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for international students 1st year studing pharmacy

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Topic 1. MAGNIFYING DEVICES. METHODS OF STUDYING CELLS

1. The subject, tasks and methods of cytology. Cytology (Latin *cytos* — a cell, *logos* — a science) — is a science studying the structure, chemical composition and functions of cells, their multiplication, development and interaction in a multicellular organism.

The tasks of cytology:

– studying the structure and function of cells and their components (membranes, organoids, inclusions and nucleus);

– studying cellular division and possibilities of their adaptation to environmental changes;

– studying interrelations between cells in a multicellular organism.

Methods of cytology:

1. *Microscopic* — they help study morphology of cells and their components (the methods of light and electron microscopy).

2. *Cytochemical (histochemical)* — they help determine the chemical composition or localization of substances in the cell (in tissue sections). They are based on special staining stuff.

3. *Biochemical* are used for studying the chemical composition of cells, determination of substance concentration in tissues. They are based on the property to absorb light waves of a definite length by different biochemical compounds.

4. *The method of differential centrifugation* helps study the composition and properties of cellular organoids: a tissue specimen is fragmentized to destroy cellular membranes, then placed into the centrifuge, where it is divided into separate fractions.

5. *The method of autography* is used for studying the dynamics of metabolic processes in cellular structures. It means the introduction of radioactive isotopes into the cell. Molecules marked with radioactive isotopes (^{3}H, ^{32}P, ^{14}C) participate in exchange reactions. Their localization, movement, accumulation and excretion are determined by radiation registered with a photoplate.

6. *Rhoentgenostructural analysis* is performed for studying the spacious structure and arrangement of molecules in the substance. This method is based on diffraction of R-rays passing through a substance crystal.

2. Magnifying devices and their purpose. The light microscope arrangement.

A biological microscope is intended for studying micro-objects in the flow of passing light. A light microscope (fig. 1) consists of 3 parts: mechanical, illuminating and optical.

The *mechanical* part includes a stand, a stage, a cremaliera (a macrometric screw), a micrometric screw, a draw-tube and a revolver.

The support consists of a draw-tube holder (column) and a base. The column contains:

– a revolver — a rotating mechanism for changing objectives;

– a draw-tube — a hollow tube for fixing an ocular;

– a system of screws for rough (macrometric) and fine (micrometric) adjustment of the microscope;

– a stage for placing an investigation object.

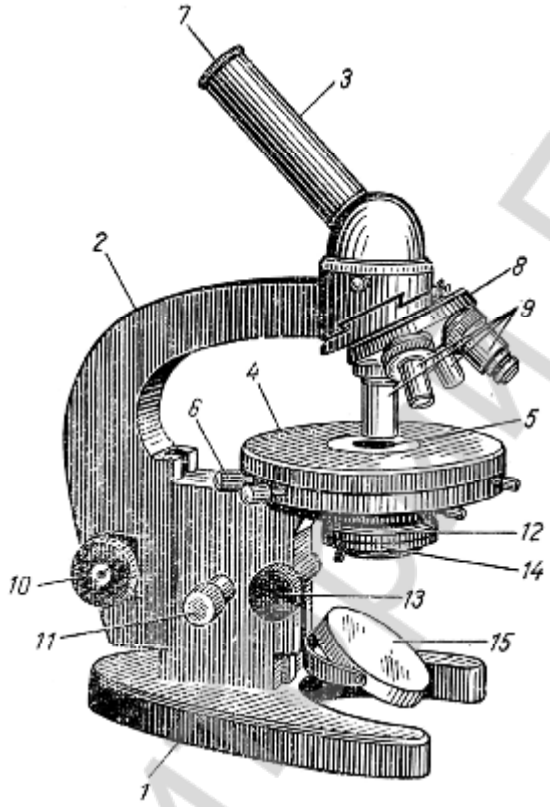


Fig. 1. The structure of a light microscope:
1 — a base; *2* — a draw-tube holder; *3* — a draw-tube; *4* — a stage; *5* — an aperture of the stage; *6* — screws for moving the stage; *7* — an ocular; *8* — a revolving device; *9* — objectives; *10* — a cremaliera; *11* — a micrometric screw (in some models it is located on the base); *12* — a condenser; *13, 14* — a screw and diaphragm of the condenser respectively; *15* — a mirror

The *illuminating* part includes a mirror (or an electric illuminator) and a condenser.

The *mirror* of the microscope is double-sided — with a convex and concave surface. A concave surface is used under natural illumination, while a flat one — under artificial illumination.

The condenser is a lens system collecting light rays into a band. The light band diameter can be regulated with a special level, changing the diaphragm lumen.

The *optical* system consists of an ocular and objectives.

The *ocular* (*oculus* — an eye) is a lens system directed towards the eye. Magnification is indicated on the ocular mount. A teaching microscope uses spare oculars with magnification 7×, 10× and 15×.

The *objective* is located at a lower end of the draw-tube — it is a lens system directed to the investigated object. Two kinds of objectives are used: with small magnification (8×) and a large one (40×).

The total magnification of the microscope is determined by multiplying the multiple of the objective and ocular magnifications. For example, the total magnification of the microscope with 40× objective magnification and 7× ocular magnification will be equal to 280.

3. Rules of working with the microscope:

1. Put the microscope column towards yourself and the mirror towards the light origin; approximately a palm width from the stage edge.
2. Set the objective 2–3 cm from the surface of the stage rotating the *macrometric* screw.
3. Check the adjustment of the objective with small magnification (8×) until it «clicks», it should be fixed opposite the aperture on the stage.
4. Put the condenser into a neutral position and open the diaphragm completely.
5. *Looking into the ocular,* direct the mirror surface to the light source for even illumination of the *field of vision*.
6. Place the micropreparation on the stage, the cover glass should be directed towards the objective!
7. *Looking on the side* (!), lower the objective 0,5 cm from the surface of the cover glass with a macrometric screw (the focal distance of the objective with 8× is *about 1 cm*).
8. Looking into the ocular, rotate *the macrometric screw towards «yourself»* slowly (!) and get a clear image of the object.
9. Study the object. Move the preparation manually.

Note: If the object is too small and is not seen at small magnification, then adjust the microscope to an edge of the cover glass. Having obtained a clear image of the glass edge, move it further to a working field in search of the object.

Rules of working with a large magnification (7 × 40) microscope:

1. Get a clear object image at small magnification (see above).
2. Center the needed area of a micropreparation — move it to the center of the field of vision.
3. Rotate the objective with large magnification (×40).using a revolver until it «clicks».
4. Put the condenser into an upper position. Looking from the side, *carefully* lower the large magnification objective with the macrometric screw until it touches the surface of the cover glass (the focal distance of 40× objective is approximately 1–2 mm).

5. Looking into the ocular, turn slightly a *macrometric screw «towards yourself»* (!) until the object outlines appear.

6. Use a *micrometric screw* for getting a better image turning it towards yourself or from yourself *no more than 0,5 turn*.

7. Study the needed area of the micropreparation.

Terminating the work with the microscope:

1. Having finished studying the object, raise the draw-tube 2–3 cm with a macrometric screw and take off the preparation off the stage.

2. Set a small magnification objective until it «clicks» by turning the revolver and fix it against the aperture on the stage.

3. Lower the objective to the stage level with a macrometric screw.

Basic terms and concepts:

1. Immersion — liquid that fills the space between the cover glass and the immersion objective (90×).

2. Condensor — is a lens system collecting light rays into a bundle.

3. Cremaliera — is a macrometric screw.

4. Objective — is a lens system, which are screwed into the revolver and are directed to the stage.

5. Ocular — is a lens system inserted into an upper aperture of the draw-tube and directed to the eye.

6. Resolution — is the ability of the optic device to differentiate small details: a minimum distance between two adjacent points (lines), which are possible to differentiate.

7. Revolving mechanism — is a rotating mechanism for changing objectives, which is fixed on the column of the support.

Topic 2. BIOLOGY OF THE CELL. THE FLOW OF SUBSTANCE AND ENERGY IN THE CELL

1. The present state of the cellular theory.

1. The cell — is an elementary structural-functional and genetic unit of all living things, open self-regulating system, through which flows of substances, energy and information pass (fig. 2).

2. Cells of all organisms have similar structure, chemical composition and processes of vital activity.

3. New cells form, when the mother cell divides.

4. Cells of a multicellular organism differentiate and form tissues for performing various functions.

2. **Differentiating signs of pro- and eukaryotic cells** (tab. 1).

Table 1

Pro- and eukaryotic cells

Prokaryotes	Eukaryotes
Differences	
Mycoplasms, bacteria, cyanobacteria	Protists, plant and animal cells
Sizes: 1–10 μm	10–100 μm
There is no nucleus, but a nucleoide	There is a formed nucleus
DNA is not linked with proteins-histones	DNA is linked with proteins-histones
There is no mitosis and membrane organoids, their functions are performed by mesosomes — drawings-in of the cellular membrane	There is mitosis and membrane organoids (fig. 3)

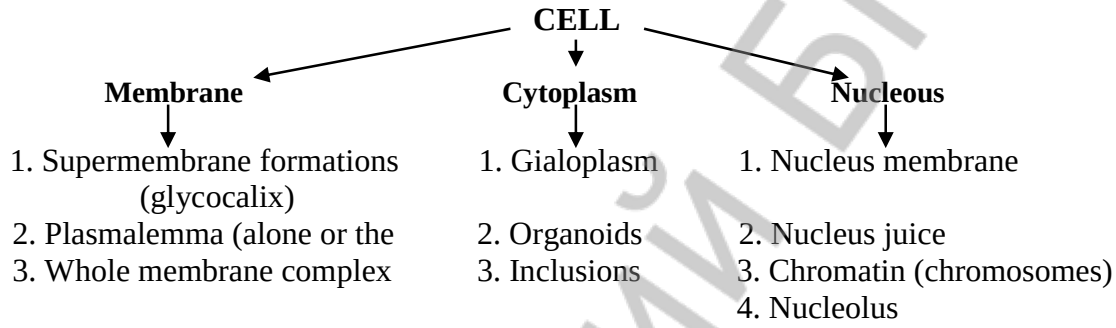


Fig. 2. The diagram of the cell structure

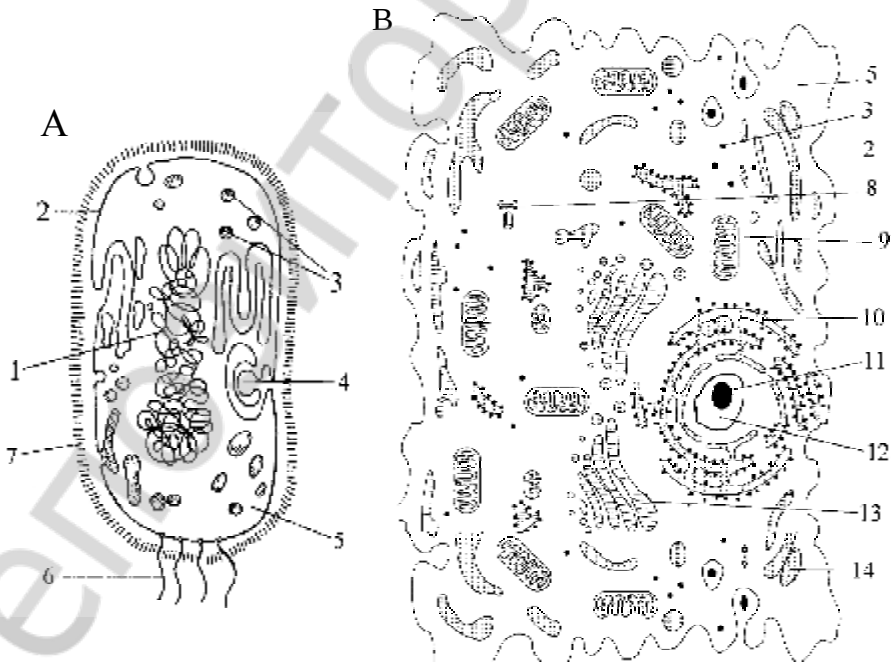


Fig. 3. The structure of a prokaryotic and eukaryotic cells:
A — prokaryotic cell, *B* — eukaryotic cell: *1* — a nucleoide; *2* — plasmalemma; *3* — ribosomes; *4* — a mesosome; *5* — cytoplasm; *6* — a filament; *7* — a cell wall; *8* — a cell center; *9* — a mitochondria; *10* — a granular EPR; *11* — a nucleolus; *12* — a nucleus; *13* — Golgi's complex; *14* — a smooth EPR

3. The structure of (a model) elementary membrane, its properties and functions.

In 1943 N. Dowson and P. Danielli proposed the first model of an elementary membrane. It was a **«sandwich» model**. Two layers of lipid molecules are located between two layers of protein molecules. Every lipid molecule has two ends — *hydrophilic* (water-soluble) and *hydrophobic* (water insoluble). Hydrophobic parts of molecules are directed towards each other, hydrophilic ones — towards proteins (fig. 4).

A fluid-mosaic model is better; it meets the requirements of properties and functions of an elementary membrane. It was proposed in 1972 by S. Singer and G. Nikolson (fig. 4).

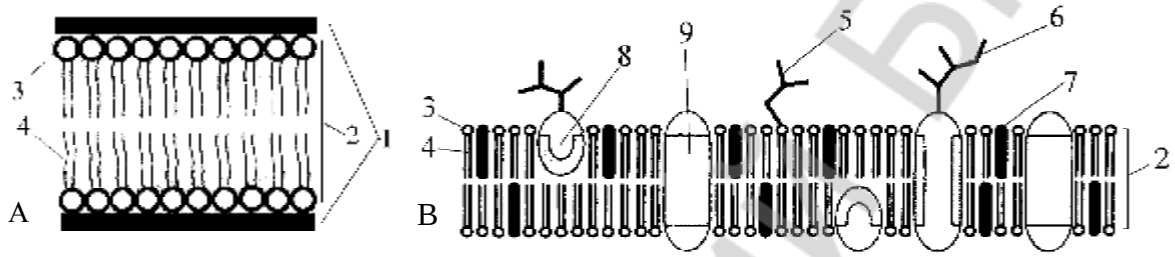


Fig. 4. The diagram of elementary membrane models:
A — sandwich, *B* — fluid-mosaic: *1* — solid protein layers; *2* — a bilipid layer; *3* — hydrophilic heads of phospholipids; *4* — hydrophobic tails of phospholipids; *5* — glycolipid; *6* — glycoprotein; *7* — cholesterol; *8* — semi-integral protein; *9* — integral protein

The basic membrane components — lipids — compose from 20 to 80 % of its mass. They are phospholipids, lecithin and cholesterol. Protein molecules are in a double layer of lipid molecules that form a «lipid sea». Protein molecules, which penetrate 2 layers of lipid molecules, are *integral*. Those protein molecules, which are immersed into one layer, are *semi-integral*. *Peripheral proteins* are on the surface of lipids. The third component of an elementary membrane — are *glycoproteins* and *glycolipids* forming a receptor apparatus on its surface (*glycocalix*).

Properties of the elementary membrane:

– plasticity (it restores quickly after impairment and also stretches and constricts in cellular movements);
– semi-permeability (passes molecules selectively);
– ability for self-locking (vesicles and vacuoles are formed).

Functions of the elementary membrane:

– structural (membranes are included into the composition of all cellular organoids except ribosomes and centrosomes);
– barrier (protects the cell from external factors and sustains its composition);
– metabolic (many enzymes are located on membranes);
– receptor (receives signals, recognizes substances).

4. Methods of passing substances into the cell:

1. *Passive transport* follows the concentration gradient without spending energy. Water and small molecules can pass into the cell by filtration, diffusion, through pores or in the process of solution in lipids.

2. *Lighted diffusion* is associated with participation of proteins-transmitters in transferring molecules — permeasis. Amino acids, sugar, fatty acids get into the cell in this way.

3. *Active transpoprt* demands energy expenditure, because it follows against the concentration gradient. Such transport demands enzymes, ATP molecules and formation of special ion canals. A sodium-potassium pump is an example of such transport.

4. *Endocytosis* — is participation of the membrane itself in catching particles or molecules and transporting them into the cell. *Endocytosis* — is a modified architectonics (outlines) of the membrane. Transport of macromolecules or hard particles is *phagocytosis*, while transport of fluid is *pinocytosis*.

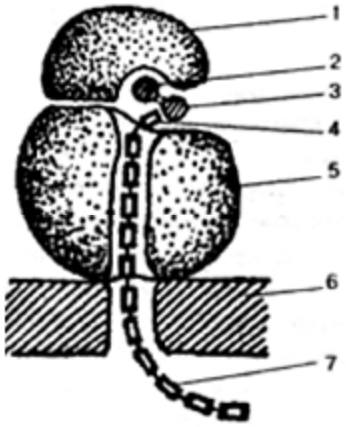


Fig. 5. The structure of ribosome: *1* — small subunit; *2* — m RNA, *3* — t RNA; *4* — amimo acids; *5* — large subunit; *6* — membrane of EPR; *7* — protein

5. The cell anabolic system. The cell anabolic system performs reactions of plastic exchange or assimilation.

Organoids — are differentiated areas of the cytoplasm. They have a constant structure and perform specific functions.

Ribosomes — are spherical bodies (15–35 nm in diameter) consisting of two subunits. They may be in hyaloplasm, on the external nucleous membrane, on membranes of the endoplasmatic net. A *large subunit* of the ribosome contains three different molecules r-RNA and 40 molecules of proteins, a *small subunit* — one r-RNA molecule and 33 protein molecules (fig. 5). Ribosome subunits are synthesized in nucleoli. The information about the r-RNI structure is contained in «*nucleoli-organizers*» (DNA molecule areas in the region of secondary constrictions of satellite chromosomes). The final assembly of ribosomes in subunits occurs in the process of translation.

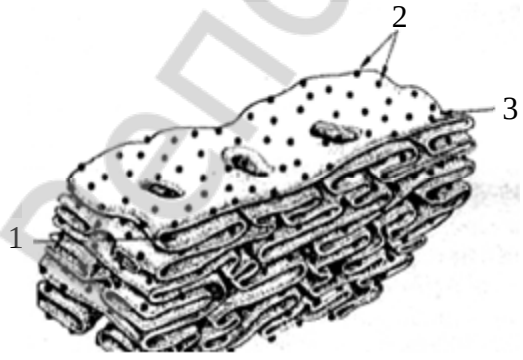


Fig. 6. The structure of granular EPR: *1* — canal; *2* — ribosomes; *3* — membrane

The function of ribosomes is assembling protein molecules (translation).

Endoplasmatic reticulum (EPR) — are canals located throughout the cell and connected with the perinuclear space of

the nucleus and cavities of Golgi's complex (fig. 6). A canal wall is an elementary membrane. EPR canals perform the function of compartmentalization of the cell cytoplasm, its division into areas, where various biochemical reactions take place. The granular EPR (ribosomes are placed on its membranes) participate in protein biosynthesis, which are later transported to Golgi's complex.

Carbohydrates and lipids are synthesized on membranes of a smooth EPR (does not contain ribosomes). It takes part in synthesizing steroid hormones, in detoxication of toxic substances (liver cells).

Golgi's complex consists of vesicles, tubules, sacs. Dictyosomes are basic elements of the complex.

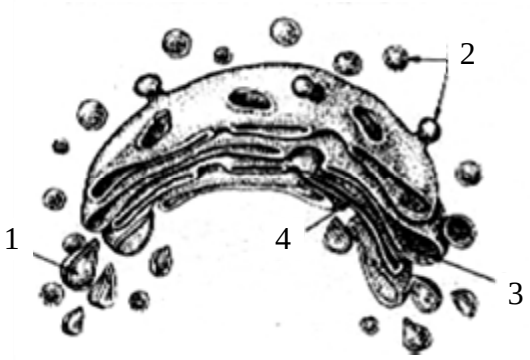


Fig. 7. The structure of Golgi's complex: *1* — vacuole; *2* — vesicles; *3* — membrane; *4* — canal

Dictyosomes — are piles of closed sacs of 10–15 elementary membranes that have dilations on the ends. These dilations form vesicles that separate and transform into lyzosomes and vacuoles (fig. 7). Part of these vesicles excrete secretes and metabolites from the cell.

Functions of Golgi's complex:

– sorting and packing substances synthesized in EPN;

– synthesizing complex compounds (lipoproteins, glycoproteins);

– assembling elementary membranes;

– forming lyzosomes, glyoxisomes and vacuoles;

– taking part in substance secretion

6. The cell catabolic system. The cell catabolic system performs energy exchange or dissimilation.

Primary lyzosomes form in Golgi's complex. They are rounded bodies (0,2–0,2 μm in diameter) covered with an elementary membrane. They include approximately 50 different hydrolytic enzymes. *Secondary lyzosomes* (phagolyzosomes) contain breakable substances.

Functions of lyzosomes:

– breaking up substances passed into the cell in phagocytosis;

– destroying impaired structures and organoids of the cell.

Peroxisomes are formed in EPN. Their enzymes (oxidazes) oxidize amino acids with formation of peroxide (H_2O_2).

Glyoxisomes are formed in Golgi's complex, their enzymes transform fats into carbohydrates.

Mitochondria have a shape of rods, filaments and granules. The size of mitochondria is from 0,5 to 7 μm. Their number is not the same in cells with different activity. A mitochondrion wall has an external and internal membrane. Projections of the internal membrane form *crysts*, between which is the matrix

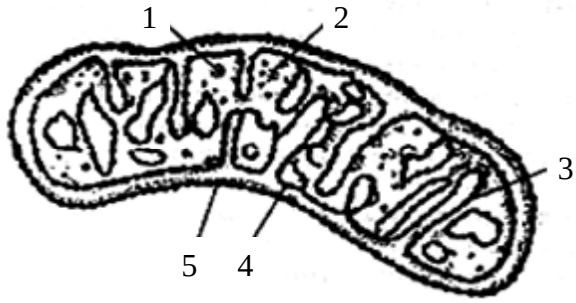


Fig. 8. The structure of mitochondria: *1* — ribosome; *2* — matrix; *3* — crysts; *4* — internal membrane; *5* — external membrane

containing enzyme systems of an oxygen stage of energy exchange and an autonomous system of protein biosynthesis (ribosomes, RNA and ring DNA molecules). The interspace between mitochondrion wall membranes is filled with perimitochondrial *space* (fig. 8).

Functions of mitochondria:

– ATP synthesis;

– Synthesis of specific proteins and steroid hormones.

7. Energy exchange in the cell. Fermentation systems of mitochondria.

Energy exchange is the sum of fermentation breaking-down reactions of complex organic compounds followed by releasing energy used for ATP synthesis.

The preparatory stage goes in the digestive system and in phagosomes of cells, where complex organic compounds break down into simple ones: polysaccharides to monosacharides, proteins to amino acids, fats to glycerol and fatty acids. The released energy is dissipated as warmth.

The Anaerobic stage (glycolysis) occurs in the cytoplasm of cells. Ten enzymes participate in it. Glucose breaks down to pyroacemic (lactic) acid and 2 ATP molecules form. The pyroacemic acid passes into mitochondria for further transformations.

Aerobic stage of energy exchange occurs in mitochondria.

There are 3 fermentation systems in mitochondria:

– Krebs cycle (of citric acid) — in the matrix;

– tissue respiration — on the internal membrane;

– oxidation phosphorilizing — ATP-somes (mushroom-shaped bodies).

Pyroacemic acid comes into the internal matrix of the mitochondrion and interacts with co-enzyme A (KoA), when Acetyl KoA (an activated form of Acetic acid) forms. CO_2 and H^o chip off Acetyl KoA. CO_2 is excreted by mitochondria, and H^+ and e (from hydrogen atoms) pass to the enzyme system of tissue respiration. Protons accumulate on the external surface of the internal membrane and electrons — on the internal one. Having reached a critical potential (200 mv), protons pass through canals into ATP-somes. Electrons give the energy away for adding the rest of phosphoric acid to ADP (ATP synthesis) and they join protons. Hydrogen atoms are formed, they mix with oxygen and form water molecules. 38 mol of ATP from 1 mol of glucose are formed as a result of all reactions of energy exchange.

Basic terms and concepts:

1. **Glycocalix** — is a receptor apparatus of an animal cell membrane.
2. **Glycolysis** — is a process of breaking down glucose without oxygen.

3. Glyoxisomes — are organoids, where transformation of fats into carbohydrates takes place.

4. Concentration gradient — is the difference of substance concentrations.

5. Mesosomes — are drawings-in of prokaryotic cells plasmolemma, which perform a role of membrane organoids.

6. Nucleoid — is a genetic apparatus of prokaryotes.

7. Peroxisomes — are organoids, where oxidation of amino acids occurs and peroxide is formed.

8. Plasmalemma — is a membrane, which is included into the cell membrane.

9. Enzymes of oxidizing phosphorilizing — are enzymes of mitochondria localized in ATP-somes.

10. Enzymes of tissue respiration — are enzymes of mitochondria localized in crysts.

11. Enzymes of Krebs cycle — are enzymes of mitochondria localized in the matrix.

Topic 3. THE FLOW OF GENETIC INFORMATION IN THE CELL

1. The structure and functions of the nucleus.

The basic genetic information is in the nucleus. The nucleus (Latin — *nucleus*; Greek — *karyon*) was described in 1831 by R. Brown. The shape of the nucleus depends on the shape and functions of the cell.

Fig. 9. The structure of nucleus: *1* — internal membrane; *2* — external membrane; *3* — pore; *4* — nucleoli; *5* — chromatin; *6* — nuclear juice

The *membrane* of an interphase nucleus (*karyolemma*) consists of an external and internal elementary membrane (fig. 9). A *prenuclear space* is between them. There are openings in membranes, *pores*. Protein molecules forming *porous complexes* are in the pores. When the cell is active, the majority of pores are open. The substance flow passes through them from the cytoplasm into the nucleus and back. The number of pores in one nucleus reaches 3–4 thousand. The external nucleus membrane is linked with endoplasmatic net canals. *Ribosomes* are usually placed on it. Proteins of the internal nuclear membrane form a *nuclear plate*. It sustains a constant shape of the nucleus and chromosomes are attached to it.

Nuclear juice — is *karyolymph*, a colloid solution in a jelly-like state, that contains proteins, lipids, carbohydrates, RNA, nucleotides, enzymes.

Nucleolus — is a temporary component of the nucleus: it disappears in the beginning of cellular division and restores in the end of it. Chemical composition: protein (~90 %), r-RNA (~6 %), lipids, enzymes. Nucleoli form in

the area of secondary constrictions of satellite chromosomes. Function: assembling ribosome subunits.

Chromatin of the nucleus — interphase chromosomes. They contain DNA, proteins-histones and RNA in ratio 1 : 1,3 : 0,2. DNA together with protein form *desoxiribonucleoprotein* (DNP). DNP spiralizes and forms chromosomes during mitotic division of the nucleus.

Functions of the nucleus:

1) forms hereditary information of the cell;
2) takes part in cellular division (multiplication);
3) regulates metabolic processes in the cell.

2. Types of chromosomes. The structure of a metaphasal chromosome. Chromosomes (Greek — *chromo* — color, *soma* — body) — is spiralized chromatin. The chromosome length is 0,2–5,0 μm, diameter — 0,2–2,0 μm.

A metaphasal chromosome consists of 2 *chromatids*, that are linked with a *centermere (primary constriction)*. It divides the chromosome into 2 *arms.* Some chromosomes have *secondary constrictions*. The area they separate is a satellite, and such chromosomes are called satellite. Terminal areas of chromosomes are telomeres (fig. 10). Each chromatid includes one DNA molecule together with proteins-histones. Chromosomal areas with intense staining are areas of strong spiralization (*heterochromatin*). Lighter areas — are areas of weak spiralization (*euchromatin*).

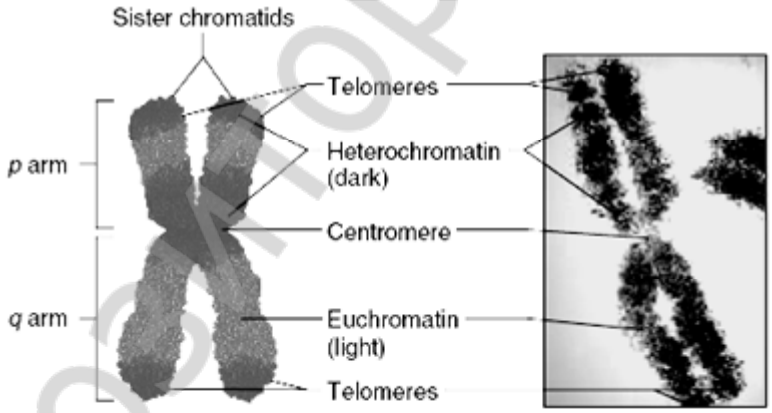


Fig. 10. The diagram of chromosome

Types of chromosomes according to the centermere position (fig. 11):

1. *Metacentric* — the centermere is in the middle, the arms are of identical length.

2. *Submetacentric* — the centermere is biased from the center, the arms are of different length.

3. *Acrocentric* — the centermere is far from the center, one arm is very short, and the other — very long.

One can meet gigantic, *polytenous chromosomes* (polyfilament chromosomes) in cells of insects (Drosophila) salivary glands.

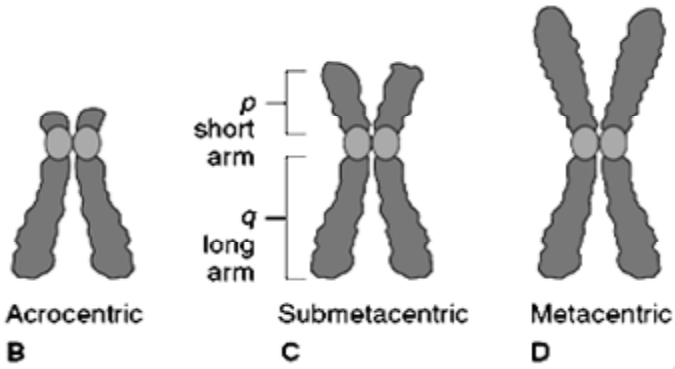


Fig. 11. The diagram types of chromosome

There are 4 rules for chromosomes of all organisms:

1. *The rule of a constant number of chromosomes*. Organisms have a constant characteristic of the species number of chromosomes. For example, in the human — 46, in the dog — 78, in Drosophila — 8.

2. *Parity of chromosomes*. In norm, every chromosome in a diploid complement has a pared chromosome — identical in shape and size.

3. *Individuality of chromosomes*. Chromosomes of different pairs differ in shape, structure and size.

4. *Continuity of chromosomes*. When genetic material is doubled, a chromosome originates from a chromosome.

Chromosomal function: storing, reproduction and transmission of genetic information, when cells and organisms multiply.

3. Cellular and mitotic cycles. There is a cellular and mitotic cycle in life of cells (fig. 12).

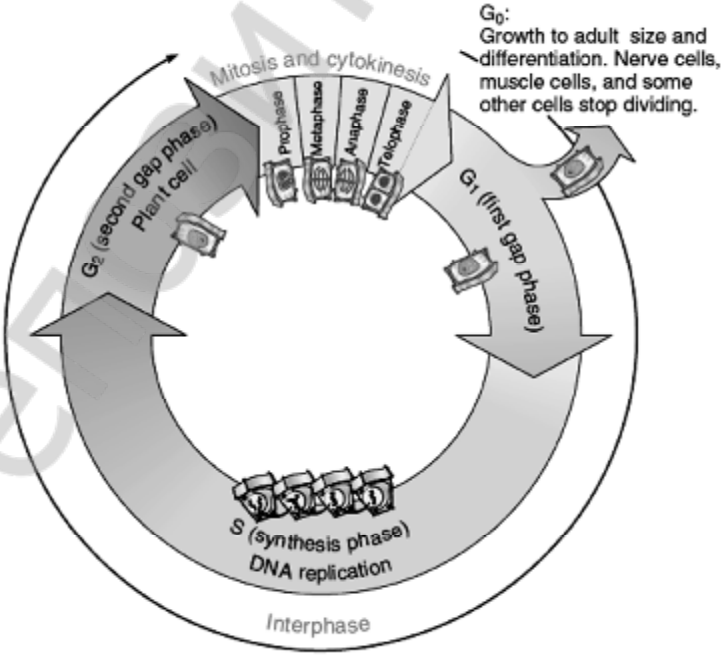


Fig. 12. The diagram types of cellular cycle

Cellular or life cycle of the cell — is a period from the appearance of the cell until its death or to the end of next cellular division. *The period of life cycle of somatic cells*: growth and differentiation, performing specific functions, preparation for division (multiplication), division. A mitotic cycle is characteristic of the majority of cells — a period of its preparation for division (interphase) and the division itself (mitosis).

4. Interphase, characteristic of periods. Reasons of mitosis.

The interphase includes three periods: G_1 — *pre-synthetic (post-mitotic)*, S — *synthetic* and G_2 — *post-synthetic (pre-mitotic)*. The content of genetic material in the cell changes during the interphase: n — a haploid complement of the chromosome, chr — the number of chromatids in the chromosome, c — the number of DNA complements.

Pre-synthetic period. The cell grows, performs its functions. RNA, proteins, DNA nucleotides are synthesized in it, the number of chromosomes increases, ATP accumulates. The period lasts 12 hours but it may take several months. The content of genetic material — 2n l chr 2c.

During the *synthetic period,* replication of DNA molecules occurs — each chromatid adds one more identical to itself. The content of genetic material becomes 2n2chr4c. Centrioles duplicate. RNA, ATP and proteins-histones are synthesized. The cell continues performing its functions. The duration of the period is up to 8 hours.

During the *post-synthetic period* energy of ATP accumulates; RNA, nuclear proteins and proteins-tubulines necessary for chromatin division spindle are actively synthesized. The content of genetic material does not change: 2n2chr4c. By the end of the period all synthetic processes become slower, the cytoplasm viscosity changes.

Reasons of mitosis:

– changing of the nuclear-cytoplasmatic ratio from $^1/_6$–$^1/_7$ to $^1/_{69}$–$^1/_{89}$;

– the presence of «mitogenetic rays» which stimulate division of adjacent cells;

– action of «wound hormones», which determine impaired cells and stimulate division of unimpaired cells.

5. Characteristic and significance of mitosis.

The basic method of dividing somatic cells is mitosis. Mitosis has four stages: a prophase, metaphase, anaphase and telophase (fig. 13).

The *prophase* starts with spiralization of chromatin: long chromatin filaments are shortened and thickened forming chromosomes. Centrioles diverge to cell poles; filaments of the division spindle are formed. Nucleoli and nuclear membrane dissolve, the nucleus volume enlarges. The content of genetic material is 2n2chr4c.

The metaphase: chromosomes are located at the cell equator forming a *metapasal plate*. Filaments of the division spindle are attached to the center-

mere of chromosomes. One can see that each chromosome consists of two chromatids. The content of genetic material does not change — 2n2chr4c.

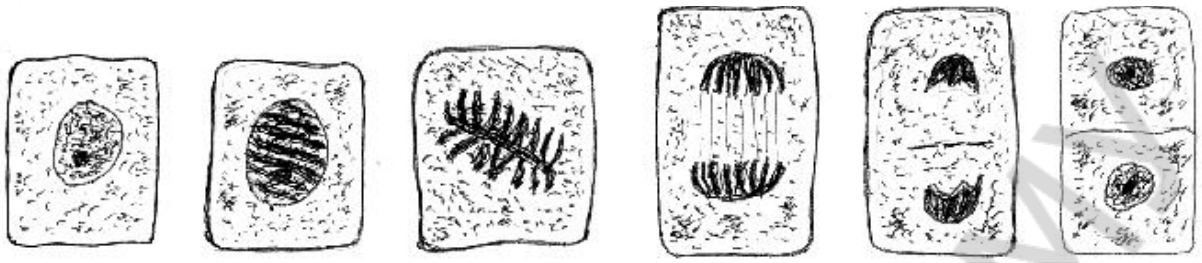


Fig. 13. The diagram of mitosis:
1 — interphase*; 2* — prophase*; 3* — metaphase*; 4* — anaphase*; 5* — telophase, *6* — daughter cells

Anaphase. Filaments of the division spindle constrict. In the region of centermeres, chromosomes are divided into two chromatids. The chromatids diverge to cell poles. They are daughter chromosomes. The content of genetic information at each pole of the cell — 2n I chr2c.

During the *telophase* the formation of daughter nuclei continues. Nuclear membranes are formed, chromosomes are despiralized, loose their clear outlines and nucleoli are restored. The final stage of mitosis is cytokinesis (division of the cytoplasm). The cellular membrane is formed by fusion vesicles of the endoplasmatic net. Two cells are formed, the content of genetic material of which — 2n I chr2c.

The significance of mitosis:

– sustaining the constancy of the chromosome number, providing genetic succession in cellular populations;

– even distribution of chromosomes and genetic information between daughter cells.

6. Characteristic and significance of meiosis.

Meiosis is a variety of mitosis. Meiosis is division of somatic cells of gonads that leads to the formation of gamets. Meiosis consists of two divisions — meiosis I and meiosis II. Each division has four phases: prophase I and prophase II, metaphase I and metaphase II, anaphase I and anaphase II, telophase I and telophase II (fig. 14).

The prophase of meiosis I is most complicated. It has 5 stages:

1. *Leptotena*: chromatin spiralizes forming thin chromatin filaments that start moving to each other with centermere parts; genetic material — 2n2chr4c.

2. *Zygotena*: *conjugation* of short and thick chromatin filaments (chromosomes) starts, they join along the whole length; genetic information does not change — 2n2chr4c.

3. *Pachitena*: homologous chromosomes are tightly joined along the whole length; the formed figures are *bivalents* of chromosomes or *tetrads* of chroma-

tids; genetic material can be recorded as $ln_{biv}4chr4c$; by the end of the stage antagonizing forces start acting in the area of centermeres and *crossing-over* occurs, exchange of homologous chromosomes parts.

4. *Diplotena*: antagonizing forces continue their action, but chromosomes stay joined in the area of chiasm (crossings); the content of genetic material is preserved — $ln_{biv}4chr4c$;

5. *Diakinesis*: chromosomal spiralization finishes, the nuclear membrane and nucleolus disappear; chromosomal bivalents linked with their ends come into the cytoplasm and move towards the center of the cell; filaments of the division spindle attach to centermeres of chromosomes; $ln_{biv}4chr4c$.

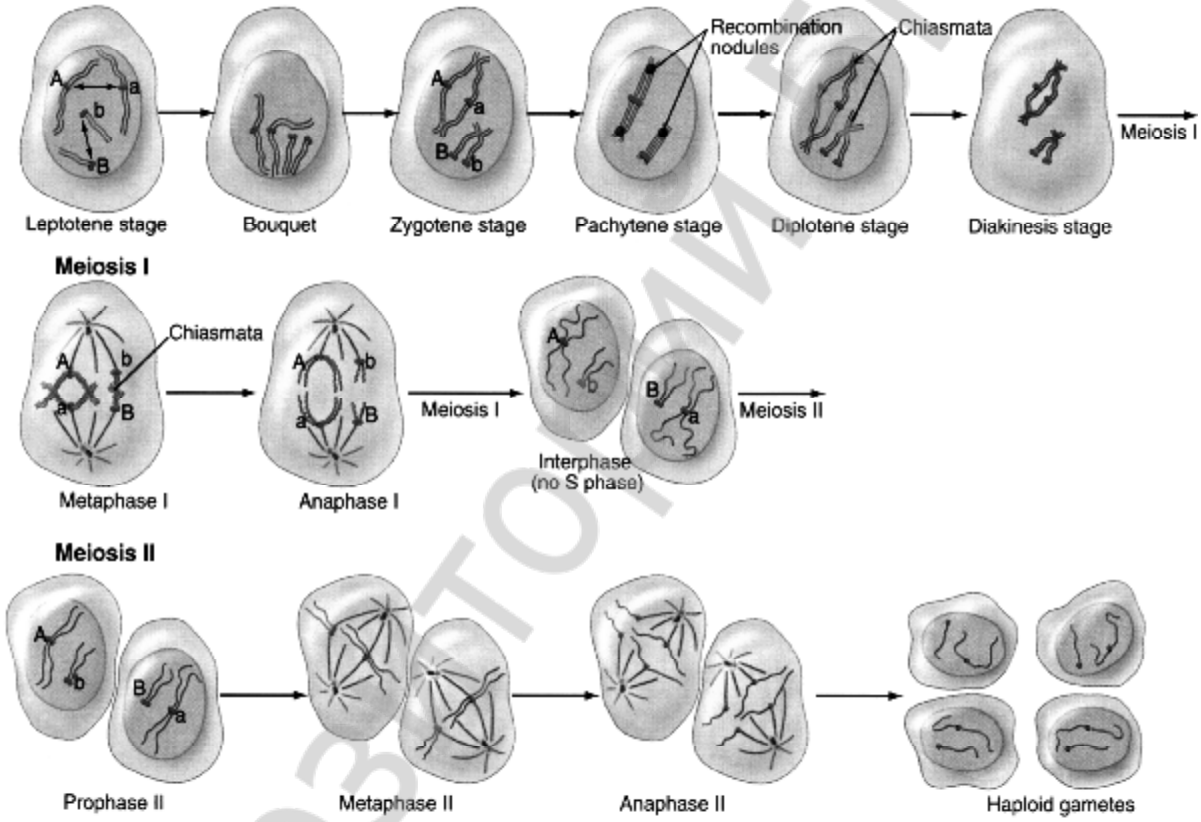


Fig. 14. The diagram of meiosis

In the **metaphase of meiosis I,** bivalents are located along the equator of the cell; separate chromosomes are clearly seen; genetic material — $ln_{biv}4chr4c$.

Anaphase I: bivalents are divided into homologous chromosomes. Filaments of the division spindle constrict, that is why chromosomes diverge to cell poles. Each chromosome still contains 2 chromatids. The content of genetic material at each cell pole — is ln2chr2c. During this phase the reduction (decrease) of the number of chromosomes occurs — a diploid complement of chromosomes becomes a haploid one.

In the **telophase of meiosis I,** cytokinesis takes place, and two-daughter haploid cells form — ln2chr2c; unlike mitosis in this phase, despiralization of chromosomes does not occur.

After meiosis I comes **interkinesis** — a short interval between two divisions. DNA replication does not occur. Interkinesis is followed by meiosis II.

Meiosis II almost does not differ from mitosis. In prophase II, spiralization of chromosomes (ln2chr2c) does not occur, and in anaphase II chromatids but not chromosomes diverge to cell poles. Each daughter cell gets a complement of genetic information 1n1chr1c.

During meiosis one mother haploid cell forms 4 cells (gamets) with a haploid complement of chromosomes.

The significance of meiosis: it is a mechanism of gamete formation; it sustains the constancy of the number of chromosomes; provides combinative variation.

7. Amitosis. During amitosis chromatin is not spiralized and the division spindle is not formed. The nucleus and cytoplasm are divided by constriction into two. Usually amitosis divides epithelial cells of mucous membranes, cancer cells (genetic information there may be distributed unevenly) and cells participating in regeneration. Amitosis can lead to the formation of multinuclear cells (the nucleus has divided, but the cytoplasm has not).

Basic terms and concepts:

1. Bivalents — two homologous chromosomes, conjugated with each other during the prophase of meiosis I. Their number is equal to a haploid complement of chromosomes.

2. Karyolymph — nuclear juice.

3. Cellular cycle — is a period from the appearance of the cell to its death or to the end of next cellular division.

4. Conjugation of chromosomes — linkage of homologous chromosomes in length.

5. Crossing-over — is exchange of identical parts of chromatids of homologous chromosomes in pachitena of the prophase of meiosis I.

6. Meiosis — is division of somatic cell of gonads, when gametes are formed.

7. Mitotic cycle — is a preparation period of the cell for division (interphase) and division itself (mitosis).

8. Telomeres of chromosomes — terminal parts of chromosomal arms.

9. Chiasms — cross of chromatids of homologous chromosomes in conjugation.

10. Chromatin — is a complex consisting of DNA and histone proteins

11. Nuclear-cytoplasmatic ratio — is a physiologically and morphologically regular ratio of the mass (volume) of the nucleus to the mass (volume) of the cytoplasm in every cell.

Topic 4. ORGANIZATION OF HEREDITARY MATERIAL

1. Nucleic acids (DNA and RNA): the structure and functions. Chargaff's rules.

In 1870 I. Misher described macromolecule in nucleus and called them **nucleic acids** (from Latin *nucleus* — nucleus). DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) refer to nucleic acids. The structure of a DNA molecule was decoded in 1953 by J. Watson, F. Krik and M. Wilkinson.

The nucleic acids are biopolymeres. Their monomeres are *nucleotides*. A nucleotide consists of a nitrogenous base, 5-carbon sugar and residue of the *phosphoric acid*. Nitrogenous bases are of types: adenine, guanine, cytosine, thymine, uracyl. Nitrogenous bases are denoted: A, G — purine, T, C, U — pyrimidine. 5-carbon sugar — is *deoxiribose* or *ribose*.

The **DNA** molecule consists of two sequences which are interwoven as spirals. Each sequence is a polynucleotide. A DNA nucleotide consists of a nitrogenous base (adenine, guanine, cytosine and thymine), deoxiribose and a residue of the phosphoric acid (fig. 15). The nucleotide sequence is linked by *phosphodieather bonds* between deoxiribose of and the residue of the phosphoric acid of the other nucleotide. There are linked nitrogenous bases within the spiral; they are linked to each other according to the principle of *complementarity*: A = T — 2 hydrogen bonds G ≡ C — 3 hydrogen bonds.

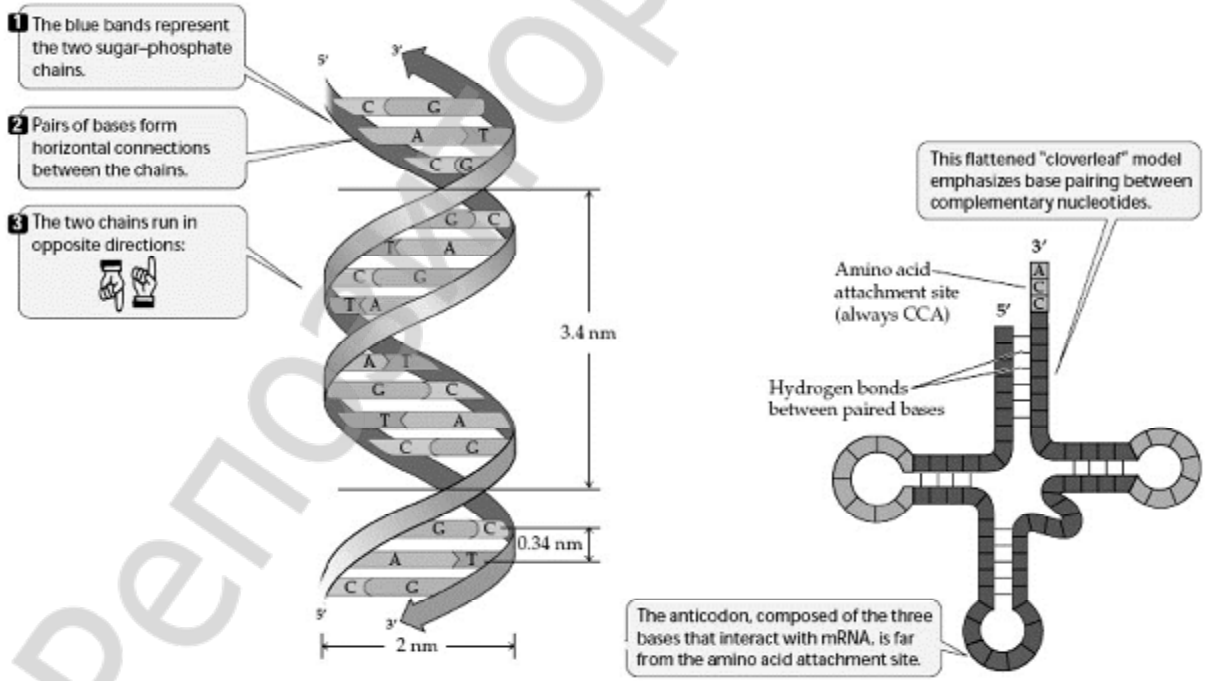


Fig. 15. Structure of a DNA molecule and tRNA

The complementarity property of nitrogenous bases is expressed in Chargaf's rules:

– the number of purine bases is equal to the number of pyrimidine bases: A + G = C + T;

– the amount of adenine is equal to the amount of thymine (A = T), the amount of guanine is equal to the amount of cytosine (G = C).

The DNA is in the cellular nucleus, in mitochondria and plastids. DNA properties: *replication* (self-reproduction) and ability to *repair* (restoration of the structure after impairment of the molecule). DNA functions: storing and transmitting genetic information during multiplication of cells and organisms.

The **RNA** molecule is a polynucleotide consisting of one sequence. In comparison with a DNA it includes uracil instead of thiamin and sugar ribose instead of deoxiribose. In some viruses, RNA has two sequences.

The cell has 3 types of RNA, they are in the nucleus, cytoplasm, mitochondria and plastids. 3–4 % of the whole RNA compose the *messenger RNA* (mRNA): it «records» the genetic information from DNA and translocates it into ribosomes — a place, where protein molecules are assembled. The *ribosomal RNA* (r-RMNA) composes 80–85 % of the whole RNA. It is included into ribosomes and provides special interposition of i-RNA and r-RNA. The *transport RNA* (t-RNA) comprises 10–20 % of the whole RNA, it transports (transfers) amino acids from the cytoplasm to ribosomes.

2. Properties of genes.

The gene is a part of a DNA molecule coding a definite polypeptide. Genes are characterized by the following properties:

1. *Specificity* — a unique sequence of nucleotides for every structural gene.
2. *Integrity* — being a functional unit (programming of protein synthesis) the gene is integral.
3. *Discretion* — the gene includes two subunits: a muton — a subunit, which is responsible for mutations; a recon, which is responsible for recombination. Their minimum number — a pair of nucleotides.
4. *Stability* — genes are relatively stable. The frequency of unconditioned mutations of a gene is approximately 10^{-5} per a generation.
5. *Lability* — they can modify, mutate.
6. *Pleotropia* — multiple genic action (one gene is responsible for several characters).
7. *Expressivity* — the degree of phenotypical manifestation of the gene. It is due to environmental factors and effect of other genes.
8. *Penetration* — frequency of appearing the gene: a ratio (in percents) of the number of individuals having this character to the number of individuals having this gene.

3. DNA replication.

Genes perform two functions in the cell. A *heterosynthetic* function is programming of biosynthesis in the cell. An *autosynthetic* function — is replication of DNA (self-doubling of DNA).

Replication of DNA occurs in the synthetic period of the interphase. Synthesis of the DNA molecule is semi-conservative: one sequence is motherly («old»), a new daughter sequence («new») is assembled on it. The new sequence is assembled according to complementarity of the mother sequence. The main enzyme of synthesis is a DNA-polymeraze (fig. 16).

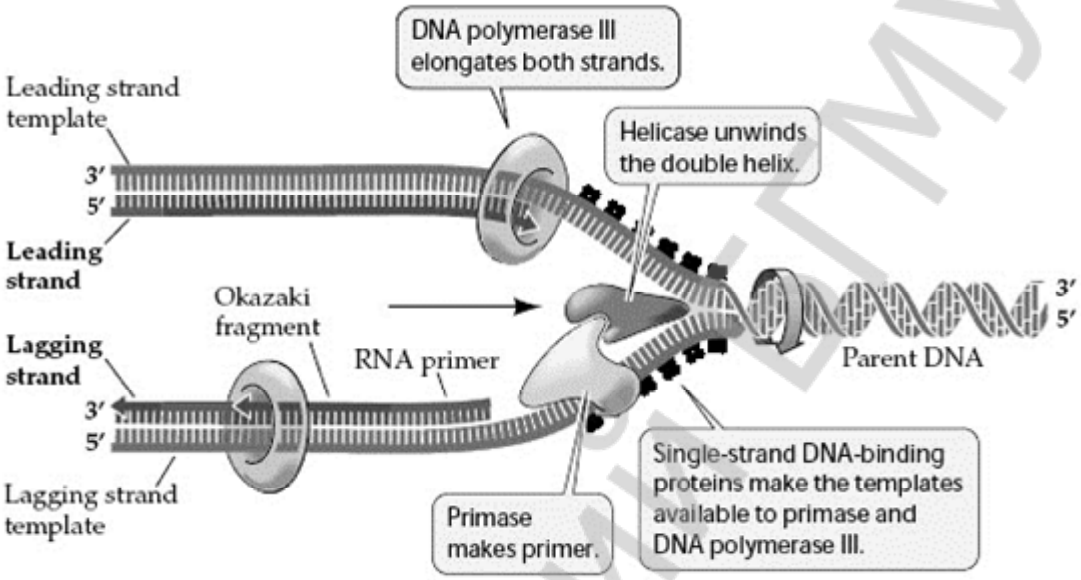


Fig. 16. Replication of a DNA molecule

The spiral of a DNA molecule under the action of the DNA-helicase enzyme is unwinded by 2 sequences, each of them performs a matrix role. Replication starts in some points of the DNA molecule. The part of DNA from the start of one replication to the start of the other is a *replicon*. Chromosomes of eukaryotes have many replicons, those of bacteria nucleoid — 1 replicon. Doubling in all replicons goes simultaneously. A replication part is called a *replication fork*.

DNA-polymerase can move along the mother sequence only from 3’ end to 5’ end. That is why assembling of daughter sequences goes *anti-parallel* (in opposite directions). Several DNA polymerases work simultaneously in every replication fork. One of daughter molecule sequences (a leading one) is continuously duplicating. The second sequence (a retarding one) is duplicating with short parts of 150–200 nucleotides under the action of DNA-polymerase, which moves in opposite from the first enzyme direction. These parts are called *Okasaki’s fragments*. All synthesized fragments of a polynucleotide sequence are linked with a *lygase* enzyme. The whole genome of the cell is replicated once during a mitotic cycle.

4. The genetic code and its properties. Protein biosynthesis.

Recording of genetic information as a nucleotide sequence in DNA and mRNA is a *genetic code*. A nucleotide triplet coding a specific amino acid is a *codon*. The codon is an elementary functional unit of the gene.

Properties of the genetic code:

– *tripletness* — one amino-acid is coded by three nucleotides — a codon (triplet);

– *universality* — one and the same codon defines one amino acid in all organisms;

– *no overlapping* — one nucleotide is included only in one triplet;

– *degeneration,* or redundancy — one amino acid can be coded by several triplets (there are 20 amino acids, by 64 possible triplets);

– *discontinuity* — there are no disjunctive symbols between codons;

– *single direction (m*RNA synthesis occurs in the direction from 5' end to 3' end);

– *presence of codons-terminators* (they define the end of protein biosynthesis).

The correspondence of the order of nucleotides in a DNA molecule to the order of amino acids in the polypeptide molecule is **co-linearity**.

Protein biosynthesis in the cell. Protein biosynthesis is a fermentation process, where nucleic acids play the main role. MRNA is synthesized in the cellular nucleus on one of DNA sequences (coding). RNA-polymerase «transcribes» the order of nucleotides arrangement in a DNA molecule (by complementarity rule). This process is called *transcription*. MRNA enters the cytoplasm through nucleous pores and directs to ribosomes.

Recognition (recognizing of its own amino acid by t-RNA) occurs in the cytoplasm. The transport RNA has a specific structure: one end of the molecule contains a nucleotide triplet, it is called an *anti-codon* and corresponds to a definite amino acid. The ribosome moves one triplet, and the amino-acyl-t-RNA passes into the peptide center. A definite amino acid joins «its own» t-RNA with the enzyme of *amino-acyl-tRNA-synthetase* and ATP. The amino acid with its t-RNA forms a complex of amino-acyl-t-RNA (fig. 17).

The process of *translation* is going on in ribosomes — a nucleotide sequence of mRNA defines the amino acid sequence of the polypeptide molecule. MRNA is linked with a small ribosome unit in the cytoplasm. The complex of ribosomes, united mRNA, is called a polysome. The beginning of translation is *initiation*, the end of translation — *termination*. The formation process of peptide links between amino acids is *elongation*. There are two mRNA codons in the ribosome simultaneously: one — the *amino-acylic center*, the second — in the *peptide* one.

If a t-RNA anti-codon and an mRNA codon, which is in the amino-acylic center, are complementary, then amino-acyl-t-RNA forms a temporary bond with an mRNA codon. The ribosome moves by one triplet, and the amino-acyl-t-RNA passes into the peptide center. The second t-RNA with the amino acid comes to the amino-acylic center. A peptide bond sets between the first and second amino acids. The ribosome moves by one triplet, the released t-RNA leaves the ribosome. The second t-RNA passes into the peptide center. The pro-

cess repeats many times. Termination of polypeptide synthesis is determined by stop-codons: UAA, UAG, UGA.

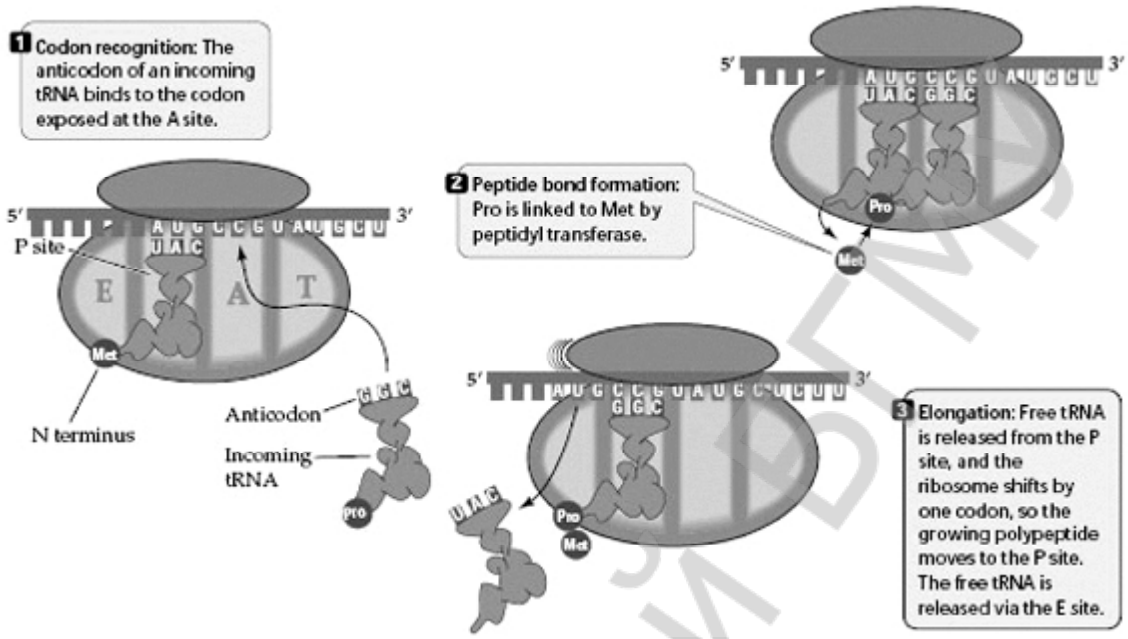


Fig. 17. Elongation

Basic terms and concepts:

1. **Anti-codon** — is a t-RNA nucleotide triplet, which is complementary to an mRNA triplet in the process of translation.
2. **Gene** — a fragment of a DNA molecule coding a definite polypeptide.
3. **Initiation** — an initial stage of translation.
4. **Codon** — a nucleotide triplet, the least functional unit of the gene.
5. **Complementarity of nitrogenous bases** — correspondence of nitrogenous bases to each other in a DNA molecule.
6. **Lability of the gene** — ability of the gene to mutate.
7. **Nucleotide** — a monomere of nucleic acids consisting of a nitrogenous base, sugar (pentose) and a residue of the phosphoric acid.
8. **Stability of the gene** — ability of the gene to preserve its structure.
9. **Termination** — finishing the polypeptide synthesis.
10. **Elongation** — is the process of translation from formation of the first peptide bond to joining the last amino acid.

Topic 5. INHERITANCE REGULARITIES. INTERACTION OF GENES

1. Genetics as a science. Basic concepts of Genetics.

Genetics is a science about laws of heredity and variation. The term «genetics» was introduced into Biology by W. Batson in 1906.

Genotype — is a sum of all genes of the organism.

Phenotype — is a sum of all characters and properties of the organism, which are determined by the genotype and environmental factors.

Alternative signs — are incompatible characters.

Allelic genes — are genes occupying identical loci of homologous chromosomes, they determine the development of one alternative character.

Non-allelic genes — are genes occupying different loci of homologous chromosomes or inhomologous chromosomes, they determine the development of different characters.

Homozygous organism — is an organism, which contains identical genes, form one type of gametes; in crossing with identical individual on the genotype no splitting of characters occurs.

Heterozygous organism — is an organism containing different allelic genes; it forms two types of gametes; in crossing with an identical on genotype individual splitting of characters occurs.

Dominant characters — are characters, which are revealed in a homozygous and heterozygous state.

Recessive characters — are characters, which are revealed only in a homozygous state.

The basic hereditary laws were described by G. Mendel (1822–1884) in his work «Experiments on vegetative hybrids» (1865). G. Mendel used a **hybridological method. Hybridization** is crossing of individuals differing on genotype and phenotype, followed by further analysis of fillies (hybrids).

2. Peculiarities of the hybridological method:

1. Crossing of pure lines (homozygotes).
2. Analysis of inheriting separate characters in fillies of some generations.
3. Precise quantitative account of fillies with different characters.

3. Inheritance regularities in monohybrid crossing.

Monohybrid crossing is crossing, when one pair of alternative characters is analyzed.

Law I — is a law of hybrid uniformity: in crossing of homozygous individuals analyzed by one pair of alternative characters one can observe uniformity of hybrids on phenotype and genotype.

P AA x aa P (parents)
G (A) (a) G (gametes)
F_1 Aa F (fillies)

Mendel crossed a homozygous plant of pea with yellow seeds and a homozygous plant of pea with green seeds. As a result of such cross Mendel obtained plants only with yellow seeds. These plants were heterozygous on genotype.

Law II — is a law of splitting characters: in crossing heterozygous organisms analyzed on one pair of alternative characters one can observe splitting on phenotype in ratio 3:1 and on genotype 1:2:1. Splitting **on phenotype**: 3 parts of individuals with a dominant character, 1 part with a recessive character. Splitting

on genotype: 1 part of individuals — are dominant homozygotes (AA), 2 parts of individuals — are heterozygotes (Aa), one part of individuals — are recessive homozygotes (aa).

P (F_1) Aa x Aa
G (A)(a) (A)(a) P (F_1) — hybrids of the 1st generation are parental
F_2 AA, Aa, Aa, aa

4. Hypothesis of «purity of gametes» and its cytological foundation.

W. Batson proposed a **hypothesis of gametes purity** in 1902 to explain the results of crossing performed by Mendel, i. e. genes in hybrids are not hybridized and are in a pure allelic state. The mechanism of meiosis is a cytological basis of Mendel's laws. Homologous chromosomes in meiosis diverge, that is why one gene from an allelic pair gets into a gamete.

5. Analyzing cross. The concept of a phenotypical radical.

Analysing cross — is crossing of an individual having a dominant character, with a recessive zygote for determining its genotype. If in the result of analyzing cross one can observe the uniformity of hybrids, then the initial organism is homozygous (AA); if one observes splitting, then the initial organism is heterozygous (Aa).

Phenotypical radical — is a short record of the genotype made on the basis of the phenotype. Record A-B-means that the phenotype does not depend on what gene will be instead of dash — a dominant or a recessive one: a dominant character will be revealed.

6. Regularities of inheritance in polyhybrid crossing. The law of independent inheritance of characters.

Dihybrid crossing — is crossing, when two pairs of alternative characters are analyzed, if there are more than two pairs — crossing is called **polyhybrid.**

Mendel's law III — is a law of independent inheritance of characters: in crossing homozygous individuals analyzed by several pairs of alternative characters, one can observe independent inheritance of characters and corresponding genes in the second generation.

Gene	Character
A	Yellow color of seeds
a	Green color of seeds
B	Smooth shape of seeds
b	Wrinkled shape of seeds

P. AABB x aabb

G. (AB) (ab)

F_1. AaBb - 100 %

P. AaBb x AaBb

G. (aB) (ab) (AB) (Ab) (aB) (ab) (AB) (Ab)

In dihybrid crossing, when plants differed in two alternative pairs of characters, Mendel got the following results:

The Pennet's lattice is used for recording results of dihybrid crossing:

All in all we get 16 combinations: 9 parts A-B-: 3 parts A-bb: 3 parts aaB-: 1 part aabb. If one separately estimates the ratio of characters in pairs 12A-: 4aa, 12B-: 4bb, we'll get the ratio 3:1 in both cases. On the bases of obtained results one can make a conclusion that in crossing of heterozygous individuals, which are analyzed by several pairs of alternative characters, there will be observed splitting on the phenotype in fillies in the ratio $(3 + 1)^n$, where n — is the number of characters in a heterozygous state.

G	***AB***	***Ab***	***aB***	***ab***
AB	*AABB*	*AABb*	*AaBB*	*AaBb*
Ab	*AABb*	*AAbb*	*AaBb*	*Aabb*
aB	*AaBB*	*AaBb*	*aaBB*	*aaBb*
ab	*AaBb*	*Aabb*	*aaBb*	*aabb*

The significance of Mendel's laws:

1. The laws are universal, they are applicable for all living organisms.
2. G. Mendel introduced a mathematical method into Biology; they are laws of large numbers.

7. Conditions limiting the manifestation of Mendel's laws. Pleotropic action of the gene. Semi-lethal and lethal genes.

Conditions limiting the manifestation of Mendel's laws:

1. Different probability of the formation of gametes and zygotes of various types.
2. Different survival of individuals of different phenotypes (the presence of lethal and semi-lethal genes). *Lethal genes* cause death of organisms before birth or at the moment of birth. *Semi-lethal genes* reduce the life span of the organism.
3. Interaction of genes (except complete domination).
4. Linkage of genes.
5. Cytoplasmatic heredity.

P Aa x Aa

G (A) (a) (A) (a)

F_1 ~~AA~~ Aa Aa aa

An example of the *action of a lethal gene*. A dominant gene **A** determines a grey color of wool in sheep, and in a homozygous state it produces a lethal action (due to underdevelopment of the stomach in lambs). A recessive gene **a** determines a black color of wool. Instead of an expected ratio 3:1 we get the ratio 2:1 on the phenotype and genotype.

The pleotropic action of the gene — one gene is responsible for manifestation of several characters. An example, the syndrome of «blue scleras»: a gene causes a blue color of scleras, fragile nails and congenital deafness in humans.

8. Intrallelic interaction of genes.

Intrallelic interactions of genes are interactions of genes from one allelic pair:

1. *Complete domination*: coloration of peas, brown and blue eyes in humans, straight and curly hair and other characters. They are called mendelizing — splitting obeys Mendel's laws.

2. *Incomplete domination* or intermediate inheritance.

Gene A — red flowers.

Gene a — white flowers.

P AA x aa → Aa

Red white pink

3. *Superdomination*: Gene action in a heterozygous state is revealed stronger than in a homozygous one. For example, in Drosophila: a lethal gene is recessive and homozygotes on this gene die; vitality in heterozygotes is stronger and they are more fertile than homozygous individuals on a dominant gene.

4. *Co-domination*. An example — blood groups on the system AB0: 2 allelic genes (I^A, I^B) are equivalent to each other, but being together in the genotype they cause the appearance of a new character — both show their action (IV blood group).

Inheriting blood groups in the human by the system AB0 is due to gene I. Alleles of gene I: I^0, I^A, I^B. The presence of gene I^0 does not cause synthesis of anti-genes in erythrocytes (group I).

Genes I^A and I^B are dominant to gene I^0. Occuring in the genotype in a homo- (I^AI^A; I^BI^B) or in a heterozygous (I^AI^0; I^BI^0) state they cause synthesis of anti-genes, either A, or B in erythrocytes: A — group II, B — blood group III. If they are in the genotype together, then 2 types of anti-genes are synthesized in erythrocytes: A and B — blood group IV(AB).

Multiple alleles — are alleles that are presented in the population by more than 2 states (alleles of the gene I — I^0, I^A, I^B).

Inheriting Rh-factor. The presence of protein, Rhesus-factor, in erythrocytes is due to Gene D.

The blood of such people is Rh-positive (Ph^+). When the Rhesus-factor (d) is absent, the blood is Rhesus-negative (Rh^-).

Inheriting blood groups on system MN. This system is due to the presence of two alleles — L^N and L^M. Gene L^M causes the presence of anti-gene M in human erythrocytes (blood group M), and gene L^N — of anti-gene N (blood group N).

The simultaneous presence of both alleles in the genotype causes the presence of both anti-genes M and N in erythrocytes (blood group MN).

9. Interallelic interaction of genes.

Interallelic interaction — is the interaction of non-allelic genes.

1. **Complementarity** — is interaction, when a gene of one allele complements the action of a gene of the other allele. Coloration of flowers in fragrant peas is determined by a combination of dominant genes of allele A and allele B. The absence of one or two dominant genes in the genotype determines the formation of white flowers.

Colored flowers: A – B –; white flowers: A-BB, aaB-, aabb

P AaBb x AaBb

Red flowers Red flowers

G (AB) (Ab) (AB) (Ab)

(aB) (ab) (aB) (ab)

F_1 9A-B-; 3A-bb; 3aaB-; 1aabb

Red White White White

(according to Mendel's law a ratio 9:3:3:1, splitting obtained according to phenotype is 9:7).

2. **Epistasis** — is interaction, when a dominant (recessive) gene of one allele suppresses the manifestation of gene action of the other allele. A suppressing gene is called *epistatic* (inhibitor or suppressor); a suppressed gene is called *hypostatic*. An example of epistasis — coloration of feathering in hens. Feather coloration is determined by gene **C**; a dominant gene of allele **I** suppresses its action.

Genotype of hens with colored feathering C – ii

Genotype of hens with white feathering C-I-, ccI-, ccii

P CcIi x CcIi

White hens White hens

F_1 9C-I-: 3C-ii: 3ccI-: 1ccii

White colored white white (splitting by Mendel is 9:3:3:1,

Splitting obtained according to phenotype is: 13 white: 3 colored)

3. **Polymeria** — several non-allelic genes enhance the phenotypic manifestation of the character.

In this way some human quantitative characters are inherited: body mass, height, skin pigmentation, blood pressure. Polymeric genes are usually denoted by identical letters but with different figure indices.

For example, skin pigmentation in the human: negroids — $P_1P_1P_2P_2P_3P_3$; europeoids — $p_1p_1p_2p_2p_3p_3$; mulates — $P_1p_1P_2p_2P_3p_3$. The more dominant genes are in the phenotype, the stronger is the character expressed.

Basic terms and concepts:

1. Allelic genes — are genes occupying identical loci of homologous chromosomes, they determine the development of different states of one character.

2. Complementarity — is interallelic interaction, when a gene of one allele complements the action of a gene of the other allele.

3. Genome — is a sum of all genes in a haploid complement of chromosomes.

4. Genotype — is a sum of all genes in the organism.

5. Homozygous organism — is an organism containing identical variants of one allele in somatic cells (AA, aa).

6. Multiple allelism — is a phenomenon, when a gene in the population is presented by more than two allelic states.

7. Phenotuypical radical — a short record of the genotype on the basis of the phenotype.

8. Phenotype — is a sum of characters and properties of the organism.

9. Polygenic inheritance — is inheritance of characters that are determined by polymeric genes.

10. Superdomination — is interaction of genes, when a dominant gene in a heterozygous state shows its action stronger than in a homozygous one.

Topic 6. LINKAGE OF GENES

1. Experiments of T. Morgan. Complete and incomplete linkage.

In 1911–1912 experiments on Drosophila were performed in the laboratories of T. Morgan. It is convenient for genetic investigations, because:

– it has few chromosomes (4 pairs);
– early sex maturity, fast change of generations;
– a great number of fillies, it is easy to make similar conditions for Drosophila.

Two pairs of alternative characters were analyzed in Drosophila on crossing.

Gene B — a grey body Gene V — normal wings
Gene b — a black body gene v — short wings

The 1st cross of flies was done according to Mendel's scheme:

P BBVV x bbvv
F_1 BbVv — grey with normal wings — 100 %

To clear out the genotype of hybrids an analyzing cross of a male of the 1st generation was performed. It is crossing of an individual with dominant characters with a recessive homozygote.

According to Mendel's law III Morgan expected to get an equal quantity of flies in the fillies of each phenotype — per 25 %. However he got flies of two phenotypes (per 50 %) with parental characters. Morgan proposed that genes of the body color and wings length are localized in one chromosome and passed together, i. e. linked. **Linkage of genes** — is a joint transmission of genes of one chromosomal pair.

A male Drosophila has a **complete linkage of genes**. One of a pair of homologous chromosomes contains 2 dominant genes (**BV**), and the other — 2 recessive (**bv**). In the process of meiosis one chromosome (with genes **BV**) gets into one gamete, and the other (with genes **bv**) in the other. Thus, there form not 4 but 2 types of gametes in a diheterozygous organism. Fillies also have such characters as their parents.

In the 3rd experiment Morgan crossed a hybrid female of Drosophila with a recessive male. He got 4 types of fillies: 2 types (83 %) with parental characters and 2 types (17 %) with a new combination of characters. Individuals composing per 8,5 % formed in the process of crossing-over and are called *crosso-*

verous. The total number of crossoverous individuals comprises 17 %, which corresponds to the distance between genes of the body color and wing length — 17 morganids.

II $P(F_1)$ bbvv x B-V- III $P(F_1)$ B-V- x bbvv

F_2 bbvv B-V- F_2 B-V- bbV- B-vv bbvv

50 % 50 % 41,5 %; 8,5 %; 8,5 %; 41,5 %

In a female Drosophila, unlike a male, crossing-over impairs linkage of genes and stimulates recombination of genetic material.

Linkage is called *complete* if crossoverous individuals are not formed (a male of Drosophila). If they are formed (a female of Drosophila), linkage will be *incomplete*.

2. Autosomal and gonosomal linkage groups.

Genes localized in one chromosome (a pair of homologous chromosomes) are transmitted together and compose a *linkage group*. The number of linkage groups is equal to the *haploid number of chromosomes*. Linkage can be *autosomal* (the groups linking chromosomes) and *gonosomal* (the groups linking sex chromosomes) There are 23 linkage groups in the human: 22 *autosomal* and 1 *gonosomal* group.

3. Crossing-over, crossoverous and non-crossoverous gametes.

Linkage of genes is disturbed by a biological phenomenon — *crossing-over*, which occurs in the prophase of meiosis I. Crossing-over is the formation of a cross and exchange of identical parts of chromatids of homologous chromosomes in a bivalent. It does not occur in a Drosophila male and a bombyx female. Crossoverous gametes — are gametes containing chromatids that have undergone crossing-over. Unmodified chromatids are included into *non-crossoverous gametes*. Crossing-over occurs not always, that is why there are always less crossoverous individuals than non-crossoverous. The linkage force between genes (frequency of crossing-over) depends on the distance between them: the more is the distance, the weaker are linkage forces, the more frequently crossing-over occurs.

4. Basic issues of the hereditary chromosomal theory.

1. Genes are arranged in chromosomes in a linear order in definite loci. Allelic genes are in identical loci of homologous chromosomes.

2. All genes of one chromosome compose a linkage group and are inherited together. The number of linkage groups is equal to the number of pairs of homologous chromosomes.

3. Crossing-over (exchange of allelic genes) is possible between homologous chromosomes.

4. The percentage of crossing-over depends on the distance between genes in the chromosome. 1 % of crossing-over is equal to 1 morganid — a unit of the distance between genes called to honor T. Morgan.

5. Maps of eukariotic chromosomes (genetic and cytological).

Knowing the distance between chromosomes one can make their maps.

A genetic map: the chromosome is presented as a straight line, along which genes are presumably located according to the results of crossing being analyzed.

A cytological map — is a precise picture or a photo of the chromosome. The arrangement order of genes is determined during comparison of analyzing cross results and chromosomal reconstructions.

Basic terms and concepts:

1. Crossoverous gametes — are gametes, into which chromatids exposed to crossing-over got.

2. Non-crossoverous gametes — are gametes, into which chromatids not exposed to crossing-over got.

3. Genetic map of the chromosome — is a part of a straight line, where the order of genes arrangement is marked.

4. A cytological map of the chromosome — is a photo or a picture of the chromosome, on which the order of genes arrangement is marked.

5. Recombinants — are organisms that are formed during the fusion of crossoverous gametes.

6. Linkage of genes — is a joint transmission of genes of one chromosome.

Topic 7. VARIATION

1. Variation and its types.

Variation — is a property of living organisms to obtain characters distinguishing them from their parents in the process of ontogenesis (fig. 18).

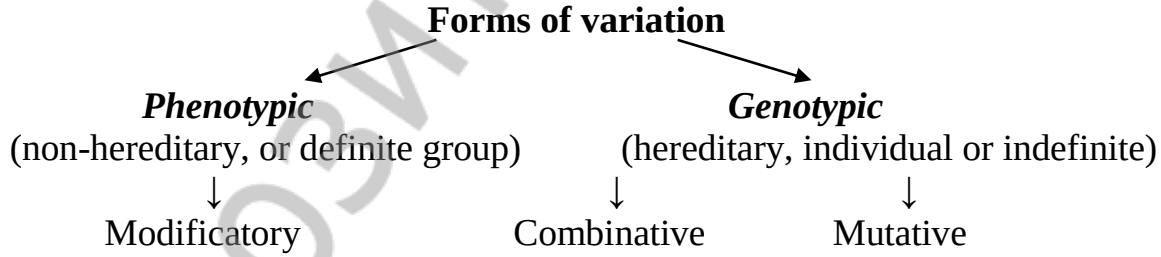


Fig.18. Forms of variation

2. Phenotypical variation. The reaction range.

A phenotypical or modificatory variation — is modification of the phenotype without changing the structure of the genotype. That is why it is *non-hereditary*. Modifications occur under the action of environmental factors, changes can be predicted for a *whole group of individuals*. As a rule, modifications have *an adaptive character* — enhancing of skin pigmentation (sun-tan) under ultra-violet radiation.

The reaction range determines the limits of modificatory variation. It is controlled by the genotype and is inherited. If the character has a narrow reaction range, it changes insignificantly (fatness of milk). The character with a broad reaction range changes in wide limits (body mass).

3. Genotypical variation and its forms.

A genotypical variation — is modification of the phenotype due to changing the genotype. It is inherited. It includes a *combinative* and *mutational* variation.

A combinative variation is associated with recombination of parental genes in fillies without changing the structure of genetic material. For example, appearance of a blue-eyed child in heterozygous brown-eyed parents.

Mechanisms of combinative variation:

1. Free combination of chromosomes and chromatids, when they diverge in meiosis.
2. Crossing-over in meiosis (recombination of genes).
3. Incidental meeting of gametes of different types during fertilization.

Mutational variation or mutations — is a sudden uneven changing of genetic material under the influence of environmental factors. It is inherited.

Differentiation of mutations from modifications (fig. 19).

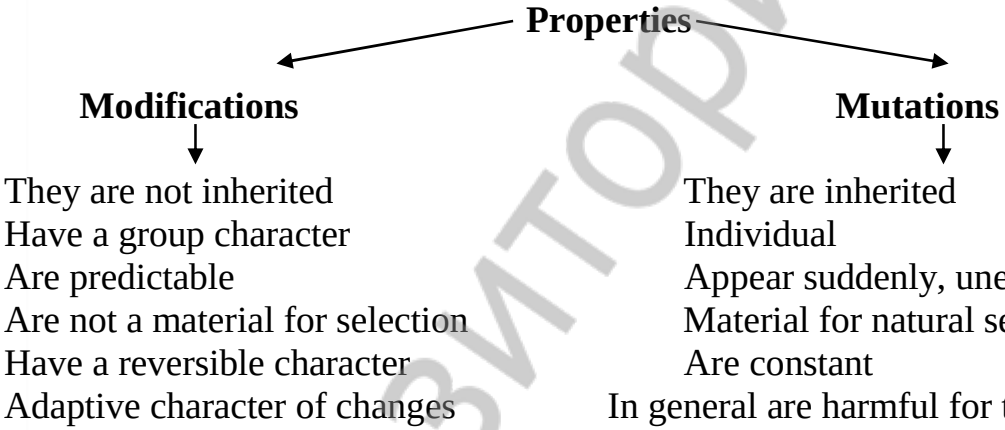


Fig. 19. Differentiation of mutations from modifications

4. Mutagenic factors.

Mutagenic factors — are factors causing mutations. Mutagenic factors are divided into physical, chemical and biological

Physical mutagens — are various kinds of radiation, temperature, humidity, etc.

They cause impairments of the structure of genes and chromosomes; formation of free radicals interacting with DNA; cuts of the division spindle threads; formation of dimeres of adjacent pyrimidine bases of one DNA sequence (T-T, T-C), etc.

Chemical mutagens — some medicines, formalin, yperite, colchicin, food conservants, etc.

They cause desamination and alkylation of DNA molecule nucleotides; replacement of nitrogenous bases for their analogues (substances with similar structure); suppress synthesis of precursors of nucleic acids (nucleotides, ribose, deoxiribose).

*Biological mutagen*s — are viruses, bacteria, metabolites — protists and helminthes.

They cause impairments of DNA synthesis, divergence of chromosomes and chromatids in the anaphase of meiosis and mitosis; waste products of parasites, act as chemical mutagens, destroy chromosomal telomeres and impair the process of crossing-over.

5. Classification of mutations.

The formation process of mutations is called *mutagenesis*.

According to etiological factors:

1. Spontaneous — appear under the influence of natural factors (mutagens) without participation of the human.
2. Induced — the result of directed effect of definite mutagenic factors.

According to mutated cells:

1. Gametic — occur in sex cells and are transmitted during sexual reproduction.
2. Somatic — occur in somatic cells, show in the individual itself and are inherited only in vegetative reproduction.

According to the outcome for the organism:

1. Negative: lethal, incompatible with life and semi-lethal, reducing vitality.
2. Neutral, affecting the vitality inconsiderably.
3. Positive, increasing the vitalality.

According to modification of the phenotype:

1. Morphological (small eyes, 6 fingers on the hand).
2. Biochemical (albinism, hemophylia).

According to modification of the genotype:

1. Genomic.
2. Chromosomal.
3. Genic.

6. Genomic, chromosomal and genic mutations.

Genomic mutations — is changing of the number of chromosomes. **Haploidy** — is a chromosomal complement ln. It occurs in drones (males) in bees. The vitality of such organisms is decreased, as all recessive genes are revealed in them. *Polyploidy* — increase of a haploid chromosomal complement (3n, 4n, 5n). Polyploidy is used in plant growing. It increases fruitfulness. For the human haploidy and polyploidy are lethal mutations.

Heteroploidy — is a change of the number of chromosomes indivisible by a haploid one (2n ± 1, 2n ± 2 and so on). *Trisomy*: an X-chromosome is added to a pair of sex chromosomes of a female organism, the trisomy syndrome de-

velops (47, XXX); if it is added to sex chromosomes of a male organism, the Kleinfelter's syndrome develops (47, XXY). *Monosomy*: absence of one chromosome in the pair — 45, X0 — syndrome of Shereshevsky–Terner. *Nullisomy*: absence of a pair of homologous chromosomes (for humans, it is a lethal mutation).

Chromosomal mutations (or chromosomal aberrations) — are modifications of the structure of chromosomes (interchromosomal or intrachromosomal).

Rearrangements **inside one chromosome**: inversions, lacking (deficiency and deletion), duplications. *Deletion* is lacking of a middle part of the chromosome; *deficiency* — of a terminal end; *duplication* — doubling of a chromosomal part; *inversion* — changing of the genes arrangement order in the chromosome. In deletion of telomere parts of both arms of chromosomes one can observe locking of the remaining structure into a ring and forming of *ring chromosomes*.

Interchromosomal mutations are translocations. Translocations can be: *reciprocal* — 2 chromosomes exchange with their parts; *non-reciprocal* — parts of one chromosome are relocated on the other; *Robertson's* — 2 acrocentric chromosomes are linked with their centermeres.

Lacking and duplications are always revealed phenotypically, because a complement of genes changes. Phenotypical inversions and translocations are not always revealed. In these cases conjugation of homologous chromosomes becomes difficult and the distribution of genetic material between daughter cells is impaired.

Genic mutations (point or transgenations). They are associated with changes of the structure of genes and cause the development of metabolic diseases.

Mutations of structural genes:

1. *Bias of the reading frame* — deletion or insertion of one or several pairs of nucleotides into a DNA molecule.

2. *Transition* — is a mutation, when there occurs a replacement of a purine base for a purine or pyrimidine one for another pyrimidine (A ↔ G or C ↔ T). Such replacement results in changing codons.

3. *Transversion* — replacement of a purine base for a pyrimidine or a pyrimidine for a purine base (A ↔ C; G ↔ T) results in changing codons. Changing of structural genes results in *missense-mutations* (changing of the codons meaning). If senseless codons are formed (UAA, UAG, UGA), they cause *nonsense-mutations*. These codons do not determine amino acids but are terminators — they determine the end of information reading.

Mutations of functional genes:

1. The protein-repressor is modified and it does not suit the gene-operator. In this case structural genes are not switched off and work permanently.

2. The protein-repressor is tightly joined with the gene-operator and is not released by the inductor. Structural genes do not work permanently.

3. The impairment of alternation of the processes of repression and induction. If the inductor is absent, a specific protein is synthesized, in the presence of the inductor it is not synthesized. Such impairments of transcripton actions are observed in mutations of a gene-regulator or a gene-operator.

In the majority of cases genic mutations are revealed phenotypically.

7. Stability and repair of genetic material, anti-mutagens.

Anti-mutagenesis is the impact on the cell or organism, which blocks or reduces the probability of mutations occurrence. Stability of genetic material provides anti-mutagenic mechanisms.

1. **Natural barriers**: a diploid complement of chromosomes (parity of chromosomes), double DNA spiral, redundancy (degeneration) of the genetic code, iteration of some genes.

2. **Repair of the DNA structure** — is an intercellular process of an impaired DNA molecule restoration.

In 1962 K. Rupert described photoreactivation or light repair. He established that when phages, bacteria and protists are radiated by ultra-violet radiation, their vitality drops. But if they are exposed to visible light, their vitallity restores. Under the action of ultraviolet radiation dimeres are formed in a DNA molecule (chemical bonds between bases T-T of one sequence). This inhibits reading of information. Visible light activates enzymes, which destroy links of dimeres.

The most common is a **dark** or *excision* repair (A. Herren) Four groups of enzymes take part in it:

a) *endonuclease* «recognizes» an impaired party and cuts a DNA thread next to it;

b) *exonuclease* removes the impaired part;

c) *DNA polymerase* synthesizes a DNA fragment instead of a destroyed one according to a complementarity principle;

d) *lygase* links the ends of an inserted part with the main DNA thread.

The impairment of the repair process may result in the development of diseases such as *pigmental xeroderma* and *Fankoni's anemia*.

3. **The presence of anti-mutagens**. These are substances of various origin, that in small concentrations are able to stabilize a mutation process; biologically active compounds — histamine and serotonin, anti-oxidants, sulphanilamide preparations, fresh vegetable juices, α-tocopherol, which decreases the number of both genic and chromosomal mutations).

8. Biological bases of cancerogenesis

Cancerogenesis is a process of formation and development of tumors.

1. *Mutational conception* — in the basis of cancerogenesis are genomic or chromosomal mutations of somatic cells (G. de Freeze, 1901).

2. *Viral-genetic conception* — viruses are causative agents of malignant growth. Mutagens and cancerogens stimulate the activity of viruses; their genome is included into the cellular DNA and changes its properties (L. A. Zilber, 1946).

3. *Epigenomic conception* — in the basis of transformation of a normal cell into a tumor are persistent impairments of the structure of functional genes (Yu. M. Olenev, 1967, and A. Yu. Bronovitsky, 1972).

4. *Oncogen conception*. Cellular DNA contains definite parts — *protooncogens*. They can be received from parents or introduced into the cell by a virus. Protooncogens are activated in mutations or when a viral promoter gets into the cell. They pass into an active form — oncogens, the cell transforms into a tumor (R. Hubner, 1969.; G. I. Abelev, 1975).

Basic terms and concepts:

1. Deletions — intrachromosomal mutations associated with a loss of a middle part of the chromosome.

2. Duplications — intrachromosomal mutations associated with doubling of a part of the chromosome.

3. Inversion — intrachromosomal mutations, when the gene arrangement order impairment occurs.

4. Cancerogenesis — a process of formation of tumor cells.

5. Ring chromosomes — chromosomes, which are formed during deletion of telomere parts and locking of the structure into a ring.

6. Reaction range — limits of modificatory variation.

7. «Bias of the reading frame» — a mutation variety of structural genes, when an insertion or deletion of nucleotides occurs.

8. Transitions — a mutation variety of structural genes, when a replacement of bases occurs: A for G or T for C.

9. Transgenations — genomic mutations.

10. Translocations — exchange of inhomologous chromosomes parts.

Topic 8. BIOLOGY AND GENETICS OF SEX

1. Sex as a biological character. Sexual characters.

Sex is a complex of morphological, physiological, biochemical and behavioral characters of the organism that provide the process of reproducing their own selves and transmission of genetic information from generation to generation.

Primary sexual characters — external and internal sex organs. They take a direct part in the process of reproduction, are germinated in the embryogenesis and are formed by the moment of birth.

Secondary sexual characters appear in the period of puberty. They include peculiarities of the bony-muscular system, distribution of the adipose tissue and hair covering, voice timbre, peculiarities of the nervous system and behavior and other characters.

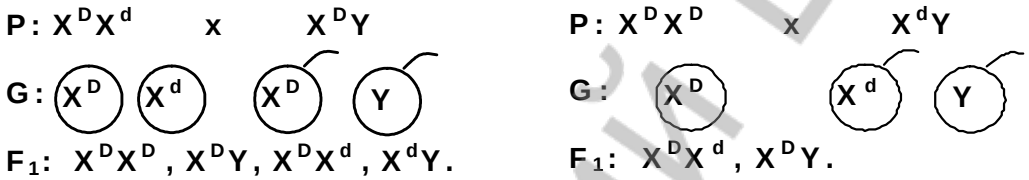
2. Characters controlled and limited by sex.

Genes determining characters limited by sex are located in autosomes of individuals of both sexes, but are revealed only in individuals of one sex (a gene of lactation is revealed in females of the cattle; a gout gene is revealed only in men).

Genes determining characters *controlled by sex* are also in autosomes of individuals of both sexes, but the degree and frequency of their manifestation is different (an alopecia gene is differently revealed in men and women).

3. Characters linked with an X-chromosome and holandric ones.

Characters *linked with sex chromosomes* are divided into characters linked with an X-chromosome and holandric. Genes located in an X-chromosome non-homologous part determine characters *linked with an X-chromosome (linked with sex)*. They are about 200 (hemophilia, daltonism).They are inherited from father only to daughter and from mother both to son and daughter.



Genes located in a Y-chromosome non-homologous part determine holandric characters; 6 of them are described (ichthyosis, membranes between toes) they are inherited from males and are revealed only in men.

4. Peculiarities of sex determination in humans and its impairments.

In the human the *germ formation* of gonads, internal and external sex organs occurs till the 4^{th} week of embryogenesis. On the initial stage it is provided by one X-chromosome. The primary gametes in humans can be revealed on the 3^{rd} week of the embryonic development in the ectoderm of the yolk sac.

Differentiation of germs into sex glands and sex organs in an embryo and fetus occurs from the 4^{th} to 12^{th} weeks of intrauterine development; at this stage it completely depends on the second sex chromosome. If it is an X-chromosome, primary sex cells develop into ovogonies and the whole sex system develops according to a female type. The development of primary sex germs according to a male type is determined by the presence of a Y-chromosome in the complement. Primary sex cells are differentiated in spermatogonies, forming testicles and external sex organs.

Physical sex determinants: genetic sex, gonad sex, gamete sex, hormone sex and morphological sex. *Physical (morphophysiological) determinants of sex* are common for humans and the majority of animals. **An Intermediate determinant**: civil sex. **Social-psychological determinants**: sex of brining up, sex of self-consciousness, sex role, choice of a sexual partner. *Social-psychological determinants* have a great significance in the formation of sex consciousness and ideas about sex role in the human. A choice of a sexual partner depends on them.

In the majority of cases it is an opposite sex (*heterosexualism*), sometimes — *homosexualism* (identical sex).

Transsexualism is a persistent discrepancy of sexual self-consciousness and its true genetic and gonad sex and a wish to change one's sex.

Transvestism is sexual perversion when the excitement and satisfaction are reached during putting on clothes of the opposite sex. In humans a *Morris's syndrome may occur. It is manifestation of* a female phenotype in genotype XY (*testicular feminization*). Male sex hormones are excreted after germination of testes, but in embryos no protein-receptor making cells sensitive to these hormones is formed. The development according to a male type stops and a female phenotype develops.

5. M. Lion's hypothesis.

In 1962 Mary Lion suggested a hypothesis of inactivation of one X-chromosome in mammal females (diagram 10). Every cell of a female embryo contains two X-chromosomes: one maternal (X_m) and the other — paternal (X_f). Up to the 16^{th} day of embryogenesis 2 active X-chromosomes get into every cell during splitting. On the 16^{th} day, inactivation of one X-chromosome takes place — a maternal or paternal with equal probability. The process of inactivation is random, that is why in one-half of all cells a paternal X-chromosome stays active, and in the other half of cells a maternal X-chromosome will be active. Maternal and paternal X-chromo-somes contain allelic genes (dominant and recessive). Two variants of enzymes can be synthesized in cells; they differ in their relation to the substrate or according to pH-indices. It helps female organisms better adapt to the environment. The essence of *female mosaicism according to sex chromosomes* is the content of different active X-chromosomes in different cells — from father and mother.

6. Chromosomal sex diseases.

When divergence of sex chromosomes in the process of meiosis is impaired, the human may develop chromosomal diseases of sex:

♂ \ ♀	X	XX	0
X	XX	XXX	X0
Y	XY	XXY	Y0
XY	XXY	XXXY	XY*
0	X0	XX*	0

1. XX and XY — a normal male and female organism.

2. XX* — a normal female organism that got both sex chromosomes from mother.

3. XY* — a normal male organism that got both sex chromosomes from father.

4. Y0, 0 — an organism lacking vital capacity.

5. XXX — an X-trisomy syndrome. Karyotype — 47, XXX. A female phenotype. Incidence frequency 1:800–1:1000. Nuclei of somatic cells have two Barr bodies. Tall height. The constitution corresponds to a male type. In 75 % of cases mental retardation is marked. Secondary and primary sex characters are

underdeveloped, the ovaries function is impaired. Sometimes they may have children.

6. X0 — Shereshevsky-Terner's syndrome. Karyotype — 45, X0. Female phenotype. Incidence frequency 1:2000–1:3000. Nuclei of somatic cells have no Barr body. A height of an adult is 135–145 cm. Specific characters: a short neck; a skin fold from the occiput to the shoulders, a low position of ear flaps, a low growth of hair at the occiput, changed joints of fingers and toes; 15 % have congenital defects of the heart and renal function anomalies. Ovaries and secondary sex characters are underdeveloped. Such patients are sterile. The intellect does not suffer in this syndrome. Treatment: early hormonotherapy.

7. XXY, XXXY — Klinefelter's syndrome. Karyotype — 47, XXY, 48, XXXY. A male phenotype. Incidence frequency 1:400–1:500. Nuclei of somatic cells contain one or two Barr bodies. Tall height. Female type of constitution. Gynecomastia — mammary glands are enlarged. Hair covering is poorly developed, testes are underdeveloped, the process of spermatogenesis is impaired (individuals are sterile), but sex reflexes are retained. The intellect is decreased. The more are X-chromosomes in the genotype, the stronger suffers the intellect.

Basic terms and concepts:

1. Hermafrodism — the presence of sex characters of both sexes in one organism.

2. Holandric characters — characters determined by genes located on a non-homologous part of a Y-chromosome.

3. Characters controlled by sex — characters that appear with various frequency and degree in individuals of different sex.

4. Characters limited by sex — characters that appear only in individuals of one sex.

5. Characters linked with an X-chromosome — characters determined by genes located on a non-homologous part of an X-chromosome.

6. Klinefelter's syndrome — a chromosomal disease due to the presence of an additional X-chromosome in a male organism,

7. Morris syndrome — formation of a female phenotype in XY genotype.

8. X-trisomy syndrome — a chromosomal disease in women, when an additional X-chromosome is present.

9. Shershevsky-Terner's syndrome — a chromosomal disease in women, when one X-chromosome is absent.

10. Physical sex determinants — morphophysiological determinants.

Topic 9. BASES OF HUMAN GENETICS

1. The human as an object of genetic investigations.

The human as an object of genetic investigations has its peculiarities and a number of difficulties.

Peculiarities of human genetics:

1) impossibility to apply a hybridological analysis and experimentation on humans;

2) a complex karyotype — many chromosomes and linkage groups;

3) late sexual maturity, a small number of fillies in the family, slow change of generations;

4) a great variety of ecological and social conditions; impossibility to create identical living conditions.

Advantages of the human as a genetic object:

1) a great number of individuals in populations, the possibility of analyinge characters on vast material;

2) international co-operation of geneticists;

3) the human is better clinically studied than other objects;

4) development of special methods for overcoming difficulties during studying human genetics.

2. Clinical-genealogical methods.

A genealogic analysis was proposed by F. Halton in 1883. The **clinical-genealogical method** was developed on its basis; it is making up genealogies and analyzing the transmission mechanism of a character in a number of generations.

The method allows determining:

– a relation degree of people in one family;

– if the character is hereditary; the type of inheritance; zygosity of the members of genealogy (homozygotes or heterozygotes);

– penetration of a gene (frequency of its appearance);

– probability of revealing the character in fillies (genetic risk).

Conditional designations used in making upa genealogy, are given in fig. 20.

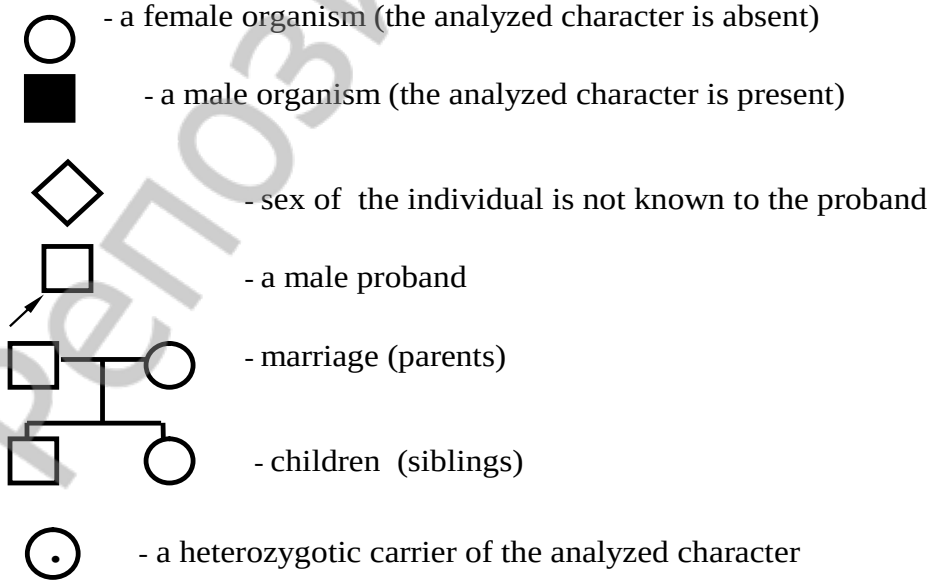


Fig. 20. Conditional designations used in a genealogy

A human, from whom a genealogy starts, is a proband and is marked with an arrow.

Genealogic analysis stages:

– taking information about relatives of the proband;
– making up a genealogy;
– analyzing the genealogy and conclusions.

Types of inheriting characters.

Autosomal-dominant type of inheritance:

– both men and women fall ill in an equal degree;
– patients are in every generation;
– a sick child in sick parents;
– a probability of inheriting the character is 100 %, if one of the parents is homozygous, 75 % — if both parents are heterozygous, 50 % — if one parent is heterozygous and the other is homozygous on the recessive gene.

Autosomal-recessive type of inheritance:

– men and women fall ill in equal degree;
– patients are not in every generation;
– a sick child in healthy parents;
– a probability of inheriting the character is 25 %, if both parents are heterozygous, 50 %, if one parent is geterozygous and the other is homozygous on a recessive character, and 100 % if both parents are recessive homozygotes.

Linked with an X-chromosome dominant type of inheritance is similar to an autosomal-dominant one, except the fact that a male passes this character (with an X-chromosome) only to daughters.

Linked with an X-chromosome recessive type of inheritance:

– predominantly men fall ill;
– patients in every generation; a sick child in healthy parents;
– a probability of inheriting the character is 25 % of all children; in boys — 50 %; in girls — 0 %, if both parents are healthy.

Holandric type of inheritance:

– patients in all generations;
– only men fall ill;
– all sons are ill in a sick father.

3. Twin method.

In 1876 F. Halton proposed a **twin method**. The method allows determining a role of heredity and environment for revealing a character in the human. The frequency of giving birth to twins is 1 %. Twins can be *monozygous* (MT). They develop from one zygote, have an identical genotype. If the twins are *dizygous* (DT), they develop from different simultaneously fertilized ova. They have a similar but not identical as in siblings genotype.

Zygosity criteria in twins: in MT the sex, blood groups, pattern of skin coverings are always identical; in DT these factors may differ.

Similarity of twins on the studied character is called *concordance*, differences on this character — *discordance*.

To reveal a share of heredity and environment in the development of a definite character a Holtsinge formula is used:

$$H = \frac{CMT\ \% - CDT\ \%}{100\ \% - CDT\ \%},$$

where H — a heredity share; CMT — concordance in monozygotic twins; CDT — concordance in dizygotic twins.

If H = 1,0, only heredity is responsible for the character development; if the amount of H approaches to 0 — the environment is mainly responsible for the character development.

4. Cytogenetic method.

A cytogenetic method is based on microscopic *study of the karyotype*. Lymphocytes, bony marrow cells are obtained and grown on trophic cultures. The mitotic cellular division is stimulated, stopped in the metaphase, the cells are treated with NaCl hypotonic solution, chromosomes are stained. They are studied under microscope, their pictures are taken and ideograms are analyzed. To detail a karyotype and map chromosomes a fluorescent analysis is used. The method reveals *genomic and chromosomal mutations*. Special designations are assumed to record mutations: q — a long chromosomal arm, p — a short chromosomal arm, «+» — redundancy of genetic material, «–» — insufficiency of genetic material. The record of a male karyotype with Down's syndrome — 47,XY,21+.

5. Biochemical methods.

Biochemical methods are used for revealing hereditary metabolic diseases on enzyme activity or on the quantity of the final product of reaction that is catalyzed by this enzyme. Chromatographic, fluorometric, radio-immunological and other methods are used to reveal gene mutations (causes of metabolic diseases). For example, phenylketonuria — the impairment of phenylalanine exchange (PhA). Phenylketonuria can be revealed by the content of phenylalanine in blood: in healthy people it is 1–2 mg %, in sick ones — 50–60 mg %. Every 30–40th person is a carrier of a phenylketonuria gene.

Heterozygosity can be revealed in injection of phenylalanine into the organism and its content in the blood is determined. If after injecting PhA the curve of its content slowly returns to its norm, a person is heterozygous on a phenylketonuria gene.

6. Methods of a recombinant DNA. The program «Human genome».

Methods of a recombinant DNA (**molecular-genetic**) allow determining a pathologic gene in the genome. Stages of the methods:

1. DNA specimen are cut by restrictases into short fragments having a point of recognition.

2. The received fragments are separated by electrophoresis in an agar jelly into fractions differing in size (a molecular mass).

3. A needed number of copies of DNA fractions is obtained with a PCR.

4. Heat denaturation is conducted of a multiplied fraction of a double-sequenced DNA into single-sequenced fragments.

5. These fragments are placed into the culture with a radioactive probe (a single-sequenced DNA corresponding to a pathologic gene). If there is a complementary pathologic gene to the probe among these fragments, a two-sequenced DNA is formed.

6. The result is registered with an X-ray sensitive film.

In 1990 an international project on making a genetic human map (Human Genome Project) was started. The tasks of the «Human Genome» program included decoding of a nuicleotide sequence (sequencing) of a human DNA molecule. In 2000 the human genome was sequenated.

7. Express-methods.

Express-methods are methods of fast preliminary diagnosis of human hereditary diseases. These methods must be economic, safe and diagnostically significant; the material for investigation should be in small amounts and be easily accessible (blood, urine).

Gatry's microbiological test. A drop of blood of the newborn is put on blotting paper and put on the agar culture of bacteria containing anti-metabolite of phenylalanine. The anti-metabolite inhibits bacterial growth. But if the blood contains a lot of phenylalanine, anti-metabolite is destroyed, and microbes start their growth.

Determination of X- and Y-sex chromatin — the cheek epithelial cells or leukocytes are investigated. X-chromatin is determined during acetorceine staining, and Y-chromatin — with acrichine-yperite. A genetic sex is determined, chromosomal diseases of sex are diagnosed.

Biochemical and chemical (colored reactions) methods are used for fast preliminary diagnosis of hereditary metabolic diseases (10 % $FeCl_3$ solution for diagnosing phenylketonuria).

8. Methods of prenatal diagnosis of hereditary diseases.

Indirect methods of prenatal (before birth) diagnosis — examination of a pregnant woman (obstetric-gynecological, genealogical, biochemical) and *direct* methods — examination of the fetus.

α-Phetoprotein (APP) — is an embryo-specific protein; it is produced by fetal cells and the placenta and passes into the mother's blood. Reducing of *α-phetoprotein* at the 13–15th weeks of embryonic development is characteristic of chromosomal diseases. Its concentration is elevated in a threatening miscarriage, intrauterine death of the fetus, plural pregnancy, nerve tube defects, congenital nephrosis.

Ultrasonography is referred to *direct non-invasive methods* (without tissues injury), it is the usage of super sound for obtaining an image of the fetus and its membranes. It is used for all pregnant women, because it is safe for the fetus and can be repeated. This method reveals vitality of the fetus, twin pregnancy and severe development defects of the brain and spinal cord and the skeleton.

Indications for diagnosis using *direct invasive methods*:

– the presence of a hereditary disease in the family;

– mother's age over 37; presence of an X-linked recessive disease in the mother;

– presence of spontaneous abortions in women at early stages of pregnancy, cases of still births, children with multiple development defects and chromosomal pathology;

– heterozygosity of both parents, having one pair of genes each with an autosomal-recessive type of inheritance.

Direct invasive methods (with tissue injury):

1. Chorion-biopcy — taking chorion cilia through the uterine cervical canal for cytogenetic and biochemical investigations and DNA analysis. It is performed under control of ultrasonography at the 8–13th weeks of gestation. The method allows revealing genic, chromosomal and genome mutations.

2. Amniocentesis. At the 15–17th weeks under control of ultrasonography a puncture of the amniotic sac is made through the abdominal wall and 15–20 ml of amniotic fluid with fetal cells are taken with a syringe for diagnosis of various hereditary diseases. Complications in this method arise in 1 % of cases.

Basic terms and concepts:

1. Amniocentesis — a method of prenatal diagnosis: taking of amniotic fluid with fetal cells for biochemical and cytogenetic investigations.

2. Chorion-biopcy — a method of prenatal diagnosis — taking of chorion cilia epithelium for cytogenetic and biochemical investigations and DNA analysis.

3. Dizygous twins — develop from two ova fertilyzed by spermatozoa.

4. Gatry's test — a preliminary method for diagnosis of phenylketonuria in neonates.

5. Genealogy — a genealogic map, where all relatives of the proband and relative ties between them are denoted by symbols.

6. Monozygous twins — develop from one fertilized ovum.

7. Proband — a person, from whom making a genealogy starts.

8. Sequencing — determination of a nucleotide sequence in the gene.

9. Ultrasonography — a diagnostic method using ultrasound for obtaining an image of the fetus and its membranes.

10. α-Phetoprotein — is protein contained in amniotic fluid and blood serum of a pregnant woman.

Topic 10. GENETIC ENGINEERING

1. Purpose of **genetic engineering** — is designing of genetic structures according to a given plan (creation of organisms with a new genetic program by translocation of genetic information from one organism to the other).

Stages of genetic engineering methods:

1. Obtaining genetic material.
2. Translocation of DNA fragments into a molecule-vector.
3. Introduction of a recombinant DNA into a cell-recipient.
4. Selection of cellular clones containing molecules of a hybrid DNA.

2. Obtaining genetic material.

Chemical-fermentative synthesis of genes. Short (8–16 nucleotides) single-sequenced DNA fragments are synthesized *in vitro*, then they are linked with lygases and treated with high temperature for the formation of double-thread DNA molecules. The gene should be **sequenced** for this method.

Fermentative synthesis of complex genes. It is performed by recurrent transcription. An isolated m-RNA is used as a matrix. Using an enzyme revertase, a coding DNA thread is synthesized on it, then it is replicated. The obtained genes do not function in cells as they have no promoter and regulation part. During transfer into a bacterium a promoter is added to structural genes, and the gene starts its work.

Isolating natural genes with restictases. Restrictases — are enzymes causing DNA hydrolysis with formation of shorter fragments of the molecule. They affect DNA of any organisms if it has sites of recognition (usually they recognize very specific parts for every enzyme with 4–6 pairs of nucleotides in length). These parts are called *palindromes*.

At present there are over 500 restrictases in genetic engineering, they are able to cut the DNA in approximately 120 sites and form double-thread (*obtuse*) ends or single-thread (*sticky*) ends in the DNA.

Gene isolation with restrictases has a number of disadvantages:

– it is not always possible to select restrictases, which allow to cut out a DNA part with a necessary gene;

– the cut out DNA fragment may contain introns, then recombinant DNA will not be able to work in prokaryotic cells due to disability for processing and splicing.

3. K. Mullis (1987) elaborated a method, which was called a polymerase chain reaction (PCR). PCR is performed in vitro using the enzyme of DNA-polymerase bacteria Thermus aquaticus, a complement of 4 nucleotides A, T, G and C and short *primings*. The enzyme is marked by its persistence to high temperature.

Thanks to primings the DNA fragment is limited, it will be copied by DNA polymerase. The PCR has 3 stages:

1. *Denaturation* — a mixture, which contains a specimen of a needed DNA, is heated to 90 °C. Meanwhile, during 15 seconds there occurs breaking of hydrogen bonds between DNA sequences, and two single-sequenced molecules are formed from one double-sequenced molecule.

2. *Hybridization of primings* — the temperature is lowered to +50 °C and primings are added. This stage lasts about 30 seconds.

3. *Polymerization* — the mixture is heated again to +70 °C. At this temperature the Taq-polymerase lengthens both primings from their 3' ends. The primings grow up to the matrix sizes. This process takes 90 sec.

As a result, the number of DNA increases by many times. During 20 cycles the number of DNA copies reaches 10^6.

4. Incorporation of DNA fragments into the molecule-vector.

Vector — is a small autonomously replicated DNA molecule, which provides multiplication and work of the incorporated definite gene.

Vector molecules should:

– contain points of replication origin and replicate autonomously;

– permanently be inherited by a host cell;

– be contained in a great number of copies in the cell;

– possess a sufficient capacity, which allows cloning big genes in their composition;

– contain «convenient» sites of restriction;

– contain selective markers, which could be used for selecting cells that have received a cloned DNA segment and the marker itself.

The most useful of «vector-host» systems are those, in which the host role play *bacteria E. coli,* and the vector role — **plasmids**.

Plasmids — are ring autonomously replicated DNA molecules that are contained in bacterial cells.

Phage vectors — are phage particles containing a recombinant DNA. Vectors for E. coli are constructed on the basis of **phage λ and phage M 13**.

Phage λ contains a double-sequenced DNA of 48 500 pairs of nucleotides in size. It is packed into the head as a linear molecule with sticky ends. After penetration into the cel, sticky ends are mutually paired, the molecule locks into a ring and is sewn by a DNA-lygase. It is possible to clone fragments of 15 000 pairs of nucleotides long in the content of vectors on the basis of phage λ**.**

Cosmids — are vectors made on the basis of plasmids and phage λ. Cosmids have cos-sites, which are located on both ends of a DNA molecule of phage λ. Complementary single-sequenced parts are 12 nucleotides long, due to which the phage has a linear shape, they join each other through cos-sites and form a long sequence of hundreds of phage DNA or concatameres.

Phasmids — are hybrid vectors that can develop both as a phage and a plasmid. The capacity of plasmids is comparable to that of phage vectors.

5. Introduction of recombinant DNA in the cell-recipient.

The following methods are used:

1. Conjugation — transmission of genetic material in bacteria may occur in direct intercellular contact. Genetic material is transmitted only in one direction.

2. Transformation — transmission of genes with a free soluble DNA (by plasmids), isolated from cells-donors;

3. Transduction — the transmission of DNA from a cell-donor to a cell-recipient may occur with participation of b vector acteriophages;

4. Transfection — infection with phages λ, ψ174 and T4;

5. Competence — ability of cells to absorb a DNA from the environment;

6. Microinjection of DNA molecules into animal cells;

7. Using liposomes for introducing DNA into animal cells. Liposomes are vesicles surrounded by one or several layers of lipids.

6. Using methods of genetic engineering in medicine.

Southern blott hybridization. The method developed in 1975 allows identifying restriction DNA fragments (fig. 21).

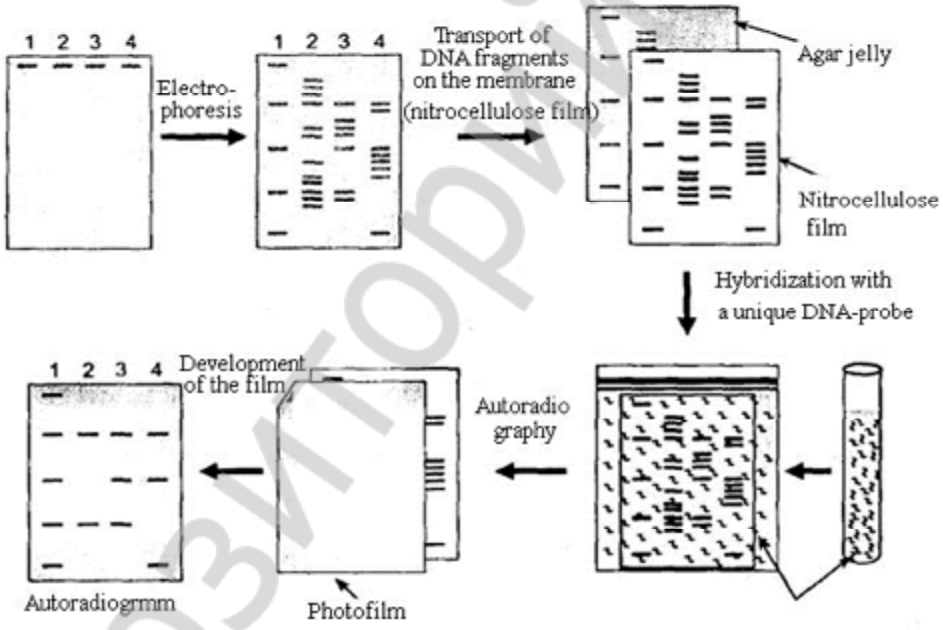


Fig. 21. Southern-blott hybridization method

A DNA treated with restrictases is placed on agar jelly in a special chamber for electrophoresis, where an electric field is formed, and under its influence DNA fragments start moving. Short fragments move faster. After electrophoresis a mixture of DNA fragments forms some fractions located some distance from each other. Each such fraction corresponds to one DNA fragment. DNA fragments separated in the agar jelly **are denaturated to single-sequenced molecules**, and then the whole electrophoresic DNA specter **is printed (blotting**) on an applied to the jelly nitrocellulose **film** and is fixed by high temperature. Then the film is placed into the culture containing a **radioactively marked DNA-probe**. The probe can hybridize only with a specific complementary to it

DNA fragment. After interaction with the DNA-probe the film is applied to the nitrocellulose membrane containing all obtained DNA fragments. After exposition there appear lighted spots corresponding to the arrangement of marked DNA fractions on the film (autoradiogram).

The method is used for revealing DNA sequences characteristic of mutated genes, it allows diagnosing gene mutations.

Gene dactyloscopy. There is a minisatellite DNA in the human genome, which presents short (9–64 nucleotide pairs), recurrent, tandem, variable DNA sequences. A tandem recurrence — are two or more identical DNA sequences located close to each other. The human has many different tandem DNA recurrences located in different chromosomes, which in total form a unique complement of minisatellite DNA for every human. The method of analyzing these fragments got the name of **gene dactyloscopy (fingerprint of DNA)**.

The technology of gene dactyloscopy: a DNA is isolated from cells and cut into fragments of various length with the help of restrictases. Then the Southern-blott analysis is made. *Fractions containing a minisatellite DNA*, are revealed with a probe, which is complementary to a link from 13 recurrent nucleotides. The probe is radioactive, it lights a roentgen film only in definite places, giving a picture of some tens of alternating dark fractions corresponding to separate minisatellites.

Basic terms and concepts:

1. Autoradiogram — is a film, where lighted fragments corresponding to the arrangement of marked DNA fractions are revealed.

2. Vector — is a small autonomously replicated DNA molecule, which provides multiplication and the work of a gene incorporated in it.

3. Genic dactyloscopy — is a method analyzing fractions of a minisatellite DNA.

4. Hybridization of primings — is a second stage of the polymerase chain reaction resulting in hybridization of DNA chains with primings.

5. DNA-probe — is a radioactively marked short specific DNA sequence.

6. Cosmids — are artificial constructions made on the basis of plasmids and phage λ.

7. «Sticky ends» — are single-thread complementary DNA ends, which are formed by restrictases.

8. Liposomes — are vesicles surrounded by one or several layers of lipids.

9. Plasmids — are small ring autonomously replicated DNA molecules, which are in bacterial cells.

10. Restrtictases — are enzymes causing DNA hydrolysis with the formation of «sticky ends».

11. Restriction sites — are sites recognized by restrictases (there are usually recognized parts of 4–6 pairs of nucleotides in length, strictly specific for every enzyme).

12. Phasmids — are hybrid vectors, which can develop both as a phage and a plasmid.

Topic 11. GENETICS OF POPULATIONS

1. Characteristic of human populations. Types of marriage.

Population is a group of species of one type having a common genotype, who are capable of free crossing, inhabit one territory for a long time and are relatively isolated from other individuals of the species.

Populations can be great and small. *Great* human populations contain over 4000 individuals. Dems and isolates — are *small populations.* The number of individuals in dems is 1500–4000 people, intergroup marriages in them compose 80–90 % and the inflow of genes from other groups is 1–2 %. *Isolates* contain up to 1500 people, intergroup marriages are over 90 %, the inflow of genes from other groups is less than 1 %. Marriages among relatives — *inbreeding (incest marriages)* are observed in dems and isolates. There is a high probability of homozygosity in relatives on one and the same pathologic gene; manifestation of hereditary pathology is possible. Outbreeding — incongeneric marriages. They sustain a high level of heterozygosity, and hereditary pathology occurs there far more rarely.Human populations are characterized by demographic factors: the number, birthrate, mortality rate, age and sex structure, occupation, ecologic state of the environment. The action of evolutionary selection is decreased there and destruction of isolates takes place.

2. Genetic processes in great populations. The law of Hardy-Weinberg.

Great populations are called *panmixed*, as the choice of a partner for marriage is not limited there. Great in their number populations approache to an *ideal* one, which is characterized by a great number, isolation from other populations of the species; complete panmixing; absence of mutations and evolutionary selection.

The law of Hardy-Weinberg: In an ideal population frequencies of genes and genotypes are in equilibrium and do not change in a number of generations.

Great populations are characterized by genetic polymorphism (AA, Aa on a definite character) and panmixia. Nine variants of marriages are possible under such conditions (taking into account genotypes):

Genetic records of marriages and fillies:

1. AA x AA → AA.
2. AA x Aa → AA + Aa.
3. AA x aa → Aa.
4. Aa x AA → AA + Aa.
5. Aa x Aa → AA + 2Aa + aa.
6. Aa x aa → Aa + aa.

m \ f	AA	Aa	aa
AA	1	4	7
Aa	2	5	8
aa	3	6	9

7. aa x AA → Aa.

8. aa x Aa → Aa + aa.

9. aa x aa → aa.

Summary: 4AA + 8Aa + 4aa or AA + 2Aa + aa

If one denotes genes frequencies as A-**p**, a-**q**, of genotypes as AA-$\mathbf{p}^2$, Aa-**2pq**, aa-$\mathbf{q}^2$, we'll get the following record: $\mathbf{p + q = 1}$ and $\mathbf{p^2 + 2pq + q^2 = 1}$.

3. Genetic processes in small populations.

There appears a **genes drift — incidental fluctuations of genes frequencies**. It is the accumulation of homozygotes of homozygous individuals. In the first generation (AA + 2Aa + aa) heterozygotes comprise 50 %, in F_2 their number will be 25 %, in F_3 — 12,5 %, etc. When lethal genes are present, the population comes to extinction due to homozygotization. Evolution in small populations is impossible, there is no genetic diversity.

Mutation process — is an incidental and undirected process. It sustains a high degree of heterogeneity of populations. Mutations can be neutral, negative or positive for the organism. When the environmental conditions change, neutral mutations can become positive or negative. Mutation frequency of a gene is 10^{-5}–10^{-7} per generation. Dominant mutations are revealed already in the first generation and are immediately exposed to evolutionary selection. At first recessive mutations accumulate in the population and are revealed phenotypically only after the appearance of recessive homozygotes, then evolutionary selection affects them. Mutations present an **elementary evolutionary material**.

Population waves or life waves — are periodical fluctuations of the number of natural populations due to fluctuations of environmental factors. Population waves change the genetic structure of populations removing the least adapted individuals from them.

Isolation — is a limitation of free crossing. It leads to separation of the population into separate groups and changing the genotype frequency. Types of isolation:

1. Geographic or territorial (mountain ridges, rivers).
2. Biological:

– genetic or hybrids sterility;

– ecologo-etological (unlikeness to meet a partner);

– morpho-physiological or impossibility to cross due to morphological differences of sex organs.

Migration of the population may increase heterozygosity in human populations. *Immigration* introduces new alleles or new genotype combinations into the population. *Emigration* changes the ratio of different genotypes in the population due to the «outflow» of genes.

Evolutionary selection is the most important evolutionary factor. It removes less favorable combinations of genes from the population and selectively preserves more favorable genotypes changing genes frequency in populations.

Three forms of evolutionary selection are distinguished — stabilizing, moving and disrupting.

4. Genetic load and its biological nature.

Saturation of populations with recessive mutations reducing adaptability of separate individuals to the environment, is called a *genetic load* of the population. A part of genetic load is passed from generation to generation (heterozygous carriage of pathologic recessive genes), other mutations arise in every new generation under the effect of mutagenic factors.

The amount of genetic load is proportional to the contamination degree of the environment (5 %).

Basic terms and concepts:

1. Dems — are populations of people containing 1500–4000 individuals.

2. Drift of genes — incidental fluctuations of genes frequencies in small populations.

3. Panmixia — absence of limitations in choosing of a partner for marriage.

4. Population — a group of individuals of one species inhabiting the given territory, freely crossing with each other and isolated from other groups of individuals of this species.

Topic 12. REPRODUCTION OF ORGANISMS

1. Forms of reproduction, their characteristic.

Reproduction is a universal organism property of all living things, which provides reproduction of their own selves and is based on transmission of genetic information from generation to generation.

Replication on a *molecular leve*l is a DNA replication, on a *subcellular level* — doubling of some organoids, on a *cellular one* — amitosis, mitosis. Cellular division is the basis of *organisms' reproduction*.

Forms of reproducing organisms. The characteristic of asexual reproduction: 1 parental individual takes part in reproduction; somatic cells are a source of genetic information; genotypes of daughter cells are identical to parental ones; the number of individuals grows fast; it ensures the species existence in unchanging environmental conditions (fig. 22).

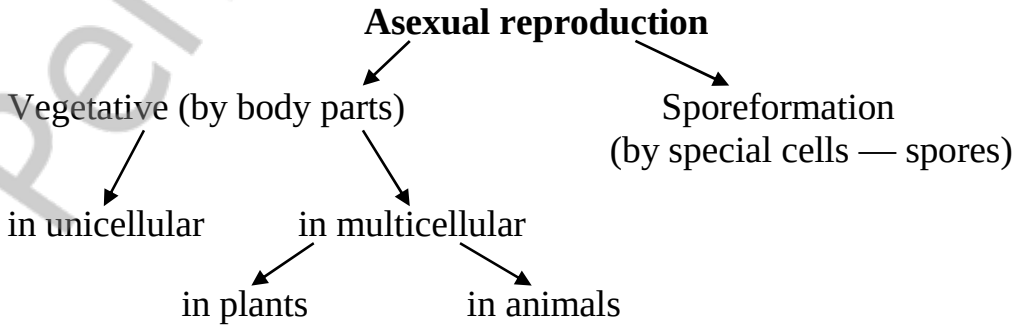


Fig. 22. Asexual reproduction

***Vegetative reproduction of unicellular organisms*:**

a) *division into two* (longitudinal division — in euglenas, transverse — in infusorians);

b) *schizogony* — is *a* multiple division — at first the nucleus is divided into multiple parts, then the cytoplasm (in a malaria plasmodium);

c) *budding* — a bud forms on the mother's cell, it grows and separates from the mother's individual (yeast, sucking infusorians).

***Vegetative reproduction in multicellular organisms*:**

A. *In plants* — by vegetative organs: the root, stem, leaves.

B. *Animals*:

a) *budding* (hydra);

b) *fragmentation* — division of the body by constrictions into several parts (cilia and ring worms);

c) *polyembryony* — division of the germ into several parts, each forming an integral organism (suckers).

***Sporeformation*:** in special organs (sporogonies) spores are formed, they give start to a new organism (water-plants, mushrooms, mosses, lycopodium, horse-tail, ferns).

Characteristic of sexual reproduction: 2 parental individuals take part in reproduction; parental sex cells are a source of genetic information; genotypes of daughter cells differ from the parental ones due to combinative variation; it promotes the adaptability of organisms to changing environmental conditions (fig. 23).

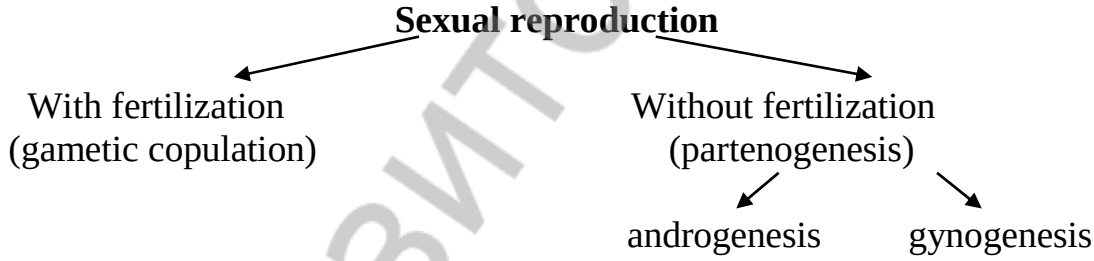


Fig. 23. Sexual reproduction

2. Evolution of the sexual process.

A sexual process is the bases of sexual reproduction. *Conjugation* is exchange of genetic information between unicellular organisms. *Copulation* is joining the genetic information of two cells. The increase of the number of individuals is not observed in the sexual process.

Conjugation is characteristic for infusorians and bacteria. During conjugation infusorians are linked with a plasmatic bridge and exchange micronucleus parts. Then they diverge and multiply in asexual way. At a definite period of their life cycle the organisms of protists perform a function of gametes. They fuse (the copulation occurs) and then multiply by division.

The copulation in sexual reproduction is called *gametic*.

3. Gametes structure.

Ova have a rounded or oval shape from 60μm to some cm in diameter. They are immovable, contain organoids and a store of nutrients (yolk). Their cytoplasm is species-specific. Ova are covered with membranes, in mammals — also with follicular epithelial cells.

Types of ova:

– *isolecital* — there is a small amount of yolk, it is evenly distributed (the Lancelet, mammals);

– *sharply telolecital* — there is a lot of yolk, it is located on the vegetative pole, and both the cytoplasm and the nucleus are on the animal pole (reptiles, birds);

– *moderately telolecital* — in fish and amphibians;

– *centrotelolecital* — there is little amount of yolk, it is in the center (insects).

A **spermatozoon** consists of a head, neck and tail. The sizes of a human spermatozoon are 52–70 μm. There is an *acrosome*, a modified Golgi's complex, at the end of the head. It provides the permeation of a spermatozoon into the ovum. The main part of the head is occupied by the nucleus surrounded by a thin layer of cytoplasm. There is a centrosome and a spiral thread consisting of mitochondria producing energy for movements of the tail in the neck.

4. Gametogenesis (oogenesis and spermatogenesis).

Depending on the presence and functioning of sex glands in the organism there are hermaphrodites and organisms with separate sexes.

The hermaphrodite is an organism having both male and female gonads forming both spermatozoa and ova. Such hermaphrodism occurs in flat and ring worms. It is a *true* hermaphrodism. In case of a *false* hermaphrodism, sex organs and secondary characters of both sexes develop in one individual and gonads are of one sex (male or female). The human may have a false hermaphrodism.

Organisms with separate sexes have either female or male gonads. Males and females are characterized by the characters of **sexual dimorphism**: differences in body sizes, coloration, structure, voice specificities, behavior and other characters. *The characters of sexual dimorphism in the human are* peculiarities of the bony-muscular system: distribution of subdermal adipose cellular tissue; the degree of hair covering development; voice timbre; peculiarities of behavior, etc.

The process of ova formation is oogenesis, that of spermatozoa — *spermatogenesis*. In gametogenesis, haploid gametes are formed from diploid somatic cells of sex glands (fig. 24).

Peculiarities of human gametogenesis:

1. Mitotic division of oogonies is completed before birth of the organism. Mitosis of spermatogonies starts with puberty.

2. A growth zone is clearly marked during oogenesis.

3. In oogenesis the 1st division of mitosis stops at the prophase diakinesis stage before puberty. The 2nd division of meiosis stops at the metaphase stage and completes after fertilization.

4. There is no zone of formation in oogenesis, in spermatogenesis the formation zone is clearly marked.

5. A newborn girl has about 30 000 oocytes in her ovaries, of them only 300–400 reach their maturity (about 13 cells a year).

6. During the period of sexual life a male organism produces up to 500 billion spermatozoa.

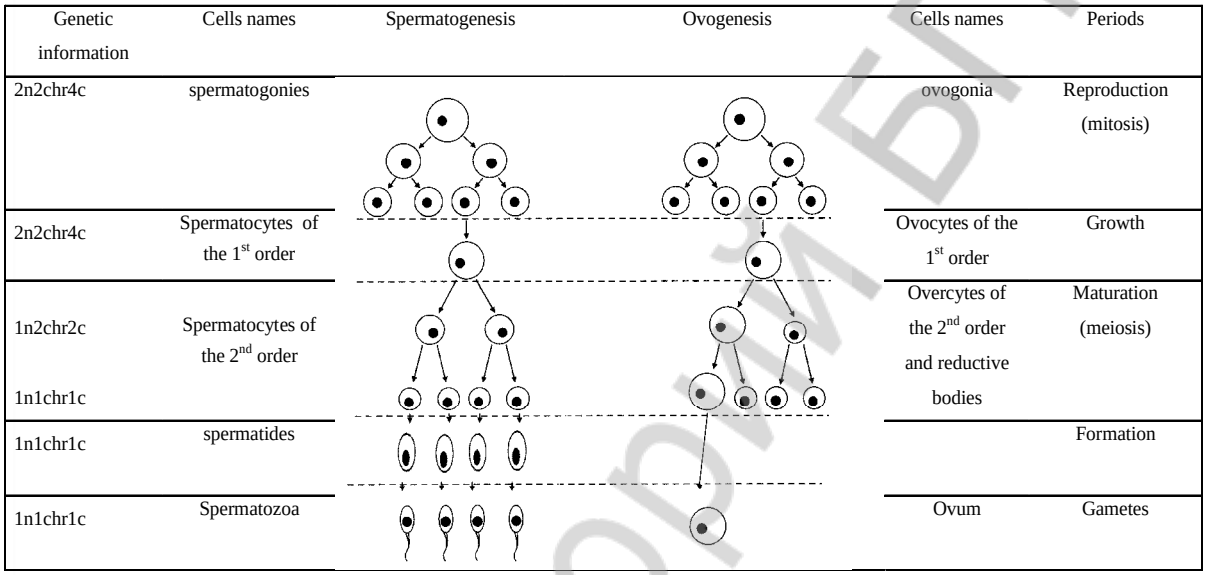


Fig. 24. Gametogenesis

5. Insemination, its forms. Fertilization and its stages.

A number of processes that provide a contact of female and male gametes is **insemination**. Water animals have an *external insemination*: gametes are excreted into the water, where their fusion occurs.

In an *internal insemination* (in ground animals), male gametes are injected into the sexual ways of a female during an intercourse.

The insemination process is followed by fertilization: fusion of gametes with a zygote formation. A contact of gametes is provided by:

– opposite charges of gametes;
– movement of spermatozoa and wall contraction of female sexual ways;
– excretion of gammons by an ovum, to which spermatozoa have a positive chemotaxis.

An external stage of fertilization — is permeation of a spermatozoon into an ovum. During the contact with the ovum a spermatozoon acrosomal membrane is destroyed and the enzyme *hyaluronidase* is excreted.

The enzyme dissolves the ovum membrane, an acrosomal thread is thrown from the acrosome; it permeates through egg membranes and fuses with

the ovum membrane. A *receiving protuberance* is formed in this part of the ovum; it catches and carries the head and centriole of the spermatozoon into the ovum cytoplasm. The ovum can be permeated by one spermatozoon (in mammals), then it is *monospermy*.

If several spermatozoa enter the ovum (in insects, fish and birds), it is *polyspermy*. After spermatozoon permeation a fertilization membrane forms on the surface of the ovum and other spermatozoa can not get inside.

Syncaryogamy is associated with an **internal stage**; it is fusion of gametes haploid nuclei and formation of a diploid nucleus of a zygote.

A *male pronucleus* (spermatozoon nucleus) enlarges to the sizes of a female pronucleus (ovum nucleus), turns by 180^{o} and moves to a *female pronucleus* with its centrosome. The pronuclei fuse, a diploid chromosomal complement restores and a zygote forms.

A special form of reproduction is **partenogenesis**, the development of organisms from unfertilized ova. A *natural partenogenesis* occurs in lower cancroids, bees, butterflies, rock lizards. Nuclei of somatic cells in such individuals can be haploid. A diploid complement restores in fusion of the ovum nucleus with the nucleus of the directing body.

6. Biological peculiarities of human reproduction.

Peculiarities are:

1. The human is not only biological but also a social being.
2. The ability for reproduction appears with puberty. Its signs are first periods in girls (on an average from 12–15 years) and pollutions in boys (from 13–16 years).
3. The duration of the reproductive period in women is to 40–45 years, in men — to an old age (gamete production by the testes occurs during the whole life).
4. During one intercourse about 200 million of spermatozoa are excreted with the semen fluid.
5. On coming puberty one oocyte of the 2^{nd} order is formed once a moon month.
6. Fertilization occurs in upper parts of the uterine tubes, usually during the first 12 hours after ovulation.
7. Spermatozoa retain their ability for fertilization during 1–2 days after getting into the female sexual ways.
8. Human reproduction, unlike that of animals, is not seasonal. It depends on a number of social-economic factors.
9. The human can regulate birthrate.

Basic terms and concepts:

1. Acrosome — is a modified Golgi's complex of a spermatozoon.

2. Conjugation — a sexual process, when exchange of genetic information between two cells occurs.

3. Copulation — is a sexual process, when joining of genetic information of two individuals occurs.

4. Oogamy — is a form of copulation with a strict differentiation of gametes: a large and immovable ovum and a small and movable spermatozoon.

5. Oogenesis — is a process of development of maturation of ova.

6. Insemination — are processes ensuring gametes contact.

7. Fertilization — is fusing of an ovum and a spermatozoon with further formation of a zygote.

8. Partenogenesis — is sexual reproduction without fertilization.

9. Sexual process — is exchange of genetic information between two cells or joining the genetic information of two cells; increase of the number of individuals is not observed.

10. Syncarion — is a nucleus of a zygote formed as a result of fusion of gametic nuclei.

11. Spermatogenesis — is a process of spermatozoa development.

Topic 13. BASES OF ONTOGENESIS (EMBRYONIC DEVELOPMENT)

1. Ontogenesis, its types, division into periods.

Ontogenesis — is individual development of the organism from a zygote formation to its death.

Division of ontogenesis into periods (fig. 25).

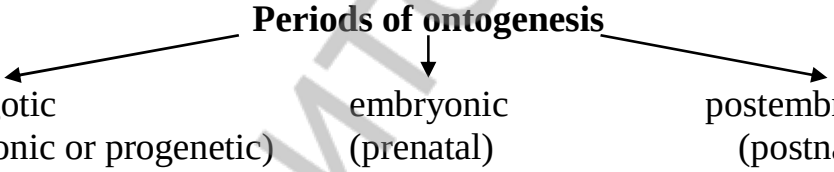


Fig. 25. Periods of ontogenesis

The pre-zygote period — is a period of formation and maturation of those parental sex cells that will form a zygote in future.

The embryonic or prenatal period starts with the moment of a zygote formation and ends with birth of a new organism or its leaving egg membranes.

The post-embryonic or post-natal period — lasts from birth of an organism or its leaving egg membranes and to death.

2. Division of the human embryonic development into periods.

Embryogenesis of the human includes:

1. Germinative or initial period — the 1st week after fertilization, a zygote is being split.

2. Embryonic period — the 2nd–3rd weeks after fertilization, a blastule and a gastrule are formed, germinal layers and axial organs are being germinated.

3. Pre-fetal period — the 4–8th weeks, formation of germs of all organ systems and the placenta.

4. Fetal period — from the 9th week an embryo is called a fetus; growth of the fetus is going on, its organs and organ systems are being formed.

Characteristic of embryogenesis stages. Provisional organs.

Zygote is a unicellular development stage of a multicellular organism; it was formed on fusion of a male and female gamete.

The type of **splitting a zygote** is determined by an ovum type that depends on the amount of nutrients (yolk) and their distribution. Cells that are formed in splitting are *blastomeres*. The process of splitting a germ in some animals reminds a raspberry (**morula**). Blastomeres of the morula are located on the periphery in one layer and form a **blastula** — a one-layer germ with a cavity inside. This layer of cells is called *blastoderma*. The cavity of the blastula is a *blastocele*.

The blastula stage is followed by **gastrullation** — formation of a gastrula, a two-layer germ. The cell layers of the gastrula got the name of germinal layers. There are 4 types of gastrulation (fig. 26).

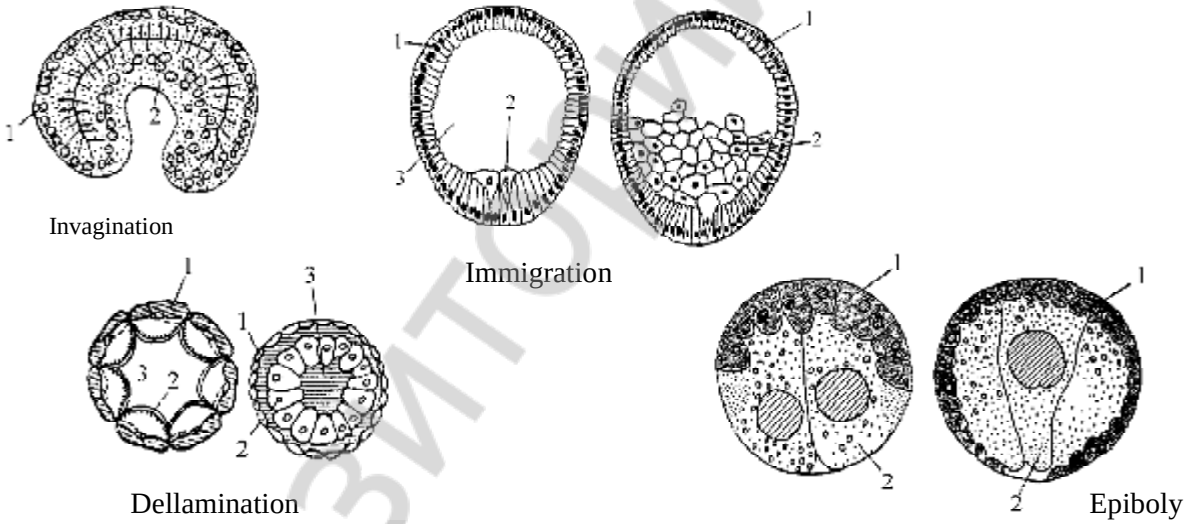


Fig. 26. Ways of gastrulation:
1 — ectoderm; *2* — entoderm; *3* — gastrocele

Invagination — is drawing in: the vegetative pole of the blastula is drawn inside, taking place under the animal pole. A 2-layer germ is formed: an external layer got the name of *ectoderm*, an internal one — *entoderm*. The gastrula cavity is called gastrocele or a primary intestine. Entrance to the intestine is a primary mouth or a blastopore. Its edges form an upper and lower lip of the blastopore. In secondary-mouthed (echinodermata and chordates) it becomes an anal opening and the mouth is formed on the opposite end of the germ.

Immigration — is «eviction» of some cells into the germ's cavity and formation of a second layer there — entoderm.

Epiboly — over-growing: the animal pole cells are divided faster than the vegetative pole cells that become the endoderm.

Delamination — splitting: all cells of one germinal layer are divided parallel to its surface and form 2 layers — the ectoderm and endoderm.

Gastrulation in the human goes on a mixed type — some of its forms combine simultaneously.

All animals (except sponges and coelenterate) have three layers. Germination of the 3rd germinal layer, **mesoderm**, occurs in two ways: *teloblastic* and *enterocelic*. The *teloblastic way* is characteristic of invertebrates. There forms one large cell, a *teloblast*, on both sides of the intestine near the blastopore. They start dividing; small cells take place between the ectoderm and entoderm and form the mesoderm. The *enterocelic way* is characteristic for chordates. There are formed bulges, *pockets* (celomic sacs) on two sides of the primary intestine. They become separated from the primary intestine, over-grow between the ectoderm and entoderm and give start to the mesoderm. After the formation of germinal layers germination of axial organs occurs; it is *histogenesis* — a process of tissue formation and *organogenesis* — a process of organ formation.

Derivatives of germinal layers. The ectoderm gives start to the epidermis and its derivatives, nervous system, sense organs, initial and final parts of the digestive tube.

The chord, middle part of the digestive tube, liver, pancreas and respiratory system are formed from the **entoderm**.

The following organs and systems are formed from the **mesoderm**: the connective and muscular system, skeletal muscles, the skeleton, derma, dentin, urogenital system, smooth musculature, heart, blood vessels, blood, lymphatic system.

Provisional (temporary) organs of the germ:

1. *Amnion* — is a sac filled with the fluid that forms water environment, protects the germ from drying and injuries.

2. *Chorion* (a serous membrane) is an external membrane adjacent to shell or mother's tissues. It serves for exchanging nutrients with the external environment.

3. *Yolk sac* takes part in feeding of the germ and is a blood-making organ.

4. *Allantois* is a process of the back intestine, a receptacle for urea and the uric acid. In mammals it forms the placenta together with the chorion.

3. Mechanisms of embryogenesis. Morphogenesis.

Mechanisms ensuring embryogenesis:

1. **Diffgerential activity of genes** — various blocks of genes have a strictly definite order of repression and depression during embryonic development.

2. **Determination** — obtaining the ability to develop in a definite direction by the cells and simultaneous limitation of their future development possibilities. At the beginning of embryogenesis blastomeres are *totypotentious* (can give start

to a whole organism) and their development depends on external inductors and adjacent cells. At later stages of embryogenesis cells become determinant (their development is predetermined) and they develop according to a given plan.

3. **Differentiation** — is a biochemical, functional and morphological specialization of cells; modification of a developing structure, when relatively homogenous formations become more and more different.

Phases of differentiation:

- *dependent* (to the stage of an early gastrula);
- *independent* (at the stage of a late gastrula).

Genetic bases of differentiation. Genetic differentiation is associated with universality of an ovum and inhomogeneity of its cytoplasm — different parts of the cytoplasm have a *different complement of chemical substances* and possess different development possibilities.

Stages of differentiation (fig. 27).

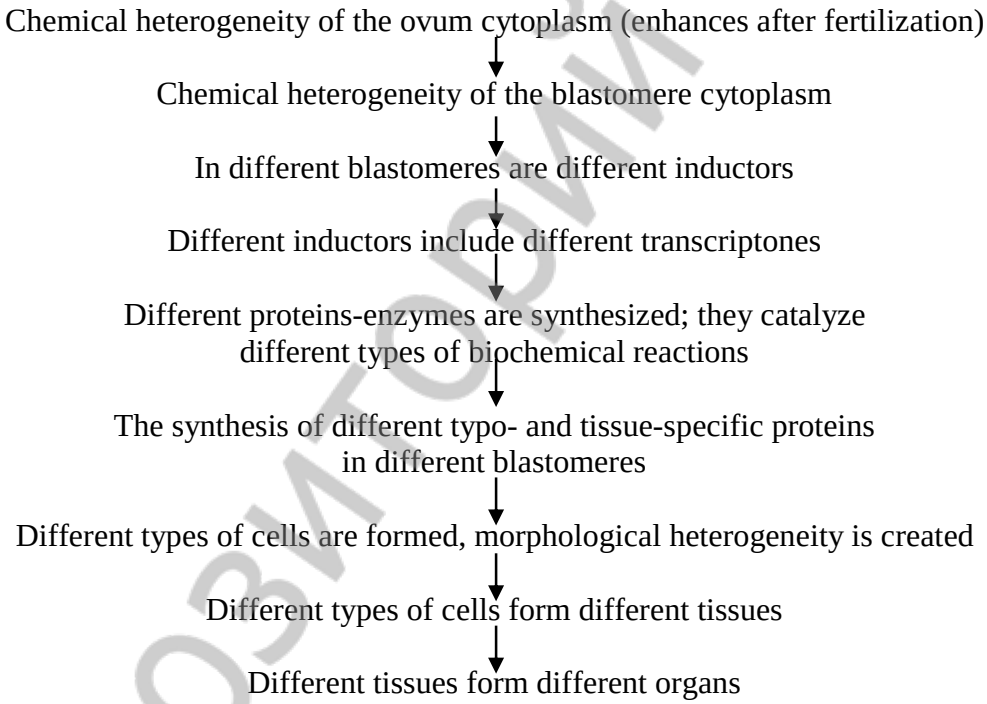


Fig. 27. Stages of differentiation

4. **Morphogenesis** — is a process of appearing new structures and modification of their form in ontogenesis.

Mechanisms of morphogenesis:

1. **Embryonic induction** — is influence of a group of embryonic cells on adjacent cells (G. Shpeman, G. Mangold). The primary inductor (*an upper lip of the blastopore*) determines the nervous tube formation, then the chord development is induced, and after this — that of the digestive tube.

2. **Morphogenetic fields** (A. G. Gurvich) — are distant cellular interactions of the electric or gravitational nature.

3. **Gradient of physiologic activity** (Ch. Child) — the intensity of substances exchange in the head department of the germ is higher than in the caudal one.

4. **Positional information of the cell** — due to intercellular interactions every cell assesses its own position in the germ of an organ and then differentiates according to this position.

4. Critical periods of the prenatal ontogenesis. Teratogenesis.

Periods of the greatest sensitivity of the germ to environmental factors are called **critical periods.**

The human has 3 basic critical periods in embryogenesis:

1) *implantation* — instillation of an embryo in the mucus of the uterus ($6–7^{th}$ day after fertilization);

2) *placentation* — the beginning of the placenta formation ($14–15^{th}$ day after fertilization);

3) *delivery* — coming out of the mother's organism, reconstruction of all organ systems, modification of the way of feeding ($39–40^{th}$ week).

Critical periods coincide with transitions from one development period to the other and modified existence conditions of the germ.

The process of the natural course impairment of embryogenesis under environmental factors is called **teratogenesis** (Greek *teras* — monster).

Factors causing teratogenesis are *teratogens*. They are medicines (antibiotics, quinine, chloride, anti-depressants, etc.), alcohol, nicotine, waste products of parasites, ionizing radiation.

Causes, development mechanisms of development defects are studied by teratology. Incidence frequency of development defects in human populations is 1–2 %.

Variants of congenital development defects: aplasia (hypoplasia), hypo- (hyper) trophy, heterotopy, atresia, stenos, etc.

Basic terms and concepts:

1. Aplasia — absence of an organ.

2. Atresia — imperforation of natural openings and canals.

3. Balstula — a one-layer multicellular germ with a cavity inside.

4. Gradients of physiologic activity — intensity of exchange processes in the head department of the germ are higher as compared to the caudal department.

5. Critical periods — are periods of the greatest sensitivity of the germ to environmental factors.

6. Morphological fields — distant cellular interactions of the electric or gravitational nature.

7. Ontogenesis — an individual development from a zygote formation to death.

8. Progenesis — the period of formation and maturation of those sex parental cells that form a zygote.

9. Teratogenesis — the impairment process of a natural course of embryogenesis under environmental factors.

10. Embryonic induction — the effect of a group of embryonic cells on adjacent cells.

Topic 14. BASES OF ONTOGENESIS (POSTEMBRYONIC DEVELOPMENT)

1. Postnatal ontogenesis. Types of development.

Post-embryonic (postnatal) period — is a period from the moment of birth or coming out of egg membranes and to death. After morphogenesis comes puberty and reproduction takes place; a final stage of ontogenesis is getting old and death.

Types of development (tab. 3).

Table 3

Types of ontogenesis

Direct development	Indirect development (with metamorphosis)
Laying eggs with a great amount of yoke (birds)	Incomplete metamorphosis, stages: egg – larva – mature individual (intestinal helminthes)
Intrauterine (mammals)	Complete metamorphosis, stages: egg – larva – chrysalis – mature individual (butterflies, 2-wing insects)

Division of the postnatal human ontogenesis into periods.

Neonatal period (1–10 days): a complex period of reconstruction of the whole organism, adaptation to new existence conditions.

Breast-feeding period (11 days – 12 months): feeding the child with mother's milk; intensive growth.

Early childhood period (1–3 years): the child learns to walk and speak, gets acquainted with the surrounding world.

The 1st childhood period (4–6 years): the child is interested in everything and tries to understand everything, masters elementary game skills.

The 2nd childhood period (7–11 years in girls, 7–12 years in boys): the growth becomes slow, intensive development of the muscular system; children go to school.

Adolescent period (12–15 years in girls, 13–16 years in boys): puberty starts and growth intensity increases.

Juvenile period (16–20 years in girls, 17–21 years in young men): puberty, growth and physical development have completed.

Middle age, I period (21–35 years in women, 22–35 years in men): an optimal period for childbirth; mastering professional skills.

Middle age, II period (36–55 years in women, 36–60 years in men): a period of the most active professional activity; the first signs of getting old appear after 35 years).

Advanced age (56–75 years in women, 61–75 years in men): the processes of aging are going on; retirement.

Senile age (76–90 years): senile changes are marked; some people retain the ability for creative work at this age.

Age of long-livers (over 90 years).

Critical periods of postnatal ontogenesis.

There are **critical periods** in the postnatal human ontogenesis:

1. *Neonatal period* (the first days after birth) — reconstruction of all organ systems for a new environment is going on.

2. *Puberty period* (12–16 years) — a hormonal reconstruction, formation of secondary *sexual* characters.

3. *Period of sexual wasting away* (about 50 years in women, 60–70 years in men) — functional fading of sex glands and the glands of internal secretion).

2. Growth. Growth types of tissues and organs in the human. Acceleration.

Growth — is enlargement of sizes and body mass. The growth can be **unlimited** (indefinite) — it lasts all life (cancroids, fish and reptiles) and **limited** (definite) — stops by a definite age (insects, birds, mammals).

The growth of the human has an uneven course. The most intensive growth is marked in the first year of life — it increases by 25 cm. In the 2nd year it increases by 10–11 cm, in the 3rd — by 8 cm. At the age from 4 to 7 years the growth increment is 5–7 cm per year. At a junior school age it is 4–5 cm per year, in puberty the growth intensity increases to7–8 cm a year. Then the growth slows down and increases only 1–2 cm a year till the age of 20–25 years.

Basic growth types for tissues and organs:

- a *general* type: the whole body, muscles, skeleton, respiratory organs, liver have a maximum growth in the 1st year of life and in puberty;
- a *lymphoid* type: the thymus, lymphatic nodes and the lymphoid tissue of the intestine, spleen, tonsils; a maximum increase of their mass occurs till the age of 11–12 years and then involution;
- a *cerebral* type: the brain and the spinal cord, eyes, the head develop earlier than other parts of the body — after birth and to 10–12 years;
- a r*eproductive* type: various parts of the reproductive system — a fast growth in puberty.

Growth regulation:

1. Somatotropin (a hypophysis hormone), thyroxin (a thyroid gland hormone).

2. Environmental factors: light, nutrition, vitamins (A, B, D), microelements, social-economic factors.

The somatotropic hormone is produced since the moment of birth till 13–16 years. When the gland's function is lowered, hypophysial nanism develops; when it is increased, gigantism develops — the human growth reaches

2 meters and more. Excretion of the hormone in an adult person results in acromegaly — bones enlargement of the hand, foot and face. *Thyroxin* increases energy exchange in the organism. The decrease of the gland's function leads to growth retardation, impairment of body proportions, retardation of sexual development, mental impairment. *Sexual hormones* produce effect on all metabolic processes. *Environmental factors* produce a great effect on growth. Balanced nutrition is necessary for normal growth of the child. It should include vitamins and microelements. The sun light plays an important role in synthesis of vitamin D (calciferole).

During the last decades the **acceleration** of physical and physiological development of children and adolescents is marked. It is manifested already on the stage of intrauterine development — lengthening of the body of newborns by 0,5–1,0 cm, body mass by 50–100 g, the terms of teeth eruption change. The growth for the last 100 years has increased on an average by 8 cm. The following factors are considered to cause acceleration: mixed marriages (increase of heterozygosity), urbanization, increase of the radiation background, changes in the Earth magnet field and a number of social factors.

3. Constitution and the human habitus.

Constitution of the human — are genetically conditioned peculiarities of morphology, physiology and behavior. In 1927 M. V. Chernorutsky proposed the classification including three types of constitution.

Ectomorphic type (asthenics): a narrow chest, low position of the diaphragm, elongated lungs, short intestines with low absorption, thin bones and long extremities, a thin layer of fat deposits. Asthenics are characterized by high excitability, inclination to neuroses, hypotonia, ulcers, tuberculosis.

Mesomorphic type (normosthenics): proportional constitution, moderate development of the hypodermal adipose tissue. Such people are energetic, alert, inclined to neuralgias, atherosclerosis and diseases of the upper respiratory tract.

Endomorphic type (hypersthenics): a broad chest, voluminous stomach and long intestines, a considerable fat deposit. The amounts of cholesterol, uric acid, erythrocytes and hemoglobin in the blood are increased. Assimilation processes predominate, they are inclined to obesity, diabetes mellitus, hypertension, diseases of kidneys and bladder.

Habitus includes peculiarities of morphology, physiology and behavior in a definite period. Habitus reflects well-being of a person and his health state at a given moment. It includes: peculiarities of the body build, pose, bearing, gait, color of the skin coverings, expression of the face, concordance of a biological and chronological age.

4. Ageing of the organism. Basic theories of ageing.

Ageing — is a common biological regularity characteristic of all living organisms. Old age is a final stage of ontogenesis. The science about old age is called **gerontology**. It studies regularities of ageing of various organ systems

and tissues. **Geriatrics** is a science about diseases of old people; it studies peculiarities of their development, course, treatment and prophylaxis.

Gerontology offers more than 300 hypotheses of ageing. The most common of them are:

1. *Energetic* (M. Rubner, 1908): the organism of each species has a definite energetic fund. It is being spent during the whole life, then the organism dies.

2. *Intoxicational* (I. Mechnikov, 1903): self-poisoning of the organism due to accumulation of products of nitrogenous exchange and putrefaction in the intestines.

3. *Associated with the connective tissue* (A. Bogomolets, 1922): the connective tissue is a nutrition regulator of cells and tissues; changes taking place there impair inter-tissue interactions and result in ageing.

4. *Overstrain of the central nervous system* (I. Pavlov, 1912. G. Celie, 1936): nervous break-downs and prolonged nervous overstrain cause untimely ageing.

5. *Changes of colloidal properties of the cellular cytoplasm* (V. Ruzhichka, M. Marinesku, 1922): a modified cytoplasm does not retain water properly, colloids from hydrophilic transform into hydrophobic, colloidal particles become bigger and their biological properties change.

6. *The programmed number of cellular mitoses* (A. Heiflick, 1965): different species have different numbers of cellular divisions: fibroblasts of human embryos give about 50 generations, the mice and hen has about 15 generations).

7. *Genetic*: accumulation of mutations: decrease of intensity and impairment of the processes of transcription, translation and repair; impairment of self-renewal of proteins.

A considerable impact on the process of human ageing has *social factors*, living conditions and way of life, various diseases. Ageing and the life span depend also on the ecological situation.

The science that studies a healthy style of life of the human and conditions increasing his life span is called **valeology**. A theoretically possible human age is 150–200 years; a maximum registered one is 115–120 years. An average life span of men in Belarus is 64–70 years, that of women — 72–79 years.

5. Clinical and biological death. Reanimation. Problems of euthanasia.

Ageing of the organism is terminated by **death**. Death ensures a change of generations. Causes of death can be different. *A physiological death*, or natural, occurs due to ageing. A *pathological death*, or untimely, is the result of a disease or an accident.

A clinical death occurs as a result of termination of vital functions (heart or respiration failure), but exchange processes of substances in cells and organs are retained. *A biological death* is termination of processes of self-renewal in cells and tissues, impairment of chemical processes, autolysis and decay of cells. In the most sensitive cells of the brain cortex necrotic changes are revealed already in 5–6 minutes. To prolong the period of nearing a clinical death one can using

general hypothermia of the organism that slows down metabolic processes and increases the persistence to oxygen starvation.

Reanimation — is a possibility to return a human to life from the state of a clinical death (when vital organs are not impaired) in 5–6 minutes, while cortical cells of the brain are still alive. Reanimation methods are used in medicine in any threatening conditions.

Euthanasia — is a medical assistance to pass from life for a terminally ill patient according to his will or request of his relatives. Euthanasia is allowed by law only in some countries.

Basic terms and concepts:

1. Acceleration — speeding-up of physical and physiological development of children and adolescents.

2. Habitus of the human — peculiarities of morphology, physiology, behavior in a definite interval.

3. Geriatrics — a science about diseases of old people; studies peculiarities of their development, course, treatment and prophylaxis.

4. Gerontology — is a science about old age.

5. Constitution of the human — is genetically conditioned peculiarities of morphology, physiology and behavior.

6. Euthanasia — is medical assistance for passing from life to a terminally ill patient according to his wish of request of his relatives.

Topic 15. INTRODUCTION TO PARASYTOLOGY

1. Origin of parasitism. Criteria of parasitism.

According to E. N. Pavlovsky, «parasites are animals that live at the cost of individuals of other species, being biologically and ecologically closely connected with them in their life cycle at its longer or shorter duration».

Criteria of parasitism:

1) special relations with the host;
2) feeding at cost of the host;
3) pathogenic action on the host (inflicted harm).

The host of the parasite is an organism that provides it with inhabitation and food and suffers a definite harm from it.

A specific habitation is characteristic of the parasite. The habitation of the 1st order is the host's organism. This environment actively reacts to the presence of a parasite. The habitation of the 2nd order is an external environment. The host is a link between the parasite and the environment.

Parasitism is a most common form of symbiosis. Parasites are all viruses, many bacteria, some kinds of mushrooms and higher plants. 10 000 species of protists, 7000 species of arthropoda, 20 000 species of helminthes are referred to

parasites. Some classes are presented completely by parasites — Cryptogamers, Suckers and Tapeworms.

Diseases caused by viruses and bacteria are infections (the flue, hepatitis, tuberculosis, etc.). Protists and helminthes cause invasions (ascariasis, teniasis, enterobiasis, etc.). Diseases caused by arthropoda (ticks and insects) are infestations (pediculosis, myiasis, scabby, etc.).

Age of parasitism: Theoretically, one can presume that parasites appeared simultaneously with protists, because parasitizing bacteria were revealed in the body of amoeba. Multicellular parasites existed already in the paleozoic era. Imprints of sea lilies (echinodermata), the stems of which had gall-like growths caused by nematodes, prove it.

Parasitism origin:

1. **Predator → ectoparasite**. Medicinal leeches are temporal ectoparasites for the human, for small animals it may be a predator, as it sucks out a great amount of blood and the animal dies.

2. **Free way of life → attached way of life → ectoparasitism.** Independently living cirripedia may pass to an attached way of life fixing themselves to underwater parts of wooden buildings or bottoms of ships. They pass to ectoparasitism if they attach themselves to living objects — mollusks' shells or fish bodies.

3. **Commensalism → ectoparasitism. Commensalism → endoparasitism.** If a commensal settles on coverings of its partner's body, it may become an ectoparasite. It becomes an endoparasite, when gets inside the organism in body cavities connected with an external environment. The enteric amoeba is an endocommensal in the human organism.

4. **Transit through the digestive tract** (larva of a filth fly).

Parasitism is an ecological event. **Ecological Parasitology** studies interrelations of parasites and their populations with each other, with the host organism and the environment.

2. The «parasite–host» system. This system includes one individual of the host and one or a group of parasites of a definite species.

For the formation of this system, the following conditions are necessary:

a) a contact between the parasite and the host;
b) providing conditions for the development of the parasite by the host;
c) the ability of the parasite to withstand the host's reactions.

The basic direction of evolution is to achieve the equilibrium, smoothing the antagonism between partners and improving the reliability of the system.

Smoothing of the antagonism is achieved due to co-adaptation:

– in the parasite — morphologic and biologic adaptations;
– in the host — complication of defense mechanisms.

Directions of evolution are also different (co-evolution):

– in the parasite — complication of adaptation mechanisms to the host;

– in the host — improving defense reactions at all levels (for destroying the parasite).

Parasitic diseases (parasitism): *protozoosis* (causative agents are protists); *helminthosis* (causative agents are helminthes); *acariasis* (causative agents are ticks); *insectosis* (causative agents are insects).

Transmissible diseases — causative agents are transmitted through the blood by a carrier — an arthropod (ticks and insects).

3. Classification of parasites and their hosts.

Classification of parasites:

1. According to relation with the host:

– *true* — a parasitic way of life is a species character (ascarids, lice);

– *false* (pseudo-parasites) — free living, but when they get into a living organism, they may exist there and produce harm (larvae of the filth fly);

– *hyper-parasites* or *super-parasites* — are parasites of parasites (bacteria in parasitizing protists).

2. According to localization in the host:

– ectoparasites inhabit body coverings of the host (lice, fleas);

– endoparasites live inside the host's organism:

a) intracellular (toxoplasm);

b) intracavital (ascarids);

c) tissue (liver sucker);

d) intradermal (scabby tick).

3. According to duration of the relation with the host:

– constant — they spend the whole life cycle in the host (an ascarids);

– temporal — they spend a part of their life cycle in the host: larval parasitism (larvae of the horse fly); immarginal parasitism — sexually mature individuals parasitize (mosquitoes, fleas).

Classification of hosts:

1. According the parasite's development stage:

a) *definitive or final* — the parasite reaches its sexual maturation and undergoes its sexual reproduction in his organism (the human for tenias);

b) *alternate or intermediate* — parasite's larvae inhabit his organism, here their asexual reproduction occurs (the human for malaria plasmodia);

c) *supplementary or secondary* (predatory fish for larvae of Diphyllobothrium).

2. According to the parasite's development conditions:

a) *obligatory or natural* — they provide optimal conditions for parasite development in the presence of biocenotic links (natural ways of infection) — the human for the ascarids;

b) *optional or permissive* — the presence of biocenotic links, but the absence of biochemical conditions for the parasite's development (the human for the pig's ascarids);

c) *potential* — the presence of biochemical conditions for the development but the absence of biocenotic links (Guiney pig for trichinella).

4. Morphophysiological adaptations of parasites. Parasites are highly specialized organisms, maximally adapted to their inhabitation:

a) **progressive**:

– *enlargement of body sizes* (up to 20 m in tape worms);

– *the sexual system reaches its most development* as compared to others;

– *hermaphrodism*;

– *diversity of fixation organs* (sucking discs of lamblii, suckers of sucking insects, botria, hooks of tape worms; claws of lice, etc);

– *external coverings* — tegument, cuticle protect from the action of host's enzymes;

– *«molecular mimicry»* — similarity of proteins of the parasite and the host;

– *excretion of anti*-enzymes, histolysines, by parasites;

b) **regressive**:

– *simplification of sense organs* — endoparasites have only tactile organs and chemical senses;

– *simplification of the organ system structure* — absence of the alimentary tract in tape worms.

Biological adaptations are associated with peculiarities of the sexual system structure, reproduction and development cycles of parasites:

a) *high fertility* (Taenia solium excretes 100 thousand eggs with every mature segment, an ascarid — 240 thousand eggs per day);

b) *various forms of asexual reproduction* (Schizogony in malaria plasmodia, polyembryony in suckers);

c) *migrations over the host organism (larvae of taenia solium and ascarids)*;

d) *complex development cycles* with changing of hosts.

The «results» of interactions of the parasite and the host on an organism level may be different: *death of a parasite, death of a host and pathogenicity*.

5. Ways of infecting the human with parasites.

Permeation ways into the host organism:

1) *alimentary* — with food and water orally (helminthes eggs, protists cysts);

2) *air-drop (respiratory)* — through the respiratory tract (cysts of soil amoebas, some viruses and bacteria);

3) *percutant* — through the intact skin (larvae of suckers);

4) *transplacental* — intrauterally from mother to fetus (toxoplasm, malaria plasmodia);

5) *transfusional* — in transfusion of infected blood (trypanosomes, malaria plasmodia);

6) *contact-household* — in contact with a sick person or animal, through utensils (scabby tick);

7) *transmissive* — with participation of an arthropod (trypanosomes, malaria plasmodia);

8) *sexual* — in sexual contacts (vaginal trichomonade).

6. Pathogenic action and specificity of parasites.

Pathogenicity is the ability to cause a disease, it depends on:

– *parasite's genotype*, its species;

– *host's age*(children and old people are more vulnerable to infection);

– *diet regimen* (improper diet increases the number of parasites in the organism and their sizes, reduces the terms of their development);

– *dose and degree of invasion (*the more eggs or larva are introduced into the organism, the more severe will be a course of the disease);

– *resistance degree of the host's organism;*

– *presence of other parasites and diseases.*

Specificity is manifestation of a historically formed adaptation degree of the parasite to the host. Specificity is manifested in the following forms:

a) *hostal* (that of a host's): monohostal — the parasite has one species of the host (ascarids), polyhostal — the parasite has hosts of various species (trichinella);

b) *topical* (a site of parasitizing): ascarids (intestines);

c) *age* enterobiasis in children);

d) *seasonal* (outbursts of amoebic dysentery — the end of spring – summer).

Pathogenic action of parasites:

1. *Mechanic action*: parasites produce it by their body mass (a ball of ascarids in the intestines, an echinococcus vesicle in the brain), by fixation organs (incarceration of the intestinal mucous membrane by suckers), impairment of the skin coverings integrity, etc. This action is revealed due to a pain syndrome.

2. *Toxic-allergic action*: is produced by metabolites of parasites that are antigens; histolyzins and decay products of dead parasites. Manifestations of this action: skin eruptions, dermatitis, eosinophilia, allergic reactions.

3. *Absorption of nutrients and vitamins* in the host's organism results in avitaminosis (mainly A and C), loss of weight, exhaustion.

4. *Impairment of the metabolic process* in the host's organism reduces resistance and increases sensitivity to pathogens of other diseases.

5. Biologically active substances produce an *immune-depressive action*.

6. Some *parasites stimulate* the formation of malignant tumors: schistosomes — cancer of the bladder and rectum.

7. Parasites produce an *unfavorable effect on the course of pregnancy and fetus development* (malaria plasmodia, toxoplasm, cat's sucker, etc.).

7. Host's response to parasitic invasion.

The basis of all reactions — is the host's immune defense. Allergy is a kind of immune reactivity. *The first reaction to a parasite* — is an attempt to

kill it with enzymes, then — to neutralize factors of its «aggression» by proteases, inhibitors of enzymes.

Reactions on a cellular level: hypertrophy and modification of the shape of affected cells (erythrocytes in malaria).

Tissue defense reactions: isolation of the parasite from a healthy tissue — the formation of a capsule in trichinellosis, formation of pseudocysts of toxoplasms.

On an organism level: humoral reactions (production of anti-bodies) and various forms of immunity: absolute — relative, active — passive, congenital — acquired.

Basic terms and concepts:

1. Anthroponoses — are diseases, pathogens of which are transmitted from a human to human.

2. Invasive diseases — are diseases caused by protists and helminthes.

3. Infectious diseases — are diseases caused by viruses and bacteria.

4. Hyper-parasitism — is parasitizing of parasites on parasites.

5. True parasites — this style of life is characteristic of all representatives of this species.

6. Pathogenicity — is the ability of the parasite to cause a disease.

7. Parasite — is an organism living at the cost of a host and inflicting harm to him.

8. Parasitism — is an antagonistic symbiosis, when the parasite used the host as a source of food and environment and does harm to him.

9. Specificity of the parasite — a historically formed adaptation degree of the parasite to its host.

10. Invasive stage — a stage, when the parasite, having got into the host, continues its development.

Topic 16. PARASYTES — PATHOGENS OF THE DISEASES

1. Trichomonas.

Trichomonas vaginalis — a pathogen of urogenital trichomoniasis. The disease is common everywhere.

Morphological peculiarities (fig. 28): an oval shape with a sharpened long thorn at the back end. Body sizes up to 30 μm. Has 5 filaments. One filament goes along an undulating membrane. A supporting core (axostyle) is in the middle of the body. There is a nucleus and digestive vacuoles in the cytoplasm.

Life cycle: infection occurs in sexual contacts, also through insterile gynecological instruments. Affects urinary ways. Does not form cysts.

Pathogenic action.

1. *Mechanic* (destruction of the urinary mucous membranes).
2. *Toxic-allergic* (poisoning by waste products).

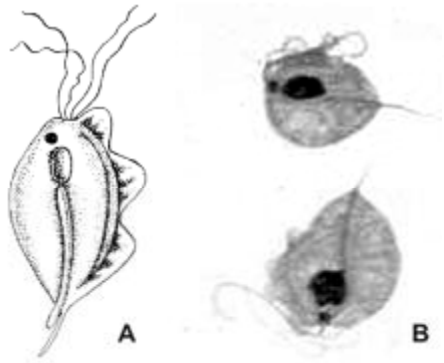


Fig. 28. Trichomonas morphology:
A — a sketch; *B* — a trophozoit (7×40)

Characteristic symptoms: in acute form — itching, a burning sensation in urogenital ways, a local inflammatory process, plentiful fluid discharge of a greenish color with unpleasant smell.

Laboratory diagnosis: revealing trophozoits in native smears of the content from urogenital ways.

Prophylaxis: revealing and treating sick persons, excluding accidental sexual contacts, observing instruments sterility in examination rooms, sanitary-popularization activity.

2. Cat liver fluke.

The cat liver fluke, Opisthorchis felineus — a biohelminth, pathogen of opisthorchiasis. The disease is common in Siberia along the banks of large rivers. Some foci occur in Belarus and other countries.

Morphological peculiarities: the body length is 10 mm. There is a uterus in its middle part, then — a rounded ovary and a bean-like semen-receiver. There are 2 rosette-like testicles in the back part of the body, and between them is an S-shaped canal of the excretory system. The middle intestine canals do not branch; viteline glands are located on both sides of the body (fig. 29).

Fig. 29. Morphological peculiarities of O. felineus:
A — a sketch of the marita's structure; *B* — a marita (×20); *C* — a sketch of the egg structure; *D* — an egg (7×40)

Development cycle: principal hosts — the human, cat, dog and other fish-eating animals. The first intermediate host — fresh water mollusks (Bithynia leachi), the 2nd — fresh water fish, of Life cycle stages: marita – egg – miracidium – sporocyst – radium – cercarium – metacercarium. Infecting of the human occurs in eating undercooked fish, containing metacercaria. Maritas are localized in the liver and pancreas of a principal host.

Pathogenic action:

1. *Mechanic* (injury of the walls of bile ducts and their obstruction by suckers, impairment of the liver and pancreas).
2. *Toxic-allergic* (poisoning by waste products).
3. *Feeding at cost of the host and impairment of metabolic processes.*
4. *Mutagenic* (The primary liver cancer is often the case).

Characteristic symptoms: severe pains in the right hypochondrium (in the liver area), worsening of appetite, nausea, vomiting, indigestion, weakness, headache. The liver is enlarged.

Laboratory diagnosis: revealing of eggs in feces or duodenal content. Eggs are 26–30 × 10–15 μm in size, of yellowish-brown color, oval, there is a lid on one pole. Immunological methods — revealing anti-bodies in the blood serum.

Prophylaxis: eating properly boiled, fried or salted fish; observing the rules of salting fish, revealing and treating sick persons, protection of water from contamination with feces of animals and people, sanitary-popularization activity.

3. Taenia solium.

Taenia solium — a biohelminth, causes teniasis in the human (a sexually mature form) and cysticercosis (a larval form).

Morphological peculiarities: the length of a sexually mature form is 2–3 m, there are 4 suckers and a proboscis with 2 rows of hooks on the skolex (fig. 30).

A hermaphrodite proglottid contains a 3-lobal ovary. A mature proglottid contains a uterus with 7–12 lateral branches. Mature segments are immobile.

Development cycle: a principal host is a human, an intermediate — domestic or wild pigs, sometimes a human. Getting infected by teniasis occurs while eating undercooked pork with cysticercs. In the intestines under the action of digestive juices a scolex cysterca screws out, fixes itself to the intestinal wall, and proglottids begin detach themselves. In 2–3 months a helminth reaches its sexual maturity. The life span of a tenia is several years.

Pathogenic action:

1. *Mechanic* (by irritation of the intestinal mucous membrane by suckers).
2. *Toxic-allergic* (poisoning by waste products).
3. *Feeding on the host's organism and impairment of metabolic processes.*

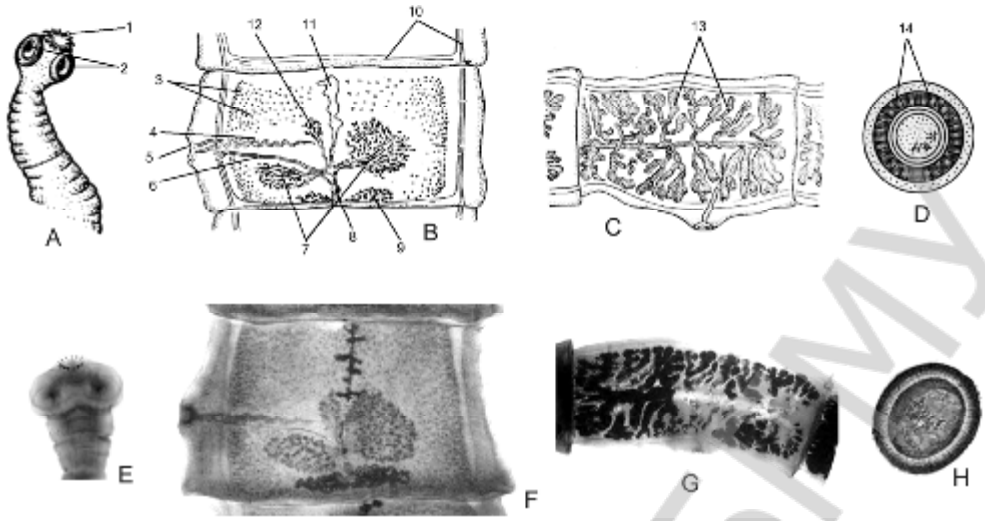


Fig. 30. Morphology peculiarities of Taenia solium:
A–D — sketches, *E–H* — microphotographs: *A*, *E* — skolexes; *B*, *F* — hermaphrodite proglottids; *C*, *G* — mature proglottids; *D*, *H* — eggs: *1* — hooks; *2* — suckers; *3* — testicles; *4* — a semen duct; *5* — a sexual cloaca; *6* — a vagina; *7* — an ovary; *8* — an ootype; *9* — viteline glan; *10* — excretory canals; *11*, *13* — uterus; *12* — additional lobe of the pvary; *14* — radial lining

Characteristic symptoms: pains in the abdomen, nausea, vomiting, indigestion, headache, dizziness, loss of weight..

Laboratory diagnosis: revealing segments or eggs in feces. Eggs of Taeniarhynchus saginatus and Taenia lolium are similar.

Prophylaxis: personal — not to eat untested pork. **Social** — veterinary expertise of carcasses of pigs and wild pigs, revealing and treating sick persons, protection of the environment from contamination with human feces, building sanitary facilities in settlements (closed toilets), sanitary-popularization activity.

Cystercosis. The pathogen of cystercosis is a larval stage of an armed цепня — cysticerc. **The human gets infected with cystercosis**:

1) when neglecting rules of personal hygiene and swallowing eggs which can be on hands and food;

2) in autoinvasion: if a person is ill with teniasis, proglottids may get into the stomach during vomiting, under the action of digestive juice oncospheres are released and in various organs (subcutaneous cellular tissue, muscles, eyes, brain) finnas develop;

3) in treating teniasis with preparations that dissolve proglottids.

Pathogenic action:

1. *Mechanic* (pressure on tissues).
2. *Toxic-allergic* (poisoning by waste products).

Symptoms depend on intensity of infection and localization of cysticercs. Their presence in CNS is accompanied by headaches, convulsion attacks, paralysis of extremities and may even end with a fatal outcome. Intra-ocular cystercosis may cause a complete loss of vision.

Laboratory diagnosis: immunological methods.

Prophylaxis: personal — observing rules of hygiene, **social** — sanitary-popularization activity, revealing and treating sick persons.

4. Human ascarides.

Human ascarides, Ascaris lumbricoides — is a geohelminth, pathogen of ascariasis. The disease is spread everywhere, excluding arctic areas, deserts and semi-deserts.

Morphological peculiarities: the length of a female is 40 cm, of a male — 25 cm. The body is cylindrical, sharpened at the ends; on the anterior end of the body are cuticular lips (fig. 31).

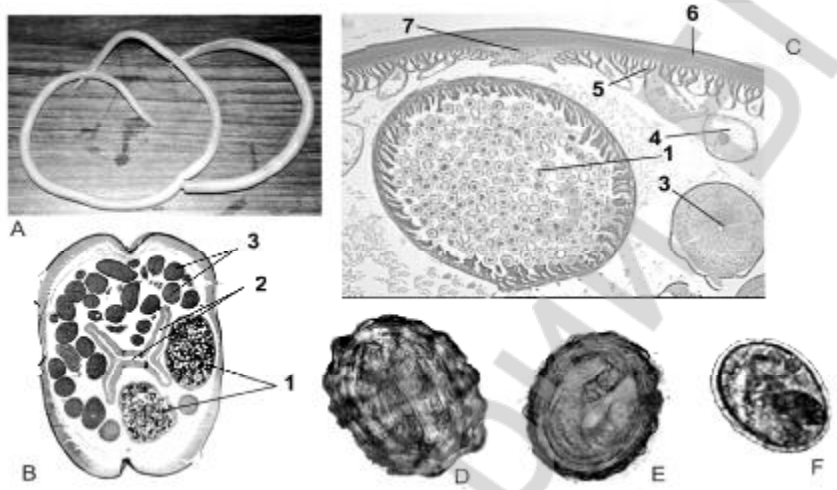


Fig. 31. Morphology of Ascaris lumbricoides:
A — sexually mature helminthes (photograph); *B* — a transverse section (7×8); *C* — a fragment of the transverse section in the uterus area (7×40): *1* — the uterus filled with eggs; *2* — a middle intestine; *3, 4* — an ovary; *5* — muscular fibers; *6* — a cuticle; *7* — a hypodermic cylinder; *D, E* — fertilized eggs with a larva (7×40); *F* — an unfertilized egg (7×40)

Development cycle: a sexually mature form is localized in a thing intestine. A fertilized female lays up to 240 000 eggs a day, they are excreted into the environment with feces. In soil, when an optimal temperature is 20–25 °C, humidity is sufficient and oxygen is available, infectiom larva develop in eggs in 21–24 days. Such eggs get into the human organism with unwashed vegetables, fruit and water. In a thin intestine larvae come out of eggs, perforate its wall, get into blood vessels and accomplish a *migration*: They pass through the liver, right atrium, right ventricle with a flow of blood; then they are carried into the pulmonary trunk and alveolar capillaries. Through the capillary walls larvae get into alveoli, ascend into bronchioles, bronchi, trachea and get into the pharynx, are swallowed. In 2,5–3 months they transform into sexually mature forms in a thin intestine. Larval migration lasts about 2 weeks. The life span of mature ascarides is 1 year.

In the human organism larvae of other ascarid species may also migrate (those of the pig, dog, etc.), they cause a syndrome of Larva migrans.

Pathogenic action of ascarid larvae:

1. *Toxic-allergic* (poisoning by waste products).
2. *Mechanic* (injury of the liver, rupture of capillaries, injury of alveoli, eosinophylic infiltrates in the lungs).
3. *Feeding on the host's organism and impairment of metabolic processes* (absorption of nutrients and vitamins).
4. *Mutagenic.*

Characteristic symptoms of migrational ascariasis: general weakness, fever, headaches, perspiration, a persistent spastic cough especially at night, itching, skin rash, edema of lids and face.

Characteristic symptoms of enteric ascariasis: pains in the abdomen, nausea, vomiting, diarrhea, worsening of appetite, weakness, irritability, worsening of memory, loss of weight.

Complications of enteric ascariasis: mechanic jaundice, purulent pancreatitis, purulent cholangitis, appendicitis, peritonitis, spastic and mechanic intestinal obstruction. Sometimes ascarides are found in frontal sinuses, cranial cavity, middle ear and ovaries.

Prophylaxis: personal — observing rules of hygiene, thorough washing of vegetables, fruit and berries with hot water. It is necessary to protect food from flies and cockroaches — mechanic transmitters of ascarid eggs. **Social** — revealing and treating sick persons, protection of the environment from contamination with ascarid eggs, sanitary-popularization activity.

5. Sarcoptic tick.

Representative: Sarcoptes scabiei — a scabby tick.

Morphological peculiarities: the sizes are 0,3–0,4 mm. Legs are shortened, of a conical shape; the body is broad, oval, of a yellow color, is covered with bristles, eyes are absent (fig. 32). It breathes with the surface of the whole body.

Fig. 32. Morphology of Sarcoptes scabiei:

Development cycle: they are permanent hyperdermal parasites of the human and animals. A tick's female gnaws passages in the thickness of the corneous layer of the skin per 2 mm a day. Males do not make any passages. Ticks feed on the host's tissues. After fertilization, the female lays about 50 eggs. The development from an egg to an imago takes about 1–2 weeks. Adult ticks live up to 2 months. Infection occurs in a direct contact with a sick person or their things, where may be ticks.

Medical significance: they cause scabby, affect the skin of the hand back side of interdigital spaces and flexor surfaces of joints. Ticks cause a severe itching, becoming worse at night. Secondary infection gets in scratches causing suppuration. Ticks of dogs, horses, pigs and other animals may parasitize on the human.

Prophylaxis of scabby: following hygienic rules in dealing with animals and sick people, neatness of the body, linen and dwelling; revealing and treating sick persons, sanitary supervision over hostels, baths, sanitary-popularization activity.

6. Order of Lice (Anoplura).

Representatives: genus of Pediculus and genus of Phthirus. The Pediculus genus is represented by one species of Pediculus humanus including 2 subspecies — a head louse and a body louse who freely cross and give fertile fillies, though they have some morphological and biological differences.

Head louse (pedioculus humanus capitis).

Morphological peculiarities: the length of a male is 2–3 mm, of a female — 3–4 mm. The posterior end of the male's body is rounded, of the female's — is forked. The oral apparatus is of a stabbing-sucking type (fig. 33).

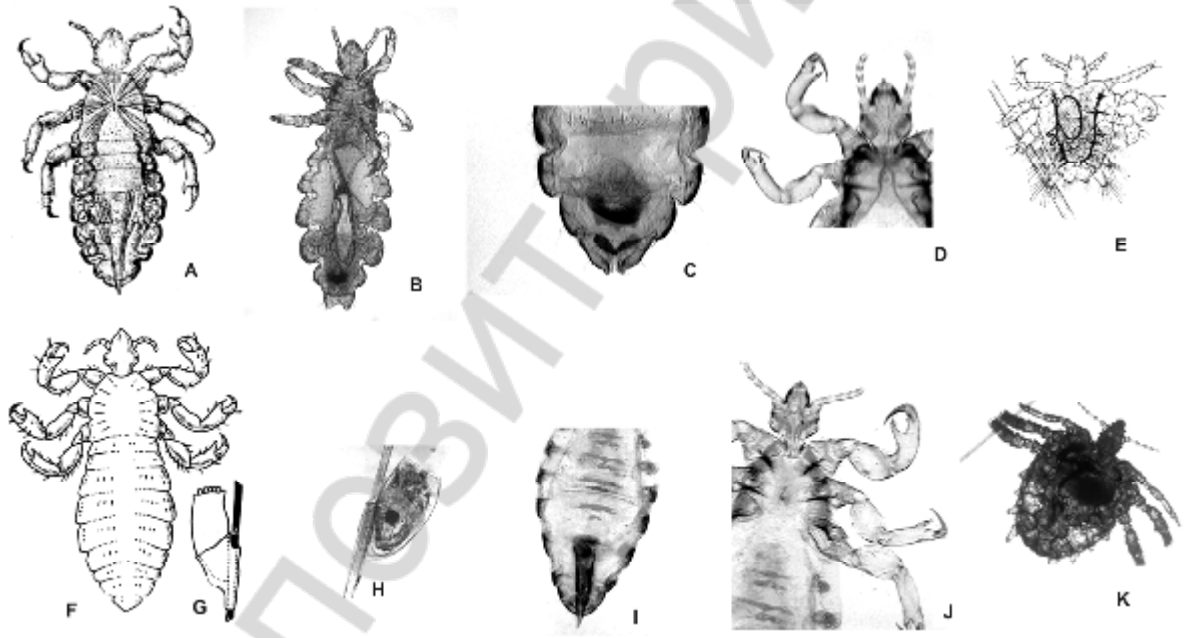


Fig. 33. Representatives of the Lice order:
A — Pediculus humanus capitis (a sketch); *B, C, D* — Pediculus humanus capitis (7×8); *F* — Pediculus humanus humanus (a sketch); *G, H* — nits; *I, J* — Pediculus humanus humanus (7×8); *E* — Phthirus pubis (a sketch); *K* — Phthirus pubis (7×8)

Development cycle: lives in the hairy area of the head. Feeds on human blood 2–3 times a day, may fast for some days. Eggs (nits) stick to hairs with a sticky secrete. During the whole life (about 38 days) a female lays about

300 eggs. A larva comes from an egg that in several days transforms into an imago (a sexually mature form).

Body louse (Pediculus humanus humanus).

Morphological peculiarities: has larger body sizes than a head louse (to 4,7 mm), carvings along the body edge are not so deep and pigmentation is slightly marked. **Development cycle:** lives on underwear and linen, but feeds on the skin. Nits stick themselves to hairs of the clothes. The life span is up to 48 days, the development cycle is no less than 16 days. By the end of its life the female can have about 4000 fillies.

Medical significance: lice of g. Pediculus cause pediculosis (a disease of tramps). Feeding on blood lice introduce saliva into the wound that causes itching in the human. Pediculosis is characterized by pigmentation and hardening of the skin. Lice are specific pathogens transmitters of a louse-born relapsing and a louse-born enteric fever. Getting infected with a louse-borne relapsing fever (pathogens — Obermeier's Spirochaeta) occurs by a specific contamination (while squashing it and rubbing its hemolymph into the skin during scratching). Getting infected with louse-borne enteric fever (pathogens — Provachek's rickettcia) occurs by *contamination* (in rubbing lice's feces into the skin or by a *specific contamination* (in squashing a louse the content of its intestine gets into bites wounds or into scratches on the skin).

Pubic louse (Phthirus pubis).

Morphological peculiarities: sizes up to 1,5 mm. The body is short, broad, trapeziform. **Life cycle**: parasitizes on the body parts covered with thin hard hair: on the pubis, in armpits, on brows and eye-lashes, in the beard. The female lays about 50 eggs during its life. The life cycle duration (from an egg to a sexually mature form that starts laying eggs) — 22–27 days. **Medical significance**: Causes phthiriosis (severe itching and hardening of the skin). Getting infected occurs in sexual contacts, rarely — through underwear and linen.

Fighting against lice: killing them in the environment, on the human body and on clothes.

Basic terms and concepts:

1. **A prglottid** — a segment of tape worms.
2. **Biohelminths** — worms, the development cycle of which occurs while changing hosts.
3. **Cisticerc** — a finna of Taenia solium.
4. **Dehelmithization** — a complex of measures to destroy parasitizing worms in the human organism.
5. **Geohelminthes** — worms the larvae of which develop in soil.
6. **Marita** — a sexually mature stage of flukers.
7. **Metacercarium** — an invasive stage for a final host in the development cycle of flukers.

8. Migration — movement of a larval stage of ring worms in the human organism.

9. Migration ascariasis — a disease caused by ascarides' larvae.

10. Miracidium — the 1st larval stage in the flukers development cycle.

11. Pediculosis — a disease caused by lice of g. Pediculus.

12. Phthiriosis — a disease caused by a pubic louse.

13. Scolex — a head of tape worms.

14. Strobila — a body of tape worms consisting of segments.

Topic 17. VENOMOUS ANIMALS

1. Classification of venomous animals (primarily-secondarily venomous, actively and passively venomous).

Animals are venomous, if their organism produces substances or accumulates metabolites, which, having got into the other organism, can cause impairment of its functions or death. There are about 5 000 species of venomous animals: protists — 21, coelenterate — 93, parasitic worms — 16, ring worms — 50, arthropoda — about 4000, mollusks — 91, echinodermata — 26, fish — 500, amphibians — 40, reptiles — 250, mammals — 1 species.

In accordance with the presence or absence of special venomous glands in animals, a specific apparatus for injecting venom into the victim and some other features, they are divided into the following groups: primarily-venomous and secondarily-venomous.

To primarily-venomous are referred animals, special glands of which produce a venomous secretion or if they have specific venomous metabolites. As a rule, venomness of these animals is a species character (jellyfish, scorpions, snakes, fish).

Secondarily-venomous animals accumulate exogenic poisons from the environment, they become toxic in case they are eaten by other organisms (fish adsorb industrial toxins from water).

Primarily-venomous animals are divided according to the ways of producing and using venoms.

Actively-venomous armed animals have a specific venomous apparatus and a wounding mechanism (striking cells on tentacles of jellyfish, a sting in hymenoptera and venomous teeth in snakes). Venom is injected into the body of the victim parenterally (avoiding the digestive tract).

Actively-venomous unarmed animals have no wounding apparatus. Secretions of their glands are toxic in direct contact with integuments of the victim (skin glands of amphibians, anal glands of insects).

Passively-venomous animals (fish, caudal amphibians, mollusks) can have toxic metabolites that are accumulated in various organs and tissues. They are dangerous only in case of getting into the digestive tract of the victim.

2. Physiological characteristic of toxins of invertebrates (jellyfish, arachnida, hymenoptera), their action on the human; the first aid and prophylactic measures against bites and poisoning.

Characteristic of animal venoms. Animal venoms or zootoxins — are biologically active substances that actively interact with biological structures. By their chemical structure, zootoxins are very diverse (alkaloids, histamine, various enzymes and their inhibitors).

By the character of physiological impact on living systems, zootoxins are subdivided into:

1) neurotoxins acting predominantly on the nervous system;
2) cytotoxins causing damage of cells and tissues;
3) hemorrhagens impairing permeability of blood vessels;
4) hemolyzins destroying erythrocytes.

A clinical picture of poisoning the human depends on: the venom composition, the site of affection, the season of the year and the time of the day as well as a general condition of the person.

Coelenterate phulum («cross» jellyfish and Portuguese man-of-war) refers to actively-venomous, armed. Striking cells excrete a neurotropic poison. It blocks synapses.

Clinics. In sites of a «burn» by tentacles of the «cross» jellyfish appears a sharp pain, reddening, rash. General manifestations: elevation of temperature, dropping of a muscular tone, pains in extremities and lumber area; impairment of consciousness, hallucinations, delirium, impairment of respiration and cardiac activity, in severe cases — death.

The first aid and prophylaxis of poisoning. One should remove parts of tentacles and striking threads from the skin surface, then paint the sites of affection with alcohol or soda solution. Not to bathe in the thicket of water plants and in places of jellyfish gatherings.

Phulum of Arthropoda, class of Arachnoidea, order of Scorpions (yellow, Italian, black). They are actively-venomous armed, have venomous glands located on the last segment of the abdomen. Excrete a neurotropic poison that blocks neuron-muscular synapses.

Clinics. At the site of a bite appears a severe pain, edema, reddening, blisters. General manifestations: headache, weakness, impairment of consciousness, breathing difficulty, tachycardia in children. Fatal outcomes are possible.

The first aid and prophylaxis of poisoning. Sucking off the venom, applying cold on the site of a bite, taking pain-killers. Injection of a specific serum. Protection from bites: examination of dwellings, bedding, clothes, shoes.

Order of Arachnoidea. Actively-venomous armed, having venomous glands, their ducts open on chelicerae.

Karakurts. The neurotropic venom: it blocks neuron-muscular synapses.

Clinics. At a bite site appears pain, numbness of extremities. General manifestations: pain quickly spreads throughout the body, headaches, breathlessness, heartbeat, bronchial spasms, vomiting and impairment of consciousness. Fatal outcomes are possible.

The first aid and prophylaxis of bites. Sucking off the venom, cauteration of the bite site, injection of an antikarakurt serum. Prevention from getting caracurts to the places of human lodging for the night.

Tarantulas. The venom contains cytotoxins and hemorrhagens, causes the impairment of wall permeability.

Clinics. At a bite site — pain, reddening, edema, skin necrosis. General manifestations: malaise, sleepiness, chills, pulse acceleration, perspiration.

The first aid and prophylaxis of bites. To paint the site with some disinfectants, provide rest, abundant drinking, pain-killers. Protection from bites.

Class of Insects, order of Hymenoptera (bees, wasps). Actively-venomous armed, have venomous glands, a sting at the end of the abdomen. The venom has a neurotropic and cytotoxic action. A strong allergen.

Clinics. After a bite — pain, edema, reddening. General manifestations: allergic reactions.

3. Physiological characteristic of toxins of vertebrate animals (fish, amphibians, reptiles), their impact on the human; the first aid and prophylactic measures against bites and poisoning.

Fishes poisonous for the human are divided into 2 groups:

1. Species having venomous glands, the secretion of which is introduced into the wound done by fin rays, teeth or thorns of branchial covers. Representatives: skates, sea dragons, ruffs and perches, murenas. They are spread predominantly in tropic latitudes of the Pacific and Atlantic Ocean.

Pathogenic action and clinics. Toxins pass into the organism through a wound on the skin. At the moment of a prick one feels pain that quickly spreads to the whole extremity.

There appears a feeling of fear, breathlessness, heart pain, vomiting, sometimes — loss of consciousness. Inflammation, sometimes ulcers and tissue necrosis develop at a bite site. A severe poisoning ends with death within a day.

Treatment: sucking off the venom from the wound, applying a tourniquet, symptomatic treatment. As prophylaxis one should put on special clothes in dealing with fish.

2. Fishes of the 2nd group cause poisoning, when it is used as food (murena, tuna, mackerel, perch-like, ball-fish). When these fishes are used as food, poisoning develops in 20–30 min. There appears numbness of the tongue and fingers, nausea, vomiting, breathlessness, speaking and breathing difficulty. The treatment is symptomatic. As prophylaxis, one should exclude the afore mentioned fishes from the diet.

Amphibians. There are some toxic substances in the skin of some amphibians. The most virulent venom is produced by African tree frogs and toads. The venom of the Columbian frog cocoa (the length of 2–3 cm, the weight — a bit more than 1 g) acts 50 times stronger than a tetanus toxin.

Other venomous amphibians are not dangerous for the human (they have no mechanism for injecting the venom into tissues). When it gets on the skin and mucous membranes, reddening and inflammation are observed.

These symptoms are relieved by washing with water. One should take care lest amphibians' venom gets into the eyes.

Class of Reptiles. Families of asps and sea snakes (a royal and Indian cobra, a glandulous snake). These are primarily-venomous armed animals. On the anterior part of the maxilla they have venomous mobile teeth with canals for the venom to flow down from venom glands.

Pathogenic action and clinics. The venom contains neurotoxins, cytotoxins, hemolyzins. At a bite site develops pain, edemas, inflammation.

General manifestations: excitation is replaced by depression of CNS; swallowing, speech and breathing are impaired. Fatal outcomes are possible.

Family of Vipers (gurza, sand efa, steppe viper, copperhead, rattle snakes). They are primarily-venomous, armed animals. They have venomous glands and venomous teeth with canals.

Pathogenic action and clinics. The venom contains neurotoxins, cytotoxins, hemolyzins, they increase blood coagulation.

At a bite site develops pain, edemas, tissue necrosis. General manifestations: weakness, nausea, dizziness, impairment of blood coagulation. Fatal outcomes are possible.

The first aid and prophylaxis. The bite site should be painted with an antiseptic and a tight dressing should be applied.

The patient should be transported in a lying position. Injection of snakes' antitoxins should be done. In places of snakes' inhabitance one should not touch them but wear high boots.

Basic terms and concepts:

1. Actively-venomous animals — have a special venomous apparatus and a wounding mechanism (striking cells or tentacles of jellyfish, a sting in hymenoptera, venomous teeth in snakes).

2. Secondarily-venomous animals — accumulate exogenic poisons and become toxic when other organisms eat them.

3. Passively-venomous animals — their metabolites accumulated in various organs and tissues may become toxic.

4. Primarily-venomous animals — are animals, special glands of which produce a venomous secretion or some of their metabolites are toxic.

OPEN TESTS

BIOLOGY OF THE CELL. THE FLOW OF SUBSTANCE AND ENERGY IN THE CELL

1. The ability of biological membranes to divide cytoplasm into compartments is called ... .

2. The receptor apparatus located on the outside surface of a plasmalemma is called ... .

3. EPR (endoplasmic reticulum) and ... form the transport system of the cell.

4. The destruction of natural frames of a cell by lisosomes is called ... .

5. Integrated proteins in the structure of the outer mitochondrion's membrane, forming pores and providing permeability of membranes, are called … .

6. The larger subunit of ribosomes contains 40–50 moleculas of proteins and … moleculas of r-RNA (ribosomal ribonucleic acid).

7. The efficiency of the anoxic stage of energy metabolism comprises ... %.

THE FLOW OF GENETIC INFORMATION IN THE CELL

8. The nuclear plate is basically formed by proteins …

9. On the site of primary metafasal chromosomal strangulation is ... which attached strands of segmentation spindle.

10. The part of the DNA molecula in the site of the secondary satellite chromosomal strangulation is called ... .

11. The content of genetical material during the G_2 interphase period is … .

12. The content of genetical material in a cell at the diploten stage prophases of meiosis I … .

13. The content of genetic material in a cell at the diakinesis stage of the prophase of meiosis I is … .

14. The content of genetic material in a cell at the pachiten stage of meiosis I … .

15. The bivalents are interconnected at the diploten stage of the prophase of meiosis I only in the parts called ... .

16. ... are found in the equatorial plane of the metaphase of meiosis I.

17. The content of genetic material in a cell in the metaphase of meiosis II is … .

ORGANIZATION OF HERIDITARY MATERIAL

18. The autosyntetical function of the DNA molecula is its … .

19. The DNA-polymerase can move along the matrix chain from the … end to the … end.

20. The direction of the genetic information reading from the 3′ to the 5′-end is the property of the genetic code called … .

21. The tRNA identification process of its amino acid is … .

22. There is the mRNA triplet … during the translation initiation in the peptidile center of a ribosome.

23. The process which begins with the first peptide bond formation and ends up with the last amino acid apposition to the polypeptide molecule is called … .

24. Antibiotics are the … of protein biosynthesis.

INHERITANCE REGULARITIES. INTERACTION OF GENES

25. The attributes with different qualitative states are called … .

26. Gene penetrance should comprise … % for exhibiting Mendel's Second and Third laws.

27. Bombay phenomenon is an example of the genetic interaction which is called … .

28. Splitting by 9 : 7 phenotype at the heterozygotes results from … of interallelic genetic interaction.

29. The result of the independent gene combination of two allelic pairs at the analyzing cross is the splitting in the first generation brooding by phenotype equal to … .

30. Alleles presented in the populations more than in two states are called … .

LINKAGE OF GENES

31. Conditions limitting manifestation of Mendel's 3rd law are gene interaction, except for full domination, lethal and semilethal genes, unequal probability of gametes formation and zygotes of different types, pleiotropic action of genes, an incomplete penetrance of a gene and a ... .

32. If diheterozygous organism forms only 2 types of gametes ... linkage of genes is present.

33. If diheterozygous organism forms 4 types of gametes ... linkage of genes is present.

34. If between the genes located in one pair of homologous chromosomes there is a crossing-over ... linkage of genes is present.

35. Biological phenomenon breaking the linkage of genes is called … .

36. The distance between genes in Morgan units is equal to % of … .

37. At the linked inheritance the maximal size of a crossing-over is ... %.

38. Individuals formed from crossover gametes are called … .

39. The number of human autosomal groups of linkage is … .

VARIATION

40. Enzymes capable of cutting out the damaged area of a molecule of DNA during reparation are called … .

41. Transgenation in which one purine base is replaced with another purine base is called ... .

42. Circulair chromosomes appear as a result of … in the terminal parts of chromosomes.

43. Infringement of repression and induction phase sequences in the regulation of gene work occurs in case of mutation of … genes.

44. Non-disjunction of chromosomes at mitosis or meiosis is leads to … mutations.

45. Type of aneuploidy when only one chromosome out of a pair of homologous chromosomes is present in karyotype is called … .

46. Type of genomic mutation when somatic cells contain a similar set of chromosomes is called … .

BIOLOGY AND GENETICS OF SEX

47. Detection in female somatic cell nuclei of two sex chromatin lumps proves a … syndrome.

48. Female phenotypic signs, low auricle location alary neck skin fold are characteristic of a … syndrome.

49. Men with a female type of body build, gynecomastia and infringement of spermatogenesis process suffer from a … syndrome.

50. Phenomenon when sexual excitement and satisfaction are achieved at changing into the clothes of an inverse sex is called … .

51. Human chromosomal sex diseases result from the infringement of … process.

52. Features determined by genes located in non-homologous part of Y-chromosome are called … .

53. Persistent discordance of person's sexual self-consciousness to his real genetic and gonadal sex is called … .

BASES OF HUMAN GENETICS

54. Man to start with medical genetic examination of family and compiling genealogy is called … .

55. A sick baby's birth probability from heterozygous parents at autosomal-dominant type of inheritance (complete dominance, gene penetrance 25 %) makes … %.

56. Probability of sick baby's birth at X-linked dominant type of inheritance from a heterozygous mother and a healthy father (gene penetrance 40 %) makes … %.

57. The method of … nucleic acids allows to determine the order of nucleotides in a molecule of DNA and to find a pathologic gene.

58. Type of inheritance at which the father transmits his hereditary feature to all daughters, but neither to sons is called ... .

59. Method of human genetic that allows to reveal the role of hereditation and environment in the formation of features is called … .

60. Genetic method that allows reveal genomic and chromosomal mutations is called … .

61. Chorion biopsy is performed on … weeks of pregnancy.

62. Each pregnant woman undergoes a compulsory … — a direct non-invasive method of prenatal diagnostics.

63. Mother's age of over 37 years, spontaneous abortions in the anamnesis, stillbirth and children with congenital malformation are indications for carrying out ... methods of prenatal diagnostics.

64. Y-sexual chromatin is determined at staining of buccal epithelium cells by … .

GENETIC ENGINEERING

65. Such enzymes as … are used in the genetic engineering for the necessary genes isolation.

66. Enzymes capable of cutting the DNA molecule in certain sites forming «sticky ends» are called … .

67. The method of … underlies the compound genes synthesis by means of the reverse transcription processes.

68. Bacterial plasmids, phages, viruses and … can be vector molecules in genetic engineering.

69. Hybrid vectors capable of developing both as a phage and as a plasmid are called … .

70. The plasmids containing the cos-site (the sticky ends) of phage λ DNA are called … .

71. Restrictase Eco R I at the ledge cut forms … in the DNA.

72. Restrictase Hind II in the break up amidst the identified recognized part of the nucleotid pairs forms … in the DNA.

GENETICS OF POPULATIONS

73. Human populations with the number not exceeding 1500 people within-which marriages surpass 90 % are called … .

74. Genetic load has no phenotypic manifestation in case if … of a pathological gene is observed.

REPRODUCTION OF ORGANISMS

75. Exchange of genetic information between individuals of one species is called ... .

76. Confluence of female and male pronuclei during fertilization is called ... .

77. Syngenesis without fertilisation is called ... .

78. Ovum, containing much yolk deposited on one of the poles, is called ... .

79. Complete equable fragmentation is typical for ... ova.

80. During gametogenesis in the period of reproduction cells devide by the mechanism of ... .

81. During gametogenesis in the period of maturation cells devide by the mechanism of ... .

82. Asexual reproduction of fetus, as a result of syngenesis, is called … .

83. Gamones, contributing to spermatozoon fixation on the ovum membrane, are called … .

84. Spermatozoons possess the ability of fertilization during … .

BASES OF ONTOGENESIS (EMBRYONIC DEVELOPMENT)

85. Mitotic division of zygote and blastomeres on the initial stage of embyogenesis is called ... .

86. Period of human embryonic development from the beginning of the 4^{th} week to the end of the 8^{th} week after fertilization is called ... .

87. Method of gastrulation, when particular cells of blastoderm move into the blastocoel, multiply there and conform the second layer of cells, is called ... .

88. Organisms, in which blastopore transmogrifies into the anally opening and mouth forms on the opposite side of the body, are called ... .

89. Amnion, chorion, allantois, yolk sac and placenta are ... organs of chordates.

90. Principle cause of differentiation of cells in the process of embryogenesis is ... of the ovum cytoplasm.

91. Impact of one group of embryo cells on the neighboring ones by excretion of certain substances is called ... .

92. Gradual decrease of metabolism intensity in fetus from head to the tail part is called ... of physiological activity.

BASES OF ONTOGENESIS (POSTEMBRYONIC DEVELOPMENT)

93. Thymus and spleen are characterized by … type of growth.

94. Specific role in regulation of a person's stature belongs to the hormone of hypophysis ... .

95. Acceleration of physical and physiological development of children and teenagers, acceleration of sexual maturity and acceleration of growth is called ... .

96. Stable, genetically determined peculiarities of morphology, physiology and behaviour of a man make his ... .

97. People of … constitutional type are predisposed to neuroses, ulcerous disease, tuberculosis.

98. Peculiarities of development, course, treatment and prevention of diseases of the elder by studies the science called ... .

99. Science, which studies healthy life style, is called ... .

100. Condition, when cardiac and respiratory failure, loss of consciousness are observed, but the metabolism isn't impaired, is called … death.

101. Voluntary cessation of the life terminally ill people with the aid of a medical worker is called ... .

INTRODUCTION TO PARASITOLOGY

102. Free-living organisms, which can be parasites in case of invading the organism of other species, are called ... .

103. Hosts providing optimal biochemical conditions for the development of the parasite and which have biocoenotic relations with it, are called ... .

104. Hosts providing biochemical conditions for the development of the parasite, but which don't have biocoenotic relations with it, are called ... .

105. Hosts characterized by the presence of biocoenotic relations with parasites, but have no optimal biochemical conditions for their development, are called ... .

106. Way of parasite invasion in to the host organism with water and foodstuffs is called ... .

107. Way of parasite invasion in to the host organism through mucous membranes of respiratory pipes is called ... .

108. Way of parasite invasion in to the host organism by immediate contact with a sick person or animal and with household objects is called ... .

109. Way of parasite invasion in to the host organism when transfusing unsterile donor blood is called ... .

PARASYTES — PATHOGENS OF THE DISEASES

110. Vegetative form of protista is called ... .

111. Supporting centre, which some representatives of class Zoomastigota can have, is called ... .

112. Trichomonas vaginalis has ... flagella.

113. Fluke, in the hindquarter of which 2 rosette-like testicles are situated, between which an shaped curved secretory channel passes, is called ... .

114. Life cycle of Cat liver fluke includes stages: egg → miracidium → sporocysts → redia → ... → metacercaria.

115. Taenia solium is characterized by the finna of ... type.

116. Hermaphrodite progottids of Taenia solium have an ovary consisting of ... sections.

117. Mature proglottids of of Taenia solium have... side branches.

118. Life span of mature Ascaris in the human body is about ... .

119. Pediculus humanus capitis and Pediculus humanus humanus cause ... in man.

120. Phthirus pubis causes … in man.

121. Lice ova is called ... .

122. Lice of Pediculus genus are specific infection carriers of pediculores … and … .

123. Pedicular louse relapsing fever pathogens are ... .

VENOMOUS ANIMALS

124. Actively poisonous animals with specialized venomous organs and injuring adaptations are called … .

125. According to physiological effect on living systems zootoxins are divided into neurotoxins, cytotoxins, hemorrhagins and … .

126. Venomous organs of Physaliae are … .

127. By physiological effect scorpion toxin refers to … .

128. By physiological effect karakurt toxin refers to … .

129. By physiological effect Brazilian spider toxins refer to cytotoxins and … .

130. By physiological effect Hymenoptera toxins refer to cytotoxins and … .

131. Poison of Colombian cocoa frog is more potent stronger than tetanus toxoid in … times.

132. Viper snakes are primarily-venomous … animals.

CLOSE TESTS

BIOLOGY OF THE CELL. THE FLOW OF SUBSTANCE AND ENERGY IN THE CELL

1. Properties of elementary membrane are: a) plasticity; b) tightness and ability to flow; c) semi-permeability; d) elasticity; e) ability for self-locking.

2. Transport of substances into the cell demanding ATP energy is: a) receipt of ions into the cell by concentration gradient; b) phagocytosis; c) pinocytosis and diffusion; d) osmosis and endocytosis; e) receipt of substances into the cells against the concentration gradient.

3. Cell anabolic system organelles are: a) mitochondria and endoplasmic reticulum; b) ribosomes and Golgi's complex; c) endoplasmic reticulum; d) lyzosomes and peroxisomes; e) glyoxysomes and ribosomes.

4. Cell catabolic system organelles are: a) mitochondria; b) ribosomes, glyoxysomes and endoplasmic reticulum; c) endoplasmic reticulum and mitochondria; d) Golgi's complex and peroxisomas; e) peroxisomas and lyzosomes.

5. Ribosomes are located: a) on membranes of endoplasmic reticulum and in hyaloplasm; b) in hyaloplasm and karyoplasm; c) on internal nuclear membrane and in chloroplasts; d) on external nuclear membrane and in the mitochondria; e) in mitochondrial matrix and lyzosomes.

6. Functions of the endoplasmic reticulum are: a) synthesis of proteins; b) DNA synthesis and compartmentalization; c) synthesis of fats and carbohydrates; d) compartmentalization and transport of substances; e) formation of peroxisomas and RNA synthesis.

7. Functions of Golgi's complex are: a) sorting, packing and secretion of substances; b) formation of lyzosomes and complex organic substances compounds; c) synthesis of ATP, proteins and glyoxysomes; d) synthesis of cytoplasmic membranes; e) protein synthesis and substance secretion.

8. Functions of mitochondria are: a) synthesis of specific proteins; b) splitting of proteins into amino acids; c) synthesis of monosaccharides and ATP; d) synthesis of AMP (adenylic acid); e) splitting of organic substances into H_2O and CO_2.

9. Anaerobic stage of energy metabolism occurs in: a) intestine; b) cytoplasm and mitochondria; c) cytoplasm and endoplasmic reticulum; d) cell cytoplasm; e) Golgi's complex and cell nucleus.

THE FLOW OF GENETIC INFORMATION IN THE CELL

10. In the pre-synthetic period of interphase occurs: a) synthesis of RNA, proteins and enzymes; b) synthesis of DNA, RNA, proteins and ATP; c) ATP synthesis and cell growth; d) accumulation of DNA nucleotides, synthesis of achromatic spindle proteins; e) synthesis of DNA, RNA and achromatic spindle proteins.

11. In the post-synthetic period of interphase occurs: a) synthesis of DNA and enzymes; b) synthesis of DNA, r-RNA, cell growth; c) ATP synthesis; d) accumulation of DNA nucleotides; e) synthesis of acromatic spindle proteins.

12. The content of cell genetic material at the end of synthetic period of interphase is: a**)** 1n 1chr 1c; b) 1n 2chr 2c; c) 2n 1chr 2c; d) 2n 2chr 4c; e) 1n 4chr 4c.

13. Reasons of mitosis are: a) increase of nuclear-cytoplasmic ratio; b) decrease of nuclear-cytoplasm ratio; c) replication of DNA molecule and «wound hormones»; d) «wound hormones» and mitogenetic rays; e) infringement of karyolemma integrity.

14. The content of cell genetic material in mitosis telophase is: a) 1n 1chr 1c; b) 1n 2chr 2c; c) 2n 1chr 2c; d) 2n 2chr 4c; e) 1n 4chr 4c.

15. Cells dividing by mitosis are: a) somatic; b) cells of gonads; c) gametogoniums; d) tumor cell; e) cells of regenerating tissues.

16. Cells dividing by amitosis are: a) somatic and old cells; b) cells of gonads and embryo; c) gametogoniums; d) tumor cells; e) cells of regenerating tissues.

17. Cells dividing by meiosis are: a) somatic and old; b) cells of gonads and embryo; c) gametocytes; d) tumor cells; e) cells of regenerating tissues.

18. Content of cell genetic material in meiosis I prophase is: a) 1n 1chr 1c; b) 1n 2chr 2c; c) 2n 1chr 2c; d) 2n 2chr 4c; e) 1nbiv 2chr 2c.

19. In meiosis I telophase occurs: a) spiralization of the chromatin and nucleolus dissolution; b) depolarization of chromosomes and nucleolus formation; c) formation of karyolemma; d) conjugation of chromosomes and crossing-over; e) cytokinesis.

ORGANIZATION OF HERIDITARY MATERIAL

20. Amount of A+G is equal to amount of: a) A + T; b) C + T; c) G + T; d) A + C; e) G +C.

21. Complementary nucleotide pairs of DNA double chain are kept by following type of bond: a) hydrogen; b) covalent; c) phosphodieather; d) peptide; e) disulfide.

22. DNA functions are: a) storing and reproduction of the genetic information; b) transport of amino acids to ribosome; c) transmission of the genetic information to daughter DNA molecules; d) transport of amino acids; e) determination of r-RNA synthesis.

23. Functions of t-RNA are: a) storing of the genetic information; b) transport of amino acids to ribosome; c) transfer of the genetic information to daughter t-RNA molecules; d) direct participation in gathering of polypeptide molecules;
e) transfer of the genetic information from DNA to the ribosome.

24. Gene properties are: a) stability and lability; b) integrity and pleotropia; c) integrity, specificity and unambiguity; d) discretion and absence of specificity; e) specificity, tripletness and universality.

25. Specificity is the gene property to: a) mutate; b) determine synthesis of the certain polypeptide; c) be responsible for exhibiting several characters; d) variate the degree of its phenotypic manifestation; e) have different frequency of phenotypic manifestations.

26. Pleotropia is the gene property to: a) mutate; b) determine synthesis of the certain polypeptide; c) be responsible for exhibiting several characters; d) variate the degree of its phenotypic manifestation; e) have different frequency of phenotypic manifestations.

27. Elementary structural gene unit is: a) nitrogenous base; b) pair of complementary nucleotides; c) codon; d) one nucleotide; e) triplet of the nucleotides.

28. Elementary functional gene unit is: a) one nucleotide; b) pair of complementary nucleotides; c) codon; d) transcripton; e) triplet of the nucleotides.

29. Heterosynthetic gene function is: a**)** transcription and replication; b) translation and transcription; c) DNA replication and reparation; d) transformation and translation; e) only translation.

30. The genes are classified into: a) structural, modifiers and repressors; b) introns, exons and inhibitors; c) functional and structural; d) corepressors and operators; e) regulators and intensifiers.

INHERITANCE REGULARITIES. INTERACTION OF GENES

31. The main features of G. Mendel's hybridological method are: a) one or of two pairs of alternative attributes is analyzed; b) many of alternative attributes are analyzed; c) analysis starts with cross of homozygous organisms; d) hybrids of several generations are analyzed; e) hybrid of just one generation is analyzed.

32. Positions of «a hypothesis of gametes cleanliness»: a) genes of one allelic pair of a hybrid organism are hybridized; b) genes of one allelic pair of a hybrid organism are not hybridized; c) genes of different allelic pairs can be hybridized; d) both allelic genes get in one gamete; e) from each pair of allelic genes one gene gets into gamete.

33. The conditions necessary for exhibiting of laws of Mendel: a) codominance; b) semidominance; c) presence of lethal genes; d) the mechanism of equiprobable formation of gametes and zygotes of a different type; e) genes of different allelic pairs are in one chromosome.

34. Analyzing cross is used to reveal: a) mutations; b) a phenotype of the individual; c) a genotype of the individual with a recessive character; d) a genotype of the individual with dominant character; e) lethal genes.

35. The characteristic of incomplete domination: a) the dominant gene does not completely suppress the action of a recessive gene; b) the dominant gene completely depresses the action of a recessive gene; c) homo-and heterozygotes are indistinguishable phenotypically; d) homo-and heterozygotes are identical phenotypically; e) the dominant gene in a heterozygous state is shown stronger, than in homozygous.

36. The characteristic of co-domination is: a) the dominant gene does not completely suppress the action of recessive gene; b) it is a type of interaction of allelic genes, genes are equivalent; c) homo-and heterozygotes are indistinguishable phenotypically; d) it is a type of interaction of not allelic genes; e) the dominant gene in a heterozygous state is shown stronger, than in homozygous.

37. The characteristic of polymeria is: a) mutual influence of genes of different alleles, that occupy the neighboring locuses of one chromosome; b) presence of 2 dominant genes from different allelic pairs leads to exhibiting of a new attribute; c) presence of 2 recessive genes from different allelic pairs leads to exhibiting of a new attribute; d) one gene influences the exhibiting of different attributes; e) genes from different allelic pairs influence a degree of manifestation of one character.

LINKAGE OF GENES

38. The phenomenon of linkage is observed in locating of genes of different allelic pairs: a) in one chromosome; b) in different chromosomes; c) only in autosomes; d) only in X-chromosome; e) only in a Y-chromosome.

39. Complete linkage of genes is observed: a) in females of Drosophila and the male of a silkworm; b) if genes of different allelic pairs are located in different chromosomes; c) if there is a crossing-over; d) if there is no crossing-over; e) in males of Drosophila and female of a silkworm.

40. Incomplete linkage of genes is observed: a) if genes of different allelic pairs are located in one chromosome; b) if genes of different allelic pairs are located in different chromosomes; c) if there is a crossing-over; d) if there is no crossing-over; e) in males of Drosophila and the female of a silkworm.

41. The main provisions of the chromosomal heredity theory are: a) allelic genes are located in the linear order in identical locus's of homologous chromosomes; b) allelic genes occupy different locus's of homologous chromosomes; c) the number of linkage groups is equal to monoploid set of chromosomes; d) the number of linkage groups is equal to diploid set of chromosomes; e) between homologous chromosomes of Drosophila male the crossing-over is possible.

42. Phenotype splitting for monohybrid cross of homozygotes at complete dominance: a) is absent; b) 3:1; c) 1:2:1; d) 9:3:3:1; e) 1:1.

43. Phenotype splitting for incomplete linkage of genes in Morgan's experiences: a) 3:1; b) 1:2:1; c) 9:3:3:1; d) 1:1; e) 41,5:8,5:8,5:41,5.

44. Phenotype splitting for complete linkage of genes in Morgan's experiences: a) 41,5:8,5:8,5:41,5; b) 3:1; c) 1:2:1; d) 9:3:3:1; e) 1:1.

VARIATION

45. The properties of modifications: a) have adaptive character; b) are inherited; c) are not inherited; d) are a stuff for natural selection; e) are a stuff for artificial selection.

46. Biological mutagens produce: a) structure infringement of genes and chromosomes; b) a polyploidy; c) formation of thymine dimers; d) haploid; e) embedding of its DNA in DNA of host cells.

47. Characteristic attributes of gametic mutations are: a) occur in sex cells; b) occur in somatic cells; c) show at the individual; d) are transferred to offsprings offsets at a syngenesis; e) are transferred to offsprings at an asexual reproduction.

48. Kinds of functional genes mutations: a) a transposition; b) infringement of alternating recognition and terminations; c) infringement of alternating initiation and elongation; d) impairment of alternating of an induction and repression; e) transitions.

49. The polyploidy is: a) not multiple monoploid augmentation of chromosome number; b) multiple monoploid augmentation of chromosome number; c) not multiple monoploid decrease of chromosome number; d) multiple monoploid decrease of chromosome number; e) a unary set of chromosomes.

50. Haploidy is: a) a positive mutation; b) nullsomy; c) monosomy; d) absence of one chromosome; e) a unary set of chromosomes.

51. Kinds of structural genes mutations: a) transductions; b) a transposition; c) translocations; d) alteration of a reading frame; e) transitions.

52. Sequence of dark stages reparations of a genetic stuff: 1) synthesis of a new field of DNA; 2) «ligation» of the synthesized field of DNA with the main strand; 3) «the recognition» the damaged field; 4) «cutting» of the damaged field; 5) replication of a DNA molecule; a) 1–5–2–3; b) 5–1–3–2; c) 3–4–5–2; d) 3–4–2–1; e) 3–4–1–2

53. In a basis of a carcinogenesis according to the concept of oncogene lays: a) protooncogenes are received from parents or introduced into the cell by viruses; b) chromosome mutations of somatic cells; c) presence of protooncogenes in somatic cells of an organism; d) genomic mutations of somatic cells; e) incorporations of virus DNA in genome of somatic cells.

BIOLOGY AND GENETICS OF SEX

54. The germ formation of gonads occurs on the week of embryogenesis: a) 1^{st}; b) 2^{nd}; c) 3^{rd}; d) $4t^{h}$; e) 5^{th}.

55. The differentiation of germs into gonads occurs on the following weeks of embryogenesis a) from 1^{st} to 4^{th}; b) from 4^{th} to 6^{th}; c) from 4^{th} to 8^{th}; d) from 4^{th} to 12^{th}; e) from 10^{th} to 15^{th}.

56. Till 4th week of an embryogenesis the germ formation of gonads goes under the control of genes of: a) autosomes; b) one X-chromosome; c) two X-chromosomes; d) Y-chromosomes; e) X-and Y-chromosomes.

57. The germ differentiation into gonads occurs under the control of genes of: a) autosomes; b) one X-chromosome; c) the second X-chromosome; d) Y-chromosomes; e) cytogene.

58. At absence in karyotype of the second gonosome gonads: a) are differentiated; b) are not differentiated; c) connective tissues are formed on their place; d) atrophy partially; e) atrophy completely.

59. Physical abnormality in the determination of sex in human: a) a genetic gender; b) homosexuality; c) transvestism; d) gametic gender; e) hermaphroditism.

60. Transvestism is the phenomenon, when the person: a) chooses the sexual partner of other gender; b) chooses the sexual partner of the same gender; c) the sexual satisfaction is reached during putting on clothes of the opposite gender; d) wishes to change his/her gender; e) infertile.

61. Record of the karyotype at Turner's syndrome is : a) 46, XY, 5p-; b) 45, X0; c) 47, XXY; d) 47, XX, 21 +; e) 46, XX, 9p +.

62. Record of the karyotype at Klinefelter's syndrome is : a) 47, XXY; b) 45, X0; c) 47, XXX; d) 46, XY; e) 46, XY, 9p +.

BASES OF HUMAN GENETICS

63. The difficulty to study human genetics is: a) simple karyotype; b) early puberty; c) small amount of offsprings; d) a plenty of offsprings; e) an experimentation opportunity.

64. The stages of genealogic analysis: a) the collecting of the anamnesis; b) definition of frequencies of genes and genotypes in a population; c) construction of a genetic map of chromosome; d) studying of a role of the environment in exhibiting of attribute; e) analysis of a family tree.

65. Sequence of cytogenetic method stages: 1) processing of the cells by hypotonic solution NaCl; 2) a staining of chromosomes; 3) a stop of a C-mitosis (colchicines) at a stage of a metaphase; 4) cultivation of cells on artificial nutrient mediums; 5) stimulation of mitosis by PHA. a) 1–5–3–4–2; b) 4–5–3–1–2; c) 4–1–5–3–2; d) 5–3–4–1–2; e) 4–5–1–3–2.

66. Holtsinge's formula is used for calculation: a) frequencies of genes and genotypes in a population; b) quotient of inheritance; c) roles of environment in exhibiting an attribute; d) probabilities of inheritance; e) degree of genetic risk.

67. Biochemical methods of human genetics are studying: a) the general blood analysis; b) activity of enzymes of a blood plasma; c) activity of enzymes of a gastric juice; d) structure of primary urine; e) regional frame of enzymes.

68. Methods of recombinant DNA are based on: a) use of mathematical expression of the law of Hardy-Weinberg; b) opportunities of abjection of DNA fragments and an establishment sequence of nucleotides in them; c) construction and analysis of family trees; d) studying of enzyme systems activity; e) microscopic karyotype studying.

69. Methods recombinant DNA allow: a) to isolate separate genes and their parts; b) to reveal genomic mutations; c) to create unlimited amount of copies of genes; d) to reveal chromosome mutations; e) to reveal phylum of inheritance.

70. Microbiologic tests give the ability to: a) build genetical maps of human chromosomes; b) determine amount of X-chromosomes; c) determine amount of Y-chromosomes; d) reveal some chromosome mutations; e) reveal some metabolism defects.

71. Direct noninvasive methods of prenatal diagnostics are: a) the definition of alpha-fetoprotein; b) the ultrasonography; c) the chorionbiopcy; d) the aminoicenthesis; e) the fetoscopy.

72. Optimum terms for carrying out direct noninvasive methods of prenatal diagnostics are: a) 6–8 weeks; b) 8–10 weeks; c) 12–20 weeks; d) 23–30 weeks; e) 30–35 weeks.

GENETIC ENGINEERING

73. The purpose of gene engineering is: a) designing of genetic structures according to a given plan; b) decoding of the nucleotide order of DNA site; c) creation of organisms with the new genetic program; d) revealing of bunches of coupling; sequenation of genes; e) construction of a chromosome genetic map.

74. The basic stages of gene engineering are: a) obtaining necessary genetic materials; b) construction of a chromosome genetic map; c) decoding of the nucleotide order of a DNA site and recombinant DNA building; d) selection of the transformed cells; e) incorporation of a recombinant DNA molecules in a chromosome.

75. Means of reception of genes for transplantation: a) synthesis of simple genes by chemical reactions; b) synthesis of genes on a molecule of protein; c) synthesis of complex genes by reverse transcription; d) construction of a genetic map of a chromosome; e) a cutting of genes by restrictases.

76. Recombinant DNA molecules can be received by methods of gene embedding in: a) a protein; b) bacteria plasmid; c) a virus genome; d) a lipid; e) a bacteriophage genome.

77. The enzymes used in gene engineering are the following: a) DNA-polymerase; b) lipase and restrictase; c) revertase and restrictase; d) restrictase and amylase; e) ligase.

78. By methods of gene engineering are received: a) the strains of Escherichia coli, capable to insulin synthesize; b) the strain of Escherichia coli,

capable to somatotropinum synthesize; c) plants, capable to acquire atmosphere nitrogen; d) microorganisms, capable to synthesize carbohydrates of oil from alimentary proteins; e) antiviral serums.

79. The future of gene engineering is based on the following achievements of molecular biology: a) opportunities of genetic information transmission in eukaryote by sexual way; b) receiving of paravariations with help of chemical mutagenes; c) sequenation of genes; d) substitution of defective genes; e) including in human genome synthetically synthesized genes.

80. The chemical basis of plasmids is made of the following molecules: a) RNA; b) DNA; c) proteins; d) lipids; e) polysaccharides.

GENETICS OF POPULATIONS

81. Characteristic attributes of an ideal population are: a) great number; b) small number; c) complete panmixia; d) absence of mutations; e) presence of mutations.

82. In mathematical expression of the law of Hardy–Weinberg p designates frequency of: a) dominant gene; b) recessive gene; c) dominant homozygotes; d) recessive homozygotes; e) heterozygotes.

83. In mathematical expression of the law of Hardy-Weinberg q designates frequency of: a) dominant gene; b) recessive gene; c) dominant homozygotes; d) recessive homozygotes; e) heterozygotes.

84. In mathematical expression of the law of Hardy-Weinberg 2pq designates frequency of: a) dominant gene; b) recessive gene; c) dominant homozygotes; d) recessive homozygotes; e) heterozygotes.

85. The genetic load is: a) population saturation by positive mutations; b) population saturation by mutations, reducing adaptability of separate individuals; c) population saturation by neutral mutations; d) population saturation by negative mutations; e) absence of mutations in populations.

REPRODUCTION OF ORGANISMS

86. Asexual reproduction characteristic is: a) two individuals participate in reproduction; b) one individual participates in reproduction; c) the genotype of daughter individual differs from parental ones; d) the genotype of daughter individual is identical to parental ones; e) the number of daughter individuals increases slowly.

87. Asexual reproduction forms of metazoans are: a) by vegetative organs; b) conjugation; c) copulation; d) polyembryony; e) fragmentation.

88. Sexual reproduction characteristic is: a) two individuals participate in reproduction; b) one individual always participates in reproduction; c) the genotype of daughter individual differs from parental one; d) the genotype of daughter individual is identical to parental ones; e) the number of daughter individuals increases quickly.

89. Sexual process is: a) the reproduction; b) the fusion of two gametes; c) formation of gametes; d) genetic information exchange between same species individuals; e) genetic information joining of same species individuals.

90. Isolecital ova characteristics: a) contains a lot of yolk; b) contains small amount of yolk; c) the yolk is evenly distributed; d) the yolk is concentrated on the vegetative pole; e) the yolk is located on the animal pole.

91. Progression of spermatozoons in female sexual ways is provided by: a) motility of spermatozoons; b) ova unmotility; c) contraction of uterus muscles; d) excretion of gynogammons; e) contraction of bladder muscles.

92. Fertilization stages are: a) ova destruction by spermatozoons hyaluronidase; b) the acrosome reaction; c) ova splitting; d) permeation of head, neck and tail of spermatozoon in ova cytoplasm; e) maturing of pronucleuses.

93. Features of human reproduction are: a) women are capable for reproduction from the puberty up to advanced age; b) men are capable for reproduction from the puberty up to 50 years; c) one oocyte of the second order is formed ones a moon month in women; d) spermatozoons are formed periodically in men; e) than older is the man, the greater is time interval between meiosis-1 and meiosis-2.

BASES OF ONTOGENESIS (EMBRYONIC DEVELOPMENT)

94. The type of zygote splitting depends on: a) ova sizes; b) ova form; c) yolk quantity; d) yolk location; e) potentialities of ova cytoplasm.

95. Dermatome derivatives are: a) intestine epithelium; b) nervous system; c) respiratory system; d) urinogenital system; e) derma.

96. First causes of cells differentiation during embryogenesis are: a) chemical homogeneity of the ovum cytoplasm; b) chemical heterogeneity of the ovum cytoplasm; c) chemical homogeneity of spermatozoon cytoplasm; d) chemical heterogeneity of spermatozoon cytoplasm; e) different possibilities of animal and vegetative poles of the ovum.

97. Realization of genes action during ontogenesis is: a) DNA → protein-enzyme → mRNA → biochemical reaction → attribute; b) DNA → mRNA → protein-enzyme → biochemical reaction → attribute; c) other genes influence on attribute exhibiting; d) other genes do not influence attribute exhibiting; e) environmental factors do not influence on attribute exhibiting.

98. The main mechanisms of cells differentiation are: a) blocking of different transcriptones at the certain development stage; b) incorporation in the work of all genes at the certain development stage; c) blocking of all genes at the certain development stage; d) unblocking of different transcriptones at the certain development stage; e) blocking of one gene at the certain development stage.

99. Characteristic attributes of totipotent cells are: a) their development is programmed; b) their development is not programmed; c) each of them can

give rise to any cell type; d) each of them can give rise only to the certain cell type; e) the majority of transcriptones are blocked.

100. Characteristic attributes of determined cells are: a) their development is finally programmed; b) their development is not programmed; c) each of them can give rise to any cell type; d) each of them can give rise only to the certain cell type; e) the majority of genes blocks can join in the work.

101. The causes of embryogenesis critical periods are: a) change of conditions of embryo existence and feeding; b) transition from one development period to another one; c) appearance of new inducers; d) active dedifferentiation of cells; e) insufficient nourishment of the pregnant woman.

BASES OF ONTOGENESIS (POSTEMBRYONIC DEVELOPMENT)

102. Critical periods of a postnatal ontogenesis of the person: a) labors; b) new born; c) puberty; d) sexual withering; e) senile age.

103. The Characteristic of cerebral phylum of body height of organs and tissues of a human being: a) intensive body height since birth and till 10–12 years; b) uniform body height during the whole period; c) intensive body height in the first year of life and during puberty; d) intensive body height till 11–12 years, then decrease of volume of a tissues up to a level of an adult organism; e) a tachyauxesis during puberty.

104. Criteria of biological age: a) a degree of development of a scalp; b) the dimensions of genitals; c) skeleton maturity; d) body height of the person; e) dental maturity.

105. The Constitution of the person is: a) hereditary features of morphology, physiology and behaviour; b) a momentary state of the person; c) persistent, genetically caused disturbances of morphology, physiology and behaviour; d) a reactivity; e) resistibility to disease-producing agents.

106. Hypersthenic persons are predisposed to: a) to neurosises; b) hypertension; c) stomach ulcer; d) atherosclerosis; e) obesity.

107. The essence aging of intoxicating hypothesis: a) changes of cytoplasm colloidal properties; b) decrease in production of sexual hormones; c) accumulation of waste products in large intestine and their adsorption in blood; d) disturbance of adaptation and regulation processes; e) accumulation of mutations.

108. The essence aging of genetic hypothesis: a) changes of colloidal properties of a cell cytoplasm; b) decrease in production of sexual hormones; c) impairment of reparation and DNA replication processes; d) impairment of adaptation and regulation processes; e) genetically programmed number of cell's mitosis.

109. The proof of genetically programmed number of cell's mitoses is: a) fibroblasts of man's embryos in culture give about 50 generations; b) at each DNA replication some nucleotides of telomeres are lost; at each DNA replication some nucleotides of telomeres are added; c) with each mitosis the length of telomeres decreases; d) with each mitosis the length of telomeres increases.

INTRODUCTION TO PARASITOLOGY

110. The Parasitism — such a cohabitation of different kinds of organisms, at which: a) organisms receive mutual benefit; b) the individual of one species uses the individual of other species only as habitation; c) the individual of one species uses the individual of other species as habitation and the source of nutrition, not causing any harm; d) the individual of one species uses the individual of other species as dwelling and the source of nutrition and harms her; e) none of the organisms receive any benefit.

111. Examples of parasites progressive morpho-physiological adaptation are: a) the presence of organs of bracing and special integuments of a body (the cuticle, tegument); b) simplification of the nervous system a constitution and sense organs; c) molecular «mimicry» and anti-enzymes discharge; d) a reduction of the tape worms alimentary system; e) a high fertility and intricit development of cycles.

112. Examples of biological acclimatization of parasites: a) presence of organs of bracing and anti-enzymes; b) simplification of the nervous system and sense organs constitution; c) perfection of various forms of an asexual reproduction and a high fertility; d) complex cycles of development, change of host and larvae migration over an organism of the host; e) immunosuppressive action.

113. Pathogenic action of the parasite: a) mechanical damage of organs and tissues and toxic-allergic; b) supply of the host by vitamins; c) supply of the host by nutrients; d) absorption of nutrients and vitamins from the organism of the host; e) opening a gate for a secondary infection.

114. Pathogenicity of a parasite does not depend on: a) the host genotype and factors of the environment; b) the genotype and virulence of a parasite; c) the host age and a feeding schedule; d) body height and a sex of the host; e) presence of other parasites in the host.

115. Levels of defense reactions in host organism are: a) subcellular and cellular; b) cellular and organism; c) both specific and histic; d) cellular and histic; e) population-specific.

116. Adaptation of parasites at the population level: a) presence of cyst and active search of host's; b) simplification of the nervous system constitution and the reduction of the alimentary system in tape worms; c) molecular «mimicry» and anti-enzymes discharge; d) involving of intermediate and reservoir hosts in to the development cycle; e) synchronization parasite development cycles and hosts behavior.

PARASYTES — PATHOGENS OF THE DISEASES

117. Methods of laboratory opistorchosis diagnosis are: a) Fulleborn and Kalantaryan; b) Gorachev; c) twistings by Schulman; d) native and thick blood film with cellophane; e) a sticky tape.

118. Means of teniasis infestation of man are: a) personal hygiene neglect; b) contacts with teniasis and cysticercosis patients; c) the usage of thermally insufficient beef; d) the usage thermally insufficient pork; e) the usage thermally insufficient processed fish, shrimps and crabs.

119. Means of cystiercosis infestation of man are: a) swallowing of armed tapeworm eggs neglecting personal hygiene; b) the usage of thermally insufficient pork and beef; c) the usage of thermally insufficient shrimps and crabs; d) contact with house pigs; e) autoinvasion in teniasis.

120. Sequence of ascarids larvas migration in a human being body is: a) intestine → dextral heart → lungs → blood vessels → liver → bronchi → trachea → pharynx → intestines; b) intestine → liver → bronchi → dextral heart → lungs → blood vessels → trachea → pharynx → intestines; c) liver → bronchi → dextral heart → lungs→ blood vessels → trachea → pharynx → intestines; d) intestine → blood vessels → liver → dextral heart → lungs → bronchi → trachea → pharynx → intestines; e) intestine → blood vessels → dextral heart → lungs → liver → bronchi → trachea → pharynx → intestines.

121. Diagnostic migratory ascariasis signs are: a) an intestinal obstruction; b) fever and an asthmatic bronchitis; c) flying eosinophilic lungs infiltrates; d) the common bile duct occlusion; e) appendicitis.

122. Surgical ascariasis complications are: a) mechanical jaundice and intestinal obstruction; b) development of an adult species in an eyeball; c) perforation of the intestinal wall; d) pneumonia and bronchitis; e) pancreatitis and appendicitis.

123. The medical S. scabiei aspect is: a) a transmitting agent of Russian tick-borne and Scottish encephalitis originators; b) a transmitting agent of тularemia and brucellosis originators; c) the originator of catarrhal symptoms of gastrointestinal tract; d) causes bronchospasms; e) the originator of scabies.

124. The ways and methods of mans scabies infestation are: a) transmissible and transplantsibble; b) at contact with sick people and animals; c) the use of insufficiently thermally prepared fish; d) through bed-clothes and household goods; e) drinking water from the open sources.

125. Preventive measures scabies are: a) revealing and treatment of patients, sanitary inspection of hostels and public baths; b) elimination of transmitting agents; c) maintenance of a body, linen and dwellings cleanliness; d) careful washing of vegetables and fruit; e) sufficient thermal processing of meat products.

126. Morphological features of Pediculus type lice are: a) the dimensions of a body are of 1–4 cm, the absence of wings; b) the dimensions of a body are of 1–4 mm, the presence of one pair of wings; c) the oral cavity is of a gnawing type; d) the dimensions of a body are of 1–4 mm, the absence of wings; e) the oral cavity is of a pricking-sucking.

127. Features of Pediculus family louse life cycle are: a) lay eggs in dry dust and on food products; b) eggs stick to hair; c) the development is direct; d) the development is with semimetamorphosis; e) the duration of life cycle is 2–3 months.

128. The medical aspect of Pediculus family louse is: a) mechanical transmitting agents of helminths eggs and cyst protists; b) specific transmitting agents of the louse-born recurrent typhus originator; c) specific transmitting agents of the louse-born typhus originator; d) pediculosis originators, punctures produce itching; e) originators of phthiriosis, punctures produce itching.

129. Morphological features of Phthirus type lice are: a) a body is short and wide, the dimension is up to 10 mm; b) a body is short and wide, the dimension is up to 1,5 mm; c) a body is extended, the dimension is up to 5 mm; d) the oral cavity is of pricking-sucking type; e) the oral cavity is of gnawing type.

130. Medical aspect of P. pubis louse is: a) mechanical transmitting agents of the recurrent and classical typhus originators; b) specific transmitting agents of cyst protists and of helminths eggs; c)originators of phthiriosis; d) specific transmitting agents of malaria originators; e) damages the skin with rare rigid hair, punctures produce itching.

VENOMOUS ANIMALS

131. Actively-venomous animals: a) jellyfish and snails molluscums; b) a cobra and a tarantula; c) a python and a tarantula; d) a tarantula and a fish-fugue; e) a fish-fugue and snails molluscums.

132. Passively-venomous animals: a) jellyfishes and a tarantula; b) a cobra and a boa; c) a python and a fish-fugue; d) a tarantula and snails molluscums; e) a fish-fugue and snails molluscums.

133. The armed active-venomous animals: a) snakes and slopes; b) a fish-fugue and wasps; c) bees and amphibious; d) snails molluscums and bees; e) snakes and amphibious.

134. Unaided active-venomous animals: a) both snakes and amphibious; b) a fish-fugue and slopes; c) bees and slopes; d) snails molluscums and amphibious; e) slopes and snails molluscums.

135. Toads and frogs are animals: a) primarily-venomous unaided; b)secondary-venomous unaided; c) active-venomous unaided; d) passively-venomous unaided; e) secondary-venomous armed.

136. Bees and wasps are animals: a) primarily-venomous armed; b) again-venomous armed; c) is actively-venomous armed; d) passively-venomous armed; e) passively-venomous unaided.

137. The Factors determining zootoxins venenation are the following: a) the structure and the quantity of the venom; b) a place of a lesion; c) sex of the affected person; d) a habitus of the affected person; e) time of a day.

138. In case of scorpions venoming: a) a sharp pain**,** a hyperemia and a hypostasis of the affected place; b) hyperemia and hypostasis of the injured place**,** sense of fear; c) neither hyperemias nor hypostasis of the injured place**,** nausea and vomiting; d) a sharp pain**,** a feeling of fear; e) sense of fear**,** nausea and vomiting are observed.

139. In case of tarantula venoming: a) a sharp pain and drowsiness; b) a hyperemia and a hypostasis of the affected place, a necrosis of the skin; c) neither hyperemias nor hypostasis of the affected place; d) hyperemia and hypostasis of the affected place, drowsiness; e) drowsiness, necrosis of the skin are observed.

140. In case of bees and wasps venoming: a) sharp pain, sense of fear; b) hyperemia and hypostasis of the affected place, allergic reactions; c) neither hyperemias nor hypostasis of the injured place; d) allergic responses, a sense of fear; e) a sharp pain are observed.

141. In case of cobra venoming: a) a sharp pain, an inflammation of lymphatic vessels; b) an inflammation of lymphatic vessels, a necrosis of tissues; c) a sharp pain, a necrosis of tissues; d) exaltation, and then CNS oppression, a necrosis of tissues; e) exaltation, and then CNS oppression, impairment of respiration are observed.

142. In case of Viperidae snakes venoming: a) a sharp pain and impairment of blood clotting; b) extremities numbness and hemorrhagic hypostases; c) hemorrhagic hypostases; d) extremities numbness and impairment of respiration; e) blood clot impairment and impairment of respiration are observed.

143. First aid in a venenation with hymenopterous venom is the following: a) to suck away venom, to treat the place of stinging with disinfectants; b) to remove a sting, to treat the place of stinging with disinfectants; c) to treat the place of stinging with disinfectants, to apply heat to a place of stinging; d) to apply a warm hard bandage to the place of stinging; e) to abandon a sting, to treat the place of stinging with disinfectants.

144. First aid in a venenation with a snakes venom is the following: a) to suck away venom and to treat the place of a puncture with disinfectants; b) to cauterize the place of puncture and to put a victim in a shade; c) to cauterize and to treat the place of a puncture with disinfectants; d) to transport a victim in lying position; e) to apply a hard bandage to a place of a puncture and to transport a victim in any position.

ANSWERS TO THE OPEN TESTS

BIOLOGY OF THE CELL. THE FLOW OF SUBSTANCE AND ENERGY IN THE CELL

1. compartmentalization. **2.** glycocalyx. **3.** Golgi's complex.
4. autophagy. **5.** porin. **6.** 3.
7. 40 %.

THE FLOW OF GENETIC INFORMATION IN THE CELL

8. lamins. **9.** kinetochore. **10.** nucleolar organizer.
11. 2n 2chr 4c. **12.** $1n_{biv}$ 4chr 4c. **13.** $1n_{biv}$ 4chr 4c.
14. $1n_{biv}$ 4chr 4c. **15.** chiasmas. **16.** bivalent chromosome.
17. 1n 2chr 2c.

ORGANIZATION OF THE HEREDITARY MATERIAL

18. replication. **19.** $3'$–$5'$. **20.** unidirectionality.
21. recognition. **22.** AUG. **23.** elongation.
24. inhibitor.

INHERITANCE REGULARITIES. INTERACTION OF GENES

25. alternative. **26.** 100. **27.** recessive epistasis.
28. complementary. **29.** 1:1:1:1. **30.** multiple.

LINKAGE OF GENES

31. linkage of genes. **32.** complete. **33.** incomplete.
34. incomplete. **35.** crossingover. **36.** crossingover.
37. 50. **38.** recombinant. **39.** 22.

VARIATION

40. exonuclease. **41.** transition. **42.** deletions.
43. functional. **44.** genomic. **45.** monosomy.
46. haploidy.

BIOLOGY AND GENETICS OF SEX

47. trisomy. **48.** Turner's syndrome. **49.** Klinefelter's syndrome.
50. transvestism. **51.** miosis. **52.** holandric.
53. transsexualism.

BASES OF HUMAN GENETICS

54. proband. **55.** 18,75 %. **56.** 20 %.
57. hybridization. **58.** X-lined dominant. **59**. twin.
60. cytogenetic. **61.** 8–12. **62.** ultrasonography
63. direct invasive. **64.** Acrichine-yperite.

GENETIC ENGINEERING

65. restrictase. **66.** restrictase. **67.** Fermentative synthesis.
68. liposomes. **69.** phasmids. **70.** cosmids.
71. sticky ends. **72.** obtuse ends

GENETICS OF POPULATIONS

73. isolate. **74.** Heterozygous.

REPRODUCTION OF ORGANISMS

75. Conjugation. **76.** Syncaryogamy. **77.** Partenogenesis
78. Sharply telolecithal. **79.** Isolecithal. **80.** Mitosis.
81. Miosis. **82.** Polyembryony.
83. Fertilizin (gynogamone II). **84.** 24–48 h.

BASES OF ONTOGENESIS (EMBRYONIC DEVELOPMENT)

85. Splitting **86.** Pre-fetal. **87.** Immigration.
88. Deuterostomes. **89.** Provisional. **90.** Chemical heterogeneity.
91. Embryonic induction. **92.** Gradient.

BASES OF ONTOGENESIS (POSTEMBRYONIC DEVELOPMENT)

93. Lymphoid. **94.** Somatotropin. **95.** Acceleration.
96. Constitution. **97.** Ectomorphic (asthenics). **98.** Geriatrics.
99. Valeology. **100.** Clinical. **101.** Euthanasia.

INTRODUCTION TO PARASITOLOGY

102. False parasites. **103.** Obligatory. **104.** Potential.
105. |Permissive. **106** Alimentary. **107.** Air-drop (respiratory).
108. Contact-household. **109.** Transfusive

PARASYTES — PATHOGENS OF THE DISEASES

110. Trophozoit. **111.** Axostyle. **112.** 5.
113. Cat liver fluke. **114.** Cercaria. **115.** Cysticerc.
116. 3. **117.** 7–12. **118.** One year
119. Pediculosis. **120.** Phthiriosis. **121.** Nit.
122. Louse-born relapsing and a louse-born enteric fever.
123. Obermeier’s Spirochaeta.

VENOMOUS ANIMALS

124. Armed. **125.** Hemolyzins. **126.** Striking cells.
127. Neurotoxin. **128.** Neurotoxin **129.** Hemorrhagens.
130. Neurotoxins. **131.** 50. **132.** Armed.

ANSWERS TO THE CLOSE TESTS

BIOLOGY OF THE CELL. THE FLOW OF SUBSTANCE AND ENERGY IN THE CELL

1. a, c, e. **2.** b, e. **3.** b, c. **4.** a, e. **5.** a, d.
6. a, c, d. **7.** a, b, d. **8.** a, e. **9.** d.

THE FLOW OF GENETIC INFORMATION IN THE CELL

10. a, c. **11.** c, e. **12.** d. **13.** b, d. **14.** c.
15. a, c. **16.** a, d, e. **17.** c. **18.** d. **19.** c, e.

ORGANIZATION OF THE HEREDITARY MATERIAL

20. b. **21.** a. **22.** a, c, e. **23.** b. **24.** a, b. **25.** b.
26. c. **27.** b. **28.** c, e. **29.** b. **30.** c, e.

INHERITANCE REGULARITIES. INTERACTION OF GENES

31. a, c, d. **32.** b, e. **33.** d. **34.** d. **35.** a, d. **36.** b. **37.** e.

LINKAGE OF GENES

38. a. **39.** d, e. **40.** a, c. **41.** a, c. **42.** b. **43.** e. **44.** e.

VARIATION

45. a, c. **46.** a, e. **47.** a, d. **48.** d. **49.** b.
50. e. **51.** d, e. **52.** e. **53.** a, c

BIOLOGY AND GENETICS OF SEX

54. d. **55.** d. **56.** b. **57.** c. **58.** b, c.
59. e. **60.** c. **61.** b. **62.** a.

BASES OF HUMAN GENETICS

63. c. **64.** a, e. **65.** b. **66.** b. **67.** b.
68. b. **69.** a, c. **70.** e. **71.** b. **72.** c.

GENETIC ENGINEERING

73. a, c. **74.** a, d, e. **75.** a, c, e. **76.** b, c, e.
77. a, c, e. **78.** b, c, e. **79.** d, e. **80.** b.

GENETICS OF POPULATIONS

81. a, c, d . **82.** a. **83.** b. **84.** e. **85.** b, d.

REPRODUCTION OF ORGANISMS

86. b, d. **87.** b, c. **88.** a, c. **89.** d, e.
90. b, c. **91.** a, d. **92.** b. **93.** c.

BASES OF ONTOGENESIS (EMBRYONIC DEVELOPMENT)

94. c, d. **95.** e. **96.** b, e. **97.** b, c.
98. a, d. **99.** b, c. **100.** a, d. **101.** a, c.

BASES OF ONTOGENESIS (POSTEMBRYONIC DEVELOPMENT)

102. b, c, d. **103.** a. **104.** c, e. **105.** a.
106. b, d, e. **107.** c. **108.** c, e. **109.** a.

INTRODUCTION TO PARASITOLOGY

110. d. **111.** a, c. **112.** c, d. **113.** a, d, e.
114. d. **115.** b, d. **116.** a, d, e.

PARASYTES — PATHOGENS OF THE DISEASES

117. b. **118.** d. **119.** a. **120.** d. **121.** b, c.
122. a, c, e. **123.** e. **124.** b, d. **125.** a, c. **126.** d, e.
127. b, d. **128.** b, c, d. 1**29.** b, d. **130.** c, e.

VENOMOUS ANIMALS

131. b. **132.** e. **133.** a. **134.** d. **135.** a, d.
136. a, c. **137.** a, b. **138.** a. **139.** b. **140.** b, e.
141. a, e. **142.** a, c. **143.** b. **144.** a, d.

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