Ministry of Science and Education of Russian Federation
Federal state institution of higher professional education
Ulyanovsk State University
Institute of Medicine, Ecology and Physical culture

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METHODICAL RECOMMENDATIONS

for teachers in the discipline

"BIOLOGY"

for first-year students of the Faculty of Medicine

Ulyanovsk – 2019

УДК 576(075.8)
ББК 28.05я73
К75

It was recommended by the scientific-methodological council of Institute of Medicine, Ecology and Physical culture of Ulyanovsk State University
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Methodological manual compiled in accordance with the Federal state educational standards in the direction of the preparation "General Medicine".

This manual describes in detail the content of the course "Biology", reflects the sequence of topics and their contents, presents questions and tests to prepare for classes and independent work. This greatly facilitates the preparation of teachers for classes.

The peer-reviewed methodological manual contains basic material, selected according to the programmatic issues cited, the sequence of presentation of the material reflects the traditional style of teaching biology.

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GOALS AND OBJECTIVES OF THE DISCIPLINE

***Aims*:**

The formation of students scientific world view based on knowledge in biology, fundamental to scientific and practical medicine. To study the fundamental biological mechanisms of life and living systems and based on them questions of anthropogenetic, ontogensis, homeostasis, population genetics and human ecology, as well as master the skills of research and practical work in the field of anthropogenetic, anti-parasitic and vector-borne diseases.

The main **objectives** of the discipline is:

- mastering fundamental theories of biology (cell, gene, chromosomal, evolutionary theory of the origin of life on Earth, the theory of human origins);

- mastering the basic concepts of modern biology;

- studying of systematic and historical approaches to the study of multi-level living systems as a result of the evolutionary process;

- the mastery of the concept of "biological heritage of man" as the defining basis of physical and mental health;

- the study of the cognitive skills of work with biological objects, familiarization with of methods and approaches to studying them.

2. Place of the course in the curriculum:

- Discipline "Biology" is the basic discipline of mathematical and natural cycle of disciplines of the Federal state educational standard of higher professional education specialty “General medicine”;

- Study of biology in medical schools is based on the continuity of knowledge, skills and competencies obtained in the course of biology at secondary schools, as well as knowledge of chemistry, physics, geography, mathematics, history. Students should possess the necessary amount of knowledge in specific disciplines of biology (Botany, Zoology, Anatomy, General biology), which they mastered in secondary schools, and aimed at preparation for entrance examinations for admission to universities.

- Discipline "Biology" is the antecedent for the study subjects: normal physiology, physiology of visceral systems, pharmacology, patological anatomy.

3. Proposed results:

The course is aimed at the following general professional ***competence:*** GPC – 7 - the readiness to use basic physicochemical, mathematical and other natural science concepts and methods in solving professional problems.

<u>The proposed results of the course</u>

Students have to:

know:

general laws of the origin and evolution of life, anthropogenesis. The theory of biological systems, their organization, cellular and non-cellular forms of life; Cellular organization of living organisms, the distinguishing characteristics of pro - and eukaryotic cells, the role of cellular structures in the life of the cell, the mechanisms of energy production in living systems. Regularities of processes and mechanisms for the storage, transfer and use of biological information in the cell, principles of control of gene expression; Structural and functional organization of genetic material features of the genome of prokaryotes and eukaryotes. Cytological basis of reproduction, gametogenesis, structure of germ cells. The laws of genetics and its importance for medicine. Patterns of heredity and variation in individual development, biological basis of inherited human diseases and methods of their diagnostics. Regularities of individual development of organisms, human ontogenesis, molecular mechanisms of embryonic development, critical periods of ontogenesis. Environmental category environmental health issues, bioecological disease. The phenomenon of parasitism. The morphological features of the parasites, their life cycles, ways of infection, pathogenic action, symptoms, diagnosis, prevention of diseases. Parasitological and medical characteristics of arthropod - vectors and pathogens.

***be able to*:**

use educational, scientific, popular scientific literature, the Internet for professional activities. To use biological equipment. Research with magnifying equipment (microscopes, optical and simple loops). Cooking time and explore their products under a light microscope and magnifying glass. Put a simple biological experiment and analyze the results. Read and analyze the electron diffraction pattern of cell structures. In the form of generalized diagrams show the processes occurring in the cell. Using this notation, to solve problems on mitosis, meiosis, gametogenesis. Explain the causes and possible mechanisms of birth of children with chromosomal diseases. Solve problems on genetics, molecular, make the pedigrees using standard notation, analyze pedigrees. Compile and analyze the ideograms, using the Denver classification system chromosomes. Identify the type of parasite, stage of development of the proposed drug. To solve situational problems in parasitology.

be skilled at:

research with a microscope. Skills cooking time products. Skills mapping studied objects in the figures; Electron diffraction analysis skills. Skills determining of karyotype. Genetic approaches to solving problems. Standard notation for drawing pedigrees. Denver classification system for the analysis of chromosome ideograms microscopy.

TOTAL EMPLOYMENT OF DISCIPLINE

The volume of discipline in credits (total): 7 CU.

By type of academic work (in hours): 252

Type of educational work	**Number of hours**		
	Workload	**Hours per term**	
		1	**2**
Contact work of students with a teacher	144	72	72
Classroom:			
Lectures	36	18	18
Tutorials and practical's work	90	54	54
Independent work	54	36	36
Scope of testing (examination, test, colloquium)	36 Exam	Not provided	36
Total course of workload	252/10*	108	144
Total workload in credit units	7	3	4

Units and formats of academic activities

Form of study: full-time

Units	Total	Format			
		Class studies			Independent work
		Lectures	Laboratory work	Tutorials and work practical's	
Section 1. Cellular and molecular-genetically levels of organization of life					
Unit 1. Introduction to biology. The organization of life on Earth	8	2	-	4	2
Unit 2. Cell – the basic unit of life. The most important	8	2	-	4	2

biopolymers of the cell					
Unit 3. Chemical composition of cells	8	-	-	4	4
Unit 4. Morphofunctional organization of the cell	6	-	-	4	2
Unit 5. Classification and structure of cell organelles	8	2	-	4	2
Unit 6. Cell nucleus	6	2	-	2	2
Unit 7. Features of the organization of the cells of plants, animals and bacteria. Non-cellular forms of life	4	-	-	2	2
Unit 8. The cell as an open system. Energy metabolism	8	2	-	4	2
Unit 9. Cell life cycle	10	2	-	4	4
Section 2. Organismic (ontogenetic) level of organization of biological systems					
Unit 10. Reproduction of organisms	6	2	-	2	2
Unit 11. Genetics – is the science of heredity and variation. Genetic level of organization of the genetic information	10	2	-	4	4
Unit 12. Types and variants of Mendelian inheritance. The interaction of genes	6		-	4	2
Unit 13. Chromosomal and genomic levels of organization of the genetic information	6	-	-	4	2
Unit 14. Modification and combined variability	7	1	-	4	2
Unit 15. Mutational variability	7	1	-	4	2
Unit 16. Individual development of organisms	6	2	-	4	2
Unit 17. Embryonic development of	4	-	-	4	2

organisms					
Unit 18. Regularities and mechanisms of ontogenesis	6	2	-	4	2
Section 3. Population-specific level of organization of the living systems. Biogeocenotic and biosphere levels of organization of the biological systems.					
Unit 19. Evolution	6	2	-	4	2
Unit 20. The notion of biological species.	3	-	-	4	2
Unit 21. Anthropogenesis	6	2	-	4	2
Unit 22. Ecology	5	2	-	4	4
Unit 23. Parasitology. Protists. Class Sarcodina	5	2	-	4	4
Unit 24. Protists. Class Zoomastigophora	7	2	-	4	4
Unit 25. Protists. Classes Sporozoa and Cilliophora	3	-	-	4	4
Unit 26. Class Trematoda. Class Cestoda	6	2	-	6	2
Unit 27. Nemathelminthes. Medical importance of class Arachnids	7	2	-	4	2
Unit 28. Medical importance of class Insects	5	-	-	4	4
TOTAL:	180	36		108	54

Course contents.

<u>Section 1. Cellular and molecular-genetical levels of organization of life.</u>

Unit 1. Introduction to biology. The organization of life on Earth. Biology as a science of patterns, the mechanisms of functioning and development of organisms. Biology in the medical school. The definition of the essence of life. Fundamental properties of life. Evolutionary-based levels of organization of the life. Structure and working principles of the light microscope.

Unit 2. Cell – the basic unit of life. The most important biopolymers of the cell. The stages of development and the basic tenets (basic postulates) of cell theory (M. Schleiden and T. Schwann, R. Virchow). Modern cell theory. The most important biopolymers of the cell. Structure and function of proteins.

Unit 3. Chemical composition of cells. Structure and function of fats, carbohydrates, deoxyribonucleic acid in the cell. Structure, types and functions of RNA.

Unit 4. Morphofunctional organization of the cell. The concept of elementary biological membrane, the model of its structure and function. Transport of substances through the membrane. Characterization of active and passive transport of the membrane. The cytoplasm is the internal environment of the cell, its properties and functions.

Unit 5. Classification and structure of cell organelles. Classification of cell organelles. Structure and function of membrane cell organelles: endoplasmic reticulum, Golgi Complex, lysosomes, mitochondria, plastids of plant cells. Structure and function of membrane cell organelles: ribosomes, centrioles, microtubules, microfilaments. The structure and functions of organelles for specific purposes: cilia and flagella, myofibrils, neurofibril.

Unit 6. Nucleus.

The role of the cell nucleus during the life of the cell. Structure and functions of each part of the cell nucleus: nuclear shell, nucleoplasm, chromatin and nucleolus. Structural organization of chromatin.

Unit 7. Features of the organization of the cells of plants, animals and bacteria. Non-cellular forms of life.

Comparative characteristics of cells prokaryotes and eukaryotes. Comparison of the structure and functions of plant and animal cells. Non-cellular forms of life. Structure and features of vital activity of viruses.

Unit 8. The cell as an open system.

The concept of metabolism and its types. The relationship of plastic and energy metabolism.

Protein biosynthesis in the cell.

Energy metabolism and its stages.

Unit 9. Life cycle of the cell.

Life cycle of the cell. The interphase and its periods. DNA replication. Mitosis, its phases, and biological significance. Cell death and its phases.

Section 2. Organismic (ontogenetic) the level of organization of biological systems.

Unit 10. Reproduction of organisms.

Reproduction is a universal feature of living. Comparative characteristics of asexual and sexual reproduction of organisms. Types of asexual and sexual reproduction of organisms. Parthenogenesis. Meiosis, its phases and biological significance.

Unit 11. Genetics – is the science of heredity and variation. Genetic level of organization of the genetic information. Subject, objectives and methods of genetics. The laws of heredity of Gregor Mendel.

Cytological basis of the laws of Gregor Mendel. Evidence for the role of DNA as the hereditary material. Properties of genetic code. Gene – a functional unit of heredity. Classification, properties and localization of genes. The relationship between gene and trait. Hypothesis Beadle-Tatum. The hypothesis of Jacob-Mono (operon hypothesis). The chemical composition and structure of chromosomes.

Unit 12. Types and variants of Mendelian inheritance. The interaction of genes. The concept of allelic genes. Types of interaction between allelic genes: complete dominance, incomplete dominance, codominance, overdominance. Multiple allelism. Inheritance of blood groups of humans. The interaction of nonallelic genes: epistasis, complementarity, polymeria. Pleiotropy genes.Types and variants of Mendelian inheritance. Monogenic inheritance. Genetics of sex. Autosomal and sex-linked inheritance. Independent and linked recessive inheritance. Polygenic inheritance of the traits. Cytoplasmic inheritance.

Unit 13. Chromosomal and genomic levels of organization of the genetic information. Chromosome as a group of adhesion genes. Chromosomal theory of inheritance by Thomas Morgan. Characterization of the genome of prokaryotes and eukaryotes.

Unit 14. Modification and combined variability. Modification variability, especially, adaptive significance in ontogenesis and evolution. The concept of norm of the reaction. Mechanisms of combined variability (genetic recombination). The value of combined variability in ensuring genotypic diversity.

Unit 15. Mutational variability. Mutational variability. Classifications of mutations. The concept of the genetic, chromosomal mutations. Genomic mutations (euploidiya and aneuplodiya). Genetic, chromosomal and genomic of human disease.

Unit 16. Individual development of organisms. The concept of ontogenesis. Periods of ontogenesis. Gametogenesis (spermatogenesis. oogenesis). Fertilization, and it stages (penetration, activation, nuclei fusion). Cleavage. Yolk distribution in three kinds of egg cells. The Blastula. Types of blastula.

Unit 17. Embryonic development of organisms. Gastrulation, modes early and late gastrulation. The Gastrula, germ layers: ectoderm, mesoderm, and endoderm. Neurulation. Organogenesis. Extraembryonic organs (amniotic membrane, chorion, yolk sac, allantois, placenta): structure and physiological importance.

Unit 18. Regularities and mechanisms of ontogenesis. Differentiation in development. Stages and factors of differentiation. The mechanisms of ontogenesis. Embryonic induction as a mechanism of ontogenesis. The regeneration of organs and tissues as a process of development. The physiological and reparative regeneration. Methods of reparative regeneration.

Section 3. Population-specific level of organization of the living systems. Biogeocoenotic and biosphere levels of organization of the biological systems.

Unit 19. Evolution. Pre-Darwinian evolutionary ideas the period of formation. J.-B. Lamarck´s theory of evolution. The main provisions of the theory of evolution of the Charles Darwin. Modern (synthesis) theory of evolution. Factors of evolution.

Unit 20. The notion of biological species. Microevolution. Macroevolution. Modes of speciation. The species. Criteria for the species. The main directions of evolution (biological progress and regression). Ways to achieve of biological progress (aromorphosis, idioadaptation, total degeneration) and its forms.

Unit 21. Anthropogenesis. The position of Homo sapiens in the animal world. The qualitative uniqueness of the person. Biological and social factors of anthropogenesis. The role of biological factors of the anthropogenesis at the present stage.

Human races and the unity of the human species.

Unit 22. Ecology. Environmental factors: classification and general patterns of action of the environmental factors on a organism. The concept of trophic levels. The rule of the ecological pyramid. The biosphere. Biogeochemical cycles.

Unit 23. Parasitology. Protists. Class Sarcodina. Parasitism as an ecological phenomenon. Classification of animal parasitic forms. Ways of origin of the various groups of parasites. Interaction between parasite and host-level individuals. Factors of the action of parasite on the host organism. Factors action hostess on the parasite. Morphophysiological adaptation to a parasitic lifestyle. Population level of interaction of the parasites and their hosts. The life cycles of parasites. Intermediate and major host. Vector-borne and natural focal, parasitic and infectious diseases. Ecological principles to combat parasitic diseases. General characteristics of the class Sarcodina. Morphophysiology and the life cycle of Entamoeba histolytica. Diagnosis and prevention of amebiasis.

Unit 24. Protists. Class Zoomastigophora. General characteristics of the class Zoomastigophora. The life cycle of pathogens, pathogenesis, diagnosis and prevention of trypanosomiasis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of leishmaniasis, trypanosomiasis and giardiasis.

Unit 25. Protists. Classes Sporozoa and Cilliophora. General characteristics of the class Sporozoa. The life cycle of Plasmodium sp., pathogenesis, diagnosis and prevention of malaria. The life cycle of pathogens, pathogenesis, diagnosis and prevention of toxoplasmosis. General characteristics of the class Cilliophora. The life cycle of pathogens, pathogenesis, diagnosis and prevention of balantidiasis.

Unit 26. Class Trematoda. Class Cestoda. Types of Platyhelminthes (flatworms). Class Trematoda: The Flukes. The life cycle of pathogens, pathogenesis, diagnosis and prevention of fasciolasis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of opistorhosis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of lung fluke disease. The life cycle of pathogens, pathogenesis, diagnosis and prevention of dicroceliasis. Morphophysiology and the life cycle of blood fluke (Schistosoma).

Class Cestoda: The Tapeworms. The life cycle of pathogens, pathogenesis, diagnosis and prevention of teniasis and cysticercosis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of teniarinhosis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of hymenolepiasis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of diphyllobothriasis.

Unit 27. Nemathelminthes. Medical importance of class Arachnids. Characteristics of class Nematoda (roundworms). The life cycle of pathogens, pathogenesis, diagnosis and prevention of ascariasis, enterobiasis and trichinosis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of ankylostomiasis, strongyloidosis. The life cycle of pathogens, pathogenesis, diagnosis and prevention of guinea worm, filariosis. General characteristics of the class Arachnids. Troop mites: morphology, life cycle, medical value.

Unit 28. Medical importance of class Insects.

Morphophysiological characteristics and life cycle of the class Insects. Morphology, life cycle and medical importance of insects - ectoparasites (lice, fleas, houses and volfartova flies). Insects - the carriers of infectious and parasitic diseases (gnats, mosquitoes, sandflies, tsetse flies, midges), morphophysiological characteristics, life cycle and medical importance.

Practical and educational content and recommendations for it.

Section 1. Cellular and molecular-genetic levels of organization of the life.

Unit 1. Introduction to biology. The organization of life on Earth. Format-practical's.
Discussion questions:

1. Biology as a science of patterns, the mechanisms of functioning and development of organisms.
2. Biology in the medical school.
3. The definition of the essence of life.
4. Fundamental properties of life.

5. Evolutionary-based levels of organization of the life.
6. Structure and working principles of the light microscope.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

unicellularorganism, multicellular organism, molecule, cell, tissue, organ, organ system, organism, species, population, community, ecosystem, biosphere, order, sensitivity, growth, development, reproduction, regulation, homeostasis.

KEY POINTS OF THE TOPIC:

A. <u>Rules of work with the microscope "Biolam P-11"</u>

1. Clean the eyepiece, lens and slides with using a swipe.
2. Use the coarse focus adjustment knob to maximize the working distance (the distance between the stage and the objective lens).
3. Rotate the revolver into position with the scanning power (x8) objective lens in the viewing position. Turn the revolver until you hear a slight click and the lens is fixed.
4. Using coarse focus adjustment knob lift the lens above the stage to a height of approximately 0,5 cm. **Remember that the study of any object starts with a small magnification.**
5. Open the diaphragm and slightly lift the condenser. Looking into the eyepiece of its left eye, rotate the mirror in different directions until the field of view is illuminated brightly and evenly.
6. Place the slide on the stage so that the object was in the center of its hole.
7. Look into the eyepiece. At the same time slowly rotating a coarse focus adjustment knob on yourself lift the objective lens up until an image of the object is shown in the field of view (**remember that the focal length for a small magnification of approximately 0,7 cm**).
8. For consideration of the object at high magnification of the microscope, place it in the center of the field of view. Adjust the sharpness of the image using a fine focus adjustment knob.
9. Rotating the revolver, put in the working position of the lens at high magnification. **Remember that when focusing on an object at high magnification is necessary to work only with fine focus adjustment knob.**
10. Rotate the fine focus adjustment knob in one direction or another to achieve a crisp image of the object.
11. If the image of the object is missing, repeat the operations specified in paragraphs 6-9.
12. Draw the object.

B<u>. Properties of Life</u>

1. Order.

All organisms consist of one or more cells with highly ordered structures: atoms make up molecules, which construct cellular organelles, which are contained within cells. This hierarchical organization continues at higher levels in multicellular organisms and among organisms.

2. Sensitivity.

All organisms respond to stimuli. Plants grow toward a source of light, and your pupils dilate when you walk into a dark room.

3. Growth, development, and reproduction.

All organisms are capable of growing and reproducing, and they all possess hereditary molecules that are passed to their offspring, ensuring that the offsprings are of the same species. Although crystals also “grow,” their growth does not involve hereditary molecules.

4. Regulation.

All organisms have regulatory mechanisms that coordinate the organism's internal functions. These functions include supplying cells with nutrients, transporting substances through the organism, and many others.

5. Homeostasis.

All organisms maintain relatively constant internal conditions, different from their environment, a process called homeostasis.

All living things share certain key characteristics: order, sensitivity, growth, development and reproduction, regulation, and homeostasis.

C. The levels of life organization

In unicellular (single-celled) organisms, the single cell performs all life functions. It functions independently. However, multicellular (many celled) organisms have various levels of organization within them. Individual cells may perform specific functions and also work together for the good of the entire organism. The cells become dependent on one another.

Molecular level

At this level some of the properties have a living DNA molecule. They are able to store hereditary information and to reproduce by replication.

The cellular level of life organization

Cells are the basic unit of structure and function in living things. They may serve a specific function within the organism.

Cell is an open system, bounded from the environment by a membrane and containing within the cytoplasm with organelles and a nucleus.

Examples - blood cells, nerve cells, bone cells, etc.

Tissue level of organization of life

Tissue is a group of cells and their derivatives, having a common origin, similar structure and functions grouped together to perform a specific activity.

- muscle tissue
- nervous tissue
- epithelial tissue
- connective tissue

Organ level of organization of life

Organ is a constant structure of the body, consisting of several tissues that have a particular shape, size, and performs a specific function.

System-organ level of organization of life

Organ system is a group of organs that together perform a common activity.

For example, the nervous system, endocrine system, circulatory system, etc.

Organismal level of organization of life

The organism - an open system consisting of interconnected organs and organ systems which have the ability to self-regulation and have new features which are not in individual organ systems.

Usually made up of organ systems, but an organism may be made up of only one cell such as bacteria or protist.

Population-species level of organization of life

Species - a group of individuals similar in morphological, physiological, biochemical and other characteristics, occupying a certain territory, having panmixia and giving fertile offspring.

Population - group of individuals of one species living in isolation from similar groups of individuals of this species and is characterized by higher levels of interbreeding.

Community level of organization of life

Community - a group of interdependent organisms of different species growing or living together in a specified habitat.

The ecosystem level of organization of life

Ecosystem - a biological community of living organisms of different species, closely interacting with each other and with their environment, having the ability to self-replicate and self-regulation.

Biosphere level of organization of life

Biosphere - the totality of the planet's living organisms that inhabit certain areas of the atmosphere, hydrosphere and lithosphere.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Fill in the gaps in sentences

1._____ is ability to maintain relatively constant internal conditions, different from their environment.

2._____ - the process of increasing the weight or volume of the structure of the organism, which is accompanied by quantitative changes. For example, increasing the number of cells.

3._____- the process of transition from one state to another, more perfect, the transition from an old qualitative state to a new qualitative state, from simple to complex, from lower to higher.

4._____is the ability to reproduce itself.

5._____ - the ability to coordinate the internal functions of the body.

6._____ is the body's ability to respond to stimuli of the internal and external environment.

RECOMMENDED TASKS FOR INDEPENDENT WORK

Fill in the gaps in sentences

1._____is group of individuals of one species living in isolation from similar groups of individuals of this species and is characterized by higher levels of interbreeding.

2._____ is a constant structure of the body, consisting of several tissues that have a particular shape, size, and performs a specific function.

3._____is a biological community of living organisms of different species, closely interacting with each other and with their environment, having the ability to self-replicate and self-regulation.

4._____is an open system, bounded from the environment by a membrane and containing within the cytoplasm with organelles and a nucleus.

5._____is a group of organs that together perform a common activity.

6._____is a group of individuals similar in morphological, physiological, biochemical and other characteristics, occupying a certain territory, having panmixia and giving fertile offspring.

7._____is a group of interdependent organisms of different species growing or living together in a specified habitat.

8._____is the totality of the planet's living organisms that inhabit certain areas of the atmosphere, hydrosphere and lithosphere.

9._____ is a group of cells and their derivatives, having a common origin, similar structure and functions grouped together to perform a specific activity.

10._____ is an open system consisting of interconnected organs and organ systems, and have the ability to self-regulation and has new features which are not in individual organ systems.

Unit 2. Cell – the basic unit of life. The most important biopolymers of the cell. Format-practical's.

Discussion questions:

1. The stages of development and the basic tenets (basic postulates) of cell theory (M. Schleiden and T. Schwann, R. Virchow).
2. Modern cell theory.
3. The most important biopolymers of the cell. Structure and function of proteins.

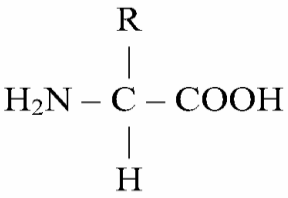
IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

protein, amino acid, peptide bond, functional group, carboxyl group, amino group, covalent polar bond, hydrogen bond, hydrophilic, hydrophobic, radical, disulfide bridge, hemoglobin, monomer, polymer

KEY POINTS OF THE TOPIC:

A. The structure and function of proteins in the cell.

Protein – heteropolymer, the monomers of which are amino acids. The protein may include up to 20 different amino acids. General formula of amino acids:



Each amino acid has a hydrocarbon radical and two functional groups: the carboxyl group and amino group. Amino acids in the protein are connected by peptide bonds. It is formed between the carboxyl group of one amino acid and amino group of another amino acid. It is a covalent polar bond.

There are 4 patterns of protein:

1. Primary structure – chain of amino acids connected by peptide bonds.

The specific amino acid sequence of a protein is determined by the nucleotide sequence of the gene that encodes the protein.

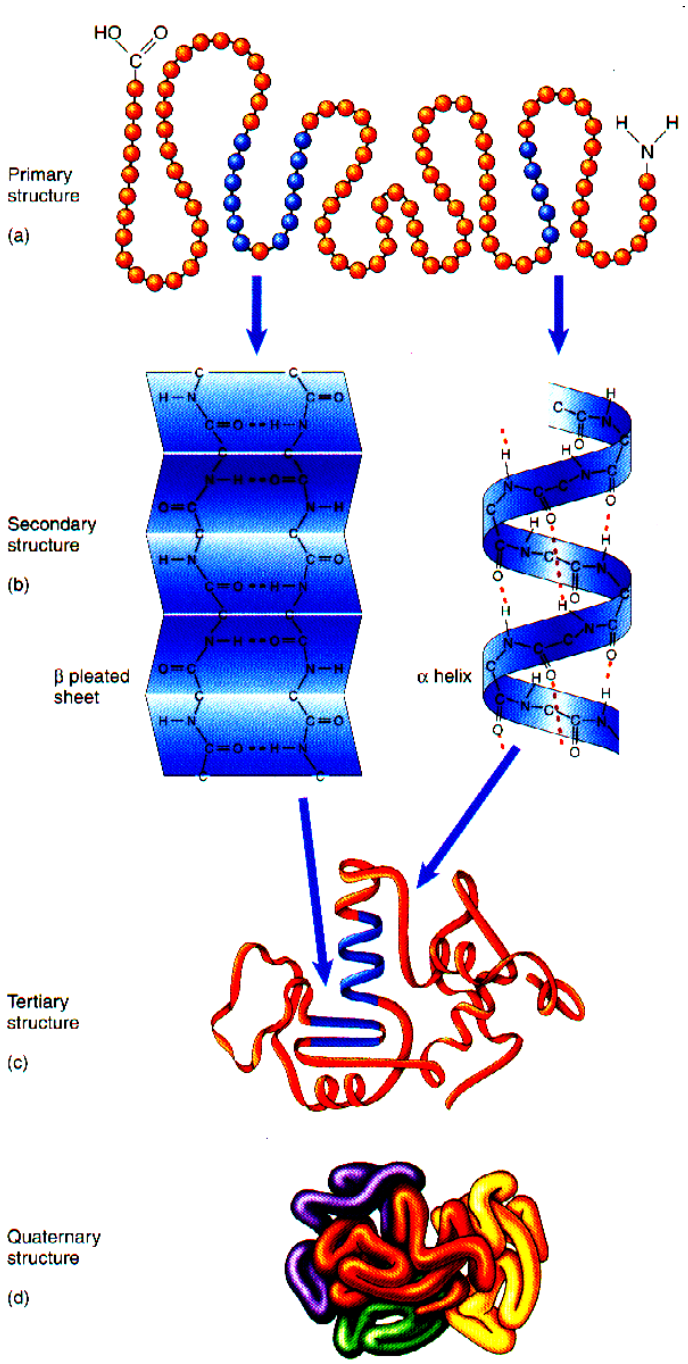
2. Secondary structure – helix. The amino acid chain is twisted in a spiral due to the formation of hydrogen bonds.

3. Tertiary structure is globule.

Helix is folded in the form of globules by:

A) the formation of more hydrogen bonds.

B) hydrophilic and hydrophobic interactions hydrophilic radicals of amino acids are on the outside of the globules, hydrophobic radicals of amino acids are located within the globule.



C) formation of disulfide bridges between the radicals of amino acids that contain sulfur (cysteine)

D) ionic interactions

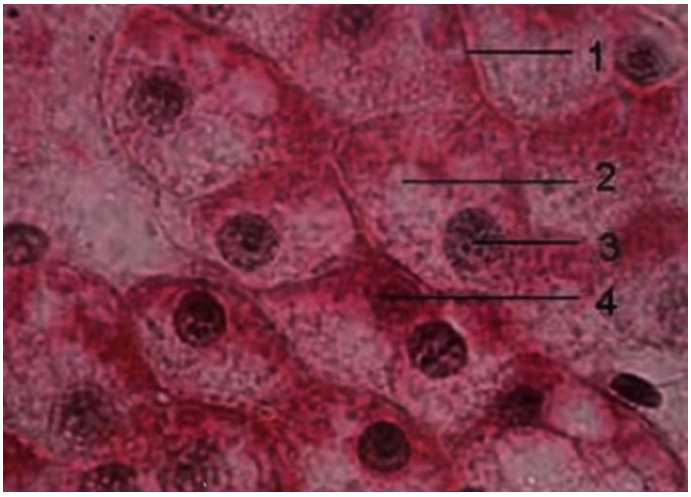
Domains. Many proteins in your body are encoded within your genes in functional sections called exons. Each exon-encoded section of a protein, typically 100 to 200 amino acids long, folds into a structurally independent functional unit called a domain. As the polypeptide chain folds, the domains fold into their proper shape, each more-or-less independent of the others. A single polypeptide chain connects the domains of a protein. Often the domains of a protein have quite separate functions—one domain of an enzyme might bind a cofactor, for example, and another the enzyme's substrate.

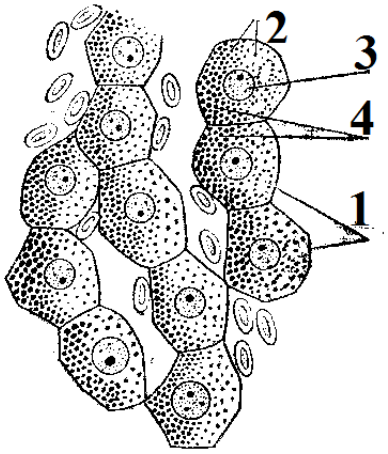
4. Quaternary structure – complex of several globules, a combined group of non-protein atoms. The hemoglobin protein consists of 4 polypeptide chains and gems that contain iron

B. Slides used in class

1. The inclusion of glycogen in the liver cells of amphibians (coloring method is best)

At high magnification, consider the Central part of the slice. Around the nucleus, painted in purple, in the cytoplasm are red lumps of glycogen. On the edge of the cut they can be offset one-half of the cell is the result of processing of the slice during fixation (artifact). Draw the plot of the slice with multiple cells.

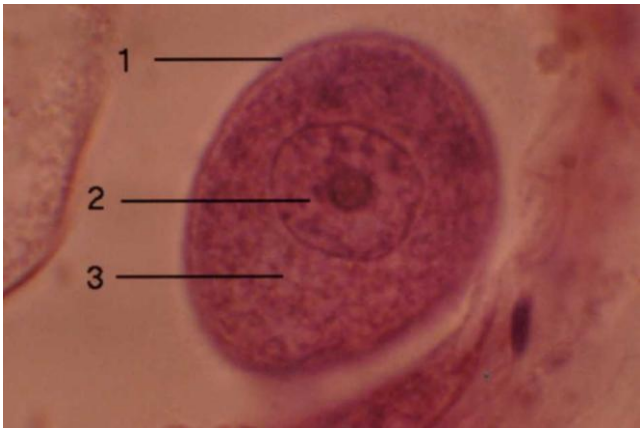


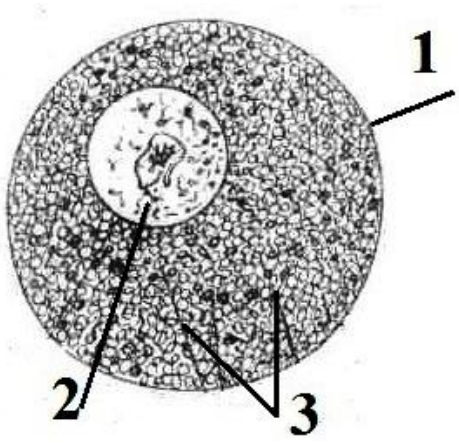


Refer figure: 1) the cell boundaries; 2) cytoplasm; 3) the core; 4) the granules of glycogen.

2. The inclusion of protein in the egg bezzubki (dyed with hematoxylin-eosin)

At low magnification find the egg bezzubki round shape pink color. At high magnification, consider slightly lowering the condenser and rotating screws, dark red the formation of protein granules in the cytoplasm of the cell. Draw an egg protein pellets.

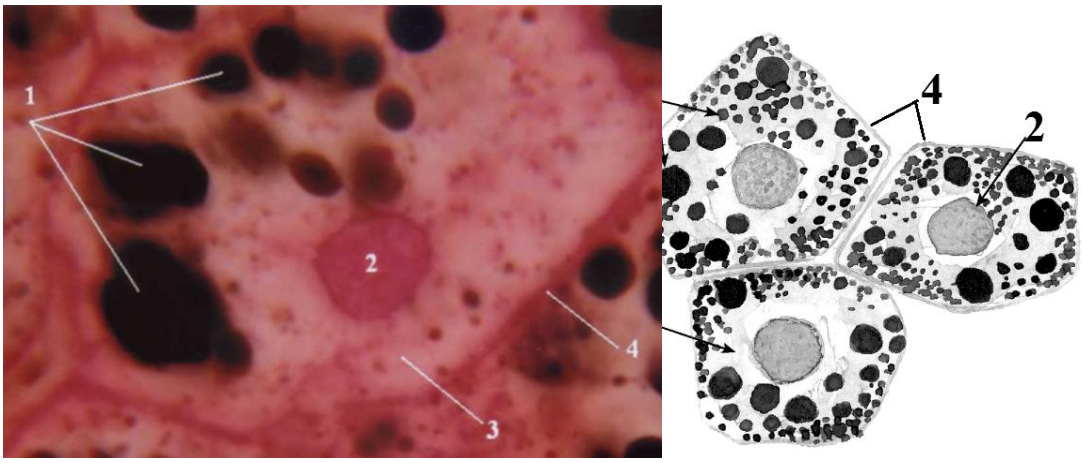




Refer figure: 1) the cell boundaries; 2) nucleus; 3) the inclusion of protein

3. The inclusion of fat in the liver cells of amphibians (colour osmium acid)

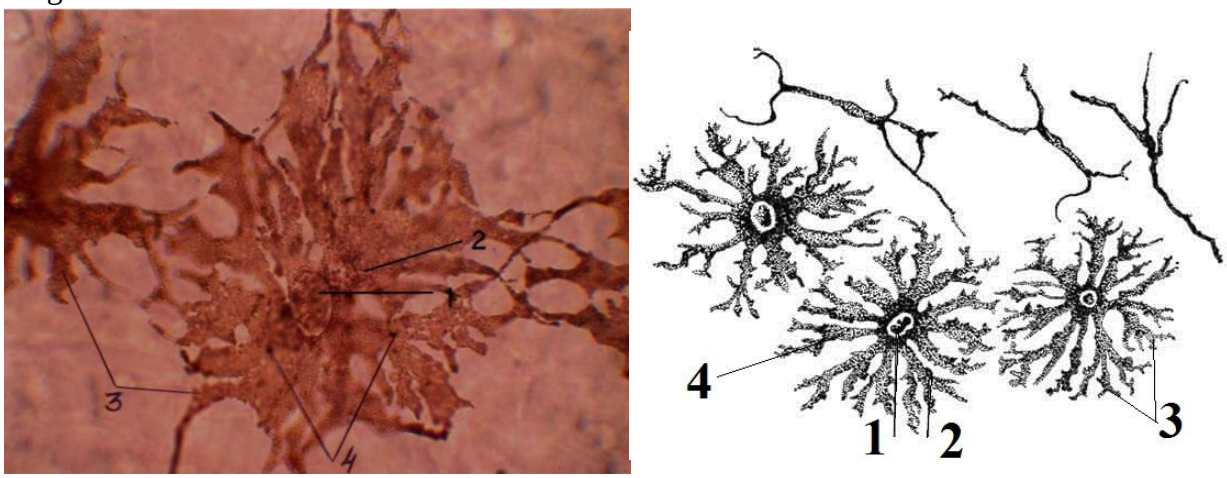
At low magnification of the microscope, locate the cells of polygonal shape pink color. At high magnification, consider the inclusion of fat in the form of black rounded formations of various sizes. Large nuclei are colored pink. Draw the plot of the slice with 2-3 cells.



Refer figure: 1) fat droplets; 2) nucleus; 3) the cytoplasm; 4) the cell border.

4. Pigment inclusions in the skin cells of a tadpole (product is not painted)

At low magnification microscope, find cell process forms. At high magnification, consider the cytoplasm and cell processes, which are filled with greenish-brown pigment granules. In the center of the cell, where is the unstained nucleus, seen round or oval enlightenment. Draw 1-2 cells.



Refer figure: 1) nucleus; 2) the cytoplasm; 3) processes of cells; 4) pigment granules

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

1. Protein – heteropolymer, the monomers of which are

a) nucleotides
b) amino acids
c) phospholipids
d) nitrogenous bases

2. In the protein amino acids are connected by

a) hydrogen bond
b) ionic bond

c) metallic bond
d) peptide bond.

3. Peptide bond is formed between the carboxyl group of one amino acid and
a) carboxyl group of another amino acid
b) amino group of another amino acid
c) phosphate group of another amino acid
d) hydroxyl group of another amino acid

4. Peptide bond is
a) covalent polar bond.
b) covalent nonpolar bond.
c) hydrogen bond
d) ionic bond

5. Primary structure of the protein
a) chain of amino acids connected by hydrogen bonds
b) chain of amino acids connected by peptide bonds
c) chain of nucleotides connected by peptide bonds
d) chain of amino acids connected by covalent nonpolar bonds

6. Secondary structure of the protein
a) helix
b) globule
c) chain
d) two chain

7. Helix is folded in the form of globules by
a) formation of disulfide bridges between the radicals of amino acids
b) metallic bond
c) peptide bonds
d) covalent nonpolar bonds

8. The enzymes are
a) structural proteins
b) regulatory proteins
c) protective molecules
d) biological catalysts

9. The function of antibodies
a) transport
b) defense
c) catalysis
d) regulation

10. The protein which transports oxygen in the blood
a) insulin
b) hemoglobin
c) myosin
d) tubulin

RECOMMENDED TASKS FOR INDEPENDENT WORK

Insert missed words

1. Protein – heteropolymer, the monomers of which are _____.
2. In the protein amino acids are connected by _____ bond.
3. Peptide bond is formed between the carboxyl group of one amino acid and _____ of another amino acid.
4. Peptide bond is _____ bond.

5. Primary structure of the protein is chain of amino acids connected by_____ bonds

6. Secondary structure of the protein is _____.

7. Helix is folded in the form of globules by formation of _____between the radicals of amino acids.

8. The enzymes are proteins, which function as _____.

9. The function of antibodies is _____.

10. The protein which transports oxygen in the blood is _____.

Unit 3. Chemical composition of cells. Format- study discussion.

Discussion questions:

1. Structure and function of fats.
2. Structure and function of carbohydrates.
3. Structure and function of deoxyribonucleic acid in the cell.
4. Structure, types and functions of RNA.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

heteropolymer, monomer, nucleotide, nitrogen base, carbohydrate, lipid, deoxyribose, ribose, phosphodiester bond, covalent polar bond, complementarity, nitrogen bases, genetic code, codon, triplet, anticodon, monosaccharide, disaccharide, polysaccharide, hereditary information, protein synthesis.

KEY POINTS OF THE TOPIC:

A. Structure and function of lipids in the cell.

Fats consist of a glycerol molecule to which is attached three fatty acids, one to each carbon of the glycerol backbone. Because it contains three fatty acids, a fat molecule is called a triglyceride, or, more properly, a triacylglycerol. Because triglyceride molecules lack a polar end, they are not soluble in water. Placed in water, they spontaneously clump together, forming fat globules that are very large relative to the size of the individual molecules.

Fats perform the following functions in living organism.

1. The structure function. Fats (lipids) are part of the membrane and organelles of the cell membrane.

2. Energy function. Fats are the most energy-intensive organic matter: the complete oxidation of 1g of fat releases 38.9 kJ of energy.

3. A function of storing nutrients. Subcutaneous adipose tissue in mammals is a place to store nutrients.

4. Fat as a thermal insulator (cetaceans subcutaneous fat layer thickness can reach up to 1m, allowing them to swim in the cold Arctic seas).

5. The function of mechanical protection. Subcutaneous adipose tissue of animals protects organs from knocks and bumps.

6. The source function of education:

• endogenous water - water produced within the body as a result of the biochemical reactions. The camel is the humps in fat. The oxidation of 100 g fat 105 g of water is released.

• sex hormone (testosterone, estrogens, progesterone, etc.);

• fat-soluble vitamins (A, D, E).

7. Grease as a lubricant at the aquatic animals.

Phospholipids are among the most important molecules of the cell, as they form the core of all biological membranes. An individual phospholipid is a composite molecule, made up of three kinds of subunits:

1. Glycerol, a three-carbon alcohol, with each carbon bearing a hydroxyl group. Glycerol forms the back bone of the phospholipid molecule.

2. Fatty acids, long chains of C—H bonds (hydrocarbon chains) ending in a carboxyl (—COOH) group. Two fatty acids are attached to the glycerol backbone in a phospholipid molecule.

3. Phosphate group, attached to one end of the glycerol. The charged phosphate group usually has a charged organic molecule linked to it, such as choline, ethanolamine, or the amino acid serine. The phospholipid molecule can be thought of as having a polar "head" at one end (the phosphate group) and two long, very nonpolar "tails" at the other. In water, the non-polar tails of nearby phospholipids aggregate away from the water, forming two layers of tails pointed toward each other—a lipid bilayer. Because the C—H bonds in lipids are very nonpolar, they are not water-soluble, and aggregate together in water. This kind of aggregation by phospholipids forms biological membranes.

B. Structure and function of carbohydrates in the cell.

Carbohydrates - organic compound containing hydrogen, carbon and oxygen. According to the complexity of the structure, they are divided into monosaccharides, oligosaccharides and polysaccharides.

Monosaccharides - carbohydrates are the most simple structure. According to the number of carbon atoms in the molecule, all monosaccharides separated into three-carbon sugars (pyruvic acid), four-carbon sugars (erythrose), five-carbon sugars (ribose, deoxyribose), six-carbon sugars (glucose and fructose).

Oligosaccharides are carbohydrates having from 2 to 10 monosaccharide residues. Disaccharides contain two monosaccharide residue. For example, sucrose consisting of glucose and fructose. Maltose contains two glucose residues. Lactose contains residues of galactose and glucose.

Polysaccharides are polymers of the monomer which are monosaccharides. For example the monomer of starch, cellulose and glycogen is glucose.

As monosaccharides and especially polysaccharides have a number of important functions in the body.

1. Construction (plastic) function. Polysaccharides are part of cell walls: cellulose in plants, bacteria murein, chitin in fungi. Carbohydrates are part glycocalyx animal cells.

2. Energy function. Carbohydrates main substrate for energy production in the cell. Complete oxidation of 1g carbohydrate culminates in the formation of 17.6 kJ of energy.

3. The function is stored. In plant cells store starch, animal cells stored glycogen.

4. The protective function. Carbohydrates in complex proteins, glycoproteins form mucus coating the inner surface of the respiratory tract, digestive tract, bladder, and others. The mucus provides the relevant bodies and the body in general, mechanical, chemical and biological defense.

5. Receptor function. Carbohydrates are membrane glycoproteins composed receptors.

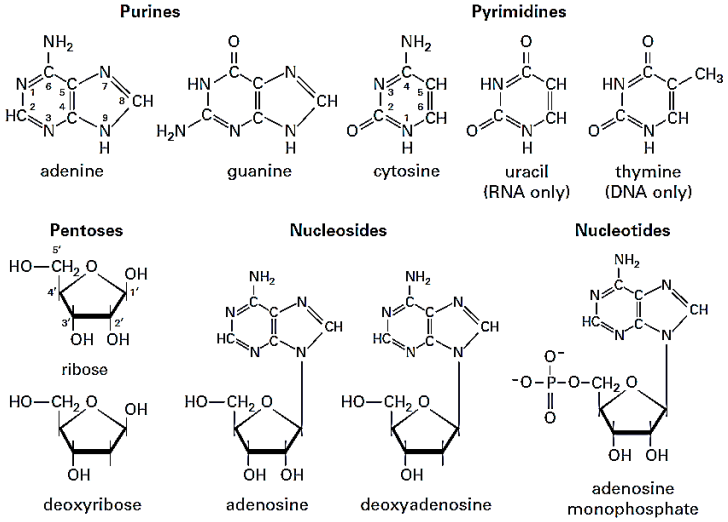
6. The primary source for the synthesis of substances. Carbohydrates formed by photosynthesis, is the primary basis for the synthesis of other organic compounds.

C. Structure of nucleic acids.

Genetic information in a living organism is encoded in ***deoxyribonucleic acid*** (***DNA***) and ***ribonucleic acid*** (***RNA***). DNA and RNA are composed of monomers called ***nucleotides***; these often are referred to as bases because their structures contain cyclic organic bases. Each nucleotide is composed of *a five-membered pentose carbon sugar* (2-deoxyribose in DNA and ribose in RNA), *a nitrogenous base* (purine or pyrimidine) and *a phosphate group*. The carbon atoms in a sugar molecule are labeled 1′ to 5′. A nucleotide, or nucleoside phosphate, is formed by the attachment of a phosphate to the 5′ position of a nucleoside by an ester linkage.

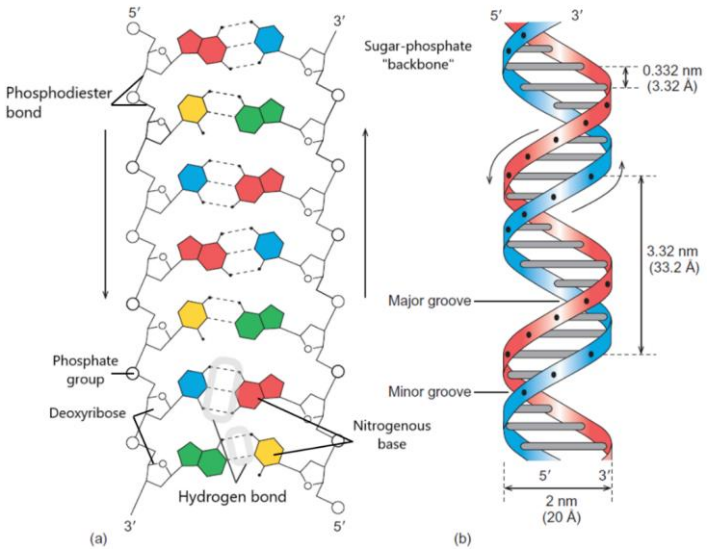
Long polynucleotide molecules are formed when nucleotides are joined together by the formation of an ester bond by reaction between the phosphate of one nucleotide and the 3′ hydroxyl of another, thus generating a 5′ to 3′ phosphodiester bond between adjacent sugars.

The purine bases (composed of fused five- and six-membered rings), adenine (A) and guanine (G) and the pyrimidine (a single six-membered ring) cytosine (C) are found in both RNA and DNA. The other pyrimidines are each restricted to one type of nucleic acid: uracil (U) occurs exclusively in RNA, whilst thymine (T) is limited to DNA. Thus it is possible to distinguish between RNA and DNA on the basis of the presence of ribose and uracil in RNA, and deoxyribose and thymine in DNA.



Cellular RNA range in length from less than one hundred to many thousands of nucleotides; the number of nucleotides or bases is used as a measure of length. Cellular DNA molecules can be as long as several hundred million nucleotides. The number of base pairs (bp) is used as a measure of length of a doublestranded DNA. In practice, the unit of length used for DNA is the kilobase pair (kb or kbp), corresponding to 1000 base pairs, or the megabase pair (Mb or Mbp) corresponding to 1 000 000 base pairs.

DNA has two polynucleotide strands: one strand runs 5′ to 3′, whilst the other strand runs in the opposite direction 3′ to 5′. The polarity of the two strands of the molecule is in opposite directions, and thus DNA is described as an antiparallel structure. The strands are held together by hydrogen bonds between the bases. The two polynucleotide chains in DNA are usually found in the shape of ***a right-handed double helix***, in which the bases of the two strands lie in the centre of the molecule, with the sugar–phosphate backbones on the outside. The spatial relationship between the two strands creates furrows – the major and minor grooves.



In the double helix of DNA, nucleotide A pairs only with T, and C pairs only with G, we can say A and T are ***complementary*** and so are G and C. This complementary matching of the two strands is so strong that if complementary strands are separated, they will spontaneously zip back together in the right salt and temperature conditions. If, however, a DNA solution is heated to approximately 90 °C or above there will be enough kinetic energy to denature the DNA completely, causing it to separate into single strands. This is termed denaturation. If melted DNA is cooled it is possible for the separated strands to reassociate, a process known as renaturation. Strands of

RNA and DNA will associate with each other, if their sequences are complementary, to give double-stranded, hybrid molecules.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Choose the correct answer

1. Monomers of DNA are
A. nucleotides
B. amino acids
C. phospholipids
D. nitrogenous bases
2. Each DNA nucleotide is composed of three parts:
A. phosphate, pentose sugar - ribose, nitrogenous base
B. carbonate, pentose sugar - deoxyribose, nitrogenous base
C. phosphate, pentose sugar - deoxyribose, nitrogenous base
D. phosphate, pentose sugar - deoxyribose, glucose
3. DNA consists of 4 types of nitrogenous bases
A. adenine, uracil, thymine, cytosine
B. adenine, guanine, uracil, cytosine
C. adenine, guanine, thymine, cytosine
D. adenine, guanine, thymine, uracil
4. Nucleotides of DNA are linked by
A. covalent polar bond
B. covalent nonpolar bond
C. hydrogen bond
D. ionic bond
5. Covalent polar bond is formed between
A. phosphate grope of one nucleotide and nitrogenous base of the second nucleotide
B. nitrogenous base of one nucleotide and sugar of the second nucleotide
C. nitrogenous base of one nucleotide and nitrogenous base of the second nucleotide
D. phosphate grope of one nucleotide and sugar of the second nucleotide
6. DNA chains are interconnected by
A. covalent polar bond.
B. covalent nonpolar bond.
C. hydrogen bond
D. ionic bond
7. In the DNA double helix:
A. adenine is complementary to thymine
B. adenine is complementary to guanine
C. uracil is complementary to thymine
D. cytosine is complementary to thymine
8. The structure of RNA nucleotides, unlike the DNA includes
A. sugar - ribose and the nitrogenous base adenine
B. sugar - deoxyribose and the nitrogenous base cytosine
C. sugar - deoxyribose and the nitrogenous base uracil
D. sugar - ribose and the nitrogenous base uracil
9. Chromatin is composed of
A. DNA and protein
B. RNA and protein
C. proteins only
D. DNA only
10. Highly condensed chromatin is called
A. euchromatin

B. heterochromatin
C. nucleosome
D. scaffold protein

RECOMMENDED TASKS FOR INDEPENDENT WORK

Task 1. Add the missing words

1. The process of DNA duplication is called _____.
2. The information in the language of nucleotides is copied into another language – the language of amino acids during the process of _____.
3. The monomers of DNA are _____.
4. Each nucleotide of DNA is composed of three parts: phosphate, _____ and _____.
5. DNA consists of 4 types of nitrogenous bases: adenine, guanine, _____and _____.
6. Polynucleotide molecules are formed when nucleotides are joined together by the formation of _____ bond by reaction between _____ of one nucleotide and the _____ of another nucleotide.
7. DNA chains are interconnected by _____ bond.
8. DNA is found in the _____ in Eukaryotic cells.
9. DNA is found in the _____in prokaryotic cells like bacteria.
10. The structure of RNA nucleotides, unlike the DNA, includes _____ and _____.
11. One _____ codes for one protein.
12. Cells with two copies of the genome are called _____.

Task 2. Find and correct mistakes, if any

1. DNA has two polynucleotide strands: one strand runs 5′ to 3′, whilst the other strand runs in the opposite direction 3′ to 5′.
2. Each nucleotide is composed of a five-membered pentose carbon sugar, a nitrogenous base (purine or pyrimidine) and an amino acid.
3. The purine bases (composed of fused five- and six-membered rings), adenine (A) and guanine (G) and the pyrimidine (a single six-membered ring) cytosine (C) and thymine (T) are found in both RNA and DNA.
4. In the double helix of DNA, nucleotide A pairs only with T, and C pairs only with G.
5. All bacteria, many viruses, mitochondria and chloroplasts have circular DNA.
6. First-order packaging involves the winding of the DNA around a core complex of five small proteins repeated twice, termed histones (H1, H2A, H2B, H3 and H4).
7. During G1 phase, each chromosome is duplicated, identical chromosomes (sister chromatids) remain attached to one another at a point called the centromere.
8. Most plants and animals contain two copies of their genome and called haploid.
9. Genome can be defined as the complete set of genes of a cell, organelle or virus.
10. There is a relation between the size of genome, number of genes, and organism complexity.

<u>Unit 4.</u> Morphofunctional organization of the cell. Format-practical's.

Discussion questions:

1. The concept of elementary biological membrane, the model of its structure and function.
2. Transport of substances through the membrane.
3. Characterization of active and passive transport of the membrane.
4. The cytoplasm is the internal environment of the cell, its properties and functions.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

phospholipid, bilipid layer, hydrophilic head, hydrophobic tails, cholesterol, integral proteins, channel proteins, transferring proteins, peripheral proteins, glycolipid, glycoprotein, osmosis, diffusion, passive transport, active transport, potassium sodium pump, facilitated diffusion, hypertonic solution, isotone solution, hypotonic solution.

KEY POINTS OF THE TOPIC:

A. Fluid mosaic model of membrane structure

The current concepts of membrane structure derive from the work of Singer and Nicholson in the early 1970s. In this model, cell membranes consist basically of phospholipid molecules arranged as a bilayer.

Phospholipid molecules are amphipathic, i.e. they consist of a polar, hydrophilic (water-loving) head and a non-polar, hydrophobic (water-hating) tail. The polar heads are mainly derived from glycerol conjugated to a nitrogenous compound such as choline, ethanolamine or serine via a phosphate bridge. The phosphate group is negatively charged whereas the nitrogenous group is positively charged. The non-polar tail of the phospholipid molecule consists of two long-chain fatty acids each covalently linked to the glycerol component of the polar head.

Phospholipids in aqueous solution will spontaneously form a bilayer with the hydrophilic (polar) heads directed outwards and the hydrophobic tails forced together inwards. The weak intermolecular forces which hold the bilayer together allow individual phospholipid molecules to move relatively freely within each layer and sometimes to 'flip' between layers.

Cholesterol molecules are also present in the bilayer in an almost one-to¬one ratio with phospholipids. Cholesterol molecules can regulate the fluidity and can stabilise the phospholipid bilayer.

Associated with the bilayer are a variety of protein molecules which make up almost half of the total mass of the membrane. Some proteins are incorporated within the membrane (intrinsic or integral proteins) whereas others are held to the inner or outer surface by weaker electrostatic forces (extrinsic or peripheral proteins). Some intrinsic proteins span the entire thickness of the membrane (transmembrane proteins) to be exposed to each surface, some functioning as 'pores' through which hydrophilic molecules are actively or passively transported across the membrane. Many proteins are not fixed but rather 'float' within the membrane such that they are freely mobile within the plane of the phospholipid bilayer. This has led to the use of the term fluid mosaic model of membrane structure. Whilst the lipid component of the membrane principally determines its mechanical properties, the dynamic functions of the membrane as an interface between biological compartments is a function of the membrane proteins. Other integral proteins may be fixed by attachment to elements of the cytoskeleton.

On the external surface of the plasma membranes of animal cells, many of the membrane proteins and some of the membrane lipids are conjugated with short chains of polysaccharide; these glycoproteins and glycolipids respectively project from the surface of the bilayer forming an outer coating which may be analogous to the cell walls of plants, bacteria and fungi. This polysaccharide layer has been termed the glycocalyx and appears to vary in thickness in different cell types; a similar layer is often also present on membrane surfaces within the cell which are not exposed to the cytosol (e.g. luminal aspects of membrane systems). The glycocalyx appears to be involved in cell recognition phenomena, in the formation of intercellular adhesions and in the adsorption of molecules to the cell surface; in some situations the glycocalyx also provides mechanical and chemical protection for the plasma membrane.

B. Transport across plasma membranes

Plasma membranes mediate the exchange of molecules between the internal and external environments of the cell in four principal ways enabling the cell to control the quality of its internal environment with a high degree of specificity.

• **Passive diffusion.** This type of transport is entirely dependent on the presence of a concentration gradient across the plasma membrane. Lipids and lipid-soluble metabolites such as ethanol pass freely through plasma membranes which also offer little barrier to the diffusion of gases such as oxygen and carbon dioxide. The plasma membrane is, in general, impermeable to hydrophilic molecules. Nevertheless some small molecules including water and urea, and inorganic ions such as bicarbonate, are able to pass down osmotic and electrochemical gradients through the membrane via hydrophilic regions, the nature of which remains obscure.

• **Facilitated diffusion.** This type of transport is also concentration-dependent and involves the transport of larger hydrophilic metabolites such as glucose and amino acids. This process is strictly passive but requires the presence of so-called 'carriers' to which the metabolites bind specifically, but reversibly, in a manner analogous to the binding of substrate with enzyme.

• **Active transport.** This mode of transport is not only independent of concentration gradients but also often operates against extreme concentration gradients. The classic example of this form of transport is the continuous transport of sodium out of the cell by the 'sodium pump'; this process requires the expenditure of energy provided in the form of ATP. Active transport is mediated by 'dynamic pores' consisting of transmembrane protein systems. Both active and passive transport processes are enhanced if the area of the plasma membrane is increased by folds or projections of the cell surface as exemplified by the absorptive cells lining the small intestine.

• **Bulk transport.** This involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound *vacuoles (vesicles)* within the cytoplasm. When the process involves the creation of small vacuoles it is known as *pinocytosis,* and when large vacuoles are formed it is called *phagocytosis.*

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Task 1 - test

1. The basis of the cell membrane is formed
a) by two layers of proteins
b) fatty acids
c) by two layers of nitrogenous compounds
d) by two layers of lipids
2. Each phospholipid has
a) hydrophilic (polar) head and three hydrophobic (nonpolar) tails.
b) hydrophilic (polar) head and two hydrophobic (nonpolar) tails
c) hydrophobic (nonpolar) head and two hydrophilic (polar) tails
d) hydrophilic (polar) tail and two hydrophobic (nonpolar) heads
3. The non-polar tails of the phospholipid molecule consist of
a) two long-chain glycerol
b) two long-chain choline
c) two long-chain fatty acids
d) three long-chain fatty acids
4. The polar heads of phospholipids in the bilipid layer
a) are located on its outer side
b) are located inside
c) are arranged randomly
d) are located both outside and inside
5. Model of membrane structure is
a) sandwich model

b) fluid mosaic model
c) lipid-electron model
d) mathematical model

6. Transmembrane proteins are

a) extrinsic proteins
b) peripheral proteins
c) integral proteins
d) hormones

7. The term fluid mosaic model of membrane structure. is used because

a) many proteins are not fixed but 'float' within the membrane so they are freely mobile within the plane of the phospholipid bilayer
b) proteins form a continuous layer on the surface of lipids
c) lipids form a continuous layer on the surface of proteins
d) many proteins are firmly fixed in the lipid bilayer

8. Polysaccharide layer on the external surface of the plasma membranes of animal cells has been termed

a) glycocalyx
b) cell wall
c) acrosome
d) dictyosome

9. The glycocalyx takes part

a) in cell division
b) in energy metabolism
c) in the formation of intercellular adhesions
d) to the enzymatic cleavage substances

10. Passive diffusion

a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.
b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.

Task 2. Add the missing words

1. The basis of the cell membrane is formed by two layers of _____.
2. Each phospholipid has a hydrophilic (polar) head and two hydrophobic _____.
3. The non-polar tail of the phospholipid molecule consists of two long-chain _____.
4. On the external surface of the plasma membranes of animal cells, many of the membrane proteins and some of the membrane lipids are conjugated with short chains of polysaccharide forming _____.
5. The type of transport which entirely dependent on the presence of a concentration gradient across the plasma membrane is called _____.
6. The type of transport which concentration-dependent and involves the transport of larger hydrophilic metabolites with help of so-called 'carriers' with which the metabolites bind specifically is called _____.
7. The type of transport which not only independent of concentration gradients but also often operates against extreme concentration gradients is called_____.

RECOMMENDED TASKS FOR INDEPENDENT WORK

Task 1 - test

1. Facilitated diffusion
a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.
b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.
2. Active transport
a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.
b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.
3. Bulk transport
a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.
b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.
4. Passive transport of substances through the membrane include
a) osmosis
b) exocytosis
c) endocytosis
d) pinocytosys
5. Active transport of substances through the membrane include
a) osmosis
b) diffusion
c) endocytosis
d) facilitated diffusion
6. If the cells placed in a hypotonic solution
a) the water will penetrate from the cell to the outside
b) the water will penetrate in cell
c) cell shrinks
d) the cell does not change
7. If the cells placed in hypertonic solution
a) the water will penetrate from the cell to the outside
b) the water will penetrate in cell
c) cell ruptures
d) the cell does not change
8. Phagocytosis
a) the process of penetration into the cell liquid droplets
b) the process of penetration of solid particles into the cell
c) the process of penetration of water into the cell
d) the process of penetration ions into the cell
9. Pinocytosis
a) the process of penetration into the cell liquid droplets
b) the process of penetration of solid particles into the cell
c) the process of penetration of water into the cell
d) the process of penetration ions into the cell
10. Cholesterol molecules of membrane can
a) play the role of enzymes
b) stabilise the phospholipid bilayer
c) participate in the process of osmosis

d) participate in the formation of cell-cell contacts

Task 2. Fill in the table "Transport across plasma membranes"

Type of transport	**Dependence from concentration gradients**	**Examples of transported materials**	**Structures of membranes involved in the transport of substances**
Passive diffusion			
Facilitated diffusion			
Active transport			
Bulk transport			

Unit 5. Classification and structure of cell organelles. Format-practical's.

Discussion questions:

1. Classification of cell organelles.
2. Structure and function of membrane cell organelles: endoplasmic reticulum, Golgi Complex, lysosomes, mitochondria, plastids of plant cells.
3. Structure and function of membrane cell organelles: ribosomes, centrioles, microtubules, microfilaments.
4. The structure and functions of organelles for specific purposes: cilia and flagella, myofibrils, neurofibril.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

organelle, Golgi complex, endoplasmic reticulum, lysosomes, mitochondria, crista, matrix, thylakoid, chloroplast, photosynthesis, cytoskeleton, microtubule, microfilament, cell center, flagellum, myofibril

KEY POINTS OF THE TOPIC:

A. Membrane organoids

ENDOPLASMIC RETICULUM is a system of cavities, channels and vesicles bounded by a membrane from the cytoplasm.

There are 2 types:

1. The granular (roughened EPS) has the ribosome on the surface. Its main function is protein synthesis.
2. Agranular (smooth) EPS has not ribosomes on the surface, its main function is the synthesis of carbohydrates and lipids.

EPS also performs the functions of:

3. Collects products synthesis of substances.
4. Convert substances (sulfation of proteins performs in EPS channels).
5. Transports synthesis products to the Golgi complex.
6. Shares the cell into separate compartaments.
7. Participates in the formation of the nuclear membrane (rough EPS).

Specific functions:

8. In muscle cells EPS deposits of calcium needed for muscle contraction.
9. EPS liver cells involved in the detoxification of substances.

GOLGI APPARATUS is a system of cavities (tanks), channels vacuoles bounded by cytoplasmic membrane. Flattened cavity usually located in a pile forming dictyosomes.

The convex surface facing the core surface is called cis-surface and concave surface is called trans-surface. Bubbles with primary secret formed in EPS, pouring into the tank of the side of the Golgi complex cis-surface. Membrane vesicles with prepared secret separated from the trans-surface.

Functions of the Golgi complex:

1. The accumulation of substances.
2. Sorting of substances.
3. Formation of more complex substances from the primary products of the synthesis. For example, the formation of lipoproteins from lipids and proteins.
4. Identification of the substance (accession of the receptor).
5. Packing of synthesis products into membrane vesicles and transport them out of the cell by exocytosis.
6. The formation of lysosomes.
7. Detoxification of substances

LYSOSOMES are the organelles having a circular shape bounded by a membrane and containing hydrolytic (digestive) enzymes.

There are 4 types:

1. The primary lysosomes - are formed in the Golgi apparatus and also contain inactive enzymes.
2. The secondary lysosomes (phagolysosome) - formed after the merger of the primary lysosomes and endosomes (or phagosome, or pinosomy). They digest substances under the action of digestive enzymes to useful products enter the cytoplasm and undigested substainces remain inside.
3. The tertiary lysosomes (telolizosomy) are lysosomes containing undigested residues. They either accumulate in the cytoplasm, or removed by exocytosis.
4. Aytolysosome - a kind of secondary lysosomes, provide the digestion of intracellular structures that have lost their meaning. Also provides a process of apoptosis and metamorphosis.

The functions of lysosomes:

1. Digestion substances (trophic).
2. The protective function (destroying old structures of cells, involved in the process of metamorphosis and apoptosis)

PEROXISOMES - organelles rounded, limited by membrane and containing a set of enzymes that neutralize hydrogen peroxide.

MITOCHONDRIA is an organelle mainly oval, delimited from cytoplasm by two membranes. The outer membrane is smooth, and the internal membrane forms numerous protrusions, called Christie. The liquid contents of mitochondria is called matrix. It is a colloidal solution. The matrix has its own circular double-stranded DNA (like bacteria), 70S ribosomes (like bacteria), all kinds of RNA.

Oxygen step of energy metabolism passes in mitochondria: in a matrix - the Krebs cycle, on the inside of the membrane - the processes of oxidative phosphorylation, leading to the synthesis of ATP.

The main functions of mitochondria:

1. Synthesis of ATP.
2. Synthesis of its own proteins.
3. Storage of hereditary information (cytoplasmic inheritance, maternal effect).

There is a symbiotic hypothesis of the origin of mitochondria. It is believed that mitochondria were previously aerobic bacteria that have penetrated into the cell and left there for rights of symbionts: they give energy in the form of ATP to the cell, and a cell give them substrate for oxidation.

Evidence: 1) the inner membrane of mitochondria by amino acid composition is close to the membrane of bacteria; 2) circular DNA and ribosomes 70S are like bacteria; 3) the ability to divide by 2, independently from cell division.

PLASTID is organelles of plant cells.

There are 3 types:

1. Chloroplasts - the green plastids contain the pigment chlorophyll, the function - photosynthesis.

2. Chromoplasts - yellow-orange color contain carotenoids, the function - coloring autumn leaves and fruit.

3. Leucoplasts - colorless plastids the function - the supply of nutrients (starch).

CHLOROPLASTS are oval-shaped organelles, bounded from the cytoplasm by two membranes. The outer membrane is smooth, and the internal forms numerous protrusions in the form of one-membrane cavities called thylakoids. The cavities are stacked into piles called granum. Membranes connecting granum, called the stroma thylakoids or lamellae. Photosynthetic pigments are in the thylakoid membrane. They take part in the process of photosynthesis. The liquid contents of the chloroplast is called stroma, it take part in dark phase of photosynthesis. The stroma has an own circular double-stranded DNA (such as bacteria), their own ribosomes 70S (like bacteria), all kinds of RNA.

The functions of chloroplasts:

1. Photosynthesis.
2. The synthesis of its own proteins.
3. Storage of hereditary information (cytoplasmic inheritance, maternal effect).

B. Non-membrane organoids

RIBOSOMES are organelles consisting of two subunits - large and small. The large subunit has the shape of the bucket, it is composed of proteins and 3 molecules of rRNA in eukaryotes, and 2 molecules of rRNA in prokaryotes. The small subunit has the shape of the handset, it is composed of proteins and one molecule of rRNA. During protein synthesis mRNA connects with the small subunit, so that in the active site of the ribosome is two codon (triplet) mRNA. The large subunit participate in the formation of a peptide bond between amino acids. The function of ribosomes: protein synthesis.

CELLULAR CENTER is formed centrioles and system of microtubules radiating from centrioles.

Centrioles look like 2 cylinders arranged perpendicular to each other. The wall of each cylinder is formed by nine triplets of microtubules. There are not microtubules in the center of centriole. The formula, which reflects the structure of centrioles: 9x3 +0.

Options centrioles:

1. Education Center microtubules. Therefore centrioles refers to elements of the cytoskeleton of the cell.

2. Form a basal bodies of cilia and flagella.

3. Form a thread spindle during cell division.

MICROTUBULES are tubes of small diameter, the wall of which is formed by globular protein – tubulin. It can be polymerized. Microtubules are polar opposites: one end is increasing, with the other broken.

Microtubule function:

1. Provide support and shape of cells (cytoskeleton).

2. Transport of substances and organelles of a cell.

3. Form the centrioles, cilia, flagella.

4. Are the thread spindle.

MICROFILAMENTS is thin filaments formed mainly actin protein capable of polymerization. Actin microfilament are located mainly under plasmolemma of cell, where they form a dense network, also they are located the cytoplasm.

Functions of microfilaments:

1. Provide support and shape of the cells.

2. Provide the transport of substances. For example, a membrane package (endocytosis and exocytosis).

3. They form the inner frame of the microvilli.

4. Microfilament are part of myofibrils muscle cells and fibers.

FLAGELLUM (cilium) - a protrusion of the outer membrane of the cell. Axoneme passes in the center of the flagellum which ends in cytoplasm by basal body (structure like centrioles (9x3 + 0)). Axoneme formed nine doublets microtubules arranged circumferentially and two unpaired microtubules are in the center (formula – 9x2 + 2).

MYOFIBRILS are contractile organelles of muscle cells and fibers. They are formed thick - myosin microfilaments and thin - actin microfilaments. Protein Z-line are located in the center of actin filaments. Plot myofibrils between the two Z-lines is called a sarcomere. Sarcomere is a structural and functional unit of myofibrils. Actin filaments are located between the myosin. With the reduction of myofibrils actin filaments as if entering between the myosin myofibril and myofibril are shortened.

On the myofibril are:

I-band: consists of actin filaments;

H-band: it consists only of myosin filaments;

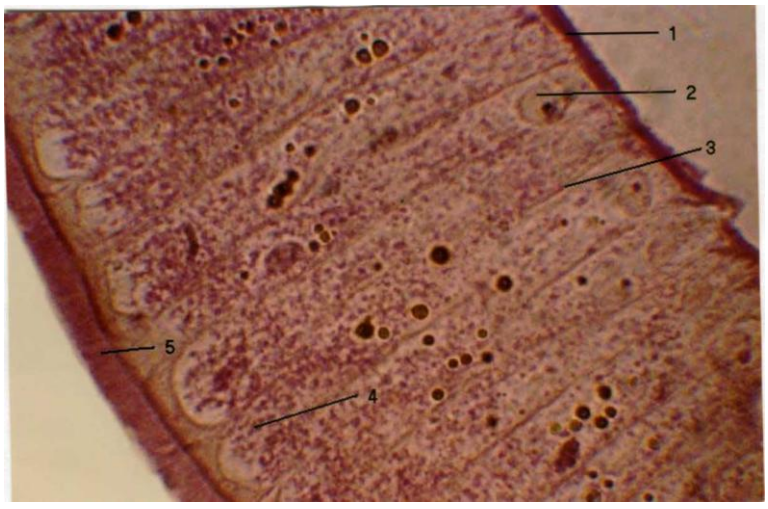
A-band: determined by the length of the filaments of myosin, myosin filaments, and includes the ends of actin filaments.

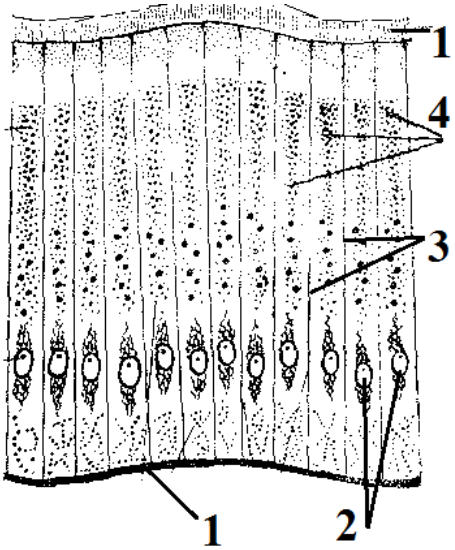
C. Slides used in class

Chondriosomes (mitochondria) in the epithelial cells of the intestinal roundworm (dyed by iron haematoxylin)

At low magnification of the microscope, select the area of the wall of the intestine roundworm with more visible grain in the cytoplasm of cells and place it in sight. Consider at high magnification. The nuclei are located on the same level in the basal part of the cells. In the cytoplasm are many rod-shaped, filamentous, or curved mitochondria. Transversely cut the mitochondria have the appearance of grains.

Draw the plot of the slice with multiple cells.



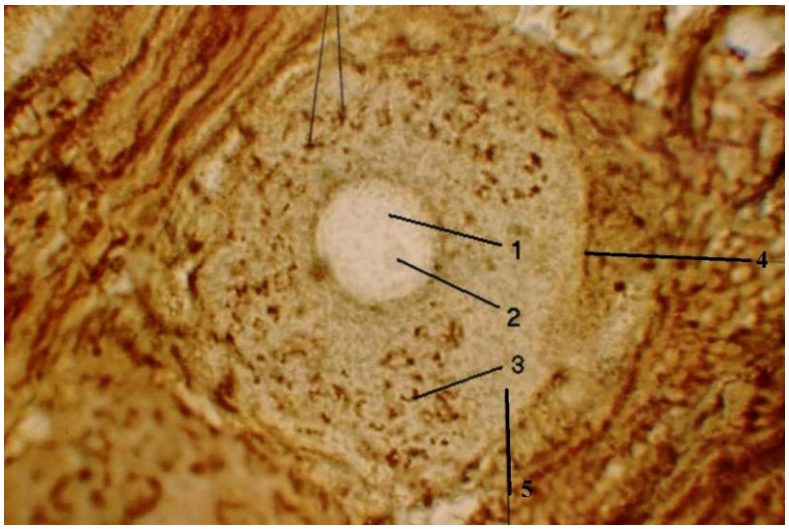


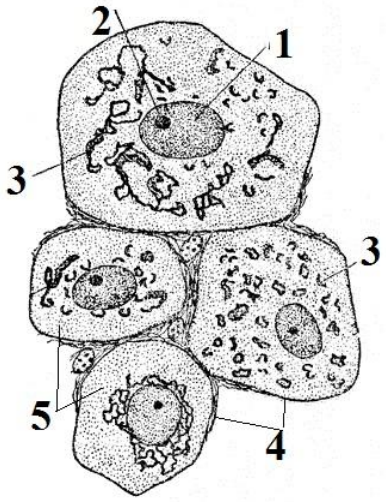
Indicate in the figure: 1) basal membrane; 2) the core; 3) plasmalemma; 4) mitochondria; 5) brush border (microvilli).

The Golgi complex (by impregnation with silver salts)

At low magnification find a large square round shape with pale vesicular nucleus, in the cytoplasm which are clearly visible convoluted dark thread. Place it in the center of the field of view and set the lens at high magnification. Consider a large bright nucleus with a dark nucleolus, cytoplasm and surrounding the nucleus in the form of a coil (baskets), dark thread of the Golgi complex. Sometimes the threads are scattered throughout the cytoplasm.

Draw the plot of the slice with one or more cells.



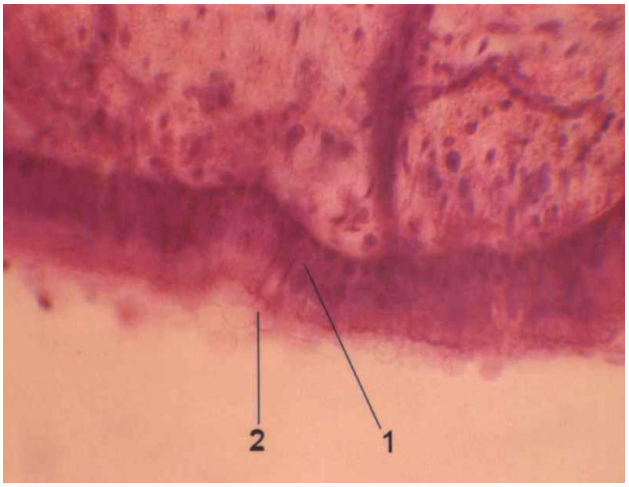


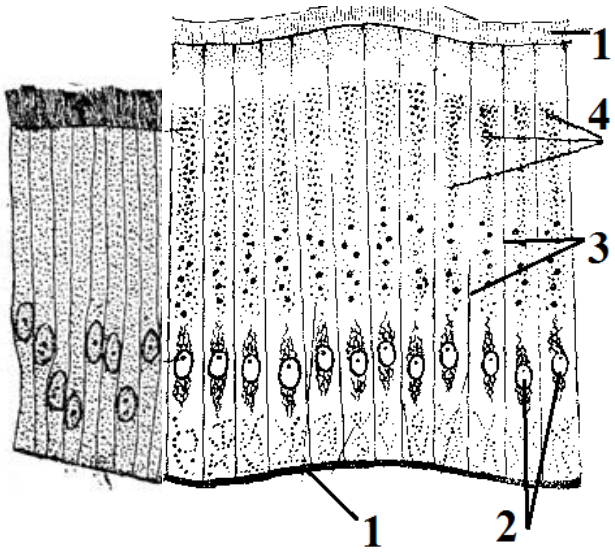
Indicate in the figure: 1) nucleus; 2) the nucleolus; 3) the Golgi complex; 4) the cell boundaries; 5) the cytoplasm.

Ciliated cilia of epithelial cells of the trachea (coloring with hematoxylin-eosin)

Note edging apical end of epithelial cells formed cilia.

Draw the plot of the slice with multiple cells.



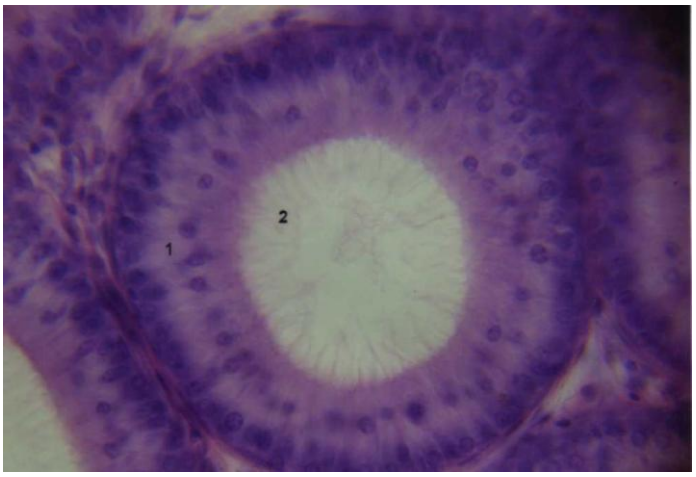


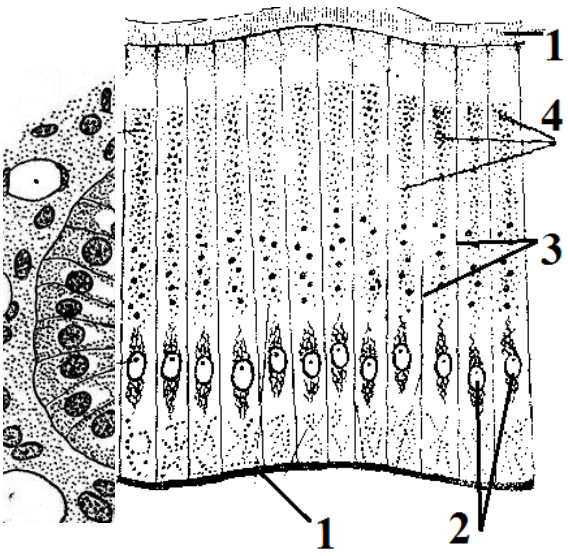
Refer figure: 1) epithelial cell: 2) cilia.

Ciliated cilia of epithelial cells of the canal of the epididymis testicles (dyed with hematoxylin-eosin).

Note edging apical end of epithelial cells formed cilia.

Draw the plot of the slice with multiple cells.





RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

1. The composition of the outer membrane of the cell includes:
a) proteins and lipids
b) carbohydrates and RNA
c) DNA and RNA
d) carbohydrates and DNA

2. The cell membrane organelles include
a) ribosomes
b) cell center
c) mitochondria
d) microtubules

3. The function of ATP synthesis in the cell is performed
a) ribosomes
b) cell center
c) mitochondria
d) microtubules

4. Protein synthesis was carried out in a cell
a) ribosomes
b) cell center
c) mitochondria
d) microtubules

5. The two membranes are limited
a) ribosomes
b) cell center
c) mitochondria
d) microtubules

6. Synthesis of complex substances in the cell provides a simple
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS

7. Dictyosome part of the

a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS

8. Have their own DNA

a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS

9. A stack of flat tank called the Golgi complex

a) dictyosome
b) matrix
c) chromatin
d) cristae

10. The liquid contents of mitochondria is called

a) dictyosome
b) matrix
c) chromatin
d) cristae

11. The function of storing genetic information in the cell is performed

a) ribosomes
b) microfilaments
c) mitochondria
d) core

12. The transport function of the membrane is provided

a) lipids
b) surface proteins
c) carbohydrates
d) integral proteins

13. rRNA and proteins are part of

a) ribosomes
b) microfilaments
c) mitochondria
d) core

14. The structures formed by the mitochondrial inner membrane, called

a) thylakoids
b) crista
c) grana
d) stroma

15. The pigment chlorophyll contained in

a) chloroplasts
b) chromoplasts
c) lekoplastah
d) leukocytes

16. The function of photosynthesis performed

a) chloroplasts
b) chromoplasts
c) lekoplasty
d) leukocytes

RECOMMENDED TASKS FOR INDEPENDENT WORK

Insert the missing word or answer the questions

1. The _____ is composed of DNA and protein.

A. chromatin
B. ribosome
C. flagellum
D. centriole
E. mitochondrion

2. Ribosomal subunits are manufactured by the _____.

A. peroxisome
B. lysosome
C. smooth endoplasmic reticulum
D. rough endoplasmic reticulum
E. nucleolus

3. _____ are the sites of protein synthesis.

A. Peroxisomes
B. Ribosomes
C. Golgi apparatuses
D. Mitochondria
E. Microfilaments

4. Which of these manufactures cellular membranes by adding membrane proteins and phospholipids to its own membrane?

A. ribosomes
B. nucleolus
C. Golgi apparatus
D. rough endoplasmic reticulum
E. lysosomes

5. The _____ is a selective barrier, regulating the passage of material into and out of the cell.

A. plasma membrane
B. lysosome
C. nuclear envelope
D. chloroplast
E. nucleus

6. Where is calcium stored?

A. centrioles
B. mitochondria
C. smooth endoplasmic reticulum
D. microtubules
E. rough endoplasmic reticulum

7. Which of these are hollow rods that shape and support the cell?

A. plasma membrane
B. peroxisomes
C. microtubules
D. microfilaments
E. chloroplasts

8._____ is/are identical in structure to centrioles.

A. Chromatin
B. Mitochondria
C. Basal bodies
D. Nuclear envelopes
E. Microfilaments

9. Which of these cannot rapidly pass directly through the phospholipids of the plasma membrane?

A. Water, glucose and hydrogen ion
B. Water
C. Hydrogen ion
D. Lipid soluble molecule
E. Glucose

10. What name is given to the process by which water crosses a selectively permeable membrane?

A. passive transport
B. phagocytosis
C. pinocytosis
D. osmosis
E. diffusion

11. Which of these organelles carries out cellular respiration?

A. smooth endoplasmic reticulum
B. mitochondrion
C. chromatin
D. ribosomes
E. nucleolus

Unit 6. Nucleus. Format-practical's.

Discussion questions:

1. The role of the cell nucleus during the life of the cell.
2. Structure and functions of each part of the cell nucleus: nuclear shell, nucleoplasm, chromatin and nucleolus.
3. Structural organization of chromatin.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Nucleus, nuclear envelope, nucleolus, nucleoplasm, genetic information, chromatin, nucleosome, octamer, chromatid, primary constriction, chromosome shoulder, heterochromatin, euchromatin

KEY POINTS OF THE TOPIC:

NUCLEUS is an essential organelle typical for eukaryotes.

Nucleus functions:

1. Storage of genetic information;
2. The regulation of all vital processes in the cell.

The nucleus consists of:

1) nuclear envelope
2) nucleoplasma
3) chromatin
4) nucleoli

Nuclear envelope - formed by 2 membranes: outer membrane is often a continuation of the granular EPS and bears on the surface of the ribosome; inner membrane - smooth, it enters into a complex with the internal structure called lamina (involved in maintaining the shape of the nucleus, in the packing of chromatin). The nuclear envelope contains numerous nuclear pores. Each pore consists of a ring of proteins with a central channel, the whole complex being secured to and stabilised by the nuclear lamina. Nuclear pores regulate the exchange of metabolites, macromolecules and ribosomal subunits between nucleus and cytoplasm.

Chromatin is the complex of DNA with histone proteins (there are 9 of histone proteins: 4 paired

H2A, H2B, H3, H4, 1 unpaired - H1). 8 proteins form a globular structure - octamer. Around each octamer almost twice the DNA helix is wound, forming a nucleosome. DNA between nucleosomes enters the complex with the 9th protein histone H1. H1 take part to the further DNA packaging. This level of DNA packaging is called a nucleosomal level. There are euchromatin and heterochromatin. Euchromatin is almost not visible in the light microscope and contains functionally active DNA (from it can read information). Heterochromatin has the form of grains and clumps in the light microscope , contains functionally inactive DNA (reading of information does not occur).

Nucleolus is an electron-dense body, is a place where accumulate a large number of organic materials (copies of rRNA, ribosomal proteins), large and small subunits of the ribosomes around the fragment of DNA encoding rRNA. The function of the nucleolus is the formation of ribosomes.

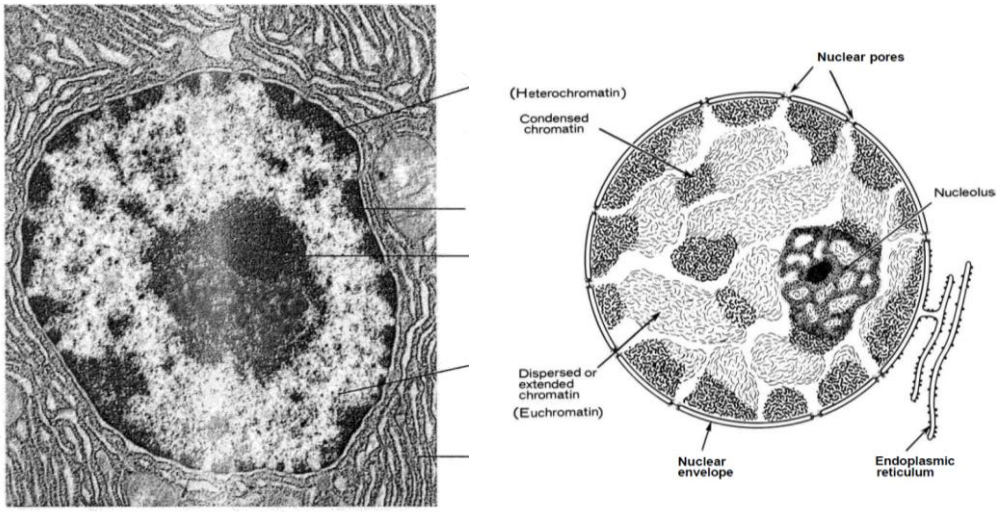
RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

1. In DNA, _____ binds to thymine, guanine binds to _____ through _____ bonds.
2. A molecule of DNA or RNA is a polymer of _____.
3. Nucleosomal filament is_____.
4. Nucleus functions _____.
5. The double helix structure of a molecule of DNA is stabilized_____.
6. In DNA double helix a region along one DNA strand has this sequence of nitrogenous bases:
   5'-TACGGTTAGGCCT-3'.
   List the base sequence along the other strand molecule, clearly indicating the 5' and 3' ends of this strand.
7.
8. Each nucleotide is composed of three parts _____.
9. Chromatin fiber is_____.
10. _____ is almost not visible in the light microscope and contains functionally active DNA.
11. The nucleus consists of nuclear envelope, _____,_____, nucleoli.
12. Each pore consists of a ring of _____ with a central channel.
13. Chromatin is the complex of _____with _____.
14. _____ has the form of grains and clumps in the light microscope , contains functionally inactive DNA
15. _____ is an electron-dense body, is a place where accumulate a large number of organic materials, large and small subunits of the ribosomes around the fragment of DNA encoding rRNA.
16. The function of the nucleolus is _____
17. The nuclear envelope contains numerous _____.

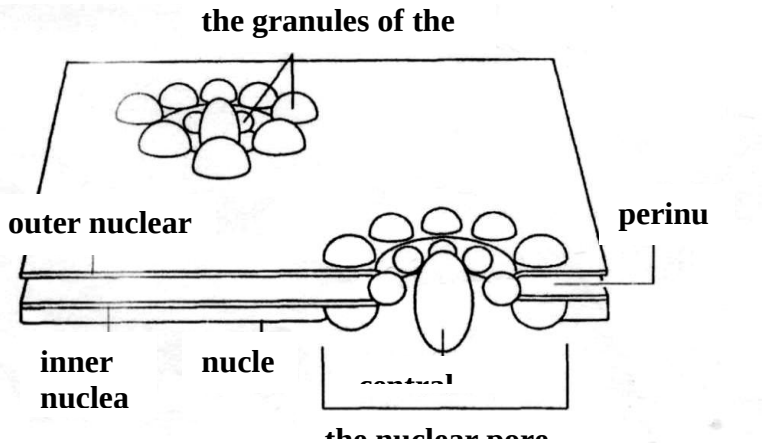
RECOMMENDED TASKS FOR INDEPENDENT WORK

Task 1. Consider an electron micrograph of the nucleus.

Draw the micrograph. Mark the corresponding figures the following structures: the nuclear envelope (1), heterochromatin, occupying a peripheral position (2), euchromatin (4), the nucleolus (3), tanks EPS (5). Describe the main differences between heterochromatin from euchromatin.

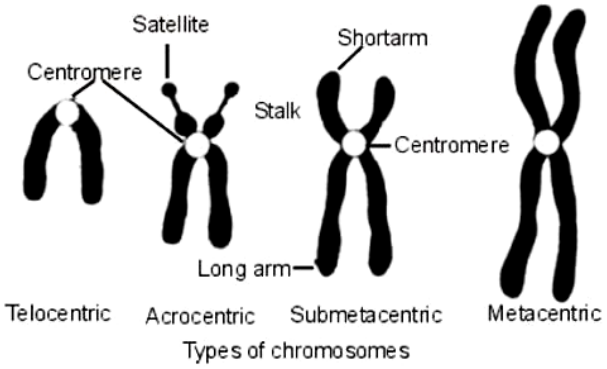


Task 2. Look at the diagram of the structure of the pore complex.

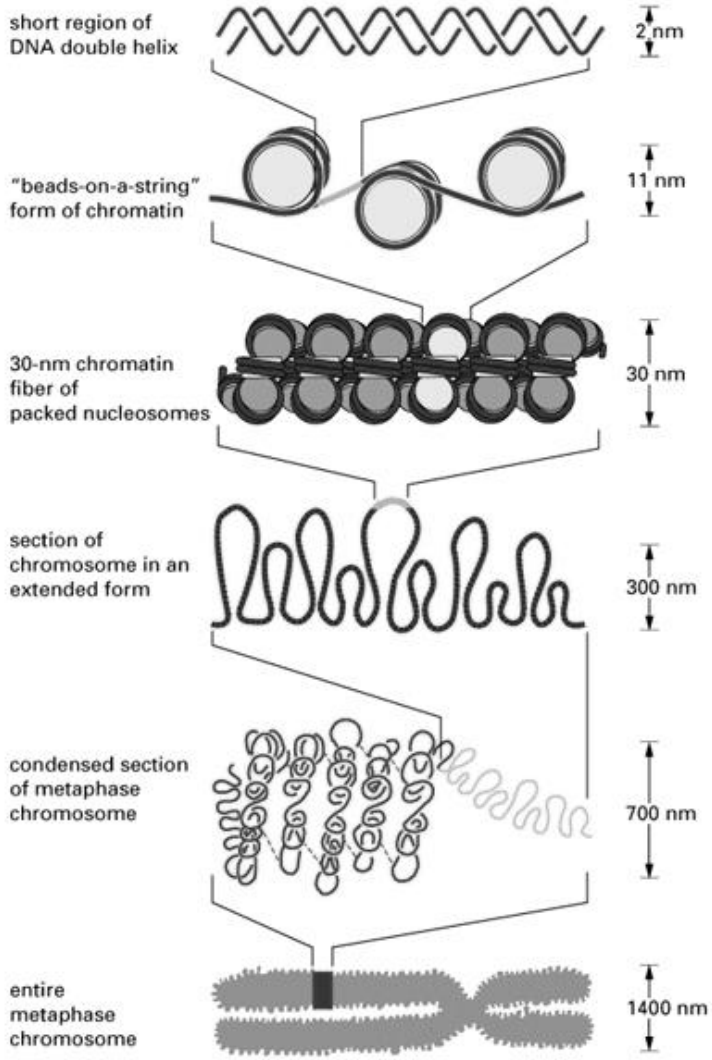


The nuclear pore complex formed by 8 large protein granules, forming a circle near the edge of the pores and connecting the two nuclear membranes (inner and outer). Often at the center of the pores present large central pellet. It consists of newly synthesized subunits of the ribosome that was transported into the cytoplasm.

Task 5. Classification of chromosomes.
Consider the main types of chromosomes, draw them.



Task 4. Levels of packaging of chromatin in the cell nucleus.
Draw levels of DNA packaging, make a notation.



<u>Unit 7.</u> Features of the organization of the cells of plants, animals and bacteria. Non-cellular forms of life. Format- study discussion.

<u>Discussion questions:</u>

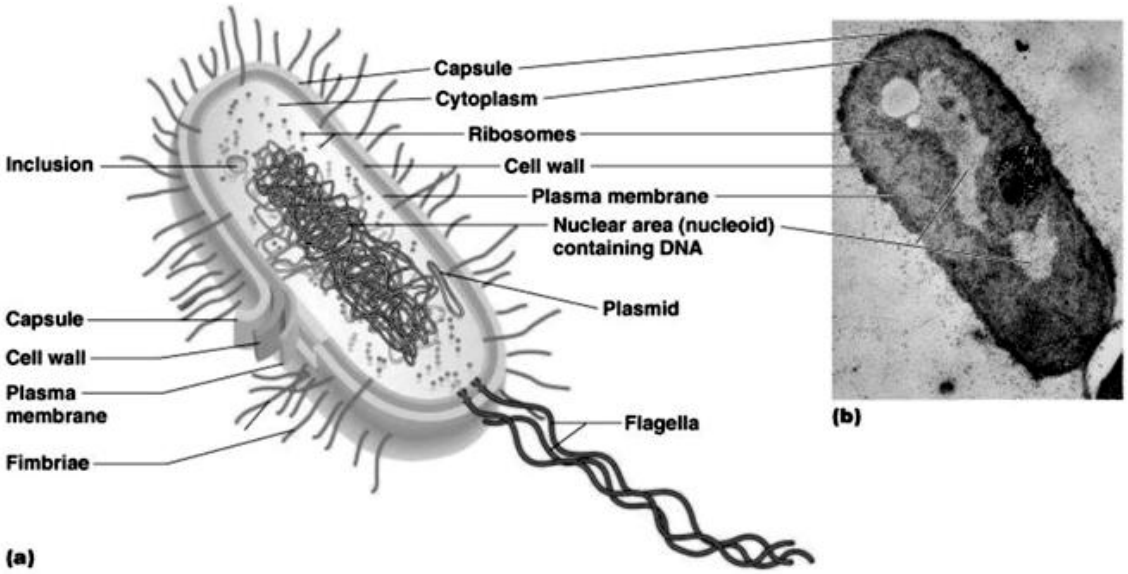
1. Comparative characteristics of cells prokaryotes and eukaryotes.
2. Comparison of the structure and functions of plant and animal cells.
3. Non-cellular forms of life.
4. Structure and features of vital activity of viruses.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Bacteria, viruses, prokaryotes, eukaryotes, plasmids, mureins. capsid, obligate parasite, cocci, bacilli, spirillas, conjugation, transformation, transduction, mesosomes

KEY POINTS OF THE TOPIC
<u>A. BACTERIAL CELLS</u>

Bacteria are single-celled organisms. They are prokaryotes. Bacterial cells have no nucleus.



Their circular double-stranded DNA is free located in the cytoplasm. Bacterial DNA forms a complex with the non-histone proteins, forming nucleoid.

Bacterial cells surrounded by an outer membrane. The cell wall is arranged outside the membrane and comprises a polysaccharide murein. Some bacteria may be covered with a mucous capsule.

Bacteria do not have a membrane organelles. Bacteria have no cell center, microtubules, microfilaments. Bacteria have only 70S ribosomes. Some bacteri a may have flagellum. The bacterial flagellum has a simple structure. It is a protein strand and unlimited membrane.

THE FORMS OF BACTERIA

Prokaryotic cells have various shapes; the four basic shapes of bacteria are:

Cocci – spherical

Bacilli – rod-shaped

Spirochaete – spiral-shaped

Vibrio – comma-shaped

By way of nutrution bacteria can be divided into autotrophic and heterotrophic organisms.

Autotrophic bacteria are divided into photosynthetic bacteria and chemosynthetic bacteria.

Heterotrophic bacteria are divided into the following types:

1. Bacteria - parasites. They feed on living organisms and cause various diseases.

2. Bacteria - saprotrophs. They feed on the dead remains. These bacteria convert the organic matter of the dead bodies in minerals. Thus closes the cycle of substances in nature.

3. The bacteria - symbionts. These bacteria form a mutually beneficial relationship with other organisms. For example E. coli in the human colon helps to digest cellulose, creates an acidic environment where harmful bacteria and fungi do not develop, are involved in the formation of some vitamins

The bacteria can be aerobic and anaerobic respiration by the method.

The bacteria survive in the form of spores in adverse conditions , and for a long time can survive.

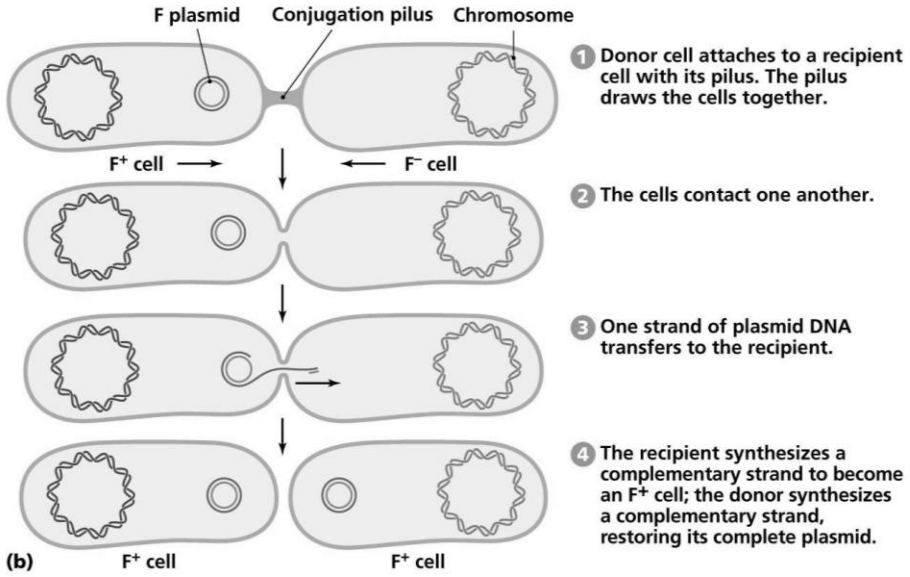
Bacteria reproduce through asexual reproduction, usually by binary fission.

Bacteria do not have a sexual reproduction, but there is sexual recombination. There are three types of sexual recombination: conjugation, transformation, transduction.

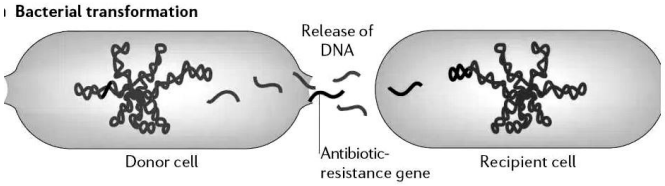
Conjugation.

Some bacteria are in addition to the basic DNA (the bacterial chromosome) has additional DNA called plasmids.

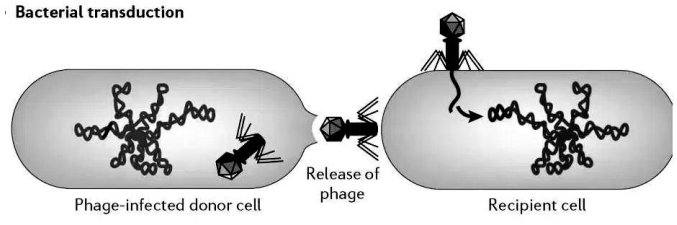
Donor bacterium having the plasmid may form cytoplasmic bridge by using sexual rod with a bacterium which has no plasmid. First, double-stranded plasmid DNA is separated into two chains. One of the chains is transferred to the recipient bacterium. Then, each bacterium completes the missing chain on the principle of complementarity.



Transformation - the transfer of a fragment of DNA from dead bacteria to live, where the fragment replaces the homologous site.

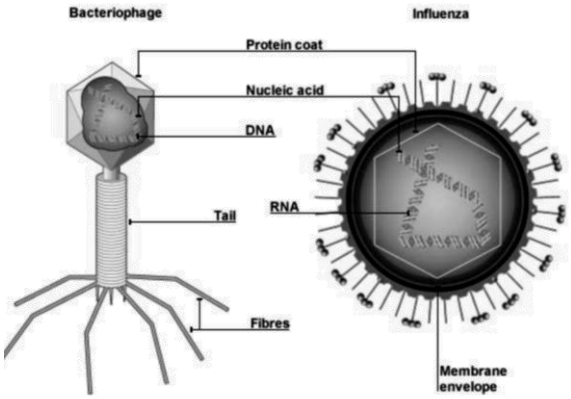


Transduction - the transfer of DNA fragments from one bacterium to another by using viruses - bacteriophages. Penetrating into the bacterial cell the virus multiplies and forms a protein capsid. Sometimes virus capsid randomly encompasses fragments of bacterial DNA. This forms a transducing particle. When such a virus infects a new mutated bacterium, it injects its DNA fragment of the first bacterium and second bacterium acquires new properties.



B. VIRUSES

Viruses - organisms having no cellular structure. They consist of nucleic acid (DNA or RNA), which is surrounded by a protein shell called a capsid. Above the capsid may be located lipoprotein envelope, which often is a fragment of the membrane of the host cell from which the virus was released.



Metabolism, growth and development are processes that are not typical for viruses.

Viruses are permanent parasites that exhibit properties of living within the host cell. Heredity, variation and reproduction are characterized for viruses. Outside the host cell viruses behave like structure of inanimate nature. Therefore, viruses is a bridge between the animate and inanimate nature.

Viruses are very specific. They penetrate into the cells of a specific type only. Viruses have the receptors to specific cells. For example, hepatitis B virus affects the liver cells the AIDS virus affects blood lymphocytes.

THE BEHAVIOR OF THE VIRUS IN THE CELL

First, the virus recognizes the cell by using receptors. It then enters the cell by one of the methods. Animal viruses enter the cell by phagocytosis.

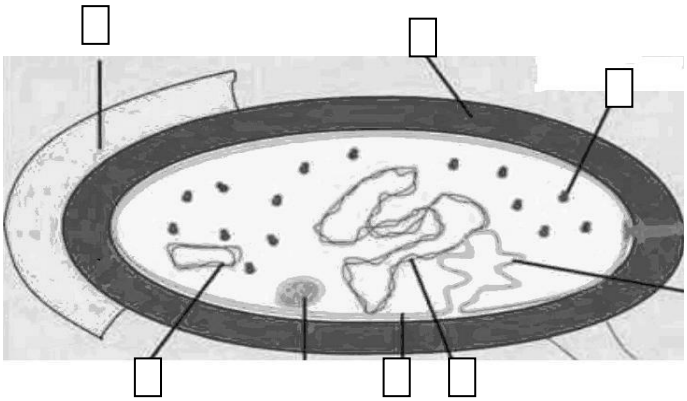
Plant viruses and fungi viruses penetrate into the cell through the damaged cell wall.

Viruses bacteria - bacteriophages - enter the cell by injection.

Once in the cytoplasm of the cell, the nucleic acid of the virus is copied many times. Organels and materials of the host cell are used for this. The virus protein coat (capsid) is formed on the base of the viral nucleic acid.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Task 1. Consider the structure of bacteria. Draw the scheme and make a mark. What structures are labeled 1-6?

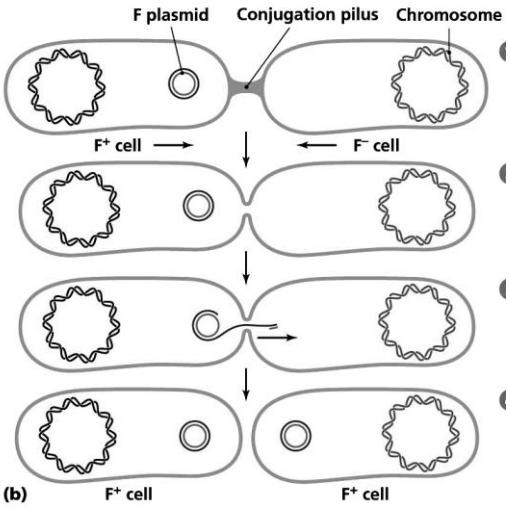


Task 2. Fill in the table "The difference between prokaryotes from eukaryotes"

Main features	Prokaryotes	Eukaryotes
Polysaccharide which is part of the cell wall		
The presence of the nucleus		

DNA characterization		
The presence of membranous organelles		
The presence of nonmembranous organelles		
The presence of plasmids		
Kinds of reproduction		

Task 3. Consider the scheme of bacterial conjugation.

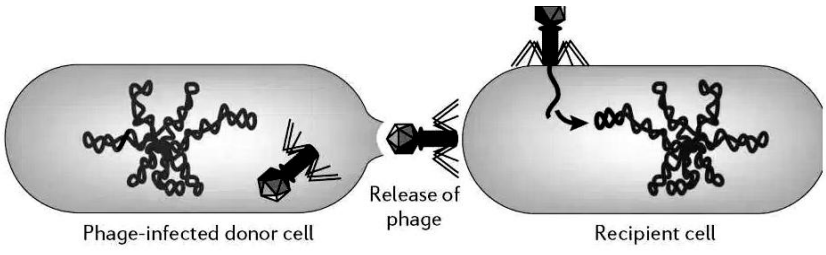


RECOMMENDED TASKS FOR INDEPENDENT WORK

Task1. Complete the sentences:

1. Some bacteria has additional DNA called _____.
2. Donor bacterium having the plasmid may form _____ by using sexual rod with a bacterium which has no plasmid.
3. First, double-stranded plasmid DNA is separated into two chains. One of the chains is transferred to _____.
4. Then, each bacterium completes the missing chain on the principle of _____.

Task 2. Consider the scheme of bacterial transduction.



Answer the questions in writing:

1. Who carries the fragment of DNA from one bacterium to another during transduction?
2. What to do after the penetration of the virus into a bacterium?
3. What is produced when the virus capsid surrounds the DNA of the bacteria?

Task 3. Read the text, find errors and correct them.

1. Viruses are permanent parasites that exhibit properties of living outside the host cell.
2. Heredity, variation and reproduction are characterized for viruses.
3. Outside the host cell viruses behave like structure of animate nature.
4. The viruses is a bridge between the animate and inanimate nature.
5. Viruses are not specific. They penetrate into the cells of a different type.
6. Viruses have the receptors to specific cells.
7. Animal viruses enter the cell by through the damaged cell wall.
8. Viruses bacteria - bacteriophages - enter the cell by injection.
9. The virus protein coat (capsid) is formed on the base of the nucleic acid of the host cell.
10. Virions leave the cell, either simultaneously or progressively by one.

Unit 8. The cell as an open system. Format-practical's.

Discussion questions:

1. The concept of metabolism and its types. The relationship of plastic and energy metabolism.
2. Protein biosynthesis in the cell.
3. Energy metabolism and its stages.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Transcription, translation, RNA processing, exons, introns, genetic code, glycolysis, Krebs cycle, complete oxidation, oxidative phosphorylation, coenzyme A

KEY POINTS OF THE TOPIC:

A. Genetic code

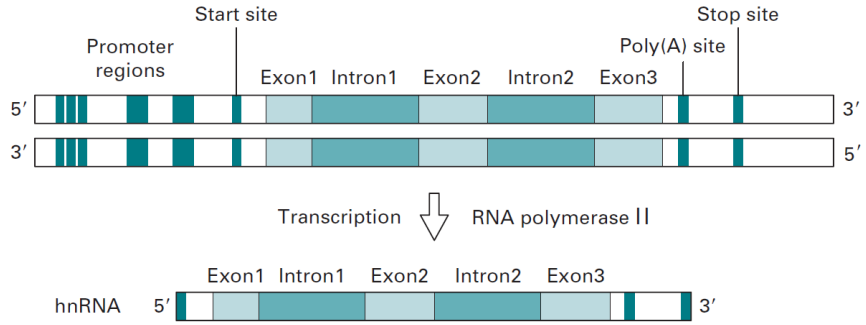
The relationship between the sequence of nucleotides in DNA and the sequence of amino acids in a protein is called the genetic code. There are several important properties of the code:

1. The code is read in the group of three nucleotides (**triplet**) called ***codon.***
2. Each codon encodes **one** amino acid.
3. The code is **nonoverlapping**, i.e. each base is part of only one codon. For example, if the sequence AUGUUC is read from the beginning, the codons will be AUG and UUC only.
4. There are **no gaps** in the code, that is, each base in the coding region of an mRNA is part of a codon.
5. The code is always read in the ***5′→3′ direction***, which means the code has **polarity**.
6. The code is highly **degenerate**. Since there are four nucleotide bases (A, C, G and T), possible total number of codons is $4^3 = 64$. ***61 codons*** code for the 20 common amino acids. ***3 codons*** signal termination of protein synthesis, or code for selenocysteine (Sel, the 21st amino acid found in > 15 genes in prokaryotes that are involved in redox reactions, and in > 40 genes in eukaryotes that code for various antioxidants and the type I iodothyronine deiodinase of the thyroid gland) and pyrrolysine (the 22nd amino acid identified in a few archaebacteria and eubacteria). It means many amino acids are specified by more than one codon (see Table 3). Such redundancy provides fault tolerance in case of mutations in the nucleotide sequences in DNA or mRNA. For example, a change in the codon UUA may result in UUG in mRNA but in any case the amino acid leucine is formed. Similarly, three codons UAA, UAG, and UGA cause termination of the polypeptide sequence and a single mutation from A to G or from G to A still causes termination.
7. Initially, the genetic code was thought to be **universal**. Now, it is known that in certain organisms and organelles the meaning of select codons has been changed; for example, CUG codes for serine in *Candida albicans*, UGA codes for tryptophan and AGA/AGG are stop codons in mitochondria, UAA and UAG code for glycine in ciliated protozoa.

A sequence bounded by a start and a stop codon containing a number of codons that may be read in-frame to represent a continuous protein sequence is termed an ***open reading frame (ORF)***.

B. Transcription in eukaryotes

Compared to prokaryotic operons, eukaryotic genes devoted to a single pathway are most often physically separated in the DNA; indeed such genes usually are located on different chromosomes. The eukaryotic genes exist in pieces of coding sequence, the ***exons***, separated by non-protein-coding segments, the ***introns***. Although introns are common in multicellular eukaryotes, they are extremely rare in bacteria and archaea and uncommon in many unicellular eukaryotes such as baker′s yeast. However, introns are present in the DNA of viruses that infect eukaryotic cells.



Eukaryotic gene structure and its transcription to hnRNA

The gene promoter consists of ***core promoter elements*** and ***proximal promoter elements*** that are required for the initiation of transcription or that increase the frequency of initiation only when positioned near the transcriptional start site.

In eukaryotes, three different ***RNA polymerases*** exist, designated I, II and III, in addition, RNA polymerase IV and V are found in plants

1. Initiation

The process of transcription in eukaryotes is very complex. The initiation step involves the assembly of several transcription factors to form ***a preinitiation complex***. ***Transcription factors*** are sequence-specific DNA-binding proteins that bind to gene promoters and other regulatory elements, interpret the information present in these regulatory elements, and transmit the appropriate response to the ***RNA polymerase II transcriptional machinery***. There is also an assortment of coregulators that bridge the DNA-binding factors to the transcriptional machinery, a number of chromatin remodeling factors that mobilize nucleosomes, and a variety of enzymes that catalyze covalent modification of histones and other proteins.

RNA polymerase II is absolutely dependent on the auxiliary transcription factors for the initiation of transcription. A set of general transcription factors (TFIIB, TFIID, TFIIE, TFIIF, and TFIIH) is responsible for promoter recognition and for unwinding the promoter DNA.

The ***transcription preinitiation complex*** is synthesized following several steps:

- Binding of the general transcription factor ***TFIID*** responsible for the recognition of the core promoter elements to the ***TATA box*** (DNA sequence with a lot of Ts and As). It provides a platform to recruit other general transcription factors and RNA polymerase II to the gene promoter.
- Binding of ***TFIIB*** to TFIID and RNA polymerase II to act as bridging protein.
- Binding of ***TFIIE, TFIIF, TFIIH*** and other transcription factors.

There are also ***long-range regulatory DNA elements*** that act over distances of 100 kb or more from the gene promoter. Gene promoter activity downstream or upstream relative to promoter is increased by ***enhancers*** and repressed by ***silencers***. ***Insulators*** act as barriers between regions of heterochromatin and euchromatin and block enhancer or silencer activity of neighboring genes.

After assembly of the preinitiation complex, there is a period of **abortive initiation** before the polymerase escapes the promoter region and enters the elongation phase. During abortive initiation, the polymerase synthesizes a series of short transcripts. As RNA polymerase II moves, it holds the DNA strands apart forming a transcription “bubble” (Fig. 22). TFIIB contacts both DNA strands within the transcription bubble and stabilizes the transcribing complex until a

complete 8 or 9 bp DNA–RNA hybrid is formed. The bubble expands downstream until 18 base pairs are unwound and the RNA is at least seven nucleotides long. When this point is reached, the upstream approximately eight bases of the bubble reanneal. This so-called "bubble collapse" marks the end of the need for the TFIIH helicase for transcript elongation. Synthesis of RNA greater than about 10 residues in length leads to displacement of TFIIB from RNA polymerase II, because the TFIIB-binding site overlaps the RNA exit site.

Promoter clearance requires phosphorylation of the ***C-terminal domain (CTD)*** of RNA polymerase II. Hyperphosphorylation of the CTD tail is essential for activating the polymerase and allowing it to begin the elongation phase. Once phosphorylated, RNA pol II can unwind DNA, polymerize (synthesize) RNA, and proofread. Addition of these phosphates helps RNA pol II to leave behind most of the general transcription factors used for initiation. TFIID remains bound and allows the rapid formation of a new preinitiation complex.

2. Elongation

Transcription elongation is the process by which RNA polymerase II moves through the coding region of the gene and adds rNTPs to the growing RNA chain in the 5′ to 3′ direction. Incoming (downstream) DNA is unwound before the polymerase active site and is rewound beyond it to form the exiting (upstream) duplex. In the unwound region, the DNA template strand forms ***a hybrid duplex*** with growing mRNA. RNA polymerase II selects rNTPs in a DNA template-directed manner and phosphodiester bond formation occurs. Then, translocation occurs to repeat the cycle. At the upstream end of the hybrid duplex, RNA polymerase II separates the nascent RNA from the DNA.

There are two mechanisms for the progression of RNA polymerases through chromatin:

1) nucleosome mobilization or "octamer transfer" (i.e. movement of the octamer on the DNA);

2) H2A-H2B dimer depletion (the displacement of a dimer of H2A-H2B in front of RNA polymerase II).

Two types of RNA polymerase II proofreading reactions may occur: removal of a misincorporated nucleotide directly after its addition, or cleavage of a dinucleotide after misincorporation and backtracking by one nucleotide.

3. Termination

The termination of transcription is different for the different polymerases. There are no specific terminating signals for RNA polymerase II in the protein-encoding genes. RNA Polymerase II can continue to transcribe RNA from a few to thousands of bp past the actual end of the gene and the transcript or pre-mRNA is cleaved before RNA polymerase II finishes transcribing. The cleavage site of pre-mRNA is determined by specific sequences of basepairs (e.g., Poly(A) and CoTC sites for the human b-globin gene) that are recognized by protein complexes responsible for cleavage of the pre-mRNA chain and the addition to it a 3′ poly-A tail (Fig. 23a). The remaining transcript is attacked by the Xrn2 exonuclease (Rat1 in yeast) while it is still associated with RNA polymerase II. Xrn2 "chases" after the polymerase and when it catches up with the polymerase, transcription is terminated (Fig. 23 b and c).

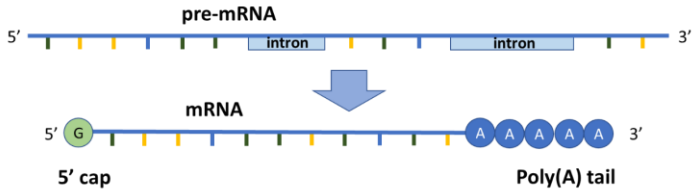
RNA polymerases I and III require termination signals. Genes transcribed by RNA polymerase I contain a specific 18-nucleotide sequence that is recognized by a termination protein. This protein binds the DNA at its recognition sequence and blocks further transcription, causing the RNA polymerase I to disengage from the template DNA strand and to release the nascent RNA.

The process of termination in RNA polymerase III involves hairpin-dependent termination similar to rho-independent termination of transcription in prokaryotes.

Post-transcriptional modification

Some of the bacterial RNA and most of the eukaryotic RNA are processed to various extent after their synthesis. Transcription of a eukaryotic gene results in the production of a heterogeneous nuclear RNA transcript (hnRNA) which represents the entire structural gene. Eukaryotic pre-mRNA is processed in three ways prior to export from the nucleus (Fig. 24):

1. Transcripts are ***capped*** at their 5′ end with a methylated guanosine nucleotide. The 5′ terminal cap is a unique feature of ***RNA polymerase II*** transcripts, including mRNAs and snRNAs. During the transcription, when the nascent RNA is about 22–40 bases long, the cap is added by a sequence of enzyme-mediated steps. The cap provides: (1) protection of the mRNA from degradation; (2) enhancement of the mRNA's translatability; (3) transport of at least some RNAs out of the nucleus; and (4) proper splicing of the pre-mRNA.



Post-transcriptional modification of mRNA

2. 3′ ends are cleaved and extended with ***a poly(A) tail***. After cleavage and release of the mRNA, the 3′ end of almost all eukaryotic mRNAs is polyadenylated. This is accomplished by the enzyme poly(A) polymerase which adds 100–250 adenosine 5′-monophosphates (AMP) to the 3′ end. Poly(A) enhances both the lifetime and translatability of mRNA.

3. Introns are removed by ***splicing***. Introns are removed from a hnRNA transcript at precisely defined splice points, and the ends of the remaining RNA are rejoined to form a continuous mRNA, rRNA, or tRNA. Nuclear pre-mRNA splicing takes place on a dynamic ribonucleoprotein particles called the ***spliceosome***. Introns are usually removed in a sequential manner from the 5′ to the 3′ end and their number varies between different genes. Some introns encode snoRNA and miRNA, and some exons do not encode a functional product. In some cases, however, the hnRNA transcript from the same gene may be processed in different ways to produce different mRNAs in a process known as ***alternative splicing*** (Figure 25). In higher eukaryotes, alternative splicing is an important mechanism for production of different forms of a protein, called ***isoforms***, by different types of cells. In rare cases, an exon from one pre-mRNA can join to an exon from another pre-mRNA by ***trans-splicing***.

C. Translation process

The translation process takes place in three stages: initiation, elongation and termination. Each stage involves multiple accessory factors and energy from GTP hydrolysis. Initiation

Initiation is a slow and the most complex step in protein synthesis. During initiation, the ribosome is assembled at the initiation codon in the mRNA with a methionyl initiator tRNA (Met-$tRNA_i^{Met}$) bound in its P-site. Assembling of translation initiation complexes is assisted by several ***initiation factors (IF)***. The eukaryotic initiation factor names all begin with ***e***, which stands for "eukaryotic".

Dissociation of ribosomes. Both bacterial and eukaryotic cells build initiation complexes on the small ribosomal subunit. Hence, the two ribosomal subunits must dissociate after each round of translation for a new initiation complex to form. In *bacteria*, the 70S ribosome dissociate into 50S and 30S subunits under the influence of ribosome release factor (RRF) that acts in conjunction with an elongation factor (EF-G). An initiation factor **IF3** binds to the small subunit and keeps it from reassociating with the large subunit. In *eukaryotes*, large and small ribosomal subunits are kept apart by binding of two initiation factors (**eIF3** for 40S and **eIF6** for 60S).

Initiation steps in *bacteria*:

Step 1. Initiation factors **IF1**, **IF2** and **GTP** bind alongside IF3 on the 30S ribosome subunit. This step probably occurs simultaneously with factor **IF3** binding.

Step 2. mRNA and **fMet-$tRNA_i^{f\text{-}Met}$** bind to the 30S subunit to form the ***30S initiation complex***. The complete 30S initiation complex contains one 30S ribosomal subunit plus one molecule each of mRNA, fMet-$tRNA_i^{f\text{-}Met}$, GTP, IF1, IF2, and IF3.

The ***initiation codon*** in bacterial mRNA is usually AUG, but it can also be GUG, or more rarely, UUG. A short purine-rich sequence (AGGAGGU in *E.coli*) called ***Shine–Dalgarno sequence*** (for John Shine and Lynn Dalgarno) lies just upstream of the initiation codon. Binding

between the 30S prokaryotic ribosomal subunit and the initiation site of a mRNA depends on base pairing between the Shine–Dalgarno sequence and a complementary sequence at the 3'-end of the 16S rRNA. This binding is mediated by **IF3**, with help from IF1 and IF2. Transcription and translation are coupled processes in prokaryotes. Hence, as soon as the Shine–Dalgarno sequence emerges from the transcriptional apparatus it can base pair with a complementary sequence at the 3'-end of the 16S rRNA. Most bacterial mRNAs are polycistronic, where each cistron has its own initiation codon and ribosome-binding site.

IF2 is the major factor promoting binding of **fMet-tRNA$_i^{f\text{-}Met}$** to the 30S initiation complex. The other two initiation factors play important supporting roles.

Step 3. IF1 and IF3 dissociate from the complex and the 50S subunit binds.

Step 4. IF2 dissociate from the complex, with simultaneous *hydrolysis of GTP*. The product is the 70S initiation complex, ready to begin elongation.

Initiation steps in *eukaryotes*:

Step 1. A ternary complex assembles. It consists of eukaryotic initiation factor 2 (**eIF2**), **GTP**, and the amino acid-charged initiator tRNA **(Met-tRNA$_i^{Met}$)**. This complex binds to the 40S ribosomal subunit, in association with other initiation factors, to form a ***43S preinitiation complex***.

Step 2. **mRNA** binds to the 43S complex with assistance of **eIF4F**, forming the ***48S initiation complex***. Two features of the eukaryotic mRNA become important at this point: the 5′ cap and the poly(A) tail. **eIF4F** is a cap-binding protein that allows the 40S ribosomal subunit to bind (through **eIF3**) to the m^{7}GpppN cap of the 5'-end of the mRNA. Specific initiation factors with RNA helicase activity (**eIF4G** and **eIF4E**) associate with the 5′ cap of the mRNA, unwind any secondary and tertiary structures, and remove any RNA-binding proteins. Poly(A)-binding proteins bind to the 3′-poly(A) tail. By interacting with these proteins, **eIF4G** can recruit the 43S complex to the mRNA.

Step 3. Once the mRNA is loaded, the 43S complex starts scanning along the mRNA from 5′ to 3′ looking for the start codon. The helicase activity of eIF4A uses energy from ATP hydrolysis to unwind the RNA secondary structure. Scanning stops when the Met-tRNA$_i^{Met}$ anticodon in the ternary complex recognizes the start codon, which is usually the first AUG downstream from the 5' end in a favorable context. Selection of the initiating AUG is facilitated by specific surrounding nucleotides called the ***Kozak sequence*** (for Marilyn Kozak): 5'-ACCAUGG-3'. Recognition of the start codon leads to *hydrolysis of the GTP* associated with eIF2 that prevents further scanning.

Step 4. Once the small ribosomal subunit with its bound Met-tRNA$_i^{Met}$ is correctly positioned at the start codon, the large (60S) ribosomal subunit binds forming an ***80S ribosome***. This requires the action of eIF5 and *hydrolysis of a GTP* associated with it. The ribosomal subunits do not dissociate until the entire mRNA is translated and protein synthesis is terminated.

1. Elongation

In both *prokaryotes* and *eukaryotes*, elongation of a polypeptide chain occurs in a three-step cycle (the elongation cycle) that is repeated over and over. The key steps in elongation are (a) entry of each succeeding aminoacyl-tRNA, (b) formation of a peptide bond, and (c) the movement, or translocation, of the ribosome one codon at a time along the mRNA. A set of ***elongation factors (EFs)*** are required to carry out this process.

(a) **Binding an aminoacyl-tRNA to the A-site of the ribosome.** In the beginning of elongation, fMet-tRNA$_i^{f\text{-}Met}$ in *prokaryotes* or Met-tRNA$_i^{Met}$ in *eukaryotes* is bound to the P site on the assembled ribosome. The second mRNA codon is in the A site, and the second aminoacyl-tRNA with a complementary anticodon binds to this site. Such binding requires a protein elongation factor EF-Tu in *bacteria* or eEF1A in *eukaryotes* associated with GTP. If the anticodon of the second aminoacyl-tRNA correctly base-pairs with the second codon of the mRNA, the GTP is hydrolyzed. It leads to tight binding of the aminoacyl-tRNA in the A site and release of the resulting EF-Tu-GDP (or eEF1A-GDP) complex. EF-Tu–GTP complex is regenerated involving EF-Ts in *bacteria* and eEF1B in *eukaryotes* as well as GTP.

Proofreading can occur if a mistake is made in the initial recognition step:

- The ternary complex (fMet-$tRNA_i^{f\text{-}Met}$+IF2+GTP) can dissociate from the ribosome after binding, and this happens more readily if a ternary complex with the wrong aminoacyl-tRNA has bound.
- The aminoacyl-tRNA (derived from the ternary complex) can dissociate from the ribosome. This happens at a much higher rate if the aminoacyl-tRNA is incorrect than it does when it is correct, because of the weakness of the imperfect codon–anticodon base pairing.

This is generally fast enough that an incorrect aminoacyl-tRNA dissociates from the ribosome before its amino acid has a chance to be incorporated into the nascent polypeptide.

(b) **Peptide bond formation.** The first peptide bond forms by the enzyme called ***peptidyl transferase***, which is a part of the large ribosomal subunit. It transfers the fMet in *prokaryotes* or Met in *eukaryotes* from its tRNA in the P site to the aminoacyl-tRNA in the A site. This forms a dipeptidyl-tRNA with two-amino acid chain (dipeptide) linked to the tRNA in the A site. A deacylated tRNA (tRNA without its amino acid) is left in the P site.

(c) **Translocation.** During translocation the mRNA and peptidyl-tRNA move one codon's length to the left through the ribosome. As a result, deacylated tRNA moves from the P-site into the exit E-site; the dipeptidyl-tRNA moves from the A-site into the P site; the mRNA moves by three nucleotides to place the next codon into the A site, which is open and ready to accept another aminoacyl-tRNA. Translocation requires an elongation factor EF-G in *prokaryotes* and eEF2 in *eukaryotes* and hydrolysis of GTP. The tRNA in the E site is released as a new tRNA enters the A site.

The elongation cycle repeats over and over until a stop codon is reached and the process of termination begins.

2. Termination

The termination of translation occurs when a stop codon (UAG, UAA, or UGA) enters in the ribosomal A-site. The end result of this process is the release of the completed polypeptide by hydrolysis of the ester bond linking the polypeptide to the tRNA in P-site. The termination of protein synthesis by the ribosome requires **release factors (RF)** of two classes. When any of the stop codons are present in the ribosome A-site, they are recognized by **class 1** release factors.

In *prokaryotes*, **RF1** recognizes the termination codons UAA and UAG; **RF2** recognizes UAA and UGA. In *eukaryotes*, **eRF1** recognizes all three termination codons. **Class 2** factors (**RF3** in *bacteria* and **eRF3** in *eukaryotes*) are GTPases that stimulate the activity of class 1 release factors. The final steps in protein synthesis involve the release of the completed polypeptide, removal of the tRNA from the E site, dissociation of the ribosome from the mRNA, and dissociation of the small and large subunits.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Task 1. Choose the correct answer:

1. The function of tRNA is to
   A. provide a site for polypeptide synthesis
   B. transport amino acids to the ribosome
   C. travel to the ribosome to direct the assembly of polypeptides
   D. transcribe DNA
   E. translates DNA
2. The function of mRNA is to
   A. provide a site for polypeptide synthesis
   B. transport amino acids to the ribosome
   C. travel to the ribosome to direct the assembly of polypeptides
   D. transcribe DNA
   E. translates DNA
3. Together with proteins, rRNA
   A. provides a site for polypeptide synthesis

B. transports amino acids to the ribosome
C. travels to the ribosome to direct the assembly of polypeptides
D. transcribes DNA
E. translates DNA

4. Transcription is initiated when RNA polymerase binds to
A. a promoter
B. an initiator
C. a transcriptor
D. a codon

5. Each time a nucleotide is added as the transcription bubble passes down the DNA, the RNA-DNA complex
A. elongates
B. rotates
C. shrinks
D. disassembles

6. Eukaryotic mRNA transcripts are protected from modification by
A. 5' caps
B. 5' poly-A caps
C. 3' caps
D. 5'-3' poly tails

7. In the process of transcription
A. the base sequence of DNA is copied into tRNA
B. a polypeptide is formed as specified by the genes in a chromosome
C. rRNA is specified by exons in DNA
D. a strand of mRNA is formed with base sequences complementary to those of DNA
E. mRNA is formed as coded by introns

8. The direct result of transcription is:
A. a duplicate DNA molecule
B. an RNA polymerase
C. a protein
D. mRNA
E. none of the above

9. The process of _____ cuts introns from the primary transcript and the final "processed" mRNA is produced.
A. RNA cleaving
B. RNA translocation
C. RNA elongation
D. RNA splicing
E. RNA releasing

10. Modifications of 3' ends of eukaryotic mRNA is called
A. polyadenylation
B. capping
C. splicing
D. translation

Task 2. Fill in the table

Type of RNA	Function	Location
rRNA		
mRNA		
tRNA		

snRNA		
snoRNA		
siRNA		
miRNA		

Task 3. Add the missing words

1. Most prokaryotic genes are made up of ____ main regions. At the centre, there is the sequence which will be copied in the form of RNA, called _____. To the 5′ side (upstream) of the strand which will be copied (the plus (+) strand) lies a region called the_____, and downstream of the transcription unit is the _____ region.

2. In prokaryotes the arrangement of genes in a functional group is called _____. The genes are closely packed with very few _____ gaps.

3. A single primary transcript (pre-mRNA) or "polycistronic mRNA" contains information from multiple genes, or _____.

4. The lactose (lac) operon encodes _____ involved in the regulation of _____ metabolism in *E. coli*. It contains three structural genes: ____, ____ and ____.

5. In bacteria, the structural genes are transcribed as a single mRNA, under control of one _____ and a regulator gene with its own _____.

6. In the absence of lactose, _____ synthesised by the regulator gene binds to the _____ DNA site and blocks RNA polymerase from binding the promoter.

7. In the presence of lactose, allolactose (a lactose isomer) binds _____ and cause its conformational change which alters its _____ domain. Catabolite activator protein (CAP) binds its DNA site (the CAP site) and recruits _____ to the promoter.

8. Compared to prokaryotic operons, eukaryotic genes devoted to a single pathway are most often physically _____ in the DNA; indeed such genes usually are located on different _____.

9. The eukaryotic genes exist in pieces of coding sequence, _____, separated by non-protein-coding segments, _____.

10. Some of the bacterial RNA and most of the eukaryotic RNA are _____ to various extent after their synthesis.

Task 4. Find and correct mistakes, if any

1. In prokaryotes, RNA polymerase binds to the promoter on DNA and starts building the RNA chain complementary to the minus (-) strand of the DNA, moving along this strand in a 5′ to 3′ direction.

2. Rho-independent terminators cause termination of transcription in the absence of any external factors by encoding an inverted nucleotide repeat.

3. Transcription of an operon produces several pre-mRNAs each encoding one structural gene.

4. In eukaryotes, TFIIB factor binds to the TATA box and recruits other general transcription factors and RNA polymerase II to the gene promoter.

5. The process of termination in RNA polymerase III involves hairpin-dependent termination similar to rho-independent termination of transcription in prokaryotes.

6. RNA Polymerase II continue to transcribe RNA until the terminator region.

7. The 5′ terminal cap is necessary for protection of mRNAs from degradation.

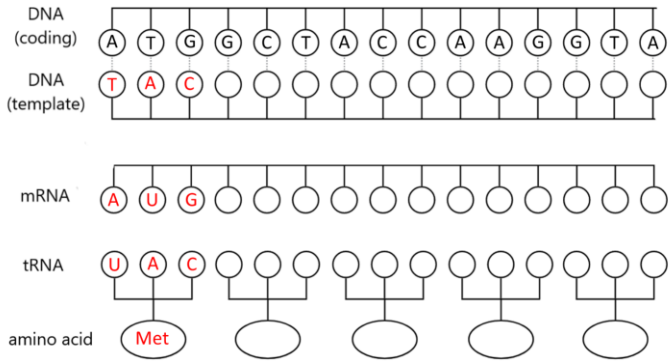
8. After cleavage and release of the mRNA, the 3′ end of almost all eukaryotic mRNAs is methylated.

9. In the process of alternative splicing different mRNAs are produced from the hnRNA transcripts from different genes.

10. An exon from one pre-mRNA can join to an exon from another pre-mRNA by the process called trans-splicing.

RECOMMENDED TASKS FOR INDEPENDENT WORK

Task 1. Following the example fill in the nucleotide and polypeptide chains produced as a result of transcription and translation of the coding DNA sequence:



Task 2. Choose the correct answer:

1. The genetic code consists of groups of three nucleotides called
A) codon
B) intron
C) anticodon
D) reading frame
E) exon
2. In eukaryotes, there are _____ codons that specify amino acids.
A) 21
B) 24
C) 61
D) 64
E) 60
3. Protein is a heteropolymer, the monomers of which are
A) nucleotides
B) amino acids
C) phospholipids
D) nitrogenous bases
4. In a protein, amino acids are connected by
A) hydrogen bonds
B) ionic bonds
C) metallic bonds
D) peptide bonds
5. Peptide bond is formed between the carboxyl group of one amino acid and
A) carboxyl group of another amino acid
B) amino group of another amino acid
C) phosphate group of another amino acid
D) hydroxyl group of another amino acid
6. Peptide bond is
A) covalent polar bond
B) covalent nonpolar bond
C) hydrogen bond
D) ionic bond
7. Primary structure of the protein
A) chain of amino acids connected by hydrogen bonds
B) chain of amino acids connected by peptide bonds
C) chain of nucleotides connected by peptide bonds

D) chain of amino acids connected by covalent nonpolar bonds
8. Secondary structure of the protein
A) helix
B) globule
C) chain
D) two chain
9. Helix is folded in the form of globules by
A) formation of disulfide bridges between the functional groups of amino acids
B) metallic bond
C) peptide bonds
D) covalent nonpolar bonds
10. In mitochondrial genomes, _____ is a "stop" codon.
A) UGA
B) UUU
C) AUA
D) UAA
E) AGA
11. In mRNA, the series of nucleotides CCC specifies
A) serine
B) proline
C) alanine
D) arginine
E) stop
12. In eukaryotes, the "start" codon also specifies the amino acid,
A) phenylalanine
B) valine
C) aspartate
D) methionine
13. The order in which nucleotides are moved along the ribosomes binding sites is
A) APE
B) PEA
C) EPA
D) EAP
14. In the formation of an initiation complex, a _____ is positioned first.
A) met-tRNA
B) ser-tRNA
C) tyr-rRNA
D) mval-tRNA
E) cyst-tRNA
15. Enzymes called amino acyl-tRNA synthetases
A) synthesizes tRNA
B) attaches amino acids to tRNA
C) strips tRNA from its amino acid in the process of translation
D) destroys excess tRNA molecules
E) helps tRNA synthesize amino acids
16. In mRNA the "start" sequence is
A) UAA
B) UAG
C) UGA
D) AUG
E) GUU
17. In the process of translation,

A) a strand of mRNA is formed with nucleotide sequences complementary to those of DNA
B) nucleotide sequences of tRNA are established
C) a polypeptide is formed in response to the rRNA nucleotide sequence
D) rRNA is synthesized with sequences complementary to those of tRNA
E) a polypeptide is formed as dictated by the nucleotide sequence in mRNA

18. A molecule of tRNA with the anticodon AAA will transport the amino acid
A) phenylalanine
B) lysine
C) proline
D) glycine
E) arginine

19. In messenger RNA, the nucleotide series UAG specifies
A) arginine
B) serine
C) stop
D) proline
E) aspartate

20. The direct result of translation is:
A) a duplicate DNA molecule
B) nRNA
C) a protein
D) mRNA
E) all of the above

21. Eukaryotic large ribosome subunit is
A) 30S
B) 40S
C) 50S
D) 60S
E) 70S

22. Prokaryotic large ribosome subunit is
A) 30S
B) 40S
C) 50S
D) 60S
E) 70S

23. Which of the following act as a template for the process of protein synthesis that takes place on ribosomes?
A) rRNA
B) DNA
C) tRNA
D) mRNA

24. The Shine-Dalgarno sequence is
A) a Wobble position
B) a stop codon
C) the reading frame of a gene
D) a short sequence that acts as a ribosomal binding site

Task 3. Insert the correct word:

1. Protein is a heteropolymer, the monomers of which are _____.
2. In the protein amino acids are connected by _____ bond.
3. Peptide bond is formed between the carboxyl group of one amino acid and _____ of another amino acid.
4. Peptide bond is _____ bond.

5. Primary structure of the protein is chain of amino acids connected by_____ bonds.

6. Secondary structures of the protein are _____ and _____.

7. α-Helix is folded in the form of globules by formation of _____between the functional groups of amino acids.

8. The folding of a newly synthesized protein is facilitated by other proteins called _____.

9. _____ increase the diversity of amino acids in proteins from 20 to about 100.

10. Insulin, synthesized as a longer precursor polypeptide, forms by two _____.

Task 4. Find and correct mistakes, if any:

1. The process of linking an amino acid to its specific tRNA is termed charging.
2. Anticodon in the rRNA base-pairs with a codon in mRNA so that the activated nitrogenous bases can be added to the growing polypeptide chain.
3. The number of tRNAs in most cells is more than the number of amino acids used in protein synthesis.
4. There are four tRNA binding sites on a ribosome.
5. Both prokaryotes and eukaryotes contain two different methionine tRNAs.
6. During initiation, the ribosome is assembled at the initiation codon in the rRNA with a methionyl initiator tRNA.
7. Both bacterial and eukaryotic cells build initiation complexes on the large ribosomal subunit.
8. The initiation codon in bacterial mRNA is usually AUG, but it can also be GUG, or more rarely, UUG.
9. The first peptide bond forms by the enzyme called peptidyl transferase, which is a part of the small ribosomal subunit.
10. The termination of translation occurs when a stop codon (UAG, UAA, or UGA) enters in the ribosomal A-site.

<u>Unit 9</u>. Life cycle of the cell. Format-practical's.

Discussion questions:

1. Life cycle of the cell.
2. The interphase and its periods.
3. DNA replication.
4. Mitosis, its phases, and biological significance.
5. Cell death and its phases.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Mitosis, chromosomes, mitotic spindle, chromosome centromere, kinetochore, centrioli, genetic information, indirect division, interphase, DNA replication

KEY POINTS OF THE TOPIC:

<u>A. MITOSIS AND ITS BIOLOGICAL SIGNIFICANCE</u>

MITOSIS - indirect cell division in which one parent cell 2 is formed a subsidiary, in which the genetic material is the same as in the parent cells.

<u>Includes 4 phases</u>:

Prophase

DNA spiralized, and chromosomes become visible. The nuclear envelope breaks down, the nucleolus disappears, the centriole go to different poles. Between them begin to form filaments of the mitotic spindle. In the cell 2n4c.

Metaphase

In this phase the chromosomes are most clearly visible. Each chromosome consists of two chromatids that are connected in the region of the centromere.

Dwukrotnie chromosomes line up in the equator, forming the parent star. To centromeres chromosomes attach to the spindle fibers division. In the cell 2n4c.

Anaphase

There is a separation of the centromere of the chromosome. Each chromosome splits into 2 chromatids, which become independent of sister chromosomes. Chromatids (sister chromosome) diverge to different poles of the cell. At the poles becomes 2n2c, and in General in the cage 4n4c.

Telophase

DNA deserialized. Chromosomes are not visible. Formed nuclear envelope, inside the nucleus the nucleolus is formed. Then cytokinesis occurs (catatonia) – division of cytoplasm, and forms 2 daughter cells with a set PS.

Significance of mitosis:

1. Ensures genetic stability, as the daughter cells are exact genetic copy of the parent cells.
2. Ensures the growth of organisms.
3. Provides embryonic development of organisms.
4. Provides for the recovery of organisms.
5. Is the basis of asexual reproduction.

B. THE LIFE CYCLE OF CELLS

The life cycle of the cell is a period of cell life from the moment of its formation during the subsequent division to division, or death.

The cell cycle is composed of mitosis and the period between the divisions - interphase.

There are 3 periods in interphase:

1. G1- period (post-mitotic or presynthetic period):

There is an active synthesis of proteins, fats, carbohydrates, the number increases to the number of organelles characteristic of mature cells.

The synthesis of specific "trigger" proteins also occurs during this period. If their concentration reaches a particular threshold, called "restriction point" (the point «R»), the cell can continue the life cycle, and go to the next synthetic period.

The cell begins to actively synthesize nucleotides and enzymes necessary for DNA replication. If the concentration of proteins does not reach the trigger point «R», the cell enters a period G0 - a period of rest. There are three reasons why the cell can not reach the point of restriction:

a) cells showed significant breaks in the DNA, which must be corrected (the repair process is the process of correcting errors in DNA);

b) the cell is experiencing adverse effects of the environment

c) the cell starts to differentiate, acquiring the characteristics of specialization, the specific time to fulfill its function and then dies.

2) S- period (synthesis period). There is a process of DNA replication. There is an active synthesis of histone proteins necessary for packaging the DNA subsidiaries. It starts doubling of centrioles.

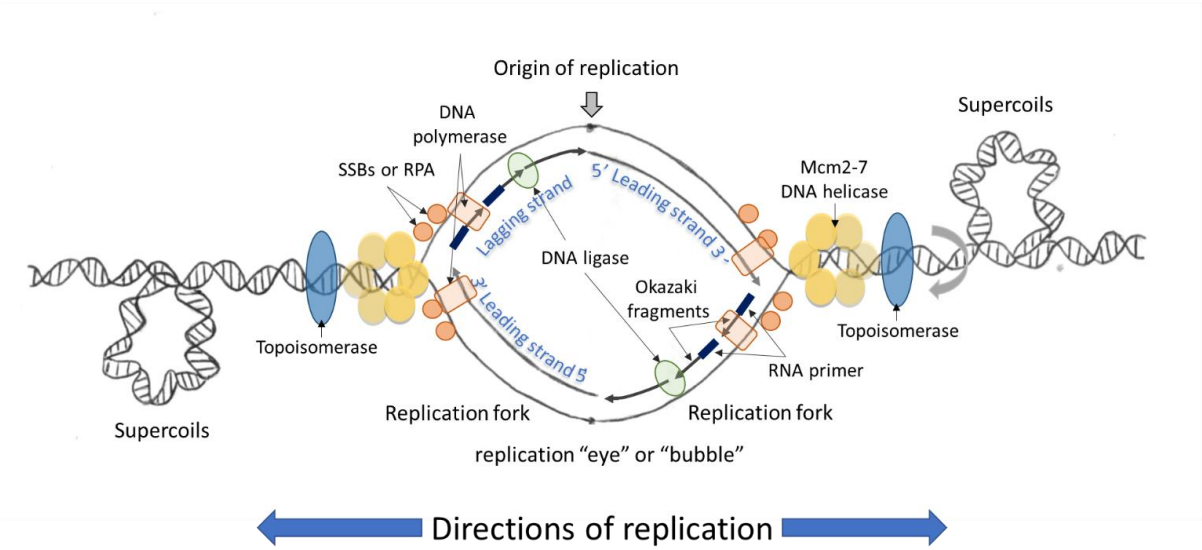
3) G2- period (premitotichesky, postsynthetic). The cells are ready for the forthcoming mitosis, is the accumulation of ATP and tubulin protein synthesis necessary to build spindle microtubules.

C. THE REPLICATION PROCESS

The replication process can be divided into three main stages:

1. **Initiation**

DNA has to be unwound before any of the proteins and enzymes needed for replication can act, and this involves separating the double-helical DNA into single strands at the replication origins. This process is carried out by the enzymes ***DNA helicases***. In *bacterial cells*, as soon as the ***initiator proteins*** accumulate at the origin, DNA helicases are recruited to the origin and initiation begins. In *eukaryotic cells* specific ***initiator proteins*** recognize and bind origin DNA sequences, forming an ***origin recognition complex (ORC)***. The process called ***replication "licensing"*** regulate the activation of the origin only once during the replication cycle (in S-phase) to avoid over-replication of the genome. The regulation involves the formation of a prereplication complex (pre-RC) on the base of the ORC that prevents the initiation of replication before G1/S transition phase when pre-RC is disassembled. Only licensed origins containing Mcm2-7 (minichromosome maintenance), a hexameric (six subunits, numbered 2–7) complex with helicase activity, can initiate replication in *eukaryotes*. The helicase activity separates the two strands in the double helix at an origin of replication, exposing bases to form a ***replication "eye"*** or ***"bubble"*** that contains two ***replication forks*** (Fig. 10). Once the forks are initiated, Mcm2-7 is displaced from the origin and moves with the replication fork. The two replication forks proceed in opposite directions (***bidirectional replication***) from the origin.



Schematic representation of the semidiscontinuous bidirectional DNA replication.

Once helicases have unwound the parental DNA at an origin, a specialized RNA polymerase called ***primase*** in *E.coli* or ***DNA polymerase α*** in *eukaryotes* forms a short ***RNA primer*** complementary to the unwound template DNA strands. Then this RNA primer is used as a starting point for synthesis of a new DNA strand by a ***DNA polymerase,*** using the original DNA as a template. The primer is vital since it leaves an exposed 3′ hydroxyl group. This is necessary since the DNA polymerase can only add new nucleotides to the 3′ end and not the 5′ end of a nucleic acid.

Localized unwinding of a DNA molecule, induces torsional stress as the molecule ends are not free to rotate. As a result, the DNA molecule twists back on itself, forming ***supercoils***. Bacterial and eukaryotic cells, however, contain ***topoisomerase I***, which can relieve any torsional stress that develops in cellular DNA molecules during replication or other processes. Accessory proteins also play a role in initiation, such as ***single-stranded DNA binding proteins (SSBs)*** in E. coli and ***replication protein A (RPA)*** in mammals that prevent the single strands from re-annealing.

2. Elongation

The replication fork is asymmetric as the two strands of the parental DNA duplex are antiparallel. DNA polymerases can add nucleotides only in the 5′ to 3′ direction from the RNA

primer. This DNA strand is usually termed the ***leading strand*** and provides the means for ***continuous*** DNA synthesis in the *same direction as movement of the replication fork*. The DNA polymerase on the leading strand template does not release until it meets a replication fork moving in the opposite direction, or until the entire strand is replicated.

Synthesis of the other strand, usually termed the ***lagging strand***, is more complex. DNA is copied in short segments (1000–2000 nucleotides in prokaryotes and 100–200 nucleotides in eukaryotes) *moving in the opposite direction to the replication fork*. These short segments were first described in 1969 by Reiji and Tuneko Okazaki, and are thus called "**Okazaki fragments**." A new RNA primer has to be synthesised every few hundred bases or so on the second parental strand. Each of these primers, base-paired to their template strand, is elongated in the 5′ to 3′ direction, forming ***discontinuous*** Okazaki fragments. The RNA primer of each Okazaki fragment is then removed and replaced by DNA chain built from the neighboring Okazaki fragment by DNA polymerase; finally an enzyme called ***DNA ligase*** joins the adjacent fragments. Therefore, this mechanism of DNA replication in which one strand is made continuously and the other is made discontinuously is called ***semidiscontinuous*** DNA replication. During replication, the chromosome of *E. coli* looks like the Greek letter theta (θ) by electron microscopy. Replication intermediates are thus termed "theta structures."

The replicative polymerases can generate spontaneous errors when copying DNA. During each round of replication, there is one mistake for every 10 000 to 100 000 bp. Many replicative polymerases have an associated proofreading exonuclease that excises 90–99% of misincorporated nucleotides. For example, DNA polymerase δ has a subunit with 3′ → 5′ exonuclease activity. Incorporation of an incorrect base at the 3′ end causes a melting of the end of the duplex. As a result, the polymerase pauses and excises the mispaired base, then elongation resumes.

3. Termination

In *E. coli*, the replication forks meet each other at the ***terminus*** to generate two daughter molecules. The terminus region contains sequence-specific replication arrest sites that block fork progression and limit the end of the replication cycle to this region.

In eukaryotes, some sequences at specific sites that can arrest the progress of DNA replication forks have been identified, but it is not clear whether these are a common feature associated with all origins. Replication probably continues until one fork meets a fork proceeding towards it from the adjacent replicon. Nucleosomes re-form within approximately 250 bp behind the replication fork. Thus, histone deposition occurs almost as soon as enough DNA is available to form nucleosomes (approximately 180 bp). ***Chromatin assembly factor 1 (CAF-1)*** brings histones to the DNA replication fork. Rapid histone deposition behind the replication fork is necessary to prevent spontaneous DNA double-strand breaks and S phase arrest in human cells.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Task 1. Add the missing words

1. DNA replication process is based on the principle of _____.
2. DNA replicates in a _____ manner, i.e. each daughter duplex has one parental strand and one new strand.
3. DNA synthesis occurs from ___′ to ___′.
4. Enzymes that polymerize nucleotides into a new DNA strand are called _____.
5. The replication process starts at unique segments in a DNA molecule called _____.
6. The DNA under the control of one replication origin is called _____.
7. A specialized RNA polymerase called primase in E.coli or _____ in eukaryotes forms a short _____ complementary to the unwound template DNA strands.

8. DNA polymerases can add nucleotides only in the __′ to __′ direction from the RNA primer.
9. Finally, an enzyme called _____ joins the adjacent Okazaki fragments.
10. The process of ending DNA replication is called _____.

Task 2. Choose the correct answer

1. A template strand of DNA is 3' TAGGCATTGCA 5'. What is the complementary DNA strand that is created from this template during replication?

A. 5′ TGCAATGCCTA 3′
B. 5′ ATCCGTAACGT 3′
C. 5′ AUCCGUAACGU 3′
D. 5′ TAGGCATTGCA 3′

2. Which of the following correctly pairs the DNA replication enzyme with its function?
A. Topoisomerases work ahead of the replication fork to prevent supercoiling.
B. DNA polymerase I opens up the DNA at the replication fork.
C. Helicase seals gaps between DNA fragments.
D. DNA primase extends primers by adding nucleotides to the 3' prime end.

3. Which enzyme is responsible for binding Okazaki fragments together?
A. DNA ligase
B. DNA polymerase
C. RNA primase
D. DNA helicase

4. DNA replication results in two DNA molecules,
A. each one with two original strands
B. each one with two new strands
C. each one with one new strand and one original strand
D. one with two new strands and the other with two original strands

5. What enzyme cuts hydrogen bonds between strands of DNA during replication?
A. DNA ligase
B. DNA polymerase
C. RNA primase
D. DNA helicase

6. DNA polymerase synthesizes a daughter DNA chain in the direction of:
A. 5′ - 3′
B. 3′- 5′
C. 5′ - 5′
D. 3′ - 3′

7. Okazaki fragments contain the following number of nucleotides in eukaryotes:
A. 100-200
B. 1000-2000
C. 10-20
D. 10000-20000

8. RNA primers in prokaryotes are synthesized by the enzyme:
A. DNA ligase
B. DNA polymerase
C. RNA primase
D. DNA helicase

9. The lagging DNA chain is formed in the period:
A. Elongation
B. Termination
C. Initiation
D. Transcription

10. Fragments of Okazaki are formed in the period:

A. Elongation
B. Termination
C. Initiation
D. Transcription

Task 3. Find and correct mistakes, if any

1. DNA replicates in a conservative manner, i.e. each daughter duplex has one parental strand and one new strand.
2. DNA synthesis occurs from 5′ to 3′.
3. Nucleotides are added one at a time to the 5′ hydroxyl end of the DNA chain, forming new phosphodiester bonds.
4. Enzymes that polymerize nucleotides into a new DNA strand are called DNA ligases.
5. DNA polymerases can only add nucleotides in the 3′ to 5′ direction by catalyzing the formation of a phosphodiester bond between the first 5′-phosphate group of a new dNTP and the 3′-hydroxyl group of the last nucleotide in the newly synthesized strand.
6. The replication process starts at unique segments in a DNA molecule called replication origins.
7. Eukaryotic chromosomes have only one replicon.
8. In eukaryotic cells specific initiator proteins recognize and bind origin DNA sequences, forming an origin recognition complex (ORC).
9. A specialized RNA polymerase called primase in *E. coli* forms a short DNA primer complementary to the unwound template DNA strands.
10. The replicative polymerases can generate spontaneous errors when copying DNA.

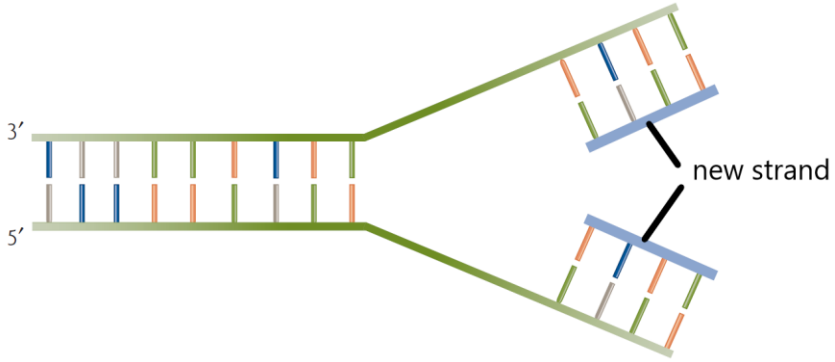
RECOMMENDED TASKS FOR INDEPENDENT WORK

Task 1. Answer the questions

1. What are the main features of DNA replication?
2. How much faster the replication happens in bacteria compared to mammals?
3. Which strand grows continuously towards the replication fork in semidiscontinuous replication?
4. What are the enzymes that participate in the replication process?
5. What enzyme replaces RNA primer on the leading strand with DNA?
6. What is the name of the fragments of the lagging strand?
7. What is a replicon? How many replicons are in *E. coli* and eukaryotic cells?
8. Why the formation of the origin recognition complex (ORC) is important in eukaryotes?
9. Which enzyme activity is responsible for the proofreading during the replication?

Task 2. The diagram below shows a replication fork in nuclear DNA.

1. Label the “leading strand” and “lagging strand” and indicate to which DNA strand Okazaki fragments are added.
2. Use arrows to show the direction of synthesis for each strand.



Section 2. Organismic (ontogenetic) the level of organization of biological systems.

Unit 10. Reproduction of organisms. Format-practical's.

Discussion questions:

1. Reproduction is a universal feature of living.
2. Comparative characteristics of asexual and sexual reproduction of organisms.
3. Types of asexual and sexual reproduction of organisms.
4. Parthenogenesis.
5. Meiosis, its phases and biological significance.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Asexual and sexual reproduction, parthenogenesis, meiosis, homologous chromosomes, conjugation, crossing over, the law of independent divergence of homologous chromosomes, schizogony, sporogony, isogamy, ovogamy, heterogamy, polyembryony

KEY POINTS OF THE TOPIC

A. MEIOSIS AND ITS BIOLOGICAL SIGNIFICANCE

Meiosis is an indirect cell division in which one diploid mother cell forms 4 haploid daughter cells, the genetic material of which is different from the genetic material of the parent cell.

Consists of 2 divisions:

1. Reduction (2n4c→1n2c) – halves the number of chromosomes.
2. Equatione (1n2c→1n1c) – the number of chromosomes is equalized with the number of DNA (chromatids).

REDUCTION DIVISION includes 4 phases:

The Prophase I includes 5 stages:

Leptotene

DNA spiralized and chromosomes become visible in the form of thin fibers.

Zygotene

Conjugate is convergence and connection of homologous chromosomes (homologous chromosomes are chromosomes similar in shape, dimensions and location of genes). The result is formation of bivalent (tetrad). Each bivalent consists of 2 homologous chromosomes (4 chromatids (DNA)).

Pachytene

Crossing over occurs – the exchange of parts between homologous chromosomes.

Diplotene

Chromosome in bivalent slightly repel each other. Become visible places chiasm – chiasmata.

Diakines

Chromosomes remain in bivalents, but completely isolated from each other. The nuclear envelope breaks down, the nucleolus disappears, the centriole go to different poles. Filaments of the mitotic spindle begin to form between them. In the cell 2n4c.

Metaphase I

Bivalency line up on the equator of the cell. The spindle fibers division attach to centromeres chromosomes. In the cell 2n4c.

Anaphase I

In anaphase I, the microtubules of the spindle fibers begin to shorten. As they shorten, they break the chiasmata and pull the centromeres toward the poles, dragging the chromosomes along with them. Because the microtubules are attached to kinetochores on only one side of each centromere, the individual centromeres are not pulled apart to form two daughter centromeres, as they are in mitosis. Instead, the entire centromere moves to one pole, taking both sister chromatids with it. When the spindle fibers have fully contracted, each pole has a complete

haploid set of chromosomes consisting of one member of each homologous pair. Because of the random orientation of homologous chromosomes on the metaphase plate, a pole may receive either the maternal or the paternal homologue from each chromosome pair. As a result, the genes on different chromosomes assort independently; that is, meiosis I results in the independent assortment of maternal and paternal chromosomes into the gametes.

Chiasmata created by crossing over have a key impact on how chromosomes align in metaphase I. In the first meiotic division, the chiasmata hold one sister chromatid to the other sister chromatid; consequently, the spindle microtubules can bind to only one side of each centromere, and the homologous chromosomes are drawn to opposite poles. In mitosis, microtubules attach to both sides of each centromere; when the microtubules shorten, the sister chromatids are split and drawn to opposite poles

Telophase I

By the beginning of telophase I, the chromosomes have segregated into two clusters, one at each pole of the cell. Now the nuclear membrane reforms around each daughter nucleus. As each chromosome replicated before meiosis I began, each chromosome now contains two sister chromatids attached by a common centromere. Importantly, *the sister chromatids are no longer identical,* because of the crossing over that occurred in prophase I. Cytokinesis may or may not occur after telophase I. The second meiotic division, meiosis II, occurs after an interval of variable length.

Between 1 and 2 divisions of meiosis may be a slight period of rest – interlines. However during it is no doubling of the DNA, since each chromosome still consists of 2 chromatids.

EQUAZIONE DIVISION (essentially, mitosis)

Includes 4 phases:

The prophase II At the two poles of the cell the clusters of chromosomes enter a brief prophase II, each nuclear envelope breaking down as a new spindle forms.

Metaphase II. In metaphase II, spindle fibers bind to both sides of the centromeres.

Anaphase II. The spindle fibers contract, splitting the centromeres and moving the sister chromatids to opposite poles.

Telophase II. Finally, the nuclear envelope reforms around the four sets of daughter chromosomes. The final result of this division is four cells containing haploid sets of chromosomes. No two are alike, because of the crossing over in prophase I. Nuclear envelopes then form around each haploid set of chromosomes. The cells that contain these haploid nuclei may develop directly into gametes, as they do in animals.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Find mistakes in the sentences (if any) and correct them:

1. Meiosis is an indirect cell division in which one diploid mother cell forms 4 haploid daughter cells, the genetic material which is the same as the parent cells.
2. Leptotene is stage of prophase I when DNA despiralized and chromosomes become visible in the form of thin fibers.
3. Each bivalent consists of 2 homologous chromosomes (2 chromatids (DNA)).
4. Formation of bivalents occurs at pachytene.
5. Crossing over is the exchange of parts between bivalents.
6. Chiasmata become visible in diplotene.
7. Bivalents line up on the equator of the cell in metaphase II.
8. The microtubules are attached to kinetochores only on one side of each centromere in anaphase I.
9. The independent assortment of chromosomes occurs in anaphase II.
10. The nuclear membrane reforms around each daughter nucleus in prophase.
11. Spindle fibers bind to both sides of the centromeres of chromosomes in telophase II.
12. Cytokinesis occurs in anaphase of mitosis.

13. The nuclear membrane disintegrates in metaphase II of meiosis.

14. You can see the bivalents in the cell in one of the phases of mitosis.

15. A chromosome is divided into two chromatids that move to different poles in metaphase of mitosis.

Unit 11. Genetics – is the science of heredity and variation. Genetic level of organization of the genetic information. Format- study discussion.

Discussion questions:

1. Subject, objectives and methods of genetics.
2. Evidence for the role of DNA as the hereditary material.
3. Properties of genetic code.
4. Gene – a functional unit of heredity.
5. Classification, properties and localization of genes.
6. The relationship between gene and trait. Hypothesis Beadle-Tatum.
7. The hypothesis of Jacob-Mono (operon hypothesis).
8. The chemical composition and structure of chromosomes.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Operon, gene regulator, promoter, operator, structural genes, terminator, alleles, homologous chromosomes, homozygote, heterozygote, phenotype, genotype, monohybrid crossbreeding, dihybrid crossbreeding, pleiotropy, dominance, epistasis

KEY POINTS OF THE TOPIC:

A. Basic concepts of genetics

Genetics is the scientific study of heredity and variation.

Heredity is the transmission of traits from one generation to the next.

You must know follow terms:

Gene is a locus (or region) of DNA that encodes a functional RNA or protein product, and is the molecular unit of heredity. We have two copies of each gene that we inherited from our mother and our father.

Locus is the location of a gene on a chromosome.

Allele is one of two or more alternative forms of a gene (*A* or *a*).

Dominant allele is an allele that is fully expressed in the phenotype of a heterozygous (*A*). For example, the allele for brown eyes is dominant, therefore you only need one copy of the 'brown eye.

Recessive alleles is an allele whose phenotypic effect is not observed in a heterozygous by the presence of a dominant allele. For example, the allele for blue eyes is recessive, therefore to have blue eyes you need to have two copies of the 'blue eye' allele (*a*).

Homologous chromosomes is a chromosome pairs of the same length, centomere position, and staining pattern that possess genes for the same characters at corresponding loci. One homologous chromosome is inherited from the organisms father. The other from mother.

Homozygous is a individual carrying identical alleles of a gene on both homologous chromosomes (*AA, bb*).

Heterozygous is a individual carrying two different alleles of a gene on two homologous chromosomes (*Aa, Bb*). Most human beings are heterozygous for many genes.

Monohybrid cross is a breeding experiment between parental generation (P generation) organisms that differ in one trait (*AA*×*aa*).

Dihybrid cross is a breeding experiment between P generation organisms that differ in two traits (*AABB*×*aabb).*

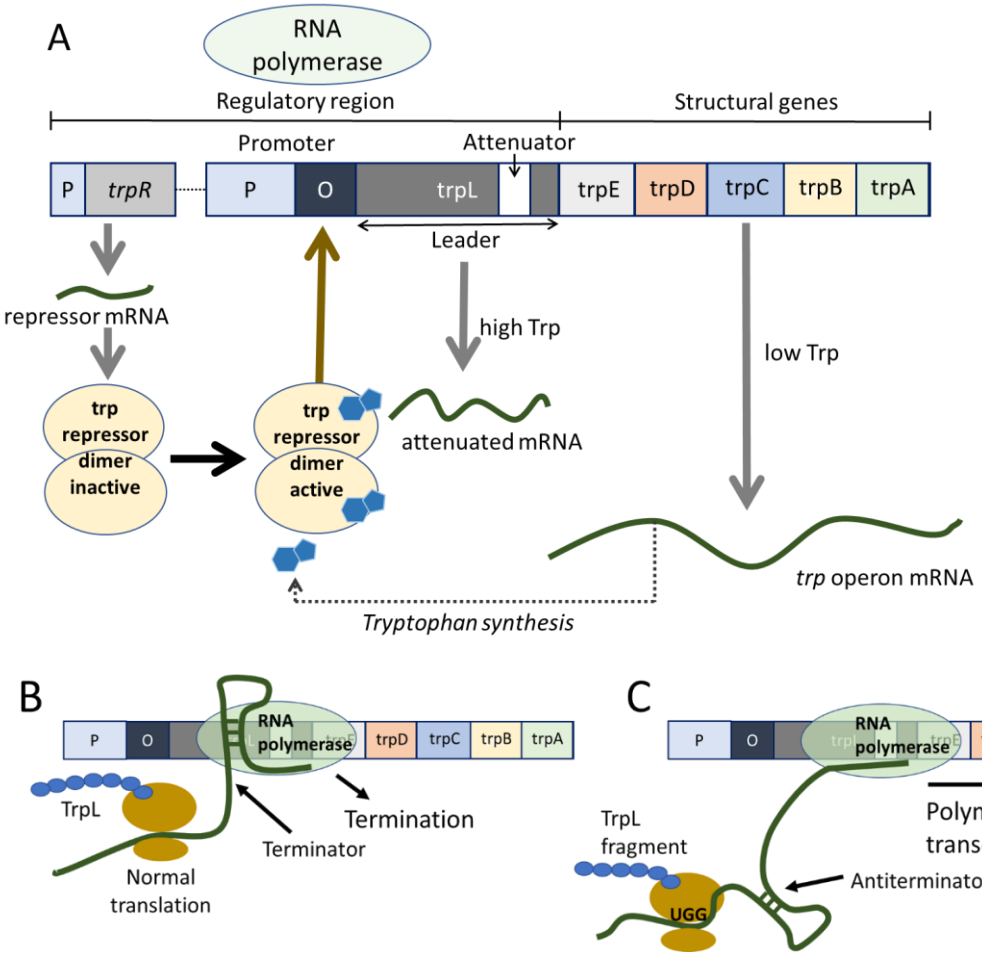
Genotype is the genetic makeup of an organism/

Phenotype is the physical and physiological traits of an organisms, which determined by its genetic makeup.

B. Control of gene expression by RNA

Differential folding of RNA: transcriptional attenuation of the tryptophan operon

Regulation of the **tryptophan (*trp*) operon** in bacteria is a classic example of transcriptional attenuation. The structural genes of the operon responsible for tryptophan biosynthesis are trpE, D, C, B and A. The *trp* operon is controlled by both a repressor protein binding to the operator region and translation-induced transcriptional attenuation. The rate of expression of the *trp* operon depends on the level of tryptophan in the cell.



When **tryptophan is abundant** in the cell it acts as ***a corepressor***. A tryptophan-activated ***repressor*** protein binds to operator sites located within the *trp* promoter region, blocking access of RNA polymerase to the *trp* promoter.

During transcription of the ***leader region*** of the *trp* operon (***trpL***), a domain of the newly synthesized RNA transcript can fold to form one of two competing hairpin structures, ***an antiterminator*** or ***a terminator***. This is known as the process of transcriptional attenuation.

When bacterial cells have **sufficient levels of tryptophan-charged tRNA^{Trp}** for protein synthesis, the leader peptide (*trpL*) is synthesized, ***the terminator*** forms in the leader transcript, and transcription is terminated .

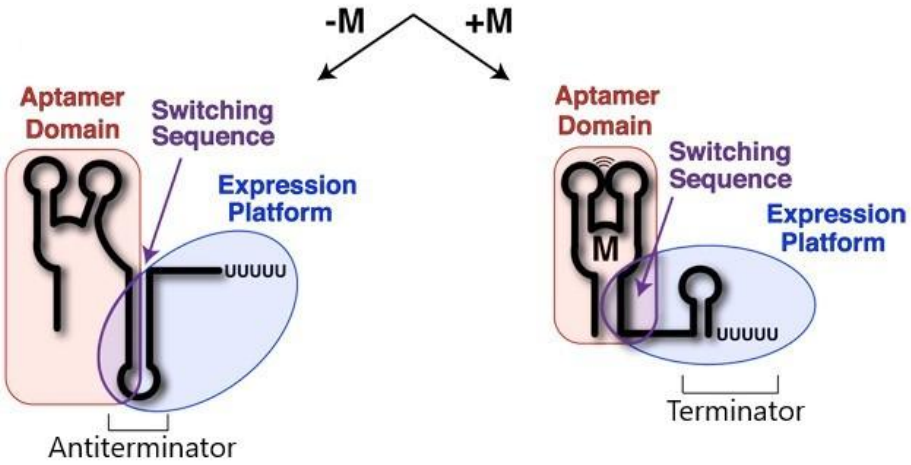
When cells are **deficient in charged tRNA^{Trp}**, the ribosome translating *trpL* stops at one of these tryptophan codons. This allows the downstream sequence to fold, forming ***an antiterminator*** structure that prevents formation of the competing terminator. Termination is blocked, allowing transcription of the structural genes involved in tryptophan biosynthesis.

Riboswitches

Specialized domains within certain mRNAs act as switchable “on–off” elements or “riboswitches,” which selectively bind metabolites or metal ions as ligands and control gene

expression without the need for protein transcription factors. RNA can function as a sensor of temperature, salt concentration, metal ions, amino acids, and other small organic metabolites. Riboswitches are widespread in bacteria. In eukaryotes, only one type of riboswitch – a thiamine pyrophosphate-sensing riboswitch – has been found in plants and fungi so far.

Riboswitches have two structural domains: ***an aptamer*** that binds the target metabolite, and ***an expression platform*** that has the potential to form alternative antiterminator and terminator hairpins. When **metabolite is not bound (-M)**, the expression platform incorporates the switching sequence into ***an antiterminator stem-loop*** and transcription continues. When **metabolite binds (+M)**, the switching sequence is incorporated into the aptamer domain, and the expression platform folds into ***a terminator stem-loop***, causing transcription to abort.



Repression either occurs by terminating transcription or preventing translation initiation or both if the stem–loop structure of the terminator also serves as a ***sequestor*** of the ribosome-binding site (RBS). The binding of a specific metabolite to the conserved RNA-sensor domain stabilizes the riboswitch structure thus preventing the formation of an alternative RNA structure that could be an antiterminator, antisequestor, terminator or sequestor of the ribosome-binding site.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Task 1. Add the missing words

1. The process of DNA duplication is called _____.
2. The information in the language of nucleotides is copied into another language – the language of amino acids during the process of _____.
3. The monomers of DNA are _____.
4. Each nucleotide of DNA is composed of three parts: phosphate, _____ and _____.
5. DNA consists of 4 types of nitrogenous bases: adenine, guanine, _____and _____.
6. Polynucleotide molecules are formed when nucleotides are joined together by the formation of _____ bond by reaction between _____ of one nucleotide and the _____ of another nucleotide.
7. DNA chains are interconnected by _____ bond.
8. DNA is found in the _____ in Eukaryotic cells.
9. DNA is found in the _____in prokaryotic cells like bacteria.
10. The structure of RNA nucleotides, unlike the DNA, includes _____ and _____.
11. One _____ codes for one protein.
12. Cells with two copies of the genome are called _____.

Task 2. Find and correct mistakes, if any

1. DNA has two polynucleotide strands: one strand runs 5′ to 3′, whilst the other strand runs in the opposite direction 3′ to 5′.

2. Each nucleotide is composed of a five-membered pentose carbon sugar, a nitrogenous base (purine or pyrimidine) and an amino acid.

3. The purine bases (composed of fused five- and six-membered rings), adenine (A) and guanine (G) and the pyrimidine (a single six-membered ring) cytosine (C) and thymine (T) are found in both RNA and DNA.

4. In the double helix of DNA, nucleotide A pairs only with T, and C pairs only with G.

5. All bacteria, many viruses, mitochondria and chloroplasts have circular DNA.

6. First-order packaging involves the winding of the DNA around a core complex of five small proteins repeated twice, termed histones (H1, H2A, H2B, H3 and H4).

7. During G1 phase, each chromosome is duplicated, identical chromosomes (sister chromatids) remain attached to one another at a point called the centromere.

8. Most plants and animals contain two copies of their genome and called haploid.

9. Genome can be defined as the complete set of genes of a cell, organelle or virus.

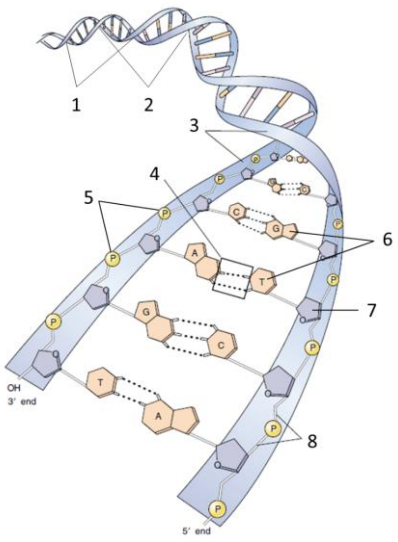
10. There is a relation between the size of genome, number of genes, and organism complexity.

RECOMMENDED TASKS FOR INDEPENDENT WORK

Task 1. Answer the questions

1. What are the 4 nitrogenous bases of DNA?
2. What are the 2 complementary base pairs of DNA? Of RNA?
3. Why the DNA helix is described as an antiparallel structure?
4. What is the denaturation and renaturation processes?
5. Which proteins participate in the DNA packaging in prokaryotes and eukaryotes?
6. What is the difference between a gene and a chromosome?
7. What is the difference in the genomes of prokaryotes, eukaryotes and viruses?

Task 2. Label the DNA structure



[fig. from *Raven, P. and Johnson, G. Biology, 6th ed. The McGraw Hill Companies, New York, 2002, 872 pp.*]

<u>Unit 12.</u> Types and variants of Mendelian inheritance. The interaction of genes. Format-practical's.

Discussion questions:

1. The laws of heredity of Gregor Mendel. Cytological basis of the laws of Gregor Mendel.

2. The concept of allelic genes.
3. Types of interaction between allelic genes: complete dominance, incomplete dominance, codominance, overdominance.
4. Multiple allelism. Inheritance of blood groups of humans.
5. The interaction of nonallelic genes: epistasis, complementarity, polymeria.
6. Pleiotropy genes.
7. Types and variants of Mendelian inheritance.
8. Monogenic inheritance. Genetics of sex.
9. Autosomal and sex-linked inheritance.
10. Independent and linked recessive inheritance.
11. Polygenic inheritance of the traits.
12. Cytoplasmic inheritance.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Autosomal and sex-linked inheritance, complete dominance, incomplete dominance, codominance, overdominance, epistasis, complementarity, polymeria, cytoplasmic inheritance.

KEY POINTS OF THE TOPIC:

A. MENDEL'S LAW

MENDEL'S FIRST LAW

Mendel formulated the **law of dominance (uniformity of hybrids of the first generation):**

In a cross of parents that are pure for contrasting traits, only one form of the trait will appear in the next generation. Offspring that are hybrid for a trait will have only the dominant trait in the phenotype.

Hybrid progeny from crossing a dominant homozygous organism and a recessive homozygous organism has the same genotype (all individuals of heterozygotes) and the same phenotype (all individuals carry a dominant trait).

MENDEL'S SECOND LAW

Mendel formulated the **law of segregation:**

When two heterozygotes are crossed, in the offspring splitting is observed according to the phenotype 3: 1, according to the genotype 1: 2: 1

When Mendel crossed the yellow-peas F1 plants, ¾ of the plants had yellow peas, but ¼ had green peas.

The **Punnett Square** allows us to visualize a cross by examining the possible combinations of gametes from the parents.

Genes have alternative forms, or alleles. In a diploid organism, the two alleles of a gene segregate (separate) during meiosis and gamete formation; each sperm or egg carries only one allele of each pair.

This law explains the 3:1 ratio of F2 phenotypes observed when monohybrids self-pollinate.

MENDEL'S THIRD LAW

Mendel also crossed plants that differed in two and more characteristics, such as color and form peas

If genes are located in different pairs of homologous chromosomes, then the characters for which they are responsible are inherited independently and combined randomly. In a cross between **dihybrids (individuals heterozygous for two genes), the offspring** have four phenotypes in a 9:3:3:1 ratio.

The 9:3:3:1 ratio observed derives from two separate 3:1 phenotypic ratios: the ratio of yellow to green is 12:4 (or 3:1) and of round to wrinkled is 12:4 (or 3:1).

Mendel formulated **the Law of Independent Assortment:**

The pair of alleles for a given gene segregates into gametes independently of the pair of alleles for any other gene.

B. THE INTERACTION OF GENES

Types of interaction of allelic genes

COMPLETE DOMINANCE – a one gene – dominant - completely masks another – recessive. A heterozygous individuals have an dominant phenotype.

INCOMPLETE DOMINANCE - the dominant allele does not completely inhibit the effect of the recessive allele, therefore heterozygotes have an intermediate phenotype. For example, plants with one red allele and one white allele have pink flowers:

CODOMINANT

No allele dominates the other allele, each allele expresses itself equally, so a new trait appears in the heterozygote.

For example, inheritance of blood groups:

ABO Blood groups

–3 alleles

–6 possible ABO genotypes: IAIA, IBIB, IAIB, IAi, IBi, or ii

4 possible phenotypes.

This example demonstrates the manifestation of multiple allelism: A gene can be represented by three alleles.

Types of interaction of non-allelic genes

COMPLEMENTATION

Two dominant alleles of genes work together to produce a new phenotype.

• In a dihybrid cross, 9:7 ratio is a phenotypic signature of complementary gene interaction where dominant alleles of two genes act together to produce a trait while other three genotypic classes do not.

Task for example:

The color of the flowers of some plant depends on the interaction of non-allelic genes. When two diheterozygous plants were crossed, offsprings with the following phenotype splitting were obtained: 27 plants with red flowers, 9 plants with yellow flowers, 9 plants with blue flowers, 3 plants with white flowers. Explain the phenotypic ratio obtained and determine the genotypes of the parents.

Decision:

When crossing diheterozygous plants, phenotype cleavage in the offspring should be in a ratio of 9: 3: 3: 1. We can conclude that the dominant gene A determines the yellow color of the flowers, the dominant gene B determines the blue color of the flowers, the recessive genes a and b determine the white color of the flowers. However, when both dominant genes are combined together in the same genotype, a new trait (red color) appears. Genotypes of parental forms are AaBb.

POLYGENIC TRAITS

Most traits are not controlled by a single gene locus, but by the combined interaction of many gene loci. These are called polygenic traits.

Polygenic traits often show continuous variation, rather then a few discrete forms.

For example: Color of skin man. The heterozygous individuals (*AaBbCc) represented by the two rectangles* at the top of this figure each carry three dark-skin alleles (black circles, which represent *A, B, or C) and three light-skin alleles (white circles,* which represent *a, b, or c).*

EPISTASIS – one gene's alleles mask the effects of another gene's alleles

Labrador retriever example – recessive epistasis – coat color can be black, chocolate brown, or golden yellow.

Pleiotropy

Phenomenon is when a single gene locus affects more than one trait.

For example, in Labrador retrievers the gene locus that controls how dark the pigment in the hair will be also affects the color of the nose, lips, and eye rims. Pleiotropic effects are characteristic of many inherited disorders, such as cystic fibrosis and sickle cell anemia, both discussed later in this chapter. In these disorders, multiple symptoms can be traced back to a single gene defect. In cystic fibrosis, patients exhibit clogged blood vessels, overly sticky mucus, salty sweat, liver and pancreas failure, and a battery of other symptoms. All are pleiotropic effects of a single defect, a mutation in a gene that encodes a chloride ion transmembrane channel. In sickle cell anemia, a defect in the oxygen-carrying hemoglobin molecule causes anemia, heart failure, increased susceptibility to pneumonia, kidney failure, enlargement of the spleen, and many other symptoms. It is usually difficult to deduce the nature of the primary defect from the range of a gene's pleiotropic effects.

C. X-Linked Characteristics

In humans, all somatic cells (typical body cells) contain 23 pairs of chromosomes. Of these, 22 pairs are autosomes, the last pair are the sex chromosomes. The sex chromosomes are related to the gender of the individual and are called X and Y. Women have two X chromosomes, men have an X and a Y. Haploid sex cells (gametes) produced by women (ova) have only the X chromosome, male gametes (sperm) have either X or Y. Sex of the offspring is determined by the male.

The X chromosome is large and carries many genes such as those for essential muscle proteins and retinal pigments. The Y chromosome, on the other hand, is quite small and carries only a few genes, mostly related to male gender development. A defective gene on the X chromosome will be phenotypically expressed in a male because there is no other X chromosome to compensate. However, a woman with the same defective gene will not express it phenotypically if her other X chromosome is normal. She will be a carrier though in that she has the defective gene but does not express it.

Red-green colorblindness is caused by a mutation in a gene for retinal pigments on the X chromosome. The defective allele is recessive to the normal one so a woman with one normal X chromosome (X) and one colorblind carrying chromosome (X^C) will have normal color vision because the X chromosome is dominant for this trait over the X^C chromosome. Men, however will be colorblind if they possess the X^C chromosome since there is no other X to be dominate over it and will exhibit red-green colorblindness

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

MONOHYBRID CROSSING

1. Brown eye color dominates the blue eye color. Homozygous brown-eyed woman marries a blue-eyed man. Determine the probability of the birth of blue-eyed children from this marriage.
2. Brown eye color dominates the blue eye color. A blue-eyed child was born from a marriage of brown-eyed parents. Determine the genotypes of the parents and the possible genotypes and phenotypes of subsequent children.
3. Brown eye color dominates the blue eye color. A blue-eyed child was born from a marriage of a brown-eyed woman and a blue-eyed man. Determine the female genotype and possible genotypes and phenotypes of subsequent children.
4. Normal skin pigmentation dominates albinism. An albino child was born from the marriage of a woman with normal skin pigmentation and an albino male. Determine the female genotype and possible genotypes and phenotypes of subsequent children.
5. Normal skin pigmentation dominates albinism. An albino child was born from a marriage of parents with normal skin pigmentation. Determine the genotypes of the parents and the possible genotypes and phenotypes of subsequent children.

6. Normal skin pigmentation dominates albinism. A homozygous woman with normal skin pigmentation marries an albino male. Determine the genotypes of the parents and the possible genotypes and phenotypes of subsequent children.
7. The black color of dog hair dominates over white. Crossed breed dogs with black and white color. What offspring can be expected from this crossing in the first and second generation?
8. The black color of the dog's fur dominates over white. The black-haired dog was crossed with a white dog. A puppy with white fur appeared in their progeny. Determine the genotype of the black dog and the possible genotypes and phenotypes of subsequent puppies.

9. The black color of the dog's fur dominates over white. What offspring can we expect from crossing heterozygous dogs with each other?
10. Myopia is determined by the dominant gene, normal vision is determined by the recessive autosomal gene. What offspring can be expected from the marriage of heterozygous myopic parents?
11. Myopia is determined by the dominant gene, normal vision is determined by the recessive autosomal gene. What offspring can be expected from marriage of myopic parents, if their first child had normal vision?
12. Myopia is determined by the dominant gene, normal vision is determined by the recessive autosomal gene. What offspring can be expected from the marriage of myopic parents, if the mothers of both spouses had normal vision?

BLOOD GROUP INHERITANCE

1. Mother has a second group of blood and brown eye color, the father has a third group of blood and blue eyes. They had a son with the first group of blood and blue eyes. What kind of blood and eye color may be the children of this a married couple. It is known that brown eye color is dominant over blue.
2. A person has blood type O. Their mother is B and father is A. What is the genotype of this person and their parents?
3. Four babies are born in a hospital, and each has a different blood type: A, B, AB, and O. The parents of these babies have the following pairs of blood groups: A and B, O and O, AB and O, and B and B. Which baby belongs to which parents?
4. A woman is married for the second time. Her first husband has blood type A and her child by that marriage has type O. Her new husband has type B blood, and when they have a child its blood type is AB. What is the woman’s blood genotype and blood type?
5. A man with type A blood marries a woman with type B blood. Their child has type O blood. What are the genotypes of these three individuals? What genotypes, and in what frequencies, would you expect in future offspring from this marriage?
6. A paternity suit involves a child whose blood type is AB. The mother is blood type B, the alleged father is O. Make a ruling on this case as to whether it is reasonably possible this is the biological father.

DIHYBRID CROSSING

1. Brown eye color dominates the blue and is determined by an autosomal gene. poridactyly determined by the dominant autosomal gene. A homozygous woman with brown eyes and polydactyles marries a blue-eyed man with a normal hand. What offspring can you expect from this marriage?
2. Brown eye color dominates the blue and is determined by an autosomal gene. poridactyly determined by the dominant autosomal gene. A woman with brown eyes and a polydactyus marries a blue-eyed man with a normal hand. What offspring can be expected from this marriage, if it is known that among the ancestors of the woman there were no blue-eyed people, and the mother of the woman had a normal hand?

3. Brown eye color dominates the blue and is determined by an autosomal gene. Polydactyly is determined by a dominant autosomal gene. From the marriage of brown-eyed parents with polydactyly was born a child with blue eyes and a normal hand. What offspring can you expect from this marriage? What is the probability of birth of brown-eyed children with a normal hand?
4. Brown eye color dominates the blue and is determined by an autosomal gene. Polydactyly is determined by a dominant autosomal gene. What offspring can be expected from marriage of brown-eyed parents with polydactyly, if the mothers of both spouses had blue eyes and a normal hand? What is the probability of birth of brown-eyed children with a normal hand?

5. Brown eye color dominates the blue and is determined by an autosomal gene. Polydactyly is determined by a dominant autosomal gene. What offspring can be expected from marriage of a brown-eyed woman with polydactyly, whose mother had blue eyes and a normal hand, with a blue-eyed man with a normal hand? What is the probability of birth of brown-eyed children with a normal hand?
6. Albinism and normal hand are determined by recessive autosomal genes. What offspring can be expected from marriage of parents with normal skin pigmentation and polydactyly, if the mothers of both spouses had a normal hand and suffered from albinism?
7. Albinism and normal hand are determined by recessive autosomal genes. What offspring can be expected from a marriage of parents with normal skin pigmentation and polydactyly, if the first child had a normal hand and suffered from albinism?
8. Albinism and normal hand are determined by recessive autosomal genes. What offspring can be expected from marriage of a woman with normal skin pigmentation and polydactyly and a man with a normal hand and albinism, if the first child had a normal hand and suffered from albinism?
9. Albinism and normal hand are determined by recessive autosomal genes. What offspring can be expected from marriage of a homozygous woman with normal skin pigmentation and polydactyly and a man with a normal hand and albinism?
10. The black color of fur and long tail in dogs are determined by the dominant autosomal gene. What offspring in the first and second generation can be expected from crossing homozygous black long-tailed dogs with white short-tailed dogs?

RECOMMENDED TASKS FOR INDEPENDENT WORK

MONOHYBRID CROSSING

1. Myopia is determined by the dominant gene, normal vision is determined by the recessive autosomal gene. What offspring can be expected from marriage of a woman with myopia and a man with normal vision? Consider all possible options.
2. The red color of the tomato fruit dominates the yellow color of the fruit. What offspring can be expected from crossing homozygous plants with red and yellow fruits in the first and second generations?
3. The red color of the tomato fruit dominates the yellow color of the fruit. Yellow fruit plant is obtained by crossing the red fruit plants with each other. Determine the genotypes of the red fruit plants and the possible genotypes and phenotypes of the offspring from this crossing.
4. Polydactyly is determined by a dominant autosomal gene. What offspring can be expected from marriage of a woman with polydactyly and a man who has a normal hand? Consider all possible options.
5. Polydactyly is determined by a dominant autosomal gene. What offspring can be expected from marriage of parents with polydactyly, if their first child had a normal hand?

6. A pea plant heterozygous for inflated pods (Ii) is crossed with a plant homozygous for constricted pods (ii). Draw a Punnett square for this cross. Assume that pollen comes from the ii plant.
7. A normally pigmented man marries an albino woman. They have three children, one of whom is an albino. What is the genotype of the father?

Myopia is determined by the dominant gene, normal vision is determined by the recessive autosomal gene. What offspring can be expected from marriage of a woman with myopia and a man with normal vision? Consider all possible options.

8. The red color of the tomato fruit dominates the yellow color of the fruit. What offspring can be expected from crossing homozygous plants with red and yellow fruits in the first and second generations?
9. The red color of the tomato fruit dominates the yellow color of the fruit. Yellow fruit plant is obtained by crossing the red fruit plants with each other. Determine the genotypes of the red fruit plants and the possible genotypes and phenotypes of the offspring from this crossing.
10. Polydactyly is determined by a dominant autosomal gene. What offspring can be expected from marriage of a woman with polydactyly and a man who has a normal hand? Consider all possible options.
11. Polydactyly is determined by a dominant autosomal gene. What offspring can be expected from marriage of parents with polydactyly, if their first child had a normal hand?
12. A pea plant heterozygous for inflated pods (Ii) is crossed with a plant homozygous for constricted pods (ii). Draw a Punnett square for this cross. Assume that pollen comes from the ii plant.
13. A normally pigmented man marries an albino woman. They have three children, one of whom is an albino. What is the genotype of the father?

BLOOD GROUP INHERITANCE

7. A woman with the first group of blood marries a man with a fourth group of blood. What blood types are possible in children from this marriage?
8. A woman with the first group of blood marries a man with a third group of blood. What blood types are possible in children from this marriage? Consider all possible options.
9. A woman with the first group of blood marries a man with the second group of blood. What blood types are possible in children from this marriage? Consider all possible options.
10. A woman with a third blood group marries a man with a second blood type. What blood types are possible in children from this marriage if the first child had the first blood type?
11. A woman with a third blood group marries a man with a second blood type. What blood types are possible in children from this marriage, if the mothers of both spouses had the first blood type?
12. What is the probability of having a child with the first blood group from a woman's marriage with the first group and a man with the fourth blood group?

DIHYBRID CROSSING

1. The black color of fur and long tail in dogs are determined by the dominant autosomal gene. What offspring can be expected from crossing black long-tailed dogs with white short-tailed dogs, if there was a white short-tailed puppy in their offspring?
2. The black color of fur and long tail in dogs are determined by the dominant autosomal gene. A black long-tailed dog intersects with a white short-tailed dog. In the offspring, there are 8 short-tailed black puppies and 9 long-tailed black puppies. Write down the genotypes of the parents and the possible genotypes and phenotypes of the offspring.
3. The black color of fur and long tail in dogs are determined by the dominant autosomal gene. From the crossing of black long-tailed dogs among themselves in the progeny, 12 black long-

tailed puppies and 4 white short-tailed puppies were obtained. Write down the genotypes of the parents and the possible genotypes and phenotypes of the offspring.

4. What is the expected phenotypic ratio in a dihybrid cross between two organisms that are heterozygous for both traits?
5. Two pea plants heterozygous for the characters of pod color and pod shape are crossed. Draw a Punnett square to determine the phenotypic ratios of the offspring.
6. Polydactyly is inherited as a dominant autosomal gene, the normal hand inherited as a recessive autosomal gene. Also analyzed the inheritance of blood groups. Woman with polydactyly and 3 blood group marries a man with polydactyly and 2 blood group. They had a child with the normal hand and 1 blood group. What is the probability of having a child with the normal hand and 3 blood group?
7. Myopia and polydactyly are inherited as autosomal dominant genes. A woman has polydactyly and myopia, but her mother did not have these diseases. She marries a man who does not have these diseases. What is the probability of the birth of children without anomalies of the couple.

Unit 13. Chromosomal and genomic levels of organization of the genetic information. Format-practical's.

Discussion questions:

1. Chromosome as a group of adhesion genes.
2. Chromosomal theory of inheritance by Thomas Morgan.
3. Characterization of the genome of prokaryotes and eukaryotes.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Chained inheritance, crossingover, distance between genes, genetic maps of chromosomes, gene linking group, locus, prokaryotes, eukaryotes, genome, introns, exons, plasmid.

KEY POINTS OF THE TOPIC:

A. CHROMOSOME THEORY OF INHERITANCE

Morgan formulated ***a chromosome theory of inheritance***:

- Each chromosome has hundreds or thousands of genes.
- Genes located on the same chromosome, linked genes, tend to be inherited together because the chromosome is passed along as a unit.
- Results of crosses with linked genes deviate from those expected according to independent assortment.
- The production of offspring with new combinations of traits inherited from two parents is genetic recombination.
- Genetic recombination can result from independent assortment of genes located on nonhomologous chromosomes or from crossing over of genes located on homologous chromosomes.

Because crossovers occur along the length of a chromosome at random, the farther apart 2 genes are, the larger the chance a crossover will occur between them, and the higher the frequency of recombinant types.

Therefore, the frequency of recombinant types can be used to construct genetic maps. ***The distance between genes is proportional to the frequency***

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

1. Cataracts and polydactyly are determined by dominant genes located in the same chromosome at a distance of 20% crossing-over. A woman with a cataract and polydactyly

marries a man who does not have these diseases. It is known that the mother of the woman did not have these diseases too. What is the probability of having a child without anomalies from this marriage?

2. Positive rhesus and elliptocytosis are determined by dominant genes localized in one chromosome at a distance of 3% crossing-over. A woman with positive rhesus and elliptocytosis marries a man with negative rhesus and the normal form of red blood cells. It is known that the mother of the woman was Rh-negative and the normal form of red blood cells. What is the probability of having children with the mother's phenotype?

3. Brown eye color and polydactyly are determined by dominant genes localized in one chromosome at a distance of 40% crossing-over. A woman with brown eyes and a polydactyus marries a man with blue eyes and a normal wrist. It is known that the father of the woman was with blue eyes and a normal hand too. What is the probability of having a baby with a father's phenotype?

4. Myopia and phenylketonuria are determined by dominant genes located in the same chromosome at a distance of 15% crossing-over. A woman with normal vision and normal metabolism marries a man with myopia and phenylketonuria. It is known that the man’s mother did not have these diseases. What is the probability of having a child without myopia and phenylketonuria?

5. Myopia and normal skin pigmentation are determined by dominant genes located in the same chromosome at a distance of 30% crossing-over. A woman with myopia and normal skin pigmentation marries a man with normal vision but suffering from albinism. It is known that the mother of the woman had normal vision and was sick with albinism. What is the probability of having a baby without myopia and albinism?

6. The red color of tomato fruits and the round shape are determined by dominant autosomal genes located on the same chromosome at a distance of 18% crossing-over. A plant with red and round fruits crossed with a plant having yellow and oval fruits. It is known that the first plant is derived from a plant with yellow oval fruits. What is the probability of offspring with yellow oval fruits?

7. Albinism and diabetes are determined by recessive genes located at the same chromosome at a distance of 10% crossing-over. A healthy woman whose mother suffered from albinism and diabetes marries a man suffering from both diseases. What is the probability of having a child without anomalies?

8. Blue eye color and diabetes are determined by recessive autosomal genes located on one chromosome at a distance of 26% crossing-over. Brown-eyed healthy woman marries a blue-eyed man with diabetes. It is known that the mother of the woman was blue-eyed and suffered from diabetes. What is the probability of having a blue-eyed baby without diabetes?

9. Cataract and eliptocytosis are determined by dominant genes located on the same chromosome at a distance of 8% crossing-over. A woman with a cataract and an elliptocytosis marries a man who does not have these diseases. It is known that the mother of the woman also did not have these diseases. What is the probability of having a child without anomalies?

10. Positive rhesus and elliptocytosis are determined by dominant genes localized in one chromosome at a distance of 3% crossing-over. A woman with positive rhesus and elliptocytosis marries a man with negative rhesus and the normal form of red blood cells. It is known that the mother of the woman was Rh-negative, and the father of the woman had the normal form of red blood cells. What is the probability of birth of children with negative Rh and the normal form of red blood cells?

RECOMMENDED TASKS FOR INDEPENDENT WORK

1. Cataracts and polydactyly are determined by dominant genes located in one chromosome at a distance of 20% crossing-over. A woman with a cataract and polydactyly marries a man with normal vision and a normal hand. It is known that the father of the woman had a normal hand, and the mother of the woman had normal vision. What is the probability of having a child without both anomalies?
2. Brown eye color and polydactyly are determined by dominant genes localized in one chromosome at a distance of 40% crossing-over. A woman with brown eyes and a polydactyus marries a man with blue eyes and a normal wrist. It is known that the father of the woman was with blue eyes, and the mother of the woman was with a normal hand. What is the probability of having a child with a father's phenotype (blue eyes, normal hand)?
3. Myopia and phenylketonuria are determined by dominant genes located in the same chromosome at a distance of 15% crossing-over. A woman with normal vision and normal metabolism marries a man with myopia and phenylketonuria. It is known that the man's mother did not have myopia, and his father did not suffer from phenylketonuria. What is the probability of having a child without myopia and phenylketonuria?
4. Myopia and normal skin pigmentation are determined by dominant genes located in the same chromosome at a distance of 30% crossing-over. A woman with myopia and normal skin pigmentation marries a man with normal vision but suffering from albinism. It is known that the mother of the woman had normal vision, and the father of the woman was sick with albinism. What is the probability of having a baby without myopia and albinism?
5. The red color of tomato fruits and the round shape are determined by dominant autosomal genes located on the same chromosome at a distance of 18% crossing-over. A plant with red and round fruits crossed with a plant having yellow and oval fruits. It is known that the first plant is derived from the crossing of a plant variety with yellow and round fruits with a plant variety with red and oval fruits. What is the probability of offspring with yellow oval fruits?
6. Albinism and diabetes are determined by recessive genes located at the same chromosome at a distance of 10% crossing-over. A healthy woman marries a man suffering from both diseases. It is known that the mother of the woman suffered from albinism, and the father of the woman had diabetes. What is the probability of having a child without anomalies?
7. Blue eye color and diabetes are determined by recessive autosomal genes located on one chromosome at a distance of 26% crossing-over. Brown-eyed healthy woman marries a blue-eyed man with diabetes. It is known that the mother of the woman was blue-eyed, and her father suffered from diabetes. What is the probability of having a blue-eyed child without diabetes?
8. Cataract and eliptocytosis are determined by dominant genes located on the same chromosome at a distance of 8% crossing-over. A woman with a cataract and an elliptocytosis marries a man who does not have these diseases. It is known that the woman's mother did not have cataracts, and the woman's father did not suffer from elliptocytosis. What is the probability of having a child without anomalies?
9. Positive rhesus (Rh) and elliptocytosis are determined by dominant genes localized in one chromosome at a distance of 3% crossing-over. Both spouses had positive rhesus and elliptocytosis. It is known that the fathers of both spouses were with negative Rh and the normal form of erythrocytes. What is the probability of birth of children with negative Rh and the normal form of red blood cells?

10. Cataracts and polydactyly are determined by dominant genes located in one chromosome at a distance of 20% crossing-over. Both spouses had cataracts and polydactyly. It is known that the mothers of both spouses did not have these diseases. What is the probability of having a child without both diseases?

<u>Unit 14.</u> Modification and combinative variability. Format-practical's.

Discussion questions:

1. Modification variability, especially, adaptive significance in ontogenesis and evolution.
2. The concept of norm of the reaction.
3. Mechanisms of combined variability (genetic recombination).
4. The value of combinative variability in ensuring genotypic diversity.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Phenotype, genotype, modifications, characters, group nature of inheritance, combinations, crossing over, the law of independent divergence of homologous chromosomes, genetic diversity of offspring.

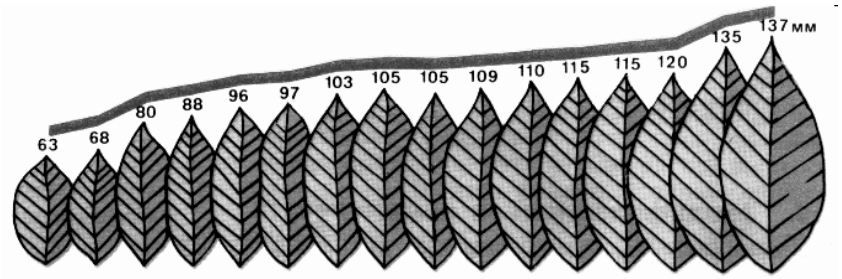
KEY POINTS OF THE TOPIC:

Variability is the body's ability to acquire new features in the process of individual development.

<u>Distinguish:</u>

1. nonhereditary (phenotypic) variability – modificational variability;
2. genetic variability (genotypic). It is divided into mutational and combinative variability.

Modificational variability - variability, affecting only the phenotype and not affecting the genotype.



Features:

1. Do not inherited (as they do not affect the genotype).
2. Wears group character as similar changes occur in a group of individuals.
3. Predictable as the result of factors can predict the actions.
4. Referred to as the changes that occur under the influence of factors that are often adaptive nature.
5. Reversibility arise because changes may be reversible. However, if action is not specific factor or it acts in a critical period of development, then there may be irreversible changes called Morphosis.
6. The boundaries of variability is called the norm of reaction and defined genotype.

Modification variability studied by the variational-statistical method.

Combinative variability is not related to changes in the genes, but only with their recombination in the offspring. It occurs during sexual reproduction.

Causes:

- Crossing over
- Independent divergence of homologous chromosomes in anaphase I of meiosis, which occurs during the formation of gametes.
- The phenomenon of random fertilization.

Unit 15. Mutational variability. Format-practical's.

Discussion questions:

1. Mutational variability.
2. Classifications of mutations.
3. The concept of the genetic, chromosomal mutations.
4. Genomic mutations (euploidiya and aneuplodiya).
5. Genetic, chromosomal and genomic of human disease.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Mutation, duplication, deletion, inversion, translocation, polyploidy, heteroploidy, cytoplasmic heredity, mutagens

KEY POINTS OF THE TOPIC:

Mutational variability is volatility, which is caused by mutations, ie unpredictable abrupt changes genotype (namely genome chromosomes or genes).

Features:

1. It is inherited, because it affects the genotype.
2. It is individual.
3. It is unpredictable because it is impossible to predict what changes occur in response to factors.
4. The changes occurring in organisms do not usually wear an adaptive character.

Classification of mutations:

1. Mutations associated with changes in the genotype: genetic, chromosomal, genomic.
2. Mutations in different ways affect the viability: the lethal, half-lethal, neutral.
3. Mutations vary in behavior in the heterozygote: dominant and recessive.
4. Mutations vary in relation to the generative ways: somatic (occur in normal cells of the body and are not inherited) and generative (occur in germ cells, therefore inherited).
5. The mutations differ in their localization in the cell: nuclear (occurring in the DNA of the nucleus) and cytoplasmic (occurring in the DNA of mitochondria and plastids).
6. The mutations differ in the causes of mutation: spontaneous (the reason is not clear) and induced (called mutagens).

Mutagens are environmental factors that cause mutation.

By nature, mutagens are:

- Physical (X-rays);
- Chemicals (asbestos, formaldehyde);
- Biological (DNA viruses).

Genome mutations are associated with a change in the number of chromosomes in the genome (haploid set of chromosomes). Normal organism is euploid with exact chromosome number that is multiple of chromosome set (2n). E.g Drosophila melanogaster normally with 8 chromosome. The species is diploid, having two sets of 4 chromosomes each.

There are 2 types:

1. Polyploidy (euploidiya) is the change in the number of chromosomes, a multiple of the haploid set.

There are autotetraploids and allopolyploid.

A) autopolyploidy associated with multiple repetition of the same chromosome set. For example, there are types of irises containing 18 chromosomes (2n), chromosome 27 (3n), chromosome 36 (4n) ... 81 chromosomes (9n).

Can happen because of a failure of the spindle fibers in mitosis or meiosis to segregate chromosomes into separate groups. Cell-division error causes production of diploid gametes.

Triploidy (3n):

— Most frequent chromomal aberration (15%) in fetuses following spontaneous abortion;
— Severe growth retardation, early lethality;
— Occasional liveborn infant with severe malformation
— Dispermia a frequent cause.

B) allopolyploidy repeated many times different chromosome sets. For example, soft wheat - allopolyploid which contains chromosome sets of 6 different wheat species. Allopolyploid in nature is rare. Interspecific hybrids are formed. Polyploidy is needed to interspecific hybrids could produce offspring. So breeder Karpechenko created the prolific hybrid of cabbage and radish.

2. Geteroploidy (aneuploidy) is the change in the number of chromosomes, not multiple haploid set. Happens when homologous chromosomes fail to segregate properly during meiosis (non disjunction).

The result is a phenomenon:

- Trisomy (2n + 1), the individual has three copies of the particular chromosome, for example, trisomy 21 by a pair of chromosomes - Down's syndrome
- Monosomy (2n-1) in which the diploid individual has only one member of a certain homologous chromosome;

Geteroploidiya usually accompanied by serious hereditary anomaliyami often incompatible with life.

Klinefelter syndrome

XXY males and XXXY males have a syndrome called *Klinefelter syndrome*. These males are often actually intersexed or hermaphroditic with partially developed sexual organs of both genders. These individuals are sterile and are often subjected to hormones and surgery to bring them into conformance with social gender roles.

The 'XYY' Jacob's syndrome men

- 47, XYY ; an extra copy of the Y chromosome
- Taller than average, but typically causes no unusual physical features. Most have normal sexual development and are able to father children.
- Associated with the risk of learning disabilities and delayed development of speech and language skills. Delayed development of motor skills (such as sitting and walking), weak muscle tone (hypotonia), hand tremors or other involuntary movements (motor tics), and behavioral and emotional difficulties are also possible.
- A small percentage of males with 47,XYY syndrome are diagnosed with autistic spectrum disorders, which are developmental conditions that affect communication and social interaction.

Chromosomal mutations are changes in chromosome structure.

There are intrachromosomal and interchromosomal aberration.

I. Intrachromosomal adjustment:

Duplication - repetition chromosome region. Zygotes produced from gametes involving duplications are often viable and may or may not have any serious problems. ***Charcot-Marie-Tooth disease*** is a group of disorders passed down through families that affect the nerves outside the brain and spine. These are called the peripheral nerves.

Deletion - loss of chromosome region. Often zygotes produced by gametes involving deletions are not viable since they do not have the full compliment of genes.

Cri du Chat results from a very rare mutation caused by the loss or deletion of a significant portion of the genetic material from chromosome number five which is vital to cell growth.

Inverse - twist chromosome region 180 degrees. Inversions happen when a whole region of genes on a chromosome gets flipped around

- 2 types of inversions.
  - **paracentric** inversions the centromere is not included in the inversion.
  - **pericentric** inversions, the centromere is involved in the inversion.

II. Interchromosomal adjustment:

1. Translocation - the gap chromosome region and its connection to other non-homologous chromosome.

For example certain types of Down syndrome involve translocations between chromosome 14 and chromosome 21.

2. Transposition - gap chromosome region and joining it to another location of the same chromosome.

Gene mutation mutation is associated with changes in the nucleotide sequence of the gene.

There are two mechanisms:

1. The first mechanism involves a change in the number of nucleotides (duplications, deletions). The composition of coding triplets after space mutation changes. This leads to a change in the amino acid composition of the protein and protein synthesis with completely different properties
2. The second mechanism is the substitution of one nucleotide for another. It alters the composition of only one triplet that may to change only a single amino acid in the protein. Substitution of one amino acid is not always essential influence on the change of properties of the protein (particularly if it is close to the properties of the original).

Gene mutations play a large role in evolution. They create a reserve of genetic variation. Since most mutations recessive in the heterozygote state for a long time can not manifest itself. This is very important, since a change in environmental conditions, the mutation may be useful and save the species from extinction.

Significance of Mutations

- Most mutations are neutral (they have little or no effect)

Mutations that cause dramatic changes in protein structure or gene activity can be very harmful

- Mutations are a source of genetic variability in a species

Polyploidy - a mutation where an organism has an extra set of chromosomes

Polyploid plants are often larger and stronger

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

(UNIT 14-15)

Task 1. Complete the table

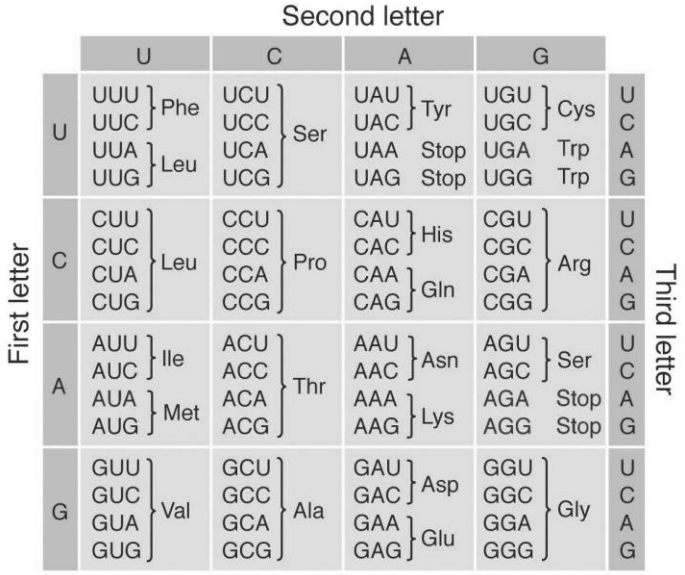
Kind of mutation	General characteristics	Importance in nature
Combinative variability		
Mutational variability		
Modification variability		

Task 2.

1. T-RNA with anticodons of the UUA, GGC, CGC, AUU, UGU participated in the biosynthesis of the polypeptide. Determine the nucleotide sequence of a portion of each strand of the DNA molecule that carries information about the synthesized polypeptide, and the number of nucleotides containing adenine (A), guanine (G), thymine (T) and cytosine (C) in the double-stranded DNA molecule. Explain the answer.
2. Molecules of tRNA with anticodons of AGC, GCC, UCA, CGA, AGA participated sequentially in the biosynthesis of a fragment of the protein molecule. Determine the amino acid sequence of the synthesized fragment of the protein molecule and the nucleotide sequence of the section of the double-stranded DNA molecule, which encodes information about the primary structure of the protein fragment. Explain the sequence of your actions. To solve the problem, use the genetic code table.
3. The tRNA molecules with the ACA, AUG, and GUA anticodons successively participated in the biosynthesis of a fragment of the protein molecule. Determine the amino acid sequence of the synthesized fragment of the protein molecule and the nucleotide sequence of the section of the double-stranded DNA molecule, which encodes information about the primary structure of the protein fragment. Explain the sequence of your actions. To solve the problem, use the genetic code table.
4. All types of RNA are synthesized on a DNA template. The fragment of the DNA molecule on which the region of the central loop of the tRNA is synthesized has the following nucleotide sequence: CTTACGGGCCATGCT. Establish the nucleotide sequence of the region of tRNA that is synthesized on this fragment, and the amino acid that this tRNA will carry in the process of protein biosynthesis, if the third triplet corresponds to the tRNA anticodon. Explain the answer. To solve the problem, use the genetic code table.
5. It is known that all types of RNA are synthesized on a DNA template. The fragment of the DNA molecule on which the region of the central loop of tRNA is synthesized has the following nucleotide sequence: TSGTTGGGCTTGGTTT. Establish the nucleotide sequence of the region of tRNA that is synthesized on this fragment, and the amino acid that this tRNA will carry in the process of protein biosynthesis, if the third triplet corresponds to the tRNA anticodon. Explain the answer. To solve the problem, use the genetic code table.
6. It is known that all types of RNA are synthesized on a DNA template. The fragment of the DNA molecule on which the region of the central loop of tRNA is synthesized has the following nucleotide sequence: TAGTGAACGGACT. Establish the nucleotide sequence of the region of tRNA synthesized on this fragment and the amino acid that this tRNA will transfer during the biosynthesis of the protein, if the third triple corresponds to the tRNA anticodon. Explain the answer. To solve the problem, use the genetic code table.
7. The DNA molecule has the following composition: G-A-T-G-A-A-T-A-G-T-G-C-T-T-C. List at least 3 consequences that may result from the random replacement of the 7th thymine nucleotide by cytosine (C).
8. The region of the DNA molecule encoding the amino acid sequence in a protein has the following composition: G-A-T-T-A-A-T-A-T-T-G-C-T-T-C. Explain the consequences of the accidental addition of the guanine nucleotide (G) between the seventh and eighth nucleotides.
9. The site of one of the two chains of the DNA molecule contains 300 nucleotides with adenine (A), 100 nucleotides with thymine (T), 150 nucleotides with guanine (G) and 200 nucleotides with cytosine (C). What is the number of nucleotides with A, T, G and C contained

in the double-stranded DNA molecule? How many amino acids must contain the protein encoded by this section of the DNA molecule? Explain the answer.

10. The region of the DNA chain encoding the primary structure of the polypeptide consists of 15 nucleotides. Determine the number of nucleotides on the mRNA encoding the amino acids, the number of amino acids in the polypeptide and the number of tRNA required to transfer these amino acids to the site of synthesis. Explain the answer.



RECOMMENDED TASKS FOR INDEPENDENT WORK

Task 1

1. Heritable variability is divided into
   a) mutational and combinative
   b) mutational and modificational
   c) phenotypic and genotypic
   d) combinative and nonhereditary
2. Modificational variability is variability, affecting
   a) only the phenotype and not affecting the genotype
   b) only the genotype and not affecting the phenotype
   c) genotype and phenotype
   d) neither genotype nor phenotype

3. Wears group character as similar changes occur in a group of individuals
   a) mutational variability
   b) modificational variability
   c) genotypic variability
   d) combinative variability

4. The boundaries of this variability is called the norm of reaction and defined genotype
   a) mutational variability
   b) modificational variability
   c) genotypic variability
   d) combinative variability

5. This variability is not related to changes in the genes, but only with their recombination in the offspring
   a) mutational variability
   b) modificational variability
   c) genotypic variability
   d) combinative variability

6. The reason of combinative variability is

a) crossing over
b) changes in genes
c) changes in chromosomes
d) modification of the phenotype

7. The changes occurring in organisms do not usually wear an adaptive character during
a) mutational variability
b) modificational variability
c) phenotypic variability
d) nonhereditary variability

8. Mutations associated with changes in the genotype are
a) lethal, half-lethal, neutral
b) genetic, chromosomal, genomic
c) somatic and generative
d) dominant and recessive

9. Genome mutations are associated
a) with a change in the structure of gene
b) with a change in the number of chromosomes in the genome
c) with a change in the structure of chromosome
d) with a loss of chromosome plot

10. There are 2 types of genome mutations
a) aneuploidy and euploidy
b) deletion and duplication
c) polyploidy and duplication
d) inversion and translocation

11. Trisomy refers to mutations
a) genetic
b) chromosomal
c) genomic
d) somatic

12. Deletion associated with
a) repetition chromosome region
b) loss of chromosome region
c) twist chromosome region 180 degrees
d) change in the number of chromosomes

13. Translocation refers to mutations
a) genetic
b) chromosomal
c) genomic
d) somatic

14. Duplication associated with
a) repetition chromosome region
b) loss of chromosome region
c) twist chromosome region 180 degrees
d) change in the number of chromosomes

15. Inverse associated with
a) repetition chromosome region
b) loss of chromosome region
c) twist chromosome region 180 degrees
d) change in the number of chromosomes

16. Change in the number of nucleotides is typical for mutation
a) gene
b) chromosomal

c) genomic
d) polyploidy

17. Somatic mutation occurs in
a) gametes
b) normal cells of the body
c) in sperm
d) the egg

18. Generative mutation occurs in
a) gametes
b) normal cells of the body
c) brain cells
d) blood cells

19. The mutations differ in their localization in the cell
a) nuclear
b) dominant
c) neutral
d) genomic

20. The mutations occurring in the DNA of mitochondria and plastids
a) nuclear
b) cytoplasmic
c) chromosomal
d) genomic

Task 2.

11. A fragment of one of the DNA strands has the sequence of nucleotides: TCGCGGAGC. Determine the mRNA nucleotide sequence and the order of amino acids in the corresponding polypeptide. How will the amino acid sequence in a polypeptide change if the second and fourth triplets of DNA are swapped? To perform the task, use the genetic code table.

12. A fragment of one of the DNA chains has the sequence of nucleotides: -ATAAGGATGCCTTTT-. Determine the nucleotide sequences in mRNA and amino acids in the polypeptide chain. What will happen in a polypeptide if a second triplet of nucleotides falls out as a result of a mutation in a gene fragment? To perform the task, use the genetic code table.

13. The DNA chain fragment has a nucleotide sequence: GGATCTAAACAT. Determine the nucleotide sequence on the second DNA strand, the mRNA, and the amino acid sequence in the fragment of the protein molecule using the table of the genetic code.

14. The DNA chain fragment has the sequence of nucleotides: GTGTGGGAAGT. Determine the nucleotide sequence for mRNA, the corresponding tRNA anticodons, and the amino acid sequence in a fragment of the protein molecule using the genetic code table.

15. The segment of the DNA molecule that determines the primary structure of the polypeptide contains the following nucleotide sequence: AATG CACG G. Determine the nucleotide sequence of mRNA, the number of tRNAs involved in peptide biosynthesis, the nucleotide composition of their anticodons and the sequence of amino acids that carry these tRNAs. To solve the problem, use the genetic code table. Explain the results.

16. The genetic apparatus of the virus is represented by an RNA molecule. A fragment of this molecule has a nucleotide sequence: GUGUAGGUCUAUCU. Determine the nucleotide sequence of a fragment of a double-stranded DNA molecule, which is synthesized as a result of reverse transcription into virus RNA. Set the nucleotide sequence in mRNA and amino acids in the fragment of the virus of the virus, which is encoded in the found fragment of DNA. The template for the synthesis of mRNA, on which the viral protein is synthesized, is the second

strand of DNA, which is complementary to the first strand of DNA found from viral RNA. To solve the problem, use the genetic code table.

17. The DNA chain fragment contains 15 nucleotides. Determine the number of nucleotides in the mRNA molecule, the number of types of tRNA molecules involved in protein synthesis, the number of amino acid residues in the protein molecule.

18. An mRNA chain fragment has the sequence of nucleotides: AUGCCAUAUCG. Determine the nucleotide sequence of the DNA fragment on which it is synthesized, the number of tRNAs required and the amino acid sequence in the fragment of the protein molecule using the table of the genetic code.

19. The mRNA chain fragment has the sequence of nucleotides: UUCCAGAUCGGC. Determine the nucleotide sequence of the DNA fragment on which it is synthesized, the number of tRNAs required and the amino acid sequence in the fragment of the protein molecule using the table of the genetic code.

20. A fragment of one of the DNA strands has the sequence of nucleotides: TCGCGGAGAC. Determine the mRNA nucleotide sequence and the order of amino acids in the corresponding polypeptide. How will the amino acid sequence in a polypeptide change if the second and fourth triplets of DNA are swapped? To perform the task, use the genetic code table.

Second letter

First letter	U	C	A	G	Third letter
U	UUU, UUC: Phe; UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr; UAA: Stop; UAG: Stop	UGU, UGC: Cys; UGA: Trp; UGG: Trp	U C A G
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His; CAA, CAG: Gln	CGU, CGC, CGA, CGG: Arg	U C A G
A	AUU, AUC: Ile; AUA, AUG: Met	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn; AAA, AAG: Lys	AGU, AGC: Ser; AGA: Stop; AGG: Stop	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp; GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G

<u>Unit 16</u>. Individual development of organisms. Format- study discussion.

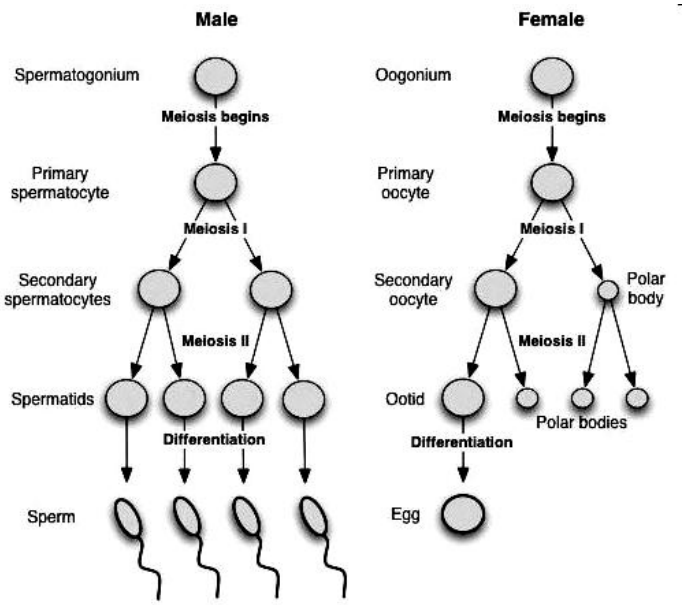
Discussion questions:

1. The concept of ontogenesis.
2. Periods of ontogenesis.
3. Gametogenesis (spermatogenesis. oogenesis).
4. Fertilization, and it stages (penetration, activation, nuclei fusion).
5. Cleavage. Yolk distribution in three kinds of egg cells.
6. The Blastula. Types of blastula.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Gametogenesis, oogonia, oocyte, spermatogonia, spermatocyte, spermatogenesis, oogenesis, blastyla, zygote, cleavage, blastomeres, coeloblastula, amphiblastula, discoblastula, blastocyst.

KEY POINTS OF THE TOPIC:
A. GAMETOGENESIS



Spermatozoa is the male reproductive cells. They are 60-70 mkm long and have a very specific shape. Each spermatozoon has a head, neck and tail.

The head of spermatozoon is of oval flattened shape. It is the most suitable shape for passage forward due to the moving of flagella. Most of the sperm's cytoplasm is eliminated during maturation, leaving only certain organelles that are modified for spermatic function. There is a special structure – acrosome (acrosomal vesicle) – at the top of spermatozoon head. It is a specifically changed Golgi apparatus, which contains enzymes hyaluronidaze and trypsin.

The neck contain a proximal centriol.

The tail consist of 3 parts; intermediate, main, end (terminal). Axial fibre is the principal component of the all tail. In the intermediate part there are many mitochondria which supply energy to him.

Each spermatozoa is able to travel long distances by whipping its tail. The tail is flagellum. Flagellum is complex structures. The major motor portion of the flagellum is called the axoneme. It is formed by microtubules emanating from the centriole at the base of the sperm nucleus. The core of the axoneme consists of two central microtubules surrounded by a row of nine doublet microtubules. Actually, only one microtubule of each doublet is complete, having 13 protofilaments; the other is C-shaped and has only 11 protofilaments. Although tubulin is the basis for the structure of the flagellum, other proteins are also critical for flagellar function. The force for spermatozoa propulsion is provided by dynein, a protein that is attached to the microtubules. Dynein hydrolyzes molecules of ATP and can convert the released chemical energy into the mechanical energy that propels the spermatozoa.

Biologic sugnificance of spermatozoa in the fertilization.

1. They give 23 "father" chromosomes.
2. The sex of future embrio depends on spermatozoon type. (x or y)
3. Give the centriol, mitochondrial DNA.

Oocyte (ovum) is female germ cell. It is the largest cell (130-150 mkm in diameter) in human body which can not move. It is covered with a few tunices. From outside they are: corona radiata (tunica granulosa), zona pellucida and ovolemma. The ovolemma is the cytolemma. Zona pellucida is a special chemical membrane which contains much glycoproteins and glycosoaminglicans. Glycoproteins presents by three types: Zp1, Zp2, Zp3. Zp3 is receptor for spermatozoa, Zp2, Zp3 prevent polysperm. The outer layer consist of numerous follicular cells

which give their processes to the ovum through the previous tunic. Their functions are protection and nutrition of the oocyte and regulation of its maturation.

Nucleus of the ovum excentrically and contains 23 chromosomes: 22 autosomes and the last one – sex chromosome (only x).

There are all the organells of a general meaning in the oocyte cytoplasm. Apparatus Goldgy is especially well developed and produces yolk inclusions.

In the peripheral layer of cytoplasm just under the plasmolemma numerous cortical granules may be seen. They take an active part in the process of fertilization.

Classification of oocytes due to the amount and location of yolk inclusions.

1. ***Alecytal oocyte*** have no inclusions (insects).
2. ***Oligolecytal oocyte*** contain litle yolk inclusions. Oligolecytal oocyte subdivided into two type oocyte: primary isolecytal and secondary isolecytal. In primary isolecytal oocytes nuclei in the center of cells, in secondary isolecytal (human oocyte) nuclei are disposed, yolk inclusions uniformly distributed in cytoplasm.
3. ***Mesolecytal oocyte*** contain the average number of yolk inclusions.
4. Fish and birds have ***polylecytal oocytes*** with great volume of yolk.

Biologic significance of oocyte in the fertilization process.

1. They give half of a necessary amount of chromosomes.
2. Supply the nutrition of embryo.

B. FERTILIZATION

There are three stages of fertilization

1. Distant interaction of gametes. Sperm and egg cells produce homones. Their joint action activates sperm and provides their movement to egg.

Capacitation means special activation of spermatozoa which occurs with them in female reproductive organs. Only after such changes they begin to move foward.

Taxis – active passage of spermatozoa. Chemotaxis (chemotropism) – toward to the oocyte, which produces special chemical substance – gamones. Rheotaxis – against the fluid flow in the uterine tube.

2. Contact interaction of gametes. This stage is characterized by the acrosomal reaction of the sperm and cortical reaction of the egg. As a result, the nucleus of sperm penetrates to the egg and the fertilization envelope which prevents the penetration of other sperm forms around the egg.

Contact stage of fertilization include penetrate of the corona radiata, penetrate of the zona pellucida , penetrate of the ovolemma, syngamy. In female this process takes place in the ampullar portion of the Fallopian (uterine) tube.

Penetrate of the corona radiata. 200-500 spermatozoa surround the egg and join into corona radiata. Due to the fact that spermatozoa tails move, the egg begins to rotate too and the corona radiata cells disperse.

Penetrate of the zona pellucida. Only one spermatozoa can penetrate of the zona pellucida. When this spermatozoa contacts with Zp3 glycoproteins of this zona, acrosomal reaction begins. Acrosomal reaction is release of acrosomal enzymes. This reaction allows spermatozoa to penetrate the zona pellucide and then to coming in contact with the plasma membrane of the oocyte.

Penetrate of the ovolemma. After adhesion, the plasma membranes of the sperm and egg is merge. The spermatozoa core, mitochondria, the part of acronema enter in the ovoplasm, but the spermatozoa plasma membrane is left behind on the oocyte surface. As soon as the spermatozoa has entered the oocyte, the egg responds by two ways:

1. Cortical reactions. The spermatozoa plasma membrane modifies of cell membrane potential (minus to plus), so that there is releasing of the Ca++ from the depot to ovoplasm. Cortical granules are released by exocytosis. As a result of the release of cortical ovocyte granules, which contain lysosomal enzymes, the ovocyte membrane becomes impenetrable to

other spermatozoa, and the zona pellucida changes its structure and composition for sperm binding and prevent penetration. These reactions prevent polyspermy (penetration of more than one spermatozoon into the oocyte). The zona pellucide becames fertilization tunica. The space between the ovolemma and tunica of fertilisation is perivitellin space, in which storaged water.

2. Resumption of the second meiotic division. The oocyte finishes its second meiotic division immediately after entry of the spermatozoon. One of the daughter cells, which receives hardly any cytoplasm, is known as the second polar body; the other daughter cell is the definitive oocyte. Its chromosomes (22 + X) arrange themselves in a vesicular nucleus known as the female pronucleus.

3. Formation synkaryon (*Syngamy).* The nuclei of the sperm and egg unite and form a diploid zygote.

Syngamy – the process of nuclear fusion. The spermatozoa core (male pronucleus) unit with female pronucleus. At the moment of their fusion such unicellular organism is named "synkarion". As the result a zygote is formed, which consists of 46 chromosomes.

C. CLEAVAGE

Cleavage (fissio) is the next process after fertilization – special mitotic division without growth of daughter cells. As a result multicellular organism - "blastula" - is developing. Blastula consists of: a wall - blastoderm consisting of individual cells - blastomeres and the cavity - blastocoel.

The pattern of cleavage is influenced by two factors:. the amount of yolk and the formation of mitotic spindles

Cleavage process directly depends on the type of oocyte, his yolk inclusions volume and disposition.

Cleavage can be:
complete (holoblastic)
incomplete (meroblastic).
Holoblastic cleavage can be:

a) uniform (if all blastomeres of equal size) and uneven (blastomeres of different sizes);
b) synchronous (blastomeres divided at the same time) and asynchronous.

Meroblastic cleavage can be superficial and discoidal.

- Yolk is the nutrient material stored in an egg. Yolk impedes the formation of a cleavage furrow.

In embryos with little or no yolk, all daughter cells tend to be of similar size, as in the sea urchin.

- When yolk quantity is larger, asymmetry of cell size is observed.

In the frog egg, the vegetal hemisphere ends up with fewer but larger cells than the animal hemisphere. Frogs have complete cleavage.

- In eggs with a lot of yolk, such as the chicken egg, cleavage is incomplete.

The cleavage furrows do not penetrate the yolk. The embryo forms a disc of cells, called the blastodisc, on top of the yolk. This type of incomplete cleavage is called discoidal cleavage and is common in birds, reptiles, and fish.

Orientation of the mitotic spindles determine the cleavage planes and arrangements of daughter cells.

- If the mitotic spindles form at right angles or parallel to the animal-vegetal axis, aradial cleavage pattern results.
- If the mitotic spindles are at oblique angles to the animal-vegetal axis, the pattern has a twist, and is called spiral cleavage.
- In mammals, the first cell division is parallel to the animal-vegetal axis and the second cell division occurs at right angles.

This pattern of cleaves is referred to as rotational cleavage and is unique to mammals. Cleavage in mammals is slow, with divisions occurring 12 to 24 hours apart. The cell divisions

are not synchronous, so the number of cells in the embryo does not follow the regular progression (2, 4, 8,16, 32, etc.) typical of other species.

Unlike other animals, gene expression plays a role during mammalian cleavage.

At the 8-cell stage of a mammal embryo, the cells form tight junctions and a compact mass. At the transition from the 16-cell to 32-cell stage, the cells separate into two masses. The inner cell mass develops into the embryo; the outer cells become the trophoblast, which becomes part of the placenta. The trophoblast cells secrete fluid which forms the blastocoel. The embryo is called a blastocyst.

Fertilization in mammals occurs in the upper oviduct; cleavage occurs as the zygote travels down the oviduct.

When the blastocyst arrives in the uterus, the trophoblast adheres to the uterine wall (the endometrium), which begins the process of implantation.

Early implantation in the oviduct wall is prevented by the zona pellucida.

In the uterus, the blastocyst hatches out of the zona pellucida, and implantation can occur.

In all animals, cleavage results in the repackaging of the egg cytoplasm into the cells of the blastula. The cells get different amounts of nutrients and cytoplasmic determinants.

In the next stage, the cells of the blastula begin to move and differentiate.

The cells can be labeled with dyes to determine what tissues and organs develop from each. Fate maps of the blastula are the result.

Blastomeres become determined, or committed to a specific fate, at different times in different animals.

Roundworm and clam blastomeres are already determined at the 8-cell stage.

If one cell is removed, a portion of the-embryo fails to develop normally. This is called mosaic development.

Other animals have regulative development. If some cells are lost during cleavage, other cells can compensate.

If blastomeres are separated in an early stage, two embryos can result.

Since the two embryos came from the same zygote, they are monozygotic twins, or genetically identic identical twins.

Non-identical twins are the result of two separate eggs fertilized by two separate sperm and are not genetically identical.

Unit 17. Embryonic development of organisms. Format-practical's.

Discussion questions:

1. Gastrulation, modes early and late gastrulation.
2. The Gastrula, germ layers: ectoderm, mesoderm, and endoderm.
3. Neurulation.
4. Organogenesis.
5. Extraembryonic organs (amniotic membrane, chorion, yolk sac, allantois, placenta): structure and physiological importance.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Gastrulation, gastrula, ectoderm, mesoderm, endoderm, neurulation, organogenesis, extraembryonic organs, amniotic membrane, chorion, yolk sac, allantois, placenta.

KEY POINTS OF THE TOPIC:

A. GASTRULATION

Gastrulation is the process in which a blastula is transformed into an embryo with three tissue layers and body axes.

During gastrulation, three germ layer form:

- the inner germ layer is the endoderm and gives rise to the digestive tract, circulatory tract, and respiratory tract.
- the outer germ layer is the ectoderm and gives rise to the epidermis and nervous system.
- the middle germ layer, the mesoderm, contributes to formation of bone, muscle, heart and blood vessels.

Ways of early gastrulation:

Invagination - blastoderm located on the vegetal pole inside blastocoel and forming the inner layer - the endoderm and the outer layer - the ectoderm.

Epiboly - micromers of animal pole of blastula divide faster macromers of vegetal pole and overgrown them, forming ectoderm.

Immigration - some blastomers of the blastula migrate into the cavity and form the endoderm.

Delamination - blastoderm stratified into two pieces: the inner - endoderm and the outer - ectoderm.

Mammal eggs have no yolk. The inner cell mass of the blastocyst splits into an epiblast and hypoblast with a fluid-filled cavitj in between.

The embryo forms from the epiblast; the extraembryonic membranes form from the hypoblast. The epiblast also splits off a layer of cells that form the amnion. The amnion grows around the developing embryo. Gastrulation is similar to that in birds; a primitive groove forms and cells migrate through it to become endoderm and mesoderm.

B. NEURULATION: INITIATING THE NERVOUS SYSTEM

Gastrulation produces an embryo with three germ layers.

Organogenesis occurs next and involves the formation of organs and organ systems.

Neurulation occurs early in organogenesis and begins the formation of the nervous system in vertebrates.

The first cells to pass over the dorsal lip become the endodermal lining of the digestive tract. The second group of cells become mesoderm. The dorsal mesoderm closest to the midline (chordomesoderm) becomes the notochord. The notochord is connective tissue and is eventually replaced by the vetebfal column. The chordomesoderm induces the overlying ectoderm to begin forming the nervous system.

Neurulation begins with thickening of the ectoderm above the notochord to form the neural plate. Edges of the neural plate thicken to form ridges. Between the ridges a grove forms and deepens. The ridges fuse, forming a cylinder—the neural tube. The anterior end of the neural tube becomes the brain.

In humans, failure of the neural tube to close completely at the posterior end results in spina bifida. If the tube fails to close at the anterior end, the result is anencephaly, in which the forebrain does not develop. Neural tube defects can be reduced if pregnant women receive adequate folic acid (a B vitamin).

Body segmentation develops during neurulation. Blocks of mesoderm called somites form on both sides of the neural tube. Somites produce cells that form the vertebrae, ribs, and muscles of the trunk and limbs. They also guide the organization of the peripheral nerves.

When the neural tube closes, cells called neural crest cells break loose; they migrate inward between the epidermis and the somites and under the somites.

The neural crest cells give rise to many structures and organs of the body.

C. EXTRAEMBRYONIC MEMBRANES

Extraembryonic membranes originate from the germ layers of the embryo and function in nutrition, gas exchange, and waste removal.

In the chicken, the yolk sac is the first to form, by extension of the endodermal tissue of the hypoblast. It constricts at the top to create a tube that is continuous with the gut of the embryo.

Yolk is digested by the endodermal cells of the yolk sac, and the nutrients are transported through blood vessels lining the outer surface of the yolk sac.

The allantoic membrane, an outgrowth of the extraembryonic ectoderm, forms the allantois, a sac for storage of metabolic wastes.

Ectoderm and mesoderm combine and extend beyond the embryo to form the amnion and the chorion. The amnion surrounds the embryo, forminc a cavity. The amnion secretes fluid into the cavity that provides protection for the embryo. The chorion form a continous membrane just under the eggshell. It limits water loss.

In mammals, the first extraembryonic membrane to form is the trophoblast. When the blastocyst hatches from the zona pellucida, the trophoblast cells attach to the uterine wall, This is the beginning of implantation. The trophoblast becomes part of the uterine wall, and sends out villi to increase surface area and contact with maternal blood.

The hypoblast cells extend to form the chorion. The chorion and other tissues produce the placenta. The epiblast produces the amnion. Allantoic tissues from the umbilical cord.

Cells from the embryo that are in the amniotic fluid can be sampled and tested for efects. The test is called amniocentesis.

Problems such as Down syndrome, cystic fibrosis, and Tay Sachs disease can be detected using this technique.

A newer technique is chorionic villus sampling which makes earlier detection possible.

D. HUMAN DEVELOPMENT

The events of human gestation (pregnancy) are divided into three trimesters. The first trimester begins with fertilization. Implantation takes place 6 days later.

Then gastrulation takes place, the placenta forms, and tissues and organs begin to form. The heart first beats at 4 weeks and limbs form at 8 weeks. The embryo is particularly vulnerable to radiation, drugs, and chemicals during the first trimester. Hormonal changes can cause major responses in the mother, including morning sickness.

During the second trimester the fetus grows rapidly to about 600g. Fingers, toes, and facial features become well formed. Fetal movements are first felt by the mother early in the second trimester. By the end of the second trimester, the fetus may suck its thumb.

The fetus and the mother continue to grow during the third trimester. Throughout the third trimester, the fetus remains susceptible to environmental factors such as malnutrition, alcohol consumption, and cigarette smoking. Kidneys produce urine, the liver stores glycogen, and the brain undergoes cycles of sleep and waking.

Development does not end at birth. The organization of the nervous system exhibits a great deal of plasticity in the early years, as patterns of connections between neurons develop. For example, a child born with misaligned eyes will use mostly one eye. The connections to the brain from this eye will become stronger, while the connections to the other eye will become weak. This can be changed if the alignment is corrected within the first three years. A current area of research into this developmental plasticity in the nervous system examines the role of learning in stimulating the production and differentiation of new neurons in the brain.

Unit 18. Regularities and mechanisms of ontogenesis. Format-practical's.

Discussion questions:

1. Differentiation in development.
2. Stages and factors of differentiation.
3. The mechanisms of ontogenesis.
4. Embryonic induction as a mechanism of ontogenesis.
5. The regeneration of organs and tissues as a process of development.

6. The physiological and reparative regeneration.
7. Methods of reparative regeneration.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Differentiation, cell adhesion, embryonic induction, responsive system, competent tissue, regeneration, morpholaxis, epigenesis, hypertrophy.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

(UNIT16-18)

1. Blastula consists of:
a) blastoderm and blastocoel
b) head, body, tail
c) blastoderm and blastopore
d) ectoderm and endoderm
2. Cleavage is special mitotic division of
a) gastrula without growth of daughter cells
b) zygote without growth of daughter cells
c) zygote with growth of daughter cells
d) neurula without growth of daughter cells
3. Ways of early gastrulation
a) fertilization, epiboly, immigration, delamination
b) invagination, epiboly, immigration, delamination
c) fertilization, epiboly, gametogenesis, delamination
d) gametogenesis, epiboly, immigration, delamination
4. Micromers of animal pole of blastula divide faster macromers of vegetal pole and overgrown them, forming ectoderm during
a) invagination,
b) epiboly,
c) immigration,
d) delamination
5. Blastoderm stratified into two pieces: the inner - endoderm and the outer – ectoderm during
a) invagination,
b) epiboly,
c) immigration,
d) delamination
6. Blastoderm located on the vegetal pole inside blastocoel and forming the inner layer - the endoderm and the outer layer - the ectoderm during
a) invagination,
b) epiboly,
c) immigration,
d) delamination
7. Some blastomers of the blastula migrate into the cavity and form the endoderm during
a) invagination,
b) epiboly,
c) immigration,
d) delamination
8. Ectoderm leads to the formation of
a) nervous system,
b) circulatory system,
c) digestive system,

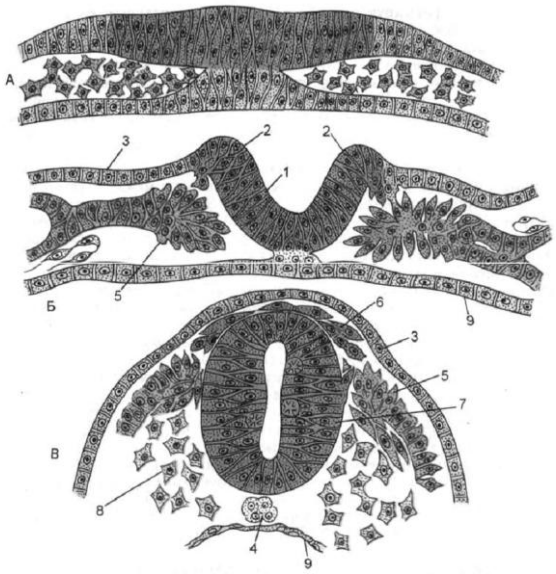
d) muscular system
9. Entoderm leads to the formation of
a) nervous system,
b) circulatory system,
c) digestive system,
d) muscular system
10. Mesoderm leads to the formation of
a) nervous system,
b) respiratory system,
c) digestive system,
d) muscular system
11. The chorion is formed from
a) only ectoderm
b) ectoderm, mesoderm
c) mesoderm and entoderm
d) only entoderm
12. The amnion is formed from
a) only ectoderm
b) ectoderm, mesoderm
c) mesoderm and entoderm
d) only entoderm
13. The allantois is formed from
a) only ectoderm
b) ectoderm, mesoderm
c) mesoderm and entoderm
d) only entoderm

RECOMMENDED TASKS FOR INDEPENDENT WORK

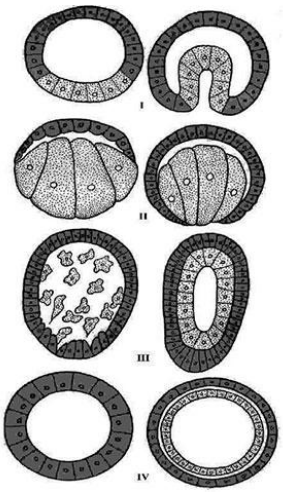
(UNIT16-18)

Task 1.

Describe the process shown in the figure. What is indicated by the numbers 1-9?



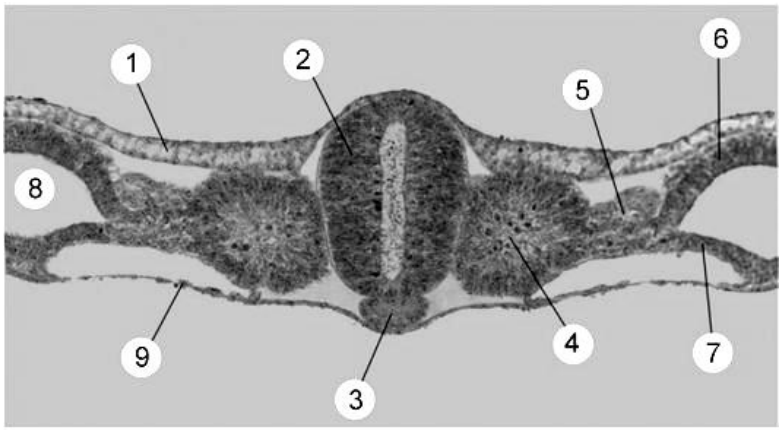
Task 2. Describe the methods of gastrulation, indicated by the numbers I-IV.



Task 3. What are the terms: zygote, cleavage, blastula, gastrula, ectoderm, endoderm, neurula

Task 4.

Describe which structures of the embryo are indicated by the numbers 1-9.



Task 5.

1. During spermatogenesis in stage of growth cells called
a) spermatogonia
b) primary spermatocytes
c) secondary spermatocytes
d) spermatids
2. During spermatogenesis in stage of reproduction cells called
a) spermatogonia
b) primary spermatocytes
c) secondary spermatocytes
d) spermatids
3. During oogenesis in stage of growth cells called
a) oogonia
b) primary oocyte
c) polar bodies
d) secondary oocyte
4. In stage of maturation during first meiosis primary oocyte is divided into two cells:
a) oogonia and primary oocyte

b) primary oocyte and secondary oocyte
c) primary oocyte and polar bodies
d) secondary oocyte and polar bodies

5. In stage of maturation during second meiosis secondary spermatocyte is divided into two cells:

a) two spermatogonia
b) two primary spermatocytes
c) two sperm
d) two spermatids

6. The acrosomal reaction of the sperm occurs during stage of

a) gametogenesis
b) contact interaction of gametes
c) distant interaction of gametes
d) formation synkaryon

7. Each spermatozoon has

a) head, body, tail
b) head, body, leg
c) neck, body, tail
d) head, neck, tail

8. Nucleus of the ovum contains 23 chromosomes:

a) 22 autosomes and the last one – sex chromosome (only y).
b) 22 autosomes and the last one – sex chromosome (only x).
c) 21 autosomes and two – sex chromosome (xx).
d) 21 autosomes and two – sex chromosome (xy).

9. Oligolecytal oocyte

a) contain moderate yolk inclusions
b) contain great volume of yolk
c) not contain egg yolk
d) contain a lot of carbohydrates

10. The embryo is formed by the cleavage

a) blastula
b) gastrula
c) neurula
d) zygote

11. The embryo is formed by the gastrulation

a) blastula
b) gastrula
c) neurula
d) zygote

12. The embryo is formed by the fertilization

a) blastula
b) gastrula
c) neurula
d) zygote

Section 3. Population-specific level of organization of the living systems. Biogeocoenotic and biosphere levels of organization of the biological systems.

Unit 19. Evolution. Format-practical's.

Discussion questions:

1. Pre-Darwinian evolutionary ideas the period of formation.
2. J.-B. Lamarck´s theory of evolution.
3. The main provisions of the theory of evolution of the Charles Darwin.
4. Modern (synthesis) theory of evolution. Factors of evolution.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Evolution, evolutionary factors, population waves, natural selection, the struggle for existence, gene drift, isolation, speciation, binary nomenclature, biological progress, biological regression, aromorphosis, idioadaptation.

KEY POINTS OF THE TOPIC:

Jean-Baptiste Lamarck first proposed the idea of evolution in nature.

He wrote the book "Philosophy of Zoology". Lamarck is the creator of the theory of gradation. He identified 14 classes of animals and placed them on the six steps - gradations. He arranged the most primitive organisms on the bottom step, and the most multi-structured organisms are placed on a high level.

Reasons, causes the body to evolve, it is their desire for self-improvement, given to them by God, on the one hand, and the impact of the environment on the other hand.

Lamarck established two laws:- The law of use and disuse of organs: organs that are used, developed, and those that are not used by the body are reduced. - The law of obligatory inheritance of useful features.

Recognizing that organisms are constantly evolving, Lamarck believed that species as a real groups in nature do not exist. The chain of variable organisms only really exists.

Lamarck Doctrine contributed to the emergence of Darwin's theory.

Evolutionary theory of Charles Darwin.

Main provisions:

1. Living organisms are able to evolve, that is, they are able to progress from simple to complex.
2. Prerequisite for the evolution is a genetic variation. It creates the genetic diversity of the offspring, thereby giving the material for natural selection.
3. Darwin releases hereditary and non-hereditary variation. He noted hereditary variation plays a most important role in evolution.
4. Darwin speaks about the struggle for existence between organisms. The struggle for existence is any relationship between living organisms and between living organisms and their habitats.
5. Darwin distinguishes three types of struggle for existence: intraspecific struggle (the struggle between individuals of the same species - for example, males fight for females), interspecies struggle (the struggle between individuals of different species) struggle with adverse environmental conditions.
6. The reason for the struggle for existence is a contradiction between the pursuit of organisms to reproduce in geometric progression, and the scarcity of natural resources: food, territory and others.
7. The struggle for existence is a process that leads to natural selection. Natural selection is survival of the fittest, i.e. individuals capable of giving fertile offspring.
8. Natural selection selecting the fittest individuals to these environmental conditions may lead to the formation of new species.

9. The result is an evolution:
   - the development of adaptations to the environment
   - the appearance of diversity of species in nature
   - the extinction of species unsuited to new environmental conditions
   - morphophysiological progress as a complication of internal organization of living organisms.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Answer the questions

1. Who is the author of the theory of gradation?
2. Who first proposed the idea of natural selection?
3. What is the premise of evolution?
4. What is the reason for the changes in living organisms on the views of Lamarck and Darwin respectively?
5. What is the essence of the law of use and disuse of organs?
6. Who wrote the book "Philosophy of Zoology"?
7. What scientists believed that species of living organisms do not really exist and why?

RECOMMENDED TASKS FOR INDEPENDENT WORK

Answer the questions

1. What is a "struggle for existence" in Darwin's opinion?
2. What kind of struggle for survival has Darwin allocated?
3. What is natural selection?
4. What is the cause of the struggle for existence?
5. What is the result of evolution?

Unit 20. The notion of biological species. Format-practical's.

Discussion questions:

1. Microevolution.
2. Macroevolution.
3. Modes of speciation.
4. The species. Criteria for the species.
5. The main directions of evolution (biological progress and regression).
6. Ways to achieve of biological progress (aromorphosis, idioadaptation, total degeneration) and its forms.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Evolution, evolutionary factors, population waves, natural selection, the struggle for existence, gene drift, isolation, speciation, binary nomenclature, biological progress, biological regression, aromorphosis, idioadaptation.

Unit 21. Anthropogenesis. Format-practical's.

Discussion questions:

1. The position of Homo sapiens in the animal world.
2. The qualitative uniqueness of the person.
3. Biological and social factors of anthropogenesis.
4. The role of biological factors of the anthropogenesis at the present stage.
5. Human races and the unity of the human species.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Evolution, evolutionary factors, population waves, natural selection, the struggle for existence, gene drift, isolation, speciation, binary nomenclature, biological progress, biological regression, aromorphosis, idioadaptation, social factors of anthropogenesis, biological factors of anthropogenesis.

Unit 22. Ecology. Format-practical's.

Discussion questions:

1. Environmental factors: classification and general patterns of action of the environmental factors on a organism.
2. The concept of trophyc levels.
3. The rule of the ecological pyramid.
4. The biosphere.
5. Biogeochemical cycles.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Decomposers, trophic levels, producers, consumers, reducers, autotrophs, heterotrophs, biosphere, the cycle of substances, ecological pyramid

KEY POINTS OF THE TOPIC

The trophic level of an organism is the position it occupies in a food chain. A food chain is a succession of organisms that eat other organisms and may, in turn, be eaten themselves. The trophic level of an organism is the number of steps it is from the start of the chain. A food chain starts at trophic level 1 with primary producers such as plants, can move to herbivores at level 2, carnivores at level 3 or higher, and typically finish with apex predators at level 4 or 5. The path along the chain can form either a one-way flow or a food "web". Ecological communities with higher biodiversity form more complex trophic paths.

The word *trophic* derives from the Greek τροφή (trophē) referring to food or nourishment.

The three basic ways in which organisms get food are as producers, consumers and decomposers.

- **Producers (**autotrophs) are typically plants or algae. Plants and algae do not usually eat other organisms, but pull nutrients from the soil or the ocean and manufacture their own food using photosynthesis. For this reason, they are called primary producers. In this way, it is energy from the sun that usually powers the base of the food chain.[4] An exception occurs in deep-sea hydrothermal ecosystems, where there is no sunlight. Here primary producers manufacture food through a process called chemosynthesis.[5]
- **Consumers** (heterotrophs) are species that cannot manufacture their own food and need to consume other organisms. Animals that eat primary producers (like plants) are called herbivores. Animals that eat other animals are called carnivores, and animals that eat both plant and other animals are called omnivores.
- **Decomposers** (detritivores) break down dead plant and animal material and wastes and release it again as energy and nutrients into the ecosystem for recycling. Decomposers, such as bacteria and fungi (mushrooms), feed on waste and dead matter, converting it into inorganic chemicals that can be recycled as mineral nutrients for plants to use again.

Trophic levels can be represented by numbers, starting at level 1 with plants. Further trophic levels are numbered subsequently according to how far the organism is along the food chain.

- Level 1: Plants and algae make their own food and are called producers.
- Level 2: Herbivores eat plants and are called primary consumers.
- Level 3: Carnivores that eat herbivores are called secondary consumers.
- Level 4: Carnivores that eat other carnivores are called tertiary consumers.

In general, each trophic level relates to the one below it by absorbing some of the energy it consumes, and in this way can be regarded as resting on, or supported by, the next lower trophic level. Food chains can be diagrammed to illustrate the amount of energy that moves from one feeding level to the next in a food chain. This is called an energy pyramid. The energy transferred between levels can also be thought of as approximating to a transfer in biomass, so energy pyramids can also be viewed as biomass pyramids, picturing the amount of biomass that results at higher levels from biomass consumed at lower levels. However, when primary producers grow rapidly and are consumed rapidly, the biomass at any one moment may be low; for example, phytoplankton (producer) biomass can be low compared to the zooplankton (consumer) biomass in the same area of ocean.[12]

The efficiency with which energy or biomass is transferred from one trophic level to the next is called the ecological efficiency. Consumers at each level convert on average only about 10% of the chemical energy in their food to their own organic tissue (the ten-percent law). For this reason, food chains rarely extend for more than 5 or 6 levels. At the lowest trophic level (the bottom of the food chain), plants convert about 1% of the sunlight they receive into chemical energy. It follows from this that the total energy originally present in the incident sunlight that is finally embodied in a tertiary consumer is about 0.001%

Unit 23. Parasitology. Protists. Class Sarcodina. Format-practical's.

Discussion questions:

1. Parasitism as an ecological phenomenon.
2. Classification of animal parasitic forms.
3. Ways of origin of the various groups of parasites.
4. Interaction between parasite and host-level individuals.
5. Factors of the action of parasite on the host organism.
6. Factors action hostess on the parasite.
7. Morphophysiological adaptation to a parasitic lifestyle.
8. Population level of interaction of the parasites and their hosts.
9. The life cycles of parasites. Intermediate and major host. Vector-borne and natural focal, parasitic and infectious diseases.
10. Ecological principles to combat parasitic diseases.
11. General characteristics of the class Sarcodina.
12. Morphophysiology and the life cycle of Entamoeba histolytica. Diagnosis and prevention of amebiasis.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Obligatory parasites, facultative parasites, accidental parasites, temporary parasite, periodic parasite, specific parasite, definitive host, intermediate host, vector.

KEY POINTS OF THE TOPIC

Types of parasites:

1. Obligatory parasites are those parasites that cannot exist without a host e.g. Malaria.

2. Facultative parasites are those parasites that are able to exist in soil and water independently of their host, when the environmental conditions are suitable leading a free living life e.g. *Strongyloides stercoralis*.

3. Accidental parasites are those parasites which enter accidentally and can live in a host different from their normal one e.g. *Dipylidium caninum, Hymenlepis dimenuta*.

4. Temporary parasite is an occasional parasite, it only visits its host for blood meals (e.g. blood-sucking insect as mosquitoes, sand flies and tsetse flies).

5. Periodic parasite passes a definite part of its life cycle as a parasite (e.g. *Cordylobia hominis, Hypoderma bovis*).

6. Specific parasite occurs in a particular host, i.e. there is a specificity in the host parasite relationship (e.g. *Trichinella spiralis* and *Taenia solium* are specific for pigs).

Parasites can also be divided according to their habitat into endoparasites which live inside their host e.g. Ancylostoma worms, and ectoparasites which are found attached to the skin of their host or its superficial tissue e.g. Pediculus.

Types of hosts:

1. Definitive host: Is the host in which the adult stage of the parasite lives or in which sexual reproduction takes place e.g. man is definitive host for *Ascaris, Anopheles pharoensis* for *Plasmodium* sp. parasites and pigs for *Taenia solium*.

2. Intermediate host: Harbours the larval (immature stages) or asexual stages of a parasite (e.g. *Culex* mosquito is an intermediate host for *Wuchereria bancrofti, Pirenella conica* is the intermediate host for *Heterophyes heterophyes, Biomphalarie* sp. for intestinal Bilaharziasis … etc.).

However the parasite may pass its larval stages in two intermediate hosts;

a) first (Primary) intermediate host which harbours the first immature stages of the parasite (e.g. *Prinella conica* for Heterophyes);

b) while the second (Transporting) intermediate host harbours the second immature stages of the same parasite, after leaving the first intermediate host.

This second host carries the parasite to man (e.g. *Mugil cephala* and *Tilapia nilotica*).

Vector is a host that transmits parasites from one host to another. Vector are usually arthropods e.g. Anopheles mosquitoes are vectors of malaria. They transmit the disease from one man to another through their bite.

- A mechanical vectors: If the transmitter is not essential in the life cycle.
- A biological vector: If the transmitter is essential in the life cycle.

Points of practical value when studying parasitology:

I. Mode of infection by the parasite

Mode of infection: means the portal of entry of the parasite into the body and this may occur from one or more of the following routes of entry:

1) Infection by mouth, through ingested contaminated water or food:

a. Infection by drinking water containing the infective stage, examples: Intestinal amoebas and flagellates, and cercaria of schistosomes through swimming or contact contaminated water.

b. Infection by ingesting food containing the mature egg or larval stage- examples: *Ascaris lumbricoides, Trichuris trichiura, Enterobius vermicularis, Taenia solium, T. saginata, Trichinella spiralis, Diphyllobothrium latum*, intestinal flukes, and liver flukes.

2) Zoonosis is the term given to the disease of animals which are transmissible to man ex: arthropods: blood sucking arthropods transmit filaria.

II. Portal of exit

For the continuation of the life cycle of the parasite it must have a portal of exit from its host and this can occur via:

1) Faeces: as eggs of most Helminthes and cysts of intestinal protozoa.

2) Urine: as eggs of *Schistosoma haematobium.*

3) Sputum: as eggs of lung flukes.

4) Blood: as Malaria and Trypanosomes.

5) Genital tract: as *Trichomonas vaginalis trophozoites*.

III. The life cycle of the parasite

In other words its route of migration inside the human or the insect body is important. Some parasites, undergo a certain cycle inside the human body as *Ancylostoma, Strongyloides* and *Ascaris*, while other restrict their development in the intestine as *Enterobius* and *Trichuris*. In the insect host the parasite may undergo a cycle in the insect body, e.g. *Malaria* and

Wuchereria and others do not as those which are transmitted by direct or indirect mechanical means.

IV. The infective stage

This may be can

- egg as Enterobius, Ascaris, Trichuris, Hymenolepis,
- a larva as Ancylostoma,
- a cercaria as Schistosoma,
- a cyst as *Entamoeba histolytica* and intestinal protozoa or
- a cysticercus as *C. Celluosae* and *C. bovis*.

V. Pathogenesis of parasitic infection

The way parasites damage their hosts occurs through different mechanisms including the following:

1. Mechanical: the parasite may obstruct a normal passage e.g. *Ascaris lumbricoides* may cause intestinal obstruction or bile duct obstruction, *Enterobius vermicularis* may cause appendicitis.

2. Traumatic: when the parasite invades the skin as in scabies or myiasis. Internal damage can also occur as in hookworms, which attach themselves by their buccal capsule to the intestinal mucosa producing ulcers.

3. Toxic: circulation of certain toxic byproducts of parasites produces generalized manifestations as in hookworms producing butterfly pigmentation of the face. Also, in *Hymenolepis nana* and *Ascaris lumbricoides* infection nervous manifestations appear. Scorpion stings produce severe toxicity in man.

4. Necrosis: enzymes elaborated by the parasite produce necrosis of tissue as in *Entamoeba histoytica*.

5. Stimulation of the host immune response: parasitic antigens stimulate both a cellular and humoral immune response provoking tissue reactions consisting of cellular proliferation and infiltration at the site of parasite antigens, or deposition of circulating immune complex in the tissues e.g. *Schistosomal granuloma* and *Plasmodium malaria* nephrosis.

6. Cellular destruction: destruction of red blood corpuscles occurs in malaria, reticuloendothelial cells in *Leishmania donovani* and other tissue cells in Trypanosoma cruzi.

7. Allergic manifestations: allergic reactions occur with insect bites.

8. Neoplastic formation: parasitic infections may contributed to tumour formation. *Schistosoma haematobium* can cause cancer bladder.

VI. The symptomatology

The symptomatology of the disease usually runs parallel with the pathological changes caused by the invading parasite.

VII. Diagnosis of parasitic infections

The diagnosis of parasitic infections has two method, of approach. Clinical and laboratory.

1. Clinical diagnosis:

Depends on the characteristic signs and symptoms related to the parasitic infection, e.g. Nocturnal perianal itching is suggestive of infection with *Entrobius vermicularis*.

2. Laboratory diagnosis can be achieved by:

a) Direct methods: which can detect the diagnostic stages of the parasite by microscopical examination of the excreta, blood, tissues or smears. Culture and animal inoculations can help in diagnosis of some parasitic infections.

d) Indirect methods: These methods on the detection of antigens or antibodies in the patients' serum. Indirect methods of diagnosis are mainly resorted to when parasites are present in tissues, e.g. Toxoplasma gondii, or in cases of closed chronic infection e.g. Schistosoma mansoni when no eggs can be detected in the faeces.

c) Molecular biological methods: These include DNA probes and the polymerase chain reaction (PCR).

VIII. The therapy and control measures

Concerning the therapy and control measures, here it may be said that an ideal drug is that which kills the parasite properly within the limits of tolerance of the patient. It then follow, that adequate information about the specific drug, its toxicity and contra-indications must be always borne in mind.

Concerning the methods of control or eradication of the parasite within a community, here one has to follow two ways:

1. The first: is that which kills the parasite in man by internal medication.

2. The other way: is that which attacks the parasite in the arthropod hosts or the reservoir. We have to know every detail about the bionomics of the insect host, and the surrounding climatic conditions so as to reach to a proper and adequate control, e.g. Malaria control.

IX. Prognosis

Lastly prognosis of the disease or its accurate history, paves the way in front of the physician to estimate with considerable accuracy the probability of rapid or prolonged recovery or fatal end.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

Fill in the gaps in the sentences

1. Parasites that cannot exist without a host are called _____.
2. Parasites that are able to exist in soil and water, regardless of the host under favorable environmental conditions are called _____.
3. Parasites which enter accidentally and can live in a host different from their normal one are called _____.
4. Parasite which only visits its host for food is called _____.
5. Parasite which passes only a definite part of its life cycle as a parasite is called _____.
6. Parasites which are found attached to the skin of their host or its superficial tissue are called _____.
7. The organism, in which the adult stage of the parasite lives or where sexual reproduction takes place is called _____.
8. The organism, in which occur the larval stage of the parasite and its asexual reproduction is called _____.
9. The host in which the parasite does not undergo any development but in which it remains alive in the larval stage and can be infective to another host is called _____.
10. The organism is able to accumulate a parasite as reservoir in addition to the main host is called _____.

RECOMMENDED TASKS FOR INDEPENDENT WORK

Properly connect the type of action of the parasite with the characteristic action

Pathogenesis of parasitic infection

Type of parasite action	Characteristics of the parasite action
Mechanical	Destruction of red blood corpuscles occurs in malaria, reticuloendothelial cells in *Leishmania donovani* and other tissue cells in Trypanosoma cruzi
Traumatic	Allergic reactions occur with insect bites
Toxic	The parasite may obstruct a normal passage e.g. *Ascaris lumbricoides* may cause intestinal obstruction or bile duct obstruction, *Enterobius vermicularis* may cause appendicitis
Necrosis	Parasitic infections may contributed to tumour

	formation. *Schistosoma haematobium* can cause cancer bladder
Stimulation of the host immune response	Parasitic antigens stimulate both a cellular and humoral immune response provoking tissue reactions consisting of cellular proliferation and infiltration at the site of parasite antigens, or deposition of circulating immune complex in the tissues
Cellular destruction	Enzymes elaborated by the parasite produce necrosis of tissue as in *Entamoeba histoytica*
Allergic manifestations	Circulation of certain toxic byproducts of parasites produces generalized manifestations as in hookworms producing butterfly pigmentation of the face
Neoplastic formation	When the parasite invades the skin as in scabies or myiasis. Internal damage can also occur as in hookworms, which attach themselves by their buccal capsule to the intestinal mucosa producing ulcers

Unit 24. Protists. Class Zoomastigophora. Format- study discussion.

Discussion questions:

1. General characteristics of the class Zoomastigophora.
2. The life cycle of pathogens, pathogenesis, diagnosis and prevention of Trichomonas vaginalis.
3. The life cycle of pathogens, pathogenesis, diagnosis and prevention of leishmaniasis, trypanosomiasis and giardiasis.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Obligatory parasites, facultative parasites, accidental parasites, temporary parasite, periodic parasite, specific parasite, definitive host, intermediate host, vector.

KEY POINTS OF THE TOPIC:

Giardia lamblia

Important features – the life cycle consists of two stages, the trophozoite and cyst. The rophozoite is 9-12 μm long and 5-15μm wide anteriorly. It is bilaterally symmetrical, pear-shaped with two nuclei (large central karyosome), four pairs of flagella, two axonemes, and a suction disc with which it attaches to the intestinal wall. The oval cyst is 8-12 μm long and 7-10 μm wide, thick-walled with four nucleus and several internal fibera? Each cyst gives rise to two trophozoites during excystation in the intestinal tract. Transmission is by ingestion of the infective cyst.

Pathogenesis

Infection with *G. lamblia* is initiated by ingestion of cysts. Gastric acid stimulates excystation, with the release of trophozoites in duodenum and jejunum. The trophozoites can attach to the intestinal villi by the ventral sucking discs without penetration of the mucosa lining, but they only feed on the mucous secretions. In symptomatic patients, however, mucosa-lining irritation may cause increased mucous secretion and dehydration. Metastatic spread of disease beyond the GIT is very rare.

Epidemiology

Giardia lamblia has a worldwide distribution, particularly common in the tropics and subtropics. It is acquired through the consumption of inadequately treated contaminated water, ingestion of contaminated uncooked vegetables or fruits, or person-to-person spread by the faecal-oral route. The cyst stage is resistant to chlorine in concentrations used in most water treatment facilities. Infection exists in 50% of symptomatic carriage, and reserves the infection in endemic form.

Clinical features

Clinical disease: Giardiasis. Symptomatic giardiasis ranges from mild diarrhea to severe malabsorption syndrome. Usually, the onset of the disease is sudden and consists of foul smelling, watery diarrhea, abdominal cramps, flatulence, and streatorrhoea. Blood & pus are rarely present in stool specimens, a feature consistent with the absence of tissue destruction

Immunity

The humoral immune response and the cellular immune mechanism are involved in giardiasis. Giardia – specific IgA is particularly important in both defense against and clearance of parasite.

Laboratory diagnosis

Examination of diarrhoeal stool- trophozoite or cyst, or both may be recovered in wet reparation. In examinations of formed stool (e.g. in asymptomatic carriers) only cysts are seen. Giardia species may occur in "showers", i.e. many organisms may be present in the stool on a given day and few or none may be detected the next day. Therefore one stool specimen per day for 3 days is important.

If microscopic examination of the stool is negative in a patient in whom giardiasis is highly suspected duodenal aspiration, string test (entero-test), or biopsy of the upper small intestine can be examined.

In addition to conventional microscopy, several immunologic tests can be implemented for the detection of parasitic antigens.

Treatment

For asymptomatic carriers and diseased patients the drug of choice is quinacrine hydrochloride or metronidazole.

Prevention

- Asymptomatic reservoirs of infection should be identified & treated.
- Avoidance of contaminated food and water.
- Drinking water from lakesand streams should be boiled, filtered and/or iodinetreated.
- Proper waste disposal and use of latrine.

Trichomonas vaginalis

Important features – it is a pear-shaped organism with a central nucleus and four anterior flagella; and undulating membrane extends about two-thirds of its length. It exists only as a trophozoite form, and measured 7-23 μm long & 5-15 μm wide. Transmission is by sexual intercourse.

Pathogenesis

The trophozoite is found in the urethra & vagina of women and the urethra & prostate gland of men. After introduction by sexual intercourse, proliferation begins which results in inflammation & large numbers of trophozoites in the tissues and the secretions. The onset of symptoms such as vaginal or vulval pruritus and discharge is often sudden and occurs during or after menstruation as a result of the increased vaginal acidity. The vaginal secretions are liquors, greenish or ellowish, sometimes frothy, and foul smelling. Infection in the male may be latent, with no symptoms, or may be present as self limited, persistent, or recurring urethritis.

Epidemiology

This parasite has worldwide distribution, and sexual intercourse is the primary mode of transmission. Occasionally, infections can be transmitted by fomites (toilet articles, clothing), although this transmission is limited by liability of the trophozoite. Rarely Infants may be

infected by passage through the mother's infected birth canal. The prevalence of this flagellate in developing countries is reported to be 5-20% in women and 2-10% in men.

Clinical features

Clinical disease – trichomoniasis.

Most infected women at the acute stage are asymptomatic or have a scanty, watery vaginal discharge. In symptomatic cases vaginitis occurs with more extensive inflammation, along with erosion of epithelial lining, and painful urination, and results in symptomatic vaginal discharge, vulvitis and dysuria.

Immunity

The infection may induce humoral, secretory, and cellular immune reactions, but they are of little diagnostic help and do not appear to produce clinically significant immunity.

Laboratory diagnosis

• In females, *T. vaginalis* may be found in urine sediment, wet preparations of vaginal secretions or vaginal scrapings.

• In males it may be found in urine, wet preparations of prostatic secretions or following massage of the prostate gland.

• Contamination of the specimen with faeces may confuse *T. vaginalis* with *T. hominis*.

Treatment

Metronidazole is the drug of choice. If resistant cases occur, re-treatment with higher doses is required.

Prevention

- Both male & female sex partners must be treated to avoid reinfection
- Good personal hygiene, avoidance of shared toilet articles & clothing.
- Safe sexual practice.

LEISHMANIA SPECIES

Clinical disease – visceral leishmaniasis; cutaneous leishmaniasis; mucocutaneous leishmaniasis.

The species of leishmania exist in two forms, amastigote (aflagellar) and promastigote (flagellated) in their life cycle. They are transmitted by certain species of sand flies (Phlebotomus & Lutzomyia).

VISCERAL LEISHMANIASIS ***Leishmania donovani***

Important features – the natural habitat of *L. donovani* in man is the reticuloendothelial system of the viscera, in which the amastigote multiplies by simple binary fission until the host cells are destroyed, whereupon new macrophages are parasitized. In the digestive tract of appropriate insects, the developmental cycle is also simple by longitudinal fission of promastigote forms.

The amastigote stage appears as an ovoidal or rounded body, measuring about 2-3 μm in length; and the promastigotes are 15-25 μm lengths by 1.5-3.5 μm breadths.

Pathogenesis

In visceral leishmaniasis, the organs of the reticuloendothelial system (liver, spleen and bone marrow) are the most severely affected organs. Reduced bone marrow activity, coupled with cellular distraction in the spleen, results in anaemia, leukopenia and thrombocytopenia. This leads to secondary infections and a tendency to bleed. The spleen and liver become markedly enlarged, and hypersplenism contributes to the development of anaemia and lymphadenopathy also occurs. Increased production of globulin results in hyperglobulinemia, and reversal of the albumin-to-globulin ratio.

Epidemiology

L. donovani donovani, infection of the classic kala-azar ("black sickness") or dumdum fever type occurs in many parts of Asia, Africa and Southeast Asia. Kala-azar occurs in three distinct epidemiologic patterns. In Mediterranean basin (European, Near Eastern, and Africa)

and parts of China and Russia, the reservoir hosts are primarily dogs & foxes; in sub-Saharan Africa, rats & small carnivores are believed to be the main reservoirs. In India and neighboring countries (and Kenya), kala-azar is anthroponosis, i.e. there is no other mammalian reservoir host other than human. The vector is the Phlebotomus sand fly. Other variants of *L. donovani* are also recognized: *L. donovani infantum* with similar geographical distribution, reservoir host and vector; with *L. donovani donovani*. *L. donovani chagasi* is found in South America, Central America, especially Mexico, and the West Indies. Reservoir hosts are dogs, foxes, and cats, and the vector is the Lutzomiya sand fly.

Clinical features

Symptoms begin with intermittent fever, weakness, and diarrhea; chills and sweating that may resemble malaria symptoms are also common early in the infection. As organisms proliferate & invade cells of the liver and spleen, marked enlargement of the organs, weight loss, anemia, and emaciation occurs. With persistence of the disease, deeply pigmented, granulomatous lesion of skin, referred to as post-kala-azar dermal leishmaniasis, occurs. Untreated visceral leishmaniasis is nearly always fatal as a result of secondary infection.

Immunity

Host cellular and humoral defence mechanisms are stimulated.

Laboratory diagnosis

• Examination of tissue biopsy, spleen aspiration, bone marrow aspiration or lymph node aspiration in properly stained smear (e.g. Giemsa stain).

• The amastigotes appear as intracellular and extra cellular *L. donovani* bodies.

• Culture of blood, bone marrow, and other tissue often demonstrates the promastigote stage of the organisms.

• Serologic testing is also available.

Treatment

The drug of choice is sodium stibogluconate, a pentavalent antimonial compound.

Alternative approaches include the addition of allopurinol and the use of pentamidine or amphotercin B.

Prevention

• Prompt treatment of human infections and control of reservoir hosts.

• Protection from sand flies by screening and insect repellents.

OLD WORLD CUTANEOUS LEISHMANIASIS (ORIENTAL SORE)

Clinical disease

L. tropica minor – dry or urban cutaneous leishmaniasis

L. tropica major – wet or rural cutaneous leishmaniasis

L. aethiopica – cutaneous leishmaniasis

Important features

These are parasites of the skin found in endothelial cells of the capillaries of the infected site, nearby lymph nodes, within large mononuclear cells, in neutrophilic leukocytes, and free in the serum exuding from the ulcerative site. Metastasis to other site or invasion of the viscera is rare.

Pathogenesis

In neutrophilic leukocytes, phagocytosis is usually successful, but in macrophages the introduced parasites round up to form amastigote and multiply. In the early stage, the lesion is characterized by the proliferation of macrophages that contain numerous amastigotes. There is a variable infiltration of lymphocytes and plasma cell. The overlying epithelium shows acanthosis and hyperkeratosis, which is usually followed by necrosis and ulceration.

Epidemiology

Cutaneous leishmaniasis produced by *L.tropica* complex is present in many parts of Asia, Africa, Mediterranean Europe and the southern region of the former Soviet Union. The urban Cutaneous leishmaniasis is thought to be an anthroponosis while the rural cutaneous leishmaniasis is zoonosis with human infections occurring only sporadically. The reservoir hosts

in *L. major* are rodents. *L. aethopica* is endemic in Ethiopia and Kenya. The disease is a zoonosis with rock & tree hyraxes serving as reservoir hosts. The vector for the old world cutaneous leishmaniasis is the Phlebotomus sand fly.

Clinical features

The first sign, a red papule, appears at the site of the fly's bite. This lesion becomes irritated, with intense itching, and begins to enlarge & ulcerate. Gradually the ulcer becomes hard and crusted and exudes a thin, serous material. At this stage, secondary bacterial infection may complicate the disease. In the case of the Ethiopian cutaneous leishmaniasis, there are similar developments of lesions, but they may also give rise to diffuse cutaneous leishmaniasis in patients who produce little or no cell mediated immunity against the parasite. This leads to the formation of disfiguring nodules over the surface of the body.

Immunity

Both humoral and cell mediated immunity are involved.

Treatment

The drug of choice is sodium stibogluconate, with an alternative treatment of applying heat directly to the lesion. Treatment of *L.aethopica* remains to be a problem as there is no safe and effective drug.

Prevention

- Prompt treatment & eradication of ulcers
- Control of sand flies & reservoir hosts.

NEW WORLD CUTANEOUS AND MUCOCUTANEOUS LEISHMANIASIS

(AMERICAN CUTANEOUS LEISHMANIASIS)

Clinical disease

Leishmania mexicana complex – cutaneous leishmaniasis.

Leishmania braziliensis complex – mucocutaneous or cutaneous leishmaniasis.

Important features

The American cutaneous leishmeniasis is the same as oriental sore. But some of the strains tend to invade the mucous membranes of the mouth, nose, pharynx, and larynx either initially by direct extension or by metastasis. The metastasis is usually via lymphatic channels but occasionally may be the bloodstream.

Pathogenesis

The lesions are confined to the skin in cutaneous leishmaiasis and to the mucous membranes, cartilage, and skin in mucocutaneous leishmaniasis. A granulomatous response occurs, and a necrotic ulcer forms at the bite site. The lesions tend to become superinfected with bacteria. Secondary lesions occur on the skin as well as in mucous membranes. Nasal, oral, and pharyngeal lesions may be polypoid initially, and then erode to form ulcers that expand to destroy the soft tissue and cartilage about the face and larynx. Regional lymphadenopathy is common.

Epidemiology

Most of the cutaneous & mucocutaneous leishmaniasis of the new world exist in enzootic cycles of infection involving wild animals, especially forest rodents. *Leishmania mexicana* occurs in South and Central America, especially in the Amazon basin, with sloths, rodents, monkeys, and raccoons as reservoir hosts. The mucocutaneous leishmaniasis is seen from the Yucatan ninsula into Central and South America, especially in rain forests where workers are exposed to sand fly bites while invading the habitat of the forest rodents. There are many jungle reservoir hosts, and domesticated dogs serve as reservoirs as well. The vector is the Lutzomyia sand fly.

Clinical features

The types of lesions are more varied than those of oriental sore and include Chiclero ulcer, Uta, Espundia, and Disseminated Cutaneous Leishmaniasis.

Laboratory diagnosis

• Demonstration of the amastigotes in properly stained smears from touch preparations of ulcer biopsy specimen.

• Serological tests based on fluorescent antibody tests.

• Leishman skin test in some species.

Immunity

The humoral and cellular immune systems are involved

Treatment

The drug of choice is sodium stibogluconate.

Prevention

• Avoiding endemic areas especially during times when local vectors are most active.

• Prompt treatment of infected individuals.

Trypanosomiasis

Etiologic agents

Trypanosoma brucei complex – African trypanosomiasis (sleeping sickness).

Trypanosoma cruzi – American trypanosomiasis (Chagas' disease).

Important features

These species may have amastigote, promastigote, epimastigote, and trypomastigote stages in their life cycle. In human trypanosomes of the African form, however, the amastigote and promastigote stages of development are absent. Typical trypanosome structure is an elongated spindle-shaped body that more or less tapers at both ends, a centrally situated nucleus, a netoplast posterior to nucleus, an undulating membrane arising from the kinetoplast and proceeding forward along the margin of the cell membrane and a single free flagellum at the anterior end.

AFRICAN TRYPANOSOMIASIS

Trypanosoma gambiense and *Trypanosoma rhodesiene* are causative agents of the African typanosomiasis, transmitted by insect bites. The vector for both is the tsetse fly.

Pathogenesis

The trypomastigotes spread from the skin through the blood to the lymph node and the brain. The typical somnolence (sleeping sickness) usually progresses to coma as a result of emyelinating encephalitis. In acute form, cyclical fever spike (approximately every 2 weeks) occurs that is related to antigenic variation. As antibody mediated agglutination and lysis of the trypomastigotes occurs, the fever subsides. With a few remains of antigenic variants new fever spike occurs and the cycle repeats itself over a long period.

Epidemiology

T. burcei gambiense is limited to tropical west and central Africa, correlating with the range of the tsetse fly vector. The tsetse flies transmitting *T.b. gambiense* prefer shaded stream banks for reproduction and proximity to human dwellings. People who work in such areas are at greatest risk of infection. An animal reservoir has not been proved for this infection. *T. burcei rhodeseinse* is found primarily in East Africa, especially the cattle-raising countries, where tsetse flies breed in the brush rather than along stream banks. *T.b. rhodeseines* also differs from *T.b. gambiense* in that domestic animal hosts (cattle and sheep) and wild game animals act as reservoir hosts. This transmission and vector cycle makes the organism more difficult to control than *T.b. gambiense*.

Clinical features

Although both species cause sleeping sickness, the progress of the disease is different. *T.gambiense* induced disease runs a low-grade chronic course over a few years. One of the earliest signs of disease is an occasional ulcer at the site of the fly bite. As reproduction of organisms continues, the lymph nodes are invaded, and fever, myalgia, arthralgia, and lymph node enlargement results. Swelling of the posterior cervical lymph nodes is characteristic of Gambian sleeping sickness and is called winterbottom's sign. Chronic disease progresses to CNS involvement with lethargy, tremors, meningoencephalitis, mental retardation, and general deterioration. In the final stages, convulsions, hemiplegia, and incontinence occur. The patient

becomes difficult to arouse or obtain a response from, eventually progressing to a comatose state. Death is the result of CNS damage and other infections, such as pneumonia. In *rhodesiense,* the disease caused is a more acute, rapidly progressive disease that is usually fatal. This more virulent organism also develops in greater numbers in the blood. Lymphadenopathy is uncommon, and early in the infection, CNS invasion occurs, resulting in lethargy, anorexia, and mental disturbance. The chronic stages described for *T.gambiense* are not often seen, because in addition to rapid CNS disease, the organism produces kidney damage and myocarditis, leading to death.

Immunity

Both the humoral and cellular immunity involve in these infections. The immune responses of the host to the presence of these parasites, however, is faced with antigenic variation, in which organisms that have changed their antigenic identity can escape the host immune response and initiate another disease process with increased level of parasitemia.

Laboratory

Examination of thin and thick films, in concentrated anticoagulated blood preparations, and in aspiration from lymph nodes and concentrated spinal fluid. Methods for concentrating parasites in blood may be helpful approaches including centrifugation of heparinized samples and an ion–exchange chromatography. Levels of parasitosis vary widely, and several attempts to visualize the organism over a number of days may be necessary.

Treatment

The same treatment protocol is applied for these parasites. For the acute stages of the disease the drug of choice is suramin with pentamidine as an alternative. In chronic disease with CNS involvement, the drug of choice is melarsoprol. Alternatives include trypars amide combined with suramin.

Prevention

• Control of breeding sites of tsetse flies and use of insecticides.

• Treatment of human cases to reduce transmission to flies.

• Avoiding insect bite by wearing protective clothing and use of screen, bed netting and insect repellants.

AMERICAN TRYPANOSOMIASIS

Trypanosoma cruzi is a pleomorphic trypanosome that includes an additional form of amastigote in its life cycle. The vector for transmission are reduviid bugs.

Pathogenesis

During the acute phase, the organism occurs in blood as a typical trypomastigote and in the reticuloendothelial cells as a typical amastigote. The amastigotes can kill cells and cause inflammation, consisting mainly of mononuclear cells. Cardiac muscle is the most frequently and severely affected tissue. In addition, neuronal damage leads to cardiac arrhythmias and loss of tone in the colon (megacolon) and esophagus (megaesophagus). In the chronic phase, the organism persists in the amastigote form.

Epidemiology

T. cruzi occurs widely in both reduviid bugs and a broad spectrum of reservoir animals in North, Central, and South America. Human disease is found most often among children in South and Central America, where there is direct correlation between infected wild animal reservoir hosts and the presence of infected bugs whose nests are found in human dwellings.

Clinical features

Chagas' disease may be asymptomatic acute or chronic disease. One of the earliest signs is development at the site of the bug bite of an erythematous and indurated area called a chagoma. This is often followed by a rash and edema around the eyes and face; in young children frequently an acute process with CNS involvement may occur. Acute infection is also characterized by fever, chills, malaise, myalgia, and fatigue. The chronic Chagas' disease is characterized by hepatosplenomegaly, myocarditis, and enlargement of the esophagus and colon as a result of the destruction of nerve cells

(E.g. Auerbach's plexus) and other tissues that control the growth of these organs. Involvement of the CNS may produce granulomas in the brain with cyst formation and a meningoencephalitis. Death from chronic Chagas' disease results from tissue destruction in the many areas invaded by the organisms, and sudden death results from complete heart block and brain damage.

Laboratory diagnosis

Examine thin or thick stained preparations for trypomastigotes. Wet preparations should also be examined to look for motile organisms that leave the blood stream and become difficult to find. Biopsy of lymph nodes, liver, spleen, or bone marrow may demonstrate organisms in amastigote stage.

Immunity

Unlike African trypanosomiasis, the antigenic variation is less common in *T.cruzi* infection. Therefore, the humoral and cellular immune responses function in the immune system.

Treatment

The drug of choice is nifurtimox. Alternative agents include allopurinol & benzimidazole.

Prevention

• Bug control, eradication of nests
• Treating infected person & exclusion of donors by screening blood.
• Development of vaccine.

Unit 25. Protists. Classes Sporozoa and Cilliophora. Format-practical's.

Discussion questions:

1. General characteristics of the class Sporozoa.
2. The life cycle of Plasmodium sp., pathogenesis, diagnosis and prevention of malaria.
3. The life cycle of pathogens, pathogenesis, diagnosis and prevention of toxoplasmosis.
4. General characteristics of the class Cilliophora. The life cycle of pathogens, pathogenesis, diagnosis and prevention of balantidiasis.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Merozoites, sporozoites, schizonts, gametocyte

KEY POINTS OF THE TOPIC:

The life cycle of Plasmodium falciparum

Infection in humans begins with the bite of an infected female *Anopheles* mosquito. *Plasmodium* sporozoites released from the salivary glands of the mosquito enter the bloodstream during feeding, quickly invading liver cells (hepatocytes). The immune system clears the sporozoites from the circulation within 30 minutes.

Sporozoites invade liver cells and undergo schizogony to produce merozoites.

Merozoites invade circulating RBCs. Each merozoite produces as many as 36 new merozoites through schizogony in RBCs. Merozoites rupture RBCs to invade other RBCs. Simultaneous lysing of RBCs causes the sudden chills due to septicaemia because of release of haemozoin granules and very high fever typical of malaria.

The length of this erythrocytic stage depends on the parasite species: an irregular interval for *P. falciparum*, 48 hours for *P. vivax* and *P. ovale* and 72 hours for *P. malariae*.

The clinical manifestations of malaria, fever and chills, are associated with the synchronous rupture of the infected erythrocytes. The released merozoites invade additional erythrocytes. Not all of the merozoites divide into schizonts; some differentiate into sexual forms, male and female gametocytes. These gametocytes are taken up by a female *Anopheles* mosquito during a blood meal. Within the mosquito midgut, the male gametocyte undergoes a

rapid nuclear division, producing eight flagellated microgametes that fertilize the female macrogamete. The resulting ookinete traverses the mosquito gut wall and encysts on the exterior of the gut wall as an oocyst. Oocyst forms Sporozoites by sporogony. Soon, the oocyst ruptures, releasing hundreds of sporozoites into the mosquito body cavity, where they eventually migrate to the mosquito salivary glands. The cycle is repeated again.

Medically important Ciliates

The intestinal protozoan *Balantidium coli* is the only member of the ciliate group that is pathogenic for humans. Disease produced by *B. coli* is similar to amebiasis, because the organisms elaborate proteolytic and cytotoxic substances that mediate tissue invasion and intestinal ulceration.

Life cycle

The life cycle of *B. coli* is simple, involving ingestion of infectious cysts, excystation, and invasion of trophozoites into the mucosal lining of the large intestine, caecum, and terminal ileum. The trophozoite is covered with rows of hair like cilia that aid in motility. Morphologically more complex than amebae, *B. coli* has a funnel-like primitive mouth called a cytostome, a large (macro) nucleus and a small (micro) nucleus involved in reproduction.

Epidemiology

B. coli are distributed worldwide. Swine and (less commonly) monkeys are the most important reservoirs. Infections are transmitted by the faecal-oral route; outbreaks are associated with contamination of water supplies with pig faeces. Person-to-person spread, including through food handlers, has been implicated in outbreaks. Risk factors associated with human disease include contact with swine and substandard hygienic conditions.

Clinical features

As with other protozoan parasites, asymptomatic carriage of *B. coli* can exist. Symptomatic disease is characterized by abdominal pain, tenderness, tenesmus, nausea, anorexia, and watery stools with blood and pus. Ulceration of the intestinal mucosa, as with amebiasis, can be seen; a secondary complication caused by bacterial invasion into the eroded intestinal mucosa can occur. Extra intestinal invasion of organs is extremely rare in balantidiasis.

Laboratory Diagnosis

Microscopic examination of faeces for trophozoite and cysts is performed. The trophozoite is very large, varying in length from 50 to 200 μm and in width from 40 to 70 μm. The surface is covered with cilia.

Treatment

The drug of choice is tetracycline; iodoquinol and metronidazole are alternative agents.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

(UNIT 24-25)

PARASITES – REPRESENTATIVES OF PROTOZOA

1. The main host of Plasmodium falciparum
   a) trophozoite
   b) man
   c) anopheles mosquito of genus Anopheles
   d) fish
2. Intermediate host of Plasmodium falciparum
   a) mollusc
   b) man
   c) anopheles mosquito of genus Anopheles
   d) fish
3. Who enters the the human body through the bite of a mosquito with malaria
   a) merozoites
   b) sporozoites

c) schizonts
d) ookinete

4. Who forms of the erythrocytes after schizogony
a) merozoites
b) sporozoites
c) schizonts
d) ookinete

5. Sporozoites are formed as a result of the process
a) schizogony
b) sporogony
c) fertilization
d) gametogenesis

6. Who fall into into the stomach of a mosquito when it feeds on the blood of human malaria patient
a) sporozoites;
b) merozoites;
c) gametocytes;
d) oocyst

7. Cyst of dysentery amoeba has
a) two nuclei
b) three nuclei
c) four nuclei
d) eight nuclei

8. Trophozoites of dezintery amoeba destroys mucous membrane and feed on
a) blood
b) kidney tissue
c) lymph
d) protozoa

9. A person infected with dysentery amoeba;
a) through unwashed hands;
b) through the meat of sick animals;
c) through blood;
d) sexually transmitted

10. Giardia *lamblia* trophozoites are located in the
a) duodenum;
b) blood;
c) skin;
d) heart

11. Giardia is characterized by the presence of
a) radial symmetry
b) two pairs of flagella
c) pear-shaped with two nuclei
d) four axonemes

12. The trophozoites of Giardia *lamblia*
a) can attach to the intestinal villi by the ventral sucking discs
b) feed on blood
c) destroy mucosa
d) penetrate the muscular layer of the intestinal wall

13. The trophozoite is found in the urethra and vagina of women and the urethra and prostate gland of men
a) in life cycle of *Giardia lamblia.*
b) in life cycle of *Trypanosoma brucei*

c) in life cycle of *Trypanosoma cruzi*
d) in life cycle of *Trichomonas*

14. The vector is the tsetse fly
    a) in life cycle of *Giardia lamblia.*
    b) in life cycle of *Trypanosoma brucei*
    c) in life cycle of *Trypanosoma cruzi*
    d) in life cycle of *Trichomonas*
15. The vector for transmission are reduviid bugs
    a) in life cycle of *Giardia lamblia.*
    b) in life cycle of *Trypanosoma brucei*
    c) in life cycle of *Trypanosoma cruzi*
    d) in life cycle of *Trichomonas*
16. The parasite that causes the formation of deep skin ulcers
    a) *Trypanosoma brucei*
    b) *Giardia lamblia*
    c) *Leishmania donovani*
    d) *Leishmania tropica minor*
17. The most severely affected organs are the organs of the reticuloendothelial system (liver, spleen and bone marrow) in lesions
    a) *Trypanosoma brucei*
    b) *Giardia lamblia*
    c) *Leishmania donovani*
    d) *Leishmania tropica minor*
18. This disease is accompanied by lethargy, tremors, meningoencephalitis, mental retardation, and general deterioration
    a) Gambian sleeping sickness
    b) mucocutaneous Leishmaniasis
    c) trichomoniasis
    d) amoebiasis
19. The vector for transmission of African trypanosomiasis is
    a) tsetse fly
    b) dogs
    c) mosquitoes
    d) clams
20. The reservoir hosts in *Leishmania major* are
    a) rodents
    b) antelope
    c) tsetse fly
    d) dogs

Unit 26. Class Trematoda. Class Cestoda. Format-practical's.

Discussion questions:

1. Types of Platyhelminthes (flatworms). Class Trematoda: The Flukes.
2. The life cycle of pathogens, pathogenesis, diagnosis and prevention of fasciolasis.
3. The life cycle of pathogens, pathogenesis, diagnosis and prevention of opistorhosis.
4. The life cycle of pathogens, pathogenesis, diagnosis and prevention of lung fluke disease.
5. The life cycle of pathogens, pathogenesis, diagnosis and prevention of dicroceliasis.
6. Morphophysiology and the life cycle of blood fluke (Schistosoma).
7. Class Cestoda: The Tapeworms.
8. The life cycle of pathogens, pathogenesis, diagnosis and prevention of teniasis and cysticercosis.
9. The life cycle of pathogens, pathogenesis, diagnosis and prevention of teniarinhosis.

10. The life cycle of pathogens, pathogenesis, diagnosis and prevention of hymenolepiasis.
11. The life cycle of pathogens, pathogenesis, diagnosis and prevention of diphyllobothriasis.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Miracidium, sporocyst, cercaria, redium, scolex, proglotids, strobilla, corolla with hooks, intermediate host, main host.

KEY POINTS OF THE TOPIC:

Paragonimus westermani is the major species of lung fluke to infects humans, causing paragonimiasis. Paragonimiasis is a food-borne parasitic infection caused by the lung fluke. It may cause a sub-acute to chronic inflammatory disease of the lung.

In size, shape, and color, *P. westermani* resembles a coffee bean when alive. Adult worms are 7.5 to 12 mm long and 4 to 6 mm wide. The thickness ranges from 3.5 to 5 mm.

The skin of the worm (tegument) is thickly covered with scalelike spines. The oral and ventral suckers are similar in size, with the latter placed slightly pre-equatorially. The excretory bladder extends from the posterior end to the pharynx. The lobed testes are adjacent from each other located at the posterior end, and the lobed ovaries are off-centered near the center of the worm (slightly postacetabular). The uterus is located in a tight coil to the right of the acetabulum, which is connected, to the vas deferens. The vitelline glands, which produce the yolk for the eggs, are widespread in the lateral field from the pharynx to the posterior end. *P. westermani* eggs range from 80 to 120 µm long by 45 to 70 µm wide. They are yellow-brown, ovoid or elongate, with a thick shell, and often asymmetrical with one end slightly flattened.

Paragonimus has a quite complex **life-cycle** that involves two intermediate hosts as well as humans. ***Eggs*** first develop in water after being expelled by coughing (unembryonated) or being passed in human feces. In the external environment, the eggs become embryonated. In the next stage, the parasite ***miracidia*** hatch and invades the first intermediate host such as a species of freshwater snail. Miracidia penetrate its soft tissues of the snail. Within the snail mother ***sporocyst*** form and produce many ***mother rediae***, which subsequently produce many ***daughter rediae*** which shed crawling cercariae into fresh water. ***Cercariae*** next invade the second intermediate host such as crabs or crayfish and encyst to develop into ***metacercariae*** within 2 months. Infection of humans or other mammals (definitive hosts) occurs via consumption of raw or undercooked crustaceans. Human infection with P. westermani occurs by eating inadequately cooked or pickled crab or crayfish that harbor metacercariae of the parasite. The metacercariae excyst in the duodenum, penetrate through the intestinal wall into the peritoneal cavity, then through the abdominal wall and diaphragm into the lungs, where they become encapsulated and develop into adults. The worms can also reach other organs and tissues, such as the brain and striated muscles, respectively. However, when this takes place completion of the life cycles is not achieved, because the eggs laid cannot exit these sites.

Diagnosis is based on microscopic demonstration of eggs in stool or sputum, but these are not present until 2 to 3 months after infection.

Fasciola hepatica is a parasitic fluke that lives in the liver. In addition to humans it infects cows and sheep. It is known as the common liver fluke and causes a disease called fascioliasis.

Fasciola hepatica is one of the largest flukes of the world, reaching a length of 30 mm and a width of 13 mm (Fasciola gigantica, on the other hand, is even bigger and can reach up to 75 mm). It is leaf-shaped, pointed at the back (posteriorly) and wide in the front (anteriorly). The oral sucker is small but powerful and is located at the end of a cone-shape projection at the anterior end. The acetabulum is a larger sucker than the oral sucker and is located at the anterior end.

The outer surface of the fluke is called the tegument. This is composed of scleroprotein and its primary function is to protect the fluke from the destructive digestive system of the host. Its also used for renewal of the surface plasma membrane and the active uptake of nutrients.

The alimentary canal of *F. hepatica* has a single mouth which leads into the blind gut; it has no anus. The mouth is located within the anterior sucker on the ventral side of the fluke. This mouth leads to the pharynx, which is then followed by a narrow oesophagus. The oesophagus, which is lined with a thin layer of epithelial cells, then opens up into the large intestine. As there is no anus, the intestine branches, with each branch ending blindly near the posterior end of the body. It has been shown that flukes migrate into smaller capillaries and bile ducts when feeding within the host. They use their mouth suckers to pull off and suck up food, bile, lymph and tissue pieces from the walls of the bile ducts. F. hepatica relies on extracellular digestion which occurs within the intestine of the host. The waste materials are egested through the mouth. The non-waste matter is adsorbed back in through the tegument and the general surface of the fluke. The tegument facilitates this adsorption by containing many small folds to increase the surface area.

F. hepatica has no respiratory organs: the adult flukes respire anaerobically (without oxygen). *F. hepatica's* excretory system contains a network of tubules surrounding one main excretory canal. This canal leads to the excretory pore at the posterior end of the fluke. This main canal branches into four sections within the dorsal and ventral regions of the body. The role of *F. hepatica's* excretory system is excretion and osmoregulation. Each tubule within the excretory system is connected to a flame cell, otherwise known as protonephridia. These cells are modified parenchyme cells. In *F. hepatica* their role is to perform excretory, but more importantly, osmoregulatory functions. Flame cells are therefore primarily used to remove excess water.

The nerve system of *F. hepatica* consists of a pair of nerve ganglia, each one is located on either side of the oesophagus. Around the oesophagus is a nerve ring. This nerve ring connects the two nerve ganglia together. The nerves stem off from this ring, reaching all the way down to the posterior end of the body. At the posterior end, one pair of nerves become thicker than the others, these are known as the lateral nerve cords. From these lateral nerve cords, the other nerves branch. Sensory organs are absent from F. hepatica.

F. hepatica adult flukes are hermaphrodite, this means each fluke contains both male and female reproductive organs. The male and female reproductive organs open up into the same chamber within the body, which is called the genital atrium. The genital atrium is an ectodermal sac which opens up to the outside of the fluke via a genital pore. The testes are formed of two branched tubules, these are located in the middle and posterior regions of the body. From the epithelium lining of the tubules sperm is produced. The sperm then passes into the vas deferens and then into the seminal vesicle. From the seminal vesicle projects the ejaculatory duct and this is what opens up into the genital atrium, many prostate glands surround this opening. On the right hand side of the anterior testis there is a branched, tubular ovary. From here, a short oviduct passes to the vitelline duct. This duct connects, via a junction, the ovaries, the uterus and the yolk reservoir. From this junction, the uterus opens into the genital atrium, this opening is surrounded by Mehlis glands.

The life cycle of *Fasciola hepatica* starts when a female lays ***eggs*** in the liver of an infected human. Immature eggs are discharged in the biliary ducts and taken out in the feces. If landed in water, the eggs become embryonated and develop larvae called ***miracidia***. Within the aquatic snail mother ***sporocyst*** form and produce many ***mother rediae***, which subsequently produce many ***daughter rediae*** which shed crawling ***cercariae***, a larva that is capable of swimming with its large tail. The cercaria exits and finds aquatic vegetation where it forms a cyst called ***metacercaria***. A human eats the raw freshwater plant containing the cyst. The metacercaria excysts in the first part of the small intestine, duodenum. It then penetrates the intestinal wall and gets into the peritoneal cavity. It finds the liver and starts eating liver cells. This happens only a few days after the initial contact with the parasite. Usually the larva spends a few weeks just browsing and eating the liver. Then it relocates to the bile duct where it begins its final stage and becomes an adult. It takes about three months for the metacercaria to develop

into an adult. Adults are about 3 cm long and 1 cm wide. Adult females can produce up to 25000 eggs per day.

In the chronic phase of fascioliasis adults in the large biliary ducts cause liver inflammation and obstruction of the biliary fluid. During the migration of the larvae (this acute phase of the disease lasts many weeks) symptoms include: diarrhea, eosinophilia (high number of white blood cells), fever, nausea, stomach ache, vomiting.

F. hepatica is found in areas where cattle and sheep are raised.

Dicrocoelium dendriticum, Dicrocoelium hospes, Eurytrema pancreaticum (pathogen – Less Common Liver Trematodes).

The adult worms of *D. dendriticum* are lancet‑shaped, flat, and transparent and measure 5 to 15 mm long by 1.5 to 2.5 mm wide. The eggs are thick-shelled, operculate, deep golden brown, and measure 38 to 45 μm by 22 to 30 μm; the eggs of the two flukes cannot be differentiated. The eggs are embryonated when passed and are resistant to drying.

Life Cycle. The life cycle is similar to that of the other liver trematodes. However, in this case, the snail intermediate host is a land snail. The ***cercariae*** are released from the snail after rains follow a long period of dry weather. They are released from the snail's respiratory chamber as slime balls that are left behind on grass as the snail crawls along the ground or on plants. The ant is the required second intermediate host for *D. dendriticum*. Human infection is acquired through accidental ingestion of ants, primarily on fresh herbs or plants used for human consumption. The ***metacercariae*** excyst and migrate to the biliary passage for *D. dendriticum*, where they then become adult flukes.

Although the life cycle is similar to that caused by *F. hepatica*, the pathogenic effects are less severe and patients may report mild symptoms. Symptoms include chronic constipation and flatulent dyspepsia. In heavy infections, there may be jaundice with an enlarged liver. There may also be vomiting and diarrhea, as well as systemic toxemia. Eosinophilia tends to be absent in this infection.

Opisthorchis viverrini

The adult flukes deposit fully developed eggs that are passed in the feces. After ingestion by a suitable snail (first intermediate host), the ***eggs*** release ***miracidia***, which undergo in the snail several developmental stages (***sporocysts, rediae, cercariae***). Cercariae are released from the snail and penetrate freshwater fish (second intermediate host), encysting as ***metacercariae*** in the muscles or under the scales. The mammalian definitive host (cats, dogs, and various fish-eating mammals including humans) become infected by ingesting undercooked fish containing metacercariae. After ingestion, the metacercariae excyst in the duodenum and ascend through the ampulla of Vater into the biliary ducts, where they attach and develop into adults, which lay eggs after 3 to 4 weeks. The adult flukes (*O. viverrini*: 5 mm to 10 mm by 1 to 2 mm; *O. felineus*: 7 mm to 12 mm by 2 mm to 3 mm) reside in the biliary and pancreatic ducts of the mammalian host, where they attach to the mucosa.

Schistosomiasis (bilharziasis) is the only fluke with separate sexes. The female worm lies in the gynecophoral canal of the male. This condition is important for transportation.

There are five medically important species:

1. *Schistosoma mansoni*: causes intestinal schistosomiasis.
2. *Schistosoma haematobium*: causes vesical (urinary) schistosomiasis.
3. *Schistosoma japonicum*: causes intestinal schistosomiasis.
4. *Schistosoma intercalatum*: causes intestinal schistosomiasis.
5. *Schistosoma mekongi*: causes intestinal schistosomiasis. This seems to cause milder disease in man. It causes disease in other vertebrate hosts.

The first two schistosomes (*S. mansoni* and *S. haematobium*) are prevalent in Ethiopia.

Schistosoma mansoni

Habitat. This species lives in the veins of the intestine.

Geographical distribution. It is found in Africa, South America, Middle East (some Arab countries) etc. Stream and lake-based transmission is common. The snail hosts that harbor *S. mansoni* are the genera: Biomphalaria (*B. glabrata*) and Trobicorbis. These have oval shells.

Morphology

Male. The male ranges in size from 1-1.4 cm in length and the body is covered by coarse tubercles. It has 6-9 testes.

Female. The female is 1.5-2.0 cm in length. The ovary is present in the anterior third and Vitelline glands occupy the posterior two-thirds. It lays about 100-300 eggs daily. The uterus is short containing few ova.

Urinary schistosomiasis

Etiology. *Schistosoma haematobium*

Habitat. The worm lives in the veins of the bladder of humans. The peak prevalence is the 10-14 year age group. The snail hosts that harbor S. haematobium are the genera Bulinus (Bulinus africanus, B. truncatus) and Physopsis.

Morphology

Male. The male ranges in size from 1-1.5 cm in length. The body is covered by fine tubercles. It has 4-5 testes.

Female. The female ranges in size from 2-2.5 cm in length. The ovary is present in the posterior third. Vitelline glands occupy the posterior thirds. Uterus is long containing many ova. It lays about 20-200 eggs daily.

Distribution. In Ethiopia, S. haematobium is found in the Lower Awash Valley in the east and in Benshangul-Gumuz (Assossa) regional state in the west in low altitudes below 1000 meters above sea level.

Schistosoma japonicum. The female adult worm lays about 500-3500 eggs daily. The eggs are ovoid, bearing only a minute lateral spine or a small knob postero-laterally. It is found in Japan, China, and Philippines, etc.

Schistosoma intercalatum. This is the rarest and least pathogenic schistosome that matures in man. It is found in Western and Central Africa. The daily egg output is about 300. The eggs have a terminal spine.

Life cycle of Schistosomes. Adult worms reside in pairs: the female lying in the gynecophoral canal of the male. After fertilization, ***eggs*** are passed into the venules. A larval form – the ***miracidium*** - develops within the egg. Its lytic enzymes and the contraction of the venule rupture the wall of the venule liberating the egg into the perivascular tissues of the intestine (*S. mansoni*) or urinary bladder (*S. haematobium*). The eggs pass into the lumens and organs and are evacuated in the feces (*S. mansoni*) or the urine (*S. haematobium*). On contact with fresh water the miracidia hatch from the eggs and swim about until they find the appropriate snail, which they penetrate. After two generations of ***sporocyst*** development and multiplication within the snail, the fork-tailed ***cercariae*** emerge. Infection to man takes place during bathing or swimming. The cercariae penetrate the skin, are carried into the systemic circulation and pass through to the portal vessels. Within the intrahepatic portion of the portal system, the worms feed and grow to maturity.

Symptoms and complications

Patients infected with *S. haematobium* suffer from terminal haematuria and painful micturition. There is inflammation of the urinary bladder (cystitis), and enlargement of spleen and liver.

Patients infected with *S. mansoni* suffer from cercarial dermatitis (swimmers itch) and dysentery (mucus and blood in stool with tenesmus) as well as enlargements of the spleen and liver.

S. haematobium causes squamous cell carcinoma in the bladder.

Laboratory Diagnosis

S. mansoni

- Microscopic examination of the stool for eggs after concentration by sedimentation method. The egg has characteristic lateral spine.

- Rectal snip.

S. haematobium

- Examination of the urine after allowing it to sediment in a conical urinalysis glass. A drop from the sediment is taken and examined for eggs. Egg has terminal spine.

- Biopsy from bladder.

CESTODES (TAPEWORMS)

The tapeworms are hermaphroditic and require an intermediate host. The adult tapeworms found in humans have flat body, white or grayish in color. They consist of an anterior attachment organ or scolex and a chain of segments (proglottids) also called strobilla. The strobilla is the entire body except the scolex. The scolex has suckers or grooves. It has rosetellum, which has 1 or 2 rows of hooks situated on the center of the scolex. Adult tapeworms inhabit the small intestine, where they live attached to the mucosa. Tapeworms do not have a digestive system. Their food is absorbed from the host's intestine.

Hymenolepis nana (dwarf tapeworm)

Morphology Adult worm measures 1-3 cm in length. It is made up of head (scolex), neck and segmented body. The head carries four suckers and a rostellum armed with one row of hooks. The segments of the body are divided into mature and gravid segments. In the mature segment, there are three testes in the middle.

Infective stage and mode of infection

The egg, which is immediately infective when passed by the patient, is rounded, about 40 microns in diameter. It contains a six- hooked oncosphere within a rigid membrane (the embryosphere). This embryosphere has two polar thickening or knobs from which project 4-8 long, thin filaments called polar filaments.

Infection takes place by:

1. Ingestion of egg with contaminated raw vegetables.
2. Direct infection from a patient
3. Auto infection: the eggs of *H. nana* are infective as soon as they are passed with feces by the patient. If the hands of the patient are contaminated by these eggs, she/he infects herself/himself again and again.

Pathogenecity

Light infections produce no symptoms. In fairly heavy infections, children may show lack of appetite, abdominal pain and diarrhea.

***Echinococcus granulosus* (dog tape worm)**

Responsible for most cases of echinococcosis. Echinococcosis is caused by larval tapeworms. The disease is common in East Africa (the highest prevalence is seen in Kenya: 10-15%).

Morphology

The adult worm measures 3-6 mm in length (up to 1 cm). It has scolex, neck and strobilla. Adult worms live in small intestine of definitive host (dog). Man is an intermediate host – carrying the hydatid cyst (larva). Man contracts infection by swallowing eggs in excreta of definitive host.

Life cycle and Pathogenecity

Oncosphere hatch in duodenum or small intestine into embryos (oncosphere) which:

- penetrate wall
- enter portal veins
- migrate via portal blood supply to organs: eg: lungs, liver, brain etc., thus, causing extra intestinal infections. In these organs, larvae develop into hydatid cysts. The cysts may be large, filled with clear fluid and contain characteristic protoscolices (immature forms of the head of the parasite).

These mature into developed scolices, which are infective for dogs.

Mode of human infection

Ingestion of eggs by the following ways:

- Ingestion of water or vegetables polluted by infected dog feces.
- Handling or caressing infected dogs where the hairs are usually contaminated with eggs.

Clinical features

Asymptomatic infection is common, but in symptomatic patients

- It may cause cough – with hemoptysis in lung hydatid disease.
- Hepatomegaly – with abdominal pain and discomfort.
- Pressure – from expanding cyst.
- Rupture of cyst – severe allergic reaction – anaphylaxis.

Diagnosis:

- X-ray or other body scans.
- Demonstration of protoscolices in cyst after operation.
- Serology.

Echinococcus multilocularis

Foxes are the definitive hosts, while various rodents such as mice serve as intermediate hosts.

Taenia saginata (beef tapeworm)

In adult stage, *T. saginata* inhabits the upper jejunum where it may survive for as long as 25 years. It causes intestinal infection, Taeniasis. It has worldwide distribution. These are one of the true and segmented tapeworms. Their body is divided into three regions:

1. Scolex: the hold fast organ
2. Neck: posterior to the scolex
3. Stobilla: the main bulk, made up of proglottids.

Adult worm measures 5-10 meters in length. The pyriform scolex has 4 suckers but no rostellum. The mature segments have irregularly alternate lateral genital pores. Each of the terminal segments contains only a uterus made up of a median stem with 15-30 lateral branches.

Life cycle

The adult worm lives in the small intestine of man. Gravid segments pass out in the stool and become disintegrated and eggs come out to the soil. The gravid proglottid uterus contains about 100,000 eggs. The egg of *T. saginata* is round, about 40 microns in diameter. The 6-hooked embryo is enclosed in a radially striated embryophore. Eggs are ingested by an intermediate host, cattle. The 6-hooked embryo escapes from its shell, penetrates through the intestinal wall into the blood vessels and is carried to the muscles where it develops into a larval stage, cysticercus bovis (made up of an invaginated /inverted head and spherical body). Infection to man takes place by the ingestion of raw or insufficiently cooked beef. In the small intestine of man, the head of the cysticercus gets invaginated and the body becomes segmented.

Pathogenecity

Infected persons may complain of epigastric pain, abdominal discomfort, diarrhea, weight loss, hunger sensation, vomiting, etc.

Diagnosis

Recovery of the gravid segments or the eggs from the stool

Prevention:

- Thorough cooking of meat (above 570ºC).
- Proper disposal of human excret

Taenia solium (pork tapeworm)

The adult worms of *T. solium* reside or inhabit the upper jejunum. Infection has worldwide distribution.

Morphology

Adult worm measures about 3 meters in length. The globular scolex has rostellum with 2 rows of hooklets. There are <1000 proglottids. Gravid proglottid liberates about 30,000-50,000 eggs.

Life cycle

Embryonated eggs passed with stool are ingested by pig and the embryo is released. It penetrates the intestinal wall and is carried by vascular channels to all parts of the body. After a period of 2-3 months of development the encysted larval stage called cysticerci or bladder worm occurs in the striated muscles of the tongue, neck, trunk brain, eye, and the nervous system. The cysticercus survives for 5 years. Humans become infected by eating pork containing larvae, *cysticercus cellulosae*. When improperly cooked cysticercus infected meat is eaten by man, the scolex remains undigested and attaches itself to the intestinal wall and chain of proglottids begin to grow to adult worm.

Clinical manifestations

Resembles that of *T. saginata* infection.

Diagnosis

Demonstration of eggs in stool specimen.

Prevention:

- Treatment of infected persons.
- Thorough cooking of pork and proper processing
- Proper disposal of human excreta (good hygiene/sanitation).

Diphyllobotrium latum
(fish tapeworm or broad tapeworm)

The broad tapeworm infecting man has worldwide distribution, occurring in areas where improperly cooked or raw fresh water fish is prominent in diet.

Morphology

Diphyllobotrium latum is the broadest and longest tapeworm. The adult worm measures up to 30 feet with 3000-4000 proglottids, which are wider than they are long. The tapeworm has no rostellum hooks or suckers.

Life cycle

Unlike *Taenia*, the gravid segments are retained by the worm. Operculated eggs passed in feces hatch into small ciliated coracidium larvae which swim about freely. These are eaten by crustaceans – Cyclops or Diaptomus – in which the larvae develop into second stage larvae- the procercoid. When the crustaceans are swallowed by fresh water fish, the larvae migrate into the flesh of the muscle fish and develop to pleurocercoid or sparganum larvae. Humans are infected by ingesting raw or improperly cooked fish. The tapeworm matures in the intestine and after 3 weeks, the adult worm discharges eggs. The life cycle requires two intermediate hosts. So far there is no report of the parasite in Ethiopia.

Clinical manifestation

Most infections are asymptomatic. Rarely, it causes severe cramping, abdominal pain, vomiting, weakness and weight loss. Pernicious anemia can also result, due to interference of vitamin B12 absorption in jejunum.

Diagnosis

Eggs in stool: single shell with operculum at one end and a knob on the other.

Prevention

Prohibiting the disposal of untreated sewage into fresh water /lakes. Personal protection: cooking of all fresh water fish.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

a) The definitive main host of the Fasciola hepatica is _____.
b) Larva of Fasciola hepatica, which comes out of the eggs and introduced into the mollusk is called _____.

c) Within the aquatic snail mother sporocyst of the Fasciola hepatica form and produce many mother _____, which subsequently produce many daughter _____ which shed crawling _____, a larva that is capable of swimming with its large tail.
d) Liver fluke disease causes _____.
e) _____ is the reason Paragonimiasis.
f) The second intermediate host of lung fluke (Paragonimus) is _____.
g) The second intermediate host of Opisthorchis viverrini is _____.
h) The second intermediate host of Dicrocoelium dendriticum is _____.
i) The adult worms of Opisthorchis viverrini lives in the _____.
j) The adult worms of _____ lives in the lungs.
k) Tapeworms of cestodes do not have _____ system.
l) Adult worm of HYMENOLEPIS NANA is made up of _____, neck and _____.
m) The head of HYMENOLEPIS NANA carries _____ suckers and a rostellum armed with one row of _____.
n) Oncosphere of HYMENOLEPIS NANA penetrate the villi of the small intestine, where it forms _____.
o) The adult worm of Echinococcus granulosus measures _____ cm in length.
p) Definitive host of Echinococcus granulosus is _____.
q) Adult worms of Echinococcus granulosus live in _____ of definitive host.
r) Man is an _____ host of Echinococcus granulosus - carrying the hydatid cyst (larva).
s) Definitive host of TAENIA SAGINATA is/are _____.

RECOMMENDED TASKS FOR INDEPENDENT WORK

a) Intermediate host of TAENIA SAGINATA is/are _____.
b) Each of the terminal segments of TAENIA SAGINATA contains only _____ made up of a median stem with 15-30 lateral branches.
c) 6-hooked embryo escapes from egg of TAENIA SAGINATA, penetrates through the intestinal wall into the blood vessels and is carried to the muscles where it develops into a larval stage, _____ (made up of an invaginated /inverted head and spherical body).
d) Humans become infected TAENIA SOLIUM by eating pork containing larvae – _____.
e) The globular scolex of TAENIA SOLIUM has rostellum with _____.
f) The first larvae of DIPHYLLOBOTRIUM LATUM which hatch from the eggs in the water is called _____.
g) The second larvae of DIPHYLLOBOTRIUM LATUM which develops in the Cyclops is called _____.
h) The second intermediate host of DIPHYLLOBOTRIUM LATUM is/are _____.
i) The adult form of Dicrocoelium dendriticum lives in the _____.
j) The larvae of Opisthorchis viverrini developed in the following sequence: miracidia, _____, _____, metacercariae.
k) Under the ventral sucker of Dicrocoelium dendriticum is _____.
l) Under the ventral sucker of Opisthorchis viverrini is _____.
m) Adult worms of schistosomes reside in pairs: the female lying in the _____ of the male.
n) Adult worms of schistosomes lives in the _____.
o) Stage rediae absent in the life cycle of _____.
p) Ant is the second intermediate host of _____.
q) Crabs are the second intermediate host of _____.

r) The intermediate host of _____ is a land snail

<u>Unit 27.</u> Nemathelminthes. Medical importance of class Arachnids. Format-practical's.

Discussion questions:

1. Characteristics of class Nematoda (roundworms).
2. The life cycle of pathogens, pathogenesis, diagnosis and prevention of ascariasis, enterobiasis and trichinosis.
3. The life cycle of pathogens, pathogenesis, diagnosis and prevention of ankylostomiasis, strongyloidosis.
4. The life cycle of pathogens, pathogenesis, diagnosis and prevention of guinea worm, filariosis.
5. General characteristics of the class Arachnids. Troop mites: morphology, life cycle, medical value.

IT IS NECESSARY TO PAY ATTENTION TO THE CONTENT OF THE FOLLOWING CONCEPTS:

Larva, main host, intermediate host, filaria, rhabditoid larva, vector-borne disease

KEY POINTS OF THE TOPIC

<u>Ascaris lumbricoides (roundworm)</u>

- Adult worms – Male 15 to 30 cms, Female 20 to 40 cms, oviparous.
- Eggs – 60 µ, bile stained, Albuminous coat with unsegmented ovum.
- Infective form – Embryonated eggs.
- Mode of transmission – Ingestion.
- Site of localization – Small intestine.

Pathogenicity and clinical features

- Ascariasis – infection of *A. lumbricoides*
- Majority of infections are asymptomatic
- Clinical disease is largely restricted to individuals with a high worm load
- Symptoms divided into two groups: those produced by
  1. Migrating larvae
  2. Adult worms

Symptoms and complications

1. Symptoms produced by Migrating larvae
   - Pneumonia (loeffler's syndrome) – fever, cough, dyspnoea, blood tinged sputum that may contain larva, urticarial rash & eosinophilia
   - Visceral larva migrans – if larvae enter systemic circulation (from pulmonary capillaries) to reach other organs like brain, spinal cord, heart, kidney.
2. Symptoms produced by Adult worms
   - Abdominal discomfort, anorexia, nausea & diarrhoea.
   - PEM, Vit. A deficiency (night blindness)
   - Intestinal obstruction (particularly in children 1-5 years), intussusception & volvulus
   - Penetration through intestinal ulcer (perforation) – peritonitis
   - Hypersensitivity reactions to worm Ags (toxic body fluids) – urticaria, edema of face, conjunctivitis, irritation of URT

Pathogenicity and clinical features

1. Symptoms produced by Adult worms:

   Ectopic Ascariasis – due to migration of worm up into the stomach. It may
   - be vomited out,
   - pass up through the oesophagus at night & comes out through mouth or nose,
   - enter larynx to cause asphyxia,

- migrate to other organs and cause appendicitis, cholecystitis, biliary colic, cholangitis, pancreatitis

Laboratory diagnosis

1. Macroscopic – Direct detection of worm/s in stool or vomit
2. Microscopic – direct examination of feces following floatation method: bile stained eggs. (eggs may not be seen at least 40 days after infection)
3. Blood examination – eosinophilia.

Other modes of diagnosis

4. Imaging – large collections of worms in abdomen
5. USG – to diagnose hepatobiliary or pancreatic ascariasis
6. Serology (Ab detection) – mainly reserved for epidemiological studies.

Prevention

1. Good sanitation and personal hygiene
2. Mass treatments with single dose mebendazole or albendazole for all school-age children every three to four months – serves dual function:
   - treats the children and
   - reduces the overall worm burden in the community

Ancylostoma duodenale (hook worm)

Sites of skin penetration:

1. Thin skin between toes
2. Dorsum of the feet
3. Inner side of the soles
4. Gardeners & miners – skin of hands

Pathogenicity and clinical features

- Ancylostomiasis or hookworm disease, characterised by iron deficiency anaemia;
- Majority of infections are asymptomatic;
- Symptoms develop in heavy infections and divided into two groups: those produced by:
  1. Migrating larvae;
  2. Adult worms.

Symptoms produced by larvae

Lesions in the skin:

1. Ancylostome dermatitis or Ground itch – occurs at the site of entry (more common in necator), lasts for 2 to 4 weeks
2. Creeping eruption – reddish itchy papule along the path traversed by filariform larvae (larva migrans)
3. Lesions in the lungs – bronchitis & bronchopneumonia.

Symptoms produced by adult worm

1. Epigastric pain, diarrhoea & vomiting during early phase of infection.
2. Microcytic hypochromic (Iron deficiency) anaemia – due to chronic blood loss:

- a single adult hookworm sucks 0.2ml of blood/ day
- Hemorrhages from punctured sites

Clinical features of hookworm anemia

- Extreme pallor
- Abnormal appetite showing Pica or Geophagy – perverted taste for earth, mud or lime
- Epigastric tenderness with dyspepsia
- Constipation
- Puffy face with swelling of lower eyelids
- Pedal edema
- Growth retardation
- General appearance – pale plumpy with protuberant abdomen & dry lustreless hair.

Laboratory diagnosis

- Stool examination – microscopy: non bile stained egg, segmented

- Occult blood in stool – positive
- Blood examination – anaemia, eosinophilia

Prevention and control

- Proper sanitation measures & sewage disposal
- Personal hygiene
- Personal protection – wearing boots & gloves
- Simultaneous treatment of carriers & diseased with wholesale treatment of community

Strongyloides stercoralis

Pathogenicity

1. Skin lesions (2 types) – "larva currens"
    - At the site of entry – urticarial rash
    - In the perianal region – linear, erythematous urticarial wheal
2. Pulmonary lesions – due to migrating larva
    - Alveolar hemorrhages
    - Bronchopneumonia
3. Intestinal lesions – "burrowing lesions"
    - Epigastric pain
    - Diarrhoea with blood & mucus
    - Nausea
    - Weight loss

Laboratory diagnosis

- Stool examination – rhabditiform larva
- Culture – larva
- ELISA – to detect Abs

Treatment and prevention

- Potentially life threatening disease – treat even if its asymptomatic
- Thiabendazole for 2 days

Disseminated strongyloidosis – 5 to 7 days.

Trichinella spiralis (trichina worm)

Pathogenicity

1. Trichinelliasis / Trichinosis – clinical features depends on the stage:
    - Stage of intestinal invasion: 5-7 days, pain in abdomen, nausea, vomiting, diarrhoea
    - Stage of larval migration: fever, urticarial rash, splinter hemorrhages, periorbital & facial edema
    - Stage of encystation: asymptomatic in light infections; myalgia, weakness in heavy infections
2. Complications – during migration:
    - myocarditis, encephalitis.

Laboratory diagnosis

1. Muscle biopsy – encysted larva
2. Blood – eosinophilia between 2^{nd} and 4^{th} week
3. Serology – to detect specific Abs by:
    - Bentonite flocculation test
    - Latex agglutination test

Prevention

- Proper cooking of pork or proper storage
- Avoidance of feeding bits and refuse from slaughter houses and farms to pigs – breaks life cycle.

Enterobius vermicularis (pin worm, seatworm)

Clinical features

- Due to migration of worm - Perianal, perineal & vaginal itching (pruritis) worsens at night.
- Insomnia and restlessness
- Nocturnal enuresis

Laboratory diagnosis and treatment

- Detection of adult worms in feces or perianal region
- NIH swab – scrapings from perianal region
- Microscopy – non bile stained eggs
- Mebendazole, pyrantel pamoate

Trichuris trichiura (whio worm)

Clinical features

1. Infection – Trichuriasis
2. Symptoms depend on worm burden
3. Less than 10 worms – asymptomatic
4. Heavier infections –
    - chronic profuse mucus and bloody diarrhea with abdominal pains and edematous rectum
    - malnutrition, weight loss and anemia

Laboratory diagnosis and treatment

1. Stool examination – bile stained eggs with bipolar mucus plugs
2. Treatment – albendazole / mebendazole
3. Prevention:
    - Proper disposal of night soil
    - Prevention of consumption of uncooked vegetables & fruits.

RECOMMENDED TASKS TO CONTROL THE LEVEL OF STUDY TOPICS

1. Ascaris lumbricoides is localized in the _____ of man.
2. The infecting larvae in the egg of Ascaris lumbricoides develops in the soil within _____.
3. Definitive host of Ascaris lumbricoides is/are _____.
4. Migration on blood flow through the heart and lungs is typical for the larvae of _____, _____, _____.
5. The female of _____ comes out of the anus and lay eggs in the folds of the perineum.
6. Adult worms of Ancylostoma duodenale is localized in _____.
7. Filariform larvae of Ancylostoma duodenale penetrate the human body through _____.
8. Rabditioform larvae of _____ can produce a generation of free-living worms.
9. Intermediate host of Enterobius vermicularis is/are _____.
10. The intermediate hosts of Wuchereria bancrofti are _____.
11. Site of localization of _____ is large intestine – caecum.
12. Human is infested Trichinella eating _____.
13. The larva of Trichinella forms a capsule in meat, and can survive up to _____ days/months/years.
14. Adult worms of _____ are located in the lymph nodes, disrupting the flow of lymph.
15. Adult worms of Trichuris trichiura are located in _____.
16. Adult worms of Strongyloides stercoralis is localized in _____.
17. Rabditioform larvae of Strongyloides stercoralis develops in _____ larvae which penetrate the human body through the skin.

Unit 28. Medical importance of class Insects. Format-practical's.

Discussion questions:

1. Morphophysiological characteristics and life cycle of the class Insects.
2. Morphology, life cycle and medical importance of insects - ectoparasites (lice, fleas, houses and volfartova flies).
3. Insects - the carriers of infectious and parasitic diseases (gnats, mosquitoes, sandflies, tsetse flies, midges), morphophysiological characteristics, life cycle and medical importance.

KEY POINTS OF THE TOPIC:

LOUSE

Life cycle of louse

There are three stages in the life cycle of louse. Metamorphosis is incomplete.

Eggs: The eggs are laid singly or in groups. They are firmly attached to the hairs or seams of clothing by cemented substance. Eggs are small, pointed at one end and white in color. The female lays up to 300 eggs at the rate of 4-9 a day. Under favorable environmental conditions of temperature, the eggs will hatch in 6-9 days. The eggs will not hatch if the temperature is below 22 c.

Nymph: The nymph looks like the adult except for its smaller size. It feeds on host and develops into adult. The nymph stage may take 10-15 days.

Adult : The entire life cycle from egg to adult takes about 15-17 days under favorable conditions. Adult louse lives from 30 -60 days. If unfed lice are kept away from their host they will die within 2-5 days. Blood fed louse may survive up to 10 days. Heavily infested person have 400-500 louse on their head and clothes.

Dissemination of Lice

1. **Direct Contact**: Lice are disseminated by close contact with lousy or infested persons. Overcrowding provides an excellent opportunity for the direct transference of lice from one person to another. Children get easily infested at school when their heads come together at work or play.
2. **Indirect Contact**: Lice may also be acquired from clothing, bedding, combs or brushes used by lousy persons. Lice have been seen to leave the host whose temperature rises above or falls below the normal.

Control measures

Insecticidal control: The present recommended treatment is of lotion containing o.5% malathian . The lotion should be left for 24 hours, then the hair can be washed. It will kill the louse. Dust containing carbaryle is also effective as louse powder. The powder is applied on the inner surface of the clothing as well as socks and the body of the person.

Mechanical Control: Hand picking of louse from infested person.

Personal hygiene:

a. Daily bath with soap and water.

b. Clothing, sheets and towels should be washed with hot water and soap and pressed with hot iron.

c. Woman with long hair should wash and clean their hair frequently.

d. By Improving living standard we can easily control the louse.

FLEA

The Flea Life Cycle

Fleas undergo complete metamorphosis with four stages: egg, larva, pupa, and adult. Environmental variables influence the length of each developmental stage. Fleas prefer a warm, humid environment, with temperatures ranging between 70 and 90 F and a relative humidity of 75 percent or more. Under ideal conditions, the cat flea life cycle takes just 18 days, from egg to adult.

Adult fleas (both male and female) require a blood meal prior to mating. They prefer blood from your pet, but in the absence of a canine or feline host, fleas will bite people.

Once mated, the female flea may deposit up to 50 eggs *per day* on your dog or cat. An adult flea typically lives for several months, so just a single flea can cause a significant infestation in a short amount of time. As your pet walks around your home, many of the flea eggs fall off. Cat flea eggs are tiny, measuring a mere 1/32 inch, so they can go unnoticed in your pet's bedding, in carpets, or on upholstered furniture.

Within 2 to 5 days, wormlike larvae emerge from the eggs. Lacking eyes and legs, you might think that flea larvae would have a tough time surviving in your carpet. But flea larvae do just fine hunkered down between the carpet fibers, where they feed on anything organic, from hair to adult flea excrement.

The larvae feed and molt for 1 to 2 weeks, and then pupate within silken cocoons. The flea cocoon is often camouflaged with debris, including hair, skin particles, and carpet fibers. In a warm environment and with your cat or dog available for a blood meal, the adult may emerge in about a week. The new adult flea will jump on your pet when he passes by, and immediately begin feeding on his blood.

SELF-GUIDED WORK

№	**Section, unit**	**Summary**	**Number of hours**	**Form of control**
1.	Cellular and molecular-genetical levels of organization of life	Biology as a science of patterns and mechanisms of functioning and development of organisms. Defining the essence of life. The fundamental properties of living. . Evolutionary-based levels of organization of life. The main stages of development of the cell theory. Cell theory of Schleiden-Schwann. Modern cell theory. Structure and function of cell membrane organelles. Structure and function of cell organelles nemembrannyh. Structural and functional organization of the interphase nucleus. Comparative characteristics of pro- and eukaryotic cells. Distinctive features of the cells of plants and animals. The life cycle of the cell. Characteristics of the interphase. Mitosis: phase and biological significance. Morphofunctional characteristic of the hereditary apparatus of cells. Reproduction - the universal property of living. The evolution of reproduction. Biological aspects of sexual dimorphism. Methods of asexual	22	Questions at the exam. Interview

		and sexual reproduction. Cytological and cytogenetic characterization of meiosis.		
2.	Organismic (ontogenetic) the level of organization of biological systems	Subject, objectives, methods and stages of development of genetics. The main provisions of the chromosome theory of heredity. Linked inheritance. The gene as a functional unit of heredity. Classification, properties and localizations of gene. Mendel's laws and cytological bases. Sex linkage. Genetics of sex. The regulation of the activity of genes in prokaryotes. Modification variability, its adaptive nature, meaning in ontogeny and evolution. The concept of normal reaction. Mechanisms combinative variability. The value of combinative variability in ensuring the genotypic diversity of people. Mutational variability. Classification of mutations. The concept of genetic mutations. Genetic disease. Chromosomal mutations (aberration). The concept of chromosomal diseases. Genomic mutations. Euploidiya and aneuplodiya. The concept of ontogenesis. Periodization of ontogenesis. The life cycles of organisms as a reflection of their evolution. Cleavage. Types of cleavage. Types blastula. Gastrulation. Methods gastrulation. Primary and final organogenesis. Embryonic membranes (provisionals organs): structure and physiological significance. Differentiation in development. Stages and differentiation factors. Embryonic induction. The critical periods of development. Teratogenic agents factors. General characteristics and	19	Questions at the exam. Interview

		periodization of postnatal ontogenesis of the person. The regeneration of organs and tissues as a process of development. The physiological and reparative regeneration. Methods of reparative regeneration.		
3	Population-specific level of organization of living systems. Biogeocoenotic and biosphere levels of organization of biological systems.	Pre-Darwinian evolutionary ideas infancy. The evolutionary concept of J.B. Lamark. Darwin's contribution to the development of evolutionary theory. The main provisions of the theory of evolution. The modern synthetic theory of evolution. Population - the unit of evolution. Species - qualitative stage of evolution. Criteria for the species. Factors evolution. The main directions of evolution (biological progress and regression). Ways to achieve biological progress and its forms. Macro- and microevolution. Characteristic of their results. Speciation and its forms. The position of Homo sapiens in the animal world. The qualitative uniqueness of the person. The ratio biological and social factors in the development of human rights. Race and the unity of the human species. Ecology as a science. Environmental factors. Patterns of action of environmental factors on the organisms. The concept of ecosystem biogeocoenose, antropobiogeotsenoze. The principles of interaction of the parasite and the host at an individual level. Parasitism as a biological phenomenon. The origin of parasitism. General characteristics of the class Sarcodina. Morphophysiology and the life cycle of dysenteric amoeba. Diagnosis and prevention of amoebiasis. Morphophysiological characteristic of the class Zoomastigophora. The life cycle	13	Questions at the exam. Interview

		of pathogens, pathogenesis, diagnosis and prevention of trypanosomiasis, leishmaniasis, trichomoniasis and giardiasis. Class Sporozoa. The life cycle of Plasmodium falciparum. Pathogenesis, diagnosis and prevention of malaria and toxoplasmosis. General characteristics of the class Cilliates. The life cycle and pathogenic effect balantidiums. Prevention balantidiaza. Morphological characteristics and breeding trematodes. Features of biology and pathogenic action of opisthorchosis, fascioliasis and paragonimiasis. Features of biology and pathogenic action of tropical trematodes. Total morphophysiological characteristic of the class Cestoda. Class Cestoda. The life cycle of pathogens and pathogenic action, diagnosis and prevention of hymenolepiasis diphilobotriosis, echinococcosis and alveococcosis, teniasis, cysticercosis and teniarinhosis. Morphophysiological characterization of the class Nematoda. The morphology, development cycle and pathogenic effect ascaris, pinworm, whipworm. hookworm, strongyloidiasis, trichinosis, dracunculiasis, onchocerciasis and wuchereriasis. General characteristics of the class Arachnids. Troop mites: morphology, life cycle, medical value. Morphophysiological characteristics and life cycle of the class Insects. Morphology, life cycle and medical importance of insects - ectoparasites (lice, fleas, houses and volfartova flies). Insects - the carriers of infectious and parasitic diseases (gnats,		

		mosquitoes, sandflies, tsetse flies. Midges), morphophysiological characteristics, life cycle and medical importance.		
	Total			**54**

COURSE RESOURCE

List of recommended literature:

a) Core reading*:*

1. Cambell N.A. Biology / N.A. Cambell et al. // Benjamin Cummings, 2013. – p. 1484.
2. Kurnosova N.A., Micheeva N.A. Training toolkit "Cytology". Ulyanovsk: ULSU, 2016. – 120p.
3. Kurnosova N.A., Micheeva N.A. Training toolkit "General Biology. Part A". Ulyanovsk: ULSU, 2017. – 92p.
4. Kurnosova N.A., Micheeva N.A. Training toolkit "General Biology. Part B". Ulyanovsk: ULSU, 2017. – 91p.

b) Supplementary reading*:*

1. Raven P.H. Biology / P.H. Raven, G.B. Johnson, K.A. Mason // MGH, 2002. – p. 1239.
2. Ash, L.R. and Orihel, T.C. 1990. Atlas of Human Parasitology.3rd ed. ASCP Press.
3. Roberts, L.S. and Janovy, J.J. Jr. 2000. Gerald D. Schmidt & Larry S. Roberts. Foundations of Parasitology. 6th ed. McGraw-Hill Publishers.

c) IT software:

Standard software provided by by the Division service maintenance Service of pro-rector on scientific work and information technologies UlGU.

1. Microsoft Windows (only valid version of not lower than Windows XP);
2. Microsoft Office Professional (only valid version of not lower than Office 2003), which includes Word, Excel, Access;
3. Internet-browser of (Internet Explorer, Opera, Mozila and the like)

d) databases, information and reference systems, search systems:

database, information and referral and search engines

1. The electronic catalog of the library of USU
2. System GARANT: electronic periodic reference [electronic resource]. The electronic data. - [BI, 199-].
3. ConsultantPlus: - Search Engine [electronic resource]. The electronic data. - [BI, 199-].
4. The information system "Single window access to educational resources» (http://window.edu.ru/.).

10. **Course facilities:**

- microscopes,
- slides,
- tables,
- cytological atlases,
- research microscope.

ASSESSMENT FUND
on the subject "Biology"

1. Requirements for the results of mastering the discipline

Competence Index	Content of competence	As a result of studying the discipline, students should:		
		to know	***to be able to***	***to be skilled at***
OPC – 7	the readiness to use basic physicochemical, mathematical and other natural science concepts and methods in solving professional problems.	general laws of the origin and evolution of life, anthropogenesis. The theory of biological systems, their organization, cellular and non-cellular forms of life; Cellular organization of living organisms, the distinguishing characteristics of pro - and eukaryotic cells, the role of cellular structures in the life of the cell, the mechanisms of energy production in living systems. Regularities of processes and mechanisms for the storage, transfer and use of biological information in the cell, principles of control of gene expression; Structural and functional organization of genetic material features of the genome of prokaryotes and eukaryotes. Cytological basis of reproduction, gametogenesis, structure of germ cells. The laws of genetics and its importance for medicine. Patterns of heredity and variation in individual	use educational, scientific, popular scientific literature, the Internet for professional activities. To use biological equipment. Research with magnifying equipment (microscopes, optical and simple loops). Cooking time and explore their products under a light microscope and magnifying glass. Put a simple biological experiment and analyze the results. Read and analyze the electron diffraction pattern of cell structures. In the form of generalized diagrams show the processes occurring in the cell. Using this notation, to solve problems on mitosis, meiosis, gametogenesis. Explain the causes and possible mechanisms of birth of children with chromosomal diseases. Solve problems on genetics, molecular, make the pedigrees using standard notation, analyze pedigrees. Compile and analyze the ideograms, using the Denver classification system	research with a microscope. Skills cooking time products. Skills mapping studied objects in the figures; Electron diffraction analysis skills. Skills determining of karyotype. Genetic approaches to solving problems. Standard notation for drawing pedigrees. Denver classification system for the analysis of chromosome ideograms microscopy.

		development, biological basis of inherited human diseases and methods of their diagnostics. Regularities of individual development of organisms, human ontogenesis, molecular mechanisms of embryonic development, critical periods of ontogenesis. Environmental category environmental health issues, bioecological disease. The phenomenon of parasitism. The morphological features of the parasites, their life cycles, ways of infection, pathogenic action, symptoms, diagnosis, prevention of diseases. Parasitological and medical characteristics of arthropod - vectors and pathogens.	chromosomes. Identify the type of parasite, stage of development of the proposed drug. To solve situational problems in parasitology.	

2. Passport of fund of appraisal funds for the discipline

№	Supervised discipline sections	Competence Index	Evaluation tools		Control method
			Name	Task number	
1.	Cellular and molecular-genetical levels of organization of life	OPC – 7	Questions for the exam (to know) Situational task (to be able) Slides (to be skilled at)	1-13 1-22 1-6	Interview
2.	Organismic (ontogenetic) the level of organization of biological systems	OPC – 7	Questions for the exam (to know) Situational task (to be able) Slides (to be skilled at)	14-34 23-35 7-15	Interview
3	Population-specific level of organization of living systems. Biogeocoenotic and biosphere levels of organization of biological systems.	OPC – 7	Questions for the exam (to know) Situational task (to be able) Slides, macropreparation (to be skilled at)	35-70 36-60 16-30, 1-8	Interview

3. Evaluation tools for intermediate certification of the discipline "Biology"

3.1. Suggested final test questions of *the discipline "Biology"*

1. Biology as a science of patterns and mechanisms of functioning and development of organisms.
2. Defining the essence of life. The fundamental properties of living. . Evolutionary-based levels of organization of life.
3. The main stages of development of the cell theory. Cell theory of Schleiden-Schwann, Vi. Modern cell theory.
4. Structure and function of cell membrane organelles.
5. Structure and function of cell organelles nemembrannyh.
6. Structural and functional organization of the interphase nucleus.
7. Comparative characteristics of pro- and eukaryotic cells. Distinctive features of the cells of plants and animals.
8. The life cycle of the cell. Characteristics of the interphase.
9. Mitosis: phase and biological significance.
10. Morphofunctional characteristic of the hereditary apparatus of cells.
11. Reproduction - the universal property of living. The evolution of reproduction. Biological aspects of sexual dimorphism.
12. Methods of asexual and sexual reproduction.
13. Cytological and cytogenetic characterization of meiosis.
14. Subject, objectives, methods and stages of development of genetics.
15. The main provisions of the chromosome theory of heredity. Linked inheritance.
16. The gene as a functional unit of heredity. Classification, properties and localizations of gene.
17. Mendel's laws and cytological bases.

18. Sex linkage. Genetics of sex.
19. The regulation of the activity of genes in prokaryotes.
20. Modification variability, its adaptive nature, meaning in ontogeny and evolution. The concept of normal reaction.
21. Mechanisms combinative variability. The value of combinative variability in ensuring the genotypic diversity of people.
22. Mutational variability. Classification of mutations. The concept of genetic mutations. Genetic disease.
23. Chromosomal mutations (aberration). The concept of chromosomal diseases.
24. Genomic mutations. Euploidiya and aneuplodiya.
25. The concept of ontogenesis. Periodization of ontogenesis. The life cycles of organisms as a reflection of their evolution.
26. Cleavage. Types of cleavage. Types blastula.
27. Gastrulation. Methods gastrulation.
28. Primary and final organogenesis.
29. Embryonic membranes (provisionals organs): structure and physiological significance.
30. Differentiation in development. Stages and differentiation factors.
31. Embryonic induction.
32. The critical periods of development. Teratogenic agents factors.
33. General characteristics and periodization of postnatal ontogenesis of the person.
34. The regeneration of organs and tissues as a process of development. The physiological and reparative regeneration. Methods of reparative regeneration.
35. Pre-Darwinian evolutionary ideas infancy. The evolutionary concept of J.B. Lamark.
36. Darwin's contribution to the development of evolutionary theory. The main provisions of the theory of evolution.
37. The modern synthetic theory of evolution. Population - the unit of evolution.
38. Species - qualitative stage of evolution. Criteria for the species.
Factors evolution.
39. The main directions of evolution (biological progress and regression). Ways to achieve biological progress (aromorphosis, idioadaptation total degeneration) and its forms.
40. Macro- and microevolution. Characteristic of their results. Speciation and its forms.
41. The position of Homo sapiens in the animal world. The qualitative uniqueness of the person.
42. The ratio biological and social factors in the development of human rights.
43. Race and the unity of the human species.
44. Ecology as a science.
45. Environmental factors. Patterns of action of environmental factors on the body.
46. The concept of ecosystem biogeocoenose, antropobiogeotsenoze.
47. The principles of interaction of the parasite and the host at an individual level. Parasitism as a biological phenomenon. The origin of parasitism.
48. General characteristics of the class Sarcodina. Morphophysiology and the life cycle of dysenteric amoeba. Diagnosis and prevention of amoebiasis.
49. Morphophysiological characteristic of the class Zoomastigophora. The life cycle of pathogens, pathogenesis, diagnosis and prevention of trypanosomiasis.
50. Morphophysiological characteristic of the class Zoomastigophora. The life cycle of pathogens, pathogenesis, diagnosis and prevention of leishmaniasis.
51. Morphophysiological characteristic of the class Zoomastigophora. The life cycle of pathogens, pathogenesis, diagnosis and prevention of trichomoniasis and giardiasis.
52. Class Sporozoa. The life cycle of Plasmodium falciparum. Pathogenesis, diagnosis and prevention of malaria.
53. Morphophysiology, lifecycle and pathogenic effect of the pathogen of toxoplasmosis.
54. General characteristics of the class "Cilliates". The life cycle and pathogenic effect balantidiums. Prevention balantidiaza.

55. Class Flukes. Morphological characteristics and breeding trematodes.
56. Features of biology and pathogenic action of opisthorchosis, fascioliasis and Paragonimiasis.
57. Features of biology and pathogenic action of tropical trematodes.
58. Total morphophysiological characteristic of the class Cestoda.
59. Class Cestoda. The life cycle of pathogens and pathogenic action, diagnosis and prevention and hymenolepiasis diphilobotriosis.
60. Class Cestoda. The life cycle of pathogens and pathogenic action, diagnosis and prevention of echinococcosis and alveococcosis.
61. Class Cestoda. The life cycle of pathogens and pathogenic action, diagnosis and prevention teniasis, cysticercosis and teniarinhosis.
62. Morphophysiological characterization of the class Nematoda.
63. The morphology, development cycle and pathogenic effect ascaris, pinworm, whipworm. Laboratory diagnosis and prevention nematosis.
64. Class Nematoda. The life cycle of pathogens pathogenic action, diagnosis and prevention of hookworm, strongyloidiasis, trichinosis.
65. Class Nematoda. The life cycle of pathogens pathogenic action, diagnosis and prevention of dracunculiasis, onchocerciasis and wuchereriasis.
66. General characteristics of the class Arachnids.
67. Troop mites: morphology, life cycle, medical value.
68. Morphophysiological characteristics and life cycle of the class Insects.
69. Morphology, life cycle and medical importance of insects - ectoparasites (lice, fleas, houses and volfartova flies).
70. Insects - the carriers of infectious and parasitic diseases (gnats, mosquitoes, sandflies, tsetse flies. Midges), morphophysiological characteristics, life cycle and medical importance.

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3.3. The situational tasks

1. The microscope is installed opposite the switched on source of artificial illumination, however, the field of view in the eyepiece is dark. What should be done and in what sequence, so that the field of view becomes the most illuminated?

2. With a high magnification, the object looks fuzzy at all positions of the microscrew. Explain the sequence of your actions to overcome this situation.

3. A foreign body is visible in the field of view. How can one determine its localization (drug, objective lens, eyepiece lens) and improve image quality?

4. The microscope is installed opposite the source of artificial light. The field of view is not evenly illuminated. Observed the decomposition of light (diffraction). What should be done to overcome this situation?

5. At low magnification microscope obtained high-quality image of the object. In the transition to the consideration of the object with a high magnification microscope objective lens rests on the cover glass and can not assume the normal position. Explain the cause of the defect and the sequence of your actions to overcome this situation.

6. If during mitosis in humans did not separate one pair of chromosomes? two pairs? How many chromosomes will be in the daughter cells?

7. In human tissue culture, one chromosome was eliminated. How many chromosomes will be in the daughter cells after mitosis (consider the possibility of elimination in different phases of mitosis)?

8. Cytophotometric studies revealed single- and dual-core tetraploid cells in the liver. At what phase was the course of mitosis not completed in either case?

9. By experimental intervention, the cell was artificially divided into two parts - with and without a nucleus. What is the viability of these parts of the cell?

10. In the cage, the figures of the two daughter stars are visible. What is the phase of mitosis?

11. At mitotic division of a somatic human cell, daughter cells were formed. What set of chromosomes do they have?

12. The cell is in mitosis. Does it contain protein synthesis for "export"?

13. Using a quantitative method, it was determined that the nucleus of an interphase cell contains twice the amount of DNA. What is the cell cycle period?

14. After processing cells in tissue culture with colchicine, the researchers stopped finding dividing cells. How can this be explained, if it is known that colchicine destroys tubulin filaments?

15. Is it possible to say that between two chromosomes in one cell during the prophase of the first division of meiosis is conjugation?

16. During abnormal meiosis in the original human cell with 46 chromosomes, one pair of homologous chromosomes did not go to different poles. Where it leads?

17. As a result of the elimination of one of the chromosomes, an XO-type cell enters meiosis, where O denotes the absence of a chromosome. What cells will result from meiosis?

18. Using morphometry, comparative data on the diameter of eggs from chicken, turtles, cats and humans are obtained. Between which of them are the differences found and which are close in this indicator? Explain why?

19. In a dispute, one student claimed that the zygote contains a haploid set of chromosomes, the second one argued that it was diploid. Explain which of them is right.

20. An electron micrograph of the sperm cell shows a centriole with an axoneme extending from it. What is the sperm section?

21. At what phases of spermatogenesis is the germ cell most sensitive to the action of ionizing radiation? With what it can be connected?

22. One student claimed that the spermatozoon acrosome is a derivative of the Golgi complex; another believed that the acrosome is an analogue of lysosomes; a third student expressed the opinion that it contains hydrolytic enzymes. Rate these judgments.

23. A woman turned to the genetic counseling department, concerned that her husband had polydactyly. She wondered whether the occurrence of this disease is possible in her future children. After examining the genealogies of both spouses and finding that the father of the spouse, as well as all the relatives along the line of the wife did not have this disease, the doctor concluded that the probability of polydactylism in the children of this couple is 50%. Explain the conclusion of the doctor, if it is known that the gene of polydactyly dominates over the gene of the normal structure of the brush.

24. A deaf-and-dumb woman married a man with normal hearing. They had a deaf-mute child. The couple turned into a genetic consultation with the question, is it possible to have a healthy child? What answer did they get if the hereditary deaf-mutism gene is recessive with respect to the gene for normal hearing?

25. A man turned to genetic counseling, concerned that his child had blood group II, while he had I, and his wife had group IV. The doctor dispelled the doubts of his father. Explain the response of the genetic counseling officer.

26. In the mulatto family a white child was born. The father of the family is concerned that the boy who was born is not his son. Are his concerns justified?

27. The boy, who has a small height, is concerned that he will not grow up anymore, as his parents are also short. Can a son be higher than his parents?

28. A man with normal blood clotting is excited about the news that his wife's sister gave birth to a hemophilic boy (he thinks about the health of his future children). To what extent could he be reassured by the message that among the relatives of his maternal wife, hemophilia was never observed?

29. In the study of gastrulation revealed stratification of blastoderm cells into two layers lying one above the other. What are these two cell layers called first? What is this method of gastrulation called? For which groups of animals is it characteristic?

30. A thick ectoderm and endoderm in the form of a thin leaf, represented by flattened cells, are clearly visible on the microscope of the chicken embryo. On the midline of the embryo, the ectoderm forms an embossment in the form of a groove. The mesoderm is located between the ecto-and endoderm in the direction to the side of the midline, due to which the embryo has a three-layer structure. What stage of development of the embryo is represented on this microdrug?

31. Studying the development of the embryo of an animal, the researchers observed the process of introduction into the blastocella cavity of individual cells migrating from the wall of the blastula. What is the name of this phenomenon? For which animals is it typical?

32. With this method of gastrulation, the material of the future mesoderm is screwed together with the endoderm as part of a single gastric weaving, and in the process of invagination the boundary between the two tabs is usually indistinguishable. What group of animals has this method of laying mesoderm? What is it called?

33. After transplanting a part of cells from one embryo (donor) of amphibians onto the ventral surface of the body to the second embryo (recipient), the latter formed the caudal part of the body of the additional (second) embryo. From which part of the donor embryo were cells taken for transplantation to donor-recipient? At what stage of development of the donor and recipient can such an experiment be carried out? From which part of the donor embryo is it necessary to take cells in order to form the cranial part of the additional recipient embryo?

34. Transplantation of the otic vesicle, the nasal placode, or the pituitary gland into the lateral line region of the newt embryo has been shown to induce the development of accessory limbs. What do these experiments show? What is the role of the inducer and the reacting region in the formation of a specific response?

35. After treating the embryos of tritons at the gastrula stage with the enzyme trypsin, the destruction of the material connecting the cells to each other occurred. What happens if for dissociated cells to create conditions for free movement and connection with each other? What mechanism of ontogenesis is demonstrated by experience?

36. It is known that mutational variability in organisms supplying material for selection is random and not directed. How does microevolution then become directional?

37. Give an explanation from an evolutionary standpoint to the following expression: "Not individual genes are selected, but integral phenotypes. The phenotype is not only an object of selection, but also acts as a transmitter of hereditary information in generations."

38. Most mutations are extremely rare, independent of the number of genes in the genotype of organisms. Bacteria possessing the smallest number of genes and, consequently, the smallest number of mutations per individual, generally have a high rate of mutation in populations. Explain why? What determines the speed of the mutation process in populations?

39. Female butterflies of bear bears of normal and melanistic forms are more likely to intersect with males of a color other than their own. Why is such a crossing in natural populations occur more often?

40. Modern science in determining the type uses different criteria. What are the errors that can lead to the establishment of species by only one of the criteria? Show it with concrete examples.

41. Five races of the Sevan trout are known, which spawn in different months. The shift in the timing of reproduction of fish is small, but very significant for the existence of individual populations. What is the mechanism responsible for the differences between the populations of Sevan trout? What is its significance for the species as a whole?

42. Your comrades argue on four questions and ask you to help them figure out: How did life begin on Earth? Some argue that it originated biogenically, while others - abiogenically; What are the most important biopolymers should the bodies of the first living organisms consist of? Some believe that proteins could be such a substance, others that nucleic acids, others - proteins + nucleic acids; What organisms on the method of nutrition occurred first? Some believe that heterotrophic organisms appeared before everyone else, after them autotrophs. Others hold the opposite opinion; What type of breathing was characteristic of the first living organisms? Odnitschitaet more ancient anaerobic type, others - aerobic. What is your opinion on these issues? What arguments can you give to confirm your opinion?

43. It is known that miscarriages in humans make up 25% of all conceptions. Survival is higher in those children whose weight is close to the average. What is the evolutionary factor in question? What is the significance of this factor in the evolution of modern man?

44. The main factors in the evolution of the organic world include hereditary variability and natural selection. Which of these factors retains its value in human society? What can the effect of this factor lead to under conditions of weakening the action of natural selection?

45. Compare social insects, a herd of monkeys and modern human society and explain in the life of which of them there are biological and social factors of evolution? In the life of which of them are only biological laws?

46. In many literary sources it is written that at present the life of a person is no longer regulated by natural selection. Do you agree with this statement? Give examples of evidence that you are right.

47. What features of the structure of the body and lifestyle helped the ancient two-legged monkeys to survive in the struggle for existence? Explain how the development of the structure and lifestyle changes in human ancestors could lead to the emergence of a qualitative line between monkeys and the most ancient people?

48. Some scientists attribute Australopithecus to human ancestors, while others do not. Why are scientists' opinions about them divided?

49. The vertical position of the body in humans has led to a number of changes in the structure of the skeleton (especially the spine, pelvis, hand), muscles and internal organs. What are these changes and what is their significance?

50. Arthropod U moves to the blood supply of terrestrial vertebrates. Describe the likely set of morphological and biological adaptations that has arisen in this species.

51. In some species of trematodes S, the amount of glycogen per dry weight is about 70%, in another type of trematodes Q, this figure is about 10%. What can be said about the localization of these trematodes. Justify the answer.

52. The parasite has hairs on the surface of the tegument. What are the peculiarities of nutrition of this parasite? What is characteristic of his digestive system?

53. Endoparasite feeds on blood. What are the needs of the parasite, in addition to food, while it can be met and how?

54. Metacyclic trypanosomes of the Trypanosoma lewesi species accumulate in the posterior gut of fleas, with flea excrement they fall on the host's skin, and then through the mucous membrane into the blood. Determine how the host is infected.

55. Ducks catch the trematode Echinostoma, eating aquatic mollusks, in which these trematodes are cystic cercidated. Determine how the host is infected.

56. In cats, the strobylar stage of the cestode is parasitic, Dipylidium caninum, and in fleas, the cysticercoid of this cestode is parasitic. In the named pair of hosts, determine the final and intermediate.

57. The patient has a fever, an enlarged spleen and liver; found a decrease in the content of red blood cells. Microscopic examination of smear punctate of the sternum showed that the bone marrow leaflets contain a large number of small, unicellular, free-burning parasites. In the cytoplasm is one nucleus. When the parasite is cultivated in an artificial medium, it turns into a flagellate form. What disease can be assumed in this case?

58. Microscopic examination of the patient's discharge from skin ulcers revealed small parasites of a round or oval shape, in the body of which there are single nuclei displaced to the periphery. Parasites either fill the cytoplasm of the cells, or freely lie near the destroyed cells. When such organisms are cultivated in an artificial nutrient medium, they turn into a flagellate form. Specify the species name of the parasite.

59. A patient has an increase in body temperature, an increase in lymph nodes, on the skin of the hand, the bite of some insect is surrounded by a mild rash. In the blood smear between erythrocytes, single-terminal single-celled organisms with a single nucleus are found. Make a diagnosis.

60. A sick, middle-aged man with complaints of severe headache, high fever (39-40 C) was delivered to the infectious diseases department of the clinical hospital. From the anamnesis - a week before the disease went into the woods, took off a few ticks sucked. On examination, the neuropathologist revealed characteristic lesions in the gray matter of the spinal cord and trunk: paralysis of the muscles of the neck and forelimbs; the absence of reflexes on the hands and a decrease in the muscle tone of both hands. What is your presumptive diagnosis? What clinical and laboratory research methods need to be conducted to confirm the final diagnosis? Specify the path of infection? What recommendations should be given on measures of personal prevention?

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The microscopic slides and macropreparations.

a) the slides

1. Golgi complex.
2. Mitochondria in the cells of the intestinal roundworm.
3. Inclusion of fat in liver cells amphibian.
4. The inclusions of glycogen.
5. Pigment inclusion in chromatophores tadpole skin.
6. Mitosis in onion of root.
7. Polytene chromosomes.
8. Blastula frog.
9. Frog gastrula.
10. Frog neurula (early).
11. Frog neurula (average).
12. Frog neurula (late).
13. Primary chicken embryo strip.
14. Somites, notochord, neural tube.
15. Trunk and chicken embryo amniotic fold.
16. Lancet fluke.
17. Cat fluke.
18. Lung fluke.

19. Roundworm eggs.
20. Eggs of liver fluke.
21. Eggs of bovine tapeworm.
22. Eggs of broad tapeworm.
23. Eggs of pinworm eggs.
24. Oncosphere.
25. The tick Ixodes.
26. Gamasid mites.
27. Mouthparts of the mosquito.
28. Flea dog.
29. Head louse.
30. Nit.

b) the macropreparation

1. Ascaris (male and female).
2. Wide tapeworm.
3. Liver fluke.
4. Echinococcus.
5. Ascaris (male and female).
6. Wide tapeworm.
7. Liver fluke.
8. Echinococcus.

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