A. Complete dominance
B. Incomplete dominance
C. Complementariry
D. Epistasis
E. Co-dominance

15. Hartnup disease is caused by point mutation of only one gene which results in disturbance of tryptophane absorption in the bowels and its resorption in the renal tubules. It is the reason for disorder of both digestive and urination systems. What genetic phenomenon is observed in this case?
A Pleiotropy
B Complementary interaction
C Polymery
D Codominance
E Semidominance (incomplete dominance)

16. A woman with 0 (I) blood group has born a child with AB blood group. This woman's husband has A blood group. What genetic interaction explains this phenomenon?
A. Recessive epistasis
B. Codominance
C. Polymery
D. Incomplete dominance
E. Complementation

17. Pigmentation intensity of human skin is controlled by a few independent dominant genes. It is known that pigmentation is the more intensive, the bigger quantity of these genes. What is the type of interaction between these genes?
A. Polymery
B. Pleiotropy
C. Epistasis
D. Codominancy
E. Complementarity

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Chromosomal theory of heredity. Genetics of sex.

Practical class 14. Chromosomal theory of heredity. Genetics of sex.

The Purpose of the Lesson. To study the basic statements of the chromosome theory of heredity. To understand the peculiarities of linked inheritance. To study the inheritance of haemophilia and colour blindness in human for calculation of the probability to have healthy offspring.

TOPIC CONTENT

1. What are the main points of chromosomal theory of heredity?
2. What is sex of human and mammals is determined by?
3. Which characters of human are inherited linked with sex?
4. Groups of genes linkage. Complete genes linkage.
5. Incomplete genes linkage. Crossing over. Morgan's low and his experiences.
6. Principles of genetic and cytological maps making.

TEST QUESTIONS FOR INDIVIDUAL WORK

№	Questions	Answers
1	Sex in human and mammals is inherited as a…._____ character	
2	Give the definition of:	a) autosome -
		b) heterosome -
3	Sex chromosomes are located in _____ cells and _____ cells.	
4	In human somatic cells there are _____ autosomes and _____ sex chromosomes	
5	Give examples of organisms in which *female* sex is heterogametous: a _____ b_____	
6	Give examples of organisms in which *male* sex is heterogametous: a _____ b_____	

7	How many types of gametes (%) are formed in human	a) in woman's organism - b) in man's organism -
8	Which parent determines sex of a child? Why?	
9	Where are located genes which determine characters linked with sex?	
10	Give examples of human characters which are inherited with X-chromosome: a _____ b_____	
11	Give examples of human characters which are inherited with Y-chromosome: a _____ b_____	
12	Holandric features are …	
13	The Morgan's law (law of genes linkage) states…	
14	Give examples of complete genes linkage in human …	
15	The number of genes linkage groups is equal to ……	
16	How many groups of genes linkage are present in:	
	a) woman –	b) man –
17	Crossing over is … In which period of cell cycle does crossing over take place? _____	
18	The percentage of crossing over is proportional to …	
19	The unit of crossing between genes is named _____ in honor of _____	
20	Genes in chromosome are located in _____ order.	
21	What are the methods of genetic and cytological maps of chromosomes making: for human – a,b;	
	for drosophilae – a,b.	

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 176-187.

Chromosomal theory of heredity. Genetics of sex.

Autosomes (A) are the same CHROMOSOMES in male and female organisms.
Sex chromosomes determine the sex of an organism.
In humans female has XX, male has XY chromosomes.

P ♀44A+XX x ♂44A + XY
G 22A+X 22A + X, 22A + Y
F 44 + XX, 44A + XY
50% females 50% males

Inheritance of genes located in sex chromosomes is <u>sex-linked</u> <u>inheritance</u>.
Characters determined by genes of sex chromosomes are <u>sex-linked</u> <u>characters</u>.
Examples in humans are hemophilia (slow blood clotting), red-green colour blindness. Problem:

X^H – normal blood clotting

X^h - hemophilia

If normal woman marry man with hemophilia all their children are healthy.

healthy woman man with hemophilia

P ♀ X^HX^H x ♂X^hY

G X^H X^h, Y

F_1 X^HX^h, X^HY

healthy daughter healthy son

In next generation healthy daughters(the carriers), give birth to the sons with hemophilia.

healthy mother (carrier) healthy father

P ♀ X^HX^h x ♂ X^HY

G X^H, X^h X^H, Y

F_1 X^HX^H, X^HY, X^HX^h, X^hY (50% of sons)

healthy daughter; healthy son; healthy daughter sick son (carrier)

If mother is carrier and father is sick, there may be affected daughters.

healthy mother (carrier) hemophilia

P ♀ X^HX^h x ♂ X^hY

G X^H, X^h X^h, Y

F_1 X^HX^h, X^HY, X^hX^h, X^hY (50% of children)

healthy daughter; healthy son; hemophilia hemophilia (carrier)

X linked dominant characters(vitamin D resistant rickets) is inherited by half of the daughters and sons from affected mother (X^AX^a) and by daughters only from affected father (X^AY).

Y chromosome controls the differentiation of testis and influences the male traits. **Features determined by Y chromosome** genes are **holandric.** They are transmiited from father to all his sons and never to the daughters. Example of the Y-linked condition is hairy ears (hypertrichosis of pinna).

All the genes located on the same chromosome are linked genes. The genes of linkage group have a tendency to be inherited together but independently of the genes of other linkage groups.

Experiment done by Morgan showed the main regularities of autosomal linkage (inheritance of genes of the same autosome). He crossed of drosophila flies with the gray body (A), long wings (B) and black body (a) without wings (b). F_1 flies were gray with long wings.

P ♀ $\frac{AB}{AB}$ x ♂ $\frac{ab}{ab}$

grey winged black wingless

G AB ab

F_1 $\frac{AB}{ab}$

grey winged

The test cross of F1 males produced following offspring:

F_1 ♀ $\frac{ab}{ab}$ x ♂ $\frac{AB}{ab}$

black wingless grey winged

G ab AB, ab

F2 $\frac{AB}{ab}$ $\frac{ab}{ab}$

grey winged 50% black wingless 50%

Male organisms have A and B genes in one chromosome and show complete linkage of genes without crossing-over.

Test cross of F_1 females gives another result:

F_1 ♀ $\frac{AB}{ab}$ x ♂ $\frac{ab}{ab}$

grey winged black wingless

G AB, Ab, aB, ab ab

	$\frac{AB}{ab}$	$\frac{Ab}{ab}$	$\frac{aB}{ab}$	$\frac{ab}{ab}$
F_2	grey winged 41.5%	grey wingless 8.5%	black winged 8.5%	black wingless 41.5%

The ratio in F_2 does not follow Mendelian inheritance (expected ratio is 1:1:1:1). 17% of recombinants occur as the result of crossing-over.

Based on the results of his experiments **T.H.Morgan in 1925** enunciated the **chromosomal theory of heredity**. It was a result of studying the cellular mechanisms of heredity.

Postulates of Chromosomal Theory of Heredity:

- Genes are situated in the chromosomes in the linear order. Each gene occupies a certain place (locus).
- Genes of one chromosome form a group of linkage and are inherited together. The number of linkage groups is equal to the number of haploid set of chromosoms.
- The exchange of allele gene between chromosomes (crossing-over) occurs.
- The distance between genes is directly proportional to the percentage of crossing-over.

The more is the distance between the genes, the more is the percentage of crossing-over. Closer the genes are on the chromosome, more likely they will stay together, or less likely that crossing over occurs between them. When crossing over between genes does not occur it is considered as a complete linkage of genes.

For convenience cross over frequency of 1% is taken as a distance of 1 unit (1 Morgan) on a chromosome.

PRACTICAL WORK. Chromosomal theory of heredity

TASK 1. Write down the scheme of inheritance of sex in humans.

P ♀ x ♂

G

F

Theoretical ratio is _____

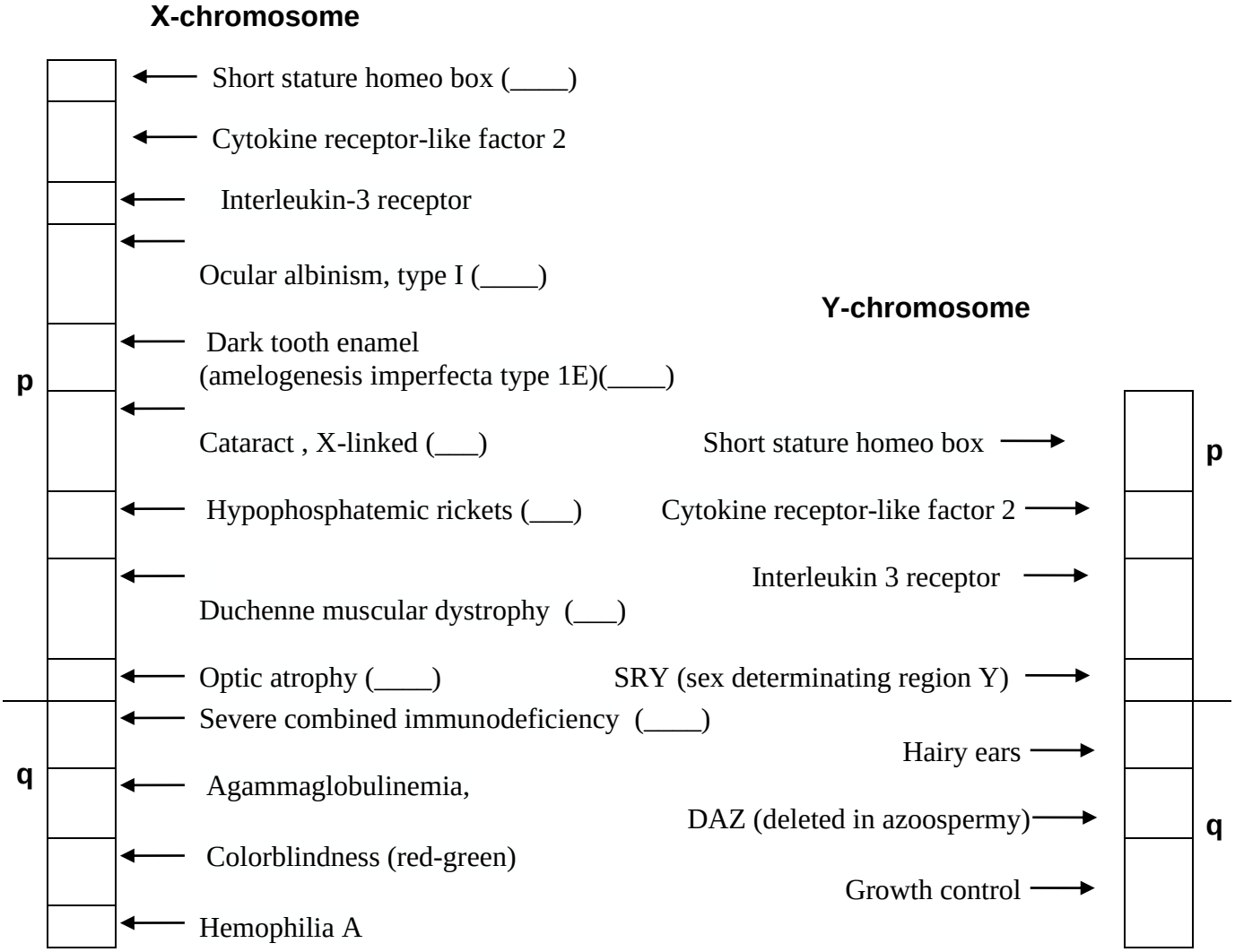
Real ratio is _____

Make a conclusion: Sex of a child is defined at the moment of _____ and depends on_____

TASK 2. Analyze inheritance of sex linked characters in humans.

Task 2. Analyze the inheritance of sex linked characters in humans.

2.1. Analyze the location of the genes in the sex chromosomes. Paint up homologous sites in the sex chromosomes. Specify dominant and recessive diseases.



2.2. Write down the scheme of inheritance of hemophilia.

Gene Character

_____ _____

_____ _____

a) Mother is healthy homozygote and father is sick P ♀ x ♂ G F	b) Mother is healthy heterozygote and father is healthy P ♀ x ♂ G F
c) Mother is healthy heterozygote and father is sick P ♀ x ♂ G	*Make a conclusion*: For X-linked recessive inheritance is characteristic: _____ _____ _____

F	_____

2.3 Write down the scheme of inheritance of vitamin D-resistant rickets

Gene Character

_____ _____

_____ _____

a) Mother is sick and heterozygote and father is healthy

P ♀ x ♂

G

F

b) Mother is healthy and father is sick

P ♀ x ♂

G

F

Make a conclusion: For X- linked dominant inheritance is characteristic:

_____

_____

2.4 Write down the scheme of inheritance of hypertrichosis

Gene Character

_____ _____

c) Mother is healthy and father is sick

P ♀ x ♂

G

F

Make a conclusion: For Y-linked inheritance is characteristic:

_____

_____

_____

_____

TASK 3. Solve the problems.

3.1 Healthy woman, whose mother suffered from red-green color blindness and father from hemophilia, got married to normal man. What is the chance to have normal children in this family?

Gene Character

_____ _____

_____ _____

P ♀ x ♂

G

F_1

P ♀ x ♂

G

F_2

Phenotypes

3.2 Healthy couple have a son sick with phenylketonuria (autosomal - recessive character) and hemophilia. Define the genotypes of the parents. What is the chance to have normal child in this family?

TASK 4. Study the autosomal-linked inheritance in Morgan's experiments with drosophila fly

Gene Character

_____ _____

a) homozygous winged female with gray body and wingless male with black body

P ♀ x ♂

_____ _____ _____ _____ _____ _____	G F_1
b) recessive homozygous female and F_1 hybrid male P ♀ x ♂ G F_2 Phenotypic ratio is	b) recessive homozygous male and F_1 hybrid female P ♀ x ♂ G F_2 Phenotypic ratio is

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Healthy couple has son sick with hemophilia. Grandfather from maternal side has hemophilia also. What is the mode of inheritance of this trait?
   A. X-linked recessive
   B. Autosomal recessive
   C. X-linked dominant
   D. Autosomal dominant
   E. Y-linked

2. Healthy woman marries man sick with hemophilia. There were no cases of hemophilia in her family history. What is the risk for their child to be affected?
   A. 0
   B. 25%
   C. 50%
   D. 75%
   E. 100%

3. Hypertrichosis (excessive hair growth) of auricles is determined by Y-linked gene. What is the chance for affected father to have affected son?
   A. 0
   B. 25%
   C. 50%
   D. 75%
   E. 100%

4. All of the males and none of females in families with hereditary hypertrichosis of auricles have this trait. This character is called
   A. Holandric
   B. Dominant
   C. Recessive
   D. Lethal
   E. X-linked

5. There is a recessive X-linked gene in humans that cause death of the embryo on early stage of development. What zygote will be eliminated?
   A. X^a Y
   B. X^AX^a
   C. X^AY
   D. X^AX^A

6. Father, his son and daughter has no premolar teeth. Same defect has grandfather on father's side. What is the pattern of inheritance of this characteristic.
   A. Autosomal dominant
   B. Autosomal recessive
   C. Dominant X-linked
   D. Recessive X-linked
   E. Y-linked

7. Hypoplasia of dental enamel is X-linked dominant disorder. Mother has normal teeth (X^hX^h), father is affected. This feature is inherited by
   A. Daughters only
   B. All children
   C. Sons only
   D. Half of the daughters
   E. Half of the sons

8. Absence of molars is autosomal dominant character. If mother is affected and homozygous the feature is inherited by
   A. Daughters only
   B. All children
   C. Sons only
   D. Half of the daughters
   E. Half of the sons

9. Ahydrotic ectodermal dysplasia (absence of sweat glands, dental defects) is X-linked recessive character. What is expected phenotypes of the offspring if man is affected and woman is healthy but has affected father.
   A. Half of the daughters and sons are affected
   B. All children are healthy
   C. All children are affected
   D. All daughters are affected
   E. All sons are affected

10. While studying of the pedigree was seen that hypertrichosis of auricles is transmitted from the fathers to the sons and only men are affected. What is the pattern of inheritance in this family?
   A. Autosomal dominant
   B. Autosomal recessive
   C. Dominant X-linked
   D. Recessive X-linked
   E. Y-linked

11. A couple came for medical genetic counseling. Man has hemophilia, woman is healthy and there were no cases of hemophilia in her family. What is the risk to have sick child in this family?
   A.100%
   B. 75%

C. 50%
D. 25%
E. 0

12. Healthy couple has son with hemophilia. Grandfather on mother's side is sick with hemophilia. Genotypes of the parents is
A. X^HX^H, X^HY
B. X^HX^h, X^HY
C. X^HX^h, X^hY
D. X^HX^H, X^hY
E. X^hX^h, X^HY

13. Healthy woman gets married with healthy man. Her father is sick with hemophilia. What are the expected phenotypes of their children?
A. 100% healthy
B. 75% healthy, 25% sick
C. 50% healthy, 50% sick
D. 25% healthy, 75% sick
E. 100% sick

14. Man with color blindness got married with healthy woman, heterozygous carrier of the disease. What is the chance to have normal child in this family?
A. 0
B. 25%
C. 50%
D. 75%
E. 100%

15. Man with hypertrichosis of auricles asks about the chance to have a normal son. The possibility is
A. 100%
B. 75%
C. 50%
D. 25%
E. 0

16. Genes situated in same chromosome form a group of linkage. Number of linkage group is equal to the haploid number of chromosomes. How many groups of linkage are in healthy man?
A. 46
B. 24
C. 23
D. 22
E. 2

17. Characteristics that are inherited through the sex chromosomes are termed as sex-linked. Choose the sex-linked characteristics
A. Rh-factor
B. Color blindness
C. ABO blood groups
D. Phenylketonuria
E. Polydactyly

18. Absence of sweat glands is X-linked recessive character. Albinism is autosomal recessive character. Healthy parents have son with both features. His genotype is
A. Aa X^bY
B. AAX^BY
C. Aa X^BY
D. aa X^bY
E. Aa X^BY

19. Genotype of the individual is AB‖ab; genes A and B are completely linked. Produced gametes are
A. AB : ab = 50% : 50%
B. Ab : aB = 50% ; 50%
C. AB : Ab : aB : ab = 25% : 25% : 25% : 25% ;
D. AB : Ab : aB : ab = 20% : 5% : 5% : 20%
E. AB = 100%

20. Genotype of the individual is BC‖bc; distance between genes B and C is 20 morganids. Produced gametes are
A. BC : Bc : bC : bc = 40% : 10% : 10% : 40%;
B. Bc : BC : bc : bC = 40% : 10% : 10% : 40%;
C. BC : bC : Bc : bc = 25% : 25% : 25% : 25% ;
D. BC : bc = 50% : 50%;
E. Bc : BC : bc : bC = 10% : 40% : 10% : 40%;

21. Genes of color blindness and hemophilia are situated in X chromosome. Distance between them is 9.8 morganids. Expected percentage of crossing over is
A. 90.2%
B. 9.8%
C. 6.53%
D. 4.9%
E. 3.26%

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Variation, its forms and manifestations

Practical class 15. Variation, its forms and manifestations

The Purpose of the Lesson. To study variation, it forms and manifestations on the organism level: phenotypic and genotypic variation. Modification and norm of reaction. Mutations and its phenotypic manifestation. Classification of mutations. Mutagens: physical, chemical, biological. Genetic danger of pollution.

TOPIC CONTENT

1. Variation: Type of variation.
2. Modification.
3. Phenocopies. Morphoses. Norm of reaction. Heterosis (hybrid power).

4. Biometry. Statistic studying of quantitative characters.
5. Types of genotype variation.
6. Mechanisms and types of combination.
7. Mutation. Autogeneses. Mutagenes.
8. Somatic, generative, induced, spontaneous mutations. Classification of mutations according to changes of genetic apparatus.
9. Mechanisms of genome, gene (point) and chromosome mutations.

TEST QUESTIONS FOR INDIVIDUAL WORK

	Questions	Answers
1	What are the main type of variation? a,b	
2	What is modification?	
3	Phenocopy is … . Give examples of phenocopies in human.	
4	Genocopy is … .	
5	Give examples of genocopies in human: a,b.	
6	Norm of reaction … .	
7	Qualitative characters are inherited according to the lows of … .	
8	Which method is used for studying of quantitative characters?	
9	Combinative variation is formation of new … .	
10	What are the mechanisms of combination of genes in children: a,b,c,d,e.	
11	Biological importance of combination is … .	
12	Mutation is … .	
13	Mutations appear in different cells of a human that's why they are … and … .	
14	Classify mutation according to the character of changes in hereditary apparatus: a,b,c.	
15	What are the mechanisms and types of 1) genome mutation – a,b; 2) chromosome aberrations – a,b,c,d; 3) gene (point) mutation – a,b,c,d.	
16	Polyploidy is … .	
17	Aneuploidy is … .	
18	What is 1) trisomy; 2) monosomy; 3) nulisomy.	
19	Give examples of disorders as a result of 1) monosomy; 2) trisomy of autosomes; 3) polysomy of heterosomes in men; 4) polysomy of heterosomes in women.	
20	The smallest locus of DNA which change results in transgeneration is anmed … .	
21	Sponataneuos mutations appear as a result of … .	
22	What are the mutagens 1) chemical – a,b,c,d,e; 2) physical – a,b,c,d; 3) biological – a,b,c.	

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 193-200.

Variation is an ability of organisms to change their features and properties.

There are two types of variations:

1. **Phenotypic variation (modifications) –** variation in phenotype **without** genotype changes (non-hereditary).
2. **Genetic variation –** variation in phenotype **caused by genotype** changes (hereditary) **.**

Phenotypic Variations or Modifications

These are the normal variants that appear due to environmental influence and do not concern genotype. Modifications provide adaptation.

Examples in humans are suntan, increase of the muscle volume after the high physical exertions

Characteristics of modifications:

- Don't shift the genes, so features are not inherited;
- are reversible;
- has unidirectional mass character;
- level of its expression depend on the strength and duration of the action of an external factor;
- limits of phenotypic variations is **norm of reaction.** Norm of reaction is determined by genotype. It might be wide (character vary greatly under the action of external factors) or narrow (character is less dependent on the environmental factors)

If external factor alter development of an organism (embryogenesis or early postembryonic stage) it can produce non-adaptive irreversible phenotypic variants. Such non-hereditary changes often are similar with genetically determined phenotypes (**phenocopy).**

A **phenocopy** is a variation in phenotype which is caused by environmental conditions, such that the organism's phenotype matches a phenotype which is determined by genetic factors. **Examples in humans are:** vitamin-D-deficient rickets (non-hereditary) and vitamin-D-resistant rickets (hereditary); congenital defects caused by rubella infection during the pregnancy (non-hereditary) and congenital defects because of chromosomal aberrations (hereditary).

Genetic Variation.

Genetic variation is a variation concerning the genotype, so it is hereditary. It is important in the evolutionary processes. There are 2 types of genetic variation - **recombination** and **mutations.**

1. Recombination is a process which makes **new combinations of genetic information**. It is provided by the following mechanisms:

- Crossing-over in prophase I of meiosis.
- The random segregation of homologous chromosomes (of maternal and paternal origin) in anaphase I of meiosis.
- Random fusion of gametes during the fertilisation.
- The chance of marriage.
- Multiple alleles.

It maintains genetic diversity of population and uniqueness of each individual. **Example in humans** is difference between the brothers and sisters in a family**.**

Genetic Variation.

Genetic variation is a variation concerning the genotype.

There are 2 types of genetic variation - **recombination and mutations.**

Recombination.

Recombination is a process which makes **new combinations of genetic information**. It is

provided by the following mechanisms:

1. The random segregation of homologous chromosomes (of maternal and paternal origin) in meiosis.
2. Crossing-over.
3. Random fusion of gametes.
4. The chance of marriage.
5. Multiple alleles.

These mechanisms do not cause the impairments of genotype. It maintains genetic diversity of population and uniqueness of each individual.

Mutations are the alterations of hereditary material, sudden and non directed changes of the genotype.

Mutations occur suddenly in single individuals. They are **non adaptive** and appear **spontaneously**. Usually they are **irreversible** and are **inherited** by the following generations.

Germ mutations occur in germ cells. These mutations are **inheritable Germ mutations cause hereditary diseases in children**

Somatic mutations occur in somatic cells, so they are **not inherited** In adult organism it may cause **formation of tumors.** If somatic mutation takes place during the embryonic development, adult organism may have both normal and mutant somatic cells. Such organism is termed as mosaic. The examples of mosaics are individuals with eyes of different colour.

According to the phenotypic manifestation mutations are dominant or recessive. They may be neutral, harmful and seldom useful. Harmful mutations cause hereditary disorder or are lethal.

Depending on the impairment of genetic material mutations are subdivided into three groups

H. genome (numerical chromosomal aberrations)

I. chromosome (structural chromosomal aberrations)

J. gene

Genome mutations are the **changes in chromosome number.** There are 3 types of genome mutations - polyploidy, aneuploidy and haploidy.

Polyploidy is the state of having **more than 2 complete sets of chromosome**s. The base haploid number of chromosomes is **n**, normal diploids have **2n** chromosomes. Polyploids are triploid (3n), tetraploid (4n) etc. (5n, 6n, 7n, 8n). Mechanism of polyploidy is non disjunction of all chromosomes in meiosis. Polyploidy is beneficial in plants and a rare harmful state in animals. In humans tripolyploidy (69 chromosomes) causes severe congenital defects and death.

Aneuploidy is changing of chromosome number unequal to haploid set. There may be nullesomy, monosomy or polysomy.

Polysomy is the presence of extra-chromosomes. Genotype of polysomic organisms is the following: *2n+1* (trisomy); *2n+2* (tetrasomy); *2n+3* (pentasomy). The most well-known chromosomal disorders caused by **autosomal trisomy** are: **Patau's syndrome** (47, XX or XY, +13); **Edward's** syndrome (47, XX or XY, +18); **Down's s**yndrome (47, XX or XY, +21).

Polysomy in sex chromosomes are: **super-female syndrome** (47, XXX; 48, XXXX; 49, XXXXX); **super-male syndrome** (47, XYY; 48, XYYY; 49, XYYYY); **Klinefelter's syndrome** (47, XXY; 48 XXXY; 49, XXXXY).

Monosomy is the presence of only one copy of homologous chromosomes ***(2n-1)***. **Monosomy** in humans is lethal, except **Shereshevsky-Turner's syndrome (45, XO).**

Nullisomy is absence of the pair of homologous chromosomes ***(2n-2)***. In humans it is lethal.

Haploidy is the state of **haploid (n)** set of chromosomes. In majority of animals haploidy is lethal.

Chromosomal aberrations (structural chromosomal mutations) is a reorganization of chromosomal material.

K. Deletion - absence of a chromosomal segment.

L. Duplication - doubling of chromosomal segment.

M. Inversion – 180^0 rotation of chromosomal segment

N. Translocation - transfer of chromosomal segment to another chromosome.

Chromosomal aberrations result in chromosomal disorders. 21 to 15 translocation causes translocation type of Down's syndrome. Another example is «cat cry syndrome» - deletion of the short arm of 5^{th} chromosome. (46, XX or XY del 5^{-}).

Gene mutations are the changes of gene (DNA) structure.

There are: deletion of nucleotide, insertion of nucleotide, substitution of nucleotides, rearrangement of DNA segments.

single gene disorders: haemophylia, sickle cell anaemia, phenylketonuria,

Mutations are spontaneous or induced.

Spontaneous mutations occur due to natural reasons as a result of replication errors. Induced mutations are induced artificially by mutagenic agents: physical, chemical and biological ones.

PRACTICAL WORK. Variation

Task 1. Compare the various characteristics of variation between modifications and mutations by marking "+" and "-".

Characteristics	Modification	Mutation
Inheritable		
Reversible		
Adaptive		
Individual		
Unidirectional		
Occurs in group		

Task 2. Define, which disorders are the examples of modifications and mutations by marking "+" in appropriate column.

Disease	Modification	Mutation
Scurvy		
Albinism		
Vitamin-D-resistant rickets		
Vitamin-D-deficient rickets		
Down's syndrome		
Fetal alcohol syndrome		
"Cat cry" syndrome		
Tick-born ecephalitis		

Task 3

Type of the cells	**Action of the external factors**	**Influence on the viability**	**Changes in hereditary material**
A **B**	**A** **B**	**A** **B** **C** **D**	**A** **B** **C**

Task 4. Give the different types of mutations according to changes in hereditary material

	Gene	Structural chromosomal aberrations	Numerical chromosomal aberrations (genome)
Level of the mutation			
Mechanisms	a) b) c) d) e)	a) b) c) e)	a) b) 1. 2. 3. - - -
Examples of the diseases			

Task 5. Fill the table.

Disease	Karyotype	Number of		Type of mutation
		Autosomes	Heterosomes	
Healthy woman				-
Healthy man				-
Down's syndrome				
Edward's syndrome				
Patau's syndrome				
"Cat cry" syndrome				
Turner's syndrome				
Klinefelter's syndrome				
"Super-female" syndrome				
"Super-male" syndrome				

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Endemic goiter is common in some geographical regions as a result of low iodine in diet. This is example of

A. Gene mutation
B. Recombination
C. Modification
D. Structural chromosomal aberration
E. Numerical chromosomal aberration

2. Patient has rare hereditary disorder, which has been never observed in family history. What is the primary

underlying defect of the disease?
A. Failure of meiotic division in parents
B. Unfavorable environmental conditions
C. Mosaicism
D. Monosomy of somatic cells

3. In human DNA adenine was replaced by cytosine. What type of mutation took place?
A. Gene mutation
B. Deletion
C. Polyploidy
D. Translocation
E. Inversion

4. Replacement of nucleotides in DNA results in
A. Single gene disorders
B. Chromosomal disorders
C. Anomaly of autosomes
D. Anomaly of sex chromosomes

5. Two nucleotides in DNA molecule were lost after X-ray irradiation. It is an example of following mutation:
A. Deletion
B. Duplication
C. Inversion
D. Translocation
E. Replication

6. Intake of talidomid by pregnant women in fiftieth led to the birth of thousands children with congenital defects of skeleton (absence of limbs). This congenital defect is a result of
A. Modifications
B. Trisomy
C. Monsomy
D. Triploidy
E. Gene mutation

7. Woman who was sick with rubella during the pregnancy gave birth to the deaf child with hare lip and cleft palate. This congenital defect is an example of
A. Phenocopy
B. Edward's syndrome
C. Genocopy
D. Patau's syndrome
E. Down's syndrome

8. Woman who was sick with toxoplasmosis during the pregnancy has child with multiple congenital defects. It is a result of
A. Cancerogenesis
B. Teratogenesis
C. Biological mutogenesis
D. Chemical mutogenesis
E. Recombination

9. Sickle cell anemia is common hereditary disease in South Africa. Main symptom of the disease is a crescent shape of RBC because of replacement of glutamin by valin. The underlying defect of hereditary material is
A. Gene mutation
B. Structural chromosomal defect
C. Crossing over
D. Numerical chromosome mutation
E. Recombination

10. Girl with blue eyes has brown spot in the right iris. It is a result of
A. Genome mutation
B. Chromosomal aberration
C. Somatic mutation
D. Gene mutation
E. Germ mutation

11. Patient with mosaic type of Down's syndrome has about 50% cell with normal karyotype and 50% cell with trisomy 21. Disease is a result of mistake in
F. First meiotic division
A. Second meiotic division
B. Mitosis
C. Amitosis
D. Endomitosis

12.After X-ray irradiation segment of DNA molecule turns around and joins in reverse direction. It is
A. Inversion
B. Deletion
C. Duplication
D. Translocation
E. Replication

13. There are three copies of 13 chromosome in the karyotype of the child with multiple congenital defects. Type of the mutation is
A. Polyploidy
B. Trisomy
C. Nullesomy
D. Monsomy
E. Chromosomal aberration

14. Chromosome has following linear order of genes ABCDEHKTM. After the mutation there is a following order of genes CDEHKTM. Type of the mutation is
A. Inversion
B. Deletion
C. Duplication
D. Translocation
E. Monosomy

15. Cytogenetic studying of aborted embryo showed 45 chromosomes, one copy of third chromosome. Type of the mutation is
A. Chromosomal aberration
B. Point mutation
C. Nullesomy
D. Polysomy
E. Monosomy

16. Gene mutation causes following changes in hereditary apparatus
A. Number of the chromosomes in diploid set
B. Number of the haploid sets
C. Structure of the chromosome
D. Structure of the gene
E. Number of the genes

17. Polyploidy is one of the genome mutations. It is
A. Structural changes of the chromosomes
B. Duplication of chromosome part
C. Increase in the entire haploid sets of the chromosomes
D. Decrease in the entire haploid sets of the chromosomes
E. Abnormal number of the chromosomes in diploid set

18. Mutagenic effect have factors of different nature. Chemical mutagen is
A. Water
B. Ethyl alcohol
C. Nicotine

D. Colchicine
E. Sodium chloride

19. Amniocentesis showed, that karyotype of the fetus is 45, XO. Diagnosis is
F. Turner's syndrome
A. Edward's syndrome
B. Patau's syndrome
C. Cat cry syndrome
D. Super female syndrome

20. Down's syndrome is the most common chromosomal disease in humans. Underlying chromosomal defect is
A. Trisomy X
B. Trisomy 13
C. Trisomy 18
D. Trisomy 21
E. Polysomy Y

21. Mutagenic effect has factors of different nature. Biological mutagen is
A. Helminthes
B. Bacteria
C. Viruses
D. Toxoplasma

22. Example of the disease that develops as a result of gene mutation is
A. Hemophilia
B. Patau's syndrome
C. Cat cry syndrome
D. Down's syndrome
E. Klinefelter's syndrome

23. Aborted embryo has 69 chromosomes. It is an example of
A. Haploidy
B. Polyploidy
C. Trisomy
D. Monosomy
E. Duplication

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Pedigree and twins methods of human genetics

Practical class 16. Pedigree and twins methods of human genetics

The Purpose of the Lesson. To realize the gist of genealogic and twins methods of human genetics. To get practical skills in pedigree composition and analysis, to detect the genotype and environment influence on the manifestation of normal and pathological characters in humans

TOPIC CONTENT

1. Human as a subject of genetics.
2. Genealogy. Stages of genealogical method.
3. Genetic symbols. Rules of pedigree composition.
4. Main characters of autosome-dominant, autosome-recessive, X-linked (dominant and recessive), Y-linked (holandric) types of inheritance.
5. Practical importance of genealogic method.
6. Peculiarities of mono- and dizygotic twins formation. Concordance and discordance of twin pairs.
7. Usage of twins method. Determination of the coefficient of hereditary and environmental influence on a character by Holtzinger's formula.

TEST QUESTIONS FOR INDIVIDUAL WORK

№	Questions	Answers
1	What are the stages of genealogical method?	**a**
		b
		c
2	How do we term a person whose pedigree is composed?_____	
3	What are the rules of pedigree charting?	**a**
		b
		c
		d
4	What are the main	**a**

	goals of usage of the genealogical method?	**b**
		c
5	*What are the characters of types of inheritance:*	
	Autosome-dominant	**a**
		b
		c
	Autosome-recessive	**a**
		b
		c
	X-linked dominant	**a**
		b
		c
	X-linked recessive	**a**
		b
		c
	Y linked	**a**
6	Twins method is used for a calculation of the roles of _____ and _____ in manifestation of characters.	
7	Monozygotic twins are formed as a result of fusion of _____ and _____ following by _____.	
8	Monozygotic twins are characterized by …	**a**
		b
		c
9	Dizygotic twins are formed as a result of_____ and _____ .	
10	Dizygotic twins are characterized by …	**a**
		b
		c
11	Write down formulas for calculations of coefficient of:	
	paired concordance (Kn) -	
	role of heredity (H) -	
	role of environment influence – (E).	

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 204-211.

Pedigree and twins methods of human genetics

Pedigree analysis is the method based on **composition of the pedigree** (family tree) and its analysis. It allows:

- to define a pattern of inheritance;
- to define genotype of any member of the pedigree;
- to predict the probability of affected child birth.

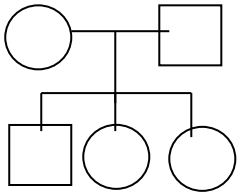
Stages of the pedigree analysis are:

1. **Collection of information about the family.**
2. **Pedigree charting.**
3. **Pedigree analysis.**

A **person**, whose genealogy is composed, is **proband (propositus** or **proposita**). Brothers and sisters **of proband** are **siblings**.

Main symbols of pedigree

Healthy woman and man Sick woman and man



Parents

Children

The possible patterns of heredity are:

- **Autosomal-dominant**
  - O. character is transmitted directly from a parent to a child (**vertical inheritance),** is present in all generations
  - P. Character is present equally in women and men,

Sick persons have genotype **AA** or **Aa;** healthy persons have genotype **aa**
Risk to have an affected child for sick (Aa) anf healthy (aa) parent is 50% .

- **Autosomal-recessive**
  - character is present in few persons in pedigree;
  - the parents of sick child are healthy, but more than one child might be affected (**horizontal inheritance**);
  - Character is present equally in women and men

Sick persons have genotype **aa;** healthy persons have genotype **AA** or **Aa;** Healthy heterozygous parents (Aa) have 25% probability of a sick child birth**.**

- **Recessive X-linked**
  - Mainly males are affected**,**
  - disorder is transmitted through healthy **mothers to half of her sons** .

Sick boy has genotype $X^{a}Y$**;** healthy boy has genotype $X^{A}Y$**;**
Sick girl has genotype $X^{a}X^{a}$**;** healthy boy has genotype $X^{A}X^{A}$ or $X^{A}X^{a}$**;**

9. **Y – linked** –
   - F. disorder is inherited from sick father to all sons .

Twins method

is based on studying characters in identical and fraternal twins. It allows to determines the role of environment and genotype in phenotype formation.

Monozygotic or identical twins (IT) - develop from 1 zygote (1 sperm + 1 egg) and have the same genotype, they are always of the same sex.

Dizygotic fraternal twins (FT) develop from 2 zygotes (2 ova are fertilized by 2 sperms). They share 50% of genes, can be of the same or different sex.

If the character **manifests in both twins, these twins are called concordant**. If one the twins has the character and another doesn't have **these twins are called discordant**.

the **coefficient of pair concordance (K):**

$$K = \frac{C}{C+D} 100$$

C is the number of concordant twin pairs; **D** is the number of discordant twin pairs.

To determine the **role of heredity and environment in the manifestation of character** the concordance of identical and fraternal twins is compared by calculation of **coefficient of heredity (H)** :

$$H = \frac{Cit - Cft}{100 - Cft} 100$$

,

where **C** it % coefficient of concordance of identical twins,

C ft % - coefficient of concordance of fraternal twins.

If H is 70% - 100% mainly genotype influence the feature.

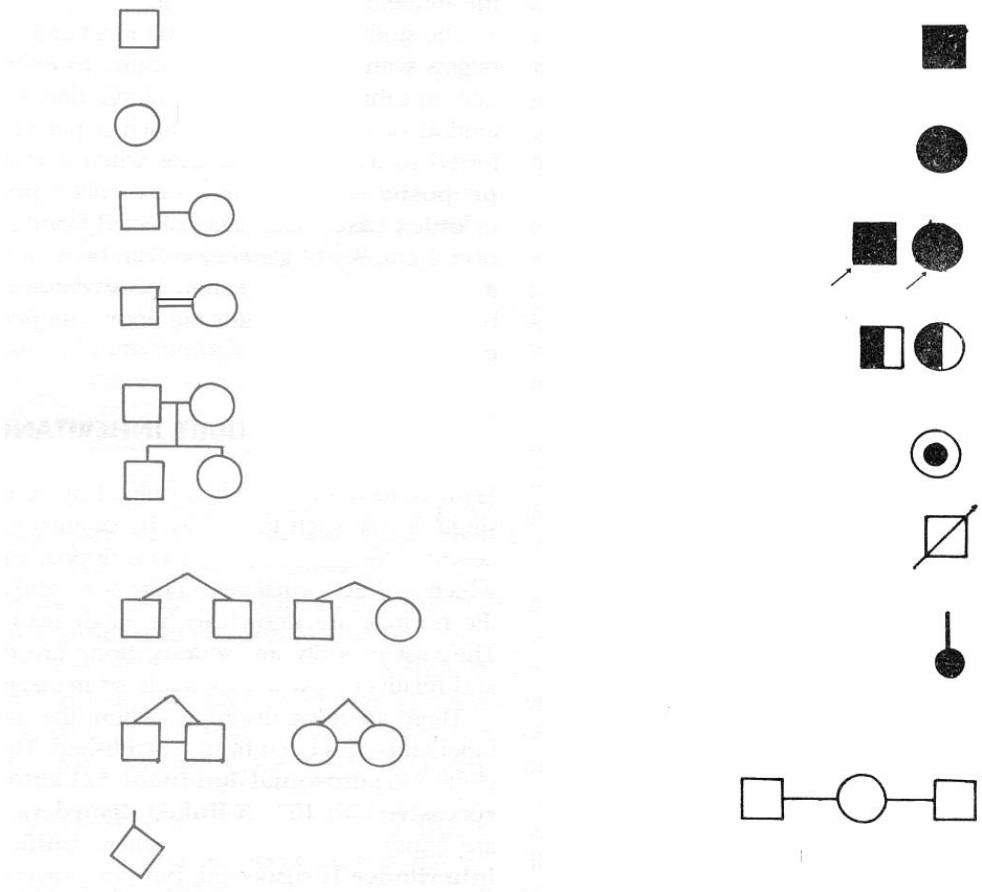
If H is 70%-30% - the feature depend on both environment and genotype.

If H is 0 -30% environment is the main factor influencing the feature.

Coefficient of environment influence **C=100% - H.**

PRACTICAL WORK. Pedigree analysis. Twins method.

Task 1. Write down the meanings of the symbols used for pedigree analysis.



Task 2. Compose and analyze the pedigrees with different modes of inheritance. Give the characteristics of typical patterns of inheritance and examples of the disorders.

2.1 Propositus (proband) is an affected boy. His father is sick, mother is normal. All further information concerns father's relatives. Proband has sick and healthy uncles, and sick and healthy aunts. Probands sick uncle was married twice. In first marriage he has sick daughter, in second marriage he has four children: two sick daughters and sick son, and normal daughter. Proband's healthy aunt got married with normal man. They have healthy boy and two healthy girls. Proband's grandmother is sick, grandfather is healthy.

Mode of inheritance is_____
Typical features are_____
_____
_____
_____

Examples_____

2.2 Proposita (proband) is an affected girl. Her parents and grandparents on both sides are healthy. Grandmother of the proband on maternal side and grandmother of the proband on paternal side are sisters. Grandgrandmother and grandgrandfather of proband were healthy but it is known that grandgrandfather had a brother with same disease. What is the risk to have another affected child in this family?

Mode of inheritance is_____
Typical features are_____

_____
_____
_____

Examples_____

2.3 Propositus is an affected boy. He has healthy brother and two sisters. His parents are healthy. Proband's mother has two healthy brothers, healthy sister and affected brother. Mother's sister has healthy husband, healthy daughter and affected son. Grandmother and grandfather on maternal side are healthy. What is the risk to have affected child if propositus will marry a woman with same genotype as his mother has?

Mode of inheritance is_____
Typical features are_____
_____
_____
_____

Examples_____

2.4 Propositus (proband) is healthy. His four sisters are sick. Proband's mother is healthy and father is sick. Proband's father has sick brother and sick sister. Sick brother is married with normal woman. They have two affected daughters and two normal sons. Proband's sick aunt is married with normal man. They have sick daughter and son and healthy daughter. Proband's grandfather on paternal side is healthy, grandmother is sick. What is expected phenotype of the children if he will marry heterozygous woman?

Mode of inheritance is_____
Typical features are_____
_____
_____
_____

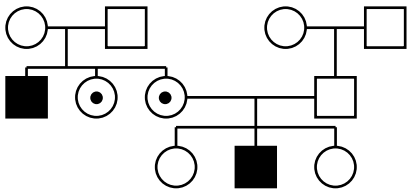
Examples_____

2.5 Propositus (proband) is sick boy. His brother is sick and two sisters are healthy. Proband's mother is healthy. Proband's father is sick and has two sick brothers. Both brothers are married with normal women. One brother has two healthy daughters and another one has normal daughter and affected son. Proband's grandfather is sick, grand mother is healthy.

Mode of inheritance is_____
Typical features are_____
_____
_____

Examples_____

Task 3. Recognize the modes of inheritance.



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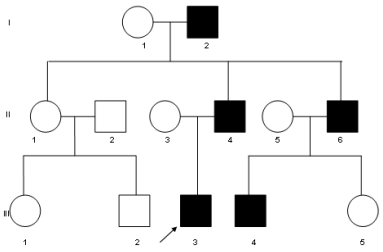

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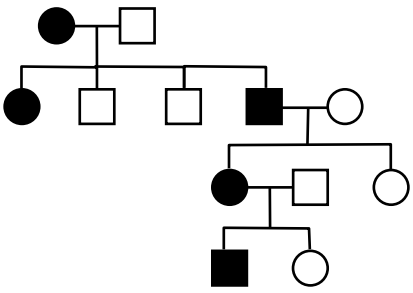

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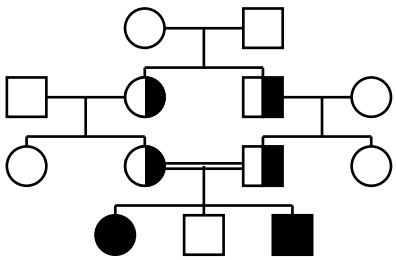

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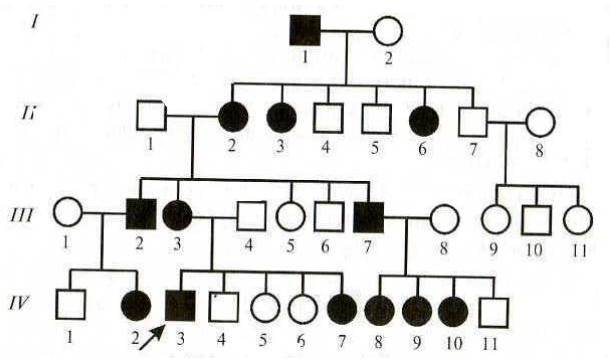

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Task 4. Solve the problems, using twins method

4.1 There are 100 pairs of dizygotic (fraternal) twins in population, 3 pairs among them are concordant in clubfoot. Among 40 pairs of monozygotic (identical) twins 12 pairs are concordant in clubfoot. Calculate the coefficient of concordance for fraternal and identical twins and coefficient of heredity and environmental influence.

Kn (MZ) =

Kn (DZ) =

H=

C=

Conclusion _____

_____

4.2 Calculate the heritability for following features. Make a conclusion about influence of heredity and environment on manifestation of the character.

Trait or disease	Concordance rate		H	E	Conclusion
	MZ twins	DZ twins			
Height	0.94	0.44			
IQ	0.76	0.51			
Tumors of the same type	0.59	0.24			
Appendicitis	0.29	0.16			
Diabetes mellitus (type1)	0.84	0.37			
Endemic goiter	0.71	0.7			
Schizophrenia	0.86	0.14			
Tuberculosis	0.69	0.25			

Characters predominantly determined by heredity are _____

_____

Characters predominantly determined by environment are _____

_____

Characters determined almost equally by both factors are_____

_____

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Father, his son and daughter lack premolar teeth. Same defect has grandfather on paternal side. What is the pattern of inheritance of this character?
   A. Autosomal dominant
   B. Autosomal recessive
   C. Dominant X-linked
   D. Recessive X-linked
   E. Y-linked
2. Pedigree analysis is the method of medical genetics used for
   A. Studying of gene frequency in population
   B. Detection of the pattern of inheritance of the character
   C. Diagnosis of chromosomal disorders
   D. Detection of the role of genetics and environment in manifestation of the character
   E. Diagnosis of inborn error of metabolism
3. A person whose pedigree is composed is termed as
   A. Proband (propsitus)
   B. Sibling
   C. Patient
   D. Donor
   E. Recipient
4. Sibling is
   A. Person whose pedigree is composed
   B. Brother or sister of the proband
   C. Parent of the proband
   D. Child of the proband
   E. Affected individual
5. Autosomal dominant pattern of inheritance is characterized by following feature
   A. Vertical inheritance of the character
   B. Both men and women are affected
   C. At least one of the parents of affected child is affected
   D. There is a 50% risk to have affected child if one of the parents is affected and homozygous and another one is healthy
   E. All of the above
6. Autosomal recessive pattern of inheritance is characterized by
   A. Small number of affected individuals
   B. Horizontal transmission of the disease
   C. Healthy parents of affected child are heterozygous carriers of the mutant gene
   D. Chance to have a healthy child for heterozygous couple is 75%.
   E. All of the above
7. Analysis of the pedigree of the family with hypertrichosis of auricles showed that character in all generations is transmitted from father to all of the sons. Pattern of inheritance of this character is
   A. Y-linked
   B. Autosomal recessive
   C. Autosomal dominant
   D. X-linked recessive
   E. X-linked dominant
8. Pedigree of the family demonstrates the affected individuals of both sexes in each generation. It is typical for following pattern of inheritance
   A. Y-linked
   B. Autosomal recessive
   C. Autosomal dominant
   D. X-linked recessive
   E.X-linked dominant
9. Yong healthy couple has two children with Tey-Sacks disease (storage disorder with accumulation of lipids). It was cleared that parents are consanguineous. What is the most possible pattern of inheritance of the disease?
   A. Y-linked
   B. Autosomal recessive
   C. Autosomal dominant
   D. X-linked recessive
   E. X-linked dominant
10. A healthy couple has came for medical genetic counseling as they are cousins. What type of single gene disorder is most possible to manifest in their children?
   A. Y-linked
   B. Autosomal recessive
   C. Autosomal dominant
   D. X-linked recessive
   E. X-linked dominant
11. Healthy woman has affected sons with same hereditary disorder in her two marriages. Both of her husbands are healthy. What is the most possible patterrn of inheritance of the disease?
   A. Y-linked
   B. Autosomal recessive
   C. Autosomal dominant
   D. X-linked recessive
   E. X-linked dominant
12. Pedigree of the family with brachidactyly is characterized by following: ratio between affected males and females is 1:1; chance to have an affected child is 50% if one of the parents is affected heterozygote. What is the pattern of inheritance of this character?
   A. Y-linked
   B. Autosomal recessive
   C. Autosomal dominant
   D. X-linked recessive
   E. X-linked dominant
13. Healthy woman is the carrier of color blindness. Her husband is healthy. What is the risk to have an affected child in this family?
   A. 0%
   B. 25% of all children
   C. 50% of the sons
   D. 50% of all children
   E. 75% of all children
14. Pedigree of the several families with deafness is characterized by following features: parents of the affected children are healthy; both sexes are equally affected; ratio between healthy and affected children in families is about 3:1. What is the pattern of inheritance of

this disease?

A. Y-linked
B. Autosomal recessive
C. Autosomal dominant
D. X-linked recessive
E. X-linked dominant

15. Family is characterized by hereditary deafness transmitted in generations. Which method helps to detect the pattern of inheritance of the disease?

A. Genealogic
B. Twins method
C. Cytogenetic
D. Population statistic
E. Biochemical

16. Twins method of human genetics is the method of

A. Diagnosis of chromosomal disorders
B. Diagnosis of inborn errors of metabolism
C. Detection of the pattern of inheritance
D. Detection of the influence of genotype and environment on the character
E. Calculation of genes frequency in population

17. Monozygotic twins are those who

A. Develop from different fertilized ova
B. Have same genotype
C. Are of the same or different sex
D. Share 50% of genes
E. All of the above

18. Dizygotic twins are those who

A. Develop from two fertilized ova
B. Have different genotypes
C. Are of the same or different sex
D. Share 50% of genes
E. All of the above

19. If H(coefficient of heredity) is 100% character

A. Equally depend on the genotype and environment
B. Depend on genotype only
C. Depend on environment only
D. Depend on the environment but influenced by genotype
E. Depend on genotype but influenced by environment

20. If H (coefficient of heredity) is 0 % character

A. Equally depend on the genotype and environment
B. Depend on genotype only
C. Depend on environment only
D. Depend on the environment but influenced by genotype
E. Depend on genotype but influenced by environment

21. If H (coefficient of heredity) is 55 % character

A. Equally depend on the genotype and environment
B. Depend on genotype only
C. Depend on environment only
D. Depend on the environment but influenced by genotype
E. Depend on genotype but influenced by environment

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Cytogenetic method of human genetics. Chromosomal disorders.

Practical class 17. Cytogenetic method of human genetics. Chromosomal disorders.

The Purpose of the Lesson. To study classification of hereditary disorders in humans. To study the main stages of karyotyping and clinical indications for karyotyping. To analysis the karyotypes of patients with chromosomal disorders. Detection of X and Y-chromatin as method of diagnosis of chromosomal disorders.

TOPIC CONTENT

1. Classification of cytogenetic methods. Its clinical importance.
2. Karyotyping method, its sense and technique.
3. The nature and mechanism of X- chromatin formation. Hypothesis of M.Layon.
4. Amniocentesis, indications, its terms and techniques, possible complications.
5. Main chromosomal disorders of human, their cytogenetic diagnostic.

TEST QUESTIONS FOR INDIVIDUAL WORK

№	Questions	Answers
1	Which methods belong to the cytogenetic?	**a** **b** **c**
2	Centromeric index is relation of a length of _____ arm to the length of _____	
3	For chromosomes indication the following methods are used:	Quantitative morphmetric analysis: **a** Measuring of _____ of chromosomes **b** Accounting of _____ index **c** The method of _____ chromosome
4	What are the indications for cytogenetic analysis	**a** **b** **c**
5	Which mutations can be determined by karyotyping?	**a** **b**
6	Sex chromatin is _____	
7	Which chromosome disorders are determined by studying of:	
	X-sex chromatin	**a** **b** **c**
	Y-sex chromatin	**a**
8	Which cytogenetic methods are used for prenatal (before delivery) diagnostic of chromosome disorders?	**a** **b**
9	Give the examples of disorders with abnormal number of	
	autosomes –	**a** **b** **c** **d**
	heterosomes	**a** **b**

		c
10	Which material of an embryo is taken during:	**a** Amniocentesis: **b** Choriocentesis: **c** Cordocentesis:
11	Which types of mutations causes the main forms of Down syndrome?	**a** **b**

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 212-219.

Cytogenetic method is a method of karyotype studying. **Karyotype** is set of the chromosomes of somatic cells. It characterized by number, shape and size of the chromosomes.

Cytogenetic method permits to detect number and structure of chromosome. It it used for diagnosis of chromosomal diseases.

The method includes

- **karyotyping**
- **detection of sex chromatin (Barr bodies).**

KARYOTYPING

Karyotyping is based on the examination of karyotype of somatic cell. It is studied in leukocytes of blood.

Karyotyping is method of diagnosis of chromosomal diseases. Chromosomal diseases are diseases caused by abnormal number or structure of the chromosomes.

Examples of chromosomal diseases:

Down's disease - Trisomy 21 (47, XX + 21 or 47, XY +21)
Patau's disease - Trisomy 13 (47, XX +13 or 47, XY +13)
Edward's disease - Trisomy 18 (47, XX+18 or 47, XY+18)
"Cat cry syndrome" (46, $5p^-$ - deletion of short arm of 5^{th} chromosome)

Klinefelter's syndrome (47, XXY; 48, XXXY; 49, XXXXY).
XYY syndrome or supermale syndrome (**47, XYY**).
XXX syndrome or superfemale syndrome (47, XXX).
Turner's syndrome (45, X0).

DETECTION OF SEX CHROMATIN

S**ex chromatin (Barr body) is an inactive X chromosome in females.**

In females (XX) one X chromosome is active and another one is inactive. Inactive X chromosome looks like small dark particle in the nucleus. It can be studied in the mucous cells of the oral cavity (dark particle attached to the nuclear membrane) or leukocytes **(drumstick projection of the nucleus). Normal woman has 1 Barr body.**

In man (XY) both sex chromosomes are active, **so normal man has no Barr bodies.**

The studying of sex chromatin is used for:
Diagnosis of chromosomal disorders with abnormal number of X-chromosomes. The number of Barr bodies is always 1 less than the number of X-chromosomes.

The number of X chromosomes = (n Barr bodies + 1)

Number of	**Sex**	**Number of Barr bodies**

sex chromosomes		
XY	**Male**	**-**
XX	**Female**	**1**
XO	**Female(Turner syndrom)**	**-**
XYY	**Male(supermale syndrom)**	**-**
XXY	**Male(Kleinfelter syndrom)**	**1**
XXX	**Female (superfemale syndrom)**	**2**
XXXY	**Male(Kleinfelter syndrom)**	**2**

Genes of **Y chromosome** are not subjected to the dosage compensation. A large portion of **Y chromosome is heterochromatic** and is a strongly **fluorescent** body, which is called **Y-chromatin**. To demonstrate it **during the interphase a fluorescence method** is used. The number of Y-chromatin bodies is equal to the number of Y chromosomes.

PRACTICAL WORK.Cytogenetic method. Chromosomal disorders.

Task 1. Study the rules of description of normal and abnormal human karyotype.

1. Point out a total number of chromosomes.

For example: 46; 47.

2. Then after coma point out sex chromosomes.

For example: 46,XX; 47,XXY.

3. Ordinal number of excessive chromosome is written after sex chromosomes with "+".

For example: 47,XY, + 21

4. In case of mosaicism both chromosomal set are written, divided by symbol "/". Normal diploid karyotype is written at the end.

For example: 47,XX,+18/46,XX

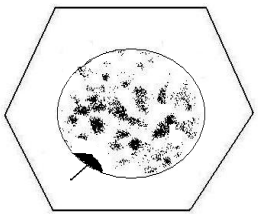
5. In case of structural chromosomal aberrations short arm is marked as *p* and long one as *q*. Type of aberration is written down after the number of chromosomes.

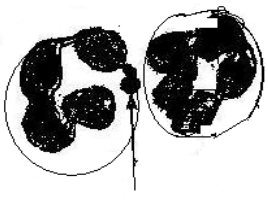
For example: -deletion: 46,XX,5p); 46,XY,5p- or 46,XX,del(5p); 46,XY,del(5p).

- duplication: 46,XX,13q+; 46,XY,13q+ or 46,XX,dup(13q); 46,XY,dup(13q).

Task 2. A) Study the epitheliocytes of buccal mucosa under the high magnification. Find a small body of sex chromatin on an inner nuclear membrane.

B) Study a blood smear under the high magnification. Find "drum sticks" in neutrophiil leukocytes.



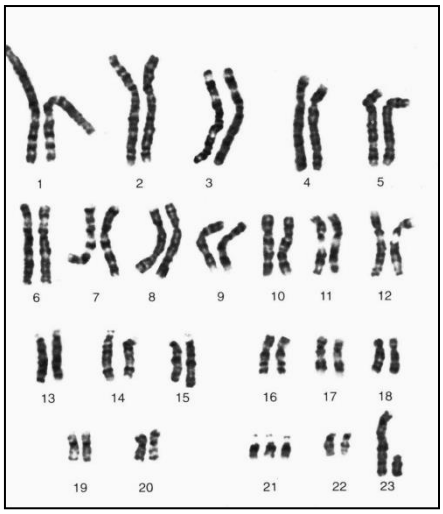


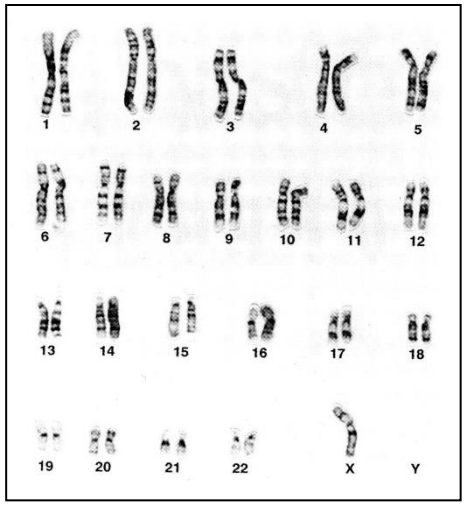
TASK 4. Analyze photokaryogrammes of healthy people and patients with different chromosomal disorders. Write down cytogenetic methods for diagnostic of these disorders.

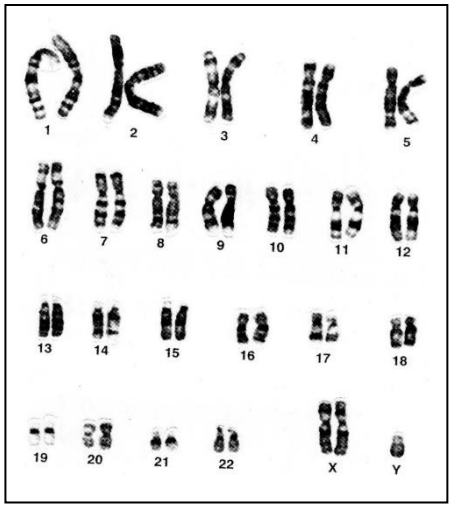
syndrome	*Type of mutation*	*Method of diagnostic*		*Result of examination*	
		karyotyping	*Sex chromatin detection*	*Probable karyotypes*	*Number of Barr bodies in nuclei*
Healthy woman	–				

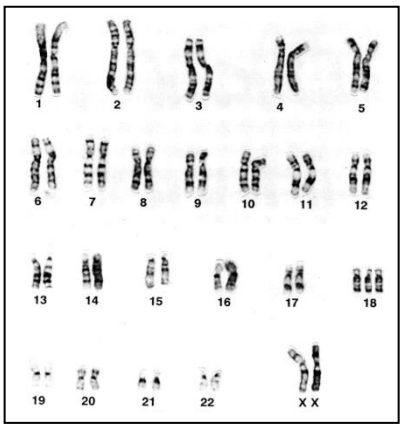
Healthy man	–				
Disorders of autosomes					
Patau syndrome					
Edwards syndrome					
Down syndrome					
Cri du chat" syndrome					
Disorders of heterosomes					
Shereshevsky-Turner syndrome					
"superfemale" syndrome (polysomy X)					
Klinefelter syndrome					
"super male" syndrome (polysomyY)					

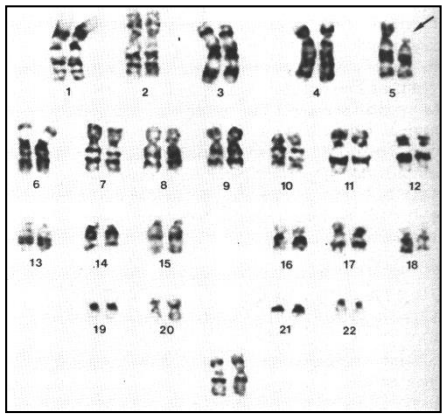
TASK 5. Detect different chromosomal disorders by analyzing karyograms.

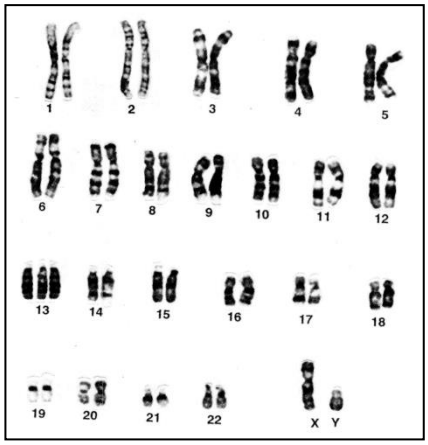


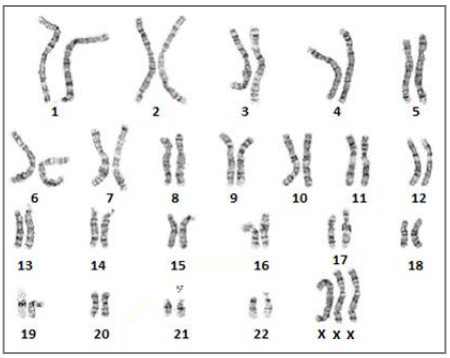


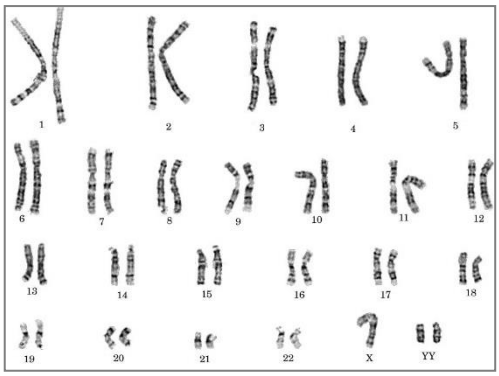


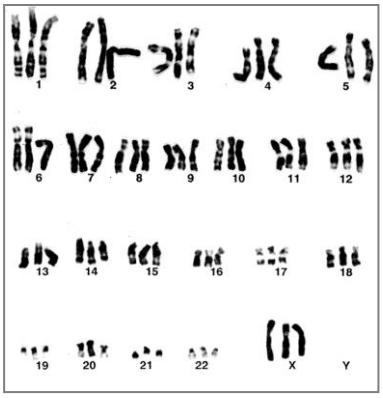












Task 6. Study a table of chromosomal disorders. Write down the karyotypes and main phenotypical characters according to your text-book.

Syndromes	Karyotype	Frequency	Phenotype characters
Down syndrome		~ 1:700	
Edwards syndrome		~ 1:6000	
Patau syndrome		~ 1:7000	
“Cri du chat” syndrome		~ 1:50,000	
Shereshevsky-Turner syndrome		~ 1:3000 (♀)	
“super female” syndrome		~1:1100 (♀)	
Klinefelter syndrome		~ 1:1000 (♂)	
“super male” syndrome		~ 1:1000 (♂)	

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1.What karyotype abnormality have persons with Shereshevsky-Turner syndrome?

A.Absence of one X chromosome
B.Absence of one 2 Ist chromosome
C.Absence of one 15st chromsome
D.Extra 21st chromosome
E.Extra 18st chromosome

2. Parents are healthy. Amniocentesis with further karyotyping showed that fetal karyotype is 47,XX, +21. What chromosomal disease has the fetus?

A. Shereshevsky-Turner's syndrome
B. Edward's syndrome
C. Down's syndrome
D. Cat cry syndrome
E Superfemale syndrome

3. Parents are healthy. Amniocentesis with farther karyotyping showed that fetal karyotype is 45, XO. What chromosomal disease has the fetus?

A. Shereshevsky-Turner's syndrome
B.Edward's syndrome
C.Down's syndrome
D. "Cri de chat" syndrome
E. "Superfemale" syndrome

4. Karyotype of the tall young man with behavioral problems is 47, XYY. Diagnosis is

A. "Supermale" syndrome
B.Patau's syndrome
C.Klinefelter's syndrome
D. Shereshevsky-Turner's syndrome
E.Edward's syndrome

5. Diagnosis of Shereshevsky Turner's syndrome is made by

A. Twins method
B. Pedigree analysis
C. Population statistic method
D. Biochemical method
E. Cytogenetic method

6.In the epithelial cells of the male patient are two Barr bodies. It indicates the following syndrome

A. Shereshevsky-Turner syndrome
B.Klinefelter's syndrome
C.Patau's syndrome
D. Superfemale" syndrome
E.Supermale" syndrome

7.Which chromosomal disease in males is characterized by one drumstick in the nucleus of the neutrophile leukocytes?

A. Shereshevsky-Turner's syndrome
B.Down's syndrome
C.Klinefelter's syndrome
D. Superfemale" syndrome
E. "Supermale" syndrome

8.By detection of Barr bodies is possible to diagnose

A. Patau's syndrome
B."Cri de chat" syndrome
C.Shereshevsky-Turner's syndrome
D. Edward's syndrome
F. Down's syndrome

9. Which of the following is the result of abnormal number of autosomes?

A. Klinefelter's syndrome
B. Down's syndrome
C. "Superfemale" syndrome
D. Shereshevsky-Turner's syndrome
E. Hemophilia

10. Forensic expert has made a conclusion that the blood spots at the place of crime belong to the woman. Which blood component has been studied?

A. Blood plasma
B. Blood serum
C. Platelets
D.RBC
E. Leukocytes

11. The karyotype of patient with Down's syndrome is

A.47,+13
B.47,+18
C.47,+21
D. 47, XXX
E.47,XXY

12. Chromosomal disease because of abnormal sex chromosome number in females is

A. Shereshevsky-Turner's syndrome
B.Edward's syndrome
C.Patau's syndrome
D.Klinefelter's syndrome
E.Down's syndrome

13. Chromosomal disease because of abnormal sex chromosome number in males is

A. Shereshevsky-Turner's syndrome
B. Edward's syndrome
C. Patau's syndrome
D. Klinefelter's syndrome
E. Down's syndrome

14. Person with 47, XXY karyotype has

A. Shereshevsky-Turner's syndrome
B.Edward's syndrome
C.Patau's syndrome
D. Klinefelter's syndrome
E. Down's syndrome

15. Person with 45, XO karyotype has

A. Shereshevsky-Turner's syndrome
B.Edward's syndrome
C.Patau's syndrome
D.Klinefelter's syndrome
E.Down's syndrome

16. Diagnosis of Edward's syndrome is made by

A.Twins method

B.Pedigree analysis
C.Population statistic method
D.Biochemical method
E.Cytogenetic method

17. Diagnosis of hemophilia, phenylketonuria, diabetes mellitus is made by
A. Twins method
B.Pedigree analysis
C.Population statistic method
D.Biochemical method
E.Cytogenetic method

18. What is the set of X chromosome if there are two Barr bodies in the cell
A.XXX
B.XX
C. XO
D.XXXX
E. XY

19. How many Barr bodies are in the cell of the patient with Shereshevsky-Turner's syndrome?
A.0
B.1
C. 2
D.3
E. 4

20. How many Barr bodies are in the cell of the patient with Klinefelter's (XXY) syndrome?
A.0
B.1
C.2
D.3
E.4

21. How many Barr bodies are in the cell of the patient with "superfemale" syndrome?
A.0
B.1
C.2
D.3
E.4

22. How many Barr bodies are in the cell of the patient with "supermale" syndrome?
A.0
B.1
C.2
D.3
E.4

23. How many X chromosomes has woman if there is one drumstick in her leukocytes.
A.XX
B.XXX
C.XY
D.XXY
E.XO

24. Woman has short stature, webbing of neck, underdeveloped secondary sex characters and infertility. What is the suspected diagnosis?
A.Shereshevsky-Turner's syndrome
B.Edward's syndrome
C."Superfemale" syndrome
D.Klinefelter's syndrome
E.Down's syndrome

25. A person with chromosomal disorder has balanced translocation of long arm of 21st chromosome to 22. What disease is of high risk in his children?
A.Shereshevsky-Turner's syndrome
B.Edward's syndrome
C.Patau's syndrome
D.Klinefelter's syndrome
E.Down's syndrome

26. Man with high stature has three bodies of Y chromatin in the nucleus. What syndrome he has?
A.Shereshevsky-Turner's syndrome
B."Superfemale" syndrome
C."Supermale" syndrome
D.Klinefelter's syndrome
E.Down's syndrome

27. Detection of X-chromatin in somatic cells is used for the quick diagnosis of hereditary diseases associated with a change in the sex chromosome number. Vast majority of a man's cells have three X-chromatin bodies. What is the man's karyotype?
A. 46, XY
B. 48, XXXY
C. 47, XXY
D. 49, XXXXY
E. 45, X

28. A child presents with body shortness, mental deficiency, mongoloid palpebral fissures, epicanthal fold, enlarged grooved tongue protruding from the mouth, high palate, maldentition, diastema, cross striation of lips. What hereditary disease are this presentation typical for?
A. Patau's syndrome
B. Turner's syndrome
C. Klinefelter's syndrome
D. Edward's syndrome
E. Down's syndrome

29. An18-year-old boy applied to a geneticist. The boy has asthenic constitution: narrow shoulders, broad pelvis, nearly hairless face. Evident mental deficiency. The provisional diagnosis was Klinefelter's syndrome. What method of clinical genetics will enable the doctor to confirm this diagnosis?
A. Genealogical
B. Populational-statstic
C. Dermatoglyphics
D. Twin study
E. Cytogenetic

30. According to the phenotypic diagnosis a female patient has been provisionally diagnosed with X-chromosome polysomia. This diagnosis can be confirmed by a cytogenetic method. What karyotype will allow to confirm the diagnosis?
A. 47, XXX
B. 48, XXXY
C. 46, XX
D. 47, XXY
E. 48 XXYY

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Biochemical method. DNA-diagnostics. Population-statistics of human genetics. Single gene disorders. Medical-genetic counseling.

Practical class 18. Biochemical method. DNA-diagnostics. Population-statistics of human genetics. Single gene disorders. Medical-genetic counseling.

The Purpose of the Lesson. To study human heredity disease concept, its classification. Principles of diagnosis of the heredity pathology. Gene (molecular) diseases, mechanisms of its development and principles of laboratory diagnosis. Gene engineering. Biotechnology. Gene therapy. Population-statistic method. Low of constancy of genetic structure of the population. To practice in usage of Hardy-Wineberg's low for studying of the genetic structure of the population..

TOPIC CONTENT

1. Characteristics of monitoring and screening diagnostic programs.
2. Main methods of molecular-genetic (DNA) diagnosis.
3. Practical application of population-statistic method.
4. Characteristics of ideal and real populations, deme, isolate.
5. Genetic structure of human population.
6. Hardy-Weinberg's law.
7. Application of Hardy Weinberg's law in medicine
8. Medical-genetic counseling. Tasks, indications, types, stages.

TEST QUESTIONS FOR INDIVIDUAL WORK

№	Questions	Answers	
1	Biochemical method is applicable in diagnosis of_____ disorders caused by _____ mutations.		
2	Which disorders are termed as monogenic (single gene disorders)? _____		
3	Failure on metabolism of which substances may cause the single gene disorders?	**a**	**c**
		b	**d**
		e	
4	What are the stages of biochemical diagnosis of single gene disorders?	**a**	
		b	
5	Give the example of express diagnosis of single gene disorder.	**a**	
		b	
6	Polymerase chain reaction (PCR) is _____ _____		
7	Which cells are used for PCR	**a**	
	b	**c**	
8	What is the application of PCR in practical medicine?		
	a) in adults	**a**	
		b	
		c	
	b) in prenatal diagnosis	**a**	
9	Which method is applicable for studying of relationship? _____		

10	What is the importance of population-statistic method in medicine? _____		
11	Hardy- Weinberg's law is the law of _____.		
12	Formulate the Hardy-Weinberg's law. _____ _____ _____		
13	Dominant genes in population don't n displace the recessive ones because _____ _____		
14	Give the characteristics of ideal population: **a**		**b**
	c		**d**
	e		**f**
15	Name the types of human populations according to number of individuals: **a**		**b**
	c		
16	What is the number of:	-individuals	-frequency of consanguineous marriages
	a ideal population		
	b natural population		
	c deme		
	d isolate		
17	Why it is possible to use Hardy-Weinberg' s law applicable for ideal population in medicine?		**a**
			b

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 229-234.

Biochemical method

Biochemical method is used for detection of inborn errors of metabolism.
These are single gene disorders caused by absence of enzymes.

examples are phenylketonuria (amino acid disorders), galactosemia (defect of carbohydrate metabolism)

Diagnosis of inborn errors of metabolism is based on studying of enzyme activity or metabolic products in urine, sweat, blood plasma, culture of the cells.

The total biochemical examination of all newborns with the aim of early diagnosis of the inborn errors of metabolism is mass screening of the newborns.
Mass screening is used for early treatment and can prevent the clinical manifestations of the disease. For example in Ukraine phenylketonuria, congenital hypothyrosis are screened.

DNA analysis

DNA diagnosis is based on studying of the genes(DNA molecule). It is for

- diagnosis of single gene disorders;
- diagnosis of infectious disorders (identification of DNA of the agent);
- DNA fingerprints in forensic science (paternity dispute cases);
- cancer research and detection;
- archeology, paleontology and evolution.

Technologies for DNA diagnosis are:

- Nucleic acid probes are single strand small DNA or RNA segments, can be

obtained from genomic DNA or synthetic oligonucleotides.

– Polymerase chain reaction (PCR) is making million copies of short specific DNA sequence for further analysis. It copies process of DNA replication.

Population genetics is studying of alleles of genes in populations

Population statistic method is based on studying frequency of pathologic genes (dominant or recessive) and genotypes (homo- and heterozygous) in population,

it is very important for the prophylaxis of hereditary diseases.

Population is a group of individuals of one species who inhabits a certain territory for a long period of time and exhibits random mating.

Human population is the group of people inhabiting certain territory and marrying each other(city population, country population, community population)

Natural population is composed of many individuals, each with unique combination of genes, but population shares a gene pool.

The frequency of dominant and recessive genes is called genetic structure of the population.

Small populations (up to 1500 persons) are isolates. The frequency of consanguineous marriages is high in isolates (over 90%). It leads to the increase of proportion of homozygous individuals and accumulation of dominant or recessive genes.

Local inbreeding population of 1500 to 4000 persons is deme. The consanguineous marriages in deme is lower - up to 80-90%.

Hardy and Weinbergs' law describes genetic processes in large populations. "gene frequencies in a population remain constant from generation to generation, if no evolutionary factors such as migration, mutation, selection and drift are operating"(algebraic formula to calculate expected gene and genotype frequencies in population)

It is a law for an ideal population without an influence of evolutionary factors changing gene frequencies.

An ideal population is a mathematical model of any population. The features of an ideal population are :

- Numerous members;
- Panmixia, or random mating;
- Absence of natural selection;
- Absence of migrations;
- Absence of mutations;

In ideal population with equal frequencies of dominant (A) and recessive (a) genes,

A + a = 100% = 1; A frequency = a frequency = 0.5.

Crossing of the individuals with Aa genotypes gives the following results:

P	♀Aa	x	♂ Aa
G	A, a		A, a
F_1	AA, Aa, Aa, aa		

Frequency of F_1 genotypes is:

$(0.5A + 0.5a) \times (0.5A + 0.5a) = 0.25AA + 0.5Aa + 0.25\ aa = (0.5A+0.5a)^2$

frequency of the dominant gene A = p

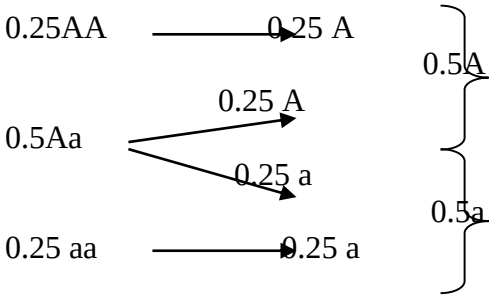
frequency of the recessive gene a = q,

we have got mathematical expression of Hardy-Weinberg's law

♂/ ♀	(p)A	(q)a
(p) A	p^2 AA	pq Aa
(q) a	pq Aa	q^2 aa

$$(p+q)^2 = p^2 + 2pq + q^2 = 1(100\%)$$

Using the **formula of Newton's binom**



So, F_2 frequency of gene A =0.5, A= a, a=0.5

The **practical purposes of Hardy –Weinberg's law are:**

- genetic structure of the population;
- Calculation of heterozygous organisms frequency
- to define quantity of alleles controlling the character.
- intensity of mutation processes;
- Ito determine the relation links between populations.

Exchange of genes between population is termed as gene flow;

- Assortative mating. If individuals choose mates with similar genotypes to themselves they will produce an excess of homozygotes;

- Subpopulations within the sample will increase the frequency of homozygotes. For example, the frequency of rare homozygotes is considerably increased by assortative mating with relatives.

Medical genetic counseling

It is important that the patient and his relatives should be informed about the correct diagnosis of the disease; steps:

- Family history.
- Examination of patient
- Laboratory investigations(biochemical investigation, chromosomal analysis and DNA studies)

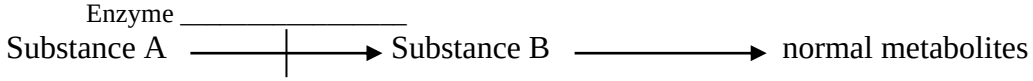
Proper **diagnosis** permits to **recognize the mode of inheritance of disorder for calculation of genetic risk.**

Prenatal diagnosis is important for the couples with high risk of having a child with genetic disorder. Prenatal diagnosis is used for detection of abnormalities in a child (fetus) before birth, techniques for **prenatal diagnosis** are **ultrasonography and amniocentesis.**

PRACTICAL WORK.

Biochemical method. DNA analysis. Population-statistic method.

Task 1. Study the scheme of pathogenesis and principle of biochemical diagnosis of enzymopathia, taking **phenylketonuria** as an example.



_____ _____ _____
_____
_____

↓

abnormal metabolites

_____

General principles of biochemical diagnosis of inborn errors of metabolism:
1. _____
2. _____
3. _____
4. _____

Task 2. Analyze information about some single gene disorders. Complete the table.

Disease	Frequency in population	Mode of inheritance	Phenotypic manifestation	Group of the disorders	Biochemical diagnosis
Phenylketonuria	1:7000(aa) 1:40 (Aa)	Autosomal-recessive	"mousy odor", depigmentation of skin, hair and cornea, mental retardation.		
Sickle cell anemia	1: 600 (aa)	Autosomal-recessive	Hemolytic anemia		
Galactosaemia	1:3500(aa) 1:100(Aa)	Autosomal-recessive	Delayed psychomotor development, hepatomegaly, jaundice, cataract.		
Cystic fibrosis	1:1600(aa) 1:20 (Aa)	Autosomal-recessive	Recurrent pneumonitis, malnutrition		

Task 3 Study the stages of biochemical diagnosis of single gene disorders.

I step – SELECTIVE screening	
Aim	
Methods	
Biological samples	
Example	
II step – precise diagnosis	
Aim	
Methods	
Example	

Mass screening

Aim	
Methods	
Example	

Task 4. Analyze genetic and mathematic models of Hardy-Weinberg law.

In population frequency of dominant and recessive gene is same in males and females and equals 0.5 (50%).What is the frequency of genes and genotypes in next generation?

♂/ ♀	A (0.5)	a (0.5)
A(0.5)		
a (0.5)		

In sum _____ + _____ + _____ = _____

F_2 generation will produce gametes

____AA → _____ A } totally _____
_____ A

____ Aa → _____a } totally _____

_____aa → _____a

Conclusion: In F_2 generation frequancy of genes _____

♂/ ♀	(p)A	(q)a
(p) A		
(q) a		

Task 5. Solve the problems.

5.1 There are 16% of Rh-negative individuals in population. Determine the frequency of genes and structure of the population.

5.2 Cystic fibrosis is the recessive metabolic disorder. What is the frequency of heterozygous carriers in Odessa if the frequency of affected individuals is 1/1600?

5.3 In population of the city among 4200 persons, 1218 persons have M antigen, 882 have N antigen and 2100 persons have both antigens. What is the frequency of the genes M and N in population?

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Genetic structure of population can be studied by
A. Genealogic method
B. Twins method
C. Cytogenetic method
D. Biochemical method
E. Population statistic method

2. Ideal population is characterized by
A. Unlimited number of individuals
B. Random mating (panmixia)
C. Absence of mutations and migrations
D. Constant ratio between AA, Aa and aa genotypes
E. All of the above

3. Real geographical population is characterized by
A. Certain number of the individuals
B. Migrations
C. Mutations
D. Assortative mating
E. All of the above

4. Small population (1500 - 4000 individuals) with frequency of consanguineous marriages about 80% - 90% is
A. Deme
B. Isolate
C. Pure line
D. Ideal population
E. Biogeocenosis

5. Human population less then 1500 individuals and high frequency of consanguineous marriage (90% or more) is
A. Deme
B. Isolate
C. Pure line
D. Ideal population
E. Biocenosis

6. Gene drift is characterized by
A. Homozygocity of the population
B. High frequency of one of the alleles in population
C. Low frequency of one of the alleles in population
D. All of the above

7. Genetic structure of the population is changed by following factors
A. Assortative mating
B. Migration
C. Isolation
D. Genetic drift
E. All of the above

8. Frequency of genotypes AA, Aa and aa stay constant in ideal population. This is a low of
A. Tijo and Levan
B. Watson and Crick
C. Hardy and Weinberg
D. 3acoband Monod
E. Shwann and Shleiden

9. Set of the genes hi population is
A. Genotype
B. Genome
C. Gene pool
D. Gene drift
E. Gene flow

10. In human population 84% persons are Rh-f. What will be the frequency of this character hi next generation?
A. 100%
B. 84%
C. 42%
D. 24%
E. 16%

11. Frequency of persons with blue eyes (**aa**) in population is 4% (0.04). What is the frequency of gene **a** in population
A. 0.04
B. 0.2
C. 0.4
D. 0.6
E. 0.8

12. Frequency of gene A is 0.6; frequency of gene a is 0.4. What is the frequency of Aa genotype in this population?
A. 0.6
B. 0.4
C. 0.24
D. 0.48
E. 0.64

13. Biochemical diagnosis is applicable for diagnosis of
A. Down syndrome
B. Phenylketonuria

C. Patau syndrome
D.Klinefelter syndrome
E. Edwards syndrome
14. DNA diagnosis is applicable for
A. diagnosis of single gene disorders;
B. diagnosis of infectious disorders
C. paternity dispute cases;
D. cancer detection;
E. All of the above.
15. Method of DNA diagnosis is
A. Karyotyping
B. Identification of Barr bodies
C. Polymerase chain reaction
D. Measuring of enzyme activity
E. Calculation of gene frequency in population.
16. Polymerase chain reaction includes
A. DNA denaturation
B. Primer annealing
C. Extension of DNA
D. All of the above

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Final practical lesson from content modules 1-4

Practical class 20. Protozoa. Sarcodina. Dysentery amoeba and other amoeba species. Infusoria. Balantidium.

The Purpose of the Lesson. To study morphology, life cycles and pathogenic action of parasitic amoebae and infusorians. To study out the methods of laboratory diagnosis and prevention of the intestinal diseases caused by these parasites.

TOPIC CONTENT

1. General characteristics of Protozoa.
2. General characteristic of Sarcodina. Free-living and parasitic amoebae.
3. Ways of infection with dysenteric amoeba. Location of dysenteric amoeba, its pathogenic action.
4. Laboratory diagnosis and prevention of amoebiasis.
5. Morphology of balantidium, its pathogenic action
6. Laboratory diagnosis and prevention of balantidiasis.

TEST QUESTIONS for individual work

№	Questions	Answers
1	Invasion is …	
2	Invasive stage is….	
3	Parasite is …	
4	Definitive host is…	
5	Intermediate host is …	
6	Reservoir host is …	
7	What are the main ways of transmission of parasitic diseases?	**a**
		b
		c
		d
8	What is vector-born (transmissive) disease?	

9	Specific(biological) vector is …	
10	Mechanical vector is…	
11	Natural-focus diseases are …	
12	The main components of natural focus are:	**a** **b** **c** **d**
13	List the main characteristics of ***Sarcodina*** species	**a** **b** **c** **d**
14	Give the main characteristic of dysentery amoeba	
	-Latin name	
	-name of the disease	
	-forms of existence	**a** **b** **c**
	-location in human organism	
	-invasive stage	
	-the way of invasion	
	-mechanical vectors are	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
15	What is the difference between the cysts of dysenteric and intestinal amoebae?	
16	What is the medical importance of facultative-pathogenic species of amoeba?	**a)** Naegleria **b)** Acanthamoeba
17	List the main characteristics of ***Infusoria*** species	**a** **b** **c** **d**
18	Give the main characteristic of balantidium	

	-Latin name	
	-name of the disease	
	-location in humans	
	-invasive stage	
	-the way of invasion	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 239-250; 270; 273-274

Protozoa. Sarcodina. Dysentery amoeba and other amoeba species. Infusoria. Balantidium.

Phylum: Sarcomastigophora
Subphylum : Sarcodina
Class : Rhizopoda
Order : Amoebina
Species : Entamoeba histolytica
Ent. coli
Ent. gingivalis

Phylum : Ciliophora
Class : Ciliata
Species : Balantidium coli

Basic Theory.

Typical features of Sarcodina are:
- Inconstant shape of the body
- pseudopodia for locomotion and capturing of food .
- 1 nucleus.

Q. Asexual reproduction (binary fission).
R. Cyst formation - under unfavorable conditions.

Entamoeba histolytica is an agent of **amoebic dysentery** or **amoebiasis**.

Geographical distribution. It is worldwide, more common in tropical regions.

Location. Parasites inhabit the **large intestine of human**. Atypical location is the **liver, brain, lungs**

Morphology. E. histolytica occurs in 3 forms:

- **Magna form** or large vegetative stage is **pathogenic** form**;20 – 40 µm.**
- It is an **erythrophage**, so it has phagocytized erythrocytes in endoplasm, lives in the **wall of the large intestine**. It produces **proteolytic enzymes,** causes formation of the **ulcers** at the acute stage of amebiasis.
- **Minuta form** or small vegetative stage, in the lumen of the large intestine and feeds on bacteria . Its size is **15 – 20 µm.**,
- **Cystic form** or **cyst** is an **infective stage,** 10 -15 µm; **mature cysts possess 4 nuclei** . **Cysts are found in stool of the patients** in the recovering period or in healthy cyst carriers.

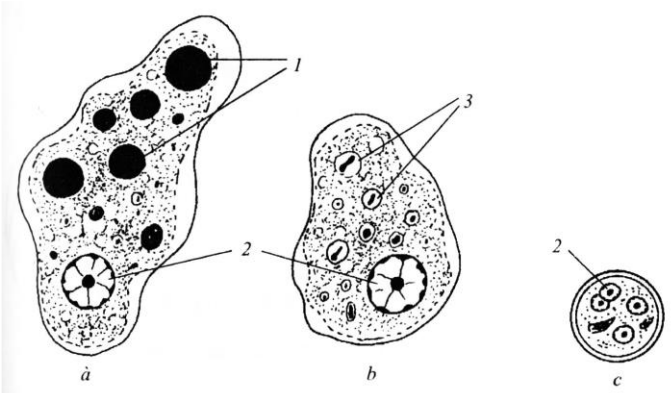


Fig. 53. Entamoeba histolytica: a — large vegetative stage; *b* — small vegetative stage; *c* — cyst stage; *1* — erytrocytes in endoplasm; *2* — nucleus; *3* — food vacuoles

Life cycle. Infection occurs by **ingestion of mature cyst** with **water or food**. In the lower part of the small intestine each nucleus of a cyst divides into two. It gives 8 **minuta forms**. They inhabit the **lumen of the large intestine**, feed on bacteria, leukocytes and are **non-pathogenic**. In the lower part of the large intestine they **turn into cysts** which are **excreted with stool** and preserved for a long time **in the soil.**

As **minuta form is nonpathogenic commensal**, a **person** with this form is a **healthy cyst carrier (asymptomatic cyst passer)**.

Under the influence of some predisposing factors (changing of intestinal microflora, dehydration, changing of pH, immunosuppression because of different factors) **minuta form turns into magna form**. It produces **proteolytic enzymes** and **causes abscesse**s, **ulcers.** Magna form can **penetrate into blood vessels** and with **blood reaches the liver, lungs, brain**.

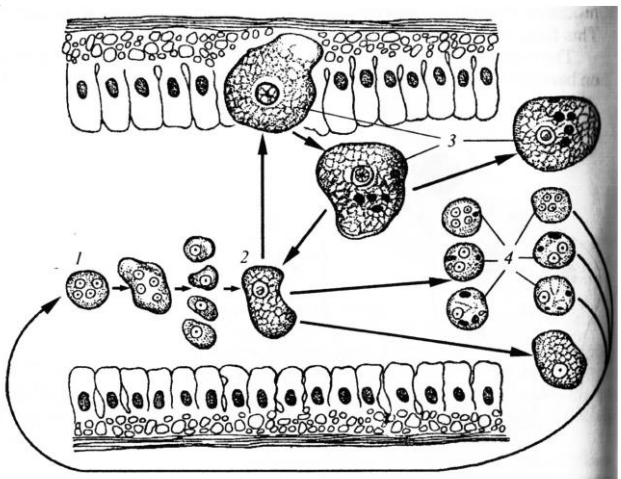


Fig. 54. Life cycle of *Entamoeba histolytica*: *1* — cyst stage in digestive tract; *2* — small vegetative stage; *3* — large vegetative stage; *4* — cyst stage in faeces

***Epidemiology*.** **Ameboiasis is an <u>anthroponosis.</u>** The **main source of** i**nfection is a healthy cyst carrier or a patient with chronic amebiasis in** the **period of remission**.

transmission is <u>fecal–oral</u>. <u>Food, water, fruit, vegetables, dirty hands</u> are transfer factors of the disease. <u>Flies and cockroaches</u> are mechanical carriers.

Pathogenicity.

If only minuta form is present infection is asymptomatic.

This clinically manifests as **<u>abdominal pain, nausea, vomiting, and diarrhea</u>**. **<u>Stool is usually loose and flecked with blood.</u> <u>Intestinal bleeding, peritonitis</u>**

Amoebic abscesses are in the liver, lungs, muscles.

***Diagnosis*.** demonstration of the **<u>magna form in stool</u>**. Microscopic examination of wet mounts.

Prophylaxis:

Personal prophylaxis is to keep the **rules of personal hygiene** (**to boil the water, wash vegetables, fruit, and hands before meals).**

Control of the disease :treatment of the patients and examination of close contacts.

Carriers should be removed from the food – handling occupations and treated properly.

Health education, hygiene of the environment and provision of safe water

Entamoeba coli is **nonpathogenic commensal of an intestinal** amoeba. It is world wide.

***Location*.** Lumen of the large intestine.

***Morphology*. Vegetative form is 20 – 40 μm**. **Cysts** are 15 - 35 μm **cyst has 8 nuclei.**

Modes of transmission are the same, as for E.histolytica.

Entamoeba gingivalis is **nonpathogenic commensal.**

***Location*.** In the **gingival pockets, in caries teeth.**

***Morphology*. Vegetative** form is 8 – 30 μm. **It does not form cysts.**

***Epidemiology*. Infection** occurs as a result of **using common spoons, forks, cups, by direct oral contact or through droplets of saliva.**

***Diagnosis*.** Examination of the wet mounts from dental deposit, gingival pockets.

Ciliates :

Typical features of Ciliates are:

- **Constant shape** of the body and presence of pellicle;
- Large number of locomotion organelles - **cilia on the whole body surface**;
- Organelles of the digestive system are oral groove (**peristome)** leading to the cell mouth (**cytostome**), c**ytopharynx, food vacuoles, cytopyge (anal pore or cytoproct);**
- 2 **contractile vacuoles** with 6 – 10 radial canals are organelles for **osmoregulation and excretion of liquid metabolic products.**
- **2** different **nuclei, macronucleus and micronucleus**. **Macronucleus** is polyploid, it controls all **metabolic activities,** growth, and asexual reproduction. **Micronucleus** is always diploid, provides storage of hereditary information and **sexual reproduction by conjugation**.
- Under unfavorable condition ciliates form **cysts**.

Balantidium coli is a causative agent of **balantidiasis.**

Geographical distribution. Worldwide

Location. Large intestine.

Morphology. The vegetative form is 30- 150 μm.**Cysts** are 40 -60 μm, contain visible micro- and macronucleus.

Life cycle: Humans become infected by **ingestion of the cyst** with contaminated **food or water** .

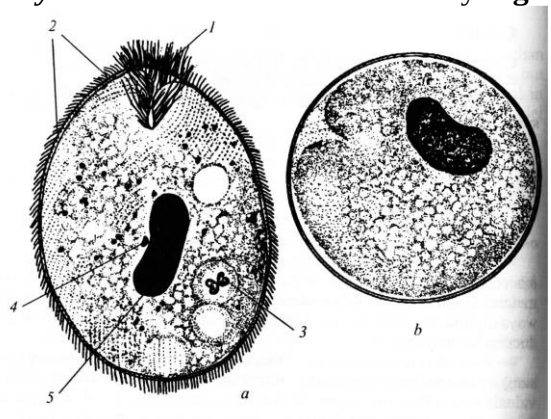


Fig. 55. Balantidium coli: a — vegetative form; *b* — cyst form; *1* — cell mouth; *2* — cilia; *3* — food vacuole; *4* — micronucleus; *5* — macronucleus

Epidemiology. **Natural hosts are pigs, man is incidental host**. B.coli has also been detected in dogs, monkeys and rats. The main source of infection is pig, rarely healthy cyst-carrier or patient with balantidiasis. **Mode of infection is fecal-oral. Flies and cockroaches may serve as mechanical carriers.**

Pathogenicity. **Infection is mostly asymptomatic**. if Balantidium starts to produce proteolytic enzymes, causing the **ulcers** on the mucous membrane of the **large intestine**.

Patients suffer from **abdominal ache, vomiting, loose stool with mucous** and **blood. Clinical manifestations resemble amoebic dysentery because of similar pathogenic effects.**

***Diagnosis*.** Demonstration of **throphozoits and cysts in stoo**l.

Prophylaxis. Personal prevention : rules of personal hygiene, especially at **pig farms.** Control of the disease is the same as for amoebiasis**.**

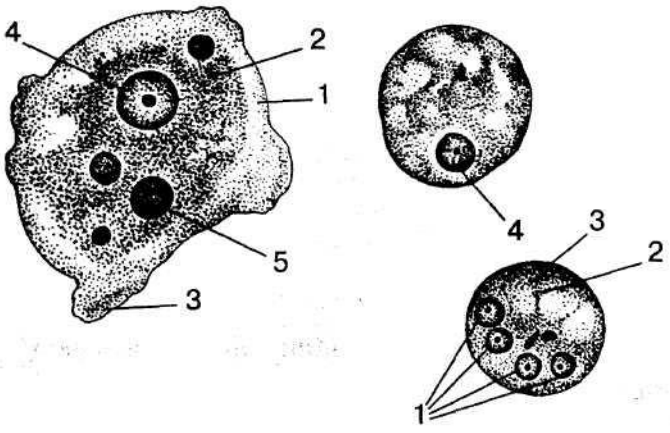
PRACTICAL WORK. Sarcodina. Dysenteric amoeba and other amoebae species. Infusoria. Balantidium.

1. Study the classification of Sarcodina and Infusoria. Write down Latin names of the parasites

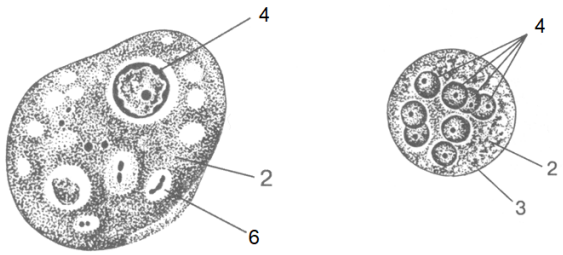
Kingdom *Zoa s.Animalia*
Subkingdom *Protozoa s. Monocytozoa*
Phylum *Sarcomastigophora*
Class *Sarcodina (Lobozea s. Rhosopoda)*
Genus *Entamoeba*
Species _____
_____
_____
_____

Phylum *Ciliophora*
Class *Ciliata*
Species _____

2. Study the trophozoites and cysts of dysenteric and intestinal amoebae. Define the species of the parasites.



A._____



B_____

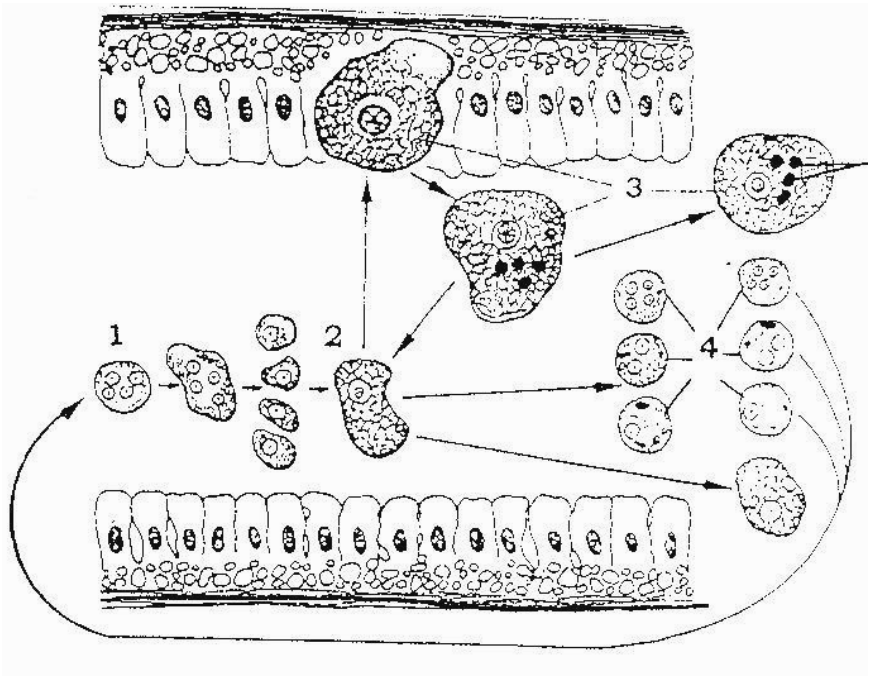
1-_____ 4-_____
2- _____ 5-_____
3-_____ 6-_____

3. Fill the table of diagnostic differences between different forms of dysenteric amoeba

	Entamoeba histolytica		
	Forma magna	Forma minuta	Forma cystica
Synonyms			

Size			
Number of nuclei			
Motility			
External covering			
Feeds on …			
Location in human intestine			
Production of proteases			
Invasive for human being			

4. Study a life cycle of ***Entamoeba histolytica***. Name the forms and processes.



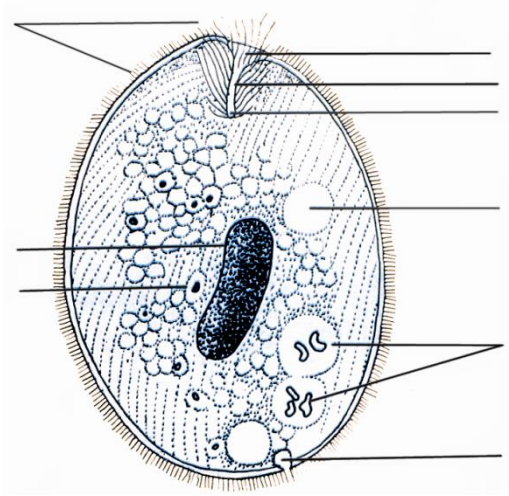
1 – _____

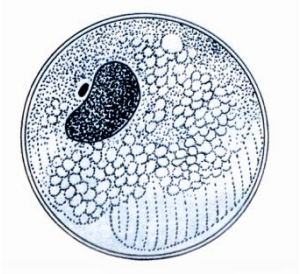
2 – _____

3 – _____

4 – _____

5. Study the trophozoite and cyst form of ***Balantidium coli***





Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. The following form of *Entamoeba histolytica*: is pathogenic
   - ***A*** Forma magna
   - ***B*** Forma minuta
   - ***C*** Cyst
   - ***D*** Spore
   - ***E*** Pre-cystic form

2. Forma minuta inhabits:
   - ***A*** Gall bladder
   - ***B*** D. Stomach
   - ***C*** Large intestine lumen
   - ***D*** Large intestine wall
   - ***E*** Small intestine

3. Which material is used for balantidiasis laboratory tests?
   - ***A*** Duodenum content
   - ***B*** Blood
   - ***C*** Feces
   - ***D*** Urine
   - ***E*** Vaginal discharges

4. *Entamoeba histolytica* is characterized morphologically by:

A Pear-shaped body, paired organelles, 4 pairs of flagella

B Spindle-shaped body, one flagella, undulating membrane

C Body shape is inconstant, 3 to 4 flagella

D D.Spindle-shaped body covered with pellicle, one nucleus

E Body shape is inconstant, covered with thickened membrane, one nucleus

5. Cysts of the following Protozoa could be discovered in feces:
   - ***A*** *Entamoeba histolytica*
   - ***B*** *Trichomonas hominis*
   - ***C*** *Entamoeba gingivalis*
   - ***D*** *Trichomonas tenax*
   - ***E*** *Trichomonas vaginalis*

6. Motile protozoa 30-200 microns long have been revealed in a man's feces. Its body is covered with cilia and has correct oval form with a little bit narrowed anterior and wide round shaped posterior end. At the anterior end a mouth is visible. In cytoplasm there are two nuclei and two contractile vacuoles. What are the described features typical for?
   - ***A*** Lamblia
   - ***B*** Balantidium
   - ***C*** Trichomonas
   - ***D*** Dysenteric amoeba
   - ***E*** Intestinal amoeba

7. Amoebiasis is characterized by ALL mentioned below EXCEPT:
   - ***A*** *Entamoeba histolytica* is an agent
   - ***B*** Cyst carriers might be healthy
   - ***C*** Fecal-oral mode of transmission
   - ***D*** Flies and cockroaches are mechanical vectors
   - ***E*** Vector-born diseases

8. Number of nuclei in cyst of amoeba is an important criterion in discrimination between *Entamoeba histolytica* and
   - ***A*** *Trichomonas hominis*
   - ***B*** *Giardia lamblia*
   - ***C*** *Entamoeba coli*
   - ***D*** *Entamoeba gingivalis*
   - ***E*** *Balantidium coli*

9. *Entamoeba coli* is:
   - ***A*** Agent of amoebiasis
   - ***B*** Non-pathogenic
   - ***C*** Agent of trichomoniasis
   - ***D*** Agent of sleeping sickness
   - ***E*** Agent of balantidiasis

10. Laboratory test for amoebiasis includes:
   - ***A*** Serological tests
   - ***B*** Microscopy of feces
   - ***C*** Microscopy of blood
   - ***D*** Skin-allergic tests
   - ***E*** Microscopy of duodenum content

11. Preventive measures against amoebiasis include ALL mentioned below EXCEPT:
   - ***A*** Sanitary control of water supply
   - ***B*** Keeping rules of personal hygiene
   - ***C*** Mosquito control
   - ***D*** D Identification and treatment of cyst carriers
   - ***E*** Identification and treatment of sick

12. In water samples from the pig farm sewage rounded cysts with two nuclei, covered with thickened envelope were discovered. These are:
   - ***A*** Giardia cycts
   - ***B*** Amoeba cycts
   - ***C*** Balantidium coli cycts
   - ***D*** Leishmania cycts
   - ***E*** Trichomonas cysts

13. Direct infection from the sick person is possible for:
   - ***A*** Amoebiasis
   - ***B*** Malaria
   - ***C*** Leishmaniasis
   - ***D*** Trypanosomosis
   - ***E*** Balantidiasis

14. Inflammation of large intestine could be caused by:
   - ***A*** *Entamoeba histolytica*
   - ***B*** *Entamoeba gingivalis*
   - ***C*** *Entamoeba coli*
   - ***D*** *Giardia lamblia*
   - ***E*** *Trichomonas vaginalis*

15. Following parasites inhabit human of the large intestine:
   - ***A*** *Giardia lamblia*
   - ***B*** *Trichomonas vaginalis*
   - ***C*** *Balantidium coli*
   - ***D*** *Leishmania*
   - ***E*** *Trypanosoma*

16. *Entamoeba gingivalis* is:
   - ***A*** Amoebiasis agent

B Balantidiasis agent
C Dental caries agent
D Giardiasis agent
E Non-pathogenic

17. Which of the mentioned below is an infective stage of *Entamoeba histolytica*?

A Forma magna
B Forma minuta
C Cyst
D Spore
E Vegetative form

18. Several patients with similar complaints applied to the doctor: weakness, pain in the intestines, disorder of GIT. Examination of the feces revealed that one patient with four nucleus cysts should be hospitalized immediately. For what protozoa are such cysts typical?

A Balantidium
B Intestinal amoeba
C Dysenteric amoeba
D Trichomonas
E Lamblia

19 .A patient with suspected liver abscess was admitted to the surgical department. The patient had been staying for a long time on business in one of the African countries and fell ill repeatedly with acute gastrointestinal disorders. What protozoan disease may the patient be now ill with?

A Amebiasis
B Trypanosomosis
C Leishmaniasis
D Malaria
E Toxoplasmosis

20. Carious cavities of a 29-year-old patient contain the parasitic protozoa. It is established that they relate to the *Sarcodina* class. Specify these single-celled organisms:

A *Amoeba proteus*
B *Entamoeba coli*
C *Entamoeba histolytica*
D *Entamoeba gingivalis*
E *Lamblia intestinalis*

21. A patient working at a pig farm complains about paroxysmal abdominal pain, liquid feces with admixtures of mucus and blood, headache, weakness, fever. Examination of large intestine revealed ulcers from 1 mm up to several cm in size; feces contain oval unicellular organisms with cilia. What disease should be suspected?

A Trichomoniasis
B Amebiasis
C Toxoplasmosis
D Lambliasis
E Balantidiasis

22. Healthy cyst carrying is the situation when clinically healthy person is the source of cysts that infect other people. This is possible for following human parasite:

A Leishmania species
B Malarial species
C Intestinal trichomonas
D Dysentery amoeba
E Intestinal amoeba

23. In the feces of patients with chronic colitis (inflammation of the colon) was revealed oval 4-nucleated cysts about 10 microns in diameter. Cysts of which parasite were detected?

A Dysenteric amoeba
B Intestinal amoeba
C Intestinal trichomonas.
D Giardia lamblia
E Balantidium

24. A 60-year-old woman suffers with severe inflammation of gums. In the microscopic examination of gum scraping were found mononuclear protozoans 3-60 microns in size with broad pseudopodia. Which protozoans were found in the patient?

A *Entamoeba gingivalis*
B *Trichomonas tenax*
C *Entamoeba histolytica*
D *Toxoplasma gondii*

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Flagellates. Lamblia, Trichomonas, Leishmania, Trypanosoma.

Practical class 21. Flagellates. Lamblia, Trichomonas, Leishmania, Trypanosoma.

The Purpose of the Lesson. To study morphology, life cycles and pathogenic action of lamblia, trichomonas, leishmania, trypanosoma. To study out the methods of laboratory diagnosis and prevention of the diseases caused by parasitic flagellates.

TOPIC CONTENT

1. General characteristics of Flagellates.
2. Giardia lamblia. Morphological peculiarities, life cycle, ways of infection, location. Methods of laboratory diagnosis and prevention of lambliasis (giardiasis)
3. Trichomonas species. Morphological peculiarities, life cycle, ways of infection, location. Methods of laboratory diagnosis and prevention of urinogenital trichomoniasis
4. Leishmania species. Morphological peculiarities, life cycle, ways of infection, location. Methods of laboratory diagnosis and prevention of cutaneous and visceral leishmaniasis.
5. Trypanosoma species. Morphological peculiarities, life cycle, ways of infection, location. Methods of laboratory diagnosis and prevention of African and South American trypanosomiasis.

TEST QUESTIONS for individual work

№	Questions	Answers
1	List the main characteristics of ***Flagellates***	**a**
		b
		c
		d
2	Give the main characteristic of lamblia (giardia)	
	-Latin name	
	-name of the disease	
	-location in human organism	
	-invasive stage	
	-the way of invasion	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
3	Which species of Trichomonas can inhabit human organism?	**a**
		b
		c
4	Give the main characteristic of urino-genital Trichomonas	
	-Latin name	

	-name of the disease		
	-location in human organism		
	-invasive stage		
	-the way of invasion		
	-pathogenic effect		
	-laboratory test		
	-personal prevention		
5	Give the main characteristic of	Cutaneous leishmaniasis agents	Visceral leishmaniasis agents
	-Latin names of the species		
	-name of the disease		
	-location in human organism		
	-invasive stage		
	-the way of invasion		
	-pathogenic effect		
	-laboratory test		
	-personal prevention		
	Give the main characteristic of	African trypanosomiasis agents	South-American trypanosomiasis agents
	-Latin name of the species		
	-name of the disease		
	-location in humans		
	-invasive stage		
	-the way of invasion		
	-pathogenic effect		
	-laboratory test		
	-personal prevention		

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 250-260; 271-274

FLAGELLATES

Giardia lamblia (Lamblia intestinalis).

Infection may be asymptomatic or cause the disease - **lambliasis** (giardiasis).

Geographical distribution. Worldwide, it is the most common intestinal protozoan pathogen, especially in children.

Location. It lives in the in the lumen of the small intestine (duodenum).

Morphology. Lamblia is in **vegetative and cyst forms.**

The vegetative form or trophozoite has **pear shape body 10-18 µm,** with 4 pairs of flagella, 2 nuclei, 2 axostyles running along the midline.

The cyst is ovoid with four nuclei.

Life cycle. **The infective stage is a cyst,** which gets into the human body through water, food or dirty hands.

The disease is **anthroponotic.**

Diagnosis. Feces and duodenal contents cyst are found in stool; in duodenal contents only trophozoits are present.

Prophylaxis. Personal prevention is by **keeping the rules of personal hygiene** (to wash hands before meals, wash vegetables, fruit, boil drinking water).

Trichomonas vaginalis.

disease - **urinogenital trichomoniasis**

worldwide

Location. It lives in the **vagina of the females and urethra and prostate of the males**

Morphology. The trophozoite is ovoid or pear-shaped. It has 4 anterior flagella, axostyle and undulating membrane. **Cysts are not formed.**

Life cycle. **Sexual transmission is the usual mode of infection.** The trophozoite is infective form. Parasites live in urinogenital tract of the patient.

The disease is anthroponotic.

Infection is asymptomatic in the males. In female patients complaints of local irritation or a burning and itching sensation in the vagina, vaginal discharges.

Diagnosis. Microscopic examination of vaginal or urethral discharge.

Prophylaxis. Personal prevention is **to avoid occasional sexual contacts** and to **use condoms**. Control of the disease is sterilization of gynecologic and urologic instruments, health education.

Leishmania

Leishmania donovani and Leishmania infantum are causative agents of **visceral leishmaniasis.**

Leishmania tropica major and minor are causative agents of **cutaneous leishmaniasis or Old World Cutaneous Leishmaniasis.**

Leishmania brasiliensis and Leishmania mexicana – are causative agents of **mucocutaneous leishmaniasis or New World Cutaneous Leishmaniasis**.

The life cycle of leishmania involves a **vertebrate host and insect host sand fly** (Phlebotomus). 2 stages:

1. **Aflagellate stage (amastigote or leishmanial form**).
2. **Flagellate stage (promastigote or leptomonade form**) is present in a gut of the sand fly (Phlebotomus).

Leishmania tropica major and Leishmania tropica minor are causative agents of **cutaneous leishmaniasis.**

Geographical distribution: countries with tropical and subtropical climate (**Mediterranean countries, Middle East, India).**

Location. Af lagellate stage is present in the **skin cells of the humans.**

Life cycle. **Infection occurs through the sand fly bite.** Parasites are present **in skin and causes ulcers.**

Leishmania tropica minor is the agent of anthroponotic urban type Epidemic chain : **human being → sand fly → human being.**

Leishmania tropica major is the agent of anthropozoonotic rural type of the disease. The main source of the disease (reservoir) is **rodents (rats, gerbils and** others)**. Rural type of the disease is a natural foci disorder.**

Epidemic chain : **rodents → sand fly → human being.**

Diagnosis. Demonstration of i**ntracellular aflagellate forms in skin cells from the edge of the ulcer.**

Leishmania donovani and Leishmania infantum are causative agents of **visceral leishmaniasis.**

Geographical distribution: *Regions with tropical and subtropical climate (Mediterranean countries, India, Sudan, China, Tropical Africa).*

Location. ***Liver, spleen, red bone marrow, lymphatic nodes.***

Morphology and life cycle are the same as for other leishmania species. After the **bite of infected sand fly** parasites from skin migrate to the red bone marrow, liver, spleen.

Epidemiology ***Infection occurs through the sand fly bite.***

L. donovani *causes* ***anthroponotic Indian visceral leishmaniasis (kala-azar)***. ***Human being is the only host and reservoir of the disease.***

L. infantum *causes* ***anthropozoonotic Mediterranean (infant) leishmaniasis.*** *Reservoir and source of infection are* ***dogs or wild canines*** *such as jackals, foxes and wolves. The disease affects mostly* ***young children.*** *Infant leishmaniasis belongs to the group of* ***natural foci disorders.***

Diagnosis:

1 – direct methods: d**emonstration of the parasite in the red bone marrow or lymph nodes aspirate.**

2 – indirect method: **immunological tests (**demonstration of antibodies to leishmania in the blood serum).

Prophylaxis. Personal prophylaxis is usage of **anti- sand fly measures: repellents, protective nets, bed curtains, mesh doors.**

Control of parasite and vector includes diagnosis and treating of an individual with the disease, eradication of reservoir rodents; reducing the sand fly population by insecticides. Health education.

Trypanosoma

Trypanosoma brucei gambiense and **Trypanosoma brucei rhodesiense** are the agents of African trypanosomiasis (sleeping sickness).

Geographical distribution: western and central parts of the equatorial Africa.

Location. Blood plasma, lymph, lymph nodes, cerebrospinal fluid, brain, spinal cord, kidneys and serous cavities.

Morphology. Body is extended, 17-28 μm in long, uninucleated. It bears one flagellum and undulating membrane.

Life cycle. The life cycle of Trypanosoma involves a vertebrate and insect host tsetse fly (Glossina). Vertebrate hosts are humans, and antelopes).

Human infection is acquired by th**e bite of tsetse fly**. Parasites multiply in skin and then enter the blood stream and lymph nodes.

Epidemiology. The disease is **anthropozoonotic**. Man is considered to be the reservoir host and source of infection for Tr. gambiense (Gambian sleeping sickness) though pigs and other domestic animals can act as chronic asymptomatic carriers of the parasite. For Tr. rhodesiense (Rhodesian sleeping sickness) main reservoirs are antelopes.

Pathogenicity. The central nervous system and internal organs are affected. The following symptoms can be observed: fever, enlargement of lymph nodes, liver and spleen. Chronic meningoencephalitis develops. This manifests by increasing headache, mental dullness, apathy and sleepiness. The patient falls into coma followed by death.

Diagnosis. Demonstration of parasite in blood , aspiration material from lymph nodes or cerebrospinal fluid.

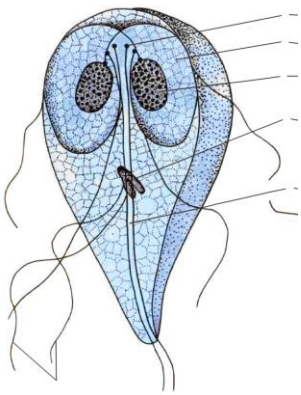
PRACTICAL WORK Flagellates

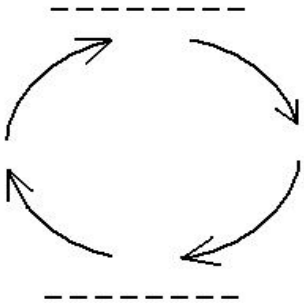
2. Study the classification of parasitic flagellates. Write down Latin names of the parasites

Kingdom Zoa s.Animalia
Subkingdom Protozoa s. Monocytozoa
Phylum Sarcomastigophora
Class Zoomastigophora
Species _____

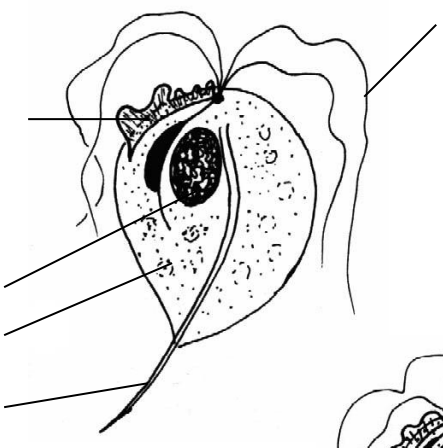
Trychomonas sp._____
_____
Leishmania sp. _____
_____
_____
_____
Tryponosoma sp. _____
_____

3. Study the structure of Lamblia under a microscope. Label the morphological peculiarities: nucleus, sucking disk, axostyle, flagellae. Sketch a scheme of Lamblia's life cycle.

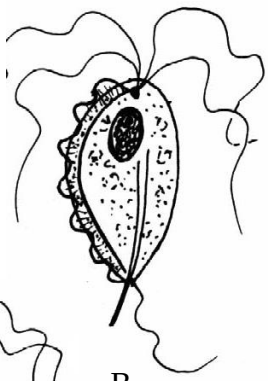




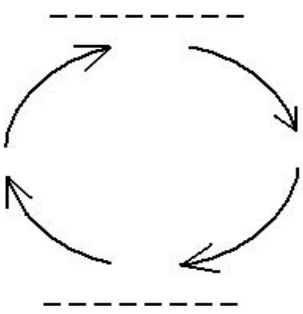
4. Study under a microscope a Trichomonas vaginalis in vaginal smear**.** Label the peculiarities of trophozoit's structure: flagella, undulating membrane, nucleus, axostyle. Label the non-pathogenic trichomonas species. **S**ketch the life cycle of Trychomonas vaginalis.



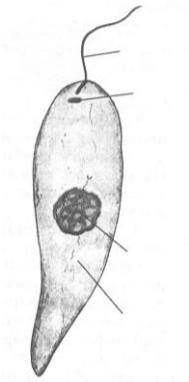
A. _____

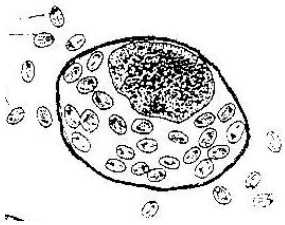


B _____

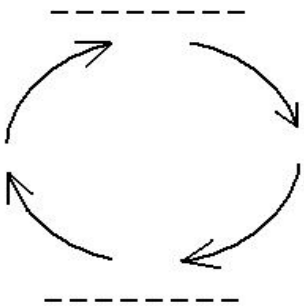


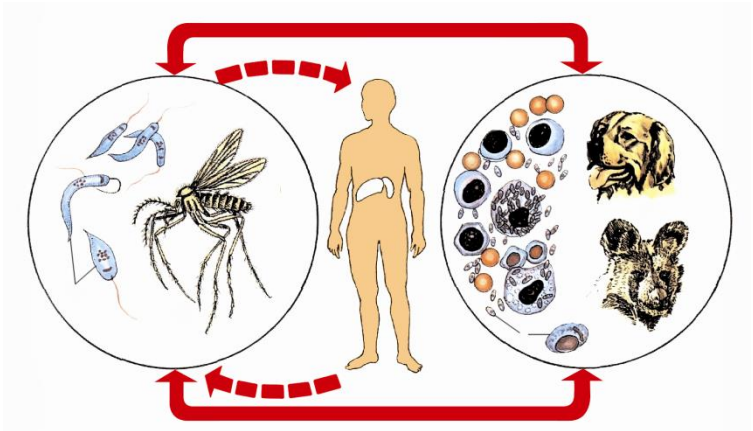
5. Study under a microscope flagellated and non-flagellated forms of *Leishmania.*
Label the flagellated and non-flagellated forms of *Leishmania* and its morphology. Study a scheme of life cycle of *Leishmania*.





Visceral leishmaniosis cycle

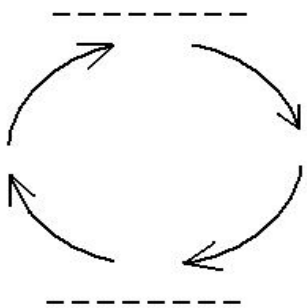


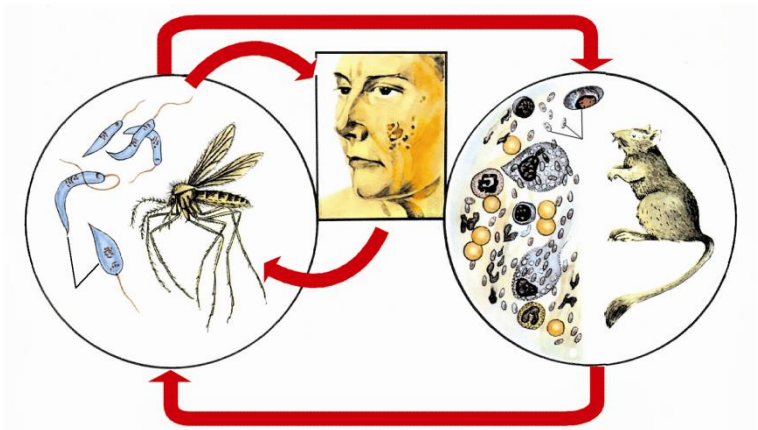


a) anthroponotic leishamniasis
_____(disease)

b) anthropozoonotic leishmaniasis
_____(disease)

Cutaneouse leishmaniosis cycle

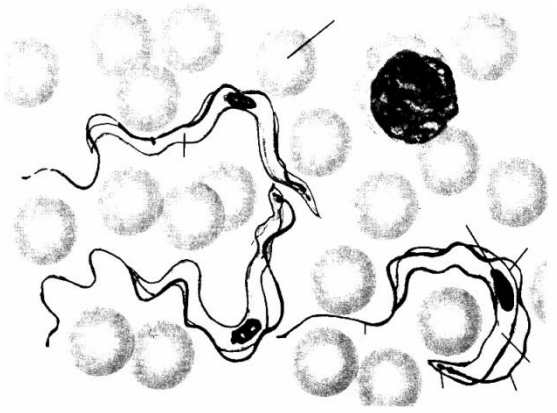




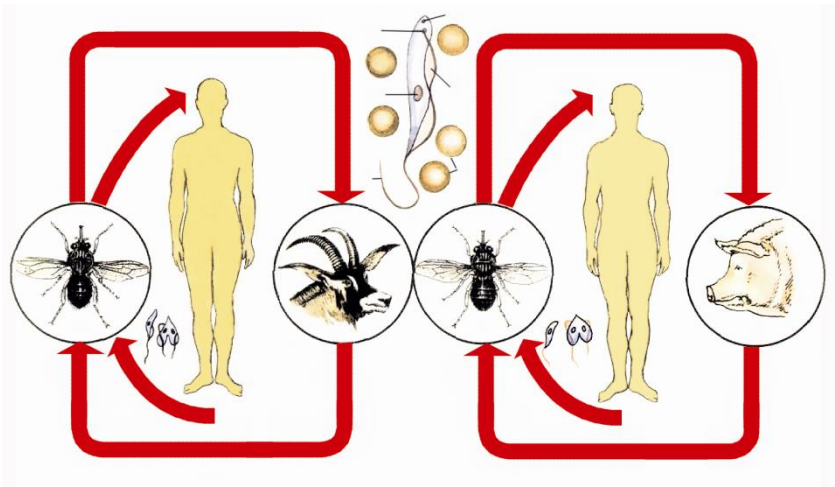
a) anthroponotic leishamniasis
_____(disease)

b) anthropozoonotic leishmaniasis
_____(disease)

6. Study *Trypanosoma* paraisires in blood smear under a microscope**.** Label morphological peculiarities of *Trypanosoma*. Study the schemes of life cycles of African and American *Trypanosoma*.

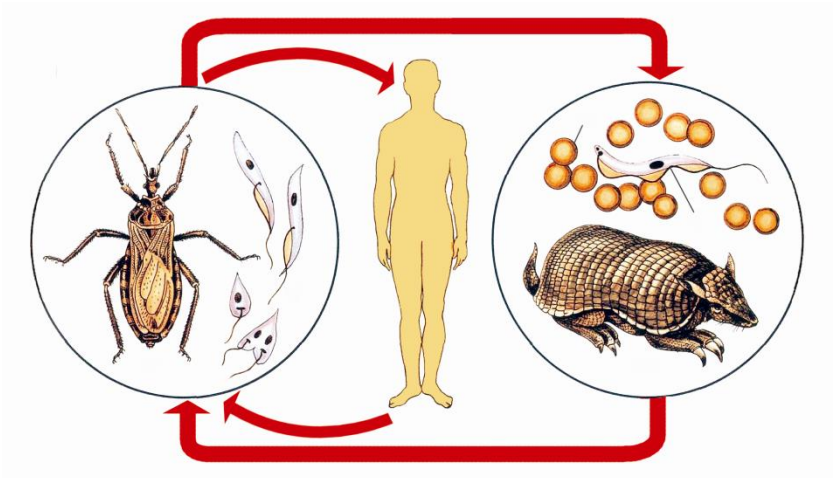


African trypanosomiasis cycle



a) _____ b)_____
(type of the disease)

American trypanosomiasis cycle



_____(disease)

Materials for self-control of the training quality

A. Tests for self-control with standard answer.

Choose the correct answer.

1. Which parasites from mentioned below inhabit human small intestine:
   - *A* *Balantidium coli;*
   - *B* *Giardia lamblia;*
   - *C* *Trichomonas vaginalis;*
   - *D* *Leischmania*
   - *E* *Entamoeba histolytica.*

2. Examination of duodenal contents revealed some pyriform protozoa with twin nuclei and four pairs of flagella. There were two supporting filaments between the nuclei and a sucking disc on the ventral side. What representative of protozoa was revealed in this patient?
   - *A* Lamblia
   - *B* Toxoplasma
   - *C* Leishmania
   - *D* Intestinal trichomonad
   - *E* Trypanosome

3. *Giardia lamblia* inhabits:
   - *A* Large intestine;
   - *B* Stomach;
   - *C* Bile bladder;
   - *D* Duodenum;
   - *E* Liver.

4. Which form of *Giardia lamblia* is infective for the human being:
   - *A* Vegetative form;
   - *B* Sporocyst
   - *C* Sporozoit;
   - *D* Cyst;
   - *E* Pseudocyst

5. Morphologically *Trichomonas vaginalis* is characterized by:
   - *A* Spindle-shaped body with one flagella and undulating membrane;
   - *B* Pear-shaped body, paired organelles;
   - *C* Pear-shaped body with axostyle and undulating membrane;
   - *D* Spindle-shaped body with numerous flagella;
   - *E* Inconstant body shape.

6. The ability of the parasites to produce harmful effect and to cause a disease is a:
   - *A* Pathogenicity;
   - *B* Mutualism;
   - *C* Parasitism;
   - *D* Preying;
   - *E* Commensalism.

7. Sexual transmission is possible in:
   - *A* Giardiasis;
   - *B* Toxoplasmosis;
   - *C* Trichomonosis;
   - *D* Leischmaniasis;
   - *E* Trypanosomosis.

8. A gynaecologist was examining a patient and revealed symptoms of genital tract inflammation. A smear from vagina contains pyriform protozoa with a spine, flagella at their front; there is also an undulating membrane. What disease can be suspected?
   - *A* Urogenital trichomoniasis
   - *B* Lambliasis
   - *C* Intestinal trichomoniasis
   - *D* Toxoplasmosis
   - *E* Balantidiasis

9. Parasites inhabiting inner organs of the host are:
   - *A* Ectoparasites;
   - *B* Endoparasites;
   - *C* Optional parasites;
   - *D* Obligatory parasites;
   - *E* True parasites

10. Preventive measures against Giardiasis include:
   - *A* Washing hands;
   - *B* Washing fruits and vegetables;
   - *C* Boiling of water;
   - *D* Treatment of the patients;
   - *E* All of the above

11. Laboratory tests for Trichomoniasis include microscopic examination of:
   - *A* Feces smear;
   - *B* Blood smear;
   - *C* Lymphatic nodes puncture;
   - *D* Vaginal discharges;
   - *E* Cerebrospinal fluid.

12. A patient has symptoms of inflammation of urinogenital tracts. Examination of a vaginal smear revealed big monocellular, pear-shaped organisms with the pointed spike at the posterior end of body, big nucleus and undulating membrane. What protozoa were found in the smear?
   - *A* *Trypanosoma gambiense*
   - *B* *Trichomonas hominis*
   - *C* *Trichomonas tenax*
   - *D* *Trichomonas vaginalis*
   - *E* *Lamblia intestinalis*

13. Trophozoites of which Protozoa are infective for human:
   - *A* *Trichomonas vaginalis*;
   - *B* *Giardia lamblia;*
   - *C* *Entamoeba histolytica;*
   - *D* *Balantidium coli;*
   - *E* *Entamoeba coli*

14. Laboratory diagnosis of giardiasis is done by:
   - *A* Microscopy of duodenum content;
   - *B* Serologic tests;
   - *C* Infection of laboratory animals;
   - *D* Microscopy of blood smear;
   - *E* Sputum microscopy.

15. Diseases that affect both humans and animals are termed as:
   - *A* Zoonosis;
   - *B* Anthroponosis;
   - *C* Anthropozoonosis;
   - *D* Vector-born;
   - *E* Nature-focal

16. Diseases that affect animals only are:
   - *A* Zoonosis;
   - *B* Anthroponosis;
   - *C* Anthropozoonosis;
   - *D* Vector-born;
   - *E* Nature focal

17. Diseases that affect humans only are:
   - *A* Zoonosis;
   - *B* Anthroponosis;

C Anthropozoonosis;
D Vector-born;
E Nature focal

18. Leischmaniasis is characterized by ALL mentioned below EXCEPT for:
A Nature focal;
B Trasmitted through bites of blood sucking insects;
C Vector is a sand-fly;
D Skin cells are affected:
E Cats are definitive hosts

19. Sand-flies are the vectors of:
A Malaria;
B B, Leischmaniasis;
C Trypanosomiasis:
D Toxoplasmosis;
E Amoebiasis.

20. Nature focal diseases:
A. Exist in certain biogeocenosis independently on human presence;
B. Agents circulate among wild animals;
C. Exist on territories with certain geographic conditions;
D. Leischmaniosis is an example;
E. ALL of the above

21. Control of Leischmaniasis nclude all exept:
A. Extermination of sand flies;
B. Extermination of rodents;
C. Control of mosquitoes;
D. Extermination of street dogs;
E. Treatment of sick persons

22. Blood sucking insects are vector for ALL diseases EXCEPT for:
A. Cutaneus leischmaniasis;
B. Visceral leischmaniasis;
C. Giardiasis;
D. African trypanosomiasis;
E. American trypanosomiasis;

23. Cutaneous Leischmaniasis is caused by:
A. *Leischmania tropica*;
B. *Giardia lamblia*;
C. *Leischmania donovani*;
D. *Trypanosoma cruzi*;
E. *Trypanosoma gambiense*.

24. Visceral leischmaniasis is caused by;
A. *Leischmania tropica*;
B. *Giardia lamblia*;
C. *Leischmania donovani*;
D. *Trypanosoma cruzi*;
E. *Trypanosoma gambiense*.

25. African sleeping sickness is cased by:
A. *Leischmania tropica*;
B. *Giardia lamblia*;
C. *Leischmania donovani*;
D. *Trypanosoma cruzi*;
E. *Trypanosoma gambiense.*

26. Chagas disease is caused by:
A. *Leischmania tropica*;
B. *Giardia lamblia*;
C. *Leischmania donovani*;
D. *Trypanosoma cruzi*;
E. *Trypanosoma gambiense*

27. A businesman came to India from South America. On examination the physician found that the patient was suffering from sleeping-sickness. What was the way of invasion?
A. Through dirty hands
B. With contaminated fruits and vegetables
C. As a result of mosquito's bites
D. After contact with a sick dogs
E. As a result of bug's bites

28. South American trypanosomiasis vector is:
A. Sand fly;
B. Tsetse fly;
C. Mosquito;
D. Reduviid bug

29. Parents with ill child came to the infectionist. They worked in one of the Asian countries for a long time. Child has earthy colored skin, loss of appetite, laxity, enlarged liver, spleen, peripheral glands. What protozoan illness can this child have?
A Visceral leishmaniasis
B Balantidiasis
C Amebiasis
D Toxoplasmosis
E Lamblia

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Apycomplexa (Sporozoa). Malaria parasites. Toxoplasma.

Practical class 22. Apicomplexa (Sporozoa). Malaria parasites. Toxoplasma.

The Purpose of the Lesson. To study characteristic features of *Sporozoa* taking *Plasmodium vivax* as an example. To learn the peculiarities of morphology and life cycles of different plasmodium species, laboratory diagnosis and prevention of malaria. To study out the methods of laboratory diagnosis and prevention of the intestinal diseases caused by these parasites. To study distribution, morphology, life cycles, location in the human organism and pathogenic action of toxoplasma. To study the methods of laboratory diagnosis and prevention of the congenital and acquired toxoplasmosis.

TOPIC CONTENT

1. General characteristic of Apicomlexa
2. Species of malaria, pathogenic for the humans.
3. Life cycle of the malaria parasites
4. Ways of invasion with malaria, pathogenic action of malaria on human organism.
5. Laboratory diagnosis and prevention of malaria.
6. Main morphological characteristics and life cycle of toxoplasma
7. Ways of invasion with toxopasmosis.
8. Pathogenic action of toxplasma on human organism. Congenital and acquired toxoplasmosis.
9. Laboratory diagnosis and prevention of toxoplasmosis.

TEST QUESTIONS for individual work

№	Questions	Answers
1	List the main characteristics of ***Sporozoa***	**a**
		b
		c
		d
2	Which species of malaria are pathogenic for the humans?	**a**
		b
		c
		d
3	Which organisms are the hosts for malaria parasites	a) definitive host
		b) intermediate host
4	Which kind of vector is *Anopheles* mosquito for malaria parasites?	
5	What are the possible ways of invasion with malaria	**a**
		b

		c		
6	Which stages of plasmodium life cycle occurs in human organism?	**1 (a, b)**		
		2		
7	Which stage of plasmodium is invasive for humans?			
8	Where does the exoerythrocytic schisogony take place?			
9	What are the stages of plasmodium in human liver?	**a**	**b**	
10	What are the stages of plasmodium in human blood?	**a**	**b**	
		c	**d**	**e**
11	What is the duration of erythrocytic schisogony for	*P. vivax*	*P. falciparum*	
		P. ovale	*P. malaria*	
12	At which moment of the plasmodium life cycle does the malaria attack start?			
13	What are the stages of malaria attack?	**a**		
		b		
		c		
14	What are the main methods of laboratory diagnosis of malaria?	**a**		
		b		
15	Which stage of plasmodium is invasive for *Anopheles* mosquito?			
16	Which stages of plasmodium life cycle occurs in *Anopheles* mosquito?	**a)**		
		b)		
17	What are the methods of malaria prevention	**a) personal**		
		b)social		
18	Which organisms are the hosts for toxoplasma?	Definitive **(a)**		
		intermediate **(b, c, d)**		
19	What is location of toxoplasma in organism of the human being?			

20	Give the characteristics of endozoite:	a) shape b) size
		c) number of the nuclei
		d) role of the conoid
21	What is	a) pseudocyst
		b) tissue cyst
22	How can human being be invaded with toxoplasmosis?	**a**
		b
		c
		d
23	What is the way of toxoplasma reproduction in the organism of intermediate host?	
24	At which stage toxoplasma is present in the organism of the healthy carriers	
25	What are the stages of toxoplasma life cycle in the organism of definitive host	a) b)
		c)
26	What are the forms of toxoplasmosis?	**a**
		b
27	What are the features of acute toxoplasmosis?	
28	What are the manifestations of congenital toxoplamosis if invasion occurs	a) at the first months of the pregnancy
		b) at the later stage of the pregnancy
29	What are the methods of laboratory diagnosis of toxoplasmosis	a)
		b)
		c)
		d)

Literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 260-270; 271-274

Phylum: Apicomplexa
Class : Sporozoea
Order: Haemosporina
Species: Plasmodium malariae
Pl. vivax
Pl. ovale
Pl. falciparum

4 species of Plasmodium (The Malarial Parasite) are:

- Pl. vivax - benign tertian malaria.
- Pl. malaria -quartan malaria.
- Pl. falciparum - malignant tertian malaria.
- Pl. ovale causes ovale malaria - benign tertian malaria.

Geographical distribution

Pl. vivax -temperate climate.

Pl. falciparum - tropical Africa, some parts of Asia, India, because at temperatures below 20^0 C its development is greatly retarded.

Pl. malariae - tropical Africa, Sri Lanka and parts of India.

Pl. ovale is the rarest , tropical Africa.

Location: Hepatic cells, then RBCs.

Morphology and life cycle.

life cycle stages: 1. Schizogony; 2. Gametogony; 3. Sporogony.

the life cycle involves 2 hosts:human (intermediate host) and anopheline mosquitoes(definitive host).

In human parasites have asexual reproduction in the liver (tissue schizogony) and in the RBCs (blood schizogony).

Sexual forms of the parasites develop in female ahopheline mosquitoes (gametogony and sporogony), so mosquito acts as definitive host.

Sporozoite is the infective stage of Plasmodium for human

Infected female anopheline mosquito bites man and injects a several hundred sporozoites along with saliva into the blood. The sporozoites find their way to the liver cells, the sporozoites undergo asexual reproduction by multiple fission (i.e. schizogony). After about 7days the infected liver cells burst open releasing thousands of merozoites (500-40000) which pass into the blood stream and attack the red blood cells. This is called the tissue (hepatic or pre-erythrocytic) schizogony. Duration of this stage is about 8 days (Plasmodium vivax), 18 days (Pl.malariae); 9 days (Pl.ovale) and 6 days (Pl.falciparum).

Some of tissue sporozoites (hypnozoites) of Pl.vivax and Pl.ovale may stay in the liver cells many years without development, forming a reservoir of parasites which can prolong a disease in a latent form and cause late relapses of the disease.

In erythrocytes each merozoite becomes trophozoite. stages in this process:“ring”, “amoeboid”, “mature” trophozoite. Then nucleus of the trophozoite undergoes repeated divisions, forming schizont. 24 small merozoites are formed.

This is erythrocytic (blood) schizogony and continues for 48 hours (Pl.vivax, Pl.ovale, Pl.falciparum) or 72 hours (Pl.malaria). Then the exhausted erythrocytes burst out, the merozoites are released and re-invasion of new RBCs takes place.

After several cycles of erythrocytic schizogony in some erythrocytes merozoites form micro-(male) and macro (female) gametocytes (gametogony). Gametogony is completed in 4 days. The mature gametocytes do not undergo further development in a man. This stage is infective for mosquitoes.

Anopheles mosquito female takes up some male and female gametocytes with the blood while feeding on infected person.

The gametocytes release in the stomach of mosquito and complete gametogony. Male gamete fuses with the female gamete to form zygote (ookinete).it penetrates the stomach wall and gets encysted(200 to 5000 such oocysts on the outer surface of the stomach). The oocyst ruptures and the sporozoites emerge into body cavity of the mosquito,penetrate the salivary glands of mosquito.The duration of the development of Plasmodium in mosquito is 7-45 days and depends on the temperature of the environment.

Epidemiology.

Malaria is an anthroponotic vector-born (transmissive) disease. The source of infection is human.

There are 3 modes of transmission:

- Through the bite of infected mosquito(the biological vector) Infective stage is sporozoit
- Through placenta, from mother to fetus.
- Through blood transfusion

In both cases infective are merozoites.

Pathogenicity.

The main clinical features are fever peaks followed by anemia and splenomegaly.

The typical malarial attack has 3 distinct stages:

the cold stage with chill and shivering,

hot stage with hot sensation and high temperature;

sweating stage with profuse sweating and rapid dropping of the temperature. Fever paroxysm usually lasts for 8 to 12 hours.

Diagnosis. Demonstration of parasites in blood. 2 types of blood films are prepared for examination: the thick and the thin films.

Prophylaxis. Personal prophylaxis is avoiding mosquito bites by suitable clothing, using bed curtains, (particularly nets impregnated with permethrin) or application of repellents on the exposed skin.

For travellers visiting endemic areas, chemoprophylaxis provides effective protection. Prophylaxis should begin on the day of arrival and to be continued for 4 to 6 week after departure.Control of the disease includes: 1) treatment of malaria cases; 2) vector control includes environmental modification, chemical and biological larvicides or insecticides; 2) health education.

Phylum: Apicomplexa

Class: Sporozoea

Order: Coccidia

Species: Toxoplasma gondii -3 μm by 7 μm

disease: toxoplasmosis

Geographical distribution. It is worldwide in birds, reptiles and mammals, man is an intermediate host,cat is definitive host

Location. It is an intracellular parasite(liver, spleen, brain, lymphatic nodes, eyes and muscles)

Morphology. 3 main forms – trophozoite (endozoite), tissue cyst and oocyst.

The trophozoite and tissue cyst are in asexual reproduction (endogony), the oocyst is formed by sexual reproduction (gametogony and sporogony).

Life Cycle is in 2 hosts. Definitive host is a cat(animals of cat family), which also can be an intermediate host.

Intermediate hosts are men, mice and other mammals, birds, reptiles.

Development in man.

Infection occurs after the ingestion of oocyts or by eating improperly cooked meat of infected animals.

Trophozoites can invade any nucleated cell and replicate by a process called endodyogeny or internal budding,enclosed by the host cell membrane. This is "pseudocyst" or "colony"during acute period of the disease

The tissue cyst is formed during the chronic phase of the infection and can be in the muscles,other tissues and organs, brain.

Development in cat.

Infection occurs after the ingestion of oocysts or by eating meat of infected animals. (schizogony is asexual development – cat becomes intermediate host). Then – gametogony (sexual reproduction)

Cats shed millions of oocysts per day in feces for about 2 weeks during the primary infection. The freshly passed oocyst becomes infectious only after development in soil or water for a few days.

In soil during sporogony sporocyst is formed with 8 sporozoites (the infective form)

Epidemiology. Human toxoplasmosis may be acquired as under:

- Ingesting food containing tissue cysts (raw or half-raw meat or force-meat). Infective stage is pseudocyst or tissue cyst with trophozoits;
- Through dirty hands or food contaminated with oocysts (vegetables, berries, fruit, unwashed hands);
- Transplacental transmission from mother to fetus.
- Occupational transmission to laboratory personnel, veterinarians and slaughterhouse workers through the broken skin (scratches).
- Organ transplantation and granulocyte transfusion.
- Blood transfusion – rarely.

Pathogenicity. *Clinical toxoplasmosis may be congenital or acquired.*

Congenital toxoplasmosis is transmitted transplacentally from mother to fetus. This occurs only when the mother gets primary toxoplasma infection, during the pregnancy. Spontaneous abortion or congenital defects occur at this period.

Infection acquired postnatal is mostly asymptomatic. The commonest manifestation of acute acquired toxoplasmosis is lymphadenopathy, affection of eyes

Toxoplasmosis is particularly severe in the immunocompromised persons(AIDS patients)

Diagnosis.

- Demonstration of trophozoites in blood and lymph nodes aspirate
- Isolation of T.gondii. Inoculation of body fluids, WBC, or tissue specimens into the peritoneal cavity of mice. Mice should be examined for Toxoplasma at 6 -10 days after inoculation (*biological method of diagnosis).*
- Serodiagnosis(antibodies to toxoplasma in blood serum).
- Intra-skin allergic test with Toxoplasmine. Presence of toxoplasma is marked by swelling and redness at the place of antigen injection.

Prophylaxis.

- Proper hand washing, washing of fruit and vegetables
- Proper cooking of meat. Cysts in meat can be killed by either heating upto 60 C for 30 minutes or by freezing to -20є C.

Prevention of human – cat contact. Pregnant women are advised to avoid exposure to cats.

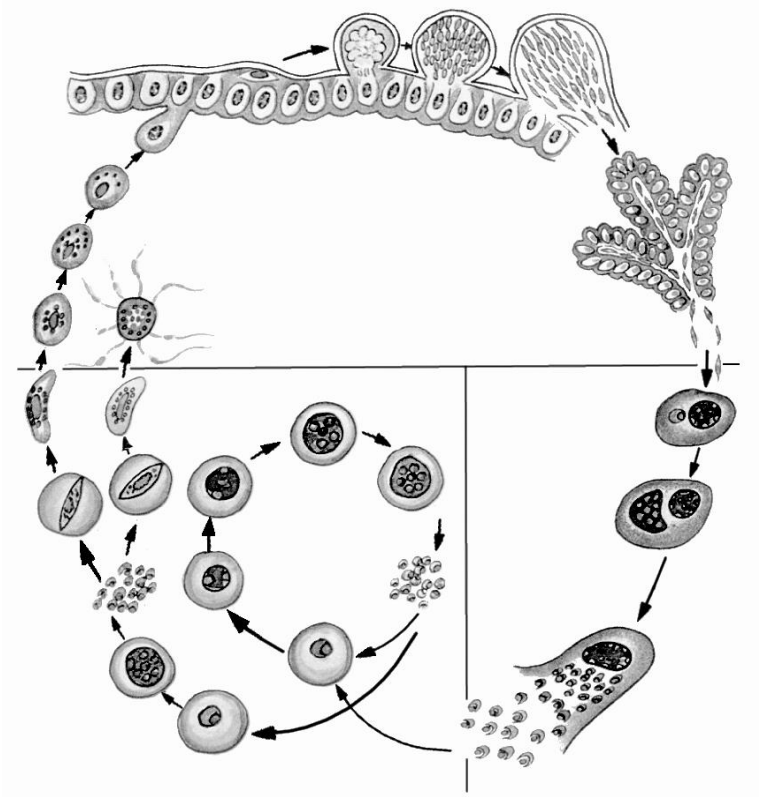
PRACTICAL WORK Apicomplexa

Study the classification of **malaria parasites** Write down Latin name of the parasites

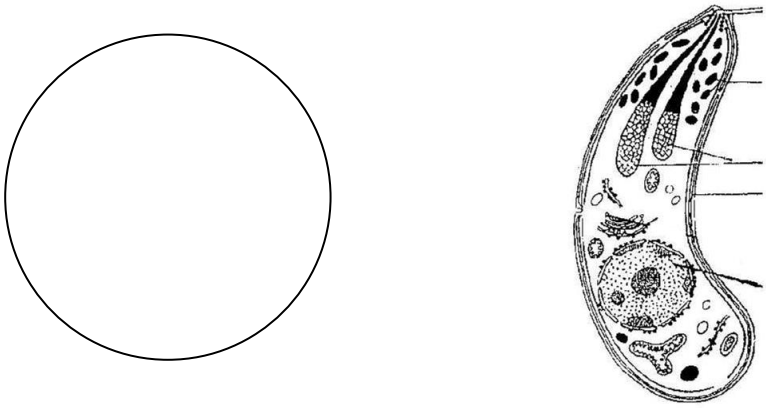
Kingdom *Zoa s.Animalia*
Subkingdom *Protozoa s. Monocytozoa*
Phylum *Apicomplexa*
Class *Sporozoa*
Order *Haemosporidia*
Species
Plasmodium _____ is an agent of_____malaria
*Plasmodium*_____ is an agent of_____malaria
Plasmodium _____ is an agent of_____malaria
*Plasmodium*_____ is an agent of_____malaria
Class *Sporozoa*
Order *Coccidia*
Species _____

2. Study a thin blood film of a patient with malaria. Define different stages of plasmodium development in RBCs (ring form, amoeboid form, mature trophozoite (early schizont) , morula, gametocytes).

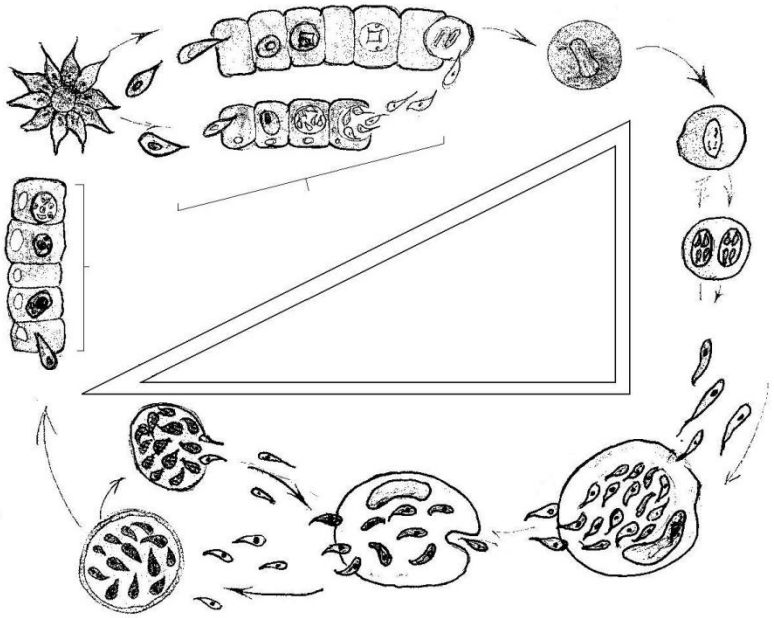
3. Study the life cycle of *Plasmodium falciparum* in the organisms of definitive and intermediate hosts. Label stages of development in human organism and in female Anopheles.



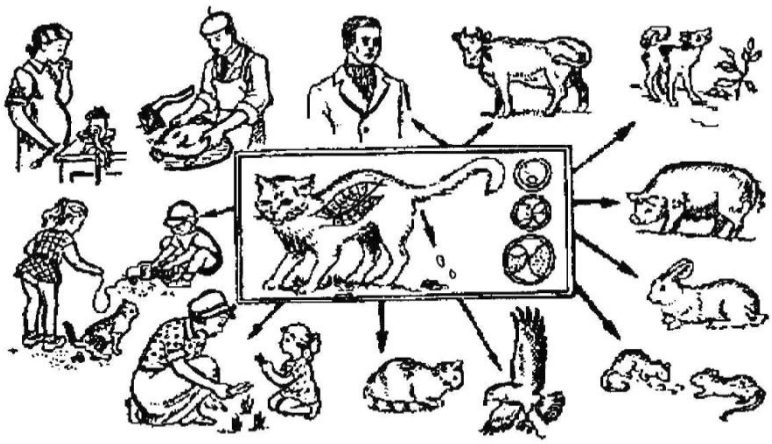
4. Study under a microscope a smear of lymphatic node of a patient with toxoplasmosis and sketch it. Label the morphological peculiarities of toxoplasma on the scheme.



5. Study a scheme of toxoplasma development. Point out stages of development in an organism of definite and intermediate hosts, in an environment.



6. Study the circulation of the toxoplasma in nature. Analyze the ways of toxoplasmosis transmission.



Materials for self-control of the training quality
Tests for self-control with standard answer.
Choose the correct answer.

1. Life cycle of Malaria parasite in human organism finishes on the following stage:
A Gametocytes
B Gametes
C Ookinete
D Sporozoits
E Schizonts

2. *Plasmodium vivax* is the agent of:
A Benign tertian malaria
B Malignant tertian malaria
C Benign quartan malaria
D Malignant quartan malaria

3. *Plasmodium malariae* is the agent of:
A Benign tertian malaria
B Malignant tertian malaria
C Benign quartan malaria
D Ovale-malaria

4. Sporozoa are characterized by ALL mentioned below EXCEPT for:
A Lack organelles of locomotion
B Lack organelles of digestion
C Alteration of sexual and asexual generations
D Asexual reproduction only
E Respiration through the body surface

5. Malaria attack in human starts due to the formation of a new generation of _____ in blood (Fill the gap):
A Sporozoits
B Merozoits
C Schizonts
D Gametocytes
E Gametes

6. All stages of malaria parasites could be revealed in RBC, **EXCEPT** for:
A Matured schizont
B Ring-like trophozoit
C Gametes
D Gametocytes
E Amoeboid trophozoit

7. Anopheles mosquito is a vector of:
A Malaria
B Leishmaniosis
C Toxoplasmosis
D Amoebiasis
E Trypanosomosis

8. Incubation period of malaria corresponds to the following stage of plasmodium life cycle in a human organism:
A Sporogony
B Tissue schizogony
C Gametogony
D Schizogony in RBC
E Endodiogeny

9. Definitive host of malaria parasite is:
A Human being
B Dog
C Anopheles mosquito
D Sand fly
E Cat

10. Individual preventive measures against malaria include:
A Protection from mosquito bites
B Identification and treatment of sick persons
C Following the rules of personal hygiene
D Flies and cockroaches control

11. Transmission of malaria is possible:
A Via vectors
B Through placenta
C Through the blood transfusion
D Via mosquito's bite
E ALL of the above

12. Malaria fever attack starts along with the following stage of malaria parasite:
A Tissue schizogony
B Gametocytes formation
C Merozoits release from RBC
D Merozoits penetrate into RBC
E Mature schizonts formation

13. Intermediate host of malaria parasite is:
A Human being
B Tsetse fly
C Mosquito
D Sand sly
E Kissing bug (Reduviid bug)

14. 48-hour duration of erythrocytic schizogony is characteristic for ALL species of malaria parasites EXCEPT:
A *Plasmodium malariae*
B *Plasmodium ovale*
C *Plasmodium falciparum*
D *Plasmodium vivax*

15. Causative agent of malignant tertian malaria is:
A *Plasmodium malariae*
B *Plasmodium ovale*
C *Plasmodium falciparum*
D *Plasmodium vivax*

16. 72-hour duration of erythrocytic schizogony and fever attacks each 4^{th} day are characteristic for
A *Plasmodium malariae*
B *Plasmodium ovale*
C *Plasmodium falciparum*
D *Plasmodium vivax*

17. A patient who has recently come from an endemic area presents with elevated body temperature, headache, chills, malaise, that is with the symptoms which are typical for a common cold. What laboratory tests are necessary to confirm or to refute the diagnosis of malaria?
A Urinalysis
B Study of lymph node punctate
C Microscopy of blood smears
D Study of cerebrospinal fluid
E Microscopy of bone marrow punctate

18. 2 weeks since the blood transfusion a recipient has developed fever. What protozoan disease can it be?

A Malaria
B Trypanosomiasis
C Amebiasis
D Toxoplasmosis
E Leishmaniasis

19. A patient is complaining of a headache, pain in left hypochondrium. The disease began acute with increasing of the temperature up to 40ºC. The attacks were repeated periodically after 48 hours. Determine the possible causative agent of the disease.

A Agent of benign tertian malaria
B Agent of malignant malaria
C Agent of quatrain malaria
D Toxoplasma
E Trypanosome

20. The female during the childbirth were transfused the blood from donor, who had arrived from Angola. Two weeks later she developed fever. What laboratory investigation should be used to confirm or exclude the diagnosis of malaria?

A. To isolate the causative agent in laboratory animals
B To study leukocyte formula
C To isolate the causative agent by cultivating on the nutritive medium.
D To study thin and thick blood films for demonstration the erythrocytic stages of the pathogen
E To study aspiration material of the lymph nodes

21. The patient experiences a typical attack of malaria with cold, hot and sweating stages. Which stage of the malaria parasite is likely to be detected in the patient's blood at the time?

A Merozoite
B Schizont
C Sporozoite
D Sporocyst
E Ookinete

22. In some regions of Ukraine local cases of malaria spread. Which insects are that confined to?

A Horseflies of family *Tabanidae*
B Sand flies of the genus *Phlebotomus*
C Midges of the genus *Simullium*
D Mosquitoes of the genus *Culex*
E Mosquitoes of the genus *Anopheles*

23**.** Sporogony of toxoplasma occurs in:

A Human;
B Cat;
C Mosquito;
D Dog;
E Outer environment

24. *Toxoplasma gondii* may develop in the following intermediate hosts, EXCEPT for:

A Human;
B Cattle
C Birds
D Pigs
E Fish

25. Which of the following Protozoans may affect brain and eyes in human?

A *Leishmania infantum*;
B *Giardia lamblia;*
C *Malaria parasites;*
D *Toxoplasma gondii;*
E *Entamoeba gingivalis*

26. Which of the following infections during pregnancy may be manifested as congenital disorders and mental retardation in the newborn?

A Toxoplasmosis;
B Trypanosomosis;
C Tryhomonosis;
D Malaria;
E Leishmaniasis

27. Infective stage of Toxoplasma in fecal-oral mode of transmission is

A Endozoit;
B Tissue cyst;
C Pseudocycts;
D Oocyst;
E Schizont.

28. Human being gets toxoplasmosis by:

A Eating contaminated meat
B Close contact with cat (through dirty hands)
C Soiled fingers
D Penetration of toxoplasma through placenta;
E All of the above

29. Human being may get infected with toxoplasmosis by consuming all products EXCEPT for:

A Pork;
B Milk;
C Poultry
D Beef
E Fish

30. Cat is the definitive host for toxoplasma, because in its organism occurs:

A Endodiogeny;
B Schizogony;
C Gametogony;
D Sporogony

31. The following methods are used in laboratory diagnosing of Toxoplasmosis:

A Serologic tests
B Parasitological methods;
C Laboratory animals inoculation
D Skin allergic tests
E ALL answers are correct

32. Which of the following organism(s) is the source of infection in case of fecal-oral mode of transmission?

A Human
B Cats;
C Cattle
D Pigs;
E Frogs

33. In the healthy toxoplasma carriers Toxoplasma persists on the following stage:

A oocysts;
B Schizont;
C true cyst
D pseudocyst

34. Toxoplasma inhabits:

A Spleen;
B Lungs;

C Brain;
D Kidneys
E ALL answers are correct

35. Serological tests are used for the diagnosis of:
A Giardiasis;
B Toxoplasmosis;
C Amoebiasis
D Trichomoniasis;
E Balantidiasis

36. Which of the following is a HIV associated infection?
A Acute toxoplasmosis in adults;
B Trichomonosis;
C Malaria;
D Amoebiasis;
E Giardiasis;

37. A lymph node punctate of a patient with suspected protozoan disease was examined. Examination of the stained specimen (Romanovsky's stain) revealed some crescent bodies with pointed end, blue cytoplasm and red nucleus. What protozoans were revealed?
A Toxoplasma
B Malarial plasmodium
C Dermotropic leishmania
D Viscerotropic leishmania
E Trypanosomes

38. A woman delivered a dead child with multiple developmental defects. What protozoan disease might have caused the intrauterine death?
A Amebiasis
B Leishmaniasis
C Malaria
D Toxoplasmosis
E Lambliasis

39. Examination of a man revealed a protozoan disease that affects brain and causes vision loss. Blood analysis revealed unicellular half-moon-shaped organisms with pointed end. The causative agent of this disease is:
A Leishmania
B Toxoplasma
C Lamblia
D Amoeba
E Trichmonas

40. A woman gave birth to a dead child with many defects. Which protozoan disease could result in intrauterine fetal death?
A Toxoplasmosis
B Amoebiasis
C Malaria
D Leishmaniasis
E Giardiasis

41. A person has a preliminary diagnosis of toxoplasmosis. What material is used for laboratory diagnosis of the disease?
A Duodenal contents
B Faeces
C Urine
D Blood
E Sputum

42. The family came for medical-genetic consultation because of the birth of a child with multiple malformations (microcephaly, idiocy, etc). Woman during pregnancy was ill, but didn't contact with any mutagens and teratogens. The karyotype of the parents and child is normal. Doctor have cleared that family keeps the cat. What could be the likely cause of the child affection?
A While pregnant woman was sick with toxoplasmosis
B While pregnant woman was sick with leishmaniasis
C While pregnant woman was sick with dysentery
D While pregnant woman was sick with balantidiasis
E While pregnant woman was sick with trichomoniasis

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Flat worms. Flukes. Liver fluke, cat fluke, Chinese liver fluke, lung fluke and lancet fluke.

Practical class 23. Flat worms. Flukes. Liver fluke, cat fluke, Chinese liver fluke, lung fluke and lancet fluke.

The Purpose of the Lesson. To study the characteristics of the flatworms, trematodes. To study morphology, life cycles and pathogenic action of trematodes, laboratory diagnosis and prevention of the diseases caused by these parasites.

TOPIC CONTENT

1. General characteristics of the Flat worms.
2. Morphology and life cycle of trematodes.
3. Liver fluke: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
4. Cat fluke: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
5. Lung fluke: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
6. Blood flukes: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.

TEST QUESTIONS for individual work

№	Questions	Answers	
1	Biohelminthes are…		
2	Geohelminthes are…….		
3	Give the general characteristics of flukes	**a)** body shape	**b)** body cavity
		c) body wall	
		d) digestive system	
		e) excretory system	
		f) nervous system	
		g) female reproductive system	
		h) male reproductive system	
4	Which of the flukes are dioecious?		
5	List the consequent stages of development of the trematodes, starting from the egg **Egg** →		
6	Give the main characteristic of liver fluke		
	-Latin name		

	-name of the disease	
	-definitive host	
	-intermediate host	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-location in a human organism	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
7	Give the main characteristic of cat fluke	
	-Latin name	
	-name of the disease	
	-definitive host	
	-intermediate host	**first** **second**
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-location in a human organism	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
8	Give the main characteristic of lung fluke	
	-Latin name	
	-name of the disease	
	-definitive host	
	-intermediate host	**first** **second**
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-location in a human organism	
	-pathogenic effect	
	-laboratory test	

	-personal prevention	
9	What are the peculiarities of blood fluke?	**a) morphological**
		b) in the life cycle

Literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 275-289; 325-331;335-336.

Phylum: Plathelminthes
Class: Trematodes
Species: *Fasciola hepatica* (the liver fluke),
Opisthorchis felineus (the cat fluke),
Clonorchis (Op.) sinensis (the Chinese liver fluke),
Paragonimus ringeri (the lung fluke),
Schistosoma haematobium (the blood fluke),
S. japonicum, S. mansoni

Parasitic worms are **helminthes,** diseases are **helminthoses**.

Flatworms includes flukes (class Trematodes) and tapeworms (class Cestodes). All of them are biohelminthes. **Biohelminthes** are worms that have definitive and intermediate hosts. Adult worms live and multiply sexually in the organism of **definitive host.** Larvae develop in the organism of **intermediate host**.

Class trematodes

Trematodes have flat leaf-like body. They have oral and ventral suckers for fixation. Flukes are hermaphrodites.

All flukes are biohelminthes.

Life cycle of Trematodes (trematode type of development):

1. **Adult worms produce eggs (ova). Eggs of trematodes are operculated.**
2. The **eggs get into water** were **miracidium** (Ist larva) hatches out**.**
3. **Miracidium** get into **intermediate host - freshwater snail (mollusk).**
4. Inside snail the **miracidium** transform into **sporocyst**, than **rediae** and **cercariae.**
5. **Cercariae come out** from mollusk and form **metacercariae,** which are **infective for definitive host. In some species metacercariae develop on water plants (adolescariae) and definitive host gets the desease with water plants. In other species cercariae get into second intermediate host. In this case definitive host gets the disease by eating meat of intermediate host with metacercariae**.

Fasciola hepatica

Fasciola hepatica or Liver fluke is an agent of fascioliasis.

Morphology. The adult worm is leaf-shaped, 30 mm long. The eggs are about 140 □m in size.

Life cycle. **Definitive hosts are herbivorous animals - sheep (main reservoir host), cattle, pigs, horses and sometimes humans.**

Intermediate host is **snail.**

Location on organism of definitive host. **Bile ducts (liver) of the definitive host.**

Man gets the disease trough water or water vegetation with adolescaria. Parasites become mature in 3-4 month.

Pathogenicity. Fasciola causes mechanical injury of the liver and **jaundice, hepatomegaly,** then **liver fibrosis and cancer**. Metabolic products of the helminthes cause **toxic-allergic reactions**.

Diagnosis. Demonstration of the e**ggs (ovoscopy) in feces or bile.**

Prophylaxis: to **boil water and to wash vegetables.**

Opistorchis felineus

Opistorchis felineus (cat fluke) and **Clonorchis sinensis** (Chinese or Oriental liver fluke) are the agents of **opistorchiasis** and **clonorchiasis**. Opistorchis species resemble C. sinensis by morphology, life cycles and medical aspects, but have different geographical distribution.

***Morphology*.** The body is 8-13 mm long.

Life cycle. Development is in 3 hosts - one definitive and 2 intermediate hosts. Definitive hosts are humans, cats, dogs, rats, pigs. ***Location*** in the organism of definitive host is the bile ducts, gall bladder, pancreatic ducts

I intermediate host is **snail**, II – **fish.** Metacercarium develops inside the fish **Infection occurs through row fish with metacercarium Parasite** live from 1 to 20 years.

Pathogenicity. Clinical manifestations is same as in fascioliasis.

Diagnosis Ovoscopy of feces or bile. Serologic tests at early stage of infection.

Prophylaxis: to cook fish properly.

Paragonimus ringeri

Paragonimus ringeri (westermani) or **lung fluke** is the agent of **paragonimiasis.**

Location. Typical location is the **lungs;** sometimes **liver, spleen, intestine, muscles, brain,** etc.

Life cycle. It passes its life cycle in **3 hosts: 1 definitive and 2 intermediate hosts. Definitive hosts are humans, dogs, cats, pigs and rodents. Intermediate host is fresh water snail**. **II host is fresh water crayfish or crab**. **The definitive host gets the disease by ingestion of raw or undercooked crayfish or crabs with metacercariae**.

***Pathogenicity*.** A patient have **cough and blood** streaked **sputum, chest pain**. A clinical and radiological picture of chronic infection **resembles tuberculosis**.

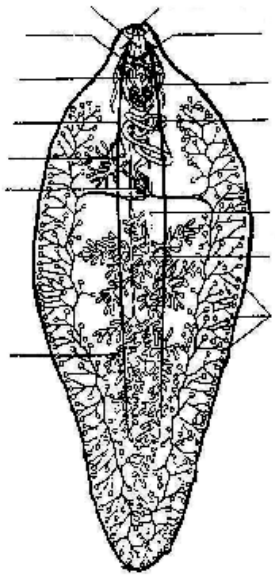
***Diagnosis.* eggs are found in sputum or feces** (ovoscopy). Serologic tests at early stage of the disease.

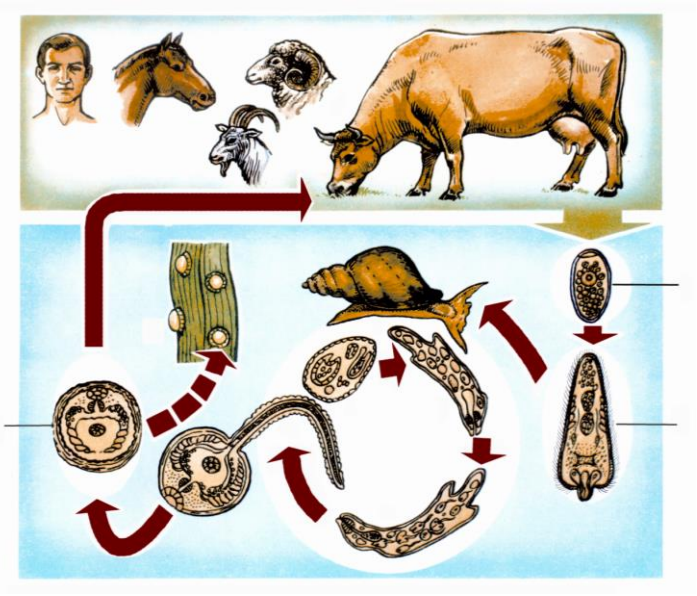
Prophylaxis: Personal prevention is adequate cooking of crabs and crayfish.

PRACTICAL WORK Trematods

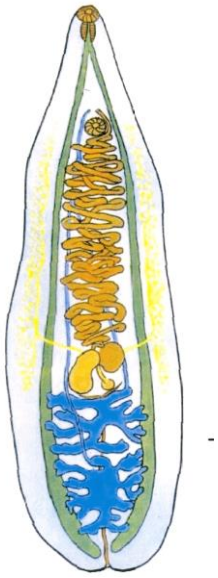
Task 1. Study under a microscope an adult form and an egg of liver fluke.

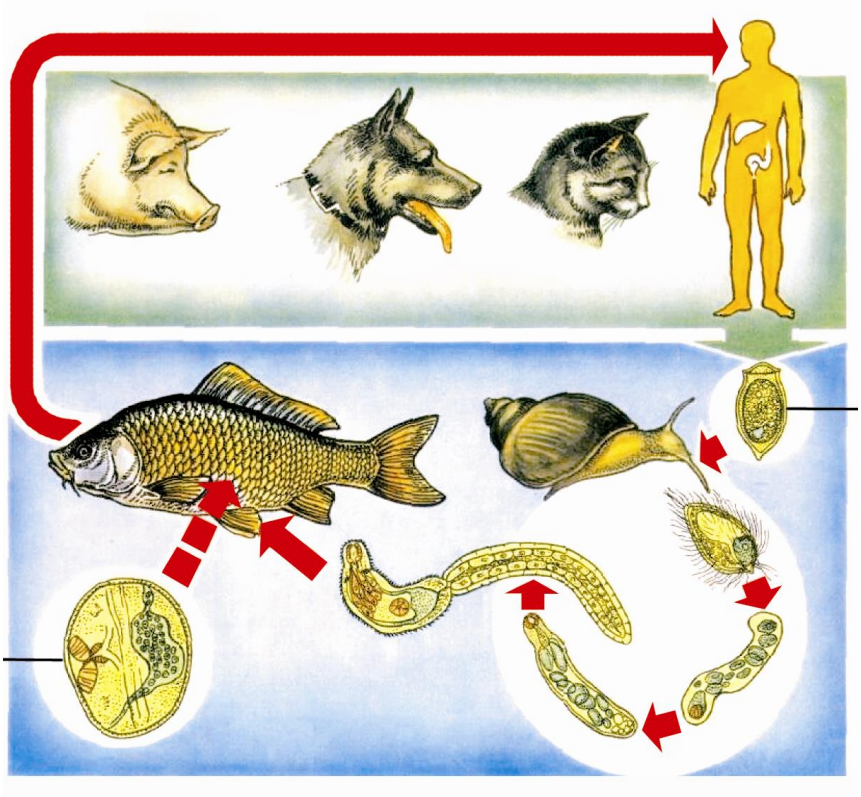
Pay attention to the shape and structure reproductive system, to shape and structure of the eggs.Study a life cycle of liver fluke development. Point out: egg, miracidium, sporocyst, redia, cercaria, adolescaria, marita of Fasciola.



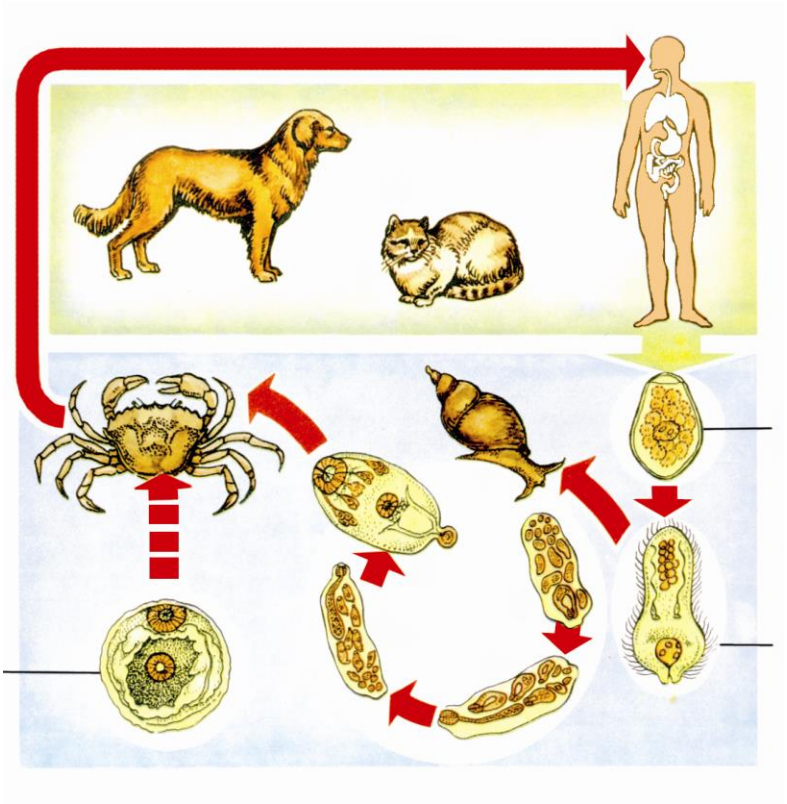


Task 2. Study under a microscope an adult form and an egg of Chinese liver fluke. Label definitive and intermediate hosts and stages of development.





Task 3. Study under a microscope an adult form and an egg of lung fluke. Label definitive and intermediate hosts and stages of development.



Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Bile ducts and gull bladder in human are inhabited by:
   - ***A*** Blood fluke
   - ***B*** Beef tapeworm
   - ***C*** Cat fluke
   - ***D*** Lung fluke
   - ***E*** Ascaris

2. Blood vessels in human may be inhabited by:
   - ***A*** *Paragonimus westermanii*
   - ***B*** *Opisthorchis felineus*
   - ***C*** *Schistosoma haematobium*
   - ***D*** *Fasciola hepatica*
   - ***E*** *Dicrocoelium lanceatum*

3. Eggs of a certain helminth were discovered in a sputum of pneumonic patient. These are the eggs of:
   - ***A*** *Fasciola hepatica*
   - ***B*** *Opisthorchis felineus*
   - ***C*** *Schistozoma haematobium*
   - ***D*** *Paragonimus ringeri*
   - ***E*** *Enterobius vermicularis*

4. The following stage of liver fluke is infective for a human:
   - ***A*** Egg
   - ***B*** Sporocyst
   - ***C*** Redia
   - ***D*** Cercaria
   - ***E*** Adolescaria

5. The following stage of cat fluke is infective for a human:
   - ***A*** Egg
   - ***B*** Sporocyst
   - ***C*** Redia
   - ***D*** Cercaria
   - ***E*** Metacercaria

6. *Paragonimus ringeri* inhabits:
   - ***A*** Blood vessels
   - ***B*** Liver
   - ***C*** Lungs
   - ***D*** Muscles
   - ***E*** Duodenum

7. Fascioliasis is caused by:
   - ***A*** Liver fluke
   - ***B*** Blood fluke
   - ***C*** Lung fluke
   - ***D*** Cat fluke
   - ***E*** Dicrocoelum

8. Fill in gap: clinical manifestation of _____ is quite close to tuberculosis manifestation:
   - ***A*** Opisthorchiasis
   - ***B*** Paragonimiasis
   - ***C*** Schistosomiasis
   - ***D*** Fascioliasis
   - ***E*** Dicrocoeliasis

9. Laboratory diagnosis of fascioliasis is based on:
   - ***A*** Muscles biopsy examination
   - ***B*** Ovoscopy of feces
   - ***C*** Serologic tests
   - ***D*** Sputum microscopy
   - ***E*** Urine microscopy

10. Laboratory test of paragonimiasis is based on:
   - ***A*** Serologic tests
   - ***B*** Urine microscopy
   - ***C*** Sputum microscopy
   - ***D*** Perianal mucous microscopy
   - ***E*** Muscles biopsy examination

11. Preventive measures against opistorchiasis include:
   - ***A*** Washing hands
   - ***B*** Washing fruits and vegetables
   - ***C*** Patients isolation
   - ***D*** Consuming well-done fish only
   - ***E*** Mechanical carriers extermination

12. Human being may get cat fluke infection by eating:
   - ***A*** Fish
   - ***B*** Crawfish and crabs
   - ***C*** Unwashed vegetables
   - ***D*** Pork
   - ***E*** Beef

13. Person complains of periodical vomiting, and stomachache. Liver is enlarged and dense. Microscopic examination of feces demonstrates large oval-shaped operculated eggs (140x80 μm in size). What disease may be suspected?
   - ***A*** Ascariasis
   - ***B*** Opistorchiasis
   - ***C*** Fascioliasis
   - ***D*** Paragonimiasis
   - ***E*** Schistosomiasis

14. Laboratory test for opisthorchiasis is:
   - ***A*** Muscle biopsy
   - ***B*** Serologic tests
   - ***C*** Feces microscopy
   - ***D*** Sputum microscopy
   - ***E*** Urine microscopy

15. Abdominal veins may be inhabited by:
   - ***A*** *Fasciola hepatica*
   - ***B*** *Opisthorchis felineus*
   - ***C*** *Paragonimus ringeri*
   - ***D*** *Schistozoma hematobium*
   - ***E*** *Dicrocoelium lanceatum*

16 The patient was diagnosed fascioliasis after the laboratory examination. He could become infected by consuming:
   - ***A*** Non-boiled water from the pond
   - ***B*** Infected crawfish
   - ***C*** Infected fish
   - ***D*** Infected liver
   - ***E*** Infected meat

17. A male patient has fever and enanthesis. As a result of the examination involving serological tests he has been diagnosed with *Fasciola hepatica*. It was found out that

the patient had been infected through raw river water. Which stage of fasciola life cycle is invasive for humans?

A Miracidium
B Ovum
C Cysticercus
D Adolescaria
E Metacercaria

18. A man visited Lebanon. Soon after return he felt pain and heaviness in the peritoneum and suprapubic region. On examination he was diagnosed with urogenital schistosimiasis. In what way could he become infected?

A By eating insufficiently salted fish
B By eating unwashed fruit and vegetables
C By eating undercooked meat of cattle
D By swimming in contaminated water
E By eating undercooked meat or crayfish and crabs

19. A patient complains of pain in the area of his liver. Duodenal intubation revealed yellowish, oval, narrowed at the poles eggs with an operculum at the end. Size of these eggs is the smallest among all helminthes eggs. What is the most probable diagnosis?

A Teniasis
B Opisthorchiasis
C Beef tapeworm infection
D Echinococcosis
E Diphyllobothriasis

20. Small operculated eggs were found during the coprologic test (laboratory analysis of feces) of a patient. It is known that the patient consume fish often. Which trematode possibly parasitizes?

A Cat fluke
B Blood fluke
C Lung fluke
D Liver fluke
E Lancelet fluke

21. The patient while coughing expels rusty-brown sputum, in which oval, golden-brown eggs about 0.1 mm the size are determined. What is the diagnosis?

A Schistosomiasis
B Paragonimiasis
C Fascioliasis
D Opisthorchiasis
E Dicroceliasis

22. A patient has been preliminarily diagnosed with paragonimiasis. This disease is caused by lung flukes. The causative agent entered into the patient's body through:

A Eating half-cooked or dried fish
B Eating unwashed vegetables
C Contact with an infected cat
D Eating half-cooked crawfish and crabs
E Drinking raw water from open reservoirs

23. The examination of a foreigner revealed intestinal schistosomiasis. How could the patient be infected?

A Through insects bites
B While eating meat
C While eating fish
D Through dirty hands
E During river swimming

24. A patient consulted an urologist about pain during urination. Analysis of his urine taken in the daytime revealed eggs with a characteristic sharp point. It is known from the anamnesis that the patient has recently returned from Australia. What is the most likely diagnosis?

A Opisthorchiasis
B Intestinal schistosomiasis
C Japanese schistosomiasis
D Urogenital schistosomiasis
E Dicroceliasis

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Tapeworms. Pork (armed) and beef (unarmed) tape worms.

Practical class 24. Pork (armed) and beef (unarmed) tape worms.

The Purpose of the Lesson. To study morphology, life cycles and pathogenic action of beef and pork tapeworms. To study out the methods of laboratory diagnosis and prevention of the taeniasis, cysticercosis, taeniarhynhiasis.

TOPIC CONTENT

1. General characteristics and life cycle of cestodes.
2. Beef tape worm: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
3. Pork tape worm: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
4. Autoinvasion. Cysticercosis: ways of infection, laboratory diagnosis, prevention.

TEST QUESTIONS for individual work

№	Questions	Answers	
1	What are the peculiarities of the tapeworms?	body shape	
		parts of the body and its function a) b) c)	
		peculiarities of structure (a) and functions(b, c) of the body covering	
		peculiarity of the nutrition	
		are they bio- or geohelminthes?	
2	List the consequent stages of development of the cestodes, starting from the egg **Egg →**		
3	What is location of the adult worm in an organism of a definitive host?		
4	Which types of phynns have cestodes? Give the examples of the worms.	a	
		b	
		c	
		d	
		e	
		f	
5	Give the main characteristics of beef tapeworm		
	-Latin name		
	-name of the disease		
	- size of the body		
	-peculiarities of the scolex		
	-definitive host		
	-intermediate host		
	-the way of invasion for a human being		
	- invasive stage for a human being		
	-pathogenic effect		
	-laboratory test		
	-personal prevention		
6	Give the main characteristics of pork tapeworm		
	-Latin name		
	-name of the diseases	**a)**	**b)**
	- size of the body		
	-peculiarities of the scolex		

	-definitive host	
	-intermediate host	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
7	What is autoinvasion?	
8	What is cysticercosis?	
9	How can human being get cysticercosis?	**a)**
		b)
10	What is laboratory test for cysticercosis?	

11 What are the main discrimination criteria between beef and pork tapeworms?

	beef tapeworm	pork tapeworm
a) scolex		
b) mature segment		
c) gravid segment		

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 289-296; 325-331;332-336.

P**hylum:Plathelminthes**
Class: Cestoidea
Subclass: Cestoda
Species: *Taenia solium* (Armed tapeworm or pork tapeworm)
***Taeniarhynchus saginatus* (Unarmed tapeworm or beef tape**

Cestodes have

- Segmented tape–like body.
- The body has small head (scolex), a short neck and trunk or strobila, composed of segments (proglottids).
- The reproductive system is hermaphrodite.
- All tapeworms are biohelminths.

The eggs of Cestodes contain the first stage larva - oncosphere. Egg with oncosphere

is an infective stage for the intermediate host.

Phynn is the infective stage for the definitive host. The adult worm or the larval form both can cause clinical disease. The diseases caused by tapeworms have a common name cestoidoses.

Armed or pork tapeworm (Taenia solium) is an agent of
taeniasis (adult worm) and cysticercosis (larva).

Location. The adult worm lives in the human small intestine,
Morphology. The adult worm is 2 to 3 meters long
The **ovary** consists of **3 lobes.**
The **mature uterus** in the gravid segments consists of **7-12 branches**.
Eggs of Taenia solium are oval or round in shape, transparent and colorless.
Phynn is of cysticercus
Life cycle. **Definitive host is human being.**
Intermediate hosts are pigs, sometimes human being, wild and domestic dogs, cats.

Human being can be infected through inadequately cooked measly pork.
Man can also be an intermediate host for solitary tapeworm:

- most commonly by the accidental ingestion of eggs w**ith water or vegetables;**
- by retrograde peristalasis the segments may be regurgitated in stomach causing **autoinfection.** Eggs are digested and thousands of eggs released. **External re-infection occurring from anus to fingers to mouth is also possible.**

Cysticerci can be in **brain, eyes, and subcutaneous tissue,** , **muscles**

Pathogenicity: Adult worm causes **taeniasis:** mechanical injuring of the intestinal mucosa, absorption of nutrients and formation of pathologic intestinal reflexes. The disease manifests as abdominal discomfort, alternating diarrhea and constipation, anemia, weakness, loss of weight, fatigue.

Cysticercus larvae in humans cause cysticercosis.: epilepsy, behavioral disorders, hydrocephalus and pareses.

***Laboratory diagnosis*:** helminthoscopy

The **diagnosis of cysticercosis** is done by **biopsy of the lesion, X-rays or CT scanning and immunodiagnosis (serologic tests).**

Prophylaxis:

Personal prevention is not to eat raw or partly cooked pork.

Control of the disease includes prevention of contamination of water and soil with human feces; adequate inspection of pork at slaughterhouses and markets; revealing and treatment of infected persons; health education.

Unarmed tapeworm or beef tapeworm (Taeniarhynchus saginatus) is the agent of **taeniarhynchiasis.**

Geographical distribution. Worldwide.

Location. The adult worm lives in the human small intestine.

Morphology. The adult worm is about 5 –12 m. Scolex is 1.5-2 mm equipped with 4 suckers. . **Ovary is composed of 2 lobes**.

The **uterus of the gravid segment has 17-35 branches.** The gravid segments are expelled singly and can crawl out of the anus, so the eggs are laid in the perianal skin.

Life cycle. The definitive host is human being, intermediate host is a cattle (cow, zebu, buffalo).

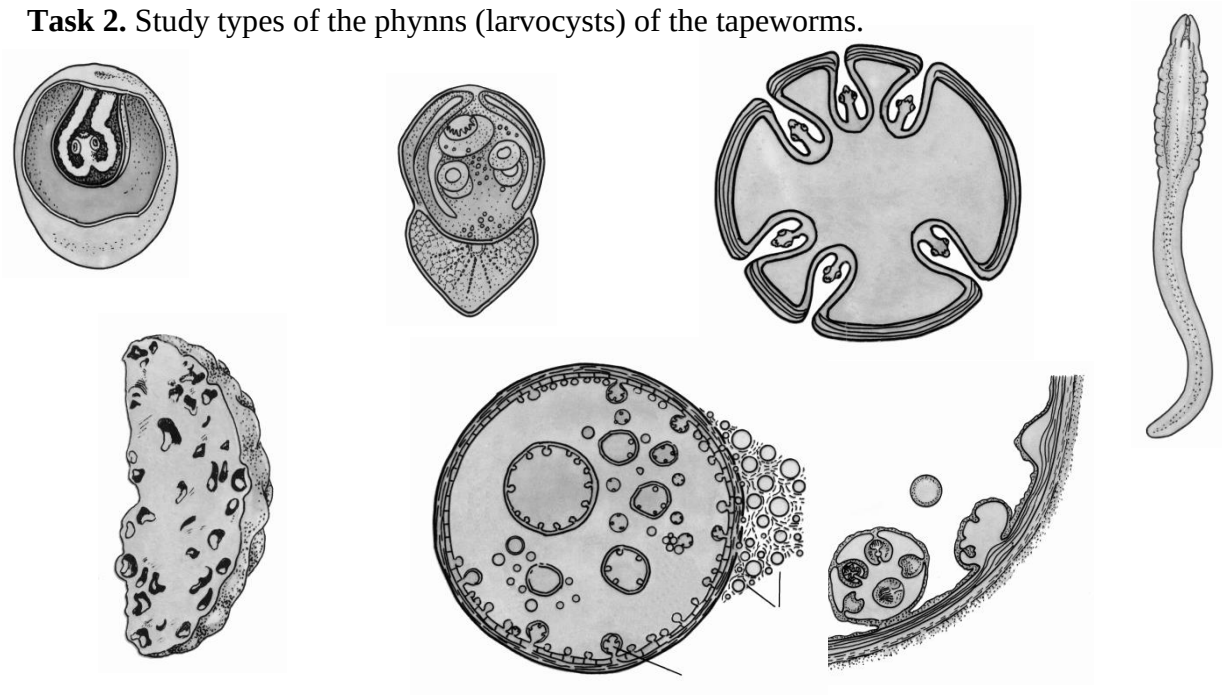
Humans are infected while eating undercooked beef with cysticerci (“measly beef”).

Diagnosis: ***demonstration of*** *proglottids in feces or eggs in perianal scraping.*

PACTICAL WORK Cestodes

Task 1. Study classification of the tape worms**.** Write down the Latin names of the parasites
Phylum *Plathelminthes*
Class *Cestoidea*
Species: Beef (unarmed) tapeworm _____
Pork (armed) tapeworm _____

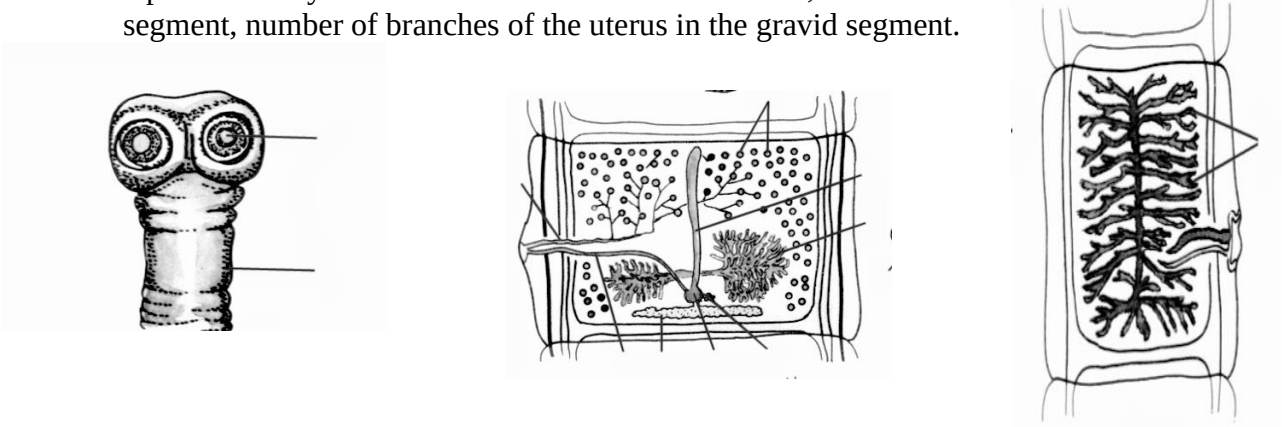
Task 2. Study types of the phynns (larvocysts) of the tapeworms.



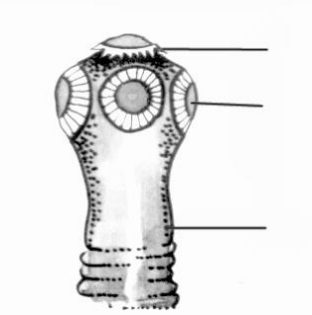
Fill the table

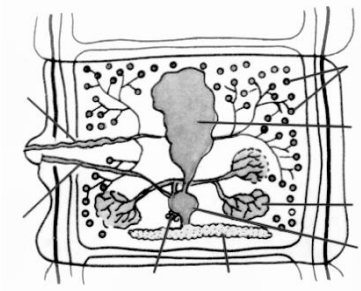
	Name of larva	Species of the tapeworms
1		
2		
3		
4		
5		
6		

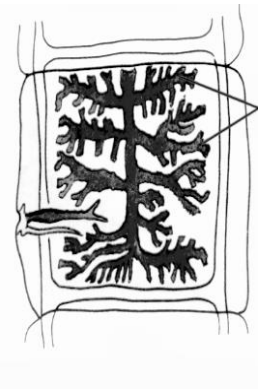
Task 3. Study under the microscope structure of scolex, mature and gravid proglottid of a beef tapeworm. Pay attention to suckers on the scolex, number of ovarian lobes in the mature segment, number of branches of the uterus in the gravid segment.



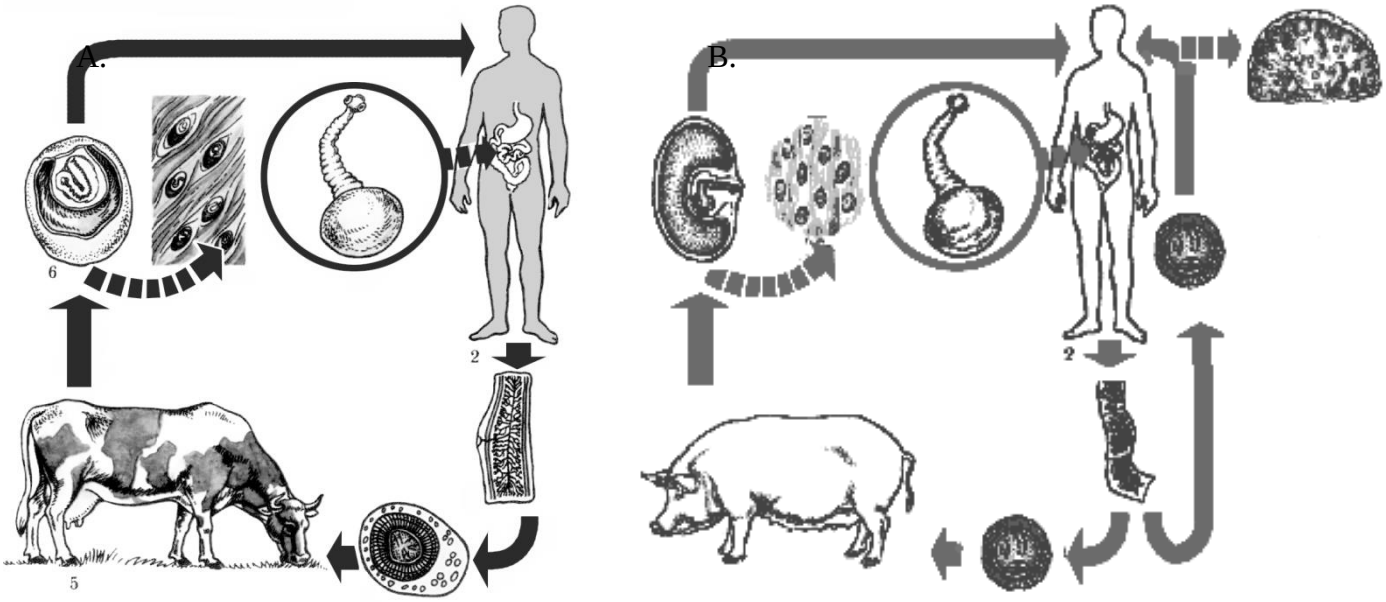
Task 4. Study under the microscope structure of scolex, mature and gravid proglottid of a pork tapeworm. Pay attention to suckers on the scolex, number of ovarian lobes in the mature segment, number of branches of the uterus in the gravid segment.







Task 5. Study a scheme of life cycles of beef (A) and pork (B) tapeworms. Label the stages of development, definitive and intermediate hosts.



Task 6. Fill a table of differential diagnostic of beef and pork tapeworms.

Diagnostic criteria	Beef tapeworm	Pork tapeworm
Length (m) of mature parasite		
Size of the proglottids		
Organs of fixation		
Number of lobes of ovary in the mature segment.		
Number of branches of uterus in the gravid segment.		

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Unarmed tapeworm is an agent of:
   - ***A*** Fascioliasis
   - ***B*** Taeniasis
   - ***C*** Paragonimiasis
   - ***D*** Taeniarhynchias
   - ***E*** Opistorchiasis

2. Armed tapeworm is an agent of:
   - ***A*** Opistorchiasis
   - ***B*** Fascioliasis
   - ***C*** Taeniasis
   - ***D*** Taeniarhynchiasis
   - ***E*** Paragonimiasis

3. Armed tapeworm larvae are agents of:
   - ***A*** Taeniasis
   - ***B*** Taeniarhynchiasis
   - ***C*** Paragonimiasis
   - ***D*** Cysticercosis
   - ***E*** Hymenolepiasis

4. Which of the following is an invasive stage of a beef tapeworm for a human being?
   - ***A*** Egg
   - ***B*** Cysticercus
   - ***C*** Cysticercoid
   - ***D*** Echinococcus (hydatid) cyst
   - ***E*** Plerocercoid

5. Laboratory diagnosis of taeniasis is based on:
   - ***A*** Demonstration of eggs in perianal mucus
   - ***B*** Demonstration of proglottides in feces
   - ***C*** Serum tests
   - ***D*** Blood tests
   - ***E*** Biopsy of muscular tissue

6. Which of the following may be regarded as taeniarhynchiasis preventive measures?
   - ***A*** Veterinary examination of pork
   - ***B*** Boiling water
   - ***C*** Keeping personal hygiene rules
   - ***D*** Proper cooking fish
   - ***E*** Proper cooking beef

7. Cysticercosis in human may result from:
   - ***A*** Echinococcosis
   - ***B*** Hymenolepiasis
   - ***C*** Taeniasis
   - ***D*** Taeniarhynchiasis
   - ***E*** Fasciolosis

8. By eating of pork which has not passed veterinary control is possible to get:
   - ***A*** *Taeniarhynchus saginatus*
   - ***B*** *Echinococcus granulosus*
   - ***C*** *Taeina solium*
   - ***D*** *Fasciola hepatica*
   - ***E*** *Opisthorchis felineus*

9. Human may be infected with *Taeniarhynchus saginatus* by:
   - ***A*** Contacts with cats
   - ***B*** Consuming crabs and crawfish
   - ***C*** Contacts with dogs
   - ***D*** Eating contaminated beef
   - ***E*** Eating contaminated pork

10. Which is a beef tapeworm infective stage for humans?
   - ***A*** Egg
   - ***B*** Cysticercus
   - ***C*** Cysticercoid
   - ***D*** Echinococcus
   - ***E*** Plerocercoid

11. Laboratory diagnosis of a Beef tapeworm infection is based on:
   - ***A*** Discovery of eggs in urine
   - ***B*** Muscles biopsy
   - ***C*** Discovery of proglottides in feces
   - ***D*** Immunological tests
   - ***E*** Blood tests

12. Which of the following may be regarded as taeniasis preventive measures:
   - ***A*** Boiling water
   - ***B*** Eating properly cooked fish
   - ***C*** Veterinary examination of pork
   - ***D*** Veterinary examination of beef
   - ***E*** Keeping personal hygiene rules

13. Which of the following may be regarded as cysticercosis preventive measures:
   - ***A*** Veterinary examination of beef
   - ***B*** Keeping personal hygiene rules
   - ***C*** Veterinary examination of pork
   - ***D*** Eating properly cooked fish
   - ***E*** Isolation of seek persons

14. Larvae of which parasite can inhabit brain?
   - ***A*** Beef tapeworm
   - ***B*** Pork tapeworm
   - ***C*** Dwarf tapeworm
   - ***D*** Liver fluke
   - ***E*** Cat fluke

15. Beef tapeworm infection manifests as:
   - ***A*** Disorders of digestion
   - ***B*** Obstruction of the bile ducts
   - ***C*** Malignant anemia
   - ***D*** Appendicitis
   - ***E*** Facial edema, edema of the eyelids

16. Father bought some pork at the market. What disease may catch members of his family provided that this meat didn't pass the veterinary control?
   - ***A*** Hymenolepiasis
   - ***B*** Beef tapeworm infection
   - ***C*** Pork tapeworm infection
   - ***D*** Echinococcosis
   - ***E*** Liver fluke infection

17. Helminth about 2 meters in length was expelled with feces during the specific treatment. The body is segmented, with a small head, which bears four suckers and hooks. Determine the species of the helminth
   - ***A*** Echinococcus
   - ***B*** Unarmed tape worm
   - ***C*** Dwarf tapeworm
   - ***D*** Armed tape worm
   - ***E*** Broad tapeworm

18. Gravid immotile segments of the tapeworm are detected in the feces of the patient with digestive disorders; the uterus in the segments has 7-12 lateral branches. Which helminthes it?
   - ***A*** Armed tape worm
   - ***B*** Unarmed tape worm
   - ***C*** Dwarf tapeworm
   - ***D*** Echinococcus
   - ***E*** Broad tapeworm

19. Cysticerci were found in brain tissue of the women during the section. The cause of death was determined the brain cysticercosis. Which parasite caused this disease?

A *Taeniarhynchus saginatus*
B *Taenia solium*
C *Fasciola hepatica*
D *Hymenolepis nana*
E *Alveococcus multilocularis*

20. A 35-year-old-man who lost his sight in one eye has been admitted to the hospital. From the life history it is known that the patient like to eat half-raw pork skewers. After X-ray and an immunological studies doctor diagnosed cysticercosis. Which helminth is the causative agent of this disease?

A *Fasciola hepatica*
B *Taeniarhynchus saginatus*
C *Taenia solium*
D *Hymenolepis nana*
E *Alveococcus multilocularis*

21. The patient complaints of presence in the feces white flat motile formations that resemble the noodles. Revealed segments have following characteristics: a long, narrow, with dendritic uterus, which has 17-35 of the lateral branches on each side Which helminth parasite in the intestine of a woman?

A *Echinococcus granulosus*
B *Taenia solium*
C *Hymenolepis nana*
D *Diphyllobothrium latum*
E *Taeniarhynchus saginatus*

22. In case of some helminthiasis an affected person can detect helminthes himself because mature segments of the causative agent are able to crawl out of the anus. This is typical for following disease:

A Beef tapeworm infection
B Pork tapeworm infection
C Bothriocephalosis
D Hymenolepiasis
E Echinococcus

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Tapeworms. Dwarf tapeworm, echinococcus, alveococcus, broad tapeworm.

Practical class 25. Tapeworms. Dwarf tapeworm, echinococcus, alveococcus, broad tapeworm.

The Purpose of the Lesson. To study morphology, life cycles and pathogenic action of the dwarf tapeworm, broad tapeworm, echinococcus and alveococcus. To study out the methods of laboratory diagnosis and prevention of the diseases caused by these parasites.

TOPIC CONTENT

1. Dwarf tapeworm: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
2. Broad tapeworm: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention
3. Echinococcus: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
4. Alveococcus: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.

TEST QUESTIONS for individual work

№	Questions	Answers
1	Give the main characteristics of a dwarf tapeworm	
	-Latin name	
	-name of the disease	
	- size of the body	
	-peculiarities of the scolex	
	- type of the phynn	
	-definitive host	
	-intermediate host	

	-the way of invasion for a human being			
	- invasive stage for a human being			
	-pathogenic effect			
	-laboratory test			
	-personal prevention			
2	Give the main characteristics of an echinococcosis			
	-Latin name			
	-name of the diseases			
	- size of the body			
	-number of the proglottids			
	-peculiarities of the scolex			
	- type of the phynn			
	-definitive host			
	-intermediate host			
	-the way of invasion for a human being			
	- invasive stage for a human being			
	- location in the human organism			
	-pathogenic effect			
	-treatment			
	-laboratory diagnosis			
	-personal prevention			
3	What distinguishes alveococcus from echinococcus?			
	a) hosts	definitive intermediate		
	b) way of invasion for a human being			
	c) structure of the phynn			
4	Give the main characteristics of a broad tapeworm			
	-Latin name			
	-name of the diseases			
	- size of the body			
	-peculiarities of the scolex			
	- shape of the gravid segment			
	- larval sages	**1st**	**2nd**	**3rd**

	-definitive host	
	-intermediate host	**first** **second**
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory diagnosis	
	-personal prevention	
5	At which of these diseases both autinvasion and autoreinvasion occurs?(a)	
6	For which of these parasites human being is a blind alley in its life cycle? (a,b)	
7	Which of these diseases are natural-foci? (a, b)	

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 296-303; 325-336.

Echinococcus granulosus is the causative agent of

echinococcosis (hydatid disease). The disease in humans is caused by larval stage of the parasite.

Geographical distribution. Worldwide. It is more prevalent in sheep and cattle raising regions with temperate climates.

Location. Hydatid cyst develops in human liver and lungs, brain, kidneys, pancreas, heart

Adult worm inhabits small intestine of the dogs.

Morphology. **The adult worm is 2-7 mm long.**

Eggs are spherical, 30 –40 μm in dogs feces

Phynn of echinococcus type (hydatid cyst) is shaped like a bladder filled with colorless toxic fluid with scolices Phynn grows in man about 5 cm a year

Life cycle is in 2 hosts. The **definitive host is a dog**

Intermediate hosts are most of mammals including sheep, cattle, goat, pigs, and man.

the eggs are passed out in the feces of the dog.

Human beings, sheep, cattle get the infection on ingestion of the eggs from contaminated food or water. Man often acquires the disease through d**irty hands after stroking infected dog**. **Eggs can be spread on grass** and then be transmitted **onto the sheep wool,** so infection may occur after **cutting the wool or its processing**.

The definitive hosts (dog, wolf) become infected while consuming the organs of animals with echinococcus cysts.

Pathogenicity

Clinical symptoms depend on the size and location of the cyst.

Diagnosis is done by **X-ray, ultra sound, CT methods, immunologic method (serologic tests)**.

Prophylaxis. Personal prevention is to wash hands after having touched dogs or taking care after sheep; to wash vegetables and fruit, boil water. Periodical deworming of guard and pet

dogs is useful.

Diphyllobothrium latum (broad tapeworm) **is an agent of** diphyllobothriosis.

Geographical distribution. The disease occurs in central and northern Europe, North America, Siberia, Japan and Central Africa.

Location. **Adult worm inhabits the small intestine of man**

Morphology. It measures 2 to 20m (usually 2-9 m) in length Scolex is elongated, spoon-shaped, 5 mm in sizewith 2 grooves (bothria)

Eggs are widely oval, operculated, bile-stained, 68-75 μm.

Phynn is of plerocercoid type 1-5 cm in length.

Life cycle. **The definitive hosts are man** , cat, dog, pig, fox, bear.

The **I intermediate host is fresh ware minor crustacean – cyclops**,

II intermediate host is fresh water fish (pike, soodak, perch, trout)

Eggs are passed in **human feces**

The **I larval stage coracidium** develops in water environment during 3-5 weeks

It **must be ingested by** a **cyclop** and turns into a **procercoid**.

If a cyclop is ingested by a **fish, plerocercoid** phynn d**evelops in its muscles, liver and ovary**.

Human being becomes infected through undercooked fish or fresh caviar. Plerocercoid larva is infective stage. Phynn turns into the mature worm in the small intestine **2 months later**. **Life span is about 10 years.**

Diphyllobothriosis is a nature-foci disease in areas with rivers and lakes.

Pathogenicity. *the infection is **mostly asymptomatic.** The infected person may suffer from abdominal pain, diarrhea, fatigue, headaches and constant loss of weight.*

It causes the **diphyllobothric anemia**

Diagnosis *is done by demonstration **of segments and eggs in stool**.*

Prophylaxis. **Personal prevention is to avoid eating raw or undercooked fish.**

PRACTICAL WORK Cestodes

Task 1. Study classification of the tape worms**.** Write down the Latin names of the parasites

Phylum *Plathelminthes*

Class *Cestoidea*

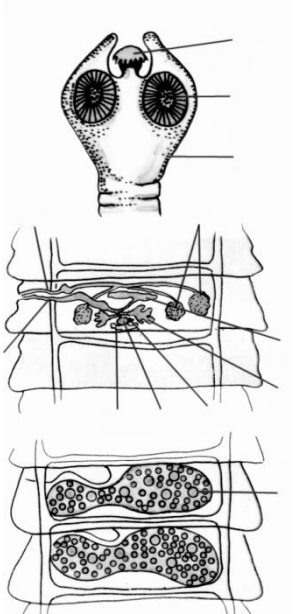
Species: dwarf tapeworm _____

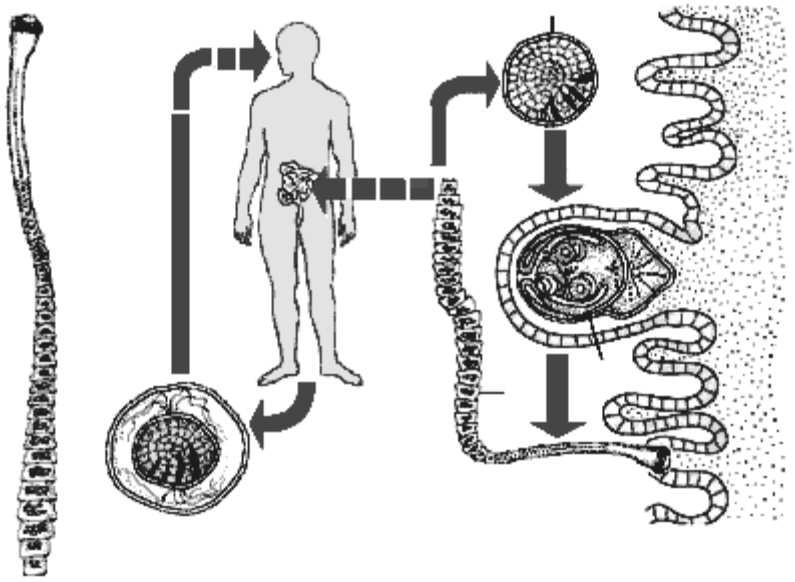
echinococcus _____

alveococcus _____

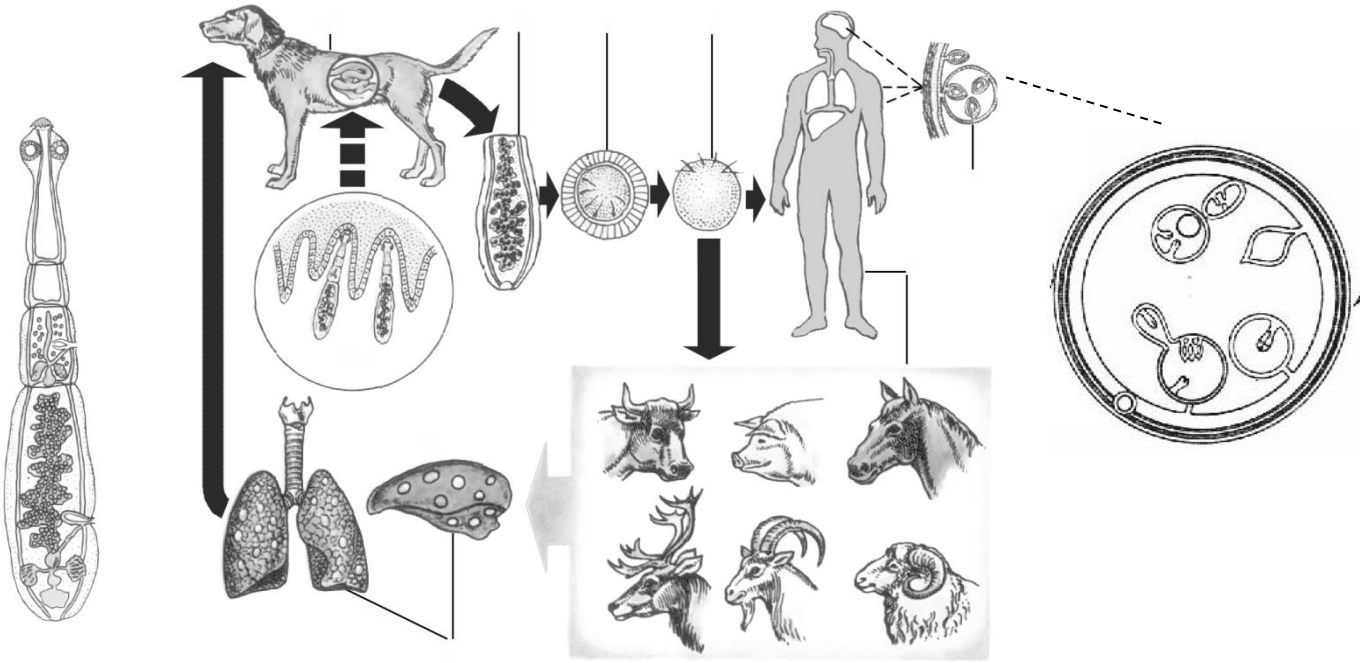
broad tapeworm _____

Task 2. Study the morphology and life cycle of dwarf tapeworm. Label the stages of development, definitive and intermediate hosts.

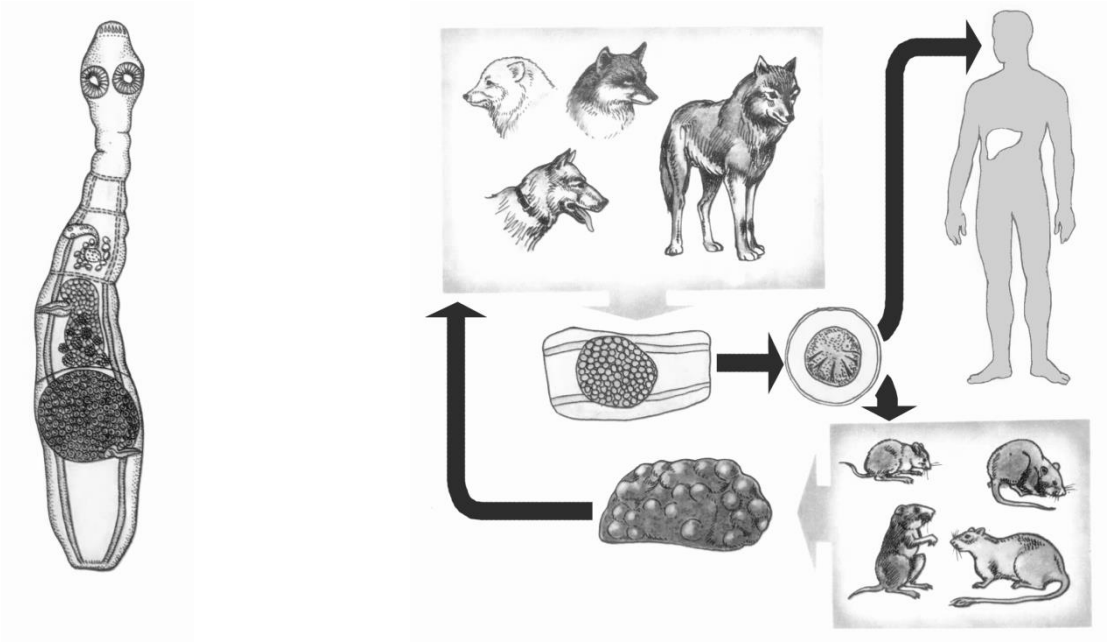




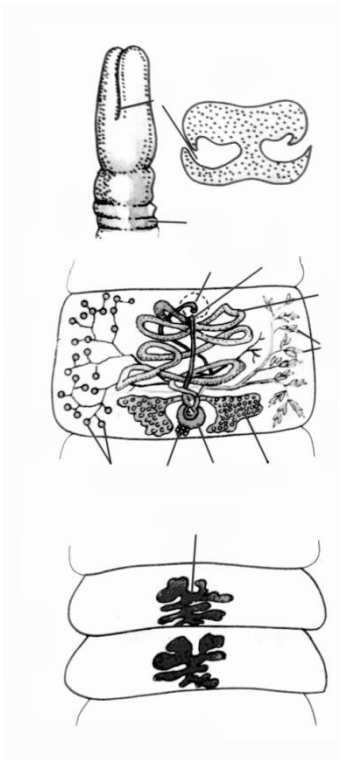
Task 3. Study the morphology and life cycle of dog tapeworm. Label the stages of development, structure of the echinococcus (hydatid) cyst, definitive and intermediate hosts.



Task 4. Study the morphology and life cycle of Alveococcus. Label the uterus of a gravid proglottid, stages of development, definitive and intermediate hosts.



Task 5. Study the morphology and life cycle of the broad tapeworm. Label the bothria on the scolex, uterus in the gravid proglottid, stages of development, definitive and intermediate hosts.



Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Long fragments of segmented helminthes were discharged with feces after a treatment of the patient. Width of the proglottids exceeds their length. Rosette-like uterus is in the center of proglottid. These are fragments of:
   - ***A*** Beef tapeworm
   - ***B*** Pork tapeworm
   - ***C*** Echinococcus
   - ***D*** Dwarf tape worm
   - ***E*** Broad tapeworm
2. It is possible to get diphyllobotriasis by eating:
   - ***A*** Crabs and crawfish
   - ***B*** Unwashed vegetables
   - ***C*** Improperly cooked meat
   - ***D*** Improperly cooked fish
   - ***E*** Contaminated water
3. Human being may get infected with hymenolepiasis through:
   - ***A*** Fish
   - ***B*** Dirty hands, contaminated vegetables and fruits
   - ***C*** Mosquito bites
   - ***D*** Crabs and crawfish
   - ***E*** Insufficiently roasted beef
4. What is the pathogenic action of a dwarf tapeworm?
   - ***A*** Liver, lungs and brain affection
   - ***B*** Malignant anemia
   - ***C*** Intestine villi destruction, intoxication
   - ***D*** Anemia, neurological disorders, appendicitis
   - ***E*** Eyelids and facial edema, fever and muscle pain
5. Laboratory diagnosis of echinococcosis (hydatid disease) includes:
   - ***A*** Immunological tests
   - ***B*** Feces examination
   - ***C*** Muscle biopsy
   - ***D*** Ovoscopy of urine
   - ***E*** Ovoscopy of the stool
6. Which of the following is the infective stage of Echinococcus for humans:
   - ***A*** Egg
   - ***B*** Plerocercoid
   - ***C*** Metacercaria
   - ***D*** Cysticercoid
   - ***E*** Cysticercus
7. Laboratory diagnosis of diphyllobotriasis includes:
   - ***A*** Feces examination
   - ***B*** Urine ovoscopy
   - ***C*** Immunological reactions
   - ***D*** Muscle biopsy
   - ***E*** Sputum microscopy

8. Which of the following refers to hymenolepiasis preventive measures:
A Keeping personal hygiene rules
B Consuming properly cooked fish
C Consuming properly cooked meat
D Veterinary control in markets and stores
E Consuming properly cooked crabs and crawfish

9. Which of the following refers to echinococcosis (hydatid disease) preventive measures?
A Veterinary control in the markets and stores
B Consuming properly cooked fish
C Washing hands after touching the dogs
D Consuming well-done meat
E Consuming properly cooked crabs and crawfish

10. Anemia due to the lack B12 vitamin is a symptom of:
A Taeniasis
B Taeriarhynchiasis
C Hymenolepiasis
D Echinococcosis
E Diphyllobotriasis

11. For which of the following infections human is the definitive host only:
A Taeniasis
B Alveococcosis
C Hymenolepiasis
D Echinococcosis
E Diphyllobotriasis

12. Malignant anemia is a symptom of infection caused by:
A Beef tapeworm
B Pork tapeworm
C Broad tapeworm
D Dwarf tapeworm
E Echinococcus

13. Vermiform white colored larvae up to 6 mm in length with two grooves on the frontal part of the body were discovered in muscles of fish. Eating this fish may be dangerous because of risk of
A Fascioliasis
B Opistorchiasis
C Paragonimiasis
D Taeniasis
E Diphyllobotriasis

14. What is the most typical location of Echinococcus larva in a human organism?
A Large intestine
B Small intestine
C Liver
D Blood
E Skin

15. Which of the following refers to diphyllobotriasis preventive measures?
A Avoid consuming raw or improperly cooked fish
B Keeping personal hygiene rules
C Beef veterinary control
D Pork veterinary control
E Consuming properly cooked crabs and crawfish

16. Brain is a possible habitat for:
A Cats fluke
B Echinococcus
C Dwarf tapeworm
D Unarmed tapeworm
E Broad tapeworm

I7. Which of the following helminthes is a hymenolepiasis agent?
A Dwarf tapeworm
B Beef tapeworm
C Broad tapeworm
D Pork tapeworm
E Liver fluke

18. Which of the following helminthes is a diphyllobotriasis agent?
A Dwarf tapeworm
B Beef tapeworm
C Broad tapeworm
D Pork tapeworm
E Liver fluke

19. Which of the cestodoses is a disease with a natural focus?
A Fascioliasis
B Hymenolepiasis
C Opistorchiasis
D Diphyllobotriasis
E Taeniasis

20. Small white segmented helminthes 1 to 2 cm in length were discovered in feces. Four suckers and trunk with hooks were found on scolex. These parasites are the agents of:
A Taeniasis
B Diphyllobotriasis
C Taeniarhynchiasis
D Hymenolepiaosis
E Echinococcosis (hydatid desease)

21. It is possible to get echinococcosis by:
A Consuming contaminated meat
B Contacting to sick persons
C Contacting to dogs
D Eating unwashed vegetables
E Through mosquito bites

22. Examination of FRESH feces is essential for laboratory diagnosis of
A Diphyllobotriasis
B Fascioliasis
C Opistorchiasis
D Hymenolepiasis
E Taeniarhynchiasis

23. The guide of the scientific expedition in India was native who always was with his dog. What invasive diseases can be transmitted by the dog if it is the source of invasion?
A Echinococcosis
B Teniasis
C Paragonimiasis
D Dicroceliasis
E Fascioliasis

24. A shepherd who has tended sheep together with dogs consulted a doctor about pain in his right subcostal area, nausea, vomiting. Roentgenoscopy revealed a tumor-like formation. What kind of helminthiasis might be suspected?
A Enterobiasis
B Ascaridiasis
C Echinococcosis
D Taeniarhynchosis

E Taeniasis

25. Conglomerate of tightly joined small bubbles with small amount of fluid was found in the liver of a patient during the surgical treatment. Which helminthiasis is found in the patient?

A Alveococcosis
B Clonorchiasis
C Opisthorchiasis
D Dicroceliasis
E Fascioliasis

26. Long segmented fragments of a certain helminth were detected in a patient after the treatment. Width of the segments exceeds the length; rosette-like structure is situated in the centre of the segments. Determine the species of helminth.

A Broad tape worm
B Armed tape worm
C Unarmed tape worm
D Alveococcus
E Dwarf tapeworm

27. The patient complains of loss of appetite, nausea, vomiting. B12 deficient anemia is detected. Which parasite that inhabits small intestines can cause this pathology?

A Broad tape worm
B Dwarf tapeworm
C Echiniciccus
D Alveococcus
E Whip worm

28. A female patient consulted a physician about digestive disorder, extended abdominal pain. Examination revealed drastic decrease in hemoglobin concentration. It is known from the anamnesis that while living in the Far East the patient used to eat freshly-salted caviar. Some relatives living with her had the similar condition. What is the most likely diagnosis?

A Diphyllobothriasis
B Echinococcosis
C Teniasis
D Trichiniasis
E Ascariasis

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Roundworms. Ascaris, pinworm, whipworm.

Practical class 26. Roundworms. Ascaris, pinworm, whipworm.

The Purpose of the Lesson. To study morphology, life cycles and pathogenic action of the ascaris, pinworm, whipworm. To study out the methods of laboratory diagnosis and prevention of the diseases caused by these parasites.

TOPIC CONTENT

1. General organization of the nematodes. Progressive features of roundworms. Notion of geogelminth
2. Ascaris: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
3. Pinworm: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention
4. Whipworm: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.

TEST QUESTIONS for individual work

№	Questions	Answers
1	Give the main characteristics of an ascaris	
	-Latin name	
	-name of the disease	
	- size of the body	
	- characteristics of the eggs	a) size b) color c) peculiarities
	- location in the human	

	being	
	-life span in the human organism	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
2	What is the main peculiarity of ascaris life cycle?	
3	Give the main characteristics of a pinworm	
	-Latin name	
	-name of the diseases	
	- size of the body	
	- characteristics of the eggs	a) size b) color c) peculiarities
	- location in the human being	
	-life span in the human organism	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
4	Why patient can be sick with enterobiasis quit long, despite the short life span of a pin worm?	
5	Give the main characteristics of a whipworm	
	-Latin name	
	-name of the diseases	
	- size of the body	
	- characteristics of the eggs	a) size b) color c) peculiarities
	- location in the human being	

	-life span in the human organism	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
6	What is the period required for maturation of the eggs of the a) ascaris b) pinworm c)whipworm	

Literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 304-310; 325-336.

Diseases caused by Roundworms are **nematodoses.**

Ascaris lumbricoides is the agent of **ascariasis.**

Geographical distribution Worldwide

Morphology. A **female** is **20-40 cm** . **Male** is **15-25 cm.**

A female produce **fertilized and unfertilized eggs** of oval shape **50-70/40-50 μm,** golden brown .

The unfertilized egg is 50-106 mcm

Location. The mature worm passes its life in human small intestine.

Life cycle. **Ascaris is a geohelminth (eggs passed in feces undergo maturation in soil). Female produces about 240 000 eggs per day.** Development at the temperature +24-+37 C lasts for 12 to 24 days (**3 weeks**)

Man gets the infection by the ingestion of infective eggs with dirt, food, vegetables, water.

Larva hatches from the egg in the small intestine, penetrates into blood vessels are carried by circulation i**nto the liver** and via **right heart** into **lungs**. **In the lungs the larvae penetrate into alveoli** Then larvae crawl up to **bronchi, trachea, larynx and then are swallowed** again. The **migration lasts for 14-15 days.**

Larvae become mature in the small intestine in 2-3 months.

Life span of the mature worm is about a year.

Ascariasis is an anthroponosis.

Pathogenicity. Ascaris causes toxic and mechanical injury and allergy. During the first **pulmonary stage** (**migration of larvae)** clinical symptoms are **pain in the chest, cough, urticarial rush.**

During the **intestinal stage clinical symptoms include vomiting, stomachache, diarrhea, headache, insomnia. Possible complications of the disease are:**

- **perforation of the intestine;**
- **intestinal obstruction;**
- **mechanical jaundice because of blockage of the bile ducts;**
- **abscess of the liver;**
- **appendicitis;**
- **asphyxia because of migration of adult worms to the respiratory tract.**

Diagnosis. At the **pulmonary stage** is (**larvoscopy of phlegm**). at the **intestinal**

stage of ascariasis the **ovoscopy of feces** is done. When only males or females are present in the organism of the host, eggs in the feces are absent.

Prophylaxis:

- personal prevention is to wash hands, vegetables, fruit, to boil water.

Control of the disease:

- treatment of affected individuals;
- proper disposal of human feces;
- struggle with flies and cockroaches;
- health education.

***Enterobius vermicularis* (pinworm)** is the agent of **enterobiasis**.

Geographical distribution Worldwide.

Morphology. Pinworm is a small worm of white color.

Female is **9-12 mm** , **male is 2-5 mm**

Eggs are transparent, asymmetric Size of eggs is **50/60**μm.

Location. Lower part of the small intestine.

***Life cycle*.** Pinworm is a **geohelminth**, parasites **in humans only**. . Females migrate to the rectum, creep out of anus at night and l**ay the eggs on the skin of the perineal region**.

4-6 hours after having been laid eggs reach the infective stage.

Females laying eggs cause severe itching. Patients scratch the itching regions while sleeping. Thus the eggs get on fingers of the patient, under the nails, on bed linen and then on food, toys, dishes. If the patient neglects the hygienic rules he gets infection again. So, enterobiasis is characterized by repeated self infection – autoreinfection.

Life span is about 1 month but the disease can last for years due to **autoinfection.**

Enterobiasis is an **anthroponosis.**

The main symptoms of enterobiasis are itching and skin inflammation in the perineal region.

***Diagnosis*. Demonstration of pinworms in stool and eggs in a perineal scrapings, Graham's method (adhesive skin test)**.

Prophylaxis. Personal prevention is proper personal hygiene (frequent hand washing before meals and after defecation). Fingers should not be put in the mouth as a habit.

To prevent autoinfection patient has to take a bath every morning and wash his hands carefully. Linen should be ironed every morning. Children must keep their fingernails short.

Control of the disease.

- Treatment of the infected case and all members of the family.
- Observe the personal hygiene of kindergartens and food handling occupations.

***Thrichocephalus trichiurus or Trichiurus trichiura* (the whipworm)** is the agent of **thrichocephaliasis** (trichuriasis).

Geographical distribution Worldwide.

***Morphology.* Mature female is 3-5 cm** in length, **male is 3-4,5 cm** in length. Thrichocephalus is a **hemathophage**, it **consumes blood and tissue liquid.**

Eggs are **yellowish-brown** , shaped as a lemon Size of an egg is **50/60**

***Location.* Large intestine of man, especially the caecum and appendix.**

Life cycle. Thrichocephalus is a **geohelminth.**

Eggs are excreted with feces. It takes about 25-30 days for the egg to develop in the moist soil in optimal conditions (tє 25-40 єC, oxygen, moist). Life span is abou**t 3-5 years.**

Epidemiology. Thrichocephaliasis is an **anthroponosis(**through the dirty hands, fruit, vegetables, berries, or water contaminated with eggs) Eggs can survive in soil for 3 years. Flies are mechanical carriers

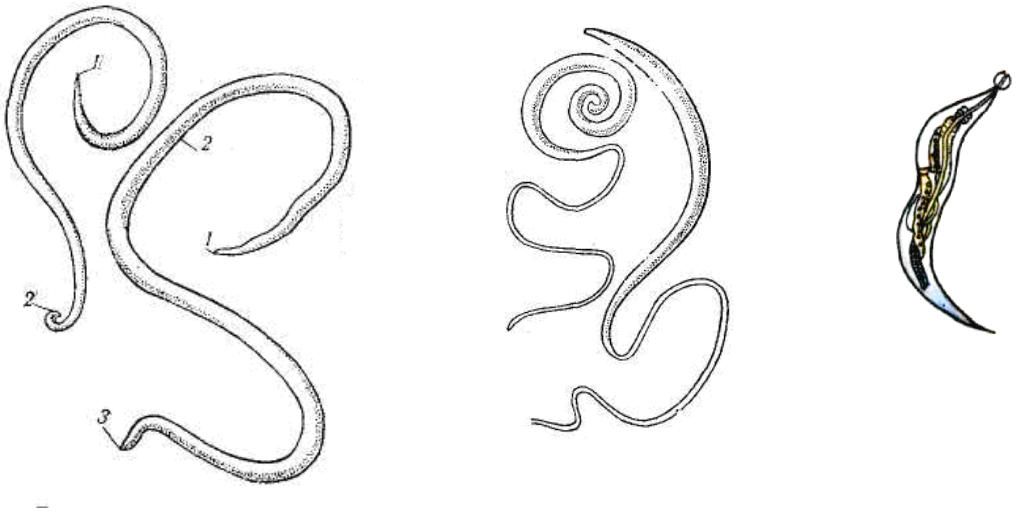
Pathogenicity. Thrichocephalus causes mechanical injuring of the intestinal mucosa and toxic-allergic reactions,appendicitis, anemia.

Diagnosis. ovoscopy of feces

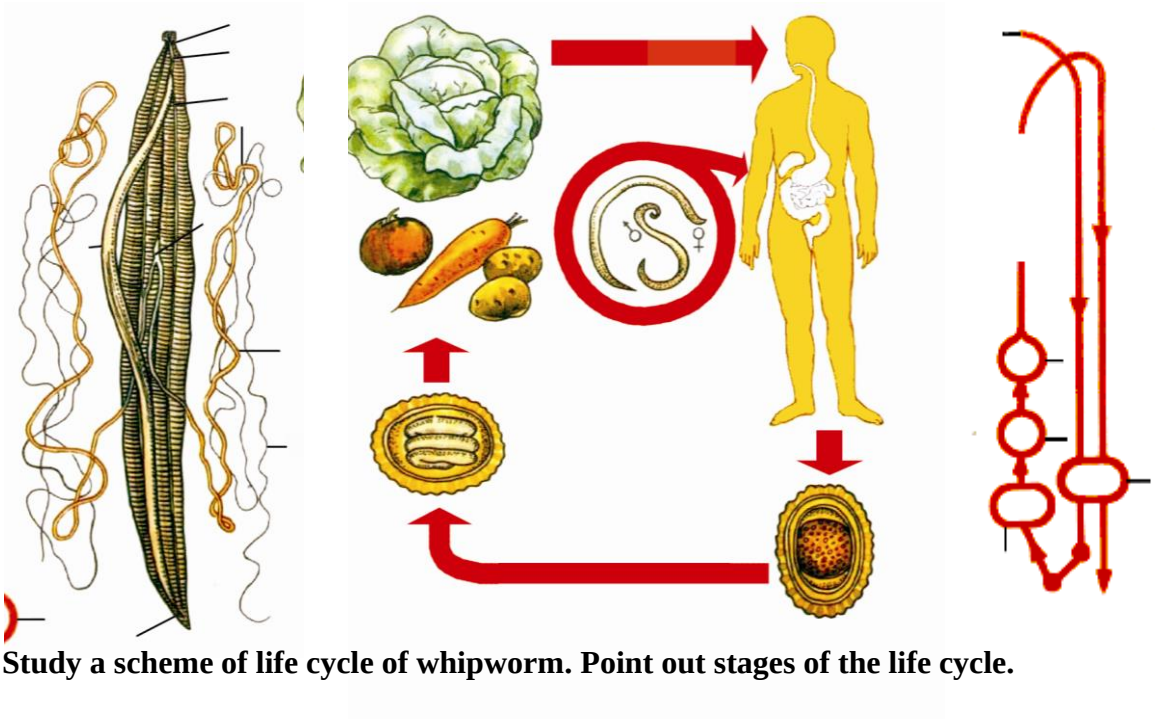
Prophylaxis. The same as in case of ascariasis.

PRACTICAL WORK Nematods

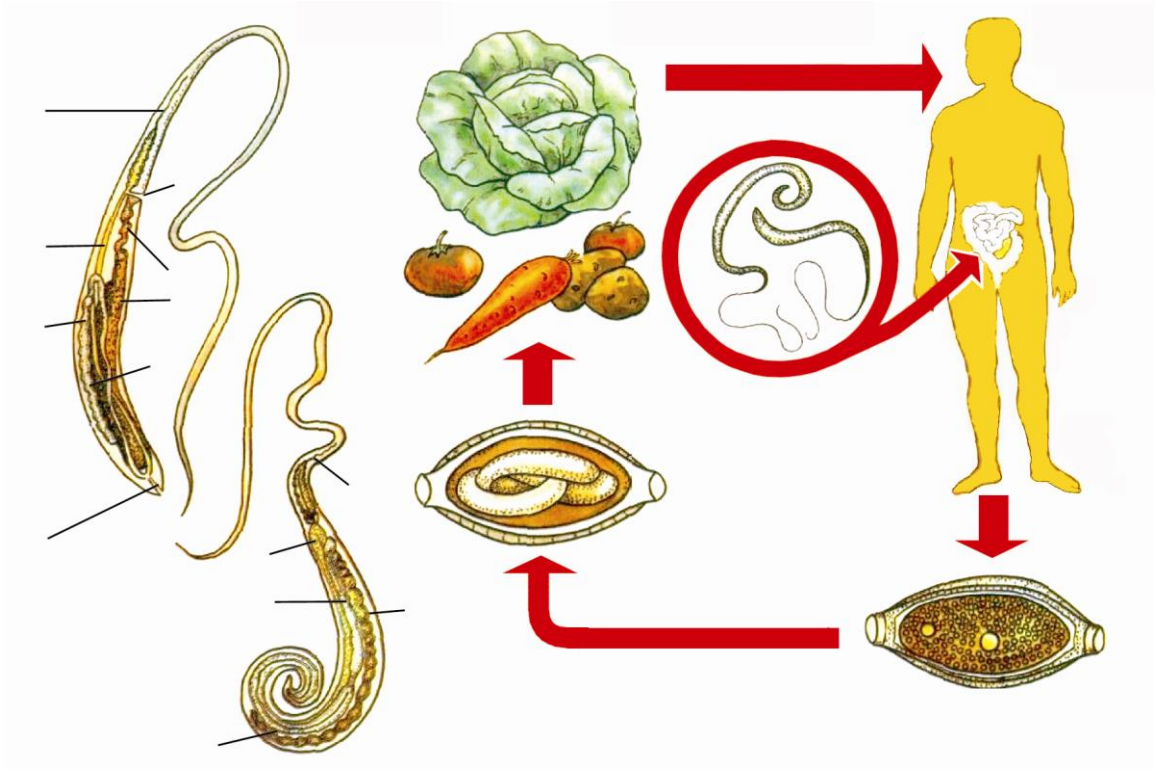
Task 1. Identify the species of round worms and its sex. Detect its actual size.



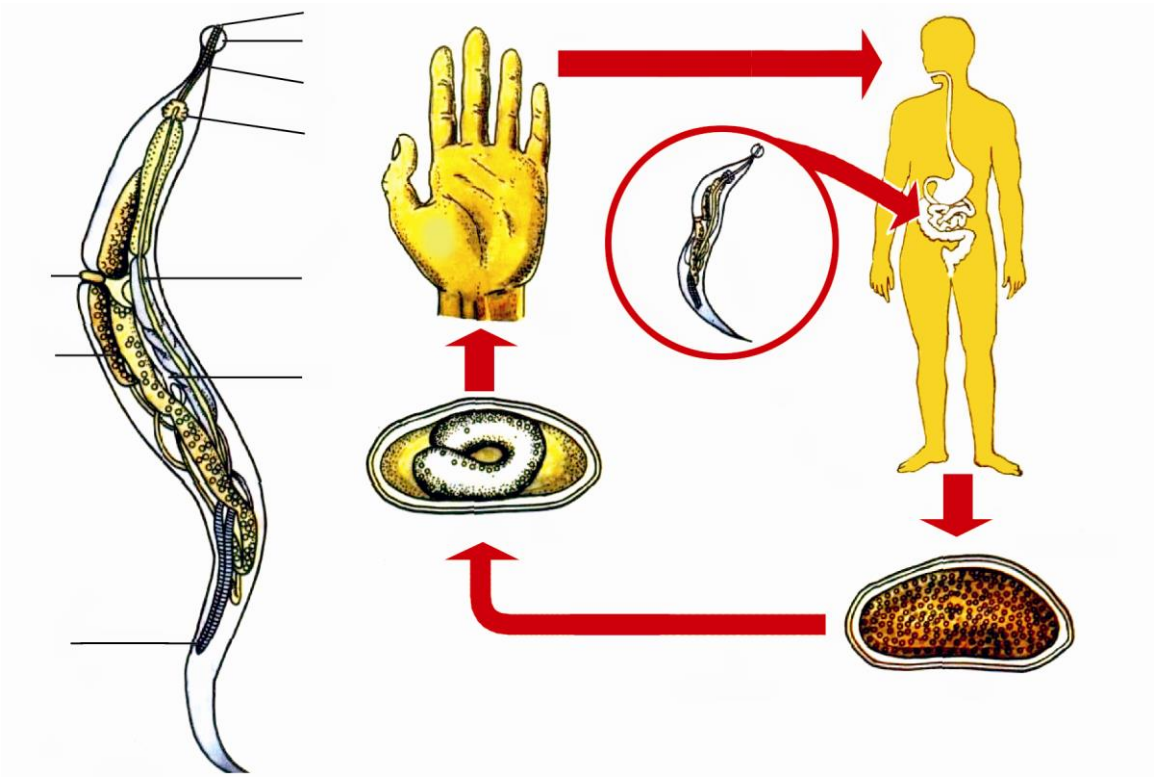
Task 2. Study morphology of female Ascaris and scheme of its life cycle. Label structure, stages of development, and way of migration in human organism.



Task 3. Study a scheme of life cycle of whipworm. Point out stages of the life cycle.



Task 4. Study a scheme of life cycle of whipworm. Point out stages of the life cycle.



Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. Migration via lungs and respiratory system is typical for:

A *Enterobius vermicularis*
B *Trichocephalus trichiurus*
C *Ascaris lumbricoides*
D *Echinooccus granulosus*
E *Taenia solium*

2. White helminthes 5 to 10 mm in length were discovered in human feces. Esophagus of parasite is expanded in the frontal part. Microscopic examination of material scraped off perianal area demonstrated presence of transparent asymmetrical eggs 50 to 60 μm in length. Determine the species of parasite:

A Ascaris
B Whipworm
C Pinworm
D Echinococcus
E Dwarf tapeworm

3. The nematode is characterized by a direct development without migration. Eggs need 25 to 30 days for maturation in the soil. Consuming vegetables, berries or drinking water contaminated by matured eggs may infect human being. Determine species of helminthes:

A Ascaris
B Pinworm
C Whipworm
D Echinococcus
E Broad tapeworm

4. Intestinal obstruction is a possible complication of:

A Hymenolepiasis
B Fascioliasis
C Opisthorchiasis
D Ascariasis
E Enterobiasis

5. Inflammation of appendix is a possible complication of:

A Opisthorchiasis
B Fascioliasis
C Taeniasis
D Hymenolepiasis
E Trichocephaliasis

6. Contaminated vegetables is a possible source of

A Taeniasis
B Taeniarhynchiasis
C Opisthorchiasis
D Trichocephaliasis
E Diphyllobotriasis

7. The enterobiasis agent is:

A Ascaris
B Pinworm
C Whipworm
D Echinococcus
E Dwarf tape worm

8. Infective stage of pinworm for a human being is:

A Sporocyst
B Cysticercus
C Metacercaria
D Filariaform larva
E Egg

9. Which of the following refers to enterobiasis laboratory diagnosing?

A Immunological tests
B Feces ovoscopy
C Microscopy of perianal scrapes
D Blood test
E Muscle biopsy

10. Ascaris eggs get matured in

A 21 days
B 4 to 6 hours
C One week
D One day
E 25 to 30 days

11. Whipworm eggs get matured in:

A 21 days
B 4 to 6 hours
C One week
D One day
E 25 to 30 days

12. Which of the following is the whipworm infective stage for a human being?

A Egg
B Cysticercus
C Cysticercoid
D Plerocercoid
E Hydatid cyst

13. Which of the following refers to ascariasis laboratory diagnosis?

A Muscle biopsy
B Urine sediment microscopy
C Feces microscopy
D Serological tests
E Microscopy of perianal scrapes

14. Which of the following refers to enterobiasis preventive measures?

A Keeping personal hygiene rules
B Veterinary examination of pork
C Consuming properly cooked fish
D Veterinary examination of beef
E Consuming properly cooked meat

15. Lemon-shaped eggs 50 x 30 μm in size with corks on the both poles were discovered in human feces. Clinical manifestations include appendix inflammation. The possible agent is:

A Cat fluke
B Ascaris
C Pinworm
D Whipworm
E Echinococcus

16. Approximate time required for pinworm eggs maturation is:

A 21 days
B 4 to 6 hours
C One day
D 25 to 30 days
E One week

17. Which of the following refers to trichocephaliasis preventive measures?

A Do not walk barefoot
B Keep personal hygiene rules
C Veterinary control in the markets
D Consuming well-done beef and pork
E Sick persons isolation

18. Autoinvasion is possible in:

A Trichocephaliasis
B Diphyllobotriasis
C Enterobiasis
D Paragonimiasis
E Ascariasis

19. The sick child periodically has liquid stools, sometimes pain in the abdomen, nausea, vomiting. Mother says that once spindle-shape helminth about 25 cm in size comes out with the vomited mass. Which helminthiasis can be suspected?

A Enterobiasis
B Trichocephalosis
C Ascariasis
D Dracunculosis
E Trichinosis

20. The patient complains of indigestion, abdominal pain, drowsiness. Similar symptoms manifested before. Tuberous oval eggs were found in the feces of the patient during the laboratory tests. Determine the possible cause of the health disorder:

A Fascioliasis
B Trichocephalosis
C Diphyllobothriasis
D Enterobiasis
E Ascariasis

21. Yellow-brown eggs with tuberous shell were detected in the smear of the feces of a school child. Which helminth these eggs belong to?

A Dwarf tapeworm
B Pin worm
C Whip woprm
D Ascaris
E Broad tapeworm

22. Larvae were detected occasionally on the microscopic examination of the sputum of the patient with pneumonia. Eosinophiles were detected on the blood examination. What helminthiasis can be diagnosed?

A Enterobiosis
B Ascariasis
C Trichocephaliasis
D Paragonimiasis
E Opistorchiasis

23. A patient consulted a physician about chest pain, cough, and fever. Roentgenography of lungs revealed eosinophylic infiltrates which are found to contain larvae. What kind of helminthiasis are these presentations typical for?

A Trichinosis
B Cysticercosis
C Echinococcosis
D Ascariasis
E Fascioliasis

24. A 10-year-old child complains of weakness, nausea, irritability. Helminthes of white color and 5-10 mm long were found on the underwear. On microscopy of the scrape from the perianal folds achromic ova of the unsymmetrical form were revealed. Indicate what helminth is parasiting on the child?

A *Ascaris lumbricoides*
B *Enterobins vermicularis*
C *Ancylostoma duodenalis*
D *Trichinela spiralis*
E *Trichuris trichiura*

25. In the perianal folds of a 5-year-old girl her mother has found some white "worms" that caused itch and anxiety in the child. The "worms" were sent to the laboratory. During examination the physician saw white filiform helminths

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Roundworms. Hookworm, American hookworm, trichina worm, Guinea worm.

Practical class 27. Roundworms. Hookworm, American hookworm, trichina worm, Guinea worm.

The Purpose of the Lesson. To study morphology, life cycles and pathogenic action of the ancylostoma, necator, trichinella, guinea worm, filarias. To study out the methods of laboratory diagnosis and prevention of the diseases caused by these parasites.

TOPIC CONTENT

1. Notion of biogelminth.
2. Hookworms (Ancylostoma, Necator): morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
3. Trichinella: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention
4. Guinea worm: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention.
5. Wuhereria bancrofti: morphology, life cycle, ways of infection, pathogenic action, laboratory diagnosis, prevention. Filarias: Brugia, Loa Loa, Oncocerca.
6. Syndrome of “migrant larva”: agents of visceral and cutaneous forms.

TEST QUESTIONS for individual work

№	Questions	Answers
1	Give the main characteristics of a Hookworm	
	-Latin name	
	-name of the disease	
	- size of the body	
	- characteristics of the eggs	a) size b) color c) peculiarities
	- location in the human being	
	-life span in the human organism	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
2	What is the main peculiarity of Ancylostoma life cycle?	

3	Give the main characteristics of a trichina worm	
	-Latin name	
	-name of the diseases	
	- size of the body	
	- location in the human being	
	-life span in the human organism	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
4	Why human is a blind alley for the trichina worm?	
5	Give the main characteristics of a guinea worm	
	-Latin name	
	-name of the diseases	
	- size of the body	
	- location in the human being	
	-life span in the human organism	
	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
6	Give the main characteristics of a *Wuchereria bancrofti*	
	-Latin name	
	-name of the diseases	
	- size of the body	
	- location in the human being	
	-life span in the human organism	

	-the way of invasion for a human being	
	- invasive stage for a human being	
	-pathogenic effect	
	-laboratory test	
	-personal prevention	
7	Which of these infective diseases belongs to natural-focal disorders?	

Recommended iterature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 311-324; 325-336.

Ancylostoma duodenale (The Hook worm) is the agent of **ancylostomiasis or hookworm disease**.

Geographical distribution: along the Mediterranian coast of Europe and Africa, in Northern India, China and Japan.

Morphology.The female is 9-15 mm, the male is 7-10 mm

The buccal capsule is with **4 hook-like teeth**

Eggs are **65μm long** oval , colorless **with 4 blastomeres** .

Location The adult worm lives in the small intestine, in the duodenum.

Life cycle. Ancylostoma is a geohelminth. Eggs are passed out in the human feces. In shaded **moist and warm soil (28-30 C) rhabditiform larvae hatch from the** eggs **in 24-48 hours** This larva is 0.2-0.3 mm. It feeds on the organic matter in soil.

The **larva becomes infective filariform larva.** This stage is **0.5-0.8 mm** for 7-10 days. The filariform larvae are non-feeding. They can survive in the soil for about 5 weeks. Direct sunlight or salt water can kill the larvae.

If infection occurs by ingestion of the larva it develops **directly in the digestive tract without migration**.

Life span of the worm is 2-5 years.

The disease is anthroponotic. Eggs are not infective. One can get the disease by the following ways:

- **Through penetration of the skin by filariform larvae - feet and hands**
- By **accidental ingestion of filariform larvae with food.**

***Pathogenicity*. Ancylostoma is a haematophage,** it causes **anemia**

During the various stages of development parasite causes **toxic-allergic and mechanical damag**e. Migration of larvae causes rash and **intensive pruritus of the skin**

Diagnosis. **ovoscopy of feces,** larvae in feces (larvascopy, Harada-Mori filter paper strip technique). Adult hookworms may sometimes be seen in feces as small red worms.

Prophylaxis. Personal prevention is not to walk barefoot and avoid consuming fruit and vegetables growing in the region of endemic infection without washing. Control of the disease includes prevention of fecal-soil contact by proper sewage disposal; destroying of the larvae in the soil; treatment of patients, health education.

Necator americanus (the American hookworm) is the agent of **necatorosis.**

Geographical distribution. Central and South America, Central and Southern Africa, Southern India, the Far East and Southern Pacific region). I

Morphology 8-13.5 mm and male is 5-10 mm The buccal capsule is equipped with 2ventral and two dorsal cutting plates.

The life cycle, pathogenicity, diagnosis, prevention are the same as described for Ancylostoma. The eggs of *Necator americanus* and *Ancylostoma duodenale* are indistinguishable. Differential diagnosis is possible by comparing of larvae.

As *Necator* and *Ancylostoma* are very closely related to each other they are often called by a common name **Ancylostomides.**

Trichinella spiralis **(The Trichina Worm) is the agent of** trichinellosis.
Geographical distribution. **World wide with the exception of Australia.**
The female is 2.2-3.6 mm and male 1.4-1.6 mm

Location. Adult worms **live in the small intestine of the host, larvae are situated in striated muscles.**

***Life cycle*. Trichinella is a biohelminth. The life cycle is passed in one host only. The same host serves as a definitive and intermediate host**

Trichina worm is found in many mammals: humans, cats, dogs, bears, pigs, rats, wolves, rodents.

Man becomes infected mainly by eating undercooked pork. Rare source of the infection is the meat of wild animals like wild pig, bear, polar bear

Infective stage for the host is larvae. **The female is ovoviviparous. on the 4-7th day after the infection.**

Life span of the female in the human intestine is about 45-50 days **and it produce up to 2500 larvae during this period.** The larvae penetrate the intestinal wall and migrate through the lymphatic vessels to the bloodstream which carries them to the skeletal muscles. The most heavily affected muscles are the tongue, chewing muscles, deltoid muscles, intercostal muscles, pectoral muscles, diaphragm, and muscles of the calf. **After 17-20 days the larvae undergo spiralization and become infective. The larva in the muscles can survive at least for 25 years.** Circulation of the disease in nature is maintained by the following links: pig to pig, rat to rat, rat to pig, wild rodents to various carnivores.

The trichinella infection is asymptomatic in majority

of cases in h of cases in humans. Manifestation depends upon the number of parasites. **Symptoms of the intestinal invasion stage during the first week of infection are nausea, vomiting, diarrhea, abdominal cramps. Symptoms of the muscle invasion stage on the second week of infection are severe headache, muscle ache, high temperature, edema of the face and especially eyelids, allergic rash. Symptoms are caused by the sensibility of the organism to the toxic substances produced by Trichinella. Allergic vasculites and infiltration of inner organs develops. Massive invasion causes located infection of the internal organs (pneumonia, meningoencephalites, toxic-allergic myocardites) which may result in severe complications and death of the patient.** Clinical recovering takes place after encapsulation of the larvae and occurs during the 3rd week of infection in light and to 2 to 3 months in heavy infections.

Diagnosis: larvae in the muscle biopsy. Serodiagnosis is the after 2-3 weeks. X-ray examination may show the presence of calcified cysts in the muscles.

Prophylaxis Larvae in pork are killed by heating of sliced meat 2.5 cm thick for 10 hours above 70 □C or by deep freezing at –15 □C for 20 days, **that's why personal prevention is not effective.**

Basic precautions include checking pork in slaughter houses and markets. According to the standards if in any of 24 meat samples trichinella larvae are present, meat is not fit for utilization.

Extermination of rats from pig farms limits the spread of the infection.

Dracunculus medinensis (The Guinea worm) is the agent of **dracunculiasis.**

Geographical distribution The worm is present in tropical Africa, Middle East, in Arabia, Iraq, Iran, Pakistan, India.

Morphology **The female is 30-120 mm** The male is 12-29 mm

Location. **Adult females are usually located in the subcutaneous tissue especially of the legs, arms and back,** in the **joints, pericardium, pleura.** The breast, buttocks or genitalia may also be affected.

Life cycle.

Man is a definitive host. dogs, monkeys, cattle, horses may be affected. The intermediate hosts are minute fresh water crustaceans cyclops. Man gets infected by drinking unfiltered water containing infective cyclops.

The female is viviparious. When the anterior end of the gravid female worm comes beneath the skin surface, **it secrets a toxin which causes a blister.** The blister breaks, forming an ulcer with a protruded head of the worm in the base. When the ulcer comes into contact with water, the anterior end of the worm ruptures, releasing thousands of larvae in water. Discharging of larvae continues for 2-3 weeks.

Pathogenicity. Common symptoms are **arthritis, fibrosed joints,** secondary bacterial infection at the sites of skin lesions. **Allergic** manifestations are intense **pruritus and urticarial rush, nausea, vomiting.**

Diagnosis presence of the worm under the skin.

Prophylaxis. Personal prevention is to drink boiled and filtered water. Control of the disease includes isolation and treatment of the infected persons, destruction of the cyclops, chemical treatment of water reservoirs.

Eradication of Guinea worm has been successfully done in certain territories.

Filariidae (The Filarial Worms) cause diseases (**filariasis)**

Wuchereria bancrofti causes

Wuchereriasis (filaria worm infection or Bancroftial filariasis). Geographical distribution is **tropics and subtropics of Asia, Africa and South** America. **Vectors are Culex mosquitoes.**

In human parasite locates in lymphatic vessels and nodes. Life span of the worm is about 20 years. – lymphedema and **elephantiasis**. Laboratory tests include demonstration of **microfilaria in the peripheral blood and serological tests.**

Brugia malayi causes **Malayan filariasis** or **Brugian elephantiasis.** The geographical distribution is much more restricted than that of Wuchereria and includes **India, Indonesia, Phillipines, Malaysia**

The morphology, life cycle, clinical manifestation and diagnosis are similar to that of Wuchereria. **Vectors of Brugia are Anopheles and Mansonia mosquitoes.**

Loa-loa (eye worm) causes

loiasis.

Geographical distribution is **West and Central Africa**.

Location in man is the subconjunctival tissue (in the eye) and subcutaneous tissue, through which they wander. Wanderings of the worms **tissues set up temporary swellings (calabar swelling). The vector is day biting fly of the Genus Chrysops (deer fly)**.

Diagnosis is demonstration of microphilaria in blood and adult worms removed from the skin or conjunctiva.

Onchocerca volvulus causes

onchocerciasis ("river blindness"). Geographical distribution is mainly **tropical Africa, but also in Central and South America**.

A parasite lives in the subcutaneous tissues causing formation of nodules. It often **affects the eyes and leads to blindness.** The vector is day- Simulium fly species breed in fast-flowing

rivers, so disease is more common along the course of rivers.**biting black fly of genus Simulium.** Diagnosis is **demonstration of microphilaria in the skin samples.**

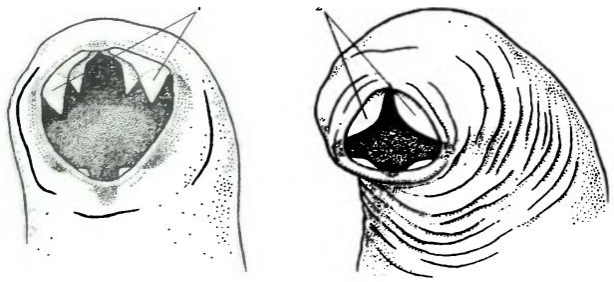
Prophylaxis Personal prevention is avoiding the vector's bites. Control of the disease includes treatment of infected persons and eradication of vectors.

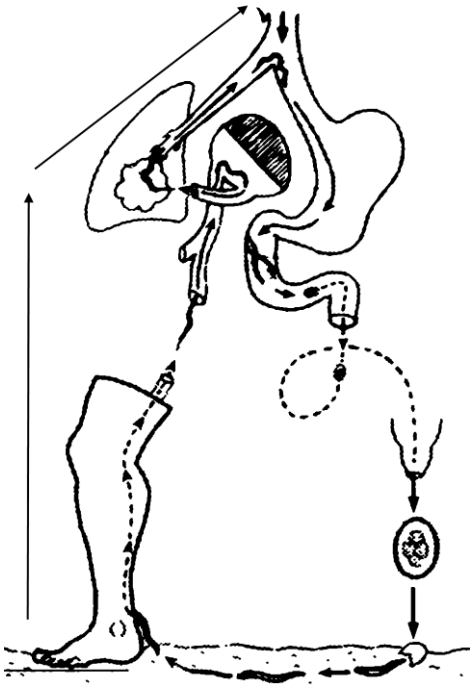
PRACTICAL WORK Nematods

Task 1. Study classification of the round worms**.** Write down the Latin names of the parasites

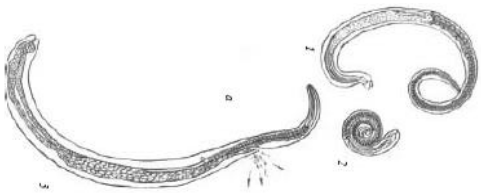
Phylum *Nemathelminthes*
Class *Nematoda*
Species: Hookworm _____
American Hookworm _____
Trichina worm _____
Guinea worm _____
Filaria worms _____
_____
_____

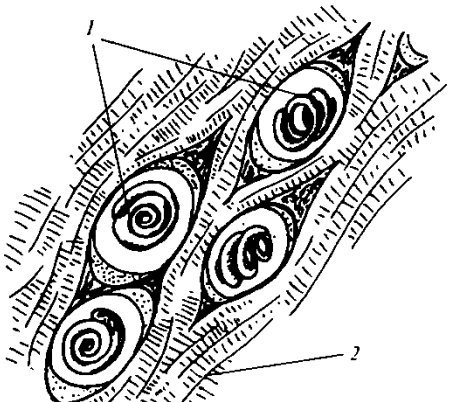
Task 2. Study morphology and life cycle of Ancylostoma and Necator. Label peculiarities of buccal capsule and stages of development.

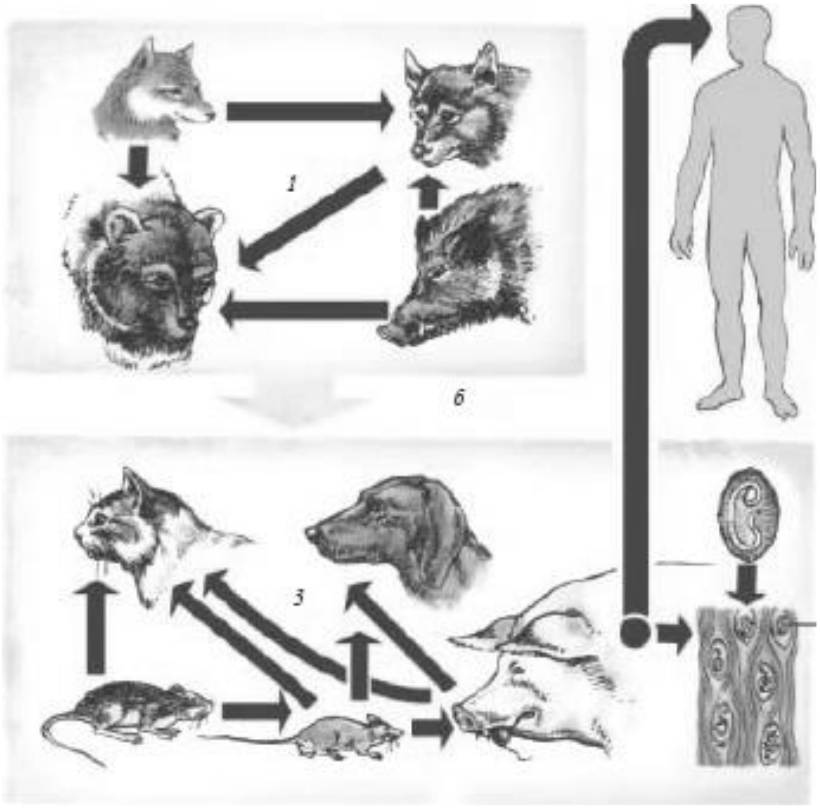




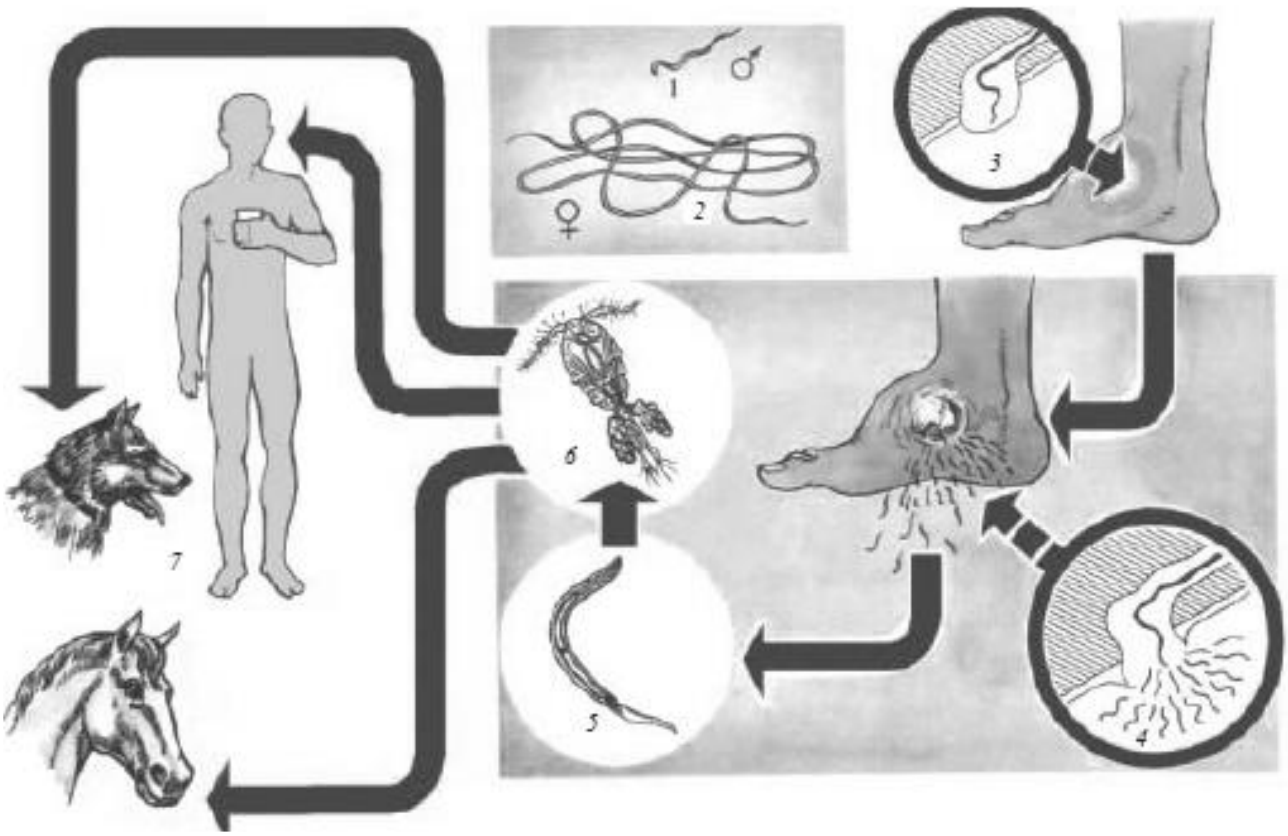
Task 3. Study the circulation of Trichina worm in nature. Label adult worms and encapsulated larvae in muscles.



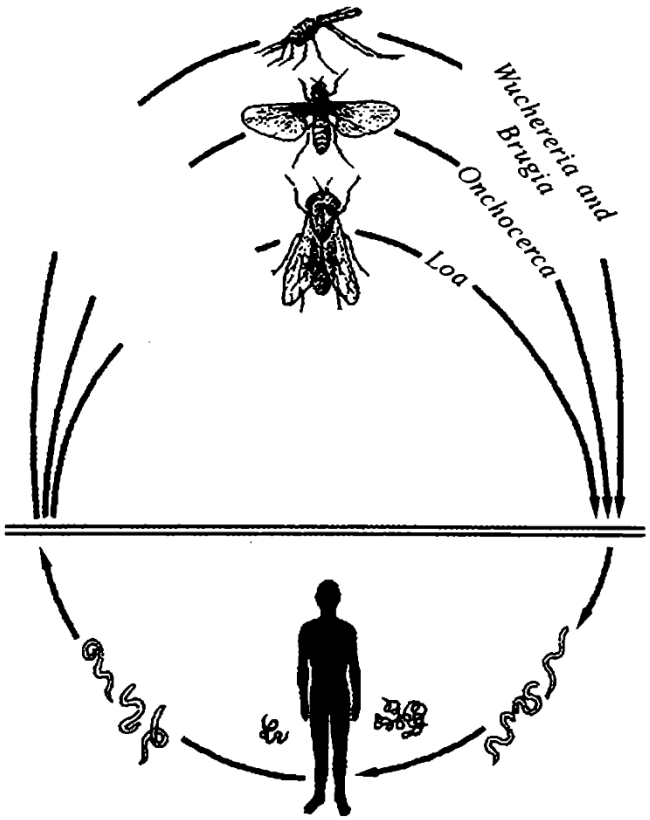




Task 4. Study life cycle of Guinea worm. Label definitive and intermediate hosts and stages of development.



Task 5. Study life cycle of filaria worm. Label specific vectors.



Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer

1. A miner consulted a physician about the appearance of the body rash followed by a loss of appetite, bloating, duodenal pain, frequent bowel movements, dizziness. Ovoscopic probes of feces and duodenal contents revealed some eggs covered with transparent membrane through which 4-8 germinal cells could be seen. What disease is likely to have occurred in the patient?

A Hymenolepiasis
B Strongyloidiasis
C Enterobiasis
D Ancylostomiasis
E Trichocephaliasis

2. Several days after consumption of smoked pork a patient got face and eye-lid edemata, gastrointestinal disturbances, abrupt temperature rise, muscle pain. Blood analysis showed full-blown eosinophilia. What helminth could the patient be infected with?

A Pinworm
B Trichina
C Ascarid
D Whipworm
E Hookworm

3. Patient has been admitted to the hospital with a preliminary diagnosis of trichinosis. Eating of which food can cause this disease?

A Pork
B Beef
C Fish
D Crayfish and crabs
E Unwashed vegetables and fruits

4. In the hunter who ate the meat of wild boar, 10 days after temperature raised greatly, face swollen, rigidity of masticatory muscles appeared. Capsules with spirally twisted larvae were found during the biopsy of calf muscles. Which disease is suspected?

A Strongiloidosis
B Hymenolepiasis
C Enterobiasis
D Trichocephaliasis
E Trichinosis

5. The doctor takes history of the disease in several residents of a village with the same symptoms as swelling of the eyelids and face, strong muscle pain, fever, and headaches. All patients three weeks ago were guests at the wedding and ate pork. The doctor

suspects trichinellosis. What method will help to confirm the diagnosis?

A Blood test
B Ovohelminthoscopy
C Immunological
D Urine analysis
E Sputum analysis

6. Certain measures for social prevention of the helminthosis which is characterized with seizures and swelling of the face were proposed. Among them special attention was paid to the prohibition of eating infected pork, even after heat treatment. What helminthiasis is it?

A Trichinellosis
B Tapeworm infection
C Ascariasis
D Echinococcosis
E Alveococcosis

7. In one of Polessye regions there was an outbreak of helminthiasis manifested by cramps and facial edemas. The developed preventive measures in particular included ban for eating infested pork even after heat processing. What helminthiasis was the case?

A Taeniarhynchosis
B Trichinosis
C Teniasis
D Echinococcosis
E Alveococcosis

8. A man has worked in an African country for 3 years. A month after his return to Ukraine he consulted an ophthalmologist and complained about eye ache, eyelid edema, lacrimation and temporary visual impairment. Underneath the eye conjunctiva the doctor revealed helminths 30-50 mm long with elongated filiform body. What diagnosis might be suspected?

A Ascaridiasis
B Diphyllobothriasis
C Filariasis
D Enterobiasis
E Trichocephaliasis

9. Larvoscopy is the method of laboratory diagnosis of

A. Trichinelosis
B. Diphyllobotriasis
C. Fasciolosis
D. Opistorchosis
E. Hymenolepidosis

10. Diagnosis of dracunculosis is

A. Immunologic tests
B. Muscle biopsy
C. Demonstration of eggs in feces
D. Ovoscopy of urine
E. Presence of visible threads under the skin

11. Larvoscopy is the method of diagnosis for

A. Ancylostomiasis
B. Hymenolepidosis
C. Diphyllobotriasis
D. Taeniarhynchosis
E. Taeniasis

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Arthropodes. Arachnoidea. Spiders, Ticks.

Practical class 28. Arthropodes. Arachnoidea. Spiders, Ticks.

The Purpose of the Lesson. To study characters of structure and classification of Arachnida.

TOPIC CONTENT

1. Characters of structure and classification of Arachnida.
2. Medical importance of spiders.
3. Peculiarities of morphology and development of ticks and mites.
5. Medical importance of Ixodida mites. Peculiarities of their transmission of agents of human invasions.
6. Medical importance of Argasida and Gamasida mites.
7. Medical importance of E.N.Pavlovsky's works about natural focal transmissive diseases,

TEST QUESTIONS FOR INDIVIDUAL WORK

	Questions	Answers
1	What are the characters of Arthropoda? I) body cavity- 1; 2) body parts -1,2,3; 3) organs of respiratory system-1; 4) peculiarities of circulatory system -1; 5) organs of nervous system-1,2; 6) peculiarities of excretory system-1; 7) development -1, 2.	
2	What are the peculiarities of Arachnida? 1) body parts-l ,2; 2) mouth apparatus -1,2; 3) number of walking legs - 1; 4) respiratory organs -1; 5) development: of spiders-l ; of ticks -1; of mites -1.	
3	What are the orders of Arachnida? 1,2,3,4.	
4	What is a medical importance of Soliphuga? 1.	
5	What are venomous Arachnida? 1,2,3	
6	What is the medical importance of Crimean scorpion-1; Karakurt ("black widow")-1 ; Southern Russian tarantula (wolf Spider)-1.	
7	What are the peculiarities of ticks and mites during their different stages of development? 1)larva -1,2,3; 2)nymph -1,2; 3) Imago -1,2,3,4.	
8	Which ticks and mites are 1) vectors of human invasions 1,2,3,4;	

9 10	2) agents of human diseases -1, 2. Transovarial transmission of viruses is … Transphase transmission of viruses is …	

Fill the table 1"Epidemiological importance of parasitic ticks"

Ticks and mites families	Latin name	Geography of inhabitance	morphology	Life cycle	Medical importance
Ixodida	Taiga tick Dog tick Meadow ticks				
Argasida					
Gamasida					

Fill the table 1"Epidemiological importance of mites"

Latin name	Itch mite	Follicle mite
Name of disease		
localization		
Morphology		
Life cycle (stages)		
Way of invasion		
Pathogen effect		
Laboratory diagnostic		

Recommended literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 337-347; 362; 364-365.

Phylum Arthropoda:

Branchiata (class Crustacea),
Chelicerata (class Arachnoidea),
Tracheata (class Insecta).

Class Crustacea.

They live in marine and fresh water reservoirs.

Cyclopes are the intermediate hosts for **broad tapeworm** and **Guinea worm**.
Crabs and crawfishes are the II intermediate hosts of lung fluke.

Class Arachnoidea.

The Arachnoidea have :

A body has 2 regions: cephalothorax and abdomen.

Cephalothorax bears two pairs of the **mouth parts called chelicerae and pedipalpi for feeding** and **4 pairs of walking legs**

Respiration occurs by trachea or book-lungs

Development is direct.

The venomous glands

The major **orders of Arachnoidea are Aranei, Solpugae, Scorpions, Acarina.**

Order Aranei.

The venomous species in South Ukraine are Karacurt (*Lacrodectus tredecimguttatus)* (one of the black-widow spider species) and tarantula or wolf spider – (*Lycosa singorensis*).

Tarantula is the large spider, about 35 mm in length, covered by thick black or sometimes red color hair. It lives in the holes in soil.

Medical importance. **Bite of tarantula spider is very painful and may cause allergic reaction – hyperemia, edema, tachycardia, sleeplessness.**

Karacurt (Lactrodectus tredecimguttatus)male is 1 cm and female is 1,5-2 cm Characteristic feature is dazzling **white spots and red dots in the center**. Karacurt lives the holes of rodents, sheds, garages, toilets, among the stones in the beaches.

Medical importance. **The poison of Karacurt may be deadly for humans** and animals as it is **neurotoxic and blocks of transmission of neuromuscular impulse.** The symptoms of poisoning are nervous pain, disturbance, tachycardia, bronchial spasm, depression, delirium.The first aid is injection of antikaracurt serum,

Order Solpugae. Solpugae (phalanges) inhabit countries with hot climate.

Medical importance. Solpugae are not poisonous, but its bite causes the inflammation as they inoculate bacteria and toxic substances from chelicerae into the biting wound.

Order Scorpions Scorpion is 1-17 cm with poison sting

Medical importance. The sting of the scorpion is very painful. The poison causes edema, sleepiness, fever. The poison of large tropical species can lead to the death, especially in children

Order Acarina

Parasitiform ticks are **Ixodidae, Argasidae, Gamasidae.**

Ixodidae ticks are **bloodsucking** arachnids. The sizes are from 2-5mm up the 3 cm.

They are **biological vectors of spring-summer encephalitis, taiga encephalitis, Rocky mountain spotted fever, tularemia**.

Ixodidae female can t**ransmit virus of encephalitis through the eggs (transovarial transmission) to the following developmental phases (transphase transmission).**

***Ixodes ricinus* (Canine tick)**

a temporary parasite of wild and domestic animals, can attack human. It lives in forests of Europe.

a male is **2.5 mm,**a hungry female is 4 mm(after bloodsucking is about **11 mm**)

Females lay the 10000-12000 eggs once a life-time into the soil.

Canine tick is the carrier of the agents of the spring-summer encephalitis, supports the circulation of tularemia among the rodents and transmits it to humans.

***Ixodes persulcatus* (Taiga tick)** inhabits the forests, taiga It parasites on the mammals, birds, rodents, and hedgehogs. **It is the main vector of taiga encephalitis**. **Transovarial and transphase transmission of the virus is present.**

the system of destruction of the ticks in biogeocenosis with the help of acaricides (chemicals killing the ticks).

Dermacentor pictus lives of steppe zone and is **the carrier of tularemia, endemic typhus, brucellosis.**

Argasidae ticks

The size of female is about **8.2 mm**, the size of male is about **5.8mm**.

Argasidae ticks ar**e ticks of shelter places.** They inhabit **caves, holes, houses**. Argasidae ticks can fasting for about 10 years.

Example of Argasidae i**s *Ornithodorus papillipes ("Persian bug").*** It is the **vector of tick-born relapsing fever** (agents are spirochetes).

Gamasidae ticks. It is numerous of very small ticks **(0,3-0,4 mm),** which are ectoparasites of various mammals and b**irds. A chicken and rat ticks attack the human**. It causes th**e irritation of skin, dermatitis.**

Acariform ticks (mites) are constant parasites. Acarus siro or Sarcoptes scabiei (itch mite) causes scabies.

Morphology. The female is 0.4-0.45 mm and male is 0.2 mm .

Location Itch mite is a **constant human intracutaneous parasite**.It lives mainly between the fingers, in armpits, lower part of the abdomen, buttocks, popliteal fossae.

Life cycle Females make tunnels in epidermis. During the **life period (50 days)** it lays **20-30 eggs**. The development occurs with the metamorpho**sis (egg, larva, nymph I, nymph II) and takes 9-14 days. Wandering of the mites in skin causes severe itch. Scratching the mites' tunnels host disseminates the parasites all over the body.**

Man-to-man transmission occurs during the contact with the patient (handshake) or through the clothes.

Laboratory diagnosis is based on ***microscope examination of skin scrubs,*** (demonstration of the parasites).

Prophylaxis is based on **personal and social hygiene, isolation and treatment of patients.**

Demodex folliculorum (**follicle mite) is the agent of demodecosis.**

It is the **vermiform mite 0,3 mm.** It parasites **in sebaceous glands of the face in regions of the nose, eyelids, forehead, and internal acoustic duct, in hair follicles of the eyebrows and eyelashes.**

The disease manifests by **loss of hair, purulent pimples, eczema**.

The invasion is by **contacts with sick person, through the towels, pillows.**

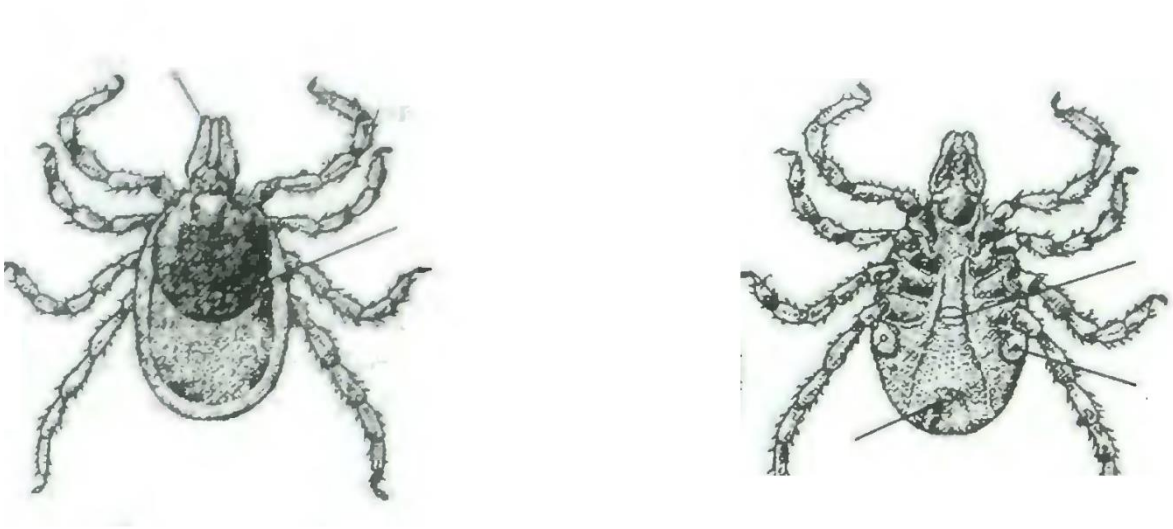
The diagnosis is based on **microscoping of the purulent contents of the pimples or removed hair follicle.**

Task 1. Study classification of the Arachnoidea**.** Write down the Latin names of the parasites

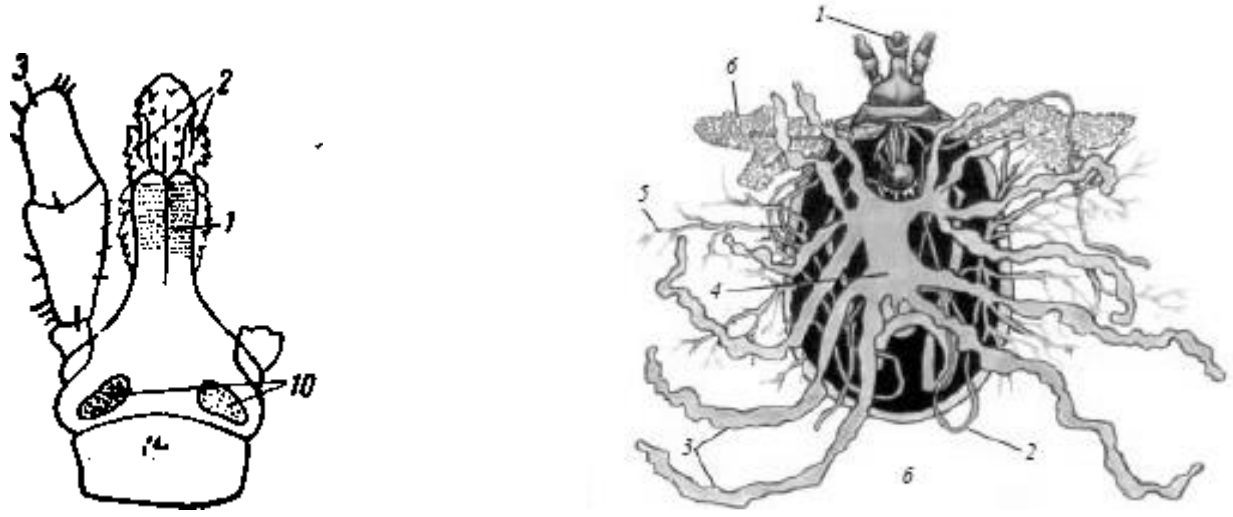
Phylum *Arthropoda*
Class *Arachnoidea*
Order *Acarina*
Species: Itch mite _____
Follicle mite _____
Taiga tick _____
Dog tick _____
Meadow tick _____
Argasidae ticks _____

Task 2. Study species of venomous Arachnoidea. Label scorpion, karakurt and tarantula.

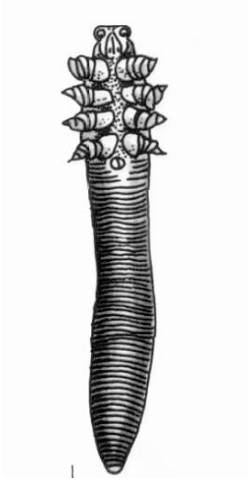
Task 3. Study female of taiga tick from abdominal and dorsal sides. Label sproboscis, dorsal shield, stigma, sexual and anal pores.

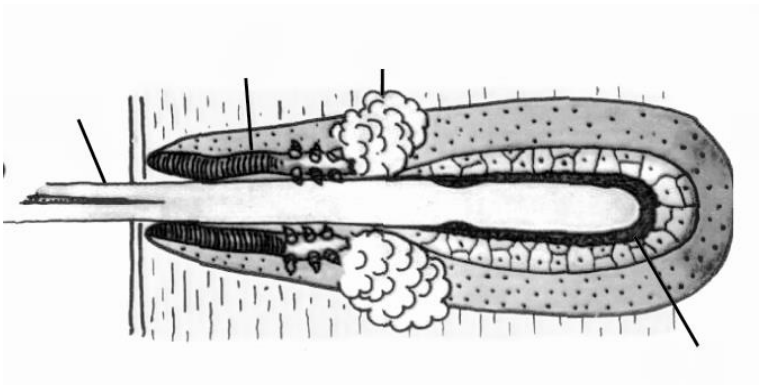


Task4. Study peculiarities of mouth apparatus and digestive system in blood-sucking ticks. Label proboscis, hypostom, chelicerae and projection of the mid gut.

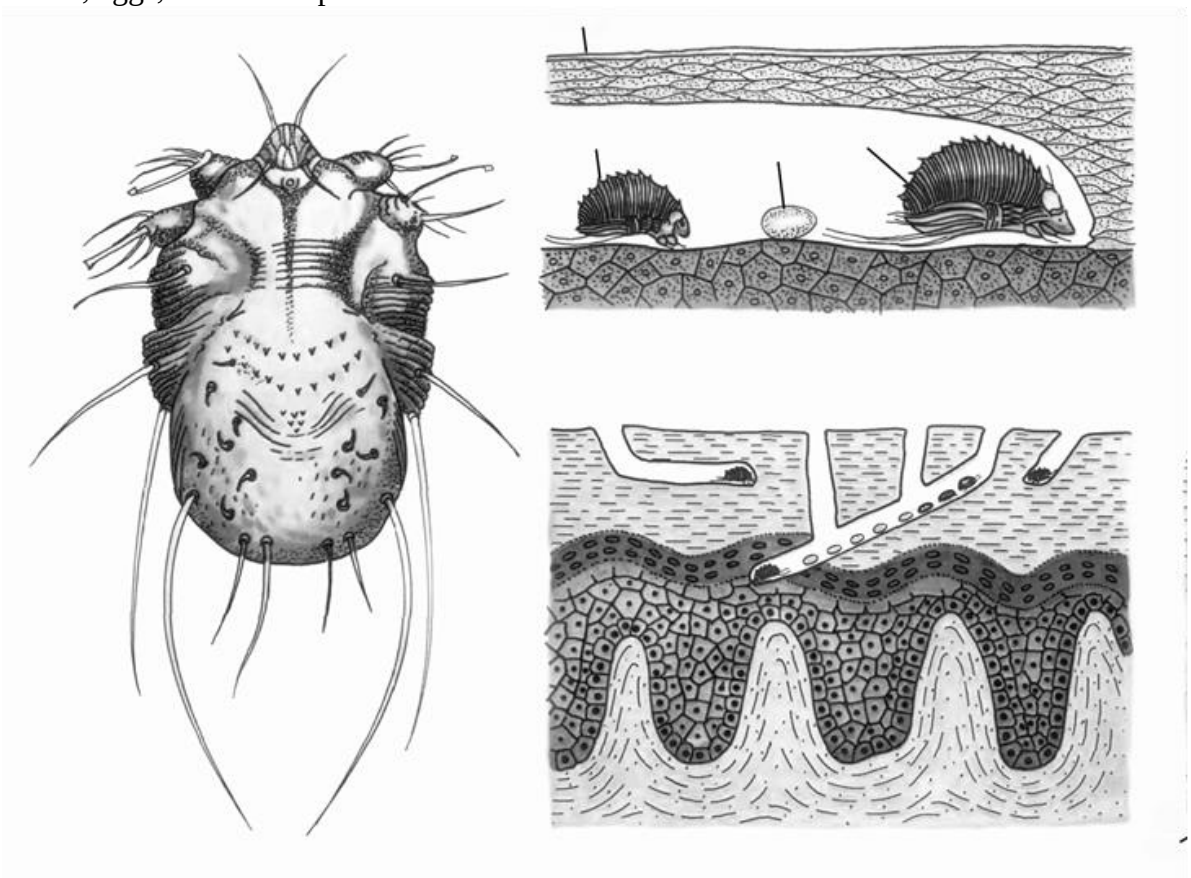


Task5. Study morphology and location of *Demodex folliculorum* (follicle mite). Labebl a parasite, hair, sebaceous gland, hair follicle.





Task5. Study morphology and location of *Sarcoptes scabiei* (itch mite). Labebl female, skin tunnel, eggs, ventilation pores.



Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. What is the medical importance of arthropods?
A. Vectors of the human diseases
B. Causative agents of the human diseases
C. Poisonous animals
D. Biological hosts of the parasites
E. All of the above

2. Causative agents of the diseases are
A. Dog tick
B. Taiga tick
C. Itch mite
D. Dermacentor tick

3. Specific vectors of vector-born disorders are
A. Itch mite
B. Follicle mite
C. Dermacentor
D. House fly
E. Black cockroach

4. Medical importance of follicle mite
A. Causative agent of scabies
B. Vector of taiga encephalitis
C. Causative agent of demodicosis
D. Vector of tick-born relapsing fever
E. Vector of tularemia

5. Dog tick is the vector of
A. Tick-born relapsing fever
B. Tularemia
C. Demodicosis
D. Scabies
E. Endemic typhus

6. *O. pappilipes* is the vector of
A. Taiga encephalitis
B. Tularemia
C. Tick-born relapsing fever
D. Plague
E. Brucellosis

7. Ticks are
A. Vectors of scabies
B. Vectors of demodicosis
C. Causative agents of plague
D. Causative agents of typhus
E. Vectors of encephalitis

8. Specific vectors of taiga encephalitis is
A. Flea
B. Itch mite
C. Follicle mite
D. Ixodida tick
E. Mosquito

9. Vector of viral encephalitis is
A. Pubic lice
B. Dog tick
C. Demodex
D. Dermacentor
E. Bed bug

10. It is possible to get scabies by all these ways except for
A. Hand shaking
B. Through the direct contacts
C. Trough the sexual contacts
D. Trough the personal things of the patient
E. By biological vectors

11. Prevention of scabies is all except
A. Treatment of the patients
B. Eradication of biological vectors
C. Disinfection of personal things of the patient
D. Keeping the rules of personal hygiene
E. Health education work

12. Ixodidae ticks are the vectors of
A. Leishmaniasis
B. Plague
C. Malaria
D. Tularemia
E. Demodicosis

13. Ticks are characterized by all except
A. Temporal parasites
B. Causative agents of tularemia
C. Feed on blood, skin epidermis
D. Intra cutaneous parasites
E. Development with metamorphosis

14. Medical importance of itch mite
A. Vector of tularemia
B. Causative agent of demodicosis
C. Causative agent of scabies
D. Causative agents of myiasis
E. Vector of encephalitis

15. Demodex feeds on
A. Blood
B. Secretion of sebaceous glands
C. Epidermis
D. Duodenal contents

16. Causative agent of demodicosis is
A. Canine tick
B. Taiga tick
C. Itch mite
D. Follicle mite
E. Dermacentor

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Insects as agents and vectors of human diseases.

Practical class 29. Insects as agents and vectors of human diseases.

The Purpose of the Lesson. To study characters of structure and classification, medical importance of insects.

TOPIC CONTENT

1. House fly. Morphology.
2. Stable fly. Life cycle, transmission of agents of diseases.
3. Wohlfahrtia fly. Life cycle, medical importance.
4. Malarial and not malarial gnats, their morphological characters.
5. Metamorphose and characteristic of gnats stages of development (egg, larva, chrysalis, and imago).
6. Organization of effective struggle against gnats.
7. Scientists role in the struggle against transmissive diseases.
8. What are the changes in louse's morphology because of their parasitic mode of life?
9. Morphology and biological peculiarities, life cycles of lice.
10. Pediculosis and phtiriasis.
11. Epidemic importance of lice.
12. Epidemic importance of fleas. Characteristic of "plague block".
13. Epidemic importance of bed-bug and kissing bug.

TEST QUESTIONS FOR INDIVIDUAL WORK

	Questions	Answers
1	What are the characters of insect's morphology? 1) parts of their body -1,2,3; 2) number of walking legs -1; 3) Respiratory organs -1. What are the stages of insects development? 1) with complete metamorphosis - 1,2,3,4; 2) With incomplete metamorphosis - 1,2,3.	
2	Which type of mouth apparatus appears in the process of evolution at first? What is it: 1) type of fly's mouth apparatus; 2) the way of agents transmission; 3) what does it transmits-l ,2,3,4,5,6; 4) The type of gnat's mouth apparatus. What is the medical importance of 1)autumn fly;	
3	2) tsetse fly; 3) Wohlfahrtia magnifica;	
4	4) Malarial gnats; 5) Not malarial gnats -1, 2, 3,4,5,6.	
5	What are the agents.of miases;	
6	1) tissular-l,2;' 2) intestinal -1,2,3;	

	3) Urinal-I, 2. What are the main ways of struggle against gnats? -1,2	
7	What are lice-human parasites? 1,2,3.	
8	What is 1) type of lice's mouth apparatus; 2) type of lice development.	
8	What are the morphological differences of head louse and body louse? 1,2, 3	
9	What is a medical importance of lice? 1) head louse-1,2; 2) body louse -1,2; 3) pubic or crab louse -1.	
10	What is a mechanism of human invasion with 1)relapsing fever -1; 2) epidemic typhus-1.	
11	What are the symptoms of 1)pediculosis -1,2,3; 2) phtiriasis -1, 2.	
12	What are the species of fleas? 1,2,3.	
13	What is a medical importance of fleas? 1,2,3.	
14	What are the ways of transmission of plague to human by fleas? 1,2.	
15	What is a medical importance of bugs: 1) bed – bug; 2) kissing bug -1, 2.	

Literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 347-365.

Class Insecta. The body consists of : the head, thorax and abdomen.

Reproduction is sexual. The development occurs with complete or incomplete metamorphosis.

Medical importance of Insects. Insects are

the agents of human diseases (lice),

mechanical vectors of intestinal diseases (flies),

biological vectors of transmissive diseases (lice, fleas, bed-bugs, mosquitoes, tsetse flies)

Phylum: Arthropoda

Subphylum: Tracheata

Class: Insecta

Order: Diptera

Family: Culicidae

Genus: **Anopheles, Culex, Aedes**

Species: Anopheles maculipennis

Culex pipiens

Family: **Muscidae**

Species: Musca domestica (House fly)

Wohlfartia magnifica (Wohlfartia fly)

Stomoxys calcitrans (Stable fly)

Glossina palpalis (Tsetse fly)

Subphylum: Tracheata

Class: Insecta

Order Anoplura

Sp.: Pediculus humanus capitis (Head louse)

Pediculus humanus humanus (Body louse)

Phtirus pubis (Pubic or crab louse)

Order Aphaniptera (Fleas)

Sp.: Pulex irritans (Human flea)

Xenopsilla cheopis (Rat flea)

Order Heteroptera

Sp.: Cimex lectularis (Bed bug)

Order Diptera.

They have 1 pair of wings

The life cycle is with complete metamorphosis (eggs, larva, pupa, imago).

Mosquitos (Culicidae) are bloodsucking temporary ectoparasites.

The important genera of mosquitoes are Anopheles, Culex and Aedes.

Medical importance-

Anopheles: vectors and definitive hosts of human malaria, intermediate hosts for Wuchereria in warm countries.

Culex are vectors of Japanese encephalitis, tularemia, filariasis;

Aedes are the vectors of the virus of Japanese encephalitis, yellow fever, Dengue fever, tularemia, filariasis.

Mosquitoes develop with **complete metamorphosis: egg, larva, pupa, imago.**

Development of all stages in water lasts from 14 to 30 days depending on temperature with 1-2 gonotrophic cycles (in northern regions) and up to 5-10 in the South.

Males live for 10-15 days. All males die in autumn.

Anopheles and Culex females are wintering.

Control of mosquitoes:

1. **Destruction of adults:**
   - killing the mosquitoes by spraying insecticides;
   - fumigation of dwellings;
   - genetic methods- imploring of sterile males into the population
- **Destruction of larvae**:
   - oiling the water reservoirs, that blocks larvae and pupa respiration:
   - spreading the insecticides over the water surface;
   - biological methods- introduction of natural enemies (Minnows and Gambusia) in a breeding place;
   - usage of viral and bacterial agents of diseases of mosquitoes
- **Elimination of breeding places:**
   - emptying of small water reservoirs like cisterns and containers;
   - water reservoirs shores are to be protected by shady trees because Anopheles larvae do not like shady places
- **Personal protection:**
   - **usage of window anti-mosquito nets and repellents.**

Family of Muscidae.

Medical Importance:

- **Flies (house fly) are mechanical vectors of intestinal diseases, eggs of helminthes and cysts of Protozoa.**

- Flies are **biological vectors of transmissive diseases** (**tsetse fly** is the vector of **African trypanosomiasis**,
  stable fly is vector of **anthrax, tularemia, brucellosis)**
- **Flies larvae** are the **causative agents of tissue and intestinal miasis**.

Intestinal miasis may be caused by **house fly, meat fly, green and blue flies**, **drosophila fly larvae.**

Urinal miasis (urether and bladder affection) may be caused by **house fly larvae**.

Musca domestica (House fly).

It feeds on human food, excrements, wound discharge.

A fly can carry up to 6 million of bacteria upon its body and to 28 million in its intestine.

Life cycle: Flies develop with complete metamorphosis. A female lays about 100-150 eggs at one time and repeats such procedures 3-6 times.

Eggs are laid into garbage, human feces, decomposing animals and plant matter. **Development of pupa** takes about **1day** at the temperature of **20^0 C.** Metamorphosis f**rom the egg to imago** takes about **16 days**.

Life span of the house fly is about 1 month.

Medical importance of flies Flies are **mechanical vector**s of **agents of infectious diseases**(dysentery, typhoid, cholera, poliomyelitis, diphtheria, tuberculosis)

They can transmit e**ggs of helminthes and cysts on their bodies**.

Control of flies:

Control of breeding- removal of trash in time, isolation of garbage.

Killing adult flies - usage of glue stripes.

Destroying of imagoes and larva with insecticides.

Genetic methods- imploring of sterile males.

Protection of food from flies, covering them with nets, usage of hermetic saucepans, drawers and glass covers.

Stomoxys calcitrans (Stable fly) looks like housefly.

Development is with incomplete metamorphosis. Females lay eggs into manure

around cattle.

Medical importance: their stings hurt. The injured spot starts itching and burning. The fly is a carrier of antropozoones - anthrax, tularemia, staphylococcus infection.

Wohlfahrtia magnifica (Wohlfahrtia fly)

They arel**arge flies (9-13 mm) colored light-gray with 3dark stripes on the thorax. These flies consume flowers nectar.**

Th**e females give birth to larvae that parasite in human and animal tissues**. The females ar**e attracted by wound pus smell. So the 120-160 larvae at one time are being born on scratches, into eyes, nose, and ears.**

Larvae are about 1 mm. **They feed on tissues and then devour bones destroying blood vessels**. Having spent **2.5-5 days in the wound** larvae fell down into soil turning into pupa and becoming imago in 11-23 days.

Medical importance: *Wohlfahrtia magnifica* parasites in animals and human tissues and causes tissue miasis. In hard cases larvae destroy large areas consuming the skin, soft tissues and affecting eyes.

Order Anoplura (lice)

Parasites of human being are head louse (*Pediculus humanus capitis*), body louse (*Pediculus humanus humanus*) and pubic louse (*Phtirus pubis*).

Pediculus humanus capitis (Head louse)

Morphology : The body is light-gray Females are 3-4mm The body is head, thorax, abdomen. The head is with 2short antennas (an olfactorial organ), 2simple eyes and mouth apparatus of piercing-and-sucking type.

Louse has 3 pairs of appendages.

Location: hairy head areas. One can get infection through combs, brushes, hats of the affected person. Negligence to personal hygienic rules helps the transmission of the parasites.

Life cycle. Eggs (nits) are being posted to the hair (3-4 eggs are being laid per day and up to 150 eggs are produced by a female during its life). Development goes with incomplete metamorphoses (egg, larvae I ,II and III, imago). Larva and imago feed on blood. The development from an egg to imago lasts about 16 days. Life span of head lice is about 27-38 days.

Medical importance: head lice is an ectoparasite, an agent of pediculosis. Affected people suffer with severe head itching.

Head lice is a carrier of obligate-transmissive diseases - relapsing fever and epidemic typhus.

Pediculus humanus humanus or *Pediculus humanus corporis* (Body louse).

Morphology : Females measure up to 4.-7.5 mm, males are up to 3.75 mm.

Life cycle: development is with incomplete metamorphosis.

Eggs (nits) are laid onto clothes folds and are stuck to the cloth.

A female lays up to 14 eggs per day and 300 per life.

Development from an egg to imago lasts for 16 days at the temperature of 25 C. The larva and imago feed on blood. Life span is 32-46 days.

Location: they live in folds of underwear.

Medical importance. Body louse is a constant human ectoparasite, an agent of pediculosis.

Basic symptoms are skin itching, pigmented spots on bites points.

Scratches from itching cover the body.

A person gets infected through contacts with an affected person or with his clothes.

Body louse is a carrier of epidemic typhus and lice-born relapsing fever.

Phtirus pubis (Pubic lice)

Morphology.A female is 1.5 mm, male is 1 mm in length.

Location: on pubic hair, eyelashes, eyebrows, in axillary cavity, moustache and beard. In case of severe infection parasites are present all over the body hair.

Life cycle: Development is with incomplete metamorphosis.

Development from an egg to imago takes 22-27 days. Life span is 17 - 22 days.

Medical importance. Pubic lice is an agent phtiriosis.

Main symptom is itching. Phtiriosis can be transmitted during sexual contacts and through underwear of an invaded person.

They do not transmit agents of any disease.

Destroying of lice:

- Mechanical way- brushing out the insects with a special brush, hair cutting or shaving.
- Chemical way- washing hair and body with special shampoos and soaps that contain insecticides, processing of clothes with insecticides
- Physical way - clothes of a carrier are to be processed in a special disinfecting camera with steam or hot ironing

Preventive means include

- Hygienic rules (regular bathing, taking shower, washing of bed linen)
- Regular inspection of children in kindergarten, school, etc. Treating of affected individuals
- Health education

Order Aphaniptera (Fleas) Fleas are blood sucking insects

Morphology. The body is light-yellow or dark-brown. The body length is 0.5-5 mm. The mouth apparatus is of piercing-and-sucking type.

Life cycle. Development is with complete metamorphosis (egg, larva, chrysalis, imago). Eggs are laid in cracks , in dry garbage, rodents' caves Life cycle lasts from 19 to 270 days depending on temperature and humidity. Mature flea lives for 1.5 years

Medical importance. Some fleas can feed on different hosts. That feature explains the medical importance of fleas as carriers of nature-foci transmissive diseases - plague, tularemia, rat epidemic typhus and others.

Plague is an extremely dangerous nature-foci disease. Its agent is plague bacilli (Pasteurella pestis). Natural reservoirs of plague are various rodents. Fleas are mechanical carriers of plague. Xenopsylla cheopis (rat flea) is the most important vector of plague.

Order Heteroptera (bugs)

Cimex lectularius (Bed-bug)

Morphology. The body is oval shaped and dark-brown . A female is 4.8-8.4 mm, male - 4.9-6.4 mm

Life cycle . Bed-bugs inhabit old houses, beds, furniture, live under wall-paper, etc. Females lay eggs in the places they inhabit. Development is with incomplete metamorphosis. A larva feeds on blood and moults several times to become imago. Development lasts 28-56 days. Imago can survive without food for a year

Medical importance. Bed-bug (Cimex lectularis) is a temporary human ectoparasite. Bites are painful and may cause allergic reactions. They don't transmit any infectious diseases.

Triatoma megista (Kissing bug) is carrier of Trypanosoma cruzi, an agent of Chaga's disease.

Task 1. Study classification of the insects**.** Write down the Latin names of the parasites

Phylum *Arthropoda*

Class *Insecta*

Order *Diptera*

Species: House fly _____

Stable fly _____

Tsetse fly _____

Wohlfahrtia fly _____

Mosquitoes _____

_____

Order *Anoplura*

Species: Head louse _____

Body louse _____

Pubic louse _____

Order *Aphaniptera*

Human flea _____

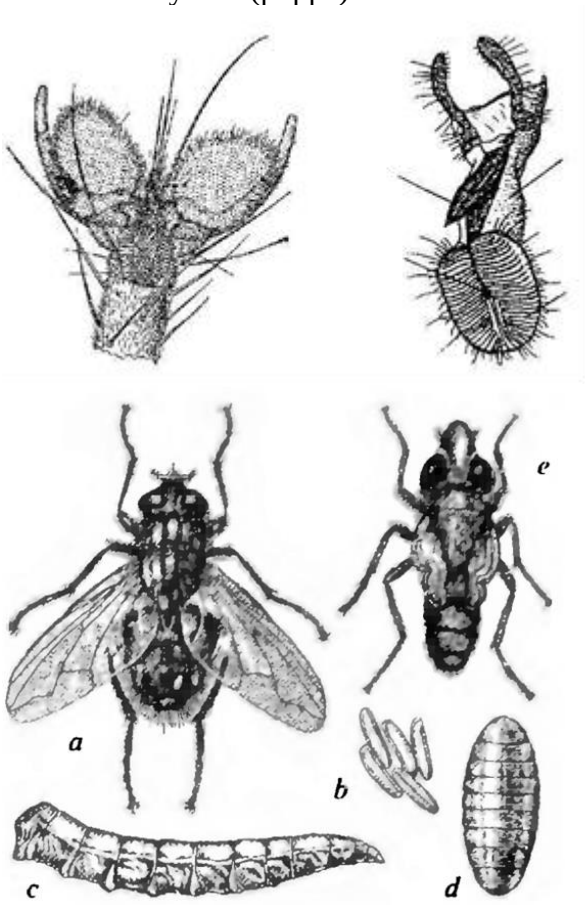
Rat flea _____

Order *Hemiptera*

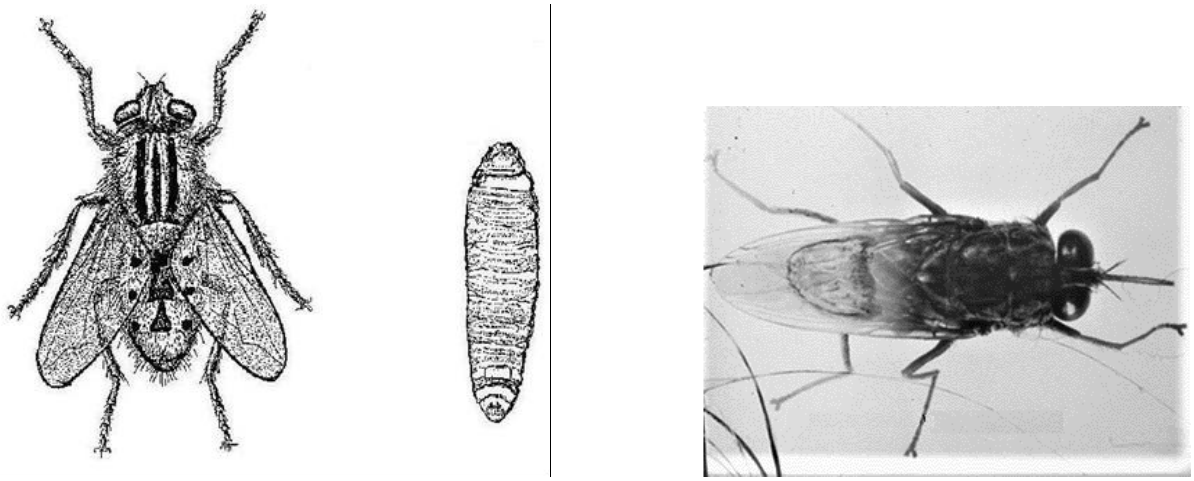
Bed bug _____

Kissing bug _____

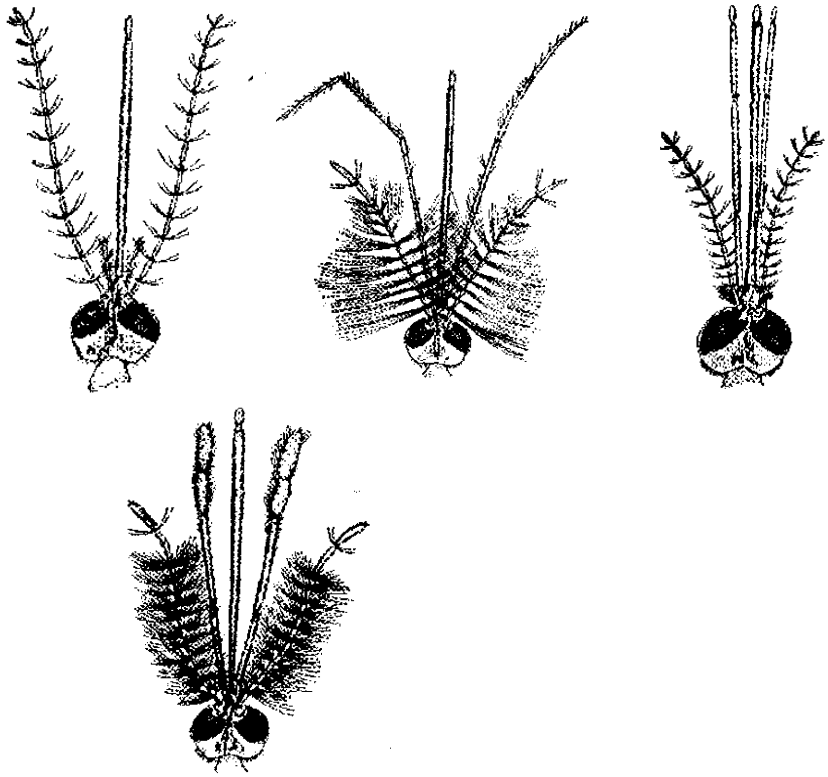
Task 2. Study mouth parts of house fly under microscope. Study morphology of imago, eggs, larva and chrysalis (puppa).



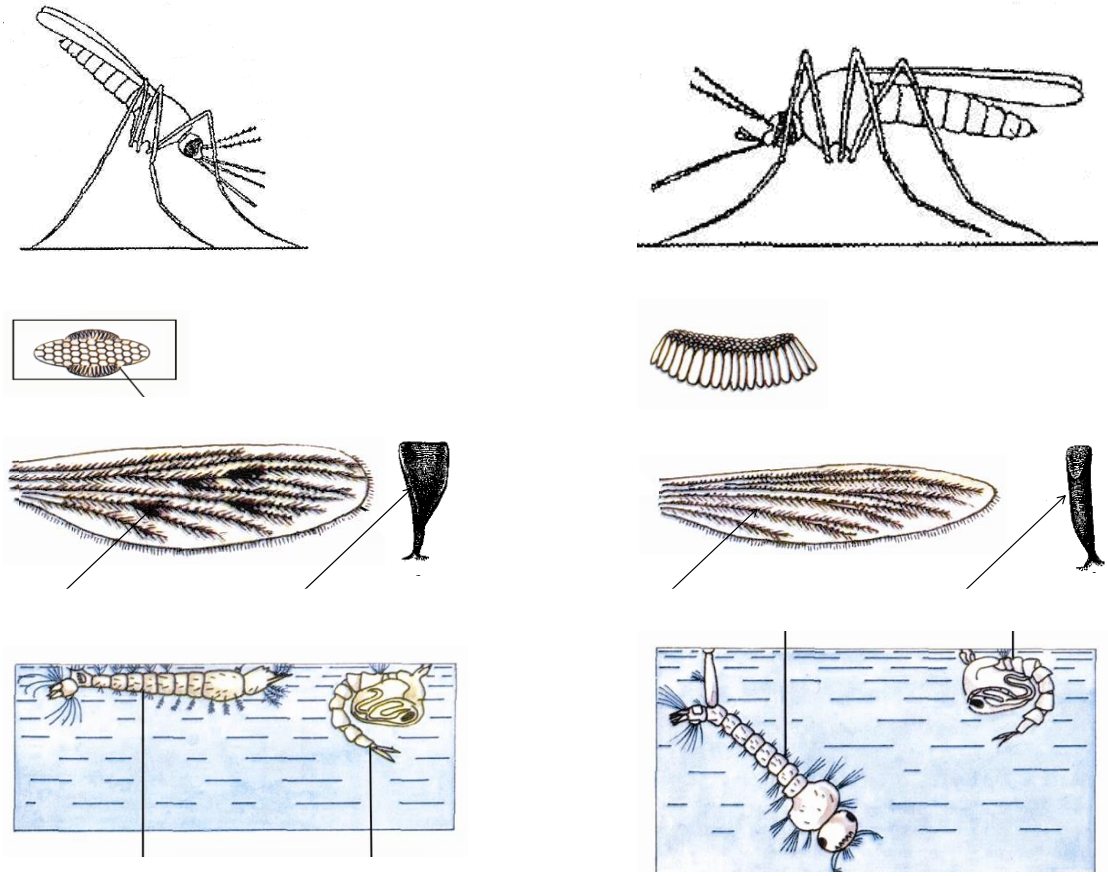
Task 3. Study morphology of Wohlfahrtia fly and its larva. Study morphology of tsetse fly.



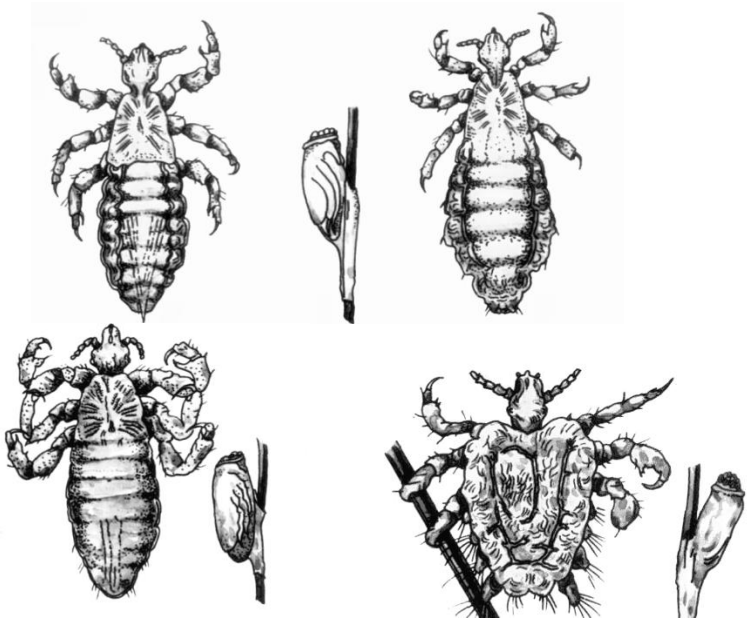
Task 4. Study the heads of Anopheles and Culex mosquito. Label antennae, maxillary palps, proboscis.



Task 5. Compare different stages of development of Anopheles and Culex mosquito.



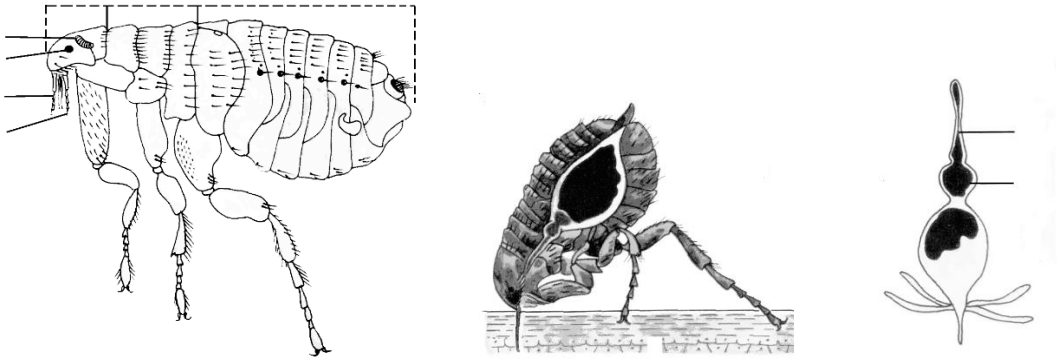
Task 6. Study on macro- and micro specimens morphological peculiarities of lice and its eggs.



Features	Head louse	Body louse	Pubic louse

Length (mm)			
Antennae			
Incisures in abdomen			
Location			
Life span of imago			
Number of eggs per life			
Duration of development			
Medical importance			

Task 7. Study the morphology of rat flea and formation of “plague block”. Mark on a sketch of imago: antennae, mouth parts, eyes, jumping legs, female sucking blood, “plague block”, prestomach, stomach.



Task4. Study the morphology of ectoparasitic bugs. Label bed bag and triatomine (kissing) bug.

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1.Which organism is a mechanical vector of cysts of Protozoa and infections agents of gastrointestinal disorders?
A. Fleas;
B. Cockroaches;
B. Bed bugs
C. Sand-flies;
D. Wohlfartia fly

2. Sand-flies are specific vectors of:
A. Japanese encephalitis;
B. Taiga encephalitis;
A. Anthrax;
B. Spotted fever;
C. Leishmaniasis

3. Wohlfartia fly is a:
A. Specific vector;
B. Mechanical vector;
C. Vector of plague agents;
D. Agent of myiasis;
E. Vector of trypanosomosis.

4. House flies are vectors of:
A. Vector-born infections;
B. Intestinal infections;
C. Leishmaniasis;
D. Relapsing fever;
E. Plague.

5. Which of the following insects is a vector of Malaria?
A. Anopheles mosquito;
B. Culex mosquito;
C. Aedes mosquito;
D. All mosquito species;
E. Sand-flies.

6. Medical importance of fleas
A. Agents of phthiriasis
B. Vectors of plague
C. Vectors o intestinal disorders
D. Vectors of typhus
E. Agents of pediculosis

7. Head louse feeds on
A. Epidermis
B. Contents of the sebaceous glands
C. Animal blood
D. Human blood
E. Lymph

8. Medical importance of head louse is
A. Endoparasite
B. Causative agent of phthiriasis
C. Vector of relapsing fever
D. Vector of encephalitis
E. Causative agent of myiasis

9. Head and body lice are causative agents of
A. Relapsing fever
B. Typhus
C. Myiasis
D. Phthiriasis
E. Pediculosis

10. Pubic louse is the causative agent of
A. Scabies
B. Phthiriasis
C. Pediculosis
D. Typhus
E. Relapsing fever

11. Infection by relapsing fever occurs
A. Trough the bite of head louse
B. Through the bite of body louse
C. Trough the bite of pubic louse
D. Bu crashing lice an inoculation of hemolymph
E. Trough the bite of wohlfartia fly

12. Bad bug is
A. Ectoparasite
B. Vector of tularemia
C. Causative agent of pediculosis
D. Vector of plague
E. Mechanical vector of intestinal infections

13. Causative agent of pediculosis is
A. Head louse
B. Body louse
C. Pubic louse
D. Head and body lice
E. Itch mite

14. Medical importance of fleas
A. Agents of phthiriasis
B. Vectors of plague
C. Vectors o intestinal disorders
D. Vectors of typhus
E. Agents of pediculosis

15. Symptoms of pediculosis are all except for
A. Lice on the eyelashes and eyebrows
B. Skin scratches
C. Skin rash
D. Nits attached to hair

16. Head louse is the vector of
A. Scabies
B. Demodecosis
C. Phthiriasis
D. Pediculosis
E. Relapsing fever

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Final practical lesson from content modules 5-7

Practical class 31. Human ecology. Adaptation and stress.

The Purpose of the Lesson. To study human ecology. Adaptation to environment. Stress.

TOPIC CONTENT

1. Human ecology is a modern line of general ecology.
2. Peculiarities of anthropogenic ecosystems. Environmental pollution. Ecologic crises. Ecologic state in Ukraine after Chernobyl disaster.
3. Adaptive ecotypes. Functional types of human constitutional reacting.
4. An influence of environmental qualitative parameters on human health.
5. Human adaptation to extreme conditions of environment.
6. Stress. General adaptative syndrome.
7. Health, disease, before disease ("the third state").State of human health as integral criterions of quality estimation of environment. Valeology, sanology.

TEST QUESTIONS FOR INDIVIDUAL WORK

	questions	answers
1	Biosphere is …	
2	What are the boarders of biosphere (km)? 1) upper in atmosphere -1; 2) lower in hydrosphere -1; 3) lower in lithosphere -1.	
3		
4	Alive substance is …	
5	What are the main functions of biosphere?1,2	
6	What are the boarding temperatures in biosphere: from… up to …	
7	Ecology studies …	
8	Ecological factors are : 1) biotic -1,2,3,4; 2) biotic -1,2,3,4.	
	What is "anthropogenic factor"?	
9		
10	Adaptation is …	
11	Adaptive ecological type (ecotype) is …	
12	What are the main adaptive human ecotypes: 1,2,3,4,5,6.	
13	What was an original adaptive ecotype in the process of evolution?	
14	What are genetically determinate functional types of human constitutional reacting? 1,2,3	
	What are the human reactions for different types of environment? 1) healthy (comfortable)-1; 2) unhealthy (discomfort able)-1;	
15	3) extreme -1.	
16		
17	Stress (H.Sellye, 1936) is …	
18	Clinical symptoms of stress are …	

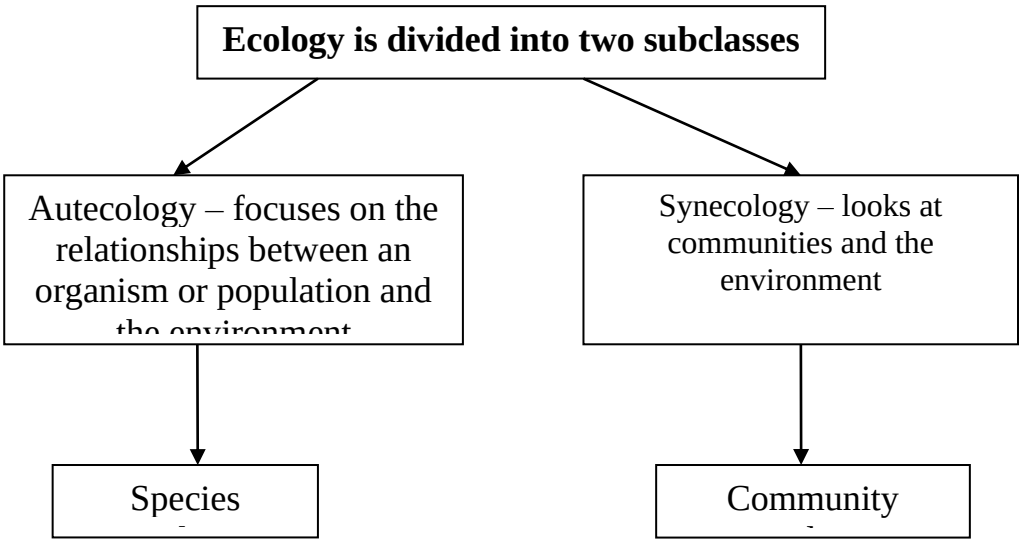
	Desadaptation develops as a result of … What are the main processes in human organism during different stages of stress: 1) anxiety -1,2; 2) resistance -1,2,3; 3) emaciation -1.	

Literature: Medical Biology : textbook / Bazhora Yu. I., Bulyk R.Ye., Chesnokova M. M. [et al]. – 2nd ed., rev. and upd. – Vinnytsia : Nova Knyha, 2019. – pp 398-413.

Ecology

Ecology is the study of the relationships of living organisms to each other and their surroundings. (Gr. - eicos - house, habitation, logos - science). The term "ecology" was introduced by the German biologist Erust Haeckel in 1869.

Modern definition of ecology – is a science of biologic interactions among individuals, populations and communities.



Population - a group of organisms of one species occupying a defined area and usually isolated to some degree from other similar groups.
Community - any group of organisms belonging to a number of different species that coexist in the same habitat or area and interact through trophic and spatial relationships.
Ecosystem - a community of organisms and their physical environment interacting as an ecological unit.
An ecosystem includes:

1. the living part (biotic component)
2. the nonliving part (abiotic component)

An ecosystem can range from a very small area to the entire planet and can be:

1. natural (an ocean, a forest)
2. man-made artificial (an aquarium, a clam, a city)

In an ecosystem there is an exchange of energy flow (materials) between the living organisms and environment in a stable cyclic manner. Therefore an ecosystem is a self-supporting unit.

The environment includes all the external conditions which called the factors of environment or ecofactors. It's may be:

1. Abiotic component (inorganic material, organic material, climate factors)
2. Biotic component (animals, plants, microorganisms)

Relationship between species (symbiosis).

Mutualism is a symbiotic relationship in which both partners benefit.
Commensalism-one organism benefits and the other is neither harmed nor helped.
Predation - one animal kills another one for food.
Parasitism - one organism (the parasite) is harmful for another one(host) but they both have to reach the balance.
Competition - occurs between two or more organisms fighting for a limited amount of food, water, nesting space, shelter and other substances and resources.
Special group of ecofactors is the anthropogenic factors of environment. These factors are formed as a result of human activity. Every organism has it's own role within the structure and function of a community - ecological niche. Niche is the totality of an organism's adaptations, it's use of resources and the lifestyle to which it is fitted. All living organisms and groups of organisms have the certain range of tolerance for every environmental factor. The range of tolerance varies from minimum to maximum and is specific for every organism. The low level of tolerance states that each ecologic factor to which an organism responds has maximum and minimum limiting effects between which lies a range of gradient - limits of tolerance. Between the upper and lower limits of tolerance there lies a broad middle zone of a gradient which is called the zone of compatibility, the zone of tolerance, or the zone of capacity adaptation. The region at either end of the zone of compatibility is called the lethal zone of resistance or zone of intolerance. The zone of compatibility includes a broad range and a narrThe upper and lower limits of tolerance are intencity levels of a factor at which only half of the organisms survive. The range of tolerance varies greatly in different species. Some have a narrow range of tolerance, while others can survive within much wider limits. Any particular species may have the narrow range of tolerance for one factor and wide ranges of tolerance for other factors. Organisms with the narrow ranges of tolerance is called stenobiotics, the ones with the wide ranges are called eurybioticsow zone of physiologic stresses in between the range of optimal and lethal zones.

Biotic components:

1. The producers are the autotrophic members of the ecosystem, the Green plants, which are capable of producing their material own food
2. The consumers are the heterotrophic members of the ecosystem almost exclusively animals, which feed upon others organisms.
3. The decomposers are the reducers sapro- trophic members of the ecosystem bacteria, fungi feed up on decaying organic and decompose it into more simple components

The important biologic principles observed in an ecosystem are:

1. Habitat and ecologic niche
2. cycle of food matter chain
3. food web
4. food pyramid
5. flow of energy

The habitat of a species or population is the specific place it lives in nature. The chemical elements circulate in the biosphere by definitive paths from environment to organisms and back to the environment from organisms biogeochemical cycles (cycle of matter).

Organisms of an ecosvstem are linked together in food chains, herbivorous organisms consume the nutrient rich vegetable substance and convert it into animal material. They may them serve as food to support carnivorous animals, who may be eaten by larger carnivores.in the succession of steps of grazing food chain: photosynthetic autotroph herbivorous heterotroph carnivorous heterotroph decay bacteria - the number and mass of the organisms in each step is limited by the amount of energy available. The food chains interact with one another and the interconnecting network of food chains is called a food web. Since some energy is lost as heat during the transformation the steps become progressively smaller near the top. Biomass is ten times less on each of a food chain. this ratio is called the "ecologic pyramid".
Biomass is the total weight of all living organisms in a ecosystem. Some organisms may have a small biomass, but the total energy they assimilate and pass on may be considerably greater than of organisms with much larger biomass. All organisms in ecosystem live in a dynamic balance.
Increased herbivores number leads to the increase of carnivores number. Predators eat up herbivorous animals and when their amount decreases, predators die due to the lack of food. So, the system stays constant by regulating itself. Such self-regulation is absent in artificial ecosystems.
Human acivity has a great influence on ecosystem and planet ecology.
Pollution:

1. Natural (volcanic eruption, forest fire)
2. Artificial (originater due to activities of man.)

The ecosystem pollutants classified into two basic types:

1. Non-degradable pollutants-they are materials and poisons such as mercury, salts, long-chain phenol chemicals and DDT. Such non-degradable pollutants not only accumulate, but are often biologically magnified as they move in biogeochemical cycles along. These may also combine with other compounds in the environmental to produce additional toxins.
2. Biodegradable pollutants - these include domestic sewage, heat, etc. The domestic sewage can be decomposed by natural processes or in engineered systems such as municipal sewage treatment plant) that enhance natures great capacity to decompose and recycle. Problems arise with these pollutants when their input in the environment exceeds the decomposition or dispersal capacity

So the main problems of modern ecology are:
- the study of antropogenic changes of environment;
-substantiation of methods of conversation and improvement of environment; -methods of regulation the population accent of harmful insects;
-effective exploitation of natural resource

Biosphere

Biosphere, or ecosphere, includes ail the living organisms and physical environment with which they interact. All the communities of all living things on Earth make up the biosphere. These living organisms depend on the Earth's physical environment.
Environment includes:

- The atmosphere, the gaseous envelope surrounding the Earth;
- The hydrosphere, the Earth's supply of water (both liquid and frozen, fresh and salty);
- The lithosphere, the soil and rock of the Earth's crust;

The ecosphere encompasses the biosphere and its interactions with the atmosphere (6 km altitude), hydrosphere (depth - 11 km), and lithosphere (6km in depth);
The biogeocenose (ecosystem) is the basic unit of biosphere
(ecosphere).

Humans in the environment (human ecology)

Homo sapiens has been present on Earth for only the past 200,000 years, which is a brief span of time compared with the age of our planet (some 4.6 billion years). Despite our relatively short tenure on Earth, our biological success has been unparalleled. Our numbers have increased dramatically - the human population is expected to surpass 6 billion by 1998 - and we have expanded our biological range, moving into almost every habitat on Earth.

The human ecology (social ecology) studies laws of interaction of a human society with environments and preservation of health of the man (preserving medicine).

The human ecology consists of:

1. environment
2. man

The man during evolution has adapted to different climatic conditions.

Adaptive types of man:

1. arctic type – develops as adaptation to cold moist climate and low oxygen. It is characterized by: high gases exchange rate; high level of immunoglobulines and cholesterol in blood; high mineralization of skeleton; larger body size; fat and protein-rich food is required.
2. tropical type – develops as adaptation to hot dry climate. It is characterized by: comparatively long extremities, small body weight; carbohydrate-rich food increase efficiency of an organism's functioning.
3. intermediate type – is characterized by intermediate between arctic and tropical types features.

There are serious environmental issues:

- declining biological diversity
- deforestation
- global climate change
- ozone depletion in the stratosphere

Carbon dioxide and other greenhouse gases cause the air to retain heat (infrared radiation), which warms Earth. The increase in CO2 and other greenhouse gases in the atmosphere is causing concerns about major climate changes that may occur during the next century.

S. The combustion of fossil fuels produces pollutants, especially $C0_2$.

T. Other greenhouse gases are chloroffluorocarbons (CFCs), methane, nitrogen oxide and tropospheric ozone.

Global warming may cause a rise in sea level, changes in precipitation patterns, death of forest , extinction of animals and plants and problems for agriculture. It could result in the displacement of thousands or even millions of people. The challenge of global warming can be met by prevention (stop polluting the air with greenhouse gases), mitigation (slow down the rate of global warming) and adaptation (adjustments to live with global warming)**.**

PRACTICAL WORK Ecology

Task 1. Give the characteristics of human adaptive ecotypes that appear in the process of evolution as a result of the influence of factors of living and inanimate nature.

Indices	human adaptive ecotypes			
	Tropic	Arctic	Temperate climate	Mountain

Climate peculiarities				
Prevalent food				
Peculiarities of metabolism				
Peculiarities of phenotype				

Task 2. Characterise the functional human types according to the features of their constitution.

Indices			
	"sprinter"	"stayer"	"mixt"
Ability to adapt to charges			
a) according to the level of charge			
b) according to duration of charge			
Reserve abilities of an organism			
Level of recovering processes			
Reaction for extra charge			

Materials for self-control of the training quality

Tests for self-control with standard answer.

Choose the correct answer.

1. A group of students has representatives of different races. One of the students has straight black hair and overhanging skin fold of superior eyelid - epicanthus. What race does this student most probably represent?

A Europeoid
B Negroid
C Mongoloid
D Australoid
E Ethiopian

2. People living in different parts of the Earth are of different phenotypic peculiarities: Negroid, Mongolian, and Caucasian. This can be explained by the selection:

A Sexual
B Artificial
C Driving

D Stabilizing
E Disruptive

3. There are South and North strains in *Plasmodium vivax* that differ in the duration of the incubation period. In the South strain it is short, and in the North strain – long. This reflects the selection:

A Disruptive
B Stabilizing
C Artificial
D Sexual
E Driving

4. In humans the concentration of carbon dioxide in the blood increases during active physical work. This leads to the deepening and acceleration of respiration, resulting in the blood decreases the concentration of carbon dioxide and hydrogen ions. This supports:

A Ortobiosis
B Immunity
C Ontogenesis
D Homeostasis
E Anabiosis

5. There is a strict time limit for staying at the altitude of over 8,000 meters above sea level without oxygen tanks for man. What is the limiting factor for surviving in this case?

A Partial pressure of oxygen in the air
B Level of ultraviolet irradiation
C Humidity level
D Temperature
E Gravity

6. People are living in the high land for a long time. What changes in blood and cardio-vascular system will be observed?

A increased diameter of the blood vessels
B increasing of the leukocytes number
C decreasing of the leukocytes number
D decrease heart rate
E increasing of the hemoglobin level

7. The representatives of one of the human populations has elongated body, considerable variation of growth, reduced muscle volume, long limbs, reduced in size and volume chest, increased sweating, decreased level of basic metabolism and fat synthesis. To which adaptive types of people this population belongs to?

A Desert
B Arctic
C Tropical
D Mountain
E Intermediate

8. Indigenous population of Pamir has the following characteristic features: high rate of base metabolism, elongated tubular bones, wide rib cage, high blood oxygen capacity due to increased number of erythrocytes, high hemoglobin content. What type of ecological adaptation is it?

A Temperate
B Mountain
C Arctic
D Tropical
E Subtropical

9. After arriving in the polar region, researchers from Australia have complained of nervous disorders, loss of appetite, aggravation of chronic diseases for 6 months. What process has been disrupted in extreme conditions?

A Adaptation
B Tolerance
C Tachyphylaxis
D Stress

Materials for self-control of mastering knowledge and skills provided by this work: tests from the data base of the licence exam Krok-1 (http://kroktest.org.ua/).

A topic of the following class: Summary test control

Main literature

1. Medical Biology / Bazhora Yu. I., Bulyk R. Ye., Chesnokova M. M. [et al.]. – 2nd ed. – Vinnytsia: Nova Knyha, 2019. 448 p.

Additional literature

1. Before we are born : Essentials of embryology and birth defects / Keith L. Moore, T. V. N. Persaud, Mark G. Torchia. – 9th ed. – Elsevier, 2016. 348 pp.

2. Campbell biology / Lisa Urry, Michael Cain, Steven Wasserman, [et al.].– 11th rectricted ed. – Hoboken : Pearson Higher Education, 2016. - 560 pp.

3. Chiodini P. L. Atlas of Medical Helmintology and Protozoology 4th ed. – Churchill Livingstone, 2003. 87 pp.

4. Peter Turnpenny, Sian Ellard. Emery's Elements of medical genetics.-15th ed.,– Elsevier, 2017. 400 pp.

5. Essential Cell Biology : textbook / B.M. Alberts, D. Bray, K. Hopkin [et al]. – 4th ed., rev. and upd. NY: Garland Publishing Inc., 2019. 862 p.

6. Bruton J. Bogitsh, Clint E. Carter. Human parasitology – 4th ed., – Elsevier, 2013. 430 pp.

7. T. W. Salder. Langman's medical embryology. – 14th ed. – Wolter Kluwer Health, 2018. - 423 pp.

8. Lynn B. Jorde, John C. Carey, Michael J. Bamshad. Medical genetics. 5th ed. Elsevier, 2016. 356 pp.

9. David. T. John, William A. Petri. Markell and Voge's Medical parasitology. – 9th ed. – Elsevier, 2017. 463 pp.

10. M. R. Speicher, S. E. Antonarakis, F. G. Motulsky. Vogel and Motulsky's human genetics. Problems and approaches.- 4th ed. – Springer, 2010. 981 pp.

11. Young Ian. D. Medical genetics. – 2nd ed. – Oxford university press, 2010. 304 pp.

13. Information resources:

1. Testing Center - the base of licensing test tasks "Krok" - 1: http://testcentr.org.ua/
2. OMIM (Online Mendelian Inheritance in Man) – An Online Catalog of Human Genes and Genetic Disorders http://omim.org/
3. The tech interactive: https://genetics.thetech.org/genetics-news
4. Phys.org internet news portal provides the latest news on science. https://phys.org/biology-news/
5. Sci-News.com provides the latest science news from around the world, covering breaking news in astronomy and astrophysics, archaeology, paleontology, medicine, biology, physics, genetics & morehttp://www.sci-news.com/news/biology
6. link to the most thought-provoking, well researched online items in the world of science and technologyhttps://scitechdaily.com/news/biology/
7. Web atlas of medical parasitology http://www.atlas.or.kr/about/index.html