Ministry of Education and Science of Ukraine

Sumy State University

Physiology and Pathophysiology Department

GUIDE
TO PRACTICAL CLASSES
IN MEDICAL BIOLOGY

by Dr. Oleg Smirnov

SPECIALTY:
222 – Medicine

General information about the discipline "Medical Biology" is presented in the site of Physiology and Pathophysiology Department (see ***here***).

1st semester – lessons 1÷16
2nd semester – lessons 17÷34

Sumy – 2021

Methodical Instructions for Lessons

For practical lessons, students should have a notebook for solving genetic problems, an album for drawing figures, a pen, a pencil, and elastic band (eraser). During a lesson, students receive marks (computers check their knowledge), view and draw preparations, fill in tables, solve problems. At the end of the lesson, a teacher gives mark for student's work.

Each student must prepare a topic of the lesson, read textbooks and lecture notes. In this manual, students can find list of terms, questions for oral answers, problems, and additional information for each lesson. Synonyms for terms and synonymic names of organisms are written in square brackets. At the end of the information for some lessons, students can find genetic problems for solving at home. Additional material is marked with an asterisk.

Reworking of missed lessons. Attendance of practical lessons is obligatory. All missed lessons must be reworked. Reworking of the missed lesson is performed as the additional lesson, according to the special schedule (day of the week, time).

Rules of Drawing

The necessary element of studying of an object (organelles, cells, organisms) is the drawing of it in an album. It allows understand and fix better in memory a form and a structure of the object. Figure is the document and the report on the work that is made. At the end of the class, a teacher signs student's work.

Each figure should have the name and signatures of details (parts). It is necessary to specify common English name and the Latin name (in brackets) of an organism.

It is necessary to draw figure large enough that details should be distinguishable. For this, do not draw more than 3–4 figures on one page. If the object is complex and large, only one figure should be drawn. It is necessary to maintain strictly proportion of the sizes (length, width), displaying specific features of object. For this purpose, it is necessary at first to draw the general contour of object, slightly to plan contour of separate details inside it and only after that to draw all parts precisely. Do not draw a circle (a field of vision of a microscope) or a square around the object. All parts of the object should be signed directly (without figures and footnotes), by drawing a line from object without an arrow. Designations should be done by pencil. Schemes can be carried out by colored pencils.

Lesson 1. Introduction to Medical Biology

This lesson starts substantial module 1 "Cytogenetics".

Course of Events.

1. Information about safety rules.
2. Methodical instructions.
3. General information about the discipline “Medical biology”.
4. Computer testing of basic knowledge on biology (school level).

Literature.

School books on biology.

Lesson 2. Biology as a Science. Light Microscopy

Reading for a lesson.

1) *Terms:* acid dye, anabolism, anatomy, angular aperture, artefact, basic dye, biology, biosphere, botany, catabolism, cell, cell biology, centrifuge, community, conclusion, condenser, contrast, control group, controlled experiment, coverslip, data, development, diaphragm, ecology, experiment, experimental group, eyepiece, fixation, fixative, focus knob, genetics, glass slide, growth, homeostasis, hypothesis, illumination, immersion oil, irritability, magnification, metabolism, microbiology, microscope, mirror, numerical aperture, objective, observation, ocular, organ, organism, physiology, population, primary image, repair, reproduction, revolving nosepiece, resolving power (resolution), science, secondary image, sensitivity, stage, stand, organ system, systematics, taxis, technology, theory, tissue, tropism, tube, turret, variable factor, virus, working distance, zoology.
2) Biology as a science. Controlled experiment. Fact, data, hypothesis, theory.
3) Living things. Growth, development. Cell, tissue, organ, system, organism, population.
4) Methods of biological investigations. Microscopes. Optical and illuminating parts of the light microscope. Objective lenses. Magnification of a compound microscope.
5) Setting up illumination in a light microscope.
6) Specimens for microscopy. Fixation, staining.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Chapter 1.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 8–11.
3. Lazarev K. "Medical Biology" (2003), pp. 3–19.

==========

PRACTICAL ASPECTS OF MICROSCOPY

The first stage of image formation in the microscope is illumination of the specimen.

a) Rotate the objective lens turret to bring the low magnification objective (8×)

into vertical position above the stage. Check the working distance (1 cm) by rotating the coarse focus knob.

b) To move the condenser up, rotate condenser lens adjustment knob counterclockwise. Check the position of a mobile lens (swing this lens inside).

c) Remove an ocular from the microscope and look down the tube. You should catch a bulb or a white cloud by means of the mirror (sunlight is *not* used as a source of light). The lamp must be in the center of the field of view. Replace the ocular. Now don't move the microscope.

d) Place the specimen on the microscope stage and center specimen under the objective lens. Metal clips on the microscope stage are used to hold the slide in place. Using the coarse focus knob, bring the low power objective into focus.

e) Low power objectives cover a wide field of view, and they are useful for examining large specimens or surveying many smaller specimens. If you want to change objective lens ans see preparation under high magnification, rotate turret to bring the high magnification objective (40×) into vertical position (do *not* move tube holder before this, do *not* rotate coarse focus knob!). Then see through ocular (image is not sharp) and rotate the course adjustment knob counterclockwise very slowly (1–2 mm) to get the image sharp, and then use fine adjustment knob to see well. Remember to be careful as you do this, since the working distance is small, and always watch lens surfaces as they approach the specimen. If focus movements are too extreme, there is a risk that the objective might break the microscope slide.

f) To see the preparation better, move condenser by rotating condenser adjustment knob clockwise and counterclockwise. Do not use a mobile lens of the condenser with high-power and immersion objectives (swing this lens aside).

General Information. An important part of good microcopy is to understand that it is a dynamic, interactive process. Virtually all specimens are three-dimensional on a microscopic scale, and it is necessary to continually scan up and down, as well as laterally through a specimen to develop a good understanding of its architecture. Light interacts with the specimen, "transparent" specimens absorb some light, and small differences in absorbance over the specimen contribute to image formation. Light that is not reflected or absorbed is transmitted through the specimen. Wavelength-dependent absorbance gives specimens color, as in a red blood cell.

==========

Practical Class Work.

1) **Draw** an optical microscope, mark its main parts.
2) **Analyse** the scheme of the pathway of light in the optical microscope when dry and immersion objectives are used.
3) **Set up** illumination in a light microscope.
4) **Prepare** a specimen of fibers of cotton wool. Separate some fibers from a piece of cotton wool, place them on a mount, place carefully a cover glass. Check that the cover glass fit tightly to the mount, without a backlash. Place slide securely on the stage, making certain it cannot slip or move. Position it so that light coming up through the condenser passes through the area with fibers. Check the distance between low-power objective and your preparation. Look through the ocular and rotate the coarse focus knob to get the image as sharp as possible. **Draw** fibers under small magnification. Change objective lens form 8× to 40×; bring the image into sharp focus using the fine focus control. Study how conditions of light exposure (move the condenser up and down, with or without the mobile lens) influence contrast and quality of the image. Draw a part of fiber under high magnification.
5) **Clean** a workplace. Leave the microscope in non-working position.

Lesson 3. Cell Structure

Reading for a lesson.

1) *Terms:* active transport, ADP, ATP, autolysis, cell, cell theory, cell wall, centriole, centrosome, chloroplast, chromatin, chromoplast, chromosome, compartment, cristae, cytoplasm, cytoskeleton, cytosol, diffusion, endocytosis, endoplasmic reticulum, endosymbiotic theory, eukaryote, exocytosis, glycoprotein, Golgi apparatus, hyaloplasm, hydrophilic, hydrophobic, leucoplast, lysosome, matrix, membrane, microfilament, microtubule, mitochondrion, nucleoid, nucleolus, nucleus, organ, organ system, organelle, organism, osmosis, passive transport, perinuclear space, peroxisome, phagocytosis, pili, pinocytosis, pore, prokaryote, ribosome, semipermeable membrane, tubulin, vacuole.
2) Cell theory.
3) Prokaryotes and eukaryotes, plant and animal cells, unicellular and multicellular organisms. Viruses.
4) Water. Salts. Macroelements, microelements. Organic compounds.
5) Cell membranes. Diffusion and osmosis. Active and passive transport.
6) Cytoplasm ans cytoskeleton.
7) Cytoplasmic organelles.
8) Nucleus and nucleoles.
9) Cell as an open system. Assimilation and dissimilation. ATP.
10) Microscopy.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Chapter 2, Sections 2.1–2.2.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 12–17, 19–24, 27–37, 49, 73–74.
3. Lazarev K. "Medical Biology" (2003), pp. 20–44, 52–53.

==========

Practical Class Work.

1) **Prepare** a specimen of human hair. Examine it in a microscope under high magnification and **draw**. **Clean** a workplace, leave the microscope in non-working position.

2) **Examine** fixed specimen of animal cell – blood of a frog. In a blood smear, red blood cells are oval with nucleus, thrombocytes are very small, with nucleus too. **Draw** one erythrocyte and one thrombocyte. Pay attention to the size and shape of each cell, presence of the nucleus, size and shape of it.
3) **Examine** fixed specimen of animal cell – blood of a man. In a blood smear, red blood cells (erythrocytes), leukocytes (larger rounded cells with the rounded or lobar (segmented) nuclei), and thrombocytes (fine fusiform cells) are present. Pink cytoplasm of erythrocytes is stained by eosin and a dark-violet nucleus is stained by hematoxylin. **Draw** erythrocytes and a leukocyte.
4) **Compare** erythrocytes of a frog and a man taking into account their shape, size and structure (presence of a nucleus).

Lesson 4. Cell Division. Gametogenesis

Reading for a lesson.

1) *Terms:* amitosis, anaphase, apoptosis, bivalent, cell cycle, cell furrow, cell plate, centromere, checkpoint, chiasma, chromatid, chromosome, cohesin, crossing over [crossover], cytokinesis, development, differentiation, diploid, diplontic organism, egg, equation division, fertilization, fission, gamete, gametogenesis, germ cell, growth factor, haploid, haplontic organism, homologous chromosomes, independent assortment, interkinesis, interphase, karyokinesis, kinetochore, M phase, meiosis, metaphase, mitosis, mitotic index, monoploid, necrosis, nondisjunction, nonhomologous chromosomes, oocyte, oogenesis, oogonium, ovum, polar body, prophase, recombinant chromatids, reduction division, schizogony, segregation, specialization, sperm, spermatid, spermatocyte, spermatogenesis, spermatogonium, spermatozoid, spindle, spindle fibers, spore, synapsis, synaptonemal complex, telophase, tetrad, tubulin, zygote.
2) Prokaryotic cell division.
3) Cell cycle in eukaryotes: interphase and M phase. Mitotic activity of tissues.
4) Control of the cell cycle. Growth factors. Cell specialization and differentiation.
5) Amitosis and schizogony.
6) Meiosis: stages, chromosomes and chromatids, bivalents. Differences between meiosis and mitosis.
7) Gametogenesis: stages. Differences between oogenesis and spermatogenesis.
8) Structure of gametes. Fertilization.
9)* (*additional reading*) Cloning of cells. Apoptosis and necrosis. Malignant growth.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Section 2.3.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 77–95, 98–102.
3. Lazarev K. "Medical Biology" (2003), pp. 44–52, 54, 57–69, 108.

==========

Practical Class Work.

1) **Examine** a specimen and a photo of mitotic cell fission of a rootlet of an onion. **Draw** such stages: interphase, prophase, metaphase, anaphase, and telophase. Pay attention to the size and shape of each cell, presence of the nucleus and nucleolus, size, shape and location of chromosomes.
2) **Examine** a specimen of spermatozoids of a guinea pig. Choose cells having dark acrosome and light head. Find that some sperm cells have one flagellum, other cells have 2–3 or more flagella. **Draw** 2–3 spermatozoids that have various morphology (one or several flagella). Designate a head with an acrosome, a neck, and a tail.
3) **Examine** and **draw** a specimen of spermatozoids of a cock (long threadlike cells).
4) **View** a specimen of a section of rat testis. Find cells that are on different meiotic stages.
5) **Draw** the genetic scheme of mitosis (*n* – haploid chromosome number, *c* – chromatid number or number of DNA molecules).

Lesson 5. Chromatin, Chromosomes, and Karyotype

Reading for a lesson.

1) *Terms:* arm, autosome, centromere, chromatin, chromomere, chromosome, colchicine, cytostatic agents, DNA, endomitosis, euchromatin, heterochromatin, histone, idiogram, isochromosome, karyogram, karyotype, karyotyping, kinetochore, lampbrush chromosome, nucleoid, nucleolar organizer, nucleosome, phytohemagglutinin, polytene chromosome, polyteny, puff, sex chromatin, sex chromosome, sister chromatids, spindle microtubules, telomere.
2) Structure of the nucleus in interphase. Chromatin structure. Chromatin types: euchromatin, heterochromatin, and sex chromatin.
3) Types of chromosomes: mitotic (metaphase), polytene, and lampbrush chromosomes. Structure of the mitotic chromosome. Endomitosis, polyteny.
4) Karyotype. Characteristics and classification of human chromosomes. Karyogram, idiogram. Normal and abnormal chromosomes.
5) Cytogenetic method: material for investigation, cytostatic agents, chromosome analysis. Banding techniques. Usage of karyotyping in medicine.
6) Bacterial chromosome.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Sections 2.4 and 2.5.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 37–46.
3. Lazarev K. "Medical Biology" (2003), pp. 165–177.

==========

Practical Class Work.

1) **Examine** a specimen of polytene chromosomes of mosquitoes (chironomid midge). Karyotype is $2n = 8$. Cell envelope and nuclear membrane are not visible. Large thick violet polytene chromosomes are visible in the light violet background. Homologous chromosomes are paired, hence, each cell contains 4 chromosomes: 3 long chromosomes and 1 very short chromosome. Alternation of disks (chromomeres) and light areas between disks is visible, this pic-

ture is specific to each chromosome. The forth short chromosome has 4 visible puffs of different size. **Draw** schematically chromosomes of the chironomid midge under low magnification. **Draw** the fourth chromosome separately under the high magnification, pay attention to the location of puffs. Write magnification in both cases.

2) **View** microphotos of metaphase chromosomes with differential staining (G-banding) and chromosomes stained by fluorescent dyes.
3) **Draw** schematically the structure of a metaphase chromosome, indicate a centromere, arms (*p* and *q*), telomeres, a secondary constriction, a satellite, and chromatids.
4) **Examine** and **draw** schematically human chromosomes, which are classified according to Denver's system. In a right top corner, draw a box instead of a photo and write the word "Photo" in this box. Write down a conclusion: number of chromosomes; is a karyotype normal or not; male or female karyotype.

Lesson 6. Mendel's First and Second Laws. Monohybrid Cross

This lesson starts substantial module 2 "Classical Genetics".

Reading for a lesson.

1) *Terms:* addition rule, allele (allelomorph), allelic genes, character (characteristic), cross, dihybrid cross, dominant, fertilization, gamete, gene, generation, genetics, genome, genotype, heterozygote, homozygote, hybrid, locus, monohybrid cross, multiplication rule, nonallelic genes, offspring, phenotype, pure-bred, probability, Punnet square, recessive, reciprocal crosses, segregation, trait, true-breeding trait.
2) Probability of a random event. Multiplication rule and addition rule.
3) Genetics, its subject, objectives, and a brief history. Main terms used in genetics. Mendel's scientific approach.
4) Mendel's experiments with one trait. Law of dominance and law of segregation.
5) Rules used for writing of schemes of crosses; steps used for solving genetics problems.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Section 3.1 and Subsections 3.2.1–3.2.2.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 154–157.
3. Lazarev K. "Medical Biology" (2003), pp. 113–120, 227–228, 231.

==========

Practical Class Work.

Solve problems:

1. When you flip a coin, what is the chance of the coin coming up head? When you flip two, three, or five coins, what is the chance that all coins come up heads? *(All students should understand that the multiplication rule will help them to predict the probability of the appearance of traits among the progeny.)*
2. What gametes does a homozygote form? What gametes does a heterozygote

form? What gametes does a homozygote for two genes form? What gametes does a diheterozygote form? What gametes do the organisms *AABbccDd* and *AabbCcDdEE* form?

3. A father is right-handed, a mother is left-handed. Right-handedness is a dominant trait. What is the probability that their child will be left-handed child; right-handed child; right-handed son; right-handed daughter? What is the probability that their two children will be left-handed sons?
4. In humans, brown eyes, *B*, are dominant to blue eyes, *b*. A brown-eyed man marries a blue-eyed woman. They have eight children, all are brown-eyed. What are the possible genotypes of each person in the family?
5. Deafness is a recessive trait. Deaf mother and healthy father have two deaf children. What is the probability that their third child will be deaf? Suppose that another family has the same genotypes but has no children; what is the probability that they will have three deaf children? Explain different answers.

==========

Home task. Solve genetic problems:

1. What gametes do the organisms *AABb* and *aaBbddEeff* form?
2. A father is rhesus-positive (a dominant trait), a mother is rhesus-negative. What is the probability that their child or children will be: a) rhesus-positive child; b) rhesus-negative daughter; c) two rhesus-negative daughters?
3. In fruit flies, long wing, *L*, is dominant to short wing, *l*. Two long-wing flies produced 49 short-wing and 148 long-wing offspring. What were the probable genotypes of the parents? What proportion of the long-wing offspring should be heterozygous?

Lesson 7. Mendel's Third Law. Types of Crosses. Lethal Genes

Reading for a lesson.

1) *Terms:* backcross, diheterozygote (dihybrid), dihybrid cross, genetic recombination, lethal allele (lethal gene), Mendelian inheritance, nonallelic genes, pathologic, polyhybrid cross, semilethal allele, statistic, test cross, unifactorial inheritance.
2) Dihybrid cross: law of independent assortment. Polyhybrid cross.
3) Chromosome theory of heredity. Cytological bases of Mendel's laws.
4) Statistical character of Mendel's laws. Conditions when Mendel's laws are performed. Deviations form Mendel's laws.
5) Test cross and its practical usage.
6) Dominant and recessive normal and pathologic human traits. Lethal and semilethal genes (achondroplasia, brachydactyly, sickle-cell anemia), deviations from the expected ratios.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Subsections 3.2.3–3.2.7.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 158–161.
3. Lazarev K. "Medical Biology" (2003), pp. 121–123.

==========

Practical Class Work.

Solve problems:

1. Right-handedness is dominant over left-handedness and brown eyes are dominant over blue eyes. Parents are dihybrids. What is the probability that their first child will be a) right-handed child with blue eyes, b) right-handed son with blue eyes, c) left-handed daughter with brown eyes? Pay attention to the genotype of the right-handed child with blue eyes: *A_bb*. Solve this problem by using different methods.
2. Achondroplasia is an inherited autosomal dominant condition that causes diminished growth in the long bones of the legs, leading to dwarfism. All people with achondroplasia are heterozygous (they have one of two possible cop-

ies of the gene), because homozygosity for this gene is lethal, and these children usually die in infancy. Achondroplasia is a dominant trait with recessive lethal effect. Parents have achondroplasia, and the father has polydactyly (dominant trait). A son is of normal height but has six fingers; a daughter is dwarf with normal fingers. Determine genotypes. What is the probability that their next child will have a) both diseases, b) no disease?

3. A woman has a free earlobe (dominant trait) and a smooth chin (recessive trait). Her husband has an attached earlobe and a chin with pit. Their son has a free earlobe and a chin with pit. A daughter resembles her mother. Determine genotypes. What is the probability that their next child will be the daughter with the same traits as her mother?
4. Left-handed father has shortsightedness, right-handed mother is healthy. Their first child is right-handed with normal vision and phenylketonuria. The second right-handed child is healthy. The third child is shortsighted and left-handed. Determine genotypes. What is the probability that their next child will be healthy and right-handed?

==========

Home task. Solve genetic problems:

1. Mother, father, and daughter are right-handed, but son is left-handed. Mother and father have normal hearing, but children are deaf. Determine genotypes. What is the probability that their third child will be a) healthy and right-handed, b) left-handed deaf daughter?
2. Rhesus factor and freckles are dominant traits. Parents are rhesus-positive; wife has freckles but her husband has not. Two daughters are rhesus-negative and have no freckles. What is the probability that: a) their child will be rhesus-negative with freckles; b) their child will be rhesus-negative son with freckles; c) next two children will be rhesus-positive without freckles?

Lesson 8. Interaction of Allelic Genes. Multiple Allelism. Blood Groups

Reading for a lesson.

1) *Terms:* agglutination, agglutinin, agglutinogen, alleles (allelic genes), antibody, antigen, bilirubin, blood group (blood type), blood serum, codominance, complete dominance, donor, fibrin, gene interaction, genotype, haemagglutination, haemolysis, haemolytic jaundice, haemotransfusion, heterosis, immunoglobulin, immunology, incomplete dominance, jaundice, locus, multiple alleles, overdominance, phenotype, placenta, recipient, Rhesus factor, Rhesus incompatibility, thrombus, transfusion, wild-type allele.
2) Allelic genes. Interaction of allelic genes: complete dominance, incomplete dominance, codominance, overdominance.
3) Multiple alleles, causes of their appearance.
4) Human blood groups. ABO, MN, and Rhesus systems. Rhesus incompatibility.
5) Introduction to immunogenetics.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Subsections 3.3.1–3.3.3.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 161–172.
3. Lazarev K. "Medical Biology" (2003), pp. 124–129, 224–225, 231.

==========

Practical Class Work.

Solve problems:

1. A husband has Type A blood and his wife has Type AB blood. Which blood types could their children have?
2. Rhesus negative woman marries rhesus positive man. Their child is rhesus positive. Which phenotype could the next child have?
3. Mother is rhesus negative with the first blood group. Her son is rhesus negative with the 3rd blood group. His sister is rhesus positive with the 2nd blood type. Father is wanted for payment of alimony. Which phenotype and genotype could he have?

4. Rhesus negative mother has Type B blood. Rhesus positive father has Type AB blood. Their rhesus negative child has Type A blood. What is the probability that their next child will be: a) rhesus positive with Type B blood; b) rhesus negative with Type O blood; c) their next two children will be rhesus positive with Type AB blood?

==========

Home task. Solve genetic problems:

1. A woman with blood type B has a child with blood type O. What are the genotypes of the mother and child? Which blood type could the father have? Which genotypes could the father not have?
2. Mary, who has type O blood, is married to David, who has type AB blood. What blood types can their children have?
3. Both rhesus negative wife and rhesus positive husband have Type AB blood. Their rhesus negative son has Type A blood. What is the probability that their child will be: a) rhesus-positive with Type AB blood; b) rhesus-negative with Type O blood; c) next two children will be rhesus-positive with Type A blood?

Lesson 9. Interaction of Nonallelic Genes

Reading for a lesson.

1) *Terms:* complementary genes, complementation, complementation test, continuous characteristic, discontinuous characteristic, epistasis, epistatic gene, hypostatic gene, locus, multiple genes, nonallelic genes, normal distribution, polygenes, polygenic character, polygenic inheritance, polygeny, qualitative characteristic, quantitative characteristic.
2) Nonallelic genes. Complementation; 9:3:3:1 and 9:7 ratios.
3) Epistasis; 13:3 and 12:3:1 ratios in the case of dominant epistasis; 9:3:4 ratio in the case of recessive epistasis.
4) Qualitative and quantitative characteristics. Polygenic traits, multiple genes. Cumulative effect in the case of polygenic inheritance.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Subsections 3.3.4–3.3.6.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 173–176.
3. Lazarev K. "Medical Biology" (2003), pp. 129–132, 230.

==========

Practical Class Work.

Solve problems:

1. An example of gene interaction that produces novel phenotype is seen in the genes that determine normal hearing and deaf mutism. One dominant gene controls normal development of acoustic nerve, the other controls normal development of cochlea. Deafness is recessive trait. Both parents are deaf-mute. Their child has normal hearing. Determine all genotypes. What is the probability that their next child will have normal hearing?
2. Parents are healthy. Their child is deaf. Determine genotypes of this family. What is the probability that their next child will have normal hearing?
3. Nearsightedness (shortsightedness, myopia) is an example of epistasis. It is a condition in which someone can see clearly objects which are close, but not ones which are further away. A dominant gene at one locus determines average form of myopia (-2 to -4 dioptres) and a dominant gene at a second locus

determines severe myopia (-5 dioptres or higher). Dioptre is a unit of measurement of the refraction of a lens. A one dioptre lens has a focal length of one metre; the greater the dioptre, the shorter the focal length. If two dominant genes are present, the gene for severe myopia masks the effect of the gene for average myopia (the first gene is epistatic and the second is hypostatic). A woman has myopia but her father and husband are normal. Her daughter has average myopia and her son has severe myopia. Determine genotypes and the form of myopia in a wife. What is the probability that the next child will have normal vision? severe myopia? average myopia?

4. Human height is a polygenic trait. Suppose that human height is determined by two nonallelic polygenes. Two dominant nonallelic genes A_1 and A_2 determine short stature; tall stature is determined by recessive genes a_1 and a_2. Stature of a person depends on gene combinations and a number of dominant alleles: four dominant alleles determine very short stature, three dominant alleles determine short stature, two dominant alleles – middle stature, one dominant allele determines – tall stature, and four recessive alleles determine very tall stature:

   $A_1A_1A_2A_2$ – very short stature – less than 155 cm (in men)
   $A_1a_1A_2A_2$ or $A_1A_1A_2a_2$ – short stature – 155-160 cm
   $A_1A_1a_2a_2$, $a_1a_1A_2A_2$ or $A_1a_1A_2a_2$ – middle stature – 160-170 cm
   $A_1a_1a_2a_2$ or $a_1a_1A_2a_2$ – tall stature – 170-180 cm
   $a_1a_1a_2a_2$ – very tall stature – 180 cm and higher.

What stature may children have, if both parents are dihybrids?

==========

Home task. Solve genetic problems:

1. Homozygous wife has middle stature. Her husband has tall stature. What is the probability that their child will have: a) middle stature, b) tall stature, c) very tall stature?
2. Tall woman marries very short man. What is the probability that their child will have: a) very tall stature, b) tall stature, c) middle stature, d) short stature, e) very short stature?

Lesson 10. Gene Linkage. Chromosome mapping

Reading for a lesson.

1) *Terms:* chromosome mapping, complete linkage, centimorgan, coupling, crossing over, deletion mapping, gene linkage, genetic map, heterokaryon, *in situ* hybridization, incomplete linkage, interference, linkage analysis, linkage group, linkage map, linked genes, nonrecombinant and recombinant gametes, nonrecombinant and recombinant progeny, physical map, recombination frequency, repulsing, somatic-cell hybridization, syntenic genes, two-point testcross.
2) Morgan's experiments with linked genes. Linkage groups. Complete and incomplete linkage.
3) Crossing over, its mechanism, cytological evidence, biological importance. Factors that influence crossing over.
4) Genetic maps, purpose and methods of their construction. Eukaryotic gene mapping, map units. Somatic-cell hybridization.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Section 3.4.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 176–181.
3. Lazarev K. "Medical Biology" (2003), pp. 135–139, 200–202, 228, 231.

==========

Practical Class Work.

Solve problems:

1. What gametes and in which combinations are produced by a dihybrid if the genes *A* and *B:* a) are located in different chromosomes; b) are linked completely; c) are linked incompletely, and distance between them is 15 centimorgan?

Table 1. Gametes produced by a dihybrid in the case of different localization of the genes *A* and *B*.

Genotype	*Gametes*			
	Non-crossover		*Crossover*	
a)				

b)				
c)				

2. The gene for Rhesus factor and the gene that is responsible for elliptocytosis (abnormal erythrocyte shape; elliptocytosis causes anemia) are dominant and located on the same chromosome. Distance between them is 3 centimorgan. A man has inherited Rh-positivity from his father and elliptocytosis from his mother. His wife is rhesus-positive and has normal erythrocytes. Their son is rhesus-negative and healthy. Determine the ratio of possible phenotypes of children in this family.

Table 2. F_1 generation.

F_1

♀ \ ♂	*Gametes*			
	Non-crossover		*Crossover*	
	%	%	%	%
	%	%	%	%

==========

Home task. Solve genetic problems:

1. Cataract and polydactyly are dominant traits, genes for these traits are linked, and crossing over between them is absent (does not revealed). A woman has inherited cataract from her mother and polydactyly from her father. Her husband is healthy. What is the probability that their child will have: a) cataract; b) polydactyly; c) both diseases; d) be healthy?
2. Genes *A*, *B*, *D*, and *I* are linked. The distance between genes *A* and *D* is 11 centimorgan, between *A* and *I* is 28 cM, between *A* and *B* is 18 cM, and between *B* and *I* is 10 centimorgan. What is the order of the genes on a linkage map? Make the scheme.

Lesson 11. Genetics of Sex. Sex Linkage. Cytoplasmic Inheritance

Reading for a lesson.

1) *Terms:* autosome, Barr's body, colour blindness, criss-cross inheritance, cytoplasmic inheritance, daltonism, deuteranopia, dichromat, genic balance system, haplodiploidy, hemizygous, hemophilia, hermaphroditism, heterogametic sex, heteroplasmon, holandric inheritance, homogametic sex, maternal inheritance, mitochondrial inheritance, mosaicism, parthenogenesis, primary sex characteristic, protanopia, pseudoautosomal region, pseudohermaphroditism, reciprocal crosses, secondary sex characteristic, sex, sex chromatin, sex chromosome, sex determination, sex linkage, sex-linked characteristic, trichromat, tritanopia, true hermaphrodite, X-inactivation, X-linked characteristic, Y-linked characteristic.
2) Sex and sex characteristics. Hermaphroditism. Sex determination in mammals, birds, reptilians, insects, worms, fish, and mollusks.
3) Inheritance of sex in human. Bisexual nature of human.
4) Autosomes, sex chromosomes. Homogametic and heterogametic sex. Biological importance of sex chromosomes. Structure of X and Y chromosomes in human. Sex chromatin.
5) Sex linkage. Dominant and recessive X-linked inheritance, holandric inheritance. Hemizygous genes.
6) Sex-linked diseases: hemophilia, colour blindness, muscular dystrophy, hypophosphatemia.
7) Cytoplasmic inheritance.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 1", Sections 3.5 and 3.6.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 181–188.
3. Lazarev K. "Medical Biology" (2003), pp. 139–143, 228, 230–231.

==========

Practical Class Work.

Solve problems:

1. Father and his son have haemophilia, mother is healthy. Determine genotypes. Father and his son have the same disease, and can you say that this son has inherited the disease from his father? What is the probability that their next child will be haemophilic son? What is the probability that their next son will have haemophilia? Pay attention to the difference in answers.
2. Albinism is an autosomal recessive trait. Atrophy of an optic nerve is X-linked recessive trait. Healthy parents have dark hairs. Their son is blind albino. Determine genotypes. What is the probability that their next child will be healthy son with dark hairs? What is the probability that their next two children will be blind albino sons?

3*. Haemophilia and color blindness are X-linked recessive traits. Distance between appropriate genes is 9.8 cM. Healthy man with normal color vision marries a woman who has healthy mother and haemophilic father. This woman is healthy but she is a carrier of the color-blind allele. What is the probability that their next child will be: a) a son with both diseases; b) a healthy son; c) daughter with both diseases; d) healthy daughter?

==========

Home task. Solve genetic problems:

1. Joe is color blind. Both his mother and his father have normal vision. Joe's oldest sister, Patty, is married to a man with normal color vision; they have two children, a 9-year-old color-blind boy and a 4-year-old girl with normal color vision. If Patty and her husband have another child, what is the probability that the child will be a color-blind boy?
2. Healthy parents have Type AB blood. Their haemophilic son has Type A blood. Determine genotypes and the probability that their child will be healthy son with Type AB blood.

Lesson 12. Genotype and Phenotype

Reading for a lesson.

1) *Terms:* age variation, clinical heterogeneity, complex trait, conditional mutation, continuos characteristic, expressivity, genetic heterogeneity, genocopies, genomic imprinting, genotype, genotypic variation, incomplete penetrance, multifactorial trait, norm of reaction, normal curve, penetrance, phenocopies, phenotype, genotypic variation, pleiotropy, polygenic trait, quantitative characteristic, seasonal variation, sex-influenced and sex-limited characteristics, simple trait, susceptibility genes, temperature sensitive mutation, variability, variation.
2) Penetrance.
3) Expressivity.
4) Pleiotropy.
5) Sex and heredity. Sex-influenced and sex-limited characteristics.
6) Variation, phenotypic and genotypic variation. Age variation.
7) Phenotype as a result of interaction of genotype with environment.
8) Genocopies and phenocopies.
9)* *(additional). Terms:* anticipation, intelligence.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 2", Chapter 4, Sections 4.1–4.3, 4.4.1, 4.4.2, 4.4.5, 4.6, 4.7 (*Additional reading:* Subsections 4.4.3–4.4.4, Section 4.5).
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 161, 176, 188, 193–195, 198.
3. Lazarev K. "Medical Biology" (2003), pp. 132–134, 178–181.

==========

Practical Class Work.

Solve problems:

1. Schizophrenia is a mental disorder characterized by loss of contact with reality and disintegration of personality, usually with hallucinations and disorder of feeling, behavior, etc. Penetrance of the dominant gene in homozygotes is 100% and in heterozygotes is 20%. Parents are heterozygotes. What can you say about their health? (What is the probability that both parents are healthy;

both have the disease; one parent is healthy and another has the disease?) Determine the probability that their child will have this disease.

2. Podagra (or gout) is a dominant trait. Penetrance of the gene in homozygotes is 100% but in heterozygotes depends on the sex: 20% in men and 0% in women. Mother is heterozygote and father is recessive homozygote. What can you say about their health? Determine the probability that their child will have the disease.
3. Arachnodactyly (fingers resemble long legs of spiders – Arachnids) is a dominant trait. Penetrance of the gene is 30% and doesn't depend on the number of alleles and sex. Parents are heterozygotes. They have a child with arachnodactyly. What can you say about health of parents? What is the probability that their next child will have the disease? What genotype can healthy child have?

==========

Home task. Solve genetic problems:

1. A man is affected with an X-linked dominant disorder. The penetrance of the disease genotype is 60%. Assuming that he mates with a genetically unaffected female, what is the probability that his daughters will be affected with this disorder?
2. One type of diabetes mellitis is a recessive trait. Penetrance of the gene is 20% (20% of homozygotes have the disease). Father has the disease but mother is heterozygous carrier. What is the probability that their child will have the disease?

Lesson 13. The Structure of Nucleic Acids. DNA Repair

This lesson starts substantial module 3 "Molecular Genetics. Mutations".

Reading for a lesson.

1) *Terms:* acid, adenine, adenosine, ADP, alkylation, AMP, angstrom, annealing of DNA, antiparallel, ATP, bacterial transformation, base, biopolymer, breaks, carbohydrates, cloverleaf structure, complementarity (of nucleotides), conformation, covalent bond, cytosine, deamination, denaturation, deoxyribonucleotide, deoxyribose, depurination, despiralization, dimerization, DNA, DNA photolyase, DNA polymerase, DNA repair, DNase, double helix, endonuclease, energy-rich bond, enzyme, excision repair, exonuclease, genetic information, guanine, guanosine, heterocyclic compounds, hydrogen bond, hydrophilic, hydrophobic, hydrophobic interactions, interstrand cross-link, ligase, ligation, light repair, macromolecule, melting of DNA, melting temperature, methylation, minor bases, molecular weight, native, nitrogenous bases, nuclease, nucleic acid, nucleoside, nucleotide, organic and inorganic compounds, pentose, phosphodiester bond, phosphorylation, photolyase, photorepair, polarity of chains, polymer, polynucleotide; primary, secondary, tertiary and quarternary structure of a molecule; purine, pyrimidine, pyrimidine dimer, pyrophosphate, renaturation, repair, replication, reverse transcription, ribonucleotide, ribose, RNA, supercoiling of DNA, thymidine, thymine, thymine dimer, topoisomerase, transcription, translation, tRNA, ultraviolet radiation, uracil, uridine, xeroderma pigmentosum, x-ray emission.
2) DNA as the genetic material. Central dogma of molecular biology.
3) Nucleotide structure. Purines and pyrimidines. Ribose and deoxyribose. Energy-rich bond.
4) Primary, secondary, and tertiary structure of DNA. RNA molecules. Phosphodiester and hydrogen bonds. Chargaff's rules.
5) Changes in DNA structure. DNA repair systems. Xeroderma pigmentosum.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 2", Chapter 5, Sections 5.1–5.2.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 50–53, 56–59.

3. Lazarev K. "Medical Biology" (2003), pp. 143–148, 231–233.

==========

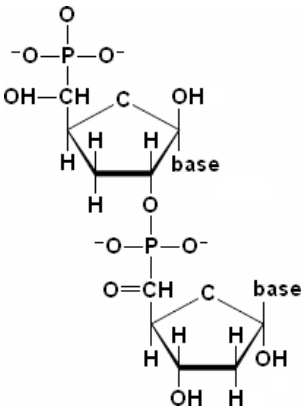
Practical Class Work.

Solve problems:

1. If a double-stranded DNA molecule is 15% thymine, what are the percentages of all the other bases?
2. In samples of DNA isolated from two unidentified species of bacteria, adenine makes up 32% and 17%, respectively, of the total bases. What relative proportions of guanine, thymine, and cytosine would you expect to find in the two DNA samples? One of these species was isolated from a hot spring (64°C). Which species is most likely the thermophilic bacterium, and why?
3. The base composition of bacteriophage M13 DNA is G, 21%; C, 20%; A, 23%; T, 36%. What does this tell you about the DNA structure of phage M13?

==========

Home task. Solve genetic problems:



1. A student drew a polynucleotide strand (see Fig.), but he made a few mistakes. Make a list of all the mistakes in the structure of this DNA polynucleotide strand. Draw the correct structure for the polynucleotide strand.
2. Cells of bacterium *Escherichia coli* are rod-shaped, about 2 μm long and 0.8 μm in diameter. The molecular weight of an *E. coli* DNA molecule is about $3.1 \cdot 10^9$ g/mol. The average molecular weight of a nucleotide is 330 g/mol, and each nucleotide pair contributes 0.34 nm to the length of DNA. Calculate the length of an *E. coli* DNA molecule. Compare the length of the DNA molecule with the cell dimensions. How does the DNA molecule fit into the cell?
3. The diploid set of chromosomes of the human being contains over 6 billion pairs of nucleotides. What is the total length of the cellular chromosomal DNA? Compare the size of this DNA to diameter of a cell nucleus (about 2 microns), draw conclusion on how does the DNA molecule fit into the nucleus.

Lesson 14. DNA Replication. Transcription

Reading for a lesson.

1) *Terms:* antibiotic, capping, coding strand, consensus sequence, conservative replication, continuous replication, discontinuous replication, DNA gyrase, DNA replication, DNA polymerase, DNA primase, DNA ligase, DNA templating, domain, elongation, enhancer, exon, exon shuffling, helicase, initiation, intron, lagging strand, leading strand, mRNA processing, nontemplate strand, nuclease, Okazaki fragments, polyadenylation, poly(A) tail, primer, promoter, proofreading, pyrophosphate, replication bubble, replication fork, replication origin, replication terminus, retrovirus, reverse transcription, reverse transcriptase, RNA polymerase, semiconservative replication, spliceosome, splicing, SSB protein, telomerase, telomere, template, template strand, termination, terminator, topoisomerase, transcription, transcription factor, transcription unit, unwinding.
2) DNA replication: mechanism, enzymes. Replication in prokaryotes and eukaryotes. Okazaki fragments. Proofreading mechanisms.
3) Transcription of a prokaryotic gene: mechanism. Structure of a prokaryotic gene: the promoter, the structural part, and the terminator.
4) Transcription of eukaryotic genes. Exons and introns. mRNA processing: capping, splicing, polyadenylation, and base modifications.
5) Influence of antibiotics on transcription.
6) Reverse transcription.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 2", Sections 5.3–5.4.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 53–56, 62–64.
3. Lazarev K. "Medical Biology" (2003), pp. 151–154, 232–233.

==========

Practical Class Work.

Solve a problem:

1. What mRNA sequence is synthesised by RNA polymerase on the given template and in which direction, if a promoter is located on the left side of this sequence? ATGCCGTATGCATTC

Lesson 15. Translation. Gene Regulation

Reading for a lesson.

1) *Terms:* acetylation, activator, amino acid, aminoacyl-tRNA synthetases, antibiotic, anticodon, attenuation, chaperone, chromatin, codon, colinearity, corepressor, demethylation, elongation, enhancer, feedback inhibition, gene expression, gene regulation, genetic code, hormone, housekeeping genes, inducer, induction, initiation, isoaccepting tRNAs, Kozak sequence, methylation, monocistronic mRNA, mRNA, negative control, operator, operon, peptide bond, peptidyl transferase, polycistronic mRNA, polyribosome, polysome, positive control, protein, regulatory genes, release factors, repression, repressor, ribosome, RNA interference, RNA silencing, sense codons, Shine-Dalgarno sequence, specificity factors, start codon, stop codons, structural genes, termination, translation, translocation, triplet, tRNA, wobble hypothesis.
2) Primary, secondary, tertiary, and quaternary structure of a protein. Peptide and disulfide bonds.
3) The genetic code and its properties. Translation, its stages (activation of amino acids, initiation, elongation, and termination). Colinearity.
4) Influence of antibiotics on translation.
5) Regulation of gene activity on the chromatin level.
6) Transcriptional level of gene regulation. An operon in prokaryotes. The *lac* and *trp* operons.
7) Translational control.
8) Posttranslational modifications of proteins.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 2", Sections 5.5–5.6.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 59–61, 62, 64–69.
3. Lazarev K. "Medical Biology" (2003), pp. 148–151, 154–164, 233–235.

==========

TABLE 3. THE GENETIC CODE

5′-P-base	*The second base*				*3′-OH-base*
	U	*C*	*A*	*G*	
U	Phe	Ser	Tyr	Cys	*U*
	Phe	Ser	Tyr	Cys	*C*
	Leu	Ser	Stop	Stop	*A*
	Leu	Ser	Stop	Trp	*G*
C	Leu	Pro	His	Arg	*U*
	Leu	Pro	His	Arg	*C*
	Leu	Pro	Gln	Arg	*A*
	Leu	Pro	Gln	Arg	*G*
A	Ile	Thr	Asn	Ser	*U*
	Ile	Thr	Asn	Ser	*C*
	Ile	Thr	Lys	Arg	*A*
	Met	Thr	Lys	Arg	*G*
G	Val	Ala	Asp	Gly	*U*
	Val	Ala	Asp	Gly	*C*
	Val	Ala	Glu	Gly	*A*
	Val	Ala	Glu	Gly	*G*

Practical Class Work.

Solve problems:

1. Write amino acid sequence that is encoded by the given mRNA sequence if translation will start at the first triplet:

A U G G A U G C C U G U U G C U A C ...

2. How many different mRNAs can encode these protein sequences:
   a) Leu–Lys–His–Val; b) Ile–Phe–Met–Trp?
3. Determine minimal number of base pairs of the gene that codes for pancreatic nuclease (124 amino acids). Why is the length of the gene really larger?
4. The part of the gene coding for F1 protein of *Yersinia pestis* (causative agent of plague) is shown. Write complementary chain of the DNA and the mRNA sequence on condition that promoter is located to the left. Mark 5′- and 3′-ends of the molecules. Underline ribosome binding site (Shine-Dalgarno

sequence) and start codon. By using the table for genetic code, write amino acid sequence. If mutations occur determine new protein structures. Mutations will be as follows: a) 20th A will replaced by G; b) 21st A will replaced by G; c) 21st A will replaced by T; d) 24th nucleotide will be deleted.

(+)-chain of DNA:

```
                    10                  20                  30
                    .                   .                   .
...GATAGAGGTAATATATGAAAAAAATCAGTTCCGTT...
```

=========

Home task. Solve genetic problems:

1. How many bases long would a strand of DNA have to be to code for 120 amino acids?
2. The following diagram represents DNA that is part of the RNA-coding sequence of a transcription unit:

   ATAGGCGATGCCA
   TATCCGCTACGGT

   Indicate the polarity of the two DNA strands. Assume that RNA polymerase proceeds along this DNA from left to right. Give the sequence found on the RNA molecule transcribed from this DNA and label the 5′ and 3′ ends of the RNA.
3. What is the base sequence on mRNA after transcription if the base sequence on DNA is 5′-TGCAGACA-3′? What is the base sequence on a DNA 'sense' strand if the base sequence on the transcription product (mRNA) is 5′-CUGAU-3′?
4. Fill in this table by using the genetic code.

					C			T				Double stranded DNA
	T					G			G	C	A	
G	A	U					A					mRNA
			Thr									Amino acids in the protein

Lesson 16. Genes and Genomes. Horizontal Gene Transfer

Reading for a lesson.

1) *Terms:* biotechnology, clone, cloning vector, conjugation, DNA ligase, episome, fertility factor, flanking direct repeats, gene, gene cloning, gene family, gene therapy, genetic engineering, genome, genomics, GMO, horizontal transmission, jumping gene, macronucleus, merozygote, micronucleus, pili, plasmid, prophage, proteome, proteomics, pseudogene, recombinant NDA technology, restriction endonuclease (restrictase), retrotransposon, satellite DNA, sex factor, sexduction, tandem repeats, terminal inverted repeats, transcriptome, transductant, transduction, transformation, transposon, vertical transmission.
2) Methods of investigation of genes and genomes. DNA sequencing.
3) The structure of prokaryotic and eukaryotic genes. Structural and regulatory genes, genes for tRNAs and rRNAs.
4) Genomes of viruses, bacteria, and eukaryotes. Pseudogenes. Transposable genetic elements.
5) Human genome.
6) Gene engineering. Biotechnology. Gene therapy.
7) Horizontal gene transfer: bacterial conjugation, bacterial transformation, and transduction; their importance for science and practice. Conjugation in infusorians.
8)* *(additional)* Genomics. Proteomics.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 2", Sections 5.7–5.9.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 59–60, 69–73.
3. Lazarev K. "Medical Biology" (2003), pp. 202–210, 519–534.

==========

Practical Class Work.

Solve problems:

1. DNA chain, which codes for a polypeptide, has 1679 nucleotides. This chain

includes six introns: two introns consist of 165 nucleotides, two introns consist of 110 nucleotides, and two introns consist of 125 nucleotides. Determine number of amino acids in the polypeptide.

2. A protein consists of 560 amino acids. Its gene has two introns, each of 10,000 base pairs, and three exons, each having equal number of base pairs. How many base pairs are present in this gene (ignore sizes of the promoter and the terminator)? How many base pairs are present in each exon? How many nucleotides are present in the coding sequence of the mRNA for this protein?

At the end of this lesson, students receive credit for the 1st semester, if they have no missed lessons.

Lesson 17. Mutations

Reading for a lesson.

1) *Terms:* alkylating agent, allopolyploid, aneuploidy, autopolyploid, auxotroph, base analog, base substitution, carcinogen, chromosome mutation, deletion, expanding trinucleotide repeats, forward mutation, frameshift mutation, free radical, gene mutation, genomic mutation, germ-line mutations, induced mutation, insertion, intercalating agent, lethal mutation, missense mutation, monosomy, mosaic, mosaicism, mutagen, mutagenesis, mutant, mutation, mutation frequency, mutation rate, mutator gene, nondisjunction, nonsense mutation, nullisomy, numerical chromosome aberration, point mutation, polyploidy, premutation, radiation, reverse mutation, shift, silent mutation, somatic mutation, spontaneous mutation, structural chromosome aberration, supressor mutation, tetrasomy, transition, translocation, transversion, trisomy, UV light.
2) Classification of mutations. Gene and chromosome mutations.
3) Molecular mechanisms of mutations.
4) Induced mutagenesis. Physical, chemical, and biological mutagens. Genetic monitoring.
5)* *(additional)* Antimutagens and comutagens. *Terms:* premutation, radioprotector, radiotherapy.

Literature.

1. Smirnov O. "Medical Biology: A Short Course. Vol. 2", Chapter 6.
2. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 61, 195–200.
3. Lazarev K. "Medical Biology" (2003), pp. 181–192, 249–250.

==========

Practical Class Work.

Solve problems:

1. What type of mutation is the following (shown as mRNA)?

Wild type	5′…AAUCCUUACGGA…3′
Mutant 1	5′…AAUCCUACGGA…3′
Mutant 2	5′…AAUCCUUGACGGA…3′
Mutant 3	5′…AAUCCUCCUUACGGA…3′

2. Hydroxylamine (HA) causes only G·C → A·T transitions in DNA. Will HA produce nonsense mutations in wild-type strains?

TABLE 3. THE GENETIC CODE

5'-P-base	*The second base*				*3'-OH-base*
	U	*C*	*A*	*G*	
U	Phe	Ser	Tyr	Cys	*U*
	Phe	Ser	Tyr	Cys	*C*
	Leu	Ser	Stop	Stop	*A*
	Leu	Ser	Stop	Trp	*G*
C	Leu	Pro	His	Arg	*U*
	Leu	Pro	His	Arg	*C*
	Leu	Pro	Gln	Arg	*A*
	Leu	Pro	Gln	Arg	*G*
A	Ile	Thr	Asn	Ser	*U*
	Ile	Thr	Asn	Ser	*C*
	Ile	Thr	Lys	Arg	*A*
	Met	Thr	Lys	Arg	*G*
G	Val	Ala	Asp	Gly	*U*
	Val	Ala	Asp	Gly	*C*
	Val	Ala	Glu	Gly	*A*
	Val	Ala	Glu	Gly	*G*

Lesson 18. Reproduction. Ontogenesis. Regeneration. Transplantation

This lesson starts substantial module 4 "Medical Genetics. Population Genetics and Evolution".

Reading for a lesson.

1) *Terms:* aging, allograft, amnion, antibody, antigen, autograft, blastocoel, blastocyst, blastomere, blastopathy, blastula, blood transfusion, chorion, cleavage, climacteric, compensatory hypertrophy, cryoprotector, critical period, death, differentiation, donor, ectoderm, egg. embryo, embryogenesis, embryonic induction, embryopathy, endoderm, endomorphosis, epimorphosis, exogenic (exogenous), fertilization, fertility, fetopathy, fetus, free radical, gametopathy, gastrula, gastrulation, geriatrics, gerontology, graft, graft rejection, grafting, growth, heterograft, heteromorphosis, histogenesis, homeostasis, homograft, homomorphosis, immunity, immunodepressant, immunodepression (immunosuppression), immunology, implantation, inducer, inhibitor, isograft, juvenile period, malformation, menopause, mesoderm, morphallaxis, morula, multifactorial, ontogenesis, organogenesis, ovum, parthenogenesis, perinatal, phylogenesis, placenta, ploidy, polyembryony, postnatal, prenatal, progeria, puberty, recipient, regeneration, reproduction, Siamese twins, somatotropin, sperm, stem cells, sterility, teratogen, teratogenesis, teratology, thalidomide, totipotency, transplant, transplantation, trophoblast, twins, xenograft, zygote.
2) Types of reproduction: asexual, sexual, and virginal (parthenogenesis).
3) Structure of gametes. Fertilization.
4) Ontogenesis: types, stages. Embryonic development of human. Differentiation.

• Ontogenesis, or ontogeny is the development of an individual organism. Phylogenesis, or phylogeny is the evolution of a genetically related group of organisms, for example, species.

• The first step in development is the union of male and female gametes, a process called **fertilization**. Following fertilization, the second major event in vertebrate reproduction is the rapid division of the zygote into a larger and larger number of smaller and smaller cells. This period of division, called **cleavage**, is not accompanied by an increase in the overall size of the embryo. The resulting tightly packed mass of about 32 cells is called a **morula**, and each individual cell in the morula is referred to as a blastomere.

As the blastomeres continue to divide, they secrete a fluid into the center of the morula. Eventually, a hollow ball of 500 to 2000 cells, the **blastula**, is formed. The fluid-filled cavity within the blastula is known as the *blastocoel*.

• During gastrulation, the cells of the embryo move, forming three primary cell layers: ectoderm, mesoderm, and endoderm. The cells in each layer have very different developmental fates. In general, the ectoderm is destined to form the epidermis and neural tissue; the mesoderm gives rise to connective tissue, skeleton, muscle, and vascular elements; and the endoderm forms the lining of the gut and its derivatives.

• During organogenesis, cells from the three primary layers combine in various ways to produce the organs of the body.

5) Experimental investigations of embryonic development. Interaction of blastomeres. Embryonic induction.
6) Cleavage and its disorders (polyembryony, twins).
7) Critical periods of development. Teratogenesis. Teratogenic factors of environment.
8) Congenital defects of development. Classification of defects: hereditary, exogenous, and multifactorial; gametopathies, blastopathies, embryopathies, and fetopathies.
9) Periods of postembryonic development of human. Influence of hormones.
10) Aging. Theories of aging.
11) Rhythms: day-night, circadian, seasonal, and circannual.
12) Types of regeneration (physiological, reparative, epimorphic, morphallactic).

• A body part can regenerate, id est to replace this part by a new growth of tissue or to undergo renewal or regrowth after injury.

13) Transplantation of tissues and organs. Types of transplantation. Graft rejection.

• Transplantation can be defined as the transfer of cells, tissues, or organs from one site in an individual to another, or between two individuals. The individual who provides the transplant organ is termed a *donor*, and the individual receiving the transplant is known as the *recipient*. Organ and tissue transplants are also called *grafts*. *Homografts* (*allografts*) are obtained from individuals of the same species. If a tissue is removed from one part of an individual's body and grafted onto another part of the body, it is termed an *autograft*. This is a common procedure in the treatment of burn victims. *Isografts* involve transplants between identical twins. *Heterografts* (*xenografts*) involve tissue transfer between individuals of different species, such as

transplanting a heart valve from a pig to a human. Organ transplants are blood (blood transfusion), cornea, heart, liver, and kidney.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 95–97, 102–109, 112–151.
2. Lazarev K. "Medical Biology" (2003), pp. 57–61, 69–106, 107–110.

==========

Practical Class Work.

Consideration of questions; discussion.

Lesson 19. Human Genetics. Twin Studies, Dermatoglyphics, Pedigree Analysis

Reading for a lesson.

1) *Terms:* arch, concordance, consanguinity, cousins, dactyloscopy, dermatoglyphics, discordance, dizygotic twins, genealogy, half-brother and half-sister, inheritance, loop, monozygotic twins, pedigree, proband (propositus), sibs (siblings), twins, uterine brother and uterine sister, whorl.
2) Methods of genetic investigations.
3) Humans as a specific subject for genetic study: disadvantages and advantages.

Humans as a Subject for Genetic Study

• Humans are the best and the worst of all organisms for genetic study. On the one hand, we know more about human anatomy, physiology, and biochemistry than we know about most other organisms; for many families, we have detailed records extending back many generations. On the other hand, the study of human genetic characteristics presents some major obstacles.

• First, controlled matings are not possible. With other organisms, geneticists carry out specific crosses to test their hypotheses about inheritance. Another obstacle is that humans have a long generation time. Human reproductive age is not normally reached until 10 to 14 years after birth, and most humans do not reproduce until they are 18 years of age or older; thus, generation time in humans is usually about 20 years. This long generation time means that geneticists would have to wait on average 40 years just to observe the F_2 progeny. In contrast, generation time in Drosophila is 2 weeks; in bacteria, it's a mere 20 minutes. Number of linkage groups is very large. Finally, human family size is generally small. Observation of even the simple genetic ratios would require a substantial number of progeny in each family. When parents produce only 2 children, it’s impossible to detect a 3:1 ratio. Even an extremely large family with 10 to 15 children would not permit the recognition of a dihybrid 9:3:3:1 ratio. So geneticists have been forced to develop techniques that are uniquely suited to human biology and culture.

4) Twin studies. Concordance and discordance, coefficient of heredity.

• Identical twins, or monozygotic twins, are twins that arise when a single egg fertilized by a single sperm splits into two separate embryos.

• Dizygotic twins are nonidentical twins that arise when two different eggs are fertilized by two different sperm; also called fraternal twins.

• Comparisons of dizygotic and monozygotic twins can be used to estimate the importance of genetic and environmental factors in producing differences in a characteristic. This is often done by calculating the concordance for a trait. If both members of a twin pair have a trait, the twins are said to be concordant; if only one member of the pair has the trait, the twins are said to be discordant.

• Concordance is percentage of twin pairs in which both twins have a particular trait.

5) Dermatoglyphics. Dermal ridge patterns.

• The skin on the fingertips folds into patterns of raised skin called dermal ridges that in turn align to form loops, whorls, and arches. A technique called dermatoglyphics ("skin writing") compares the number of ridges that comprise these patterns to identify and distinguish individuals. Dermatoglyphics is part of genetics, because certain disorders (such as Down syndrome) are characterized by unusual ridge patterns, and of course it is also part of forensics, used for fingerprint analysis. Fingerprint pattern is a multifactorial trait.

6) Pedigree analysis: purposes, rules for pedigree construction, symbols, methods of pedigree analysis.

• Pedigree is pictorial representation of a family history outlining the inheritance of one or more traits or diseases.

• The symbols commonly used in pedigrees are summarized in the table. Males in a pedigree are represented by squares, females by circles. A horizontal line drawn between two symbols representing a man and a woman indicates a mating; children are connected to their parents by vertical lines extending below the parents. Persons who exhibit the trait of interest are represented by filled circles and squares. Unaffected members are represented by open circles and squares. Twins are represented by diagonal lines extending from a common point (nonidentical twins); if the twins are identical, a horizontal line connects the two diagonal lines.

• Each generation in a pedigree is identified by a Roman numeral; within each generation, family members are assigned Arabic numerals, and children in each family are listed in birth order from left to right. When a particular characteristic or disease is observed in a person, a geneticist studies the family of this affected person and draws a pedigree. The person from whom the pedigree is initiated is called the proband and is usually designated by an

arrow.

• Proband is a person with a trait or disease for whom a pedigree is constructed.

• Pedigree analysis is based on recognizing patterns associated with different modes of inheritance.

7) Modes of inheritance of traits, criteria of inheritance of rare nuclear genes.

Pedigree Analysis

There are five modes of inheritance of nuclear genes.

1. Autosomal dominant traits should appear with equal frequency in both sexes and should not skip generations. Every person with a dominant trait must inherit the allele from at least one parent. If an autosomal dominant allele is rare, most people displaying the trait are heterozygous. When one parent is affected and heterozygous and the other parent is unaffected, approximately 1/2 of the offspring will be affected. Unaffected persons do not transmit the trait.

2. Autosomal recessive traits normally appear with equal frequency in both sexes and appear only when a person inherits two alleles for the trait, one from each parent. If the trait is uncommon, most parents carrying the allele are heterozygous and unaffected; consequently, the trait seems to skip generations. Whenever both parents are heterozygous, approximately 1/4 of the offspring are expected to express the trait, but this ratio will not be obvious unless the family is large. When an affected person mates with someone outside the family (*aa* × *AA*), usually none of the children will display the trait, although all will be carriers (i.e., heterozygous). A recessive trait is more likely to appear in a pedigree when two people within the same family mate, because there is a greater chance of both parents carrying the same recessive allele. Mating between closely related people is called consanguinity.

3. X-linked dominant traits appear more frequently in females, because females can inherit the allele through an X chromosome from affected mother or affected father. Every person with a dominant trait must inherit the allele from at least one parent. All daughters of affected father will be affected but all sons will be unaffected. When a woman is heterozygous, approximately 1/2 of her sons and 1/2 of her daughters will be affected.

4. X-linked recessive traits appear more often in males, because males need inherit only a single copy of the allele to display the trait, whereas females must inherit two copies of the allele, one from each parent, to be affected. Males are hemizygous for X-linked loci, because their cells possess a single X chromosome. Because a male inherits his X chromosome from his mother, affected

males are usually born to unaffected mothers who carry an allele for the trait. When a woman is heterozygous, approximately 1/2 of her sons will be affected and 1/2 of her daughters will be unaffected carriers. X-linked recessive trait tends to skip generations and is not passed from father to son, because a son inherits his father's Y chromosome, not his X. Affected woman must have affected father, and she has affected sons. An example of an X-linked recessive trait in humans is hemophilia A, also called classical hemophilia.

5. Y-linked traits will show up exclusively in males, passed from father to son. All sons of affected father will be affected, and each affected man has affected father.

How *to determine* **mode of inheritance:**

a) first, you need to determine whether a trait is dominant or recessive. To do this, you have to find affected persons. If each affected person has at least one affected parent, the trait is dominant. If at least one affected person has healthy parents, the trait is recessive. This is true in the case of complete penetrance of the gene.

b) second, you need to determine whether a trait is autosomal or sex-linked (X-linked or Y-linked). For this you have to calculate number of affected males and females and compare the results (statistically). Then you have to analyze how the trait is transferred from affected mother to sons or daughters and from affected father to sons or daughters. Also you have to analyze from whom (father or mother) the trait was inherited.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 204–212, 219–220.
2. Lazarev K. "Medical Biology" (2003), pp. 193–200, 236.

==========

Practical Class Work.

Solve problems:

1. Determine the coefficient of heredity for: a) diabetes mellitis, b) hypertension, c) mental retardation, d) tuberculosis, e) measles (rubeola). Discuss the results.

- **Holtsinger's formula** for calculation of the coefficient of heredity:

$H = \frac{C_{MZ} - C_{DZ}}{100 - C_{DZ}}$, where C_{MZ} – concordance of monozygotic twins, C_{DZ} –

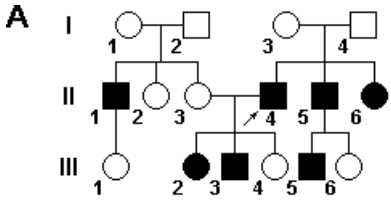
concordance of dizygotic twins.

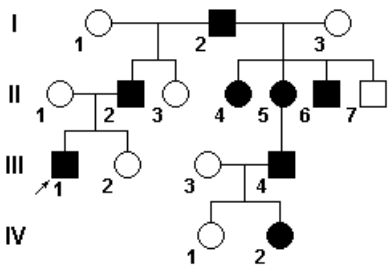
$0 \leq H \leq 1$. If $H = 0$, environmental factors influence the trait, if $H = 1$, genes only influence the trait.

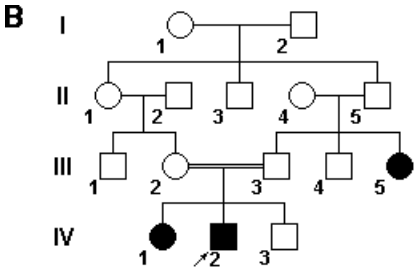
Table 4. Concordance of monozygotic and dizygotic twins for several human traits

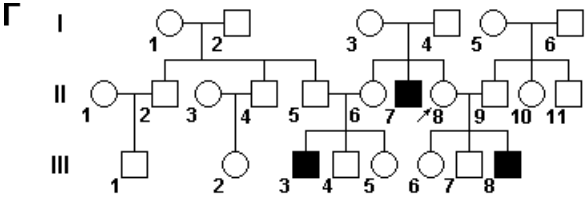
Trait	C_{MZ}	C_{DZ}
HLA	100	46
Blood groups	100	46
Hypertension	26	10
Epilepsy	67	3
Heart attack	67	43
Measles, or rubeola (корь)	98	94
Rheumatism	20	6
Mental retardation	97	37
Tuberculosis	37	15
Diabetes mellitis	65	18
Schizophrenia	70	13

2. Determine mode of inheritance and genotypes of such persons: a) II_3, II_4, III_3, III_4; b) III_3, III_4, IV_1, IV_2; c) III_1, III_2, III_3, IV_2, IV_3; d) I_3, I_4, II_7, II_8, II_9, III_7, III_8. What is the probability that the child of a proband will have a trait?







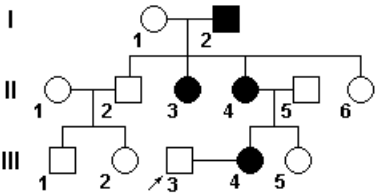


==========

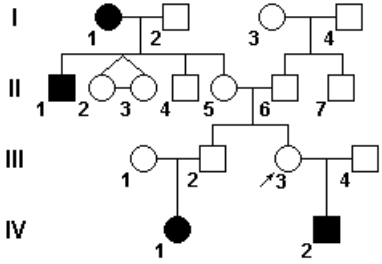
Home task. Solve genetic problems:

1) **Draw** skin figures on your fingertips, designate loops, whorls, and arches. **Determine** the angle *atd* for your palm. This angle must not exceed 57°.
2) **Solve** genetic problem:
   1. Determine mode of inheritance and genotypes of such persons: a) II_4, II_5, III_3, III_4, III_5; b) III_1, III_2, III_3, III_4, IV_1, IV_2; c) II_1, II_2, III_1, III_2, IV_1; d) II_4, II_5, III_6, III_7, III_8, III_9. What is the probability that the child of proband will have a trait?

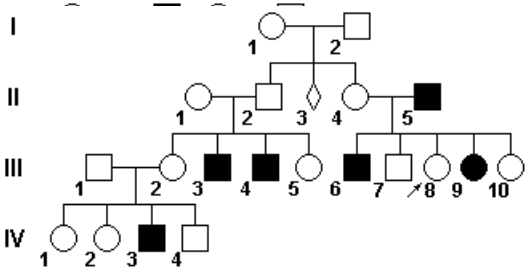
А



Б



В Г



Lesson 20. Single-Gene Disorders

Reading for a lesson.

1) *Terms:* achondroplasia, albinism, amniocentesis, anomaly, brachydactyly, chimera, color blindness, congenital and hereditary diseases, colour blindness, cordocentesis, daltonism, deletion, deuteranopia, diagnostics, diet, duplication, embryo, enzymopathy, fetal, fetoscopy, fetus, Følling test, gene and chromosome disorders, Guthrie test, hemoglobinopathy, hemophilia, hereditary susceptibility (predisposition), hybridization, insertion, inversion, metabolic disorders, mosaic, mosaicism, multifactorial diseases, mutant, mutation, nonessential and essential amino acids, phenylketonuria, prophylaxis (prevention), protanopia, sickle-cell anemia, sterility, symptom, syndrome, thalassemia, ultrasonography.
2) Classification of hereditary diseases: single-gene disorders, chromosome disorders, multifactorial disorders, and mitochondrial disorders.
3) Human molecular diseases (single-gene disorders). Classification of molecular diseases: disorders caused by defects in carbohydrate metabolism, amino acid metabolism, protein metabolism, copper metabolism; enzymopathies, hemoglobinopathies; storage diseases.
4) Phenylketonuria, hemoglobinopathies (sickle-cell anemia, thalassemia), hemophilia, color blindness, brachydactyly, and achondroplasia: genetic characteristics and mode of inheritance.
5) Laboratory diagnostics of gene disorders. Molecular diagnostics; polymerase chain reaction. Screening.
6)* *(additional)* Gene engineering, biotechnology. Gene therapy.

Single-gene Disorders. Biochemical Testing

To date, over 10 000 single-gene traits and disorders have been identified. Most of these are individually rare, but together they affect between 1% and 2% of the general population at any one time.

Disorders of the structure or synthesis of hemoglobin (Hb) are called **hemoglobinopathies**. The disorders of human Hb can be divided into two main groups, structural globin chain variants such as sickle-cell disease, and disorders of synthesis of the globin chains, the thalassemias. **Sickle-cell disease**, an autosomal recessive condition, is the most common hemoglobinopathy and the clinical manifestations are manifold, including cerebral symptoms, kidney failure,

'pneumonia', heart failure, and weakness. Hb S is less soluble than normal hemoglobin and tends to polymerize, causing the sickle-shaped deformation of the red cells. A proportion of sickle cells become irreversibly small because of damage to the red cell membrane. The shorter red cell survival time leads to consequent anemia. In addition the sickle cells have a reduced deformability, tending to obstruct small arteries, resulting in an inadequate oxygen supply to the tissues. Persons with sickle-cell disease have an increased risk of early death. Mutational basis of sickle-cell disease: the substitution of valine at the sixth position of the β-globin chain was due to an alteration in the second base of the triplet coding for glutamic acid, i.e. GAG to GTG. Patients are resistant to malaria.

Biochemical or metabolic diseases (enzymopathies) can be described as inborn errors of metabolism. They can be grouped either by the metabolite, metabolic pathway, function of the enzyme or cellular organelle involved.

There are a number of disorders of amino-acid metabolism, the best known of which is autosomal recessive **phenylketonuria** (PKU). PKU only affects approximately 1 in 10 000 persons of Western European origin. In PKU, the particular enzyme necessary for the conversion of phenylalanine to tyrosine, phenylalanine hydroxylase (PAH), is deficient. As a result of the enzyme defect, phenylalanine accumulates and is converted into phenylpyruvic acid and other metabolites that are excreted in the urine. The enzyme block leads to a deficiency of tyrosine, with a consequent reduction in melanin formation. Affected children therefore often have blond hair and blue eyes. Children with PKU, if untreated, are severely mentally retarded and often have convulsions. The mental retardation seen in children with phenylketonuria is most likely the result of an elevation of phenylalanine and/or its metabolites to toxic levels. PKU could be treated by removal of phenylalanine from the diet. This has proved to be an effective treatment. If PKU is detected early enough in infancy, mental retardation can be prevented by giving a diet containing a restricted amount of phenylalanine. Phenylalanine is an essential amino acid and therefore cannot be entirely removed from the diet. By monitoring the level of phenylalanine in the blood, it is possible to supply sufficient amounts to meet normal requirements and avoid levels that would result in mental retardation. Once brain development is complete dietary restriction can be relaxed-from adolescence onwards. Diagnostics of PKU is performed by tests that detect the presence of the metabolite of phenylalanine, phenylpyruvic acid, in the urine by its reaction with ferric chloride or through elevated levels of phenylalanine in the blood. The latter test, known as the Guthrie test, involves taking blood samples from children in the first week of life and comparing the amount of growth induced by the sample with standards in a

strain of the bacterium *Bacillus subtilis*, which requires phenylalanine for growth. This technique has been replaced by the use of a variety of biochemical assays of phenylalanine levels.

In **alkaptonuria** there is a block in the breakdown of homogentisic acid, a metabolite of tyrosine, through a deficiency of the enzyme homogentisic acid oxidase. As a consequence, homogentisic acid accumulates and is excreted in the urine, to which it imparts a dark color on exposure to air. Main clinical feature is arthritis.

The inborn errors of carbohydrate metabolism can be considered in two main groups, disorders of monosaccharide metabolism and the glycogen storage disorders. **Galactosemia** is an autosomal recessive disorder due to deficiency of the enzyme galactose-1-phosphate uridyl transferase, which is necessary for the metabolism of the dietary sugar galactose. Newborn infants with galactosemia present with vomiting, lethargy, failure to thrive and jaundice in the second week of life. If untreated, they go on to develop complications that include mental retardation, cataracts and cirrhosis of the liver.

The disorders of steroid metabolism (e.g. congenital adrenal hyperplasia).

The disorders of lipid metabolism (e.g. familial hypercholesterolemia).

Lysosomal storage disorders are characterized by a deficiency of a lysosomal enzyme involved in the degradation of complex macromolecules leads to their accumulation (e.g. mucopolysaccharidoses).

Disorder of purine/pyrimidine metabolism (e.g. gout).

Disorder of copper metabolism (e.g. Wilson disease). **Wilson disease** is the autosomal recessive disorder and includes deterioration of coordination, involuntary movements, abnormal tone, dysarthria (difficulty in speaking), dysphagia (difficulty with swallowing) and changes in behavior, abnormal liver function, which can progress to cirrhosis. High copper levels in the liver, decreased serum concentrations of the copper transport protein ceruloplasmin, and abnormal copper loading tests are suggestive of the diagnosis.

Mitochondrial diseases (optic neuropathies, myopathies and others).

Marfan syndrome, or arachnodactyly (described by the French pediatrician Bernard Marfan, in 1896). MFS is a disorder of fibrous connective tissue. Patients are tall with subjective features of long limbs and fingers, have joint laxity and scoliosis. The connective tissue defect gives rise to ectopia lentis and aortic dilatation.

Hemophilias. There are two forms of hemophilia-A and B. *Hemophilia A* is the most common severe inherited coagulation disorder, with an incidence of 1 in 5000 males. It is caused by a deficiency of factor VIII, which, together with

factor IX, plays a critical role in the intrinsic pathway activation of prothrombin to thrombin. Thrombin then converts fibrinogen to fibrin, which forms the structural framework of clotted blood. *Hemophilia B* affects approximately 1 in 40 000 males and is caused by deficiency of factor IX. It is also known as Christmas disease, whereas hemophilia A is sometimes referred to as 'classic hemophilia'. Clinical features are similar in both forms of hemophilia and vary from mild bleeding following major trauma or surgery to spontaneous hemorrhage into muscles and joints. Hemorrhage into joints causes severe pain and swelling which, if recurrent, causes a progressive arthropathy with severe disability. Both forms of hemophilia show sex-linked recessive inheritance. The loci lie close together near the distal end of the long arm of the X chromosome. Both forms of hemophilia have been treated successfully for many years using plasma-derived factor VIII or factor IX.

Biochemical Testing

A number of the inborn errors of metabolism can be screened for in the newborn period and successfully treated by dietary restriction or supplementation. Prenatal diagnosis of many of the inborn errors of metabolism is possible either by conventional biochemical methods, the use of linked DNA markers or by direct mutation detection. Biochemical analysis of cultured amniocytes obtained at mid-trimester amniocentesis is possible but has largely given way to earlier testing using direct or cultured chorionic villi (CV), which allows a diagnosis to be made by 12-14 weeks gestation. Newborn screening programs have been introduced on a widespread basis for phenylketonuria, galactosemia and other disorders.

Routine biochemical screening of newborn infants for **phenylketonuria** was recommended by the Ministry of Health in the UK in 1969 after it had been shown that a low-phenylalanine diet could prevent the severe learning disabilities that previously had been a hallmark of this condition. The screening test, which is sometimes known as the Guthrie test, is carried out on a small sample of blood obtained by heel-prick at age 7 days. An abnormal test result is further investigated by repeat analysis of phenylalanine levels in a venous blood sample. A low-phenylalanine diet is extremely effective in preventing learning disabilities. Any woman with phenylketonuria who is contemplating pregnancy should adhere to a strict low-phenylalanine diet both before and during pregnancy to minimize the risk of brain damage to her unborn child. Without strict dietary control this risk is very high.

In the case of **sickle-cell disease**, newborn screening based on hemoglobin

electrophoresis is undertaken in many countries with a significant Afro-Caribbean community. Treatment involves the use of oral penicillin to reduce the risk of pneumococcal infection resulting from immune deficiency secondary to splenic infarction.

Widespread **screening for carriers** of autosomal recessive disorders in high-incidence populations was first introduced for the hemoglobinopathies and has been extended to several other disorders (thalassemias, sickle-cell disease, Tay-Sachs disease, and others). The rationale behind these programs is that carrier detection can be supported by genetic counseling so that carrier couples can be forewarned of the 1 in 4 risk that each of their children could be affected.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 214– 215, 220–227.
2. Lazarev K. "Medical Biology" (2003), pp. 210–217, 220–224, 236.

==========

Practical Class Work.

Solve the problem:

1. A man is heterozygous for sickle-cell anemia, his wife is a healthy homozygote. What is the probability that their children will be resistant to malaria? Genes: *S* for normal erythrocytes, *s* for sickle erythrocytes. If both parents are heterozygotes, what is the probability that their children will be resistant to malaria? What part of their children will live to the sexual maturity; what proportion of them will be resistant to malaria? Consider how the content of the anemia alleles should change over several generations? Explain maintenance of mutant alleles in human populations that live in the tropics.

Lesson 21. Chromosome Disorders. Genetic Counseling

Reading for a lesson.

1) *Terms:* aberration, abortion, acentric chromosome, amniocentesis, aneuploidy [heteroploidy], anomaly, Barr's body, cleft lip, cleft palate, colchicine, cordocentesis, cytogenetics, cytostatic agent, deletion, diagnostics, dicentric chromosome, duplication, embryo, epicanthus, feminization, fetal, fetoscopy, fetus, genetic consultation, genetic counseling, genomic and chromosome mutations, gynecomastia, haploidy, intrauterine, insertion, inversion, isochromosome, karyotype, karyotyping, masculinization, monosomy, mosaic, mosaicism, mutant, mutation, nondisjunction of chromosomes, phytohemagglutinin, ploidy, polyploidy, polysomy, postnatal, pregnancy, prenatal, prenatal diagnostics, prophylaxis (prevention), ring chromosome, sex chromatin, sterility, symptom, syndrome, translocation, trisomy, ultrasonography.
2) Chromosome nutations: structural and numerical chromosome aberrations. Types of abnormal chromosomes.
3) Mutations in sex and somatic cells, their importance. Mosaicism.
4) Chromosome disorders (Down syndrome, Patau syndrome, Edwards syndrome, Klinefelter syndrome, Turner syndrome [Shereshevsky-Turner syndrome], trisomy X, cat cry syndrome [cri du chat syndrome]), their main symptoms, laboratory diagnostics.
5) Cytogenetic method. Karyotyping; normal and abnormal karyotypes. Detection of X- and Y-chromatin as a tool of diagnostics of some hereditary diseases.
6) Genetic counseling. Prevention of inherited and congenital malformations. Prenatal diagnostics of hereditary diseases.

Chromosome Disorders

To date, around 20 000 chromosomal abnormalities have been registered on laboratory databases. While on an individual basis most of these are very rare, together they make a major contribution to human morbidity and mortality. Chromosome abnormalities account for a large proportion of spontaneous pregnancy loss and childhood disability, and also contribute to the genesis of a significant proportion of malignancy in both childhood and adult life as a consequence of acquired somatic chromosome aberrations.

Chromosome abnormalities are present in at least 10% of all spermatozoa and 25% of mature oocytes. Between 15% and 20% of all recognized pregnancies end in spontaneous miscarriage, and many more zygotes and embryos are so abnormal that survival beyond the first few days or weeks after fertilization is not possible. Approximately 50% of all spontaneous miscarriages have a chromosome abnormality and the incidence of chromosomal abnormalities in morphologically normal embryos is around 20%.

Trisomy is usually caused by failure of separation of one of the pairs of homologous chromosomes during anaphase of maternal meiosis I. This failure of the bivalent to separate is called non-disjunction. Less often, trisomy can be caused by non-disjunction occurring during meiosis II when a pair of sister chromatids fail to separate. Either way the gamete receives two homologous chromosomes (disomy), and if subsequent fertilization occurs a trisomic conceptus results. Non-disjunction can also occur during an early mitotic division in the developing zygote. This results in the presence of two or more different cell lines, a phenomenon known as mosaicism.

DISORDERS OF THE AUTOSOMES

Down syndrome (trisomy 21, mongolism) (47,XX/XY, +21). The incidence of Down syndrome is 15 per 10 000 births (1 in 700). There is a strong association between the incidence of Down syndrome and advancing maternal age (see table). Clinical features: severe hypotonia, small ears and protruding tongue, epicanthic folds, single palmar creases (are found in 50% of Down syndrome children in contrast to 2-3% of the general population), cardiac abnormalities. The average IQ of young adults with Down syndrome is around 40 to 45. Social skills are relatively well advanced and most children with Down syndrome are happy and very affectionate. Adult height is usually around 150cm. In the absence of a severe cardiac anomaly, which leads to early death in 15-20% of cases, average life expectancy is 50-60 years. The additional chromosome arises most commonly as a result of non-disjunction in maternal meiosis I. Translocations account for approximately 4% of all cases. Children with mosaicism (1% of all cases) are often less severely affected than in the full syndrome. Prenatal diagnosis can be offered based on analysis of chorionic villi or cultured amniotic cells.

Maternal age	Incidence of Down syndrome
20	1 in 1500
30	1 in 900
37	1 in 250
40	1 in 100
43	1 in 50
45	1 in 30

Patau syndrome (trisomy 13). The incidence is 2 per 10 000 births. Affected baby has severe bilateral cleft lip and palate.

Edwards syndrome (trisomy 18). The incidence is 3 per 10 000 births. Affected baby has prominent occiput and tightly clenched hands. Both syndromes have a very poor prognosis, with most affected infants dying during the first days or weeks of life. Cardiac abnormalities occur in at least 90% of all cases.

DISORDERS OF THE SEX CHROMOSOMES

Klinefelter('s) syndrome (47,XXY). The incidence is 10 per 10 000 births. Adults with Klinefelter syndrome tend to be slightly taller than average with long lower limbs. Approximately 30% of adult males with Klinefelter syndrome show moderately severe gynecomastia (enlargement of the breasts) and all are infertile, with small soft testes. There is an increased incidence of leg ulcers, osteoporosis and carcinoma of the breast in adult life. Males with Klinefelter syndrome are usually infertile due to the absence of sperm in their semen (azoospermia). Diagnosis: usually the karyotype shows an additional X chromosome, the presence of a Barr body, consistent with the presence of one additional X chromosome. A small proportion of cases show mosaicism, i.e. 46,XY/47,XXY. Rarely, a male with more than two X chromosomes can be encountered, e.g. 48,XXXY or 49,XXXXY. These individuals are usually quite severely retarded and also share physical characteristics with Klinefelter men, often to a more marked degree.

Turner('s) syndrome (45,X, sometimes erroneously referred to as 45,XO). The incidence is 1-2 per 10 000 births. Syndrome arises in 80% of instances through a sex chromosome (X or Y) being lost in paternal meiosis, 20% of cases is mosaicism (45,X/46,XX). Clinical features: neck webbing, the foot of an infant shows small nails. Intelligence in Turner syndrome is normal. The two main medical problems are short stature and ovarian failure. Diagnosis: the absence of a Barr body, consistent with the presence of only one X chromosome.

XXX females (47,XXX). The incidence is 10 per 10 000 births. These women usually have no physical abnormalities but can show a mild reduction of between 10 and 20 points in intellectual skills and sometimes quite oppositional behavior. Women show a high incidence of learning difficulties. Studies have shown that the additional X chromosome is of maternal origin in 95% of cases and usually arises from an error in meiosis I. Women with a 47,XXX karyotype usually show normal fertility and have children with normal karyotypes.

Literature.

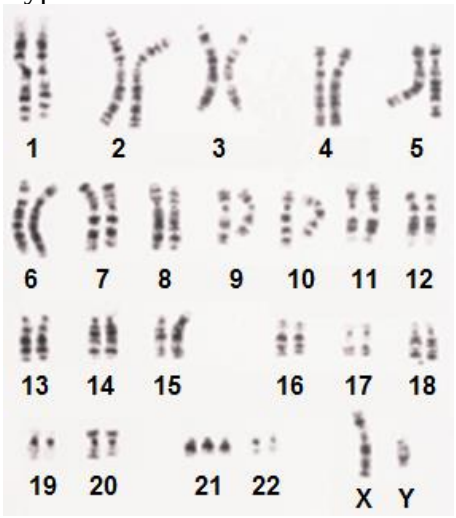
1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 212–214, 215–219, 233–234.
2. Lazarev K. "Medical Biology" (2003), pp. 217–220, 236.

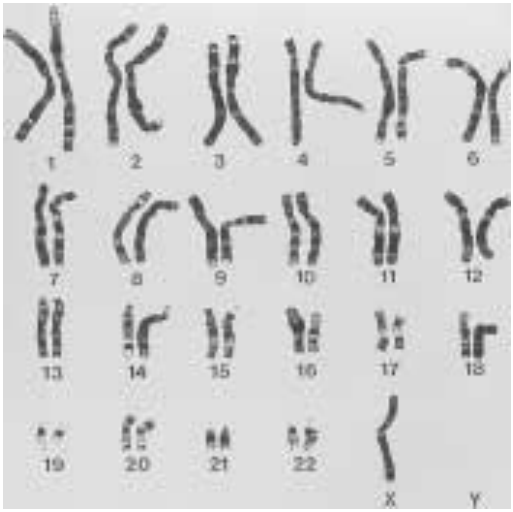
==========

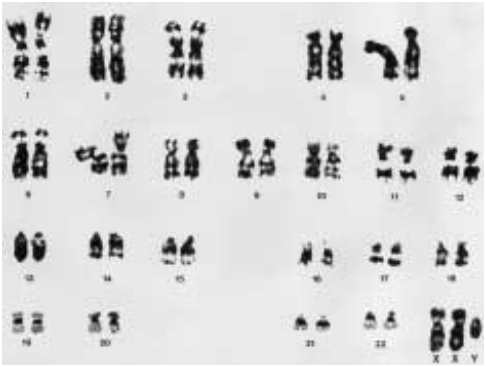
Practical Class Work.

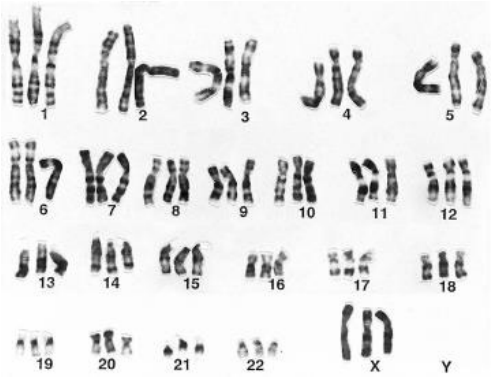
Solve problems:

1. Analyse photos of metaphase plates, determine type of karyotype (normal or abnormal, male or female). In the case of chromosome aberration, determine type of chromosome mutation.

a 

b 

c 

d 

2. Healthy woman has translocation of one chromosome of the 21^{st} pair to the 15^{th} chromosome ($2n = 45$). Healthy man has normal karyotype. What part of egg cells would result in Down syndrome in the child? What part of children could have Down syndrome?

Lesson 22. Population Genetics

Reading for a lesson.

1) *Terms:* allelic frequency, area (areal), artificial selection, assortative mating, deme, demography, disassortative mating, emigration, founder effect, gene flow, gene pool, genetic drift, idealized population, immigration, inbreeding, inbreeding depression, incest, isolate, isolation, mating, migration, mutation, natural selection, panmixia, population, population waves, random mating, selection, speciation, species.
2) Population genetics: subject and purposes. A species, a population, human population. Characteristics of population.
3) Isolation, its role in speciation.
4) Idealized population. Hardy-Weinberg law.
   • Hardy-Weinberg law is an important principle of population genetics stating that, in a large, randomly mating population not affected by mutation, migration, or natural selection, allelic frequencies will not change and genotypic frequencies stabilize after one generation in the proportions p^2 (the frequency of *AA*), $2pq$ (the frequency of *Aa*), and q^2 (the frequency of *aa*), where p equals the frequency of allele *A* and q equals the frequency of allele *a*.
5) Influence of mutations, selection and migration on the genetic structure of a population.
   Influence of mutations on the population. If mutation $A \rightarrow a$ occurs, the frequency of the dominant alleles after t generations is calculated by using such formula: $p_t = p_0(1-\mu)^t$, where p_0 – allele *A* frequency among parents; μ – mutation frequency; t – number of generations.

$$t = \frac{\lg(p_t : p_0)}{\lg(1-\mu)}.$$

6) Genetic drift. Founder effect.
7) Types of mating in populations in the nature, their influence on a population. Inbreeding: causes and consequences.
8) Usage of the Hardy-Weinberg equilibrium in medicine for analysing of the genetic structure of human population.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 227–232.

2. Lazarev K. "Medical Biology" (2003), pp. 262–270, 228, 288–289.

==========

Practical Class Work.

Solve problems:

1. A population consists of 2,000 individuals homozygous on the dominant gene *A*, 2,000 heterozygotes, and 6,000 recessive homozygotes. Whether a ratio of frequencies of genotypes in this population corresponds to an ideal ratio? The annual offspring in the given population has made 2,500 kids. What is the genotypic structure of this offspring? Mating is random in this population; mutations and selection are absent.
2. 5,000 persons in Baltimore city (USA) have been examined. From this number, 3,200 persons were capable to fold their tongues into a U-shape (a dominant trait). In assuming that the population is ideal, determine the number of dominant homozygotes and heterozygotes among persons examined.
3. Frequency of albinos in Europe is equal 1 : 20,000. What part do heterozygous carriers make?
4. Determine frequency of students of our group who are able to fold their tongues into a U-shape. Compare this frequency with an expected value.

==========

Home task. Solve genetic problems:

1. A population consists of 16,000 individuals homozygous on the dominant gene *A*, 8,000 heterozygotes, and 16,000 recessive homozygotes. Whether a ratio of frequencies of genotypes in this population corresponds to an ideal ratio? The annual offspring in the given population has made 4,000 kids. What is the genotypic structure of this offspring? Panmixia occurs in this population; mutations and selection are absent.
2. Cystic fibrosis of a pancreas meets among inhabitants at frequency of 1 in 2,000. Calculate frequency of carriers.

Topic for Independent Study. Evolution Theory. Phylogenesis of Main Organ Systems of Chordata

Questions *for independent study*

1) *Terms:* amniotes, anamniotes, anencephalia, anthropogenesis, anthropogenic factors, anthropology, anthropometry, aromorphosis, atavism, australopithecine, convergence, degeneration, divergence, ethnic, evolution, evolution factors, genealogical relationship, hydrocephaly, idioadaptation, Java man, macroevolution, microevolution, natural selection, Neanderthal man, ontogenesis, Peking man, phylogenesis [phylogeny], phylogenetic tree, pithecanthropus, polydactylia, race, racism, rudiment, species, struggle for life, syndactylia, theory.
2) Development of evolution theories. Lamarck's and Darwin's views on evolution. Synthetic theory of evolution. Evolution factors. Macro- and microevolution.
3) Special action of evolutionary factors in human populations.
4) Biogenetic law. Law of homologous series of variability.
5) Evolution of a man; evidences of evolutionary origin of a man. Biosocial nature of a man. Human races as reflection of adaptation patterns of human development. Criticism of racism.
6) Evolution of the main organ systems of Chordata. Inborn man's malformations, which are phylogenetically determined.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 366–395.
2. Lazarev K. "Medical Biology" (2003), pp. 239–261, 271–285, 286–287, 289–290, 494–506.

Lesson 23. Ecology and Biosphere. Poisonous organisms

This lesson starts substantial module 5 "Human Ecology. Medical Parasitology".

Reading for a lesson.

1) *Terms:* abiotic factors, acclimatization, adaptation, agrocenosis, amanitin, anthropogenic factors, antibiosis, atmosphere, autotroph, biocenosis, biogeocenosis, biomass, biosphere, biotic factors, biotope, carbone dioxide, carbone monoxide, carnivore, carnivorism, carrion, climax (climax community), commensalism, competition, consumer, DDT, decomposer, ecological niche (environmental niche), ecology, ecosystem, environment, eurythermic, eurytopic, exhaust, fauna, flora, food chain, food pyramid, greenhouse effect, heterotroph, homeostasis, homoiothermal, host, hydrosphere, ionizing radiation, isotope, lithosphere, monoculture, nitrogen fixation, noise, ozone, parasite, parasitism, parasitocenosis, pest, pesticide, poikilothermal, predation, predator, prey, primary consumer, producer, pyramid of biomass, radiation, radioactive, reducer, resistance, saprophyte, scavenger, secondary consumer, stenothermic, stenotopic, stratosphere, struggle for existence, succession, symbiosis, tertiary consumer, tetrodotoxin, thermoregulation, tropism, troposphere, ultraviolet radiation.
2) Ecology. Environment. Abiotic and biotic factors. Ecosystem.
3) Human and biogeocenosis. Agrocenosis. Pharmaceutical drugs in food chains.
4) Human ecology. Influence of anthropogenic factors on health. Stress. Adaptation of human to difficult environment.
5) Biosphere and its evolution. Ozone layer.
6) Poisonous fungi, plants, and animals.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 398–426.
2. Lazarev K. "Medical Biology" (2003), pp. 293–309, 310–312, 467–468, 506–508, 515–516.

==========

Practical Class Work.

Consideration of questions; discussion.

Lesson 24. Introduction to Parasitology. Protozoans. Sarcodina

Reading for a lesson.

1) *Terms:* anamnesis, animal, anthroponoses, anthropozoonoses, asymptomatic carrier condition, autotroph, cachexia, carrier, causative agent, chronic disease, classification, commensalism, control of the disease, cyst, cytoplasm, devastation, developmental stage, diagnosis, diarrhea, disease, disinfection, dysfunction, ectoparasite, ectoplasm, encystation, endocytosis, endoparasite, endoplasm, etiology, excrements, excretion, excystation, function, genus, heterotroph, high-risk group, host, hygiene, identification, illness, infection, invasion, invasive form (invasive stage), lethal, life cycle, localization, mechanical and specific vectors, medicine, mitochondrion, morphology, mutualism, nucleus, organelle, organoid, osmoregulation, pain, parasite, parasitic [invasive] diseases, parasitism, parasitology, parasitosis, pathogenicity, pathogeny, pathological, patient, phagocytosis, phylum, pinocytosis, prophylaxis, protozoan diseases, pseudopodium, reinvasion, species, stage, symbiosis, symptom, systematics, taxon, treatment, trophic, trophozoite, vacuoles digestive and contractile, vector, vegetative, zoonoses.
2) Principles of classification of living beings. Binary nomenclature.
3) Introduction to medical parasitology. Origin and evolution of parasitism. Ways of penetration of parasites into a host. Classification of parasites. Classification of hosts. Classification of vectors. Interaction of a parasite and a host.
4) Characteristics and classification of protozoans (Protozoa).
5) Phylum Sarcomastigophora, Class Rhizopoda (Lobosea). *Entamoeba histolytica, Entamoeba coli, Entamoeba gingivalis.* Distribution, morphology, life cycle of *Entamoeba histolytica*, ways of invasion, pathogenicity; laboratory diagnostics, and control of amebiasis. Different features of *Entamoeba histolytica* and *Entamoeba coli*.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 239–248.
2. Lazarev K. "Medical Biology" (2003), pp. 315–331, 509, 553, 567.

==========

Practical Class Work.

1) **Fill in** the table 5-A.
2) **View** *Amoeba* sp. under a microscope and **draw**. Designate nucleus, cytoplasm, and pseudopodium.
3) **Draw** life cycle of *Entamoeba histolytica*.

Table 5-A. Protozoans – parasites of man

Name of the parasite	*Host*	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
1. *Entamoeba histolytica*				

Lesson 25. Flagellates

Reading for a lesson.

1) *Terms:* adhesive disk, amastigote, axostyle, basal body, bilateral symmetry, duodenal, endemic disease, endoparasite, epimastigote, fibrilla, flagellum, Golgi complex, immunity, incubation [latent] period, intubation, kinetoplast, kinetosome, monoxenous and heteroxenous parasites, natural focus, natural reservoir, parabasal body, pellicle, peristome, probe, promastigote, punctate, puncture, reservoir host, scraping, transmissible diseases, trypomastigote, ulcer, ulceration, undulating membrane, vaccination, vaccine.
2) Characteristics of flagellates. The structure of a flagellum.
3) *Giardia lamblia [G. intestinalis*, *G. duodenalis*; *Lamblia intestinalis]:* distribution, morphology, life cycle, ways of invasion, pathogenicity. Laboratory diagnostics and control of giardiasis [lambliasis, lambliosis].
4) Trichomonads: *Trichomonas vaginalis* and *Trichomonas hominis [T. intestinalis]*. Distribution, morphology, life cycle of *Trichomonas vaginalis*, ways of invasion, pathogenicity; laboratory diagnostics, and control of trichomoniasis.
5) *Leishmania tropica* (old name: *L. tropica minor*), *L. major* (old name: *L. tropica major*), *L. donovani*, and *L. infantum:* distribution, morphology, life cycle, ways of invasion, pathogenicity. Laboratory diagnostics and control of cutaneous and visceral leishmaniases.
6) *Trypanosoma brucei gambiense*, *T. brucei rhodesiense*, and *T. cruzi:* distribution, morphology, life cycle, ways of invasion, pathogenicity. Laboratory diagnostics and control of trypanosomiases.
7) Endemic diseases and diseases with natural focus. Transmissible diseases.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 250–260.
2. Lazarev K. "Medical Biology" (2003), pp. 331–342, 509–510, 553–555, 563, 564, 565.

==========

Practical Class Work.

1) **Fill in** the table 5-B.
2) **Draw** trophozoite and cyst of *Giardia lamblia*. Designate nuclei, flagella, parabasal body, and adhesive disk.
3) **Draw** trophozoites of *Trichomonas hominis* and *T. vaginalis.* Designate nu-

cleus, flagella, axostyle, undulating membrane, and peristome.

4) **Draw** the scheme of life cycle of *Leishmania major*.

5) **View** blood smear of a horse with dourine and **draw** two red blood cells and *Trypanosoma equiperdum* (causative agent of dourine). Designate trypanosome, nucleus, flagellum, undulating membrane, and erythrocyte.

Table 5-B. Protozoans – parasites of man

Name of the parasite	*Host*	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
2. *Giardia lamblia*				
3. *Trichomonas vaginalis*				
4. a) *Leishmania tropica* b) *Leishmania major* c) *Leishmania donovani*				
5. a) *Trypanosoma brucei* b) *Trypanosoma cruzi*				

Lesson 26. Sporozoans. Infusorians. Methods of Diagnostics of Protozoan Diseases

Reading for a lesson.

1) *Terms:* allergy, anemia, antigen, antibody, asexual and sexual reproduction, bradyzoite, cilia, conjugation, conoid, cytostome, deratization, disinsection, endemic disease, endoparasite, erythrophage, fertilization, fever, final [definitive] host, gamete, gametocyte, gamogony, gamont, generation, hemoparasite, hemotransfusion, high-risk group, hydrocephaly, hypnozoite, immunity, incubation [latent] period, insecticides, intermediate host, intoxication, local, macrogamete, macrogametocyte, macronucleus, malignant [pernicious], merozoite, microgamete, microgametocyte, micronucleus, morula, nuclear dualism, occupational disease, oocyst, ookinete, peristome, pesticides, pseudocyst, recurrence, remission, repellent, rhoptry, schizogony, schizont, sporoblast, sporocyst, sporogony, sporozoite, synkaryon, tachyzoite, toxin, transplacental mode of invasion, trophozoite, zygote.
2) Characteristic, structure and reproduction of Sporozoa.
3) Malarial plasmodia *Plasmodium vivax, P. ovale, P. malariae* and *P. falciparum:* medical geography, morphology and life cycle, mode of infection, pathogenic influence, association between temperature of the patient and the stage of plasmodium development. Laboratory diagnostics and control of malaria.
4) *Toxoplasma gondii:* medical geography, morphology, life cycle, ways of infection, pathogenic influence. Laboratory diagnostics and control of toxoplasmosis.
5) Characteristic of infusorians. Nuclear dualism. Sexual process in infusorians.
6) *Balantidium coli:* medical geography, morphology and life cycle, ways of infection, pathogenic influence. Laboratory diagnostics and control of balantidiasis.
7) Methods of laboratory diagnostics of diseases caused by parasitic protozoa. Material that is used for diagnostics of protozoan diseases.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 248–250, 260–270.
2. Lazarev K. "Medical Biology" (2003), pp. 342–352, 509–511, 555–556, 563.

==========

Practical Class Work.

1) **Fill in** the table 5-C.
2) **View** blood smear of a mouse infected by *Plasmodium berghei*. Find infected erythrocytes and **draw** normal red blood cell and infected erythrocytes (with different stages of trophozoites).
3) **Draw** the scheme of life cycle of *Plasmodium*. Designate all stages.
4) **View** the specimen of rabbit's liver and **draw** trophozoites of *Eimeria stiedae*. Pay attention to the size and shape of *Eimeria* cells.
5) **View** the specimen of an infusorian *Paramecium* sp. and **draw** two trophozoites. Designate macronucleus. Pay attention that micronucleus is not visible in many cells.

Table 5-C. Protozoans – parasites of man

Name of the parasite	*Host*	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
6. *Toxoplasma gondii*				
7. *Plasmodia:* a) *P. vivax* b) *P. ovale* c) *P. malariae* d) *P. falciparum*				
8. *Balantidium coli*				

Lesson 27. Flatworms. Flukes: *Fasciola hepatica, Opisthorchis felineus, Clonorchis sinensis, Dicrocoelium dendriticum,* and *Metagonimus yokogawai*

Reading for a lesson.

1) *Terms:* acetabulum, adolescaria, bilateral symmetry, biohelminth, cercaria, cirrus, commissures, defecation, deworming, egg, epithelium, fixation, ganglion, geohelminth, glycogen, helminthology, helminthoses, helminths [worms], hermaphrodite, jaundice, larva, lid, locomotory, marita, mechanical jaundice, metacercaria, miracidium, obstruction, ontogenesis, operculum, ovary, oviduct, parenchyma, parthenogony, protonephridium, puberty, redia, sensillae, sporocyst, sucker, supplementary host, syncytium, taxis, tegument, trematodosis, uterus, vitelline gland,
2) Classification of Plathelminthes. General characteristic of the phylum Plathelminthes and class Flukes. Role of covering (tegument). Systems of organs. Developmental stages, morphology of larvae. Parthenogony. Changing of hosts. Adaptation of parasites to hosts.
3) Liver fluke *Fasciola hepatica*, Siberian liver fluke *Opisthorchis felineus*, Chinese liver fluke *Clonorchis sinensis*, lancet fluke *Dicrocoelium dendriticum [D. lanceatum]*, and *Metagonimus yokogawai*: medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Laboratory diagnostics and prevention of fascioliasis, opisthorchiasis, clonorchiosis, dicrocoeliosis (dicroceliasis) and metagonimosis.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 275–283, 289, 329–330, 331.
2. Lazarev K. "Medical Biology" (2003), pp. 353–364, 369, 511–512, 556–557, 562, 566.

==========

Practical Class Work.

1) **Fill in** the table 6-A, write Latin names of parasites.
2) **Examine** microscopic specimens of liver fluke, digestive and excretory systems of liver fluke (injected by ink). Find an acetabulum, a throat, branches of

intestine in the alimentary system; central canal and tubules of secretory system.

3) **View** native preparations of a liver infected by liver fluke, Siberian liver fluke, and lancet flukes (in formalin or ethanol).
4) **View** and **draw** eggs of liver fluke, Siberian liver fluke, and lancet fluke. Pay attention to a ratio of their sizes, their shape, color, and envelope thickness. Find and designate a lid [operculum].
5) **Draw** the scheme of life cycle of liver fluke, indicate all stages; pay attention to morphology of larvae.
6) **Examine** a preparation of lancet fluke (objective lens 8×, eyepiece 7×); find suckers, two testes (large unequal ovals in the center of the body, which are located diagonally), a uterus (in the back half of a body; it is filled with eggs with different extent of coloring). Pay attention to the structure of generative organs and their arrangement.
7) At the end of the class, **fill in** the table 7, which describes eggs of the studied worms.

Table 6-A. Flatworms – parasites of man

Name of the parasite	*Final host*	*Intermediate host*	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
1. Liver fluke					
2. Siberian liver fluke					
3. Chinese liver fluke					
4. Lancet fluke					
5. *Metagonimus yokogawai*					

Table 7. Morphology of eggs of worms

Size	*Shape*	*Colour*	*Envelope*	*Special features*	*Name of helminth*
					1. Liver fluke
					2. Siberian liver fluke
					3. Lancet fluke

Lesson 28. Flukes: *Paragonimus ringeri, Schistosoma* spp., and *Nanophyetus salmincola*. Tapeworms: *Diphyllobothrium latum*

Reading for a lesson.

1) *Terms:* anemia, biohelminthes, bothridium, bothrium, cestodoses, cirrus, closed and opened uterus, coenurus, constipation [obstipation], coracidium, cough, cysticercoid, cysticercus, degeneration, dermatitis, epithelium, female, fixation, fluid-filled cyst, hydatid cyst, hypovitaminosis, idioadaptation [allomorphosis], itch, male, migration of a parasite, nausea, neck, necrosis, obstruction, oncosphere, ootype, percutaneous, phlegm, plerocercoid, proglottid, schistosomulum, scolex, sensillae, sporocyst, strobile, urine,
2) Lung fluke *Paragonimus ringeri [P. westermani];* blood flukes – *Schistosoma mansoni, S. haematobium,* and *S. japonicum; Nanophyetus salmincola [Troglotrema salmincola]:* medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Laboratory diagnostics and prevention of paragonimiasis, schistosomoses and nanophyetiasis.
3) Comparative characteristic of flukes.
4) General characteristic of tapeworms. Types of larvae: solid larvae and fluid-filled cysts. The changes in morphology associated with transition to parasitism.
5) Broad tapeworm [fish tapeworm, late tapeworm, Swiss tapeworm] *Diphyllobothrium latum:* medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Laboratory diagnostics and prevention of diphyllobothriosis.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 284–289, 289–293, 302–303, 329–330, 331.
2. Lazarev K. "Medical Biology" (2003), pp. 369–385, 401–403, 511–514, 557, 558, 562, 563, 565, 566.

==========

Practical Class Work.

1) **Fill in** the table 6-B, write Latin names of parasites.
2) **Draw** eggs of lung fluke, *Schistosoma haematobium,* and *S. mansoni* (indicate terminal or lateral spine).

3) **Draw** life cycle of lung fluke.
4) **View** native preparations of fish tapeworm and cyclops.
5) **View** and **draw** scolex, mature proglottid and egg of *Diphyllobothrium latum.*
6) **Draw** life cycle of fish tapeworm.
7) At the end of the lesson, **fill in** the table 7 that describes eggs of the studied worms.

Table 6-B. Flatworms – parasites of man

Name of the parasite	*Final host*	*Intermediate host*	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
6. Lung fluke					
7. Blood fluke *Schistosoma haematobium*					
8. Fish tapeworm					

Table 7. Morphology of eggs of worms

Size	*Shape*	*Colour*	*Envelope*	*Special features*	*Name of helminth*
					4. Lung fluke
					5. Blood fluke *Schistosoma hematobium*
					6. Fish tapeworm

Lesson 29. Cyclophyllidean Tapeworms

Reading for a lesson.

1) *Terms:* autoinvasion, contact helminths, cysticercoid, cysticercosis, cysticercus, differential diagnosis, dog tapeworm, fluid-filled cyst, hydatid cyst, migration of a parasite, oncosphere, natural focus of the disease, proglottid, reinvasion, scolex, taeniid infestations, vomiting.
2) Beef tapeworm [unarmed tapeworm] *Taenia saginata [Taeniarhynchus saginatus]*, pork tapeworm [armed tapeworm] *Taenia solium,* dwarf tapeworm *Hymenolepis nana:* medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Laboratory diagnostics and prevention of beef tapeworm infection, pork tapeworm infection, cysticercosis, and hymenolepiasis. Differential diagnosis of taeniid infestations.
3) Dog tapeworm [caseworm] *Echinococcus granulosus* and *Echinococcus multilocularis [Alveococcus multilocularis]:* medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Laboratory diagnostics and prevention of echinococcosis and alveococcosis. Special treatment of echinococcosis and alveococcosis, which is associated with biology of causative agents.
4) Comparative characteristic of tapeworms according to their danger.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 293–302, 329–330, 331.
2. Lazarev K. "Medical Biology" (2003), pp. 386–401, 511–514, 557–558, 562, 566, 567.

==========

Practical Class Work.

1) **Fill in** the table 6-C, write Latin names of parasites.
2) **View** native preparations of *Taenia* proglottids and adult worms of *Taenia* and *Hymenolepis nana*.
3) **Draw** scoleces and gravid proglottids of *Taenia solium* and *Taenia saginata*. Pay attention to the differences in morphology of the uteri (number of branches) and scoleces (the presence of rostellum with hooks).
4) **View** and **draw** the egg (oncosphere) of *Taenia* spp.
5) **Draw** life cycles of *Taenia saginata* and *Taenia solium*.

6) **View** preparations of liver, lung and heart of the pig that is infected by *Echinococcus granulosus*.
7) **Draw** life cycle of *Echinococcus granulosus*.
8) At the end of the lesson, **fill in** the table 7 that describes eggs of the studied worms.

Table 6-C. Flatworms – parasites of man

Name of the parasite	*Final host*	*Intermediate host*	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
1. Beef tapeworm					
2. Pork tapeworm					
3. Dwarf tapeworm					
4. Dog tapeworm					
5. *Echinococcus multilocularis*					

Table 7. Morphology of eggs of worms

Size	*Shape*	*Colour*	*Envelope*	*Special features*	*Name of helminth*
					7. *Taenia* spp.
					8. Dwarf tapeworm

Lesson 30. Oviparous Nematodes

Reading for a lesson.

1) *Terms:* anus, aromorphosis, asphyxia, autoinvasion, biohelminth, blastocoel, bulbus, compost, composting, contact helminths, cuticle, dioecy [gonochorism], erythrophage, facultative parasite, female, filariform larva, geohelminth, hookworm diseases, hypodermis, ileus, male, migration of a parasite, molting, nematodoses, obligate parasite [obligatory parasite, true parasite, holoparasite], obstruction [constipation, obstipation], papilla, parthenogenesis, perianal, rhabditiform larva, sexual dimorphism, vesicle.
2) General characteristic of roundworms. Special features of life cycles of nematodes associated with molting of larvae. Aromorphoses in roundworms' evolution.
3) Giant intestinal roundworm [maw worm] *Ascaris lumbricoides*, whipworm *Trichuris trichiura [Trichocephalus trichiurus]*, old world hookworm [assassin worm, tunnel worm] *Ancylostoma duodenale*, new world hookworm *Necator americanus*, dwarf threadworm *Strongyloides stercoralis*, and pinworm [seatworm] *Enterobius vermicularis:* medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Migration of larvae. Special features of life cycle of dwarf threadworm. Laboratory diagnostics and prevention of ascariasis, trichuriasis [trichocephaliasis, trichocephalosis], ancylostomiasis, necatoriasis, strongyloidosis and enterobiosis. Treatment and prophylactic measures in the case of enterobiosis.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 304–315, 330–331.
2. Lazarev K. "Medical Biology" (2003), pp. 404–428, 512–514, 558–559, 562, 566, 567.

==========

Practical Class Work.

1) **Fill in** the table 8-A, write Latin names of parasites.
2) **View** native preparations of adult *A. lumbricoides*, *A. suum* and *Ascaridia galli* (causative agent of ascaridiosis in hens).
3) **View** and **draw** the egg of *A. lumbricoides*.
4) **Draw** cross section of *A. lumbricoides* female. Indicate cuticle, hypodermis,

muscles, body cavity, intestine (the largest tube), excretory canals, uteri (with thick walls and eggs), oviducts, and ovaries (the smallest tubes without eggs).

5) **Draw** the egg of *T. trichiura*.
6) **View** female and **draw** the egg of *E. vermicularis*.
7) At the end of the lesson, **fill in** the table 7 that describes eggs of the studied worms.

Table 8-A. Roundworms – parasites of man

Name of the parasite	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
1. Giant intestinal roundworm			
2. Whipworm			
3. Tunnel worm			
4. Dwarf threadworm			
5. Pinworm			

Table 7. Morphology of eggs of worms

Size	*Shape*	*Colour*	*Envelope*	*Special features*	*Name of helminth*
					9. Giant intestinal roundworm
					10. Whipworm
					11. Pinworm

Lesson 31. Viviparous Nematodes. Methods of Diagnostics of Helminthoses. Segmented Worms: Medicinal Leech

Reading for a lesson.

1) *Terms:* artifact, biopsy, biopsy material, Calabar swelling, circadian rhythm, deratization, devastation, elephantiasis, filariasis [filariosis], hirudin, hirudinization, identification, live birth [viviparity], metamerism, microfilaria, migration of a parasite, native, natural focus of a disease, obligate parasite, ovoviviparity, parapodia, perigastrium [coelom, deuterocoel], raticides [rodenticides], scatologic [scatological], synanthropic, synanthropic focus of a disease, swelling, temporary parasite, transmissible, trichina.
2) Trichinella [trichina] *Trichinella spiralis:* medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Natural and synanthropic foci of trichinosis. Laboratory diagnostics and prevention of trichinosis [trichinellosis, trichiniasis]. Rodents and methods of deratization.
3) "Larva migrans disease": *Toxocara canis, Ancylostoma braziliense*.
4) Dragon worm [Guinea worm, medina worm] *Dracunculus medinensis,* Bancroft's filaria *Wuchereria bancrofti, Brugia malayi,* blinding filaria *Onchocerca volvulus,* eye worm *Loa loa, Dirofilaria immitis* and *D. repens:* medical geography, morphology and life cycle, mode of invasion, pathogenic influence. Circadian rhythm of larvae of filariae. Laboratory diagnostics and prevention of dracunculosis [dracunculiasis, dracontiasis] and filariases (bancroftian filariasis, Malayan filariasis, onchocercosis, loiasis [loaiasis] and dirofilariasis). Special features of diagnostics and treatment of dracunculosis.
   • Vectors: mosquitoes for *Wuchereria* and *Brugia*, black fly = sand fly (*Simulium*) for *Onchocerca*, deer fly (*Chrysops*) for *Loa*.
5) Transmissible helminthoses and helminthoses characterized by natural foci.
6) Mollusks, arthropods and chordates as intermediate hosts of helminths. Importance of arthropods in the life of nematodes.
7) The principles and procedures of microscopic diagnostical methods for investigation of excrements, water, soil, etc. Scatological analysis: method of native smear, Kato’s technique, Fülleborn's method, Graham's method (adhesive tape), their advantages and disadvantages. Special features of the structure of eggs of flukes, tapeworms, and roundworms. Microscopic examination of urine, blood, and phlegm on helminthoses. Method of trichinelloscopy. Im-

munodiagnosis of helminthoses.

Methods of laboratory investigation of faecal specimens

Faecal specimens are examined for the presence of protozoa, larvae of helminths, and eggs of helminths. Adult worms and segments of tapeworms also can be found.

1. Macroscopic examination of stool. Specimens containing blood and mucus should be examined first, followed by liquid specimens. Adult worms and segments are usually visible to the naked eye.

2. Microscopic examination of stool.

a) **Native smear**. A wet mounts can be prepared directly from faecal material. Two drops of 50% glycerol solution are placed in the centre of the left half of the slide and two drops are placed in the centre of the right half of the slide. Two slides are used. With a stick, a small portion of the specimen (30-50 mg) is picked up and mixed with the drop. Four smears are prepared and examined under low magnification.

b) **Kato technique (thick-smear)**. 100 mg of the specimen are placed in the centre of the slide and covered by a piece of cellophane impregnated by 50% glycerol solution. The specimen is pressed and stored during an hour. Then this specimen is examined under low magnification.

c) **Concentration techniques**. Flotation methods or formalin-ether method can be used. In the former Soviet Union, methods of flotation developed by Fülleborn and Kalantaryan are used. In these methods particles of a material can be separated according to their relative capacity for floating on a liquid. In Fülleborn technique, saturated solution of NaCl is used (density is 1.2 g/ml), eggs of dwarf tapeworm and nematodes float, but eggs of *Taenia* sp., flukes and unfertilized eggs of *Ascaris* sink; sediment is also examined. In Kalantaryan technique, saturated solution of $NaNO_3$ is used (density is 1.38 g/ml), most of eggs float (sediment is not examined), but eggs of flukes and oncospheres of *Taenia* sp. sink.

8) K. I. Skryabin's doctrine on deworming, devastation, and disinfection of environments (elimination of eggs and larvae of helminths).

9) Characteristic of the phylum Annelids (Latin name Annelida) and class Hirudinea. Leeches. European medicinal leech [German leech, Swedish leech] *Hirudo medicinalis:* biology, usage in medicine.

• **Annelids** are a phylum (*Annelida*) of elongated segmented worms. It includes earthworms, leeches, and other worms. Members of this phylum have bodies divided into segments by rings on the outside (metameric body).

Skin cells secrete a transparent, porous outer body layer – the **cuticle**. Annelids are more complex than flatworms and roundworms. Partitions divide the body on the inside so that segmentation occurs on the inside as well as on the outside. Each segment contains muscles, a digestive tube, a nerve cord, blood vessels, and excretory organs. Segments can specialize in different tasks. Worms have a closed circulatory system. Several segments might pump blood and contain a heart. Other segments might contain a brain and direct the activities of other segments. The space between the body wall and the digestive tube is a cavity lined by mesoderm; this cavity is called the **coelom**. It has a fluid under pressure. Organs of movement are parapodia, paired lateral extensions on each segment, that may be used in swimming, crawling, and burrowing.

• **Leeches** are numerous flesh-eating or bloodsucking worms, usually freshwater worms. *Hirudinea* is the class of annelids whose members are characterized by bodies with 34 segments and have anterior and posterior suckers. They lack parapodia. The leech coelom has lost its metameric partitioning, septa are lost. Leeches prey on small invertebrates or feed on the blood of vertebrates, including human blood. Leeches are sometimes called parasites, but describing leeches as predatory is probably more accurate. The mouth of medicinal leech is armed with three chitinous jaws. Salivary glands secrete an anticoagulant called hirudin that prevents blood from clotting. Hirudin is a protein and consists of 65 amino acids. It is capable to dilate blood vessels (it serves as vasodilator). All leeches reproduce sexually and are monoecious (hermaphrodites). Hirudinization, or leeching, is the method of using of medicinal leech in medicine. Leeches are used in therapy of thrombophlebitis, hypertension, and glaucoma.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 315–331.
2. Lazarev K. "Medical Biology" (2003), pp. 432–450, 453, 514–515, 559–560, 563, 564, 566.

==========

Practical Class Work.

1) **Fill in** the table 8-B, write Latin names of parasites.
2) **Draw** incapsulated larva of *Trichinella spiralis* in muscles. Pay attention to

the shape of the capsule and position of larva. Indicate larva, capsule, and muscles.

3) **Draw** the scheme of the distribution of *T. spiralis* in the nature. Indicate the natural focus and the human-associated focus of the disease. Indicate ways of invasion of a man.
4) **View** preparations of leeches.
5) **View** native preparation of house mouse *Mus musculus*.

• **Discuss** problems of deratization (rodent control). Deratization is extermination of rats. It is a complex of measures, directed on elimination of synanthropic rodents. Synanthropic • ecologically associated with humans, for example, synanthropic flies.

Methods of deratization:

1. Mechanical methods are application of traps (mousetraps, rattraps, and live traps, for example enclosure traps, traps with balancing boards) and glue grounds.

2. Chemical methods are the use of food poison containing anticoagulants, treatment of burrows and places of moving of rodents by powdery preparations and sticky poisonous coverages.

3. Biological methods are cats, dogs (rat catchers, ratters), and microbes.

4. Ultrasound for frightening off rodents.

Table 8-B. Roundworms – parasites of man

Name of the parasite	*Invasive stage and mode of invasion of human*	*Localization in human*	*Laboratory diagnostics (material for analysis; stage)*
6. Trichinella			
7. Dragon worm			
8. Bancroft's filaria			
9. Blinding filaria			
10. Eye worm			

Lesson 32. Arthropods. Ticks and Mites

Reading for a lesson.

1) *Terms:* acariases [acarinoses, acarodermatitides], acaricides, aerosol, allergen, allergy, anabiosis, attractant, cephalothorax, cheliceras, chitin, dermatitis, dermatosis, dermatozoonosis, disinsection, dorsal, dust, ectoparasites, emulsion, endoparasites, epidemic, epistome, facetted eye [compound eye], facultative transmissible disease, gnathosoma, hemolymph, hemorrhage, hypostome, imago, insecticides, itch [pruritus], larva, larvicides, local, Malpighian tubes, mange, metamorphosis [metaboly], molt, nymph, obligate transmissible disease, ommatidium, ovicides, pandemic, pedipalps [palps], pesticides, pheromones, pupa, quarantine, repellents, rosacea, specific and mechanical vectors, sporadic disease, suspension, trachea, transovarial way of transmission of a causative agent, vector of a disease organism, ventral.
2) General characteristic of Arthropods. Classification of the phylum Arthropoda and the class Arachnida.
3) Special features of morphology, feeding, and reproduction of arachnids. Poisonous arachnids (scorpions, spiders). Karakurte *Latrodectus tredecimguttatus*, black widow spider *Latrodectus mactans*, wolf spider *Lycosa* sp.
4) Medical importance of ticks and mites as vectors of causative agents of diseases. Ticks that are vectors of diseases: systematics, life cycles, hosts. Transovarial way of transmission of causative agents. Ixodid ticks (hard ticks, ticks of the Ixodidae family): taiga tick *Ixodes persulcatus*, castor-bean tick *I. ricinus*, brown dog tick *Rhipicephalus sanguineus*, Pacific Coast tick *Dermacentor occidentalis*, *Hyalomma marginatum*. Argasid ticks (soft ticks, ticks of the Argasidae family): *Ornithodorus* spp. Mites of the Gamasoidea superfamily, Dermanyssidae family: tropical rat mite *Ornithonyssus bacoti* and house mouse mite *Allodermanyssus sanguineus*. Diseases that are transmitted by ticks and mites.

   • *Ixodes persulcatus* is a vector of spring-summer encephalitis (European and Siberian subtypes) and babesioses. *Ixodes ricinus* is a vector of Lyme disease. *Ixodes persulcatus*, *I. ricinus*, *Dermacentor pictus*, and *D. marginatus* are vectors of Omsk hemorrhagic fever. *Rhipicephalus sanguineus* is a vector of ehrlichiosis and babesioses in dogs and other mammals. *Hyalomma marginatum* is a vector of Crimean-Congo hemorrhagic fever. Some ixodid ticks are vectors of tularemia. *Ornithodorus* spp. is a vector of endemic relapsing fever, Q-fever, and other diseases. *Ornithonyssus bacoti* is a vector

of plague and Q fever. *Allodermanyssus sanguineus* is not a vector.

5) Mites of the order Acariformes as causative agents of diseases. The Sarcoptidae family: itch mite [mange mite] *Sarcoptes scabiei* – morphology, life cycle, pathogenic influence, diagnosis and prevention of scabies [sarcoptic mange]; Norwegian scabies [Norwegian itch]. The Demodicidae family: follicle mite *Demodex folliculorum* – morphology, pathogenic influence, diagnosis and prevention of demodicosis [demodectic mange]. The Epidermoptidae [Pyroglyphidae] family: house dust mites (*Dermatophagoides pteronyssinus* and others) as inhabitants of houses, their medical importance.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 337–347.
2. Lazarev K. "Medical Biology" (2003), pp. 462–476, 561, 568, 572–574.

==========

Practical Class Work.

1) **Fill in** the table 9-A, write Latin names of parasites.
2) **Draw** life cycle of *Ixodes* sp. Pay attention to the difference between larva, nymph, and imago.
3) **Draw** the structure of mouth organs of *Ixodes* sp. Indicate hypostome, epistome, chelicerae, and pedipalps.
4) **View** microscopic specimens of the larva of chicken mite *Dermanyssus gallinae* and native preparations of imagoes of hard ticks. Compare sizes of hungry female and female after blood sucking.
5) **Draw** itch mite *Sarcoptes scabiei*.

Table 9-A. Medical importance of arthropods

Name of the organism	*Parasitic stage*	*Medical importance*
1. Taiga tick		
2. *Ornithodorus*		
3. *Hyalomma*		

Name of the organism	*Parasitic stage*	*Medical importance*
4. Itch mite		
5. Follicle mite		

Lesson 33. Insects: Lice, Cockroaches, Bugs, and Fleas

Reading for a lesson.

1) *Terms:* aerosol, attractant, complete metamorphosis DDT, dermatitis, dermatozoonosis, disinsection, dust, facultative transmissible disease, imaginal disks, incomplete metamorphosis, insecticides, itch [pruritus], larvicides, , nit, obligate transmissible disease, ootheca, ovicides, pesticides, pheromones, pupa, repellent, suspension.
2) General characteristic of the class Insecta. Special features of morphology, feeding, and reproduction of insects. Types of mouthparts and types of legs in insects. Progressive and regressive changes in the organization of insects depending on habitat. Types of development of insects (with complete and incomplete metamorphosis); development of an insect in a pupal form.
    - The following types of mouthparts can be found in insects:
        - a) chewing type,
        - b) sponging [lapping] type (it includes a proboscis with a superficially enlarged tip, the surface of which consists of halfmoon-shaped plates (labella) surrounding the mouth; foods dissolved by excretion of saliva are ingested in liquid form via the superficial capillary channels, which lead to the mouth; these mouthparts are present in *Musca*),
        - c) cutting-sponging (cutting-lapping) type (mandibles are modified as sharp blades and the maxillae appear as long stylets; both may cut the host's skin; these mouthparts are present in tabanids),
        - d) piercing-sucking type (proboscis is used for blood sucking; two different channels are formed by the mouthparts, the larger one is used as a food canal, while the other conveys saliva containing an anticoagulant and several other substances; these mouthparts are present in mosquitoes, tsetse flies, other flies, lice, bedbugs, and fleas).
3) Lice: morphology, life cycle, feeding. Head louse *Pediculus humanus capitis [Pediculus capitis],* clothes louse *Pediculus humanus humanus [Pediculus humanus corporis, Pediculus vestimenti],* and crab louse [pubic louse] *Phthirus pubis [Phthirus inguinalis]*. Medical importance of lice; modes of invasion of a man with transmitted diseases. Control of lice.
4) Cockroaches, bugs (bed bugs and triatomine bugs), and fleas: morphology, development cycles, and modes of feeding. German cockroach *Blattella germanica*, oriental cockroach *Blatta orientalis*. Bed bug [bedbug] *Cimex lectu-*

larius and big bedbug [giant bed bug] *Triatoma sanguisuga*. Human flea *Pulex irritans* and rat flea *Xenopsylla cheopis*. Medical importance of cockroaches, bugs and fleas, their role as infection vectors; modes of invasion of a man with diseases. Control of cockroaches, bugs, and fleas.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 347–348, 356–361.
2. Lazarev K. "Medical Biology" (2003), pp. 476–482, 561.

==========

Practical Class Work.

1) **Fill in** the table 9-B, write Latin names of parasites.
2) **View** microscopic specimens of head louse and its nits (eggs) attached to hair, specimen of crab louse. **Draw** hair with a nit. Pay attention to the shape of a nit and layer of glue that attaches a nit to hair.
3) **View** stages of the development of cockroaches (ootheca with eggs, larva, nymph, and imago).
4) **Draw** life cycle of a flea (imago and larva in detail).
5) **View** microscopic specimens of rat flea, cat flea *Ctenocephalides felis*, and dog flea *C. canis*.

Table 9-B. Medical importance of arthropods

Name of the organism	*Parasitic stage*	*Medical importance*
6. Head louse		
7. Clothes louse		
8. Crab louse		
9. German cockroach		

Name of the organism	*Parasitic stage*	*Medical importance*
10. Human flea		
11. Bed bug		
12. Big bedbug		

Lesson 34. Dipterans. Medical Importance of Arthropods

Reading for a lesson.

1) *Terms:* accidental parasite [incidental parasite], aerosol, apiculture [bee keeping], attractant, complete metamorphosis, culicide, DDT, dermatitis, dermatozoonosis, disinsection, dust, emulsion, facultative transmissible disease, fumigants [fumigation agents], fumigation, imaginal disks, impregnation, insecticides, itch [pruritus], larvicides, myiases, obligate parasite [true parasite, holoparasite], obligate transmissible disease, ovicides, pesticides, pheromones, pupa, repellent, suspension.
2) General characteristic of the order Diptera. Differences between flies and mosquitoes.
3) Blood-sucking insects: characteristic, importance as intermediate hosts of helminths and vectors of infectious diseases. Dermatozoonoses.
4) The Culicidae family: malaria mosquito *Anopheles* and mosquitoes that do not transmit malaria *(Culex, Aëdes, Mansonia, Culiseta)*. The Simuliidae family (black flies): black fly [sand fly, buffalo gnat] *Simulium*. The Phlebotomidae [Psychodidae] family (sand flies): sand fly *Phlebotomus papatasii*, *Lutzomyia*. The Ceratopogonidae family (midges [biting midges]): *Culicoides*. Morphological features of mosquitoes and flies, breeding places, medical importance (mosquito-bite dermatitis, mosquito-borne diseases).
5) The Muscidae family: housefly [house fly, common house fly, typhoid fly] *Musca domestica,* little housefly *Fannia canicularis,* stable fly *Stomoxys calcitrans.* The Sarcophagidae family (flesh flies): *Wohlfahrtia magnifica*. The Tabanidae family (tabanids, gadflies): horse fly [gadfly] *Tabanus,* deer fly *Chrysops,* rainfall tabanid *Haematopota pluvialis*. The Glossinidae family: tsetse fly *Glossina*. The Oestridae family (nostril flies, botflies): bot fly *Oestrus ovis,* warble fly *Hypoderma bovis*. Myiases.
6) Control of bloodsucking dipterans. Usage of DDT, repellents, electrically heated fumigation mats, *Gambusia* fish.
7) Control of flies that are mechanical vectors of diseases.
8) Medical importance of arthropods: arthropods as intermediate and final hosts of parasites, as causative agents and vectors of diseases, poisonous arthropods; usage of products of apiculture.
    - Products of apiculture: honey, wax, propolis, apitoxin, royal jelly.
9) Examples of anthroponotic and zoonotic diseases, diseases with natural focus,

transmissible diseases, natural reservoirs and vectors.

Literature.

1. Bazhora Yu. et al. "Medical Biology" (Vinnytsia: Nova Knyha, 2018), pp. 349–356.
2. Lazarev K. "Medical Biology" (2003), pp. 482–494, 561, 575–578.

==========

Practical Class Work.

1) **Fill in** the table 9-C, write Latin names of parasites.
2) **View** native preparations and microscopic specimens of larvae, pupae and imagoes of mosquitoes. Pay attention to the head appendages of males and females of *Anopheles*, *Culex* and *Aëdes,* body position during blood sucking (or resting position). Head appendages of mosquitoes include antennae, maxillary palpi, and a proboscis. Pay attention to the differences between eggs of these mosquitoes (*Anopheles* eggs are laid singly on the surface of the water; they are boat-shaped and possess two air-filled floats on either side). Pay attention to the shape of larvae and pupae (worm-shaped or comma-shaped body), and respiratory siphon (present or absent) of larvae, shape of respiratory siphon of pupae.
3) **Draw** larvae and female heads of mosquitos. Designate head appendages.
4) **View** native preparations of pupae of black flies, larvae of botflies, and imagoes of different flies.
5) **View and draw** leg of a fly. Indicate coxa, trochanter (=head of the femur), femur, tibia, tarsus (that consists of five segments), and claws.

Table 9-C. Medical importance of arthropods

Name of the organism	*Parasitic stage*	*Medical importance*
13. *Anopheles*		
14. *Culex*, *Aëdes*		
15. Black fly		
16. Biting midge		
17. Sand fly		

Name of the organism	*Parasitic stage*	*Medical importance*
18. House fly		
19. *Wohlfahrtia*		
20. *Tabanus*		
21. Bot fly		
22. Tsetse fly		

EXAMEN

Information about examen and exam questions is presented ***here***.