



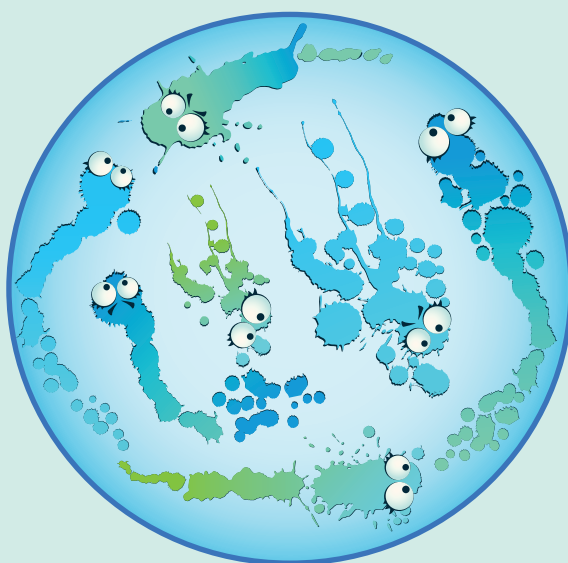
MINISTRY OF HEALTH OF THE RUSSIAN FEDERATION
PIROGOV RUSSIAN NATIONAL RESEARCH MEDICAL UNIVERSITY

Department of Biology. Pediatrics Faculty

INTRODUCTION TO MEDICAL PARASITOLOGY

STUDENT WORKBOOK

Edited by prof. A.G.Mustafin



Moscow
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UDC 576.8(075.8)

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The workbook is intended for students of medical universities enrolled in the educational programs "General Medicine", "Pediatrics", and "Dentistry" to master the discipline "Biology". It includes basic information and practical tasks that help to better understand medical parasitology. The workbook is prepared in accordance with the requirements of the Federal state educational standard of higher professional education in the areas of training 31.05.02 "Pediatrics", 31.05.01 "General medicine", 31.05.03 "Dentistry".

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TOPIC 1. PARASITIC PROTOZOA. LUMEN-DWELLING PROTOZOA

Protozoa. General characteristics

Protozoa are **unicellular eukaryotic organisms**. Their cells are typical eukaryotic — they have one or more nuclei and organelles for general and special purpose. *Protozoa* are free-living, symbiotic or parasitic organisms. There are about 60,000 species of protozoa of which 10,000 are parasitic. Protozoan cells vary in size from 1 micrometre to several millimetres (or more for some free-living organisms), their cytoplasm often has a clear outer region — ectoplasm and inner more fluid — endoplasm. Feeding and digestion is by **endocytosis**, soluble nutrients are absorbed. Gas exchange is through the cell membrane surface. Locomotion is by formation of **pseudopodia** or by means of beating **cilia** or **flagella**. **Asexual reproduction** is by binary fission or multiple fission (schizogony). **Sexual reproduction** is by copulation or conjugation (in Infusoria). If external conditions are unfavorable a **cyst** may be formed: locomotive organelles and excess water are removed and a protective covering is secreted. Active form of a protozoon is referred to as a **trophozoite**.

Some parasitic *Protozoa* inhabit human digestive tract if their cysts have been swallowed; others parasitize in tissues and are transmitted by an insect — **vector**. Some of them are **commensals** — they live in human body without making any harm to the host, and there are very few opportunistic (facultative) parasites.

Protozoa of medical importance belong to classes *Sarcodina*, *Flagellata*, *Ciliophora*, and *Sporozoa*. According to their location in human body, *Protozoa* may be divided into two groups: lumen-dwelling protozoa and tissue-dwelling protozoa.

Lumen-dwelling Protozoa

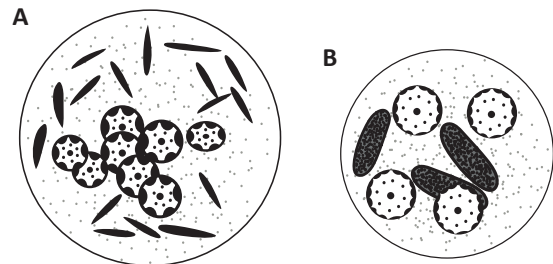
This group includes *Entamoeba histolytica*, *Giardia lamblia* and *Balantidium coli* that are parasites of digestive tract, and *Trichomonas vaginalis* that inhabits genitourinary organs. Their life cycles are simple with only one host. *Entamoeba coli* is a commensal. Among different amoebas that dwell human digestive tract only *E. histolytica* is parasite that causes serious damage to human host. All these parasites except *Trichomonas vaginalis* can form cysts when they get into the environments.



Task 1.1. Draw the life stages (forma magna, forma minuta, and cyst) of *Entamoeba histolytica*. Mark: 1 — nucleus with 2 — nucleosome and 3 — peripheral chromatin; 4 — ectoplasm; 5 — endoplasm; 6 — ingested red blood cells.



Task 1.2. Analyze cysts of two amoebas. Give the names of the species, describe the distinctive features of the cysts.



Species	Cyst features



Task 1.3. Draw the trophozoite and the cyst of *Giardia lamblia*. Mark: 1 — nucleus; 2 — suction disc; 3 — axostyle; 4 — cyst membrane; 5 — flagella.



Task 1.4. Draw the trophozoite and the cyst of *Balantidium coli*. Mark: 1 — macronucleus; 2 — micronucleus; 3 — contractile vacuole; 4 — digestive vacuole; 5 — cytopharynx; 7 — anal pore; 8 — cilia; 9 — cyst shell.



Task 1.5. Draw *Trichomonas vaginalis*. Mark: 1 — nucleus; 2 — undulating membrane; 3 — axostyle; 4 — flagellae.



Task 1.6. Fill in the fields of the form “Lumen-dwelling Protozoa”:

Class Sarcodina. *Entamoeba histolytica*

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Class Flagellata. *Giardia lamblia*

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Class Flagellata. *Trichomonas vaginalis*

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Class Ciliata. *Balantidium coli*

- Name in Russian _____
- Location in human and main symptoms of invasion _____

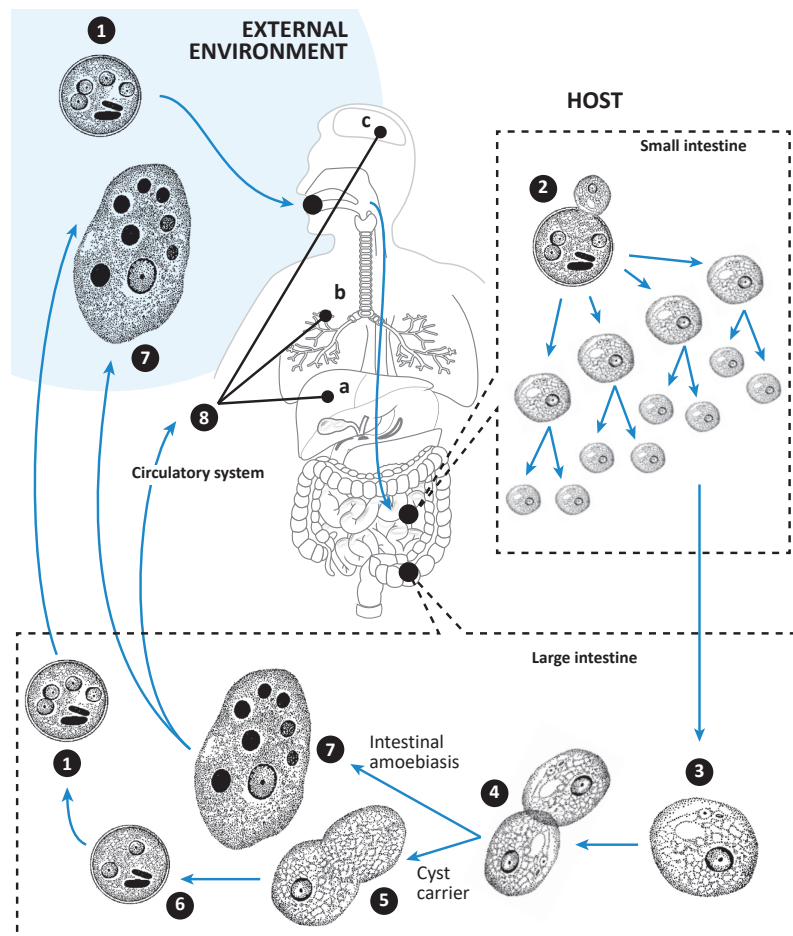
- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____



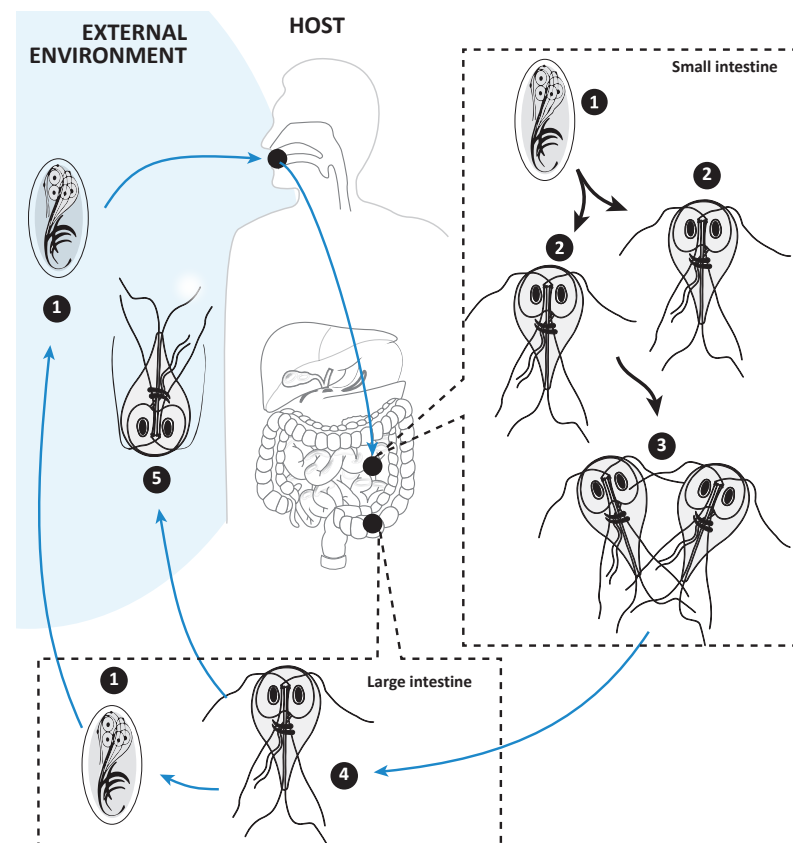
Task 1.7. Study life cycle of *Entamoeba histolytica*. Indicate stages of the life cycle that are not marked in the table below and mark diagnostic (D) and invasive (I) stages.

	Life stage
1	
2	Excystation (four small cells emerge from one cyst, each of which divides once to produce eight trophozoites)
3	
4	Reproduction f. minuta by mitotic division
5	
6	
7	Hematophage (f. magna)
8	



Task 1.8. Study *Giardia lamblia* life cycle. Indicate stages of the life cycle that are not marked in the table below and mark diagnostic (D) and invasive (I) stages.

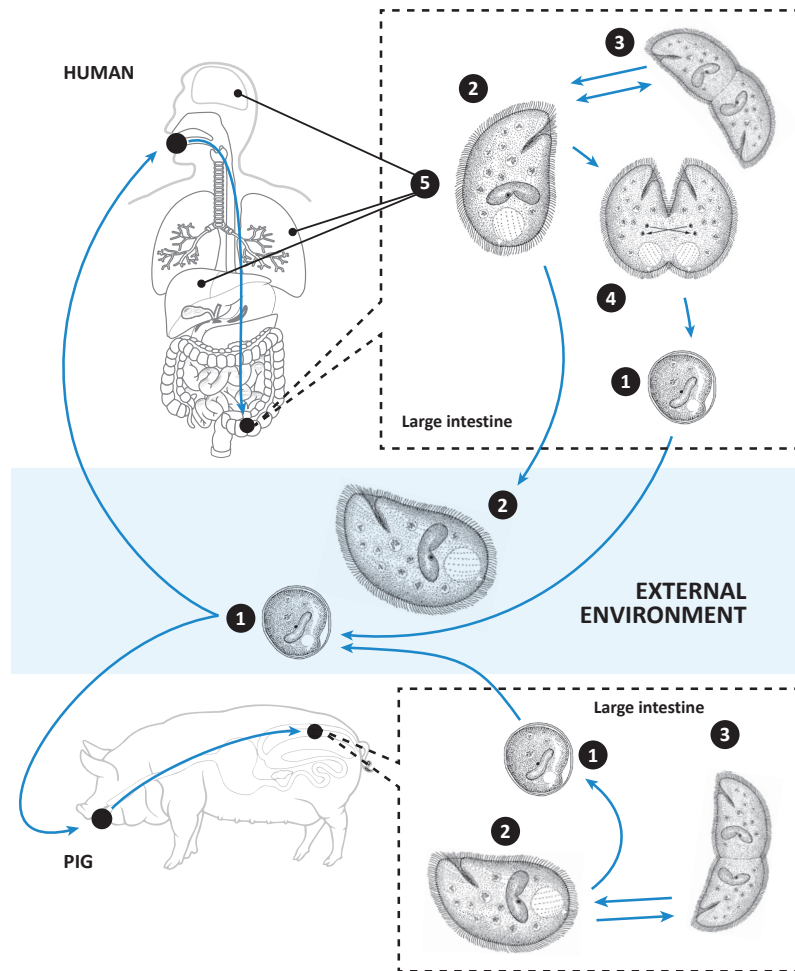
	Life stage
1	
2	
3	
4	
5	Death of trophozoite





Task 1.9. Study *Balantidium coli* life cycle. Indicate stages of the life cycle that are not marked in the table below and mark diagnostic (D) and invasive (I) stages.

	Life stage
1	Cyst (cysts are formed extremely rarely in the human body)
2	
3	
4	Sexual conjugation (it is observed very rarely, only in the human body)
5	Atypical localization because of spread of trophozoites by blood flow with the formation of abscesses in liver, lungs, and brain.



Task 1.10. Match each of the key terms (column A) with its corresponding definition (column B):

COLUMN A

- (1) Trophozoite
- (2) Cyst
- (3) Pseudopodia
- (4) Commensal
- (5) Cilia
- (6) Flagella
- (7) Vector
- (8) Undulating membrane

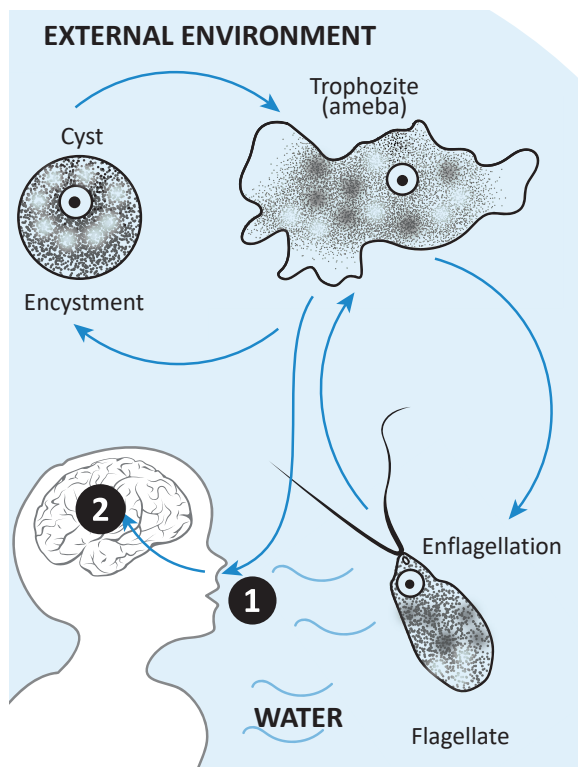
COLUMN B

- (a) long organelle for movement
- (b) dormant stage in Protozoan life cycle
- (c) short but numerous organelles for movement
- (d) organism (insect or tick) that is able to transmit parasite
- (e) fold of the protozoa's cell membrane between the flagellum and the parasite's body
- (f) cytoplasmic protrusions used for movement and phagocytosis
- (g) active and motile form of a Protozoa
- (h) organism that gets food from the host but does no harm no benefit to him

A	1	2	3	4	5	6	7	8
B								

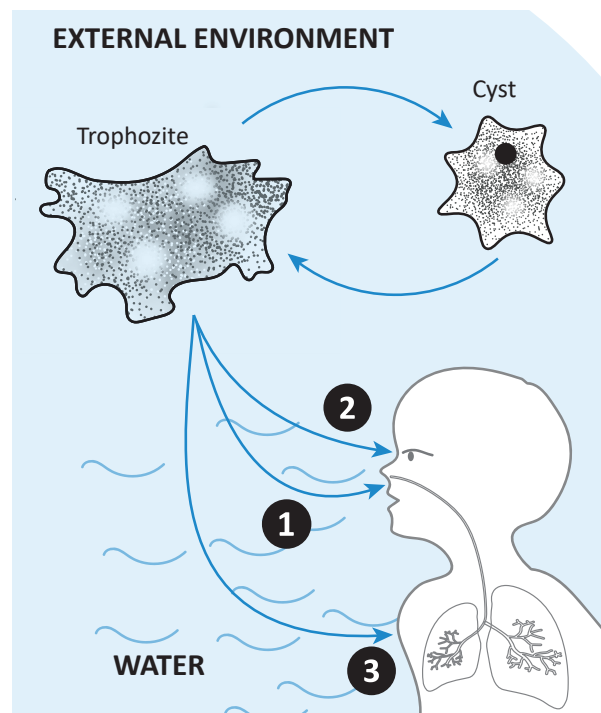
Opportunistic amoebas (examples of facultative parasites)

There are some free-living amoebas that can cause disease in human when they get with contaminated water into human eyes or nasal cavity. Life cycles of such animals are shown in Figures below.



***Naegleria fowleri* life cycle:** 1 — Trophozoites infect humans or animals by penetrating the nasal mucosa; 2 — Trophozoites migrate to the brain via the olfactory nerves causing primary amebic meningoencephalitis (PAM).

Naegleria fowleri trophozoites are found in cerebrospinal fluid (CSF) and tissue, while flagellated forms are occasionally found in CSF. Cysts are not seen in brain tissue.



***Acanthamoeba* spp life cycle:** 1 — Amoebae can enter through nasal passages and infect the lower respiratory tract, that can result in granulomatous amoebic encephalitis and/or disseminated disease in individuals with compromised immune systems; 2 — Amoebae can enter through eyes, resulting in severe eye keratitis; 3 — Amoebae entering through ulcerated or broken skin can cause granulomatous amoebic encephalitis, disseminated disease, or skin lesions in individuals with compromised immune systems.



Home work

Answer the questions using information from textbook «ESSENTIAL MEDICAL BIOLOGY», Chapters 27–29 (pp. 126–137):

1. Which of the lumen-dwelling Protozoa do not form cysts? _____
2. Which morphological forms of *E. histolytica* should be sought in the feces of a patient with an acute stage of amebiasis? With chronic stage?

3. How can we distinguish resistant cyst of *E. histolytica* and *E. coli*? _____

4. What's the difference between parasite and commensal? _____

5. Give two examples of commensal amoebas of human digestive tract: _____

6. Give two examples of opportunistic amoebas: _____

7. How can a human get infected by *Trychomonas vaginalis*? _____

8. What human parasite of phylum *Ciliophora* do you know? _____

9. Discuss the cases:

9.1. In the patient's feces were found some round cysts with 8 nuclei and some oval cysts with 4 nuclei located at one end and an axostyle. What diagnosis could be supposed?

9.2. In the feces of another patient were found big (50mkm) oval cysts with a bean-shaped macronucleus. What diagnosis could be supposed?

9.3. The patient complains of a burning sensation and discharge from the genital tract. The analysis revealed motile cells with flagellae and undulating membrane. What diagnosis could be supposed?

9.4. A 7-year-old boy had fever, diarrhea and pain in his abdomen. Ultrasonography, chest X-Ray and CT scan revealed two abscesses in the posterior segment of right lobe of liver. What protozoan invasion could give these extra-intestinal complications?

9.5. A 5-year-old girl swam in a nearby lake. Within 2 days she developed a severe headache, neck stiffness and eye pain on exposure to light (photophobia). These symptoms are typical of encephalitis. A lumbar puncture revealed 300 mononucleated cells per mm³ and a few neutrophils. Many of these cells were actively motile in a wet mount, suggesting that they were not leucocytes but amebae. Several other children who swam in the same lake also had headaches and mild neck stiffness, but recovered spontaneously. What "mononucleated motile cells" could be in the lake?

TOPIC 2. BLOOD- AND TISSUE-DWELLING PROTOZOA

Blood- and tissue-dwelling protozoa of major medical importance are *Trypanosoma*, *Leishmania* (Class Flagellata), *Plasmodium* and *Toxoplasma* (Class Apicomplexa). Blood- and tissue-dwelling protozoa have complex life cycles: they reproduce sexually in the definitive host and asexually in the intermediate host. All of them except *Toxoplasma* are transmitted by an insect vector.

Class Flagellata. *Trypanosoma* and *Leishmania*

These parasites can exist in different forms: amastigote, promastigote, epimastigote or trypomastigote depending on the position of the flagellum.



Task 2.1. Draw morphological plans of amastigote, promastigote, epimastigote, and trypomastigote. Mark: 1 — nucleus; 2 — kinetoplast; 3 — basal body; 4 — axostyle; 5 — flagellum.

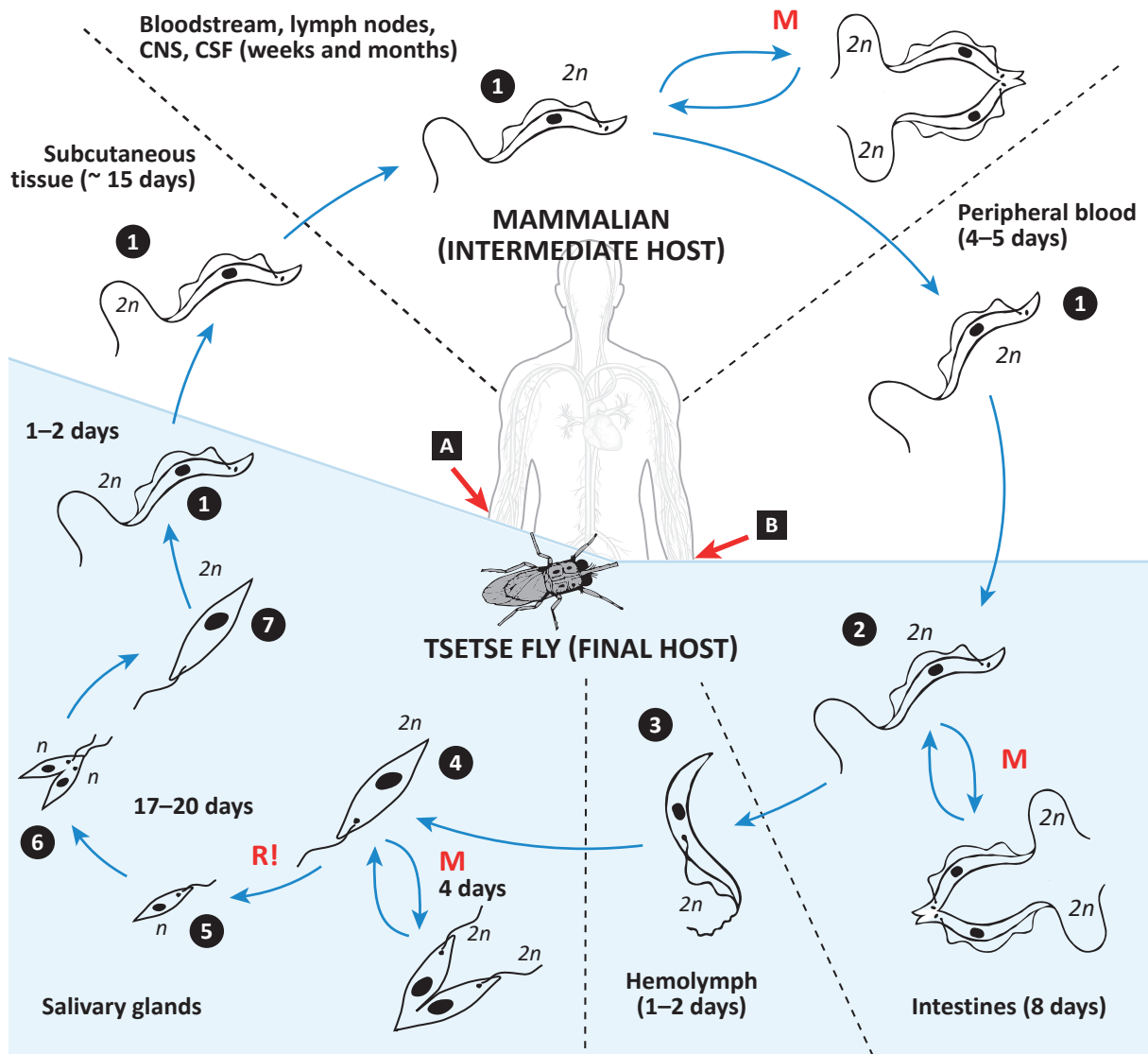


Task 2.2. Mark by different colors distribution area of *Trypanosoma brucei rhodesiense*, *Trypanosoma brucei gambiense* and *Trypanosoma cruzi*.





Task 2.3. Study *Trypanosoma brucei gambiense* life cycle. Indicate stages of the life cycle that are not marked in the table below and mark diagnostic (D) and invasive (I) stages.



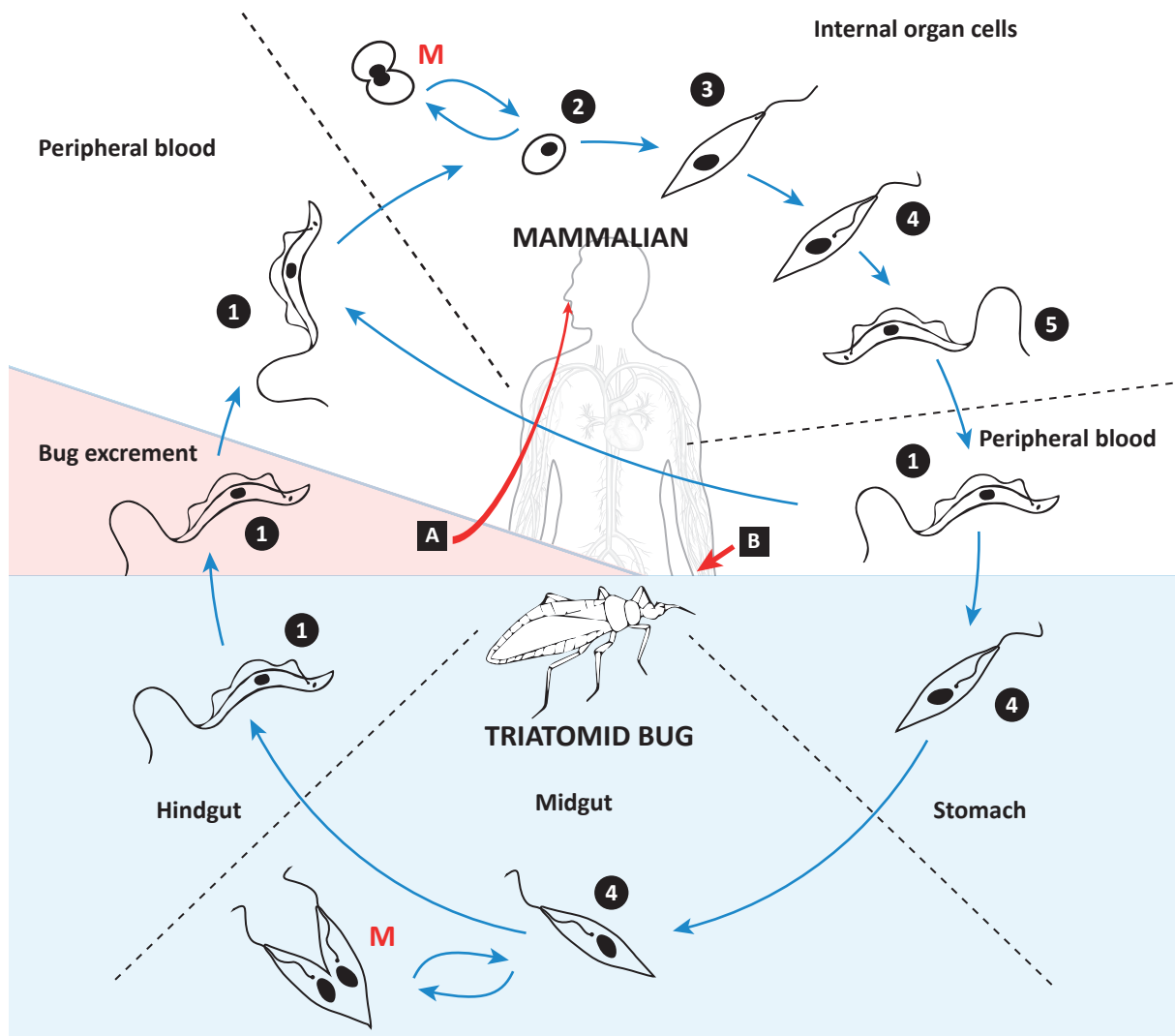
***Trypanosoma brucei gambiense* life cycle:**

A — Transmission of *T. brucei gambiense* to an intermediate host through the bite of an infected tsetse fly. B — Invasion of *T. brucei gambiense* into a tsetse fly when feeding on an infected intermediate host. R! — Meiosis. M — Reproduction by mitotic division.

	Life stage
1	Trypomastigote, metacyclic form
2	
3	
4	
5	
6	
7	Recombinant promastigote



Task 2.4. Study *Trypanosoma cruzi* life cycle. Indicate stages of the life cycle that are not marked in the table below and mark diagnostic (D) and invasive (I) stages.



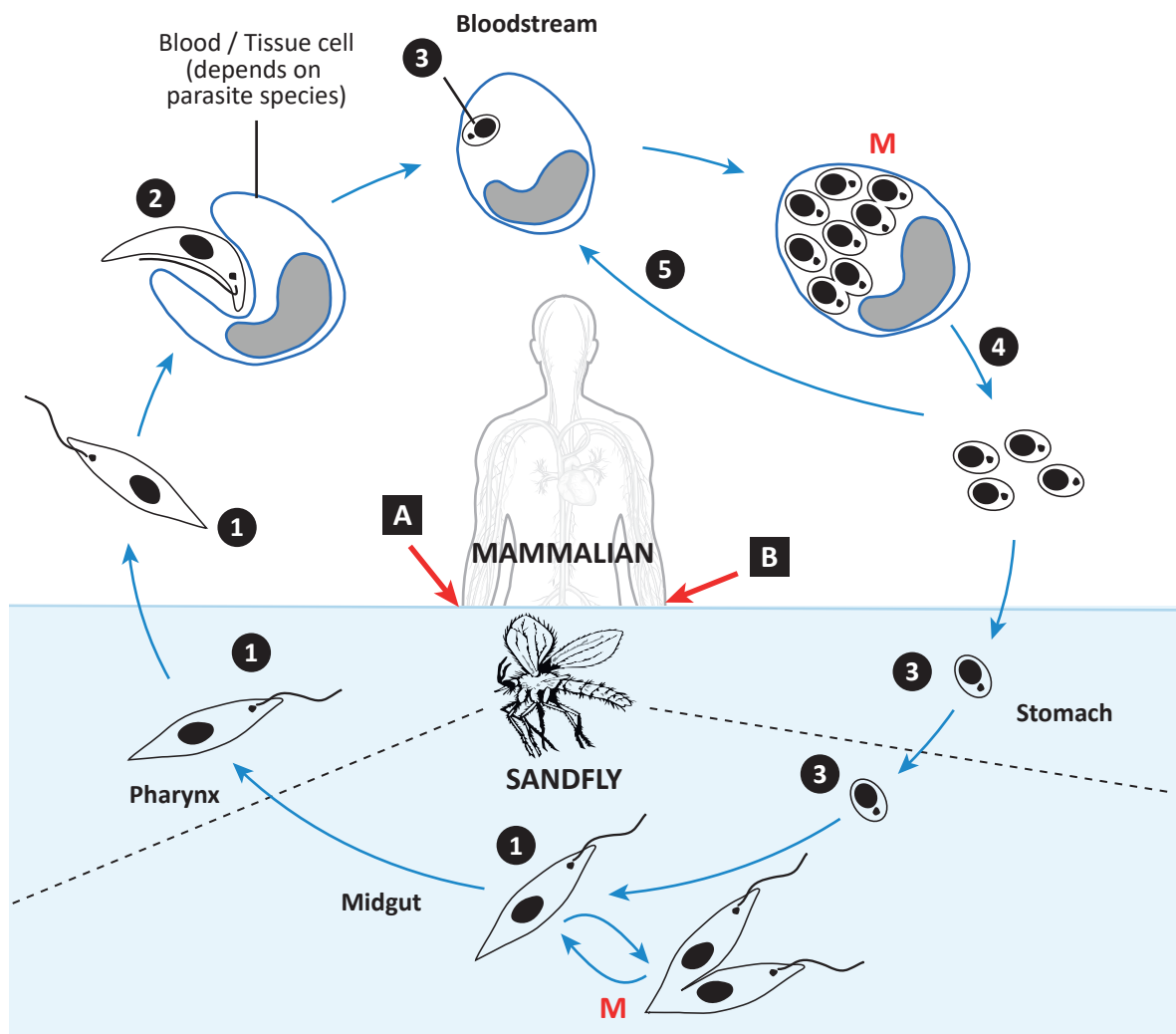
***Trypanosoma cruzi* life cycle:**

A — Invasion by *T. cruzi* from an infected bug during defecation on the skin of a healthy host. B — Transmission of *T. cruzi* to a bug when feeding on the infected host. M — Reproduction by mitotic division.

	Life stage
1	
2	
3	
4	
5	



Task 2.5. Study life cycle of the *Leishmania* in Fig. 8. Indicate stages of the life cycle that are not marked in the table below and mark diagnostic (D) and invasive (I) stages. Which type of human tissues do *L. donovani* prefer for multiplication? And what about *L. tropica* and *L. brasiliensis*? What type of leishmaniasis do they cause?



Leishmania life cycle:

A — Healthy host invasion by *Leishmania* through the bite of an infected sandfly. B — Transmission of *Leishmania* to a sandfly when feeding on the infected host. M — Reproduction by mitotic division.

	Life stage
1	
2	
3	
4	Release of amastigotes from affected cells
5	Infection of new cells with amastigotes

Species	In which tissues parasitize	Disease
<i>L. donovani</i>		
<i>L. tropica</i>		
<i>L. brasiliensis</i>		



Task 2.6. Mark by different colors distribution area of *L. donovani*, *L. tropica*, and *L. brasiliensis*.



Phylum Apicomplexa. Class Sporozoa

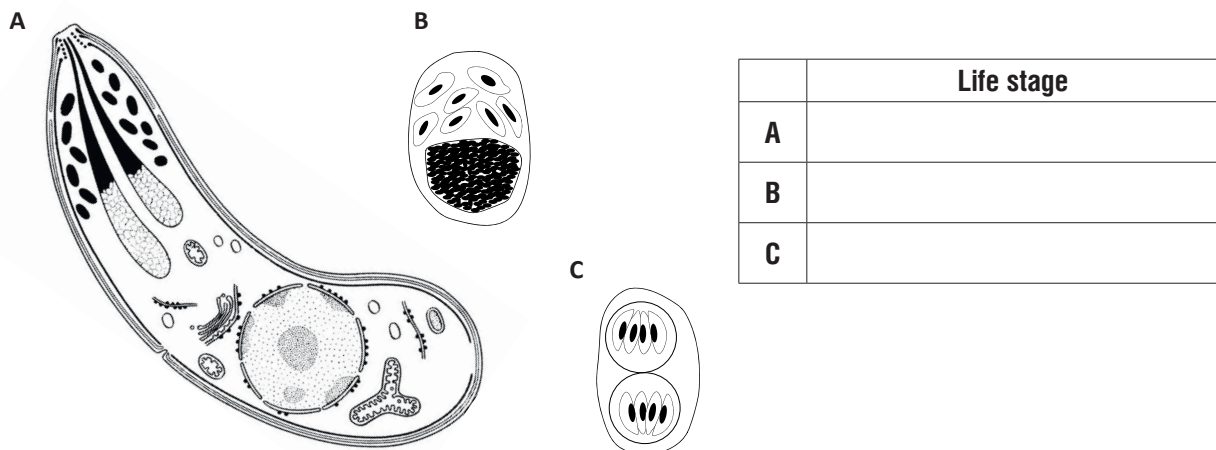
Sporozoa possess a unique form of organelle that comprises a type of plastid called an **apicoplast**, and an **apical complex** (conoid and roptries) structure for penetration into a host's cell.

Sporozoa have a complex life cycle that involves both asexual and sexual reproduction. So, the lifecycle can be divided into three periods: **sporogony**, **gametogony** and **schizogony**. Typically, a host is infected by **sporozoites** that enter his cells. Eventually, the parasitic cells divide asexually (schizogony), releasing **merozoites**, which infect new host cells. This may occur several times, until **gamonts** are produced. The gamonts (gametocytes) in turn give rise to **gametes** (gametogony). Gametes fuse to produce a zygote, then an ookinete, then a sporocyst and new sporozoites (sporogony). Many variations occur on this basic pattern, however.

Toxoplasma gondii



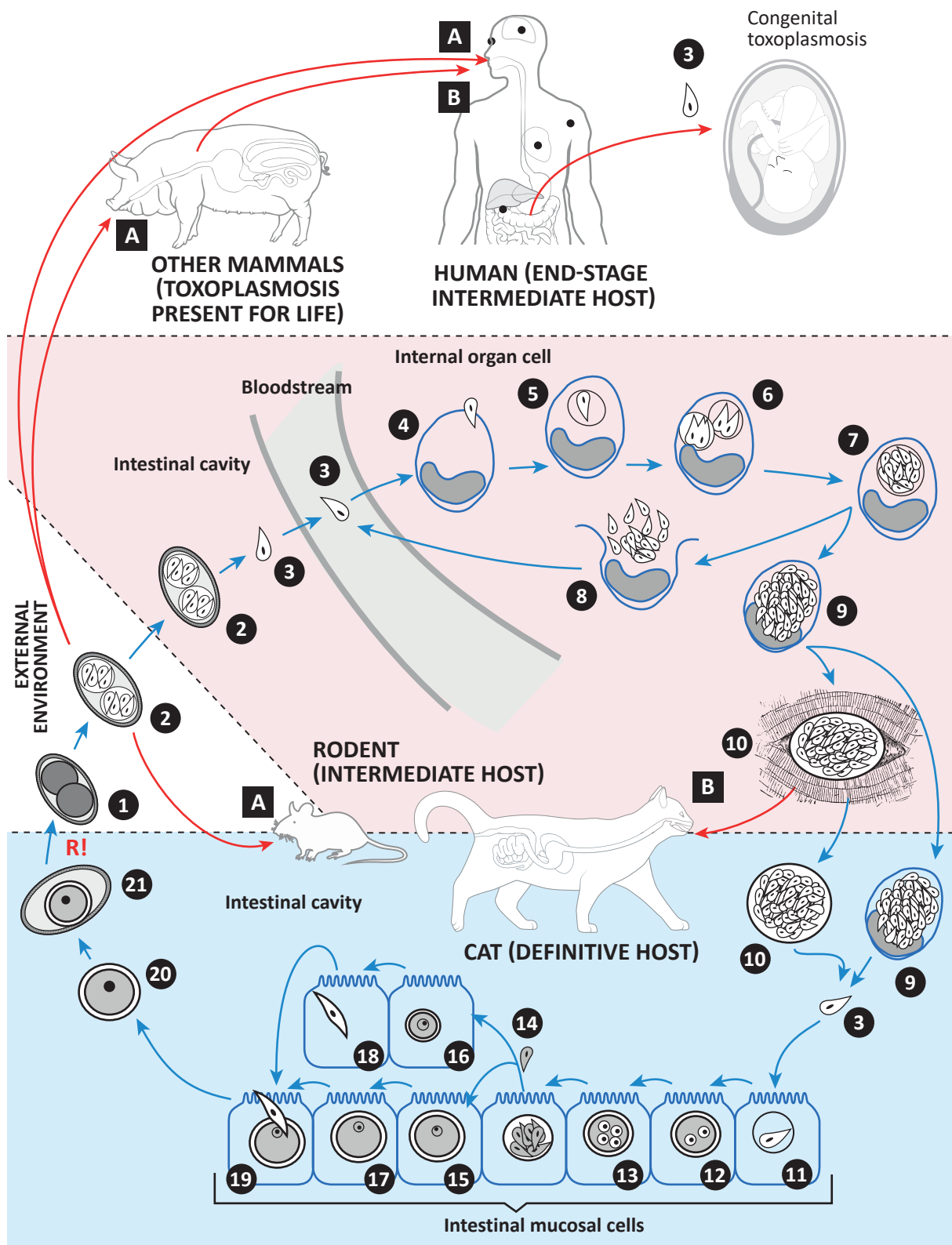
Task 2.7. Indicate *Toxoplasma* life stages¹. Mark: 1 — conoid; 2 — roptria; 3 — Golgi apparatus; 4 — nucleus; 5 — ultracytostom; 6 — mitochondrion; 7 — EPR; 8 — apicoplast.



In humans, *T. gondii* is one of the most common parasites in developed countries. For healthy adults the invasion with toxoplasma is not dangerous, while the infection in pregnant women may lead to abortion, stillbirth or other serious consequences in newborns. Infection in immunocompromised patients can be fatal if not treated. On average, one third of people are chronically infected worldwide, most of infected show no symptoms.

T. gondii is capable of infecting virtually all warm-blooded animals, but cats are the only known definitive hosts in which the parasite may undergo sexual reproduction.

¹Image source: V.A. Dougel, Zoology of Invertebrates. M.: Higher School, 1981



Toxoplasma gondii life cycle:

A — Ingestion of sporocysts in feces. B — Ingestion of cysts. R! — Meiosis. Red arrows — ways of infection transmission. 1 — formation of two sporocysts; 2 — sporocysts with four sporozoites; 3 — sporozoite; 4 — penetration sporozoite into a cell of an intermediate host; 5 — sporozoite in the parasitophore vacuole; 6 — endodiogeny; 7 — pseudocyst; 8 — exit of endozoites from pseudocyst; 9 — intracellular cyst; 10 — tissue (extracellular) cyst; 11 — merozoite in the parasitophore vacuole; 12–13 — development of the schizont; 14 — exit of merozoites from the affected cell; 15 — macrogametocyte; 16 — microgametocyte; 17 — macrogamete; 18 — microgamete; 19 — gamete fusion (copulation); 20 — zygote; 21 — non-sporulated oocyst.



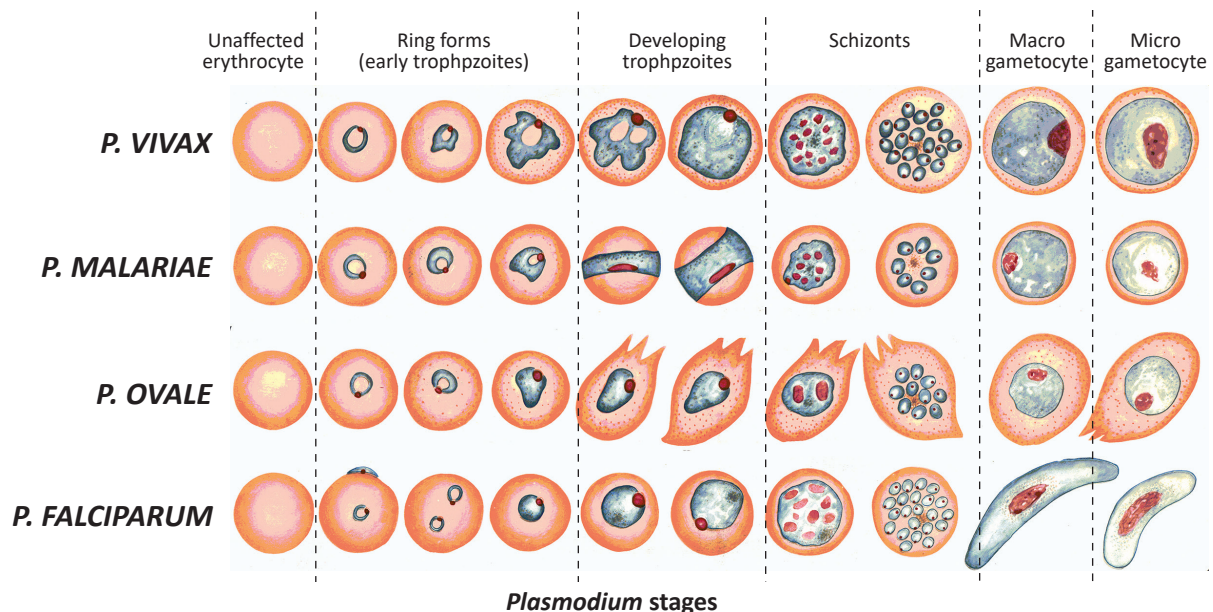
Task 2.8. Study life cycle of *Toxoplasma gondii*. Indicate, where the process takes place (in definitive or in intermediate host).

Process	Gametogony	Sporogony	Schizogony
Host			

Plasmodium spp.

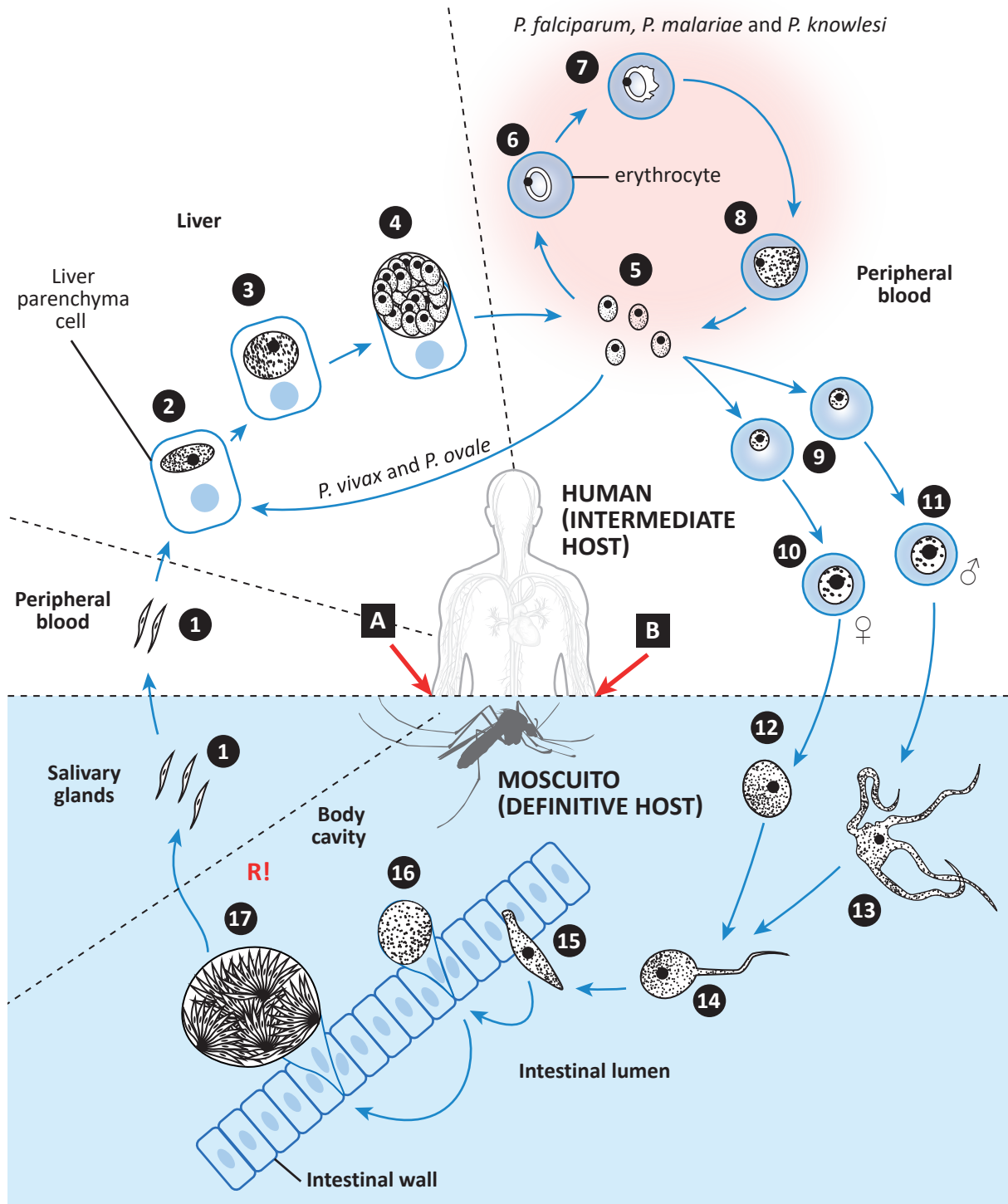
There are four species of parasites that cause malaria in human: *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium vivax*. Some of gene mutations, such as sickle-cell disease, glucose-6-phosphate dehydrogenase deficiency, or Duffy negative blood group and others make a person resistant to malaria.

- *P. malariae*, found worldwide, is the only human malaria parasite species that has a three-day cycle. Three other species have a two-day cycle. If untreated, *P. malariae* causes a long-lasting, chronic infection that in some cases can last a lifetime. In some chronically infected patients *P. malariae* can cause serious complications such as the nephrotic syndrome.
- *P. falciparum* can cause severe malaria because it multiplies rapidly in the blood, and can thus cause severe blood loss (anemia). In addition, the infected parasites can clog small blood vessels. When this occurs in the brain, cerebral malaria results, a complication that can be fatal.
- *P. vivax* is biologically and morphologically very similar to *P. ovale*. Both have dormant liver stages ("hypnozoites") that can activate and invade the blood ("relapse") several months or years after the infecting mosquito bite. However, in contrast from *P. vivax*, *P. ovale* can infect individuals who are negative for the Duffy blood group, which is the case for many residents of sub-Saharan Africa.



Task 2.9. Study *Plasmodium* life cycle shown in Fig. 4. Indicate stages of the life cycle corresponding to the noted biological processes. Mark diagnostic (D) and invasive (I) stages.

Process	Life stages
Preerythrocytic tissue schizogony	
Gamogony	
Erythrocytic schizogony	
Sporogony	



Plasmodium life cycle:

A — Healthy host invasion by *Plasmodium* through the bite of an infected mosquito. B — Transmission of *Plasmodium* to a mosquito when feeding on the infected host. R! — Meiosis. 1 — sporozoites, 2 — exoerythrocytic trophozoites, 3 — exoerythrocytic schizonts; 4 — exit of merozoites from hepatocytes into the blood; 5 — merozoites, 6 — endoerythrocytic trophozoite on ring stage, 7 — mononuclear endoerythrocytic schizont, 8 — multinuclear endoerythrocytic schizont, 9 — developing gametocyte, 10 — female gametocyte, 11 — male gametocyte, 12 — macrogametete, 13 — microgamete, 14 — gamete fusion (copulation), 15 — ookinete (penetration through the epithelium to the outer surface of the middle intestine wall); 16–17 — oocyst development.



Task 2.10. Mark areas where malaria is spread



Task 2.11. Draw the ring form, trophozoite and gametocyte of *Plasmodium falciparum*



Task 2.12. Fill in the fields of the form “Blood- and tissue- dwelling Protozoa”:

***Leishmania tropica* group**

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Leishmania brasiliensis group

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Leishmania donovani group

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Trypanosoma cruzi

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Trypanosoma brucei

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Toxoplasma gondii

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Plasmodium vivax, Plasmodium ovale, Plasmodium malariae, Plasmodium falciparum

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____



Home work

Answer the questions using information from textbook «ESSENTIAL MEDICAL BIOLOGY», Chapters 31–32 (pp. 138–149):

1. What is morphological difference between trypanosoma and leishmania? _____

2. Are the vectors of different forms of leishmaniasis the same or different? What about trypanosomiasis?

3. What parasite causes kala azar? What organisms are involved in its transmission? _____

4. What are the causative protozoa for African trypanosomiasis? What insect serves as a vector?

5. Parasitaemia in the case of African trypanosome invasions persists in spite of strong antibody response. Why?

6. Which stage of *Plasmodium* life cycle is invasive for human? For *Anopheles* mosquito? _____

7. Define hypnozoite. Which species of *Plasmodium* have this stage? _____

8. Define sporozoites, merozoites, shizonts, gamonts: _____

9. Why toxoplasmosis is especially dangerous for pregnant women? _____

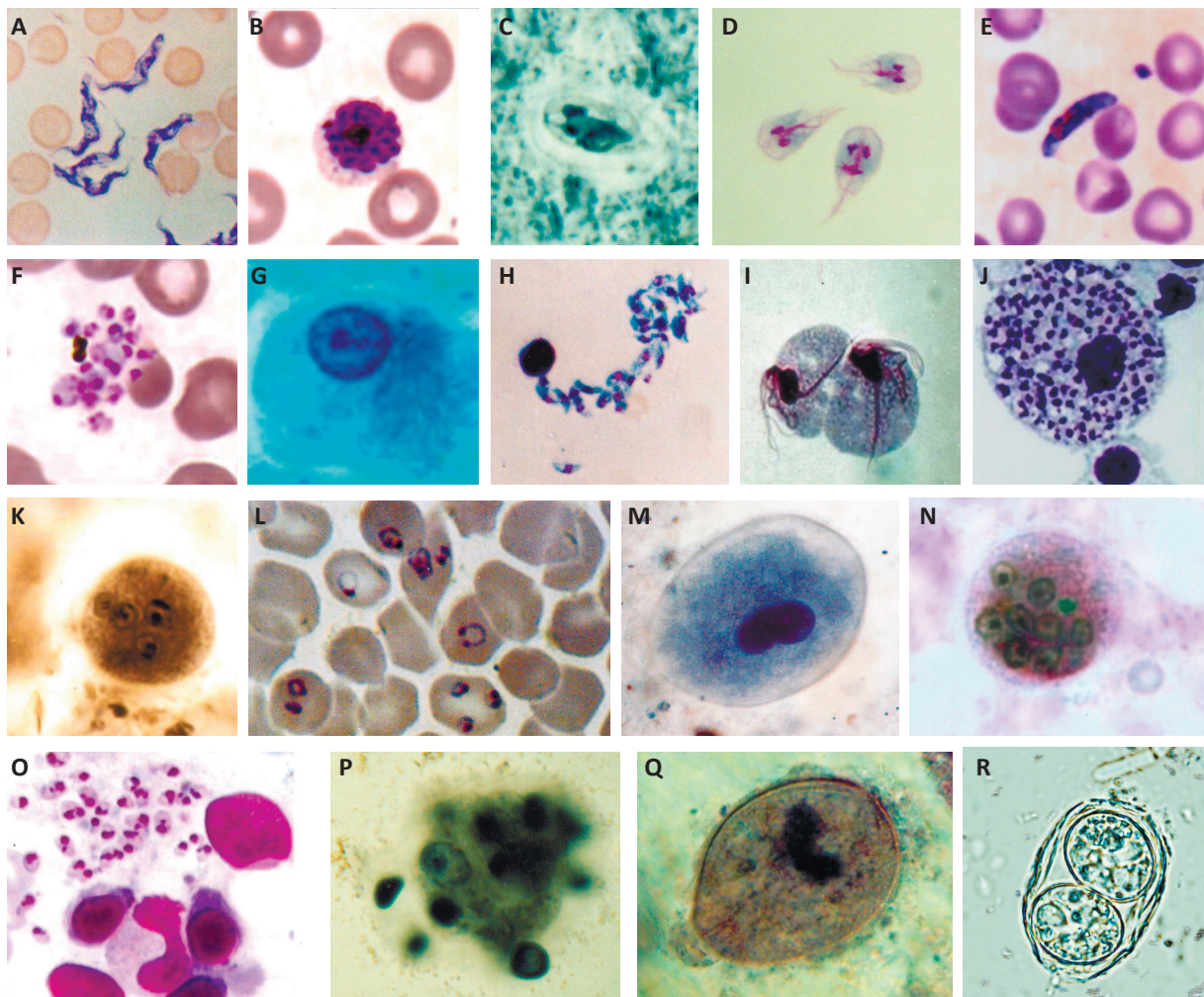
10. What animals are definitive and intermediate hosts for *Toxoplasma*? _____

11. By what means can human be infected with *Toxoplasma*? _____

12. What animal is the definitive host for *Plasmodium*? _____

13. Why sickle cell anemia is very rare at North Europe but common in some tropical regions?

14. Indicate parasites and their stages of development:



	Species (latin name)	Life stage
A		
B		
C		
D		
E		
F		

G		
H		
I		
J		
K		
L		
M		
N		
O		
P		
Q		
R		

15. Study and discuss the cases:

15.1. A patient from Kenya had fevers to 38°C and swollen lymph nodes at the back of his neck (occipital adenopathy or Winterbottom's sign) for 8 months. Two weeks ago, he developed a severe headache, stiff neck, and an aversion to light (photophobia). Trypanosomes were found on Giemsa-stained specimens of blood and cerebrospinal fluid. Suggest the name of the parasite and the method of invasion.

15.2. A 62-year-old Brazilian businessman was complaining of chronic constipation. Radiological examination of his gastrointestinal (GI) tract revealed a large dilated colon (megacolon) and a somewhat less dilated esophagus (megaesophagus). A blood sample revealed antibodies to *T. cruzi*. Because no drugs are effective after the onset of complications, he was not given antiparasitic treatment. Guess how senior R. was infected and give the Latin name of the parasite.

15.3. A student returned from a 6-month expedition to Peru with a nonhealing 2 x 5 cm lesion on his right shin. A smear of a biopsy from the edge of the lesion stained with Giemsa revealed Leishmania-containing macrophages. After anti-protozoan treatment, the lesion began to heal slowly. Suggest the name of the parasite and the method of invasion

TOPIC 3. PHYLUM PLATYHELMINTHES. CLASS TREMATODA (FLUKES)

General characteristics of Platyhelminthes

Platyhelminthes, or flat worms, are multicellular, triploblastic (have ecto-, meso- and endoderm), bilaterally symmetrical animals with unsegmented and dorso-ventrally flattened body. The wall of their body is built of epithelium and three layers of muscles – circular, longitudinal, diagonal – so called skin-muscular sac. Flat worms have no body cavity – they are acoelomates. The space between organs is filled with special type of mesodermal non-differentiated tissue – parenchyma. There are four organ systems: **digestive**, **nervous**, **excretory** and **reproductive**.

There are three classes of the phylum Platyhelminthes:

- **Class Turbellaria** is represented by free-living worms. They are covered with ciliae, have eyes and tactile organs. Example: planaria.
- **Class Trematoda**, or flukes, is represented exclusively by parasites. They possess two suckers, or “tremae”, and are leaf-like in shape and covered with a special protective cuticle – a tegument. Examples: liver, lung, intestinal and blood flukes.
- **Class Cestoda**, or tape worms, are also all parasites. They possess attachment organs – suckers, hooks or bothriae, have a ribbon-like body and no digestive system because they get nutrients via their tegument.

Class Trematoda (Flukes)

All trematodes are parasites, so they develop adaptations to parasitism. They possess protective cuticle – the tegument, have no eyes or tentacles, but reproductive and digestive systems are overdeveloped. Typical characteristic of trematodes are two suckers (tremae). Oral sucker leads into muscular pharynx and then into two branches of intestines which terminates blindly. Second sucker, ventral, serves only for fixation.

Trematodes have a **complex life-cycle**. Typical life-cycle includes: adult (marita) → egg → miracidium → sporocyst → redia → cercaria → encysted cercaria (metacercaria or adolesecaria) → adult. Definitive host is a vertebrate animal, in this host sexual reproduction occurs and fertilized eggs are passed to the environment. Intermediate host is a snail (mollusk), where asexual reproduction takes place. In most Trematodes there is a second intermediate host (fish, crab, or ant).



Task 3.1. Indicate species of flukes in the photos and their sizes:

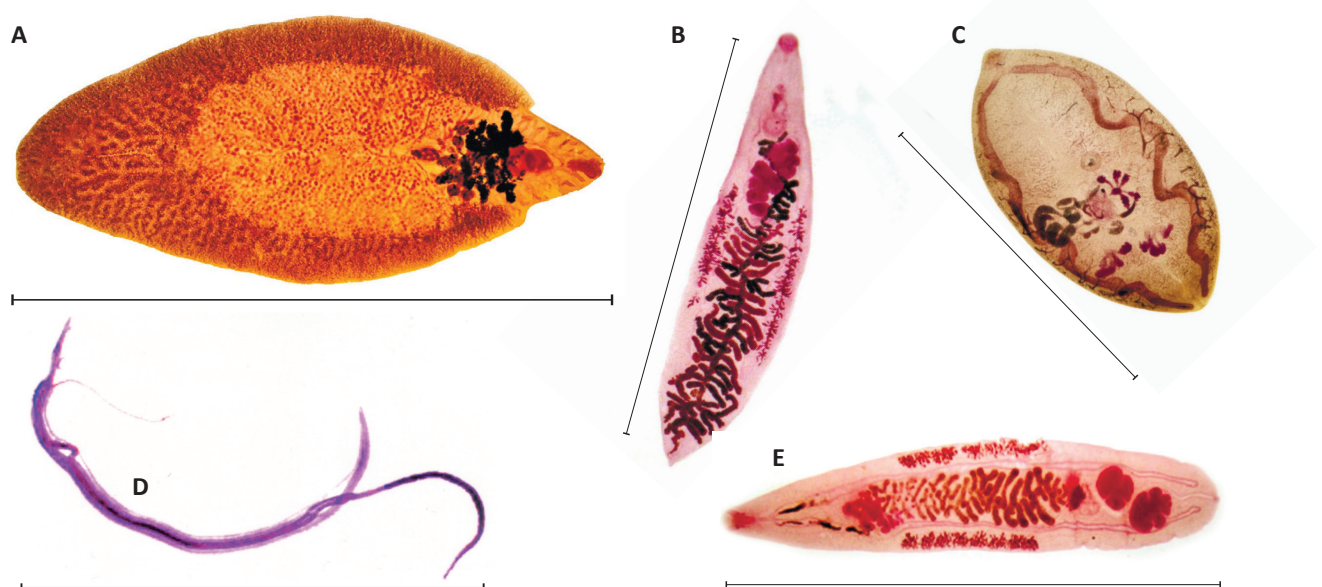


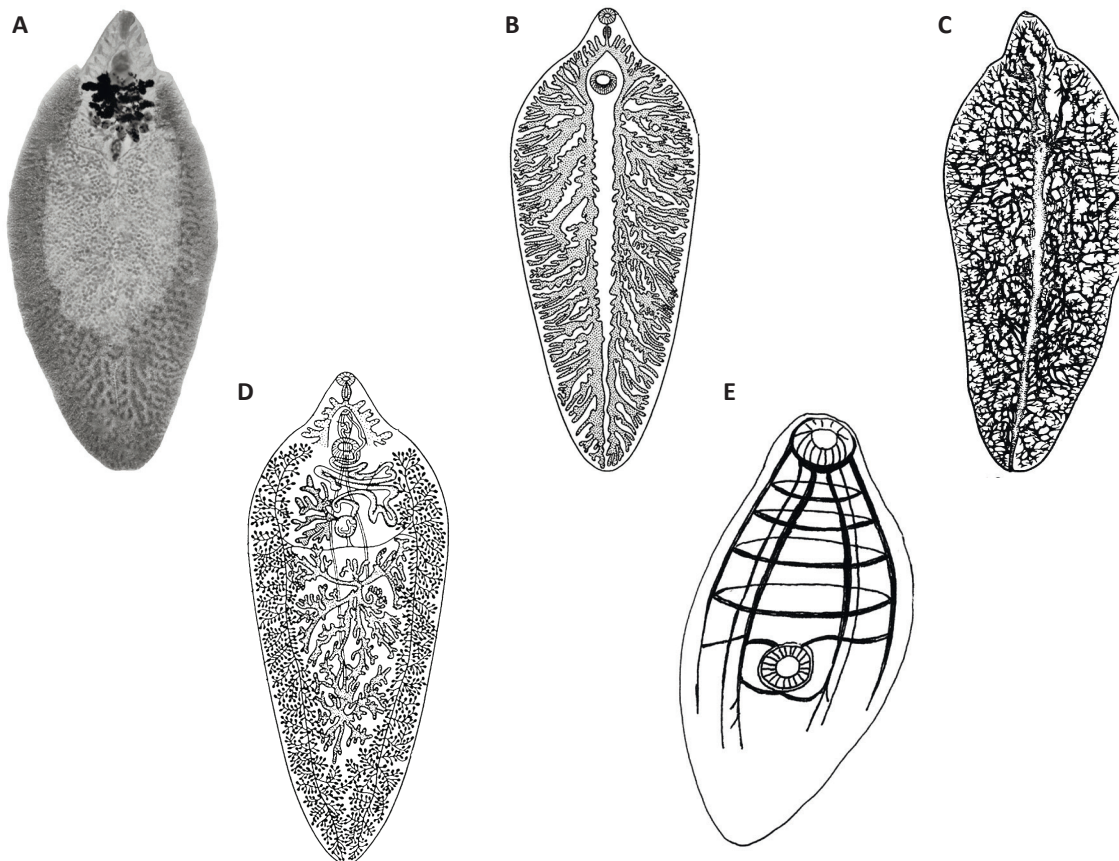
Image					
Species	<i>Opisthorchis felineus</i>	<i>Fasciola hepatica</i>	<i>Schistosoma japonicum</i>	<i>Paragonimus westermani</i>	<i>Dicrocoelium lanceatum</i>

Trematodes that parasitize in human can be divided into four groups: intestinal, liver, lung and blood flukes.

- **Intestinal fluke** *Fasciolopsis buski* inhabits small intestine of herbivorous mammals and human. Clinical symptoms may include abdominal pain and diarrhea.
- **Liver flukes** (*Fasciola hepatica*, *Opisthorchis felinus*, *Clonorchis sinensis*, *Dicrocoelium lanceatum*) are parasites of the liver and may produce changes in the epithelium of bile ducts and fibrosis around them. Massive invasion of any of them leads to portal cirrhosis, with all its associated manifestations. Cancer of liver is more common in these patients. Symptoms of liver trematodosis are: jaundice, ascites, abdominal pain and numerous other symptoms and signs. It is important to remember that often eggs of *Fasciola hepatica* and *Dicrocoelium lanceatum* in patient's feces are spurious and do not prove parasitic invasion. This happens when the patient has eaten the liver of an herbivorous animal (cow, sheep) that had flukes. These eggs are not dangerous for human and cannot cause invasion.
- **Lung fluke** (*Paragonimus westermani*) inhabits lungs and parasitizes in carnivorous mammals and human in Asia and South America. The symptoms of invasion are similar to tuberculosis: cough, bronchitis, and blood in sputum (hemoptysis). If the worm becomes disseminated and gets into the spinal cord, it can cause paralysis; parasites in the heart can cause death.
- **Blood flukes** (Schistosomes): The adult worms inhabit the mesenteric veins (*S. mansoni*, *S. japonicum*), or the veins of the vesical and pelvic venous plexuses (*S. haematobium*). They are responsible for schistosomiasis, which is considered by the World Health Organization as the second-most socioeconomically devastating parasitic disease (after malaria). Unlike other trematodes, the schistosomes are dioecious, i.e., the sexes are separate. They have no redia stage in their life cycle, cercaria has a forked tail and their eggs have no operculum, but a spine.



Task 3.2. Give characteristics of the fluke organ systems¹ and make the designations. (A) Morphology: 1 — abdominal sucker; 2 — oral sucker; 3 — tegument. (B) Digestive system: 1 — abdominal sucker; 2 — oral sucker; 3 — pharynx; 4 — main branches of the intestine; 5 — lateral branches of the intestine. (C) Excretory system: 1 — collecting ducts; 2 — central excretory canal; 3 — excretory pore. (D) Reproductive system: 1 — ovary; 2 — yolk glands; 3 — vitelline ducts; 4 — uterus; 5 — testes. (E) Nervous system: 1 — paired cerebral ganglion; 2 — longitudinal nerve trunks; 3 — ring bridges.



¹Image source: V.A. Dougel, Zoology of Invertebrates. M.: Higher School, 1981

System	Brief characteristic
Digestive system	
Excretory system	
Reproductive system	
Nervous system	



Task 3.3. Draw schistosome male and female, and eggs of *S. haematobium*, *S. japonicum*, and *S. mansoni*



Task 3.4. Match each of the key terms (column A) with its corresponding definition (column B):

COLUMN A

- (1) Flame cells
- (2) Cercaria
- (3) Miracidium
- (4) Marita
- (5) Sporocyst
- (6) Mollusk
- (7) Mehlis (shell) gland
- (8) Adolescarium
- (9) Metacercarium

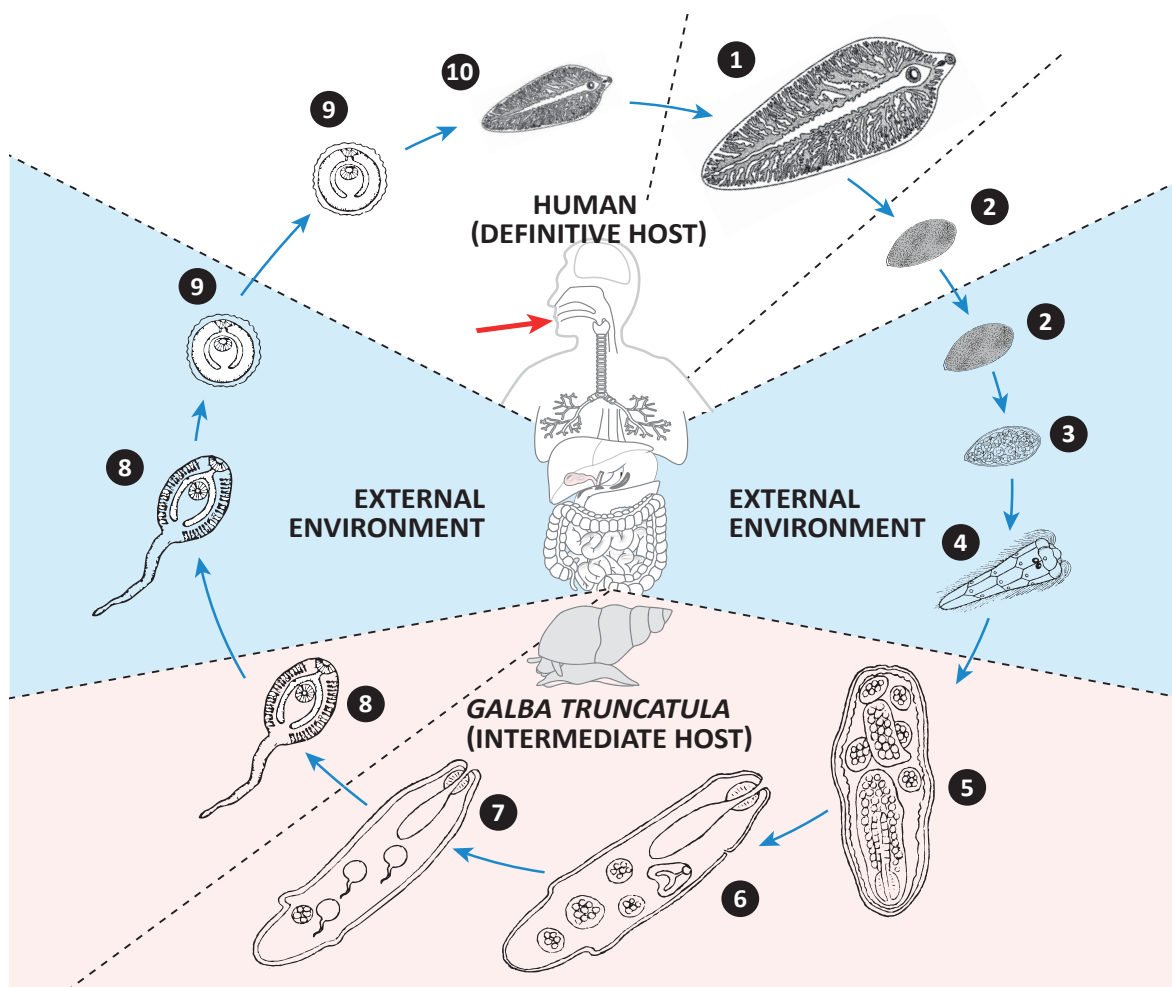
COLUMN B

- (a) This organ in Trematodes can secrete shell around egg
- (b) Dormant larval stage of a liver fluke which is on costal vegetation
- (c) A hollow cell with cilia in excretory system of flat worms
- (d) A larva with tail in Trematodes
- (e) 1st intermediate host in Trematode life cycle
- (f) An adult form of a fluke
- (g) While in mollusk, the miracidium becomes this
- (h) Larva in 2nd intermediate host (fish or crab) invasive for human
- (i) Larva of Trematodes covered with cilia

A	1	2	3	4	5	6	7	8	9
B									



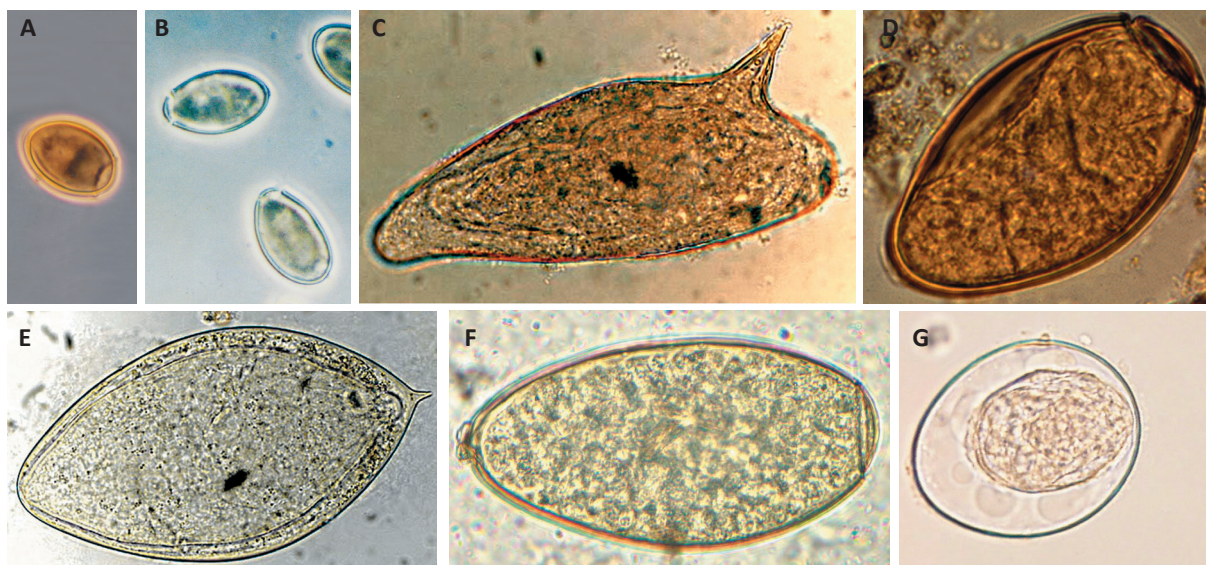
Task 3.5. Study *Fasciola hepatica* (and *F. buski*) life cycle. Indicate stages of the life cycle and mark diagnostic (D) and invasive (I) stages. Which type of human and mollusk tissues do *F. hepatica* use for multiplication?



	Life stage	Tissues / Enviroment
1		
2	Immature egg (D)	Duodenum (human) → External enviroment (feces → water)
3		
4		
5		
6		
7		
8		
9		
10		



Task 3.6. Determine which flukes the eggs belong to. Indicate the size of the eggs, describe their shape and features:



	Latin name of parasite	Size, shape and characteristics of the eggs
A		
B		
C		
D		
E		
F		
G		



Task 3.7. Fill in the fields of the form “Trematodes parasitizing humans”:

Schistosoma mansoni

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____

- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Schistosoma japonicum

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Schistosoma haematobium

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Paragonimus westermanii

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

-
- Prevention of the invasion: _____
-

Fasciola hepatica

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Fasciolopsis buski

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Opisthorchis sinensis, felineus

- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

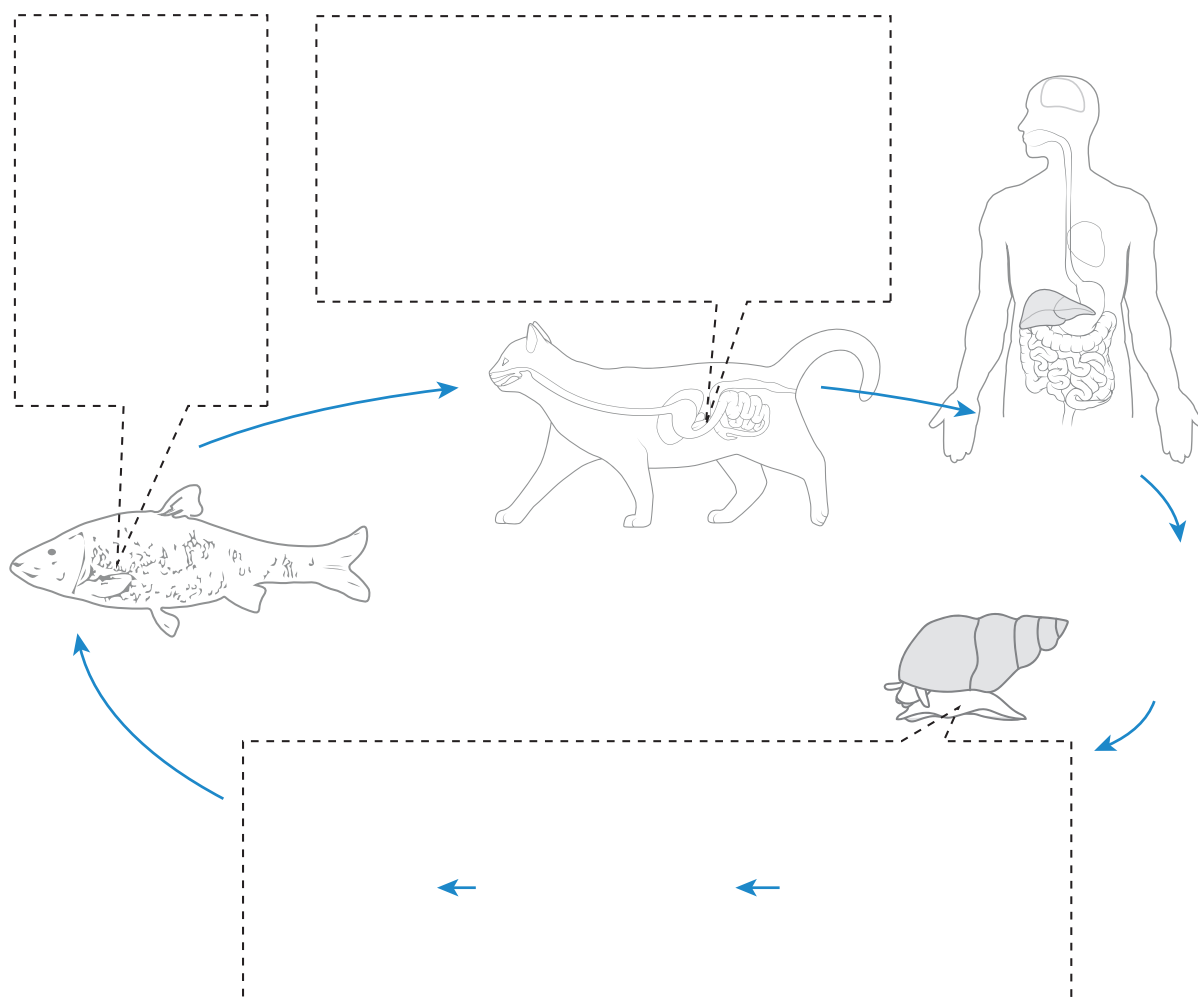
- Prevention of the invasion: _____

Dicrocoelium lanceatum

- Name in Russian _____
- Location in human and main symptoms of invasion _____
- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____
- Prevention of the invasion: _____



Task 3.8. Draw stages of *Opisthorchis felineus* life cycle and make designations of the stages.





Home work

Answer the questions using information from textbook «ESSENTIAL MEDICAL BIOLOGY», Chapters 33–36 (pp. 151 – 161):

1. Name three main classes of phylum Platyhelminthes: _____

2. Name the stages of a Trematode life cycle: _____

3. What species of liver flukes do you know? _____

4. What stage of life-history of different flukes enters the definitive host, the first and second intermediate hosts?

5. Name male and female reproductive organs of flukes. What are their roles? _____

6. Why eating of watercress may be dangerous for man? _____

7. What advice can you give to a person who likes to eat raw or pickled fresh water fish?

8. What purpose does the cercaria stage serve in the life-history of *Schistosoma*? What is “swimmer’s itch”?

9. Explain why though adult schistosomes live in circulatory system, their eggs are found in urine and feces of patient:

10. Why eating of raw fresh-water crabs and crayfish is dangerous? _____

11. If you find dark golden-brown eggs with operculum about 100 mkm in length in patient's sputum, what diagnosis can be proposed?

12. Name typical and atypical locations of *Paragonimus* in human body: _____

13. What adaptations to parasitism in Trematodes do you know? _____

14. Study the cases:

14.1. Analysis shows oval eggs with operculum about 150 mkm in length in feces of the patient. Why can't the diagnosis be made immediately? What should you ask about patient's diet?

14.2. Analysis shows brown eggs with operculum about 30 mkm in length in the patient's feces. What diagnosis can be proposed'?

14.3. A young man is a rice field worker. His urinalysis contains yellowish brown eggs about 150 microns in length with conspicuous terminal spine. What diagnosis may be supposed? In what manner has he been infected?

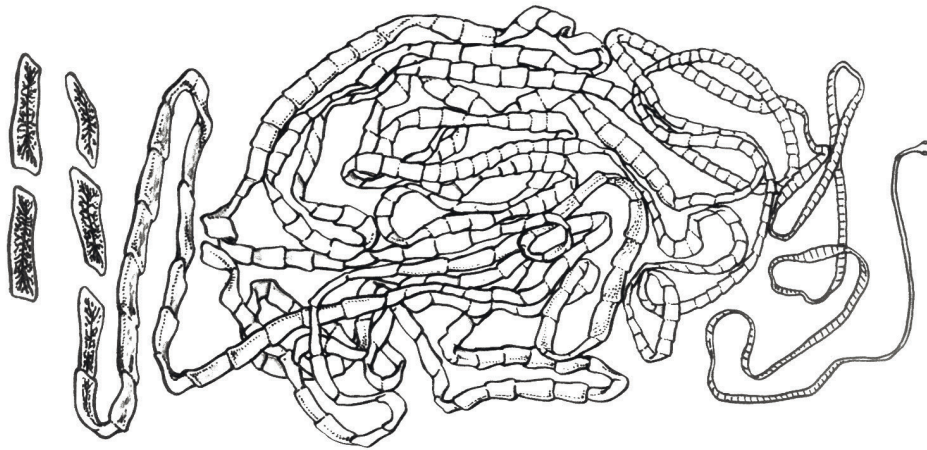
14.4. A 53-year-old woman from Egypt had noticed for many years that her stools was dark. She also had two episodes of vomiting blood. Examination of her esophagus and stomach with a fiberoptic gastro-scope revealed dilated veins in the esophagus, which were oozing large amounts of blood. There were also found eggs up to 150 mkm in length with typical lateral spine in her stool. What can be the diagnosis? How could she have been infected?

TOPIC 4. CLASS CESTODAE. PHYLUM PLATYHELMINTHES (TAPE WORMS)

Cestodes, or tape worms are a class of Phylum Platyhelminthes. All the Cestodes are parasites of the small intestine of different vertebrates. They have three organ systems: nervous, excretory and reproductive. There is **no digestive system** in tape worms; they absorb the nutrients from the host's intestines. The body of tape worms is ribbon-like, referred to as a **strobila** and consists of numerous segments, referred to as **proglottids**. The "head" of a tapeworm, referred to as a **scolex**, possesses attachment organs – **suckers, hooks** or **bothria**. The neck of a tape worm is the region where the new proglottids are formed. Proglottids are hermaphrodite – they contain both male and female reproductive organs. The mature proglottids, gravid with eggs, detach and are voided with the definitive host's faeces



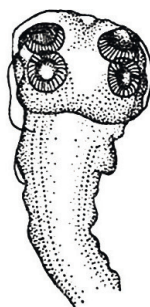
Task 4.1. Study the morphology of tapeworm¹ and designate: 1 – scolex (head); 2 – neck; 3 – strobila; 4 – proglottids.



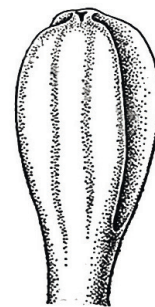
Task 4.2. Study types of scolex of tapeworms² and designate: 1 – suction cups (suckers); 2 – hooks; 3 – suction slits (bothria).



Taenia solium
(armed tapeworm)



Taenia saginata
(unarmed tapeworm)

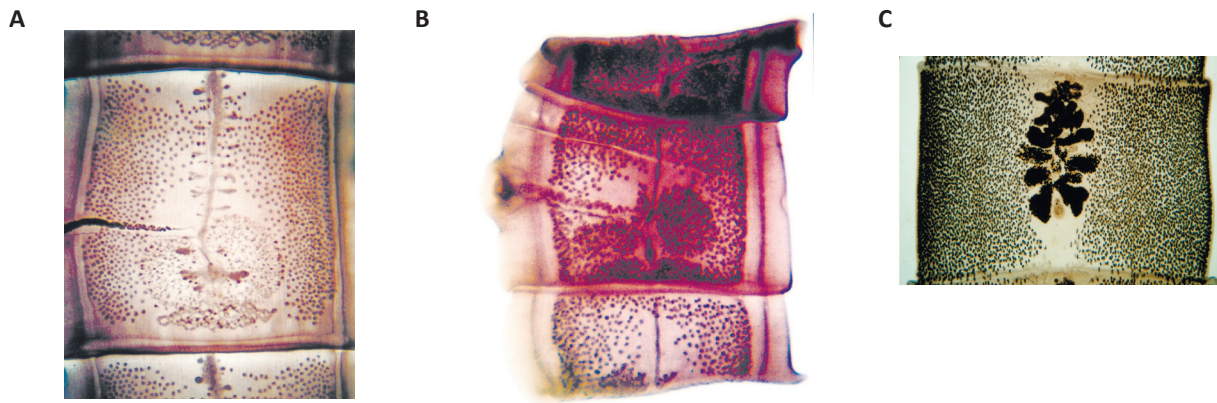


Diphylobothrium latum
(fish tapeworm)



Task 4.3. Compare immature (hermaphroditic) proglottids of several tapeworms and determine biological species and structural features of the proglottids. Mark: 1 – genital pore; 2 – excretory canals; 3 – sperm duct; 4 – testes; 5 – vagina; 6 – uterus; 7 – ovary; 8 – ootype; 9 – yolk glands.

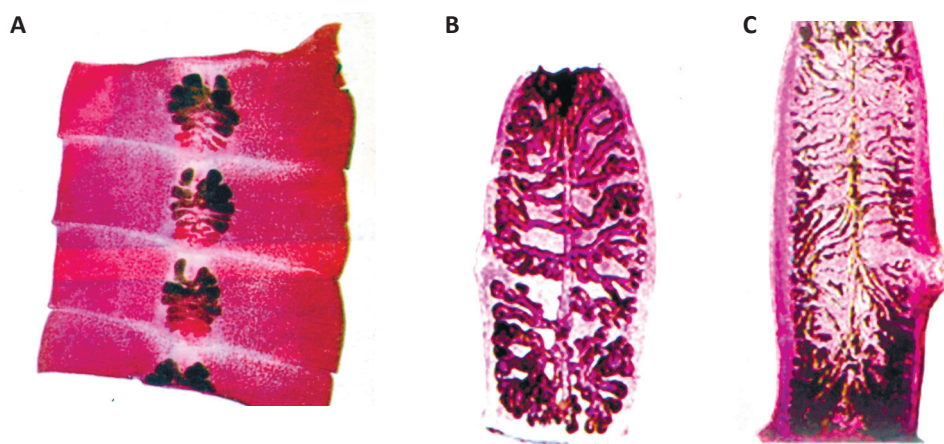
Image sources: 1 – <http://900igr.net/prezentacija/biologija/zhivye-organizmy-kak-sreda-obitaniya-148432.html>; 2 – V.A. Dougel, Zoology of Invertebrates. M.: Higher School, 1981



	Latin name of parasite	Structural features of the proglottids
A		
B		
C		



Task 4.4. In three different patient's stool analyses these three segments were found. What are the proposed diagnoses in each case? Why?



	Latin name of parasite	Diagnosis (justify the answer)
A		
B		
C		

Adult form of a tape worm parasitizes in the small intestine of the definitive host. Intermediate host is infected by ingestion of the fertilized eggs. Inside the intermediate different forms of **larvae** are formed. The definitive host becomes infected by eating organs of intermediate host. There are about 3,500 species of tapeworms.

Adaptations to parasitism in Cestodes are:

- flattened body;
- attachment organs;
- absence of digestive system;
- tegument for protection and digestion ;
- complicated hermaphrodite reproductive system;
- ability to reproduce at larval stages.

The tapeworms of major medical importance belong to two orders: Pseudophyllidea and Cyclophyllidea. These are *Diphyllobothrium latum*, *Taenia saginata* and *Taenia solium*, *Hymenolepis nana*, *Echinococcus granulosus*, and *Alveococcus multilocularis*.

Order	Pseudophyllidea	Cyclophyllidea
Attachment organs	Bothria (two grooves)	Four suckers (and hooks)
Uterus	Open type	Closed type with lateral branches
Ovum	Oval in shape with operculum	Round with double striated envelope
Life cycle	Two intermediate hosts	One intermediate host
Tapeworms	<i>Diphyllobothrium latum</i>	<i>Taenia saginata</i> , <i>Taenia solium</i> , <i>Hymenolepis nana</i> , <i>Echinococcus granulosus</i> , <i>Alveococcus multilocularis</i>

The Cestodes parasitize human at adult stage, at larval stage or at all stages of its life cycle.

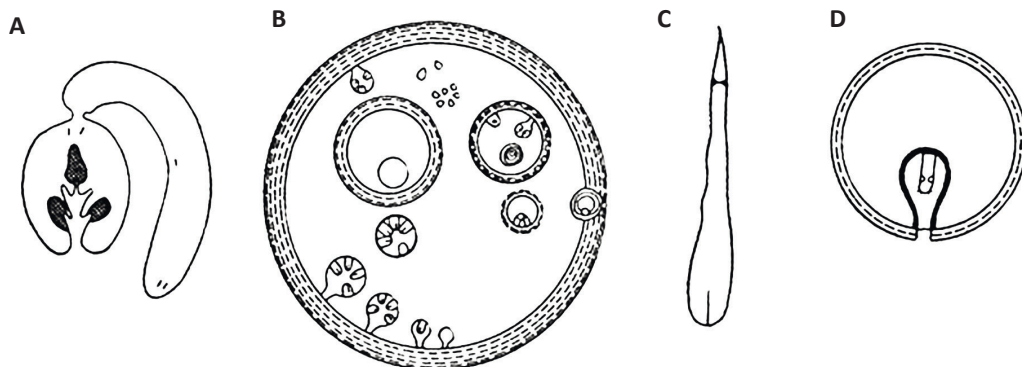
Tapeworms that are **parasites of human at adult stage** are *Diphyllobothrium latum* and *Taenia saginata*. Adult worms are found in the small intestine; these infections are usually well tolerated or asymptomatic, but may cause abdominal distress, dyspepsia, anorexia (or increased appetite), nausea, localized pain, and diarrhea.

Echinococcus granulosus and *Alveococcus multilocularis* are human **parasites at larva stages**. In human, their larvae locate in extra-intestinal tissues and produce clinical effects related to the size, number, and location of cysts.

Taenia solium and *Hymenolepis nana* can **parasitize at both, larval and adult stages**.



Task 4.5. Give the names of tapeworm larvae¹. What worms are these larvae typical of?



	Larva name	What worms are these larvae typical of?
A		
B		
C		
D		

¹Image source: G.I. Blokhin and V.A. Aleksandrov, Zoology. M.: KolosS, 2006



Task 4.6. Determine which tapeworm eggs are shown in the photographs. Indicate the size of the eggs, describe their shape and characteristics.

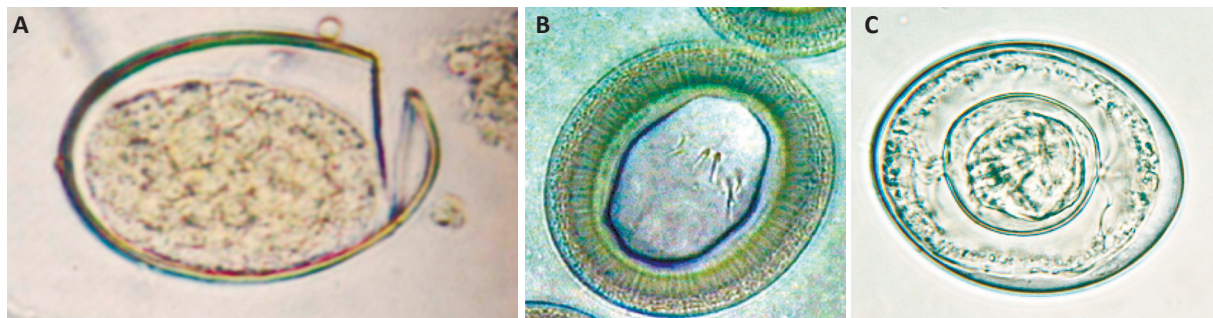


Image	Parasite	Size and structural features of the eggs
	<i>Hymenolepis nana</i>	
	<i>Diphyllobothrium latum</i>	
	<i>Taenia saginata</i>	



Task 4.7. Match each of the key terms (column A) with its corresponding definition (column B):

COLUMN A

- (1) Strobila
- (2) Scolex
- (3) Bothria
- (4) Cysticercus
- (5) Cysticercoid
- (6) Pleurocercoid
- (7) Cysticercosis
- (8) Small intestine
- (9) Neck
- (10) Gravid proglottids
- (11) Coracidium

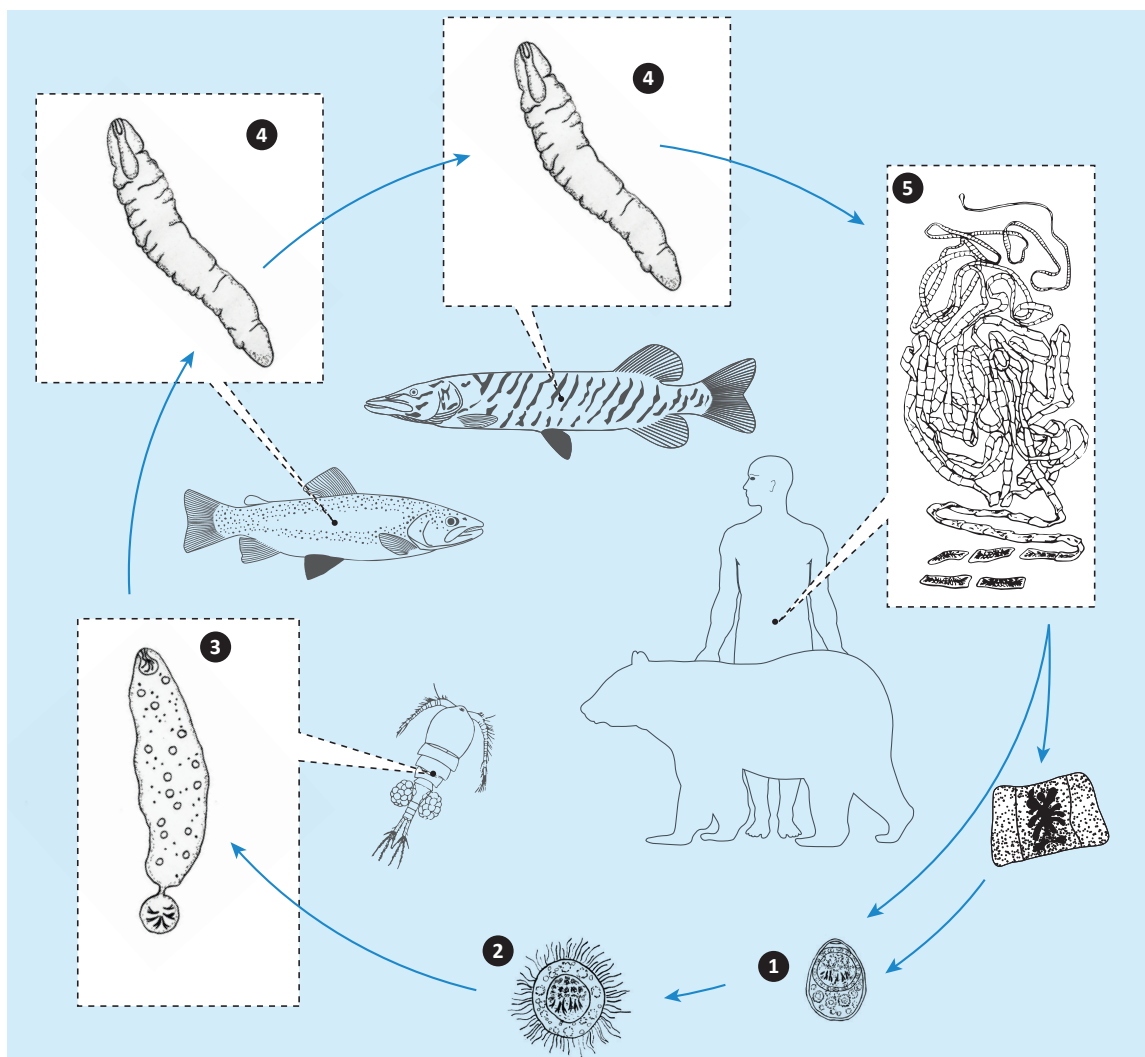
COLUMN B

- (a) Larval stage with cilia in *D. latum* life history
- (b) The part of tape worm's body where new proglottids are generated
- (c) Organ of animal or human where adult tape worm lives
- (d) Larval stage of *Taenia saginata* that is an invasive for human
- (e) Human disease caused by *Taenia solium* larval form
- (f) Segment of a tape worm which contains uterus filled with eggs
- (g) No eyes, no mouth, attachment organs only
- (h) Tape worm's body
- (i) Elongated larva of *D. latum* that develops in fish
- (j) By this grooves *D. latum* attaches to intestinal mucosa
- (k) Larval form of *H. nana* that invasive for definitive host

A	1	2	3	4	5	6	7	8	9	10	11
B											



Task 4.8. Study *Diphyllobothrium latum* life cycle and indicate main and intermediate hosts of the parasite, as well as the life stages and host tissues in which they are formed. Mark diagnostic (D) and invasive [for human] (I) stages



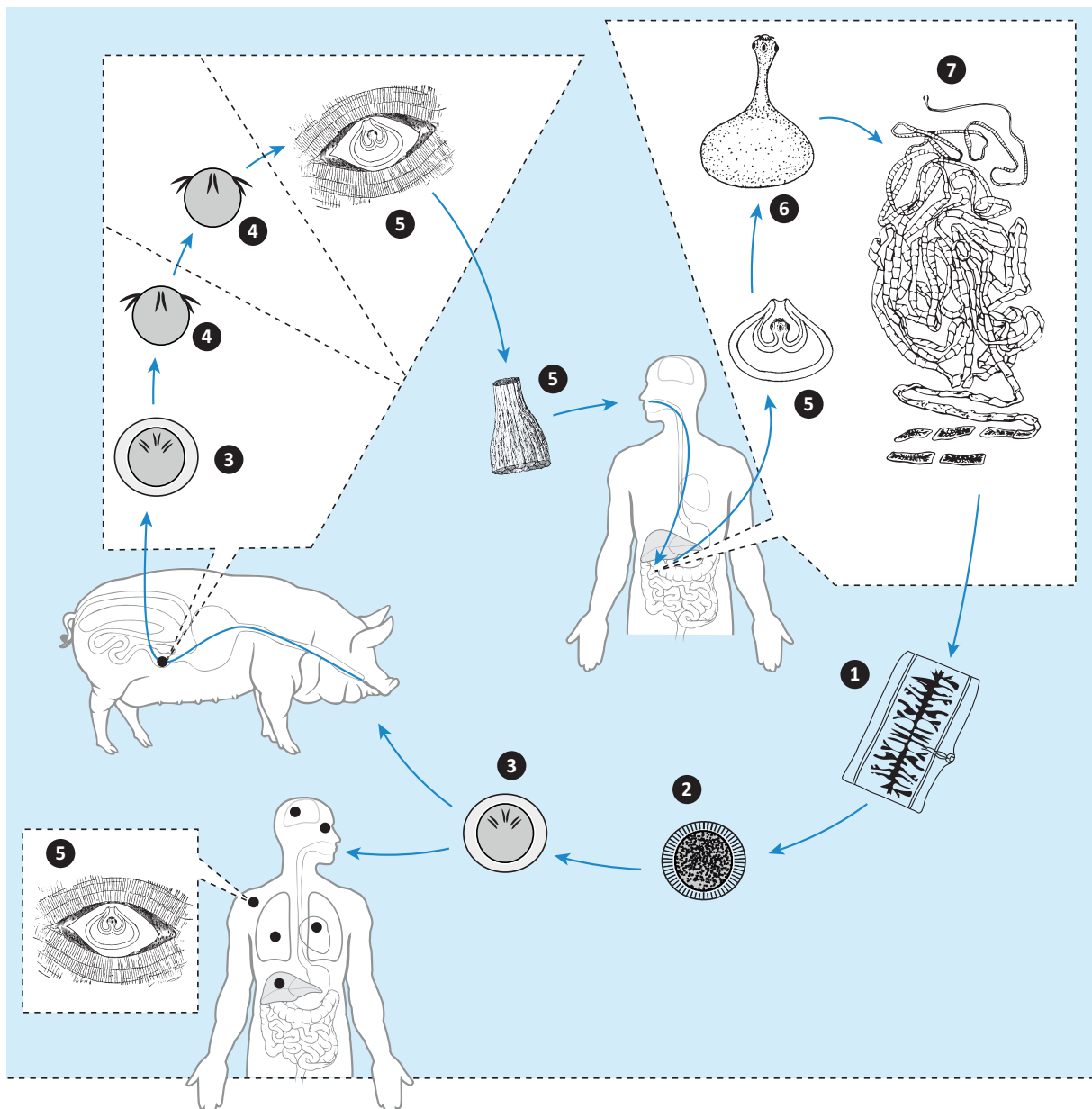
	Life stage	Where does it develop?
1		
2		
3		
4		
5		



Task 4.9. Draw *Hymenolepis nana* egg, oncosphere, cysticercoid, scolec, and adult animal.



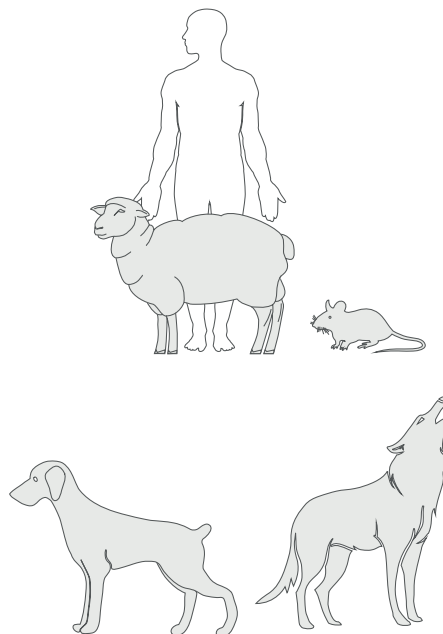
Task 4.10. Study *Taenia solium* life cycle and indicate main and intermediate hosts of the parasite, as well as the parasite life stages and host tissues in which they are located. Mark diagnostic (D) and invasive (I) stages.



	Life stage
1	
2	
3	
4	
5	
6	
7	



Task 4.11. Draw *Echinococcus granulosus* life cycle, indicate main and intermediate hosts, parasite life stages and host tissues in which they occur. Mark diagnostic (D) and invasive (I) stages. Are there any difference in the *Echinococcus* and *Alveococcus* life cycles?





Task 4.12. Fill in the fields of the form “Cestodes parasitizing human”:

***Taenia solium* (taeniasis)**

- Common English name _____
- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

***Taenia solium* (cysticercosis)**

- Common English name _____
- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Taenia saginata

- Common English name _____
- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____

- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Diphyllobothrium latum

- Common English name _____
- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Echinococcus granulosus

- Common English name _____
- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Hymenolepis nana

- Common English name _____
- Name in Russian _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Alveococcus multilocularis

- Name in Russian _____
- Location in human and main symptoms of invasion _____

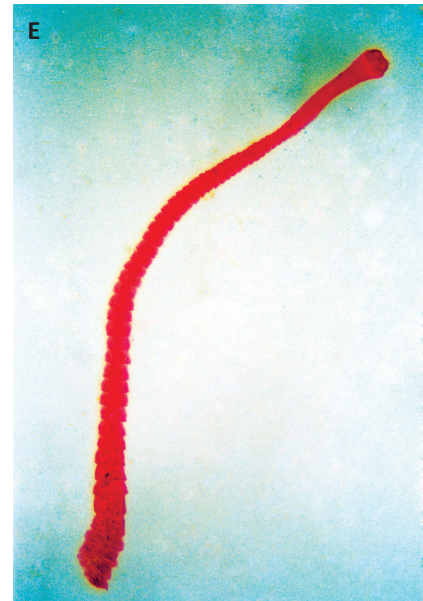
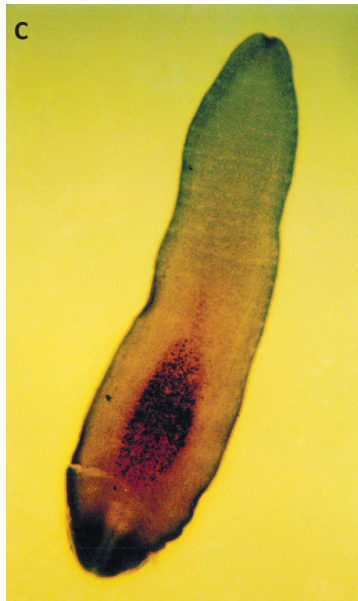
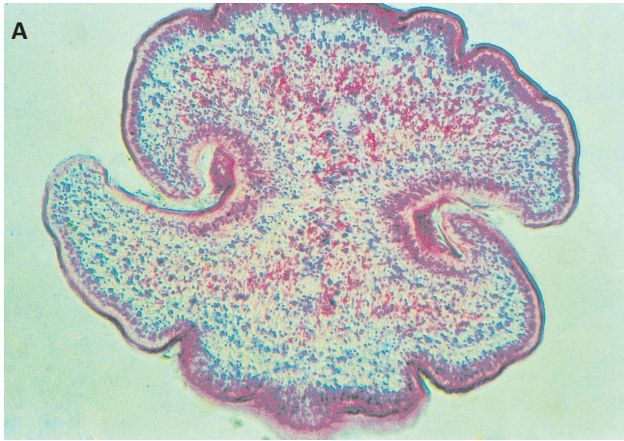
- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____



Task 4.13. Offer detailed captions for photographs, indicating (if possible) species, structures and / or life stages of the parasites.

	Photo caption
A	
B	
C	
D	
E	



Home work

Answer the questions using information from textbook «ESSENTIAL MEDICAL BIOLOGY», Chapter 37 (pp. 161–171):

1. Make sketches and designate the differences

	<i>Taenia solium</i>	<i>Taenia saginata</i>
Scolex		

Hermaphrodite segment		
Gravid segment		

2. What adaptation to parasitism in class Cestoda do you know? _____

3. What is cysticercosis and how to prevent it? _____

4. Why autoinfection is common in hymenolepidosis? _____

5. Why are there no eggs of parasite in the feces of patient with echinococcosis? _____

6. Name definitive and intermediate hosts in *Echinococcus* life cycle: _____

7. How many proglottids has *Echinococcus strobila* got? _____

8. Study the cases:

9.1. Patient is a cook in a restaurant. He complains of observing yellow-white structures about 1.5 cm long in his feces. What laboratory examinations must be done to make diagnosis? What way of infection may be supposed?

9.2. Patient had an oval cyst inside his eye. When doctor directed a beam of light at the eye, he saw a scolex of the parasite. What diagnosis could be supposed?

9.3. A man slaughtered a sheep and saw that its liver contained some large cysts. He decided not to eat the liver himself but gave it to his dog. Why was he wrong?

9.4. A 28-year-old woman had been in Thailand 5 years earlier. After her return, she found proglottids of the pork tapeworm in her feces. A CT (computer tomography) of her brain revealed 42 lesions of size about 0.5 cm consistent with larvae of a parasite. Name the disease. What would be the diagnosis and possible cause of invasion?

9.5. A 38-year-old woman had first noticed a sensation of fullness in the right upper quadrant of her abdomen two years ago. There is now an obvious swelling (8x10 cm) in the area of her liver. Feces examination revealed no tapeworm eggs. A CT scan of the liver demonstrated a large (12-cm diameter) tapeworm cyst. Serological testing revealed antibodies against some Cestode parasite. Name the tapeworm. Suppose the means of invasion.

9.6. Patient who is a fisherman has B12 deficiency anemia and there are oval eggs about 70 mkm in length and with operculum in his feces. What tapeworm invasion can be proposed?

TOPIC 5. PHYLUM NEMATHELMINTHS. CLASS NEMATODA (ROUND WORMS). GEOHELMINTES

General characteristics of round worms

Round worms have an elongated **cylindrical unsegmented body** tapering at both ends. **Dermomuscular sac** consists of epithelium, hypodermis and longitudinal smooth muscles. Body cavity of round worms is **pseudo-coelom**. They have four organ systems — **digestive, nervous, excretory and reproductive**. Sexes are separated in roundworms and **sexual dimorphism** is observed: males are smaller than females and their posterior end is curved to ventral side. There are nearly 20,000 described species, many of them are free-living but many are parasites of plant and animals. In size nematodes range from 0.3 mm to over 8 meters.

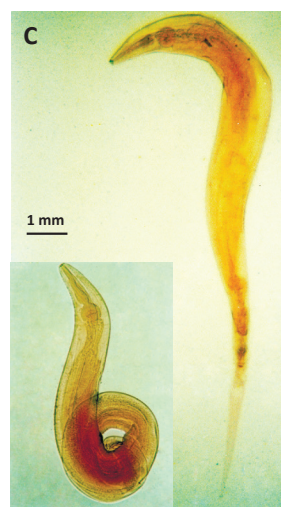
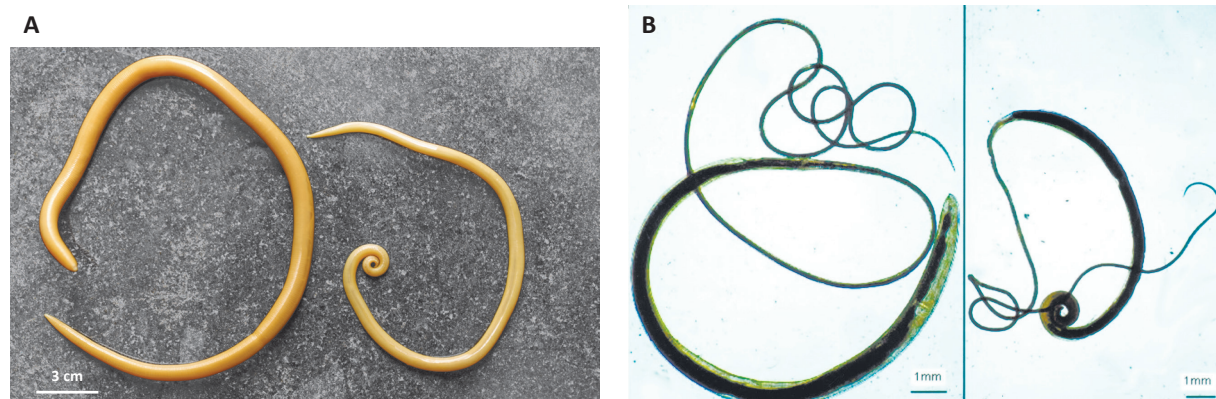
All the nematodes that parasitize humans can be divided into two groups: **geohelminthes** ("geo" means "earth" — have no intermediate host, their larvae develop in soil) and **biohelminthes** ("bio" means "life" — develop in two or more hosts).

Geohelminthes

Geohelminthes — are parasitic nematodes which **have no intermediate host** in their life cycle. All of them are parasites of the intestinal tract. Those are *Ascaris lumbricoides*, *Trichocephalus trichiuris* (= *Trichuris trichiura*), *Enterobius vermicularis*, *Strongyloides stercoralis* and ancylostomides — *Ancylostoma duodenale* and *Necator americanus*. Two of them — *Trichocephalus trichiuris* and *Enterobius vermicularis* — develop in human intestine without migration, while the others migrate via bloodstream through the lungs where undergo molting and in the end dwell the small intestine.



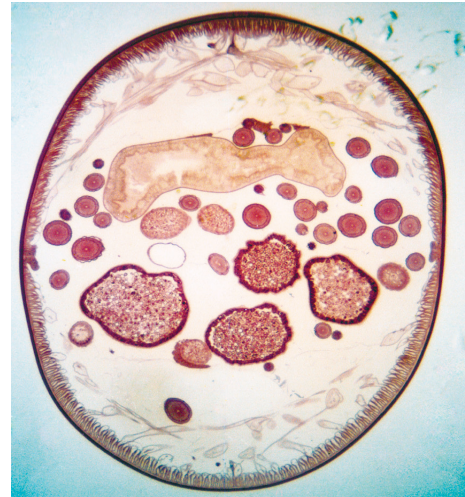
Task 5.1. Examine morphology of roundworms. Mark: 1 — front end of the body; 2 — posterior end of the body. Define species and sex of parasites. How sexual dimorphism is expressed?



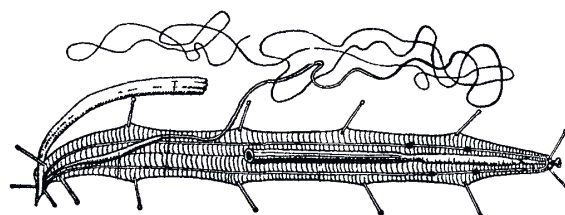
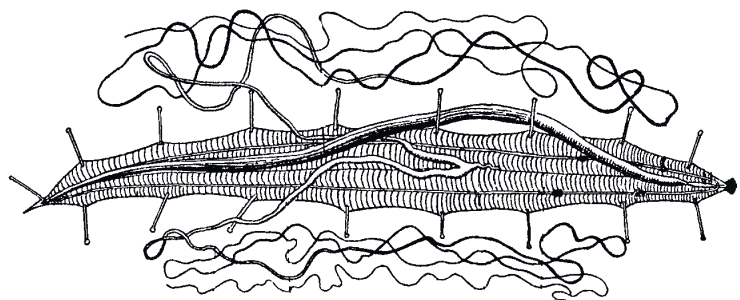
	Species
A	
B	
C	



Task 5.2. Mark on a cross section of *Ascaris lumbricoides*¹: 1 – cuticle; 2 – hypodermis; 3 – dorsal cushion of the hypodermis with a nerve trunk; 4 – abdominal cushion of the hypodermis with a nerve trunk; 5 – lateral ridges of hypodermis with excretory canals; 6 – primary body cavity; 7 – plasma processes of muscle cells; 8 – layer of longitudinal muscles (4 strands); 9 – uterus; 10 – oviducts; 11 – ovaries; 12 – intestine



Task 5.3. Examine internal structure of roundworms².
Mark A – male; B – female;
1 – front end of the body;
2 – posterior end of the body;
3 – esophagus; 4 – intestine;
5 – reproductive system:



Task 5.4. Determine which nematodes the eggs belong to. Specify the size, shape and characteristics of the eggs.

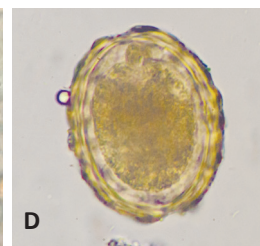
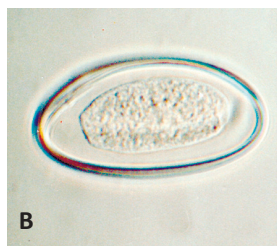
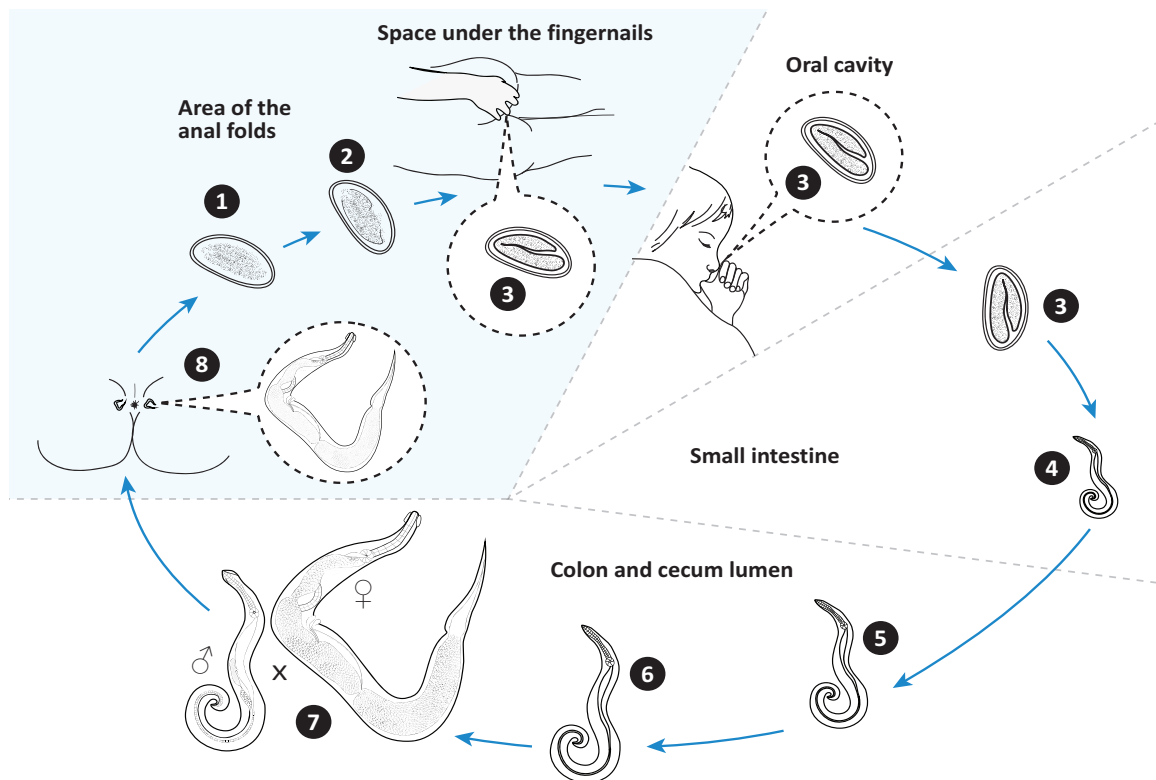


Image sources: 1 – L.A. Zenkevich, Animal Life. M.: Enlightenment, 1968; 2 – V.A. Dougel, Zoology of Invertebrates. M.: Higher School, 1981

	Latin name of parasite	Size and structural features of the eggs
A		
B		
C		
D		



Task 5.5. Study the life cycle of a nematode-heohelminth *Enterobius vermicularis* that develops without migration. Are there any differences in the life-cycle of *Trichuris trichura*? Designate I and D stages on the scheme.

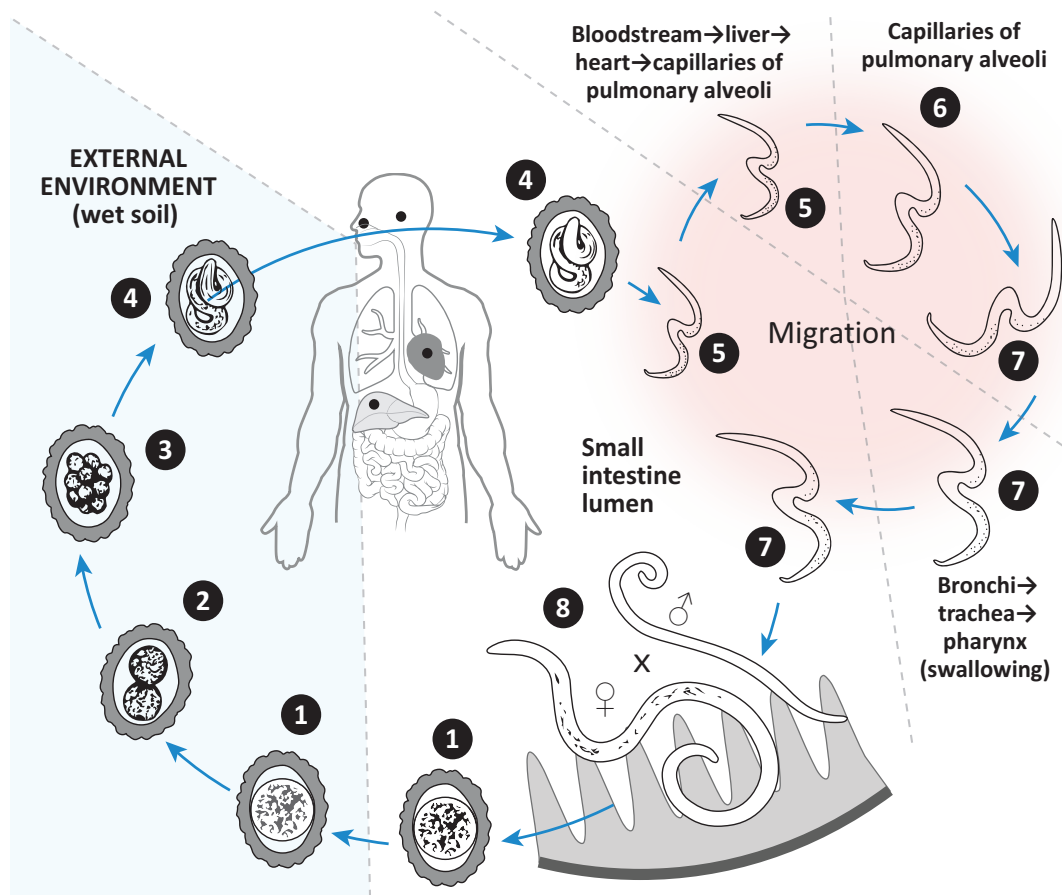


***Enterobius vermicularis* life cycle:**

1 — non-invasive egg, 2 — development of the 1st instar larva in the egg; 3 — development of the 2nd instar larva in the egg (invasive egg); 4 — after ingestion, larvae hatch from the eggs in the small intestine; 5 — 3rd instar larva; 6 — 4th instar larva; 7 — adults mate in the colon, and the males die after mating; 8 — gravid females migrate nocturnally to the anus and ovideposit eggs in the perianal area.



Task 5.6. Study life cycles of nematode-heohelminth *Ascaris lumbricoides* that develops with migration. Are there any differences in life-cycles of *Ancylostoma* and *Necator*? Designate I and D stages on the scheme.



***Ascaris lumbricoides* life cycle:** 1 — non-invasive egg; 2 — egg development; 3 — 1st instar larva in the egg; 4 — 2nd instar larva in the egg (invasive egg); 5 — 2nd instar larva; 6 — 3rd instar larva; 7 — 4th instar larva; 8 — mating of adults. Dots — atypical localization when the larva settles in liver, heart, larynx, and middle ear cavity.



Task 5.7. Fill in the fields of the form “Nematodes-geohelminthes parasitizing humans”:

***Trichuris trichiura* (*Trichocephalus trichiurus*)**

- Common English name _____
- Russian name _____
- Location in human and main symptoms of invasion _____
- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____
- Prevention of the invasion: _____

Enterobius vermicularis

- Common English name _____

- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Ascaris lumbricoides

- Common English name _____
- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Necator americanus and Ancylostoma duodenale

- Common English name _____
- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Strongiloides stercoralis

- Common English name _____
- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____



Home work

Answer the questions using information from textbook «ESSENTIAL MEDICAL BIOLOGY», Chapter 38 (pp. 172–185):

1. What morphological peculiarities of Nematodes do you know? _____

2. What are the Latin names for pinworm, hookworm, and whipworm? _____

3. Which parasitic roundworm is the most wide-spread upon the world and why? _____

4. Which stages of life-cycles of *Ascaris* and hookworm are invasive for man? _____
5. When and where does molting of the larvae take place in the life-history of *Ascaris* and *Ancylostoma*?

6. Why autoinvasion is typical of a patient suffering from enterobiosis? _____

7. What nematodes — geohelminthes can cause anemia and why? _____

8. What does the term «geohelminthes» mean? _____

9. Divide nematodes-geohelminthes into 2 groups: developing with and without migration in human body. Give their Latin names.

10. Study the cases:

10.1. S., 3-year-old girl living in Caribbean island appeared malnourished, but had otherwise been well. Two weeks before admission, she developed abdominal pain and diarrhea which become bloody 1 week later. When she was admitted to the hospital, her abdomen was rigid on palpation (consistent with peritonitis). Stool examinations revealed larvae of some round worm, although they were originally misidentified as those of hookworms. What parasite was that?

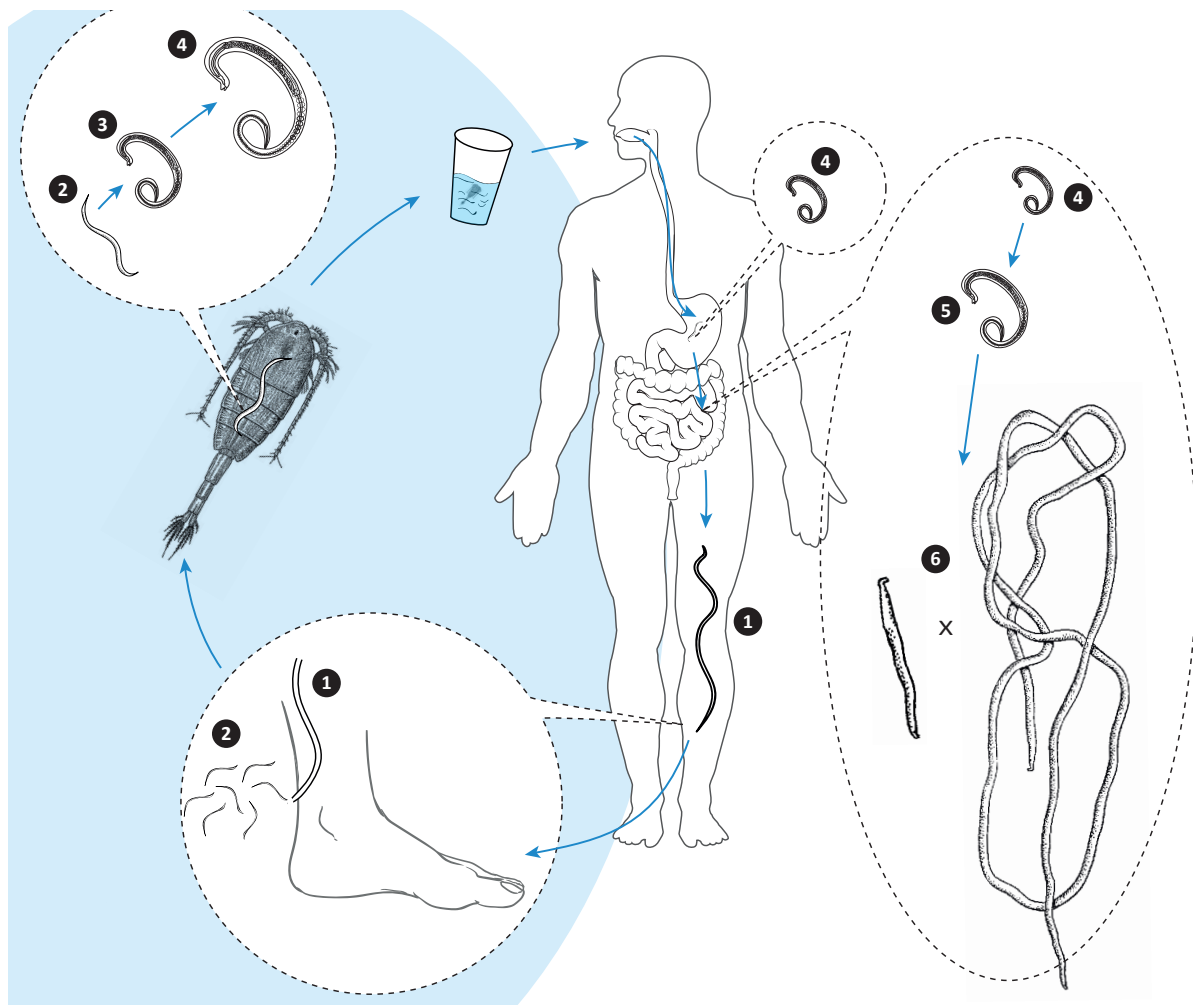
10.2. A 4-year-old boy had been well until 3 weeks previously, although he had always been small for his age. His parents reported that he passed «earthworms» with his stool. For the last 2-3 weeks, he had had vague abdominal pain with nausea. He had been unable to eat, his abdomen was distended, and he had no bowel movements for 5 days. X-rays of his abdomen were consistent with intestinal obstruction. Stool examination revealed large numbers of a roundworm's eggs. A day after the beginning of anthelmintic treatment he passed large numbers of parasites, and three days later, his abdomen was no longer distended, he was able to eat and drink, and had a normal bowel movement. Give the Latin name of the worm and suggest the means of invasion.

TOPIC 6. PHYLUM NEMATHELMINTES. CLASS NEMATODA. BIOHELMINTES

Biohelminthes — are the worms which have an intermediate host during their life-cycle. Nematodes-biohelminthes that parasitize humans are **viviparous** — they do not lay eggs but give birth to larvae. Most of them invade animals and humans, so we can say that these helminthoses are **zoonoses**. The main nematodes-biohelminthes parasitizing humans are *Trichinella spiralis*, *Dracunculus medinensis*, *Wuchereria bancrofti* (and *Brugia malayi*), *Loa loa*, and *Oncocerca volvulus*.



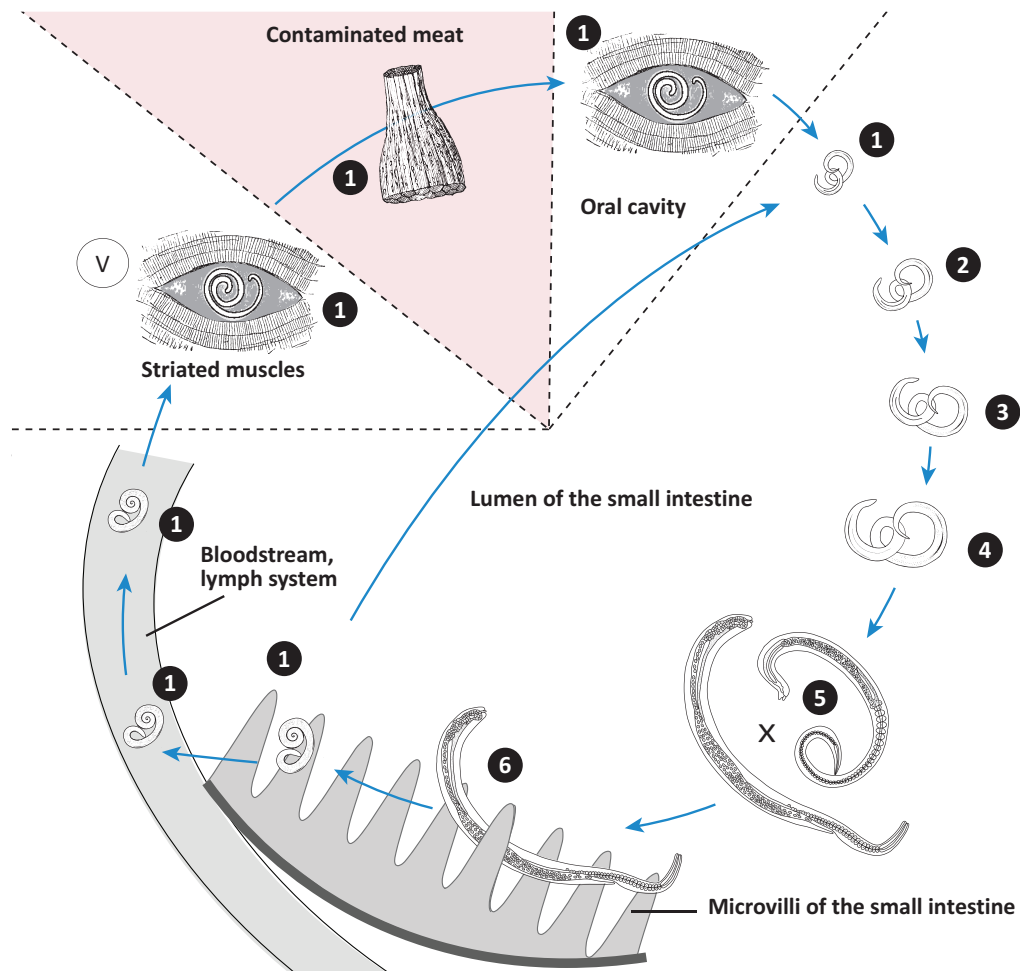
Task 6.1. Study life cycles of nematode-biohelminth *Dracunculus medinensis*. Indicate stages of life cycles, mark diagnostic (D) and invasive (I) stages; in adults, mark the sex.



	Life stage
1	
2	
3	
4	
5	
6	



Task 6.2. Study life cycles of nematode-heohelminth *Trichinella spiralis*. Indicate stages of life cycles, mark diagnostic (D) and invasive (I) stages; in adults, mark the sex.

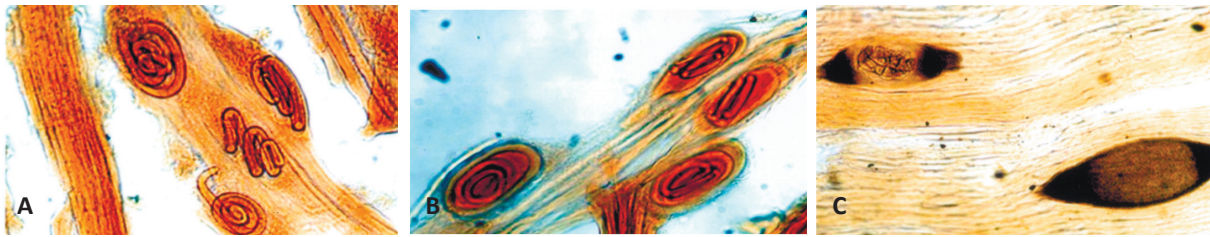


	Life stage
1	
2	
3	

	Life stage
4	
5	
6	



Task 6.2. Draw *Trichinella spiralis* in meat.

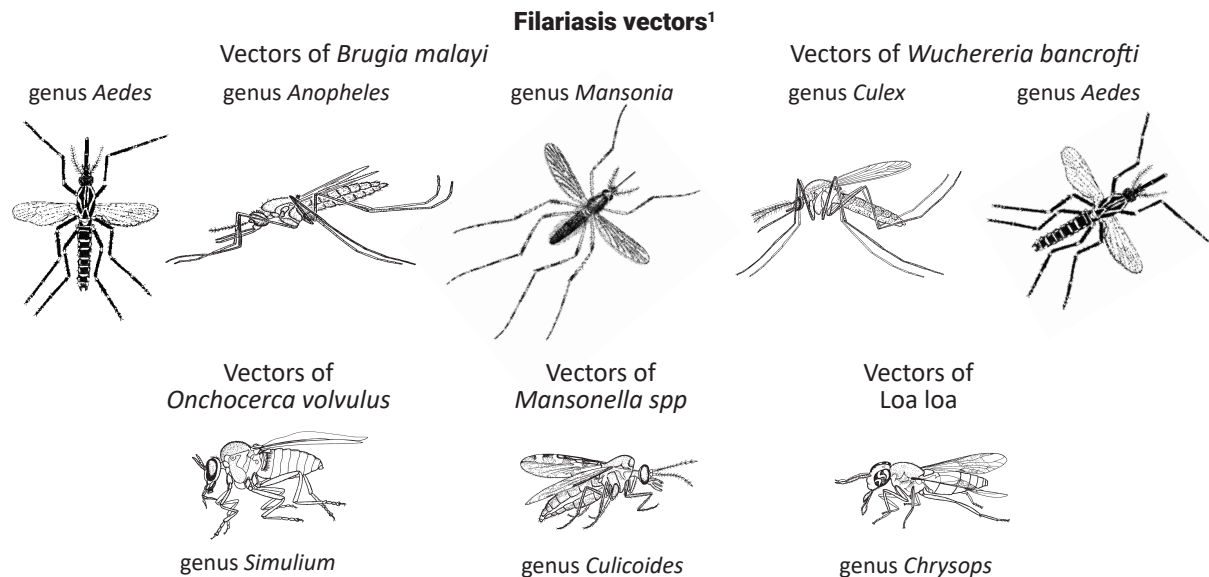


Trichinella larvae in the muscles: A – migrating larva, B – encapsulating larva, C – calcium-impregnated larva capsule.

Filariasis – transmissive invasions with roundworms of the Filarioidea type. Eight known species of filarial worms have humans as a definitive host. Different blood-feeding insects serve as vectors and intermediate hosts.

- **Lymphatic filariasis** is caused by the worms *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori*. These worms occupy the lymphatic system, including the lymph nodes; in chronic cases, the worms lead to the syndrome of elephantiasis.
- **Subcutaneous filariasis** is caused by *Loa loa* (the eye worm), *Mansonella streptocerca*, and *Onchocerca volvulus*. These worms occupy the layer just under the skin.
- **Serous cavity filariasis** is caused by *Mansonella perstans* and *Mansonella ozzardi*, which occupy the serous cavity of the abdomen.

Morphology of microfilaria in blood smears is used to diagnose filariasis.



Task 6.4. Mark by different colors areas where filarias are spread



¹Image source: Acarologiste / CC-BY / via Commons.wikimedia.org



Task 6.5. Match each of the key terms (column A) with its corresponding definition (column B):

COLUMN A

- (1) Pseudocoel
- (2) Pin worm
- (3) Black fly
- (4) Hook worm
- (5) Hypodermis
- (6) Cuticle
- (7) Microfilaria
- (8) River blindness
- (9) Guinea worm
- (10) Elephantiasis
- (11) Viviparity
- (12) Mosquito
- (13) Eye worm
- (14) Cyclop
- (15) Whip worm

COLUMN B

- (a) Mesodermal subcutaneous tissue
- (b) A symptom of wuchereriosis
- (c) Intermediate host in guinea worm life history
- (d) Filarial larva that is important in diagnosis
- (e) Dracunculus medinensis
- (f) Protective epithelium of parasitic nematodes
- (g) Primary body cavity typical of nematodes
- (h) "Giving live birth"
- (i) Enterobius vermicularis
- (j) Ancylostoma duodenale (or Necator americanus)
- (k) A symptom of oncocercosis
- (l) Vector for wuchereriosis or brugiasis
- (m) This insect can transmit Oncocerca volvulus in Africa
- (n) Trichuris trichura
- (q) Loa loa

A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B															



Task 6.6. Fill in the fields of the form "Nematodes-biohelminthes, human parasites":

Trichinella spiralis

- Common English name _____
- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Dracunculus medinensis

- Common English name _____

- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Oncocerca volvulus

- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Wuchereria bancrofti

- Russian name _____
- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____

Loa loa

- Russian name _____

- Location in human and main symptoms of invasion _____

- Disease _____
- Means of invasion, reservoir hosts if any _____
- Laboratory methods for making diagnosis _____

- Prevention of the invasion: _____



Home work

Answer the questions using information from textbook «ESSENTIAL MEDICAL BIOLOGY», Chapter 38 (pp. 172–185):

1. Which genera of *Mosquitoes* are vectors of *Wuchereria* and *Brugia*? _____

2. What does mean the term “microfilaria nocturna”? _____

3. Symptom of infection by which nematodes is elephantiasis? _____

4. Which nematode infection might be prevented by using filtered water? _____

5. For what nematode infection does the same animal serve as the final and as the intermediate host?

6. Name symptoms of trichinosis: _____

7. What filarial infections may be found in Africa? What insects are vectors of them? _____

8. Why consumption of home-made sausages is dangerous? _____

9. You are giving a lecture to oculists about parasitic nematodes. What nematodes are you going to speak about?

10. A patient is complaining of having a “snake under skin”. May it be a nematode? _____

11. Read the cases and try to explain them:

11.1. A patient had been well until 3 days after eating a highly seasoned but undercooked pork dish when he developed diarrhea and abdominal pain. Four days later, he developed severe muscular pain, swelling around the eyes and headache. Physical examination revealed splinter hemorrhages in his fingernails. Biopsies of his tender muscles and of the splinter hemorrhages revealed larvae of a roundworm. Larvae of which roundworm were there?

11.2. A patient from Philippine Island lived in a village where many men and women had elephantiasis. He first noticed swelling of his right leg when he was 20 years old. Since that time, he has had intermittent fevers to 38.5 -39.0C, associated with red streaks from his groin to the foot on both legs. Both feet and his scrotum are now chronically swollen. Typical microfilariae were seen in a Giemsa-stained blood smear taken at 2 AM. Suppose the disease and the means of invasion.

11.3 A 35-year-old woman from Nigeria was seen for an evaluation in a hospital of a nearby town. Her village was situated near a rapidly running stream where she fish and hunt. Like many of her neighbors, she began to lose vision in her late 20s. Three nodules (2x3x2 cm) are presented on her trunk. Skin snips reveal microfilariae. Suppose the disease and the mean of invasion.

TOPIC 7. PHYLUM ARTHROPODA. CLASS ARACHNIDA

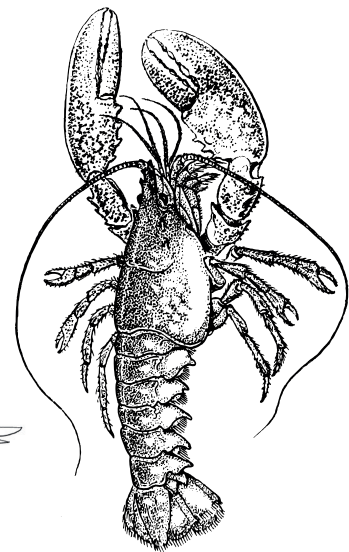
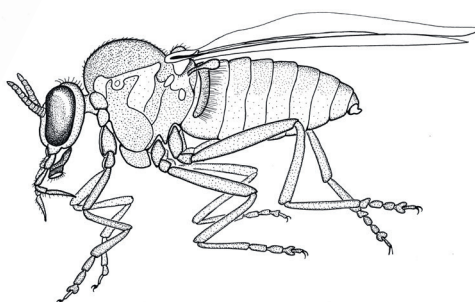
The word "**Arthropoda**" comes from two Greek words "arthron" and "podos", where arthron means "joint", and podos means "foot", which together mean "jointed feet".

- Body of arthropodes is **bilaterally symmetrical** and **metamerically segmented**.
- The segments usually groups in two or three rather distinct regions (**head, thorax** and **abdomen**). In some (crustacean and arachnida) body is divisible into cephalothorax (head and thorax are fused) and abdomen.
- Externally the body is covered with a thick, chitinous **exoskeleton**.
- The body segments bear paired **jointed appendages**.
- Arthropods have **striated muscles** that work in opposition to each other, e.g., flexor-extensors, adductors-abductors, rotators, etc.
- Arthropods are **haemocoelomate**, **circulatory system** is of **open type** and heart is positioned dorsally. The blood (haemolymph) is colorless.
- A tubular alimentary canal with anterior mouth and posterior anus always present.
- Respiration takes place by general body surface or **gills** (in *Crustaceans*) or **trachea** (in insects), or **booklungs** (*Arachnida*).
- Excretion takes place by means of **Malpighian tubules** that empty into the alimentary canal, or green glands (in aquatic forms), or coxal glands.
- Nervous system is of annelidian type, which consists of **brain** and **ventral nerve cord**. Sensory organs include antennae, sensory hairs for touch and chemoreception, simple and compound eyes, auditory organs (in insects) and statocysts (in crustacean).
- **Sexes are separate**. Fertilization is internal or external. **Development may be direct or indirect**. Estimates of the number of arthropod species vary between 1,170,000 and 5 to 10 million and account for over 80% of all known living animal species. The number of species remains difficult to determine.

Classification of *Arthropods* is very complex. There are three main classes of arthropods: *Crustacea*, *Arachnida* and *Insecta*.



Task 7.1. Study morphology of Arthropods, determine classes of animals and mark following structures (if present): 1 – head; 2 – cephalothorax; 3 – thorax; 4 – abdomen; 5 – walking legs; 6 – antennae; 7 – chelicerae; 8 – pedipalps; 9 – eyes; 10 – jaws; 11 – wings.





Task 7.2. Indicate the main differences between the classes of arthropods by filling out the table:

Characteristic	<i>Crustacea</i>	<i>Arachnida</i>	<i>Insecta</i>
Number of walking legs			
Body parts			
Number of antennae			
Number and type (simple or complex) of eyes			
Examples			



Task 7.3. Decide to which class belong the following Arthropods: (1) Butterfly; (2) Black widow spider; (3) sand fly; (4) prawn; (5) louse; (6) flea; (7) triatomid bug; (8) cyclops; (9) fresh-water crab; (10) itch mite; (11) demodex folliculorum; (12) tsetse fly.

<i>Crustacea</i>	<i>Arachnida</i>	<i>Insecta</i>

Phylum Artropoda. Class Crustacea

Crustaceans form a large, diverse arthropod taxon which includes such familiar animals as crabs, lobsters, crayfish, shrimp, krill, woodlice, and barnacles. Medical importance of crustaceans is not big. Fresh water crabs are the 2-nd intermediate host for *Paragonomus westermani* and Cyclops are intermediate host for *Dipyllobothrium latum* and *Dracunculus medinensis*.

Phylum Artropoda. Class Arachnida

There are about 110 000 known species. Most are terrestrial. Most are predacious. Class *Arachnida* includes spiders (order *Araneida*), scorpions (order *Scorpionidae*), and ticks and mites (order *Acarina*).

Order Araneida. Venomous spiders

Latrodectus is a genus that contains approximately 31 recognized species of venomous spiders. The common name **widow spider** is often used to refer to members of the genus. The female **black widow's venom** is particularly harmful to humans. The venom acts at nerve endings to prevent relaxation of muscles, causing tetany — constant, strong, painful muscle contractions. Thus, initial pain is often followed by severe muscle cramps. Contraction of musculature may extend throughout the body, though cramping in the abdomen is frequently the most severe. Standard treatments usually involve symptomatic therapy with pain medication, muscle relaxants, and antivenom.

Order Scorpionidae. Scorpions

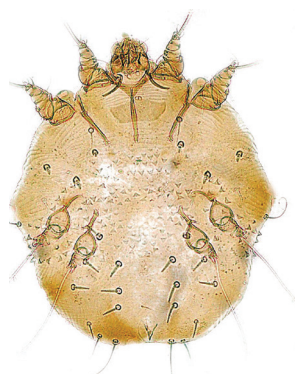
Of the 1,700-known species of scorpion, only 25 (family *Buthidae*) have venom that is deadly to humans. Scorpions rarely aggressively attack humans, but will often reflexively strike when they are handled, stepped on in bare feet, or accidentally crushed in clothing. Scorpions produce two types of venom: **hemolytic venom** induces burning, swelling and necrosis at the wound site. **Neurotoxic venom** produces intense pain at the site of the sting and causes chills, excessive salivation, vomiting and respiratory paralysis. Initial treatment: application of ice to the wound site, tourniquet above the wound and injection of specific antiserum.

Order Acarina. Ticks and mites

Tick and mites (Acar) are divided into **acariformes** and **parasitiformes**. Their life history includes stages of egg, larva (has three pairs of walking legs and no respiratory openings), nymph (4 pairs of legs, has respiratory system, but no reproductive opening) and adult (imago).

Acariformes mites. Over 32,000 described species are found in 351 families, and an estimated total of 440,000 to 929,000 species occur, including undescribed species. Most mites are tiny, less than 1 mm in length, and have a simple, unsegmented body plan. Their small size makes them easily overlooked; some species live in water, many live in soil as decomposers, others live on plants, sometimes creating galls, while others again are predators or parasites.

Acariformes mites and related diseases



Sarcoptes scabiei
(0.5 mm)



Demodex folliculorum
(0.5 mm)



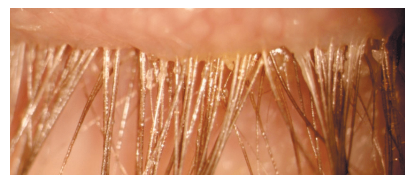
Bright red *Trombidium*
mite (4–5 mm)



House dust mite
Dermatophagoides
pteronyssinus (5–10 microns)
Credit: Gilles San Martin
(Namur, Belgium)



Scabby stroke in skin (itch mite)



Eyelash demodicosis¹

Acariformes mites are divided into two main clades: Sarcoptiformes and Trombidiformes. **Medical importance** in group Sarcoptiformes have *Sarcoptes scabiei* and *Demodex folliculorum*. Some tiny dust mites are causative agents for allergy.

Sarcoptes scabiei, or itch mite is parasite of humans that inhabit epidermis of skin and causes intense itching mostly at night.

Demodex folliculorum is a species of face mite. Demodex mites are common among many people. In fact, 97% of individuals have it on the surface of their skin. Under normal conditions, they are not harmful, and classified as commensals (the mite benefits but there is no harm or benefit to the host) rather than parasites (where the host is harmed), though under outbreak conditions (demodicosis) they can be harmful.

Parasitiformes ticks. Hard and soft ticks. This group are ectoparasites (external parasites), living by hematophagy on the blood of mammals, birds, and sometimes reptiles and amphibians. Some of them have a chitinous scutum that protect their body (**hard ticks**). Those without scutum are referred to as **soft ticks**. The scutum in males covers most of their body, in females the scutum is short because females consume more blood. Their mouth parts are adapted to blood meal. They have sharp spikes or blades that unfold so as to securely anchor in their host during feeding.

Parasitiformes ticks



Ixodes persulcatus
(3 mm)



Dermacentor marginatus
(3,8–4,2 mm)



Hyalomma plumbeum
(6–7 mm)



Ornithodoros papillipes
(12–14 mm)



Dermanyssus gallinae
(0,84 mm)

¹Image source: S.R. Fromstein [et al.] Clinical Optometry. 2018. V. 10. p. 57–63



Task 7.4. Study the morphology of ixodid ticks, make the designations: A — male (imago); B — female (imago); C — larva; D — nymph; 1 — dorsal shield; 2 — oral apparatus; 3 — walking legs; 4 — anus; 5 — genital opening; 6 — respiratory stigma. Indicate size of animals.



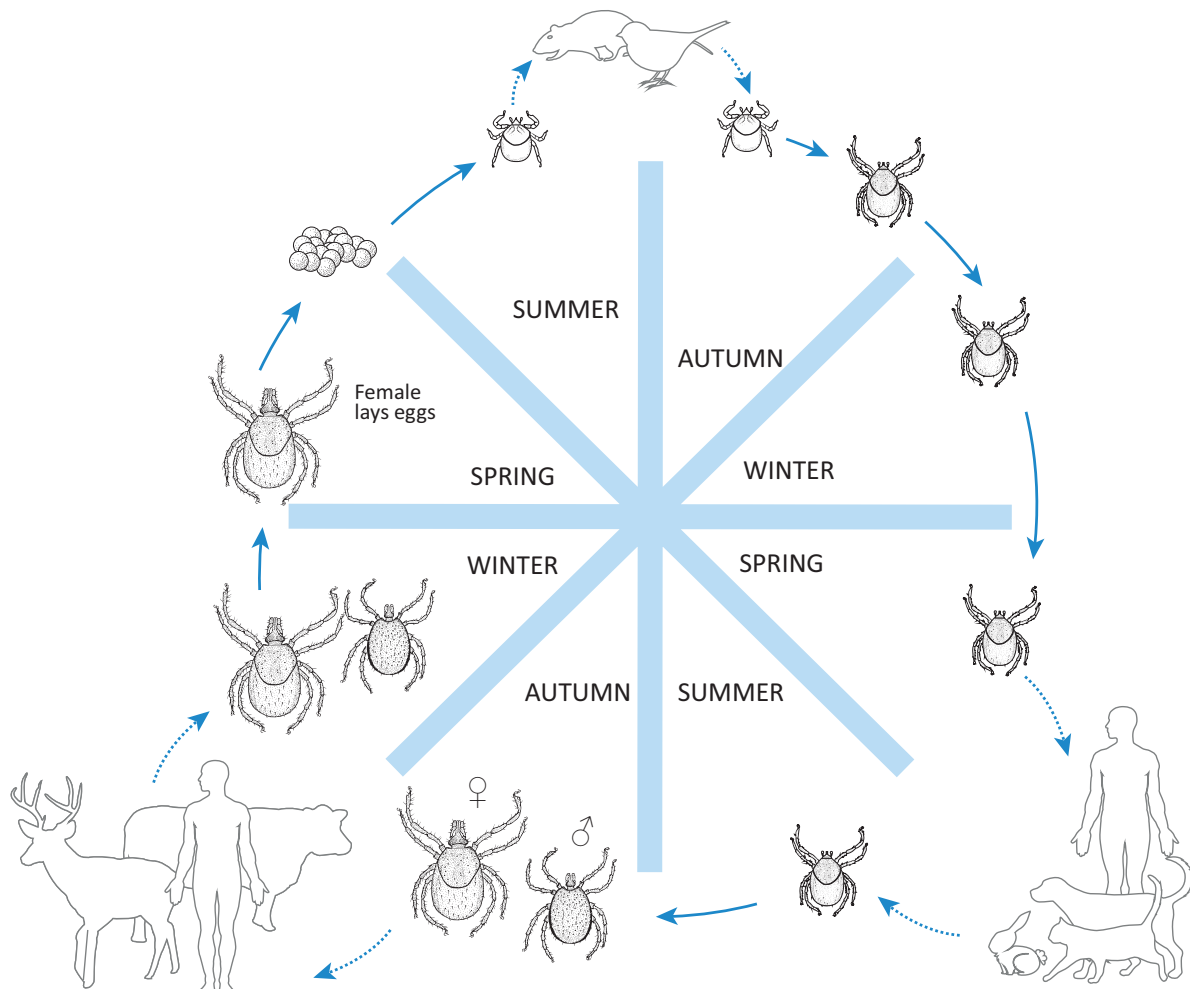
The most important family of hard ticks (family *Ixodidae*) includes several genera: *Ixodes*, *Dermacentor*, *Hyalomma*, *Amblyomma*, *Boophilus*.

Tick life cycle includes egg → larva → nymph → imago. Hard ticks can be classified by the number of host species they parasitize during their life cycle.

- **One-host ticks** will feed at each stage and develop on the same host. This group includes the genus *Boophilus*.
- **Two-host ticks:** In these species both the larvae and nymphs feed and develop on the same host. The nymphs will leave the host once they have taken a meal and develop into adults which will feed on a new host. The genus *Hyalomma* is an example.
- **Three-host ticks:** Each stage feeds on a different host. The *Ixodes* genus of ticks are three host feeders.



Task 7.5. Study life cycle of an ixodid tick. Indicate stages of the life cycle in the figure.



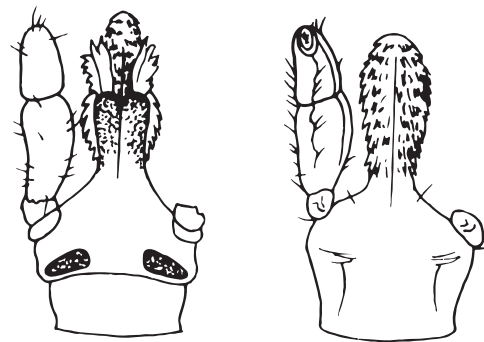


Task 7.5. Examine the structure of the mouth apparatus of the ixodid tick¹. Designate 1 – chelicera; 2 – hypostome; 3 – palps.

Family *Argasidae*. Soft ticks

Argasidae have **no scutum** and the capitulum is concealed beneath the body. The soft ticks' life cycle almost always involves multiple hosts. They feed once as larvae before moulting to become a nymph, this is followed by several more nymphal stages each involving a blood meal before moulting. Molting takes place off the host. The most important member of *Argasid* family is *Ornithodoros papillipes*, the vector of *Rickettsia prowazekii*.

Gamasoid mites are small, they are about 0,3–4 mm. The most of them are predators and small invertebrates are their prey. Some species are parasites of rats and mice. Can cause dermatitis if bite human.



DORSAL

VENTRAL

Medical importance of parasitiformes ticks

Ticks are vectors of a number of diseases that affect both humans and other animals. **Transovarian transmission** is passing of infection from parent arthropod to offspring arthropod. This is the mechanism by which many bacteriae and viruses are maintained in their arthropod hosts through generations. Tick-borne illnesses are caused by infection with a variety of pathogens, including rickettsia and other types of bacteria, viruses, and protozoa. Because individual ticks can harbor more than one disease-causing agent, patients can be infected with more than one pathogen at the same time.



Task 7.7. Match tick-borne diseases (column A) with corresponding genus of tick (column B):

COLUMN A

- (1) Tick-borne viral encephalitis, Lyme disease, tularemia
- (2) Tick-borne relapsing fever
- (3) Tularemia, viral encephalitis, rocky mountain spotted fever
- (4) Crimean–Congo hemorrhagic fever (CCHF)

COLUMN B

- (a) *Hyalomma*
- (b) *Ornithodoros*
- (c) *Ixodes*
- (d) *Dermacentor*

A	1	2	3	4
B				



Home work

Answer the questions using information from textbook «ESSENTIAL MEDICAL BIOLOGY», Chapter 39 (pp. 185–190, 194–196, 198):

1. Give three main characteristics of phylum Arthropoda: _____

2. Which classes of phylum Arthropoda have medical importance? _____

3. Patient is complaining of intense itch mainly at night. There are small burrows on skin surface. What diagnosis may be supposed? How to make definitive diagnosis?

¹Image source: V.A. Dougel, Zoology of Invertebrates. M.: Higher School, 1981

4. Patient has furuncle-like sores of long standing on his face. What diagnosis may be supposed?

5. Name the role of dust mites in human allergy: _____

6. Bite of which spider is very dangerous for man? _____

7. For what parasites can Cyclops be intermediate host? _____

8. What is the role of parasitiformes ticks in diseases transmission? What is transovarian transmission?

9. Give examples of tick-borne diseases: _____

10. Study the cases:

10.1. A 5-year-old girl, often played in the nearby high grass and weeds. Her mother had removed ticks from her body before she became sick. The girl was taken to her pediatrician two days after the onset of fever, severe headache, and muscle pains. The next day she developed nausea, vomiting, and abdominal pain and rash. She had Rocky Mountain spotted fever. Suppose how she was infected.

10.2. A 24-year-old man had intensely pruritic (itchy) rash consisting of reddened bumps (papules) located in his groin and on his elbows and hands. He had not slept well for two days because of constant itching and scratching. There are excoriations (scratch marks) on his skin. What could be the diagnosis? What are the means of invasion?

11. Make sketches of *Sarcoptes scabiei* and *Demodex folliculorum*.

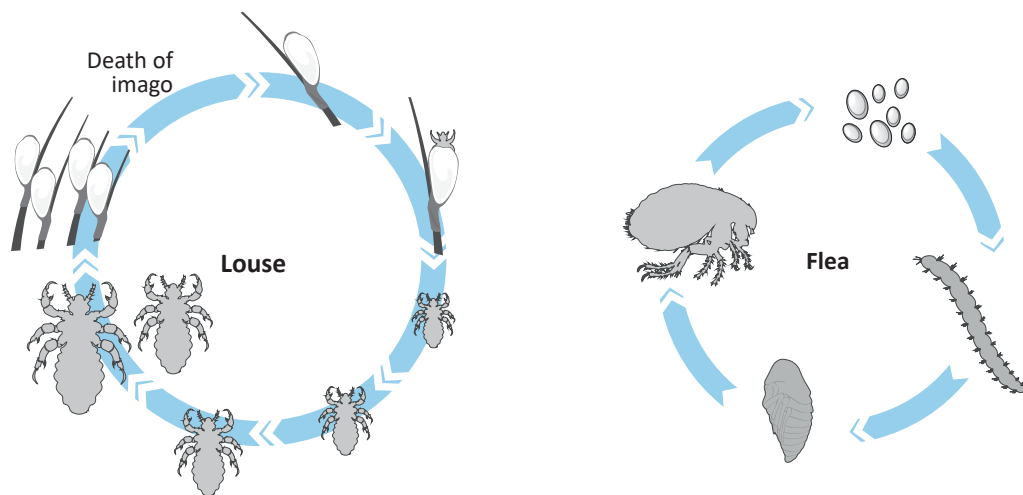
TOPIC 8. PHYLUM *ARTHROPODA*. CLASS *INSECTA*

Insects species have three-part body (head, thorax and abdomen), compound eyes and one pair of antennae on head, three pairs of jointed legs and one or two pairs of wings on thorax. Respiratory openings (stigmata) on abdomen. The insects either have hemimetabolous development, and undergo an incomplete or partial metamorphosis, or holometabolous development, which undergo a complete metamorphosis, including a pupal or resting stage between the larval and adult forms. Include more than a million described species, may be found in nearly all environments.

Insects of major medical importance belong to several orders. Anoplura (sucking lice), Heteroptera (bugs) and Blattidea (cockroaches) develop by incomplete metamorphosis. Siphonaptera (fleas), Diptera (flies, mosquitoes and others) and Hymenoptera (stinging insects) develop by complete metamorphosis.



Task 8.1. Mark the stages of life cycles of lice and fleas. Which of them illustrates development with complete metamorphosis, and which with incomplete? What is the main difference between these life cycles?



Order *Anoplura*. Human lice

There are three species of lice parasitizing human: body louse *Pediculus humanus humanus*, (corporis), head louse – *Pediculus humanus capitis* and crab louse (pubic louse) – *Phthirus pubis*. Lice are ectoparasites and cause **pediculosis**. And what is more lice of genus *Peduculus* may transmit diseases, such as louse-borne epidemic typhus, trench or 5-day fever, and louse-borne relapsing fever.

Order *Blattidea* (cockroaches)

There are over 3500 cockroach species in the world. These are flattened insects ranging in size from 2 mm to 100 mm. Most cockroach species live in the wild, but a few species thrive in human habitats. They destroy food and books and contaminate them with their excrement.

Order *Heteroptera* (bugs)

Heteroptera numbers about 40 thousand species and are found everywhere. Most bugs have odor glands which secretions of these glands have a characteristic odor unpleasant for humans. The oral apparatus is a piercing-sucking type. There are predators, parasites (in particular, hematophages) and herbivorous species. The obligate human ectoparasites are bed bugs of the Cimicidae family. Triatomic bugs are also of medical importance, which can carry pathogens of dangerous infectious diseases, for example, American trypanosomiasis.

Order Siphonaptera (fleas)

Fleas are insects whose bodies are very flattened laterally and whose highly developed rear legs enable them to jump 10 cm in height and 15 cm in distance. Their mouthparts are adapted to sucking the blood of mammals and birds. Fleas have four development stages: **egg**, **larva**, **pupa**, and **adult**. The eggs are laid in the host's bedding and on the floor of dwellings. The worm-like larva feeds on various debris from the host. A flea can live from one to four months without feeding, but can survive for up to 17 months if it takes regular blood meals. The two most important species from a medical viewpoint are the rat flea (*Xenopsylla cheopis*) and the human flea (*Pulex irritans*). They are blood-sucking ectoparasites, but the most dangerous thing is that rat flea is a vector for plague. *Yersinia pestis* (plague bacteria) can multiply in flea's stomach.

Tungiasis is an inflammatory skin disease caused by infection with the female ectoparasitic *Tunga penetrans* (also known as chigoe flea, jigger, nigua or sand flea), found in the tropical parts of Africa, the Caribbean, Central and South America, and India. *Tunga penetrans* is the smallest known flea, measuring 1 mm across. The symptoms are severe pain, itching, and a lesion at the site of infection with a black dot at the center of a swollen red lesion, surrounded by what looks like a white halo.

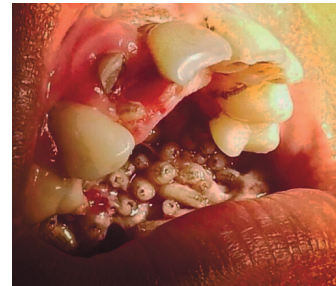
Order Hymenoptera

Hymenoptera is one of the largest orders of insects and includes many species of bees, wasps, hornets, sawflies, and ants. The majority of allergic reactions to stings are due to this order of insects. The *Hymenoptera* that have been associated with anaphylaxis come from three subfamilies: *Apidae* (honeybees); *Vespidae* (yellow jackets, wasps, and white- and yellow-faced hornets); and *Formicidae* (fire ants).

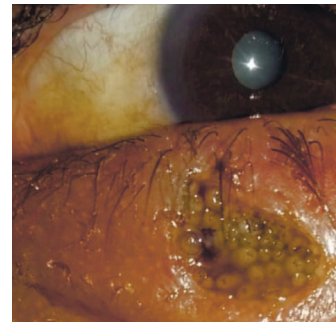
Order Diptera

Diptera are blood-sucking ectoparasites and vectors for different diseases. The order includes flies, mosquitoes, sandflies, gnats, midges, gadflies and others. The most obvious distinction from other orders of insects is that a typical fly possesses only one pair of flight wings on the thorax and a pair of halteres, derived from the hind wings.

Myiasis is the parasitic infestation of the body of a live mammal by fly larvae (maggots) that grow inside the host while feeding on its tissue. Although flies are most commonly attracted to open wounds and urine- or feces-soaked fur, some species (including the most common myiatic flies, the botfly, blowfly and screwfly) can create an infestation even on unbroken skin. The maggots that can eat up all dead tissue in the wound and produce substances that kill bacteria were used in the past for "maggot therapy".



Oral myiasis¹



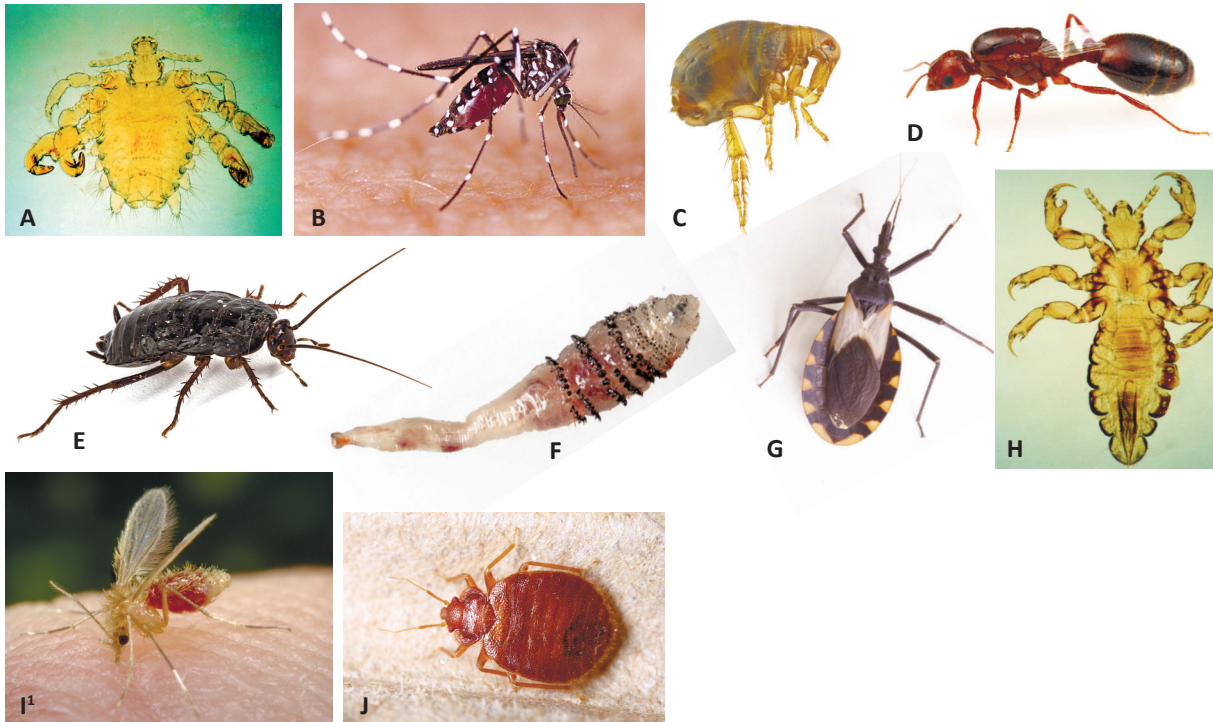
Ulcerated lesion of the eyelid, with erythematous and swollen edges, presenting numerous larvae of *Cochliomyia macellaria*²



Task 8.2. Draw a flea, an adult louse and a nit



Task 8.3. Match images with Latin names of insects, in each case determine which order the insect belongs to and what its medical significance is (pathogen, vector or poisonous animal).

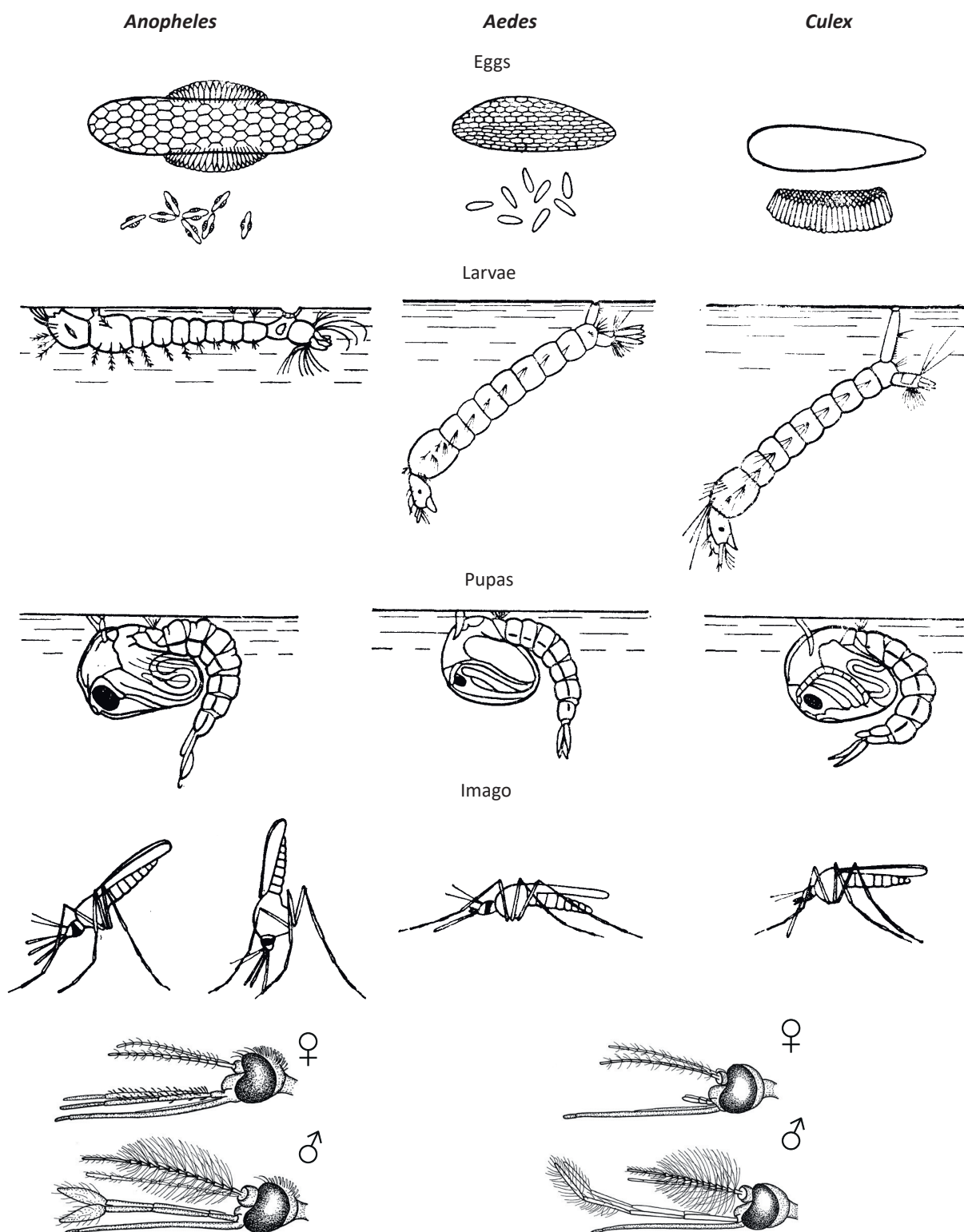


Latin name	Image	Order	Medical significance
<i>Pulex irritans</i>			
<i>Phthirus pubis</i>			
<i>Pediculus humanus capitis</i>			
<i>Cimex lectularius</i>			
<i>Triatomid bug</i>			
<i>Blatta orientalis</i>			
<i>Solenopsis invicta</i>			
<i>Dermatobia hominis</i>			
<i>Phlebotomus papatasi</i>			
<i>Aedes aegypti</i>			

¹Image source: Centers for Disease Control and Prevention/ Collins F.



Task 8.4. Write down what signs are important for determining the genus of mosquitoes¹:



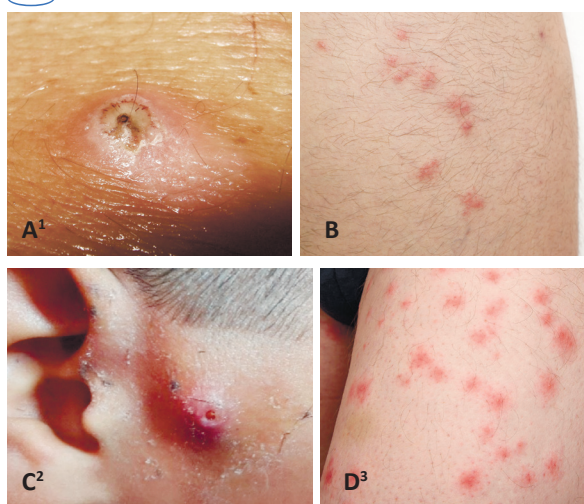
	<i>Anopheles</i>	<i>Aedes</i>	<i>Culex</i>
Eggs			

¹Image source: Great Medical Encyclopedia (BME), edited by B.V. Petrovsky, 3rd edition

	<i>Anopheles</i>	<i>Aedes</i>	<i>Culex</i>
Larva			
Pupa			
Imago			
Oral apparatus			
Landing on a horizontal surface			
Vector for (disease)			



Task 8.5. What skin lesions caused by different insects are shown in the photographs?



Insect	Photo of the skin lesion
<i>Pulex irritans</i>	
<i>Dermatobia hominis</i>	
<i>Cimex lectularius</i>	
<i>Tunga penetrans</i>	



Task 8.6. Imagine how you can use fly larvae in medicine?



Task 8.7. Match each of the key terms (column A) with its corresponding definition (column B):

COLUMN A

- (1) Pupa
- (2) Metamorphosis

COLUMN B

- (a) An arthropod that is able to transmit parasites
- (b) This insect breeds by the rivers in Africa and is a vector for *Onco-cerca volvulus*

Image sources: 1 — <https://www.flickr.com/photos/gilbertopalma/6106680059/> Palma G.M. (Patos de Minas, Brasil); 2 — Calvopina M., Ortiz-Prado E., Castañeda B. et al. PLOS Neglected Tropical Diseases, 14(2), e0007858; 3 — <https://www.nhs.uk>.

- | | |
|-------------------------------|--|
| (3) Vector | (c) This nematode is transmitted by Tabanid flies |
| (4) Sand fly | (d) In Africa, this insect is a vector for sleeping sickness |
| (5) Ixodid tick | (e) Lyme disease is transmitted by this arachnid |
| (6) Myiasis | (f) Jumps high and is a vector for bubonic plague |
| (7) Tsetse fly | (g) Aedes mosquitoes are vector of this disease |
| (8) Triatoma bug | (h) Anopheles mosquito is a definitive host in this disease |
| (9) <i>Xenopsylla cheopis</i> | (i) This stage is seen in case of complete metamorphosis |
| (10) <i>Loa loa</i> | (j) Leishmania may be transmitted by this insect |
| (11) Malaria | (k) "Kissing bug", vector for <i>Trypanosoma cruzi</i> |
| (12) Black fly | (l) Transformation from an immature form to an adult |
| (13) Dengue fever | (m) Maggots in a wound, or eye, or nose |

A	1	2	3	4	5	6	7	8	9	10	11	12	13
B													

Medical importance of insects:

- **Venomous animals.**
- **Human ectoparasites (at stages of larva or imago).**
- **Therapeutic remedies (apitherapy, maggots therapy).**
- **Vectors of protozoa, helminthes, viruses and bacteria.**



Home work

Answer the questions using information from textbook «**ESSENTIAL MEDICAL BIOLOGY**», Chapter 39 (pp. 190–194, 196–199):

1. What does term "vector" mean? Explain the difference between mechanical and biological vectors:

2. Name the vectors of *Leishmania* and *Trypanosoma*: _____

3. Name the morphological differences between mosquitoes of genus *Culex* and *Anopheles*. What infections do they transmit?

4. Suggest some biological control of mosquitoes and house fly: _____

5. Name some blood-sucking flies and the diseases transmitted by them: _____

6. Which insects are responsible for the spread of sleeping-sickness, dengue, yellow fever, leishmaniasis and loa-loa?

7. What is myiasis? In which human's organs myiasis can occur? _____

8. Patient has something small and very irritating under his toenail. What insect may it be? _____

9. What species of human lice do you know? _____

10. Which lice are vectors of epidemic typhus? _____

11. "Dr. Rieux felt his anxiety increasing after every visit. He saw rats died in the streets. That evening a neighbor of his old patient in the suburbs started vomiting, pressing his hand to his groin, and running a high fever accompanied by delirium. The lymph nodes were much bigger. One of them was beginning to suppurate, and presently, split open like an overripe fruit. Obviously, the abscesses had to be lanced. Two crisscross strokes, and the lymph nodes disgorged a mixture of blood and pus. His limbs stretched out as far as he could manage, the sick man went on bleeding. Dark patches appeared on the legs and stomach; sometimes a lymph node would stop suppurating, and then suddenly swell again. Usually the sick man died, in a stench of corruption. That was the plague" (Fragment from The Plague, French: La Peste, a novel by Albert Camus) What was the meaning of the massive die-off of rats?

QUESTIONS TO THE COLLOQUIUM

1. Classification of interspecific interactions. Examples of interspecific interactions. Classification of parasites and hosts. Transmissive invasions. Vectors.
2. Methods that parasites use to enter host. Harmful effects of parasites upon the host. Examples.
3. Adaptations to parasitism. Examples of parasitic adaptations.
4. General characteristics of *Protozoa*. Classification of *Protozoa* parasitizing human.
5. Lumen - dwelling protozoa. Life cycles of *Trichomonas vaginalis*, *Giardia lamblia*, *Balantidium coli*, *Entamoeba histolytica*. Commensal and opportunistic amoebas.
6. Tissue-dwelling *Protozoa*. American and African trypanosomiasis. Leishmaniasis. Toxoplasmosis. Malarian parasites. Life cycle of *Plasmodium vivax*, *malariae*, *falciparum* and *ovale*.
7. General characteristics of Phylum *Platyhelminthes*. Classification of *Platyhelminthes*.
8. Brief characteristics of class *Trematoda*. Morphology of *Trematodes*. A typical life cycle of *Trematodes*. Definitive and intermediate hosts, larval stages, means of invasion.
9. Liver and intestinal flukes. Life cycle of *Fasciola hepatica*, *Dicrocoelium lanceatum*, *Clonorchis* (*Opisthorchis*) spp. and *Fasciolopsis buski*.
10. Blood flukes. Lung flukes. Life cycles of *Schistosoma* spp. and *Paragonimus westermani*.
11. Brief characteristics of class *Cestoda*. Typical life cycle. Morphology of Cestodes. Adaptations to parasitism in Cestodes.
12. *Taenia solium* and *Taenia saginata*. Life cycle and medical importance. Cysticercosis. *Diphyllobothrium latum*. Life cycle and medical importance.
13. *Echinococcus granulosus* and *Alveococcus multilocularis*. Life cycle and medical importance. *Hymenolepis nana*. Life cycle and medical importance.
14. Brief characteristics of class *Nematoda*. Morphology and typical life cycles. Geo- and biohelminthes.
15. *Ascaris lumbricoides*, hookworms (*Ancylostoma duodenale* and *Necator americanus*), *Enterobius vermicularis* and *Trichocephalus trichiuris*. Life cycle and medical importance.
16. Life cycle of *Trichinella spiralis* and *Dracunculus medinensis*.
17. Filaria. Life cycles and medical importance of *Wuchereria bancrofti*, *Brugia malayi*, *Onchocerca volvulus* and *Loa loa*.
18. *Arthropodes*. Brief characteristics and classification. Class *Arachnida*. Morphology and medical importance of Order *Aranei* and *Scorpiones*. Venomous spiders and scorpions.
19. Class *Arachnida*. Order *Acari*. Ticks and mites. Life cycle of a parasitiformes tick. Morphology and medical importance of families *Ixodidae* and *Argasidae*.
20. Acariformes mites: *Demodex folliculorum* and *Sarcoptes scabiei*. Life cycles and medical importance.
21. Brief characteristics of class *Insecta*. Development with complete or incomplete metamorphosis. Examples.
22. Order *Anoplura* (lice), Order *Siphonaptera* (fleas), Order *Diptera* (flies, mosquitoes). Their role in cause of human diseases.

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