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Учебное пособие подготовлено на основании рабочей программы, действующего учебного плана и в соответствии с требованиями ФГОС ВО для изучения дисциплины «Биология».

В учебном пособии освещены вопросы паразитизма как экологического явления. Описаны морфология, биология и медицинское значение наиболее распространенных паразитических простейших, гельминтов и членистоногих, а также патогенез, симптоматика, лабораторная диагностика и меры профилактики вызываемых ими заболеваний.

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INTRODUCTION

The phenomenon of parasitism is studied by a special branch of medicine and ecology – parasitology. Parasites are pathogens of a big amount of parasitic human illnesses. The diseases caused by viruses and bacteria are called infectious. The diseases caused by animals are called invasional or parasitogenic.

In our country E.N. Pavlovsky and his school have played a prominent role in the study of various parasites and a phenomenon of parasitism caused by them. With parasitism as with other forms of interrelations of the "exploiter-victim" type an important role belongs to trophic and territorial relations between organisms. However, the importance of territorial (spatial) association is stronger in case of parasitism compared with preying, such association makes host's organism the parasite's habitat or biotope.

Medical parasitology studies parasites of a human that belong to animal kingdom in all the variety of their morphological structure, physiology, peculiarities of development, demands to the conditions of environment. Parasitology also studies the nature of relations that appear between a parasite and his host in the process of parasitizing.

Medical parasitology studies peculiarities of structure and life cycles of parasites, interrelations in the system "parasite-host" as well as the methods of diagnostics, treatment and prevention of parasitic diseases.

The forms of parasitizing are extremely diverse and it is possible to classify them according to different principles.

This study-guide is aimed at the formation of the following competences: general professional competences (ОПК-1, ОПК-7).

DIFFERENT TYPES OF RELATIONSHIP BETWEEN ORGANISMS. PARASITISM AS AN ECOLOGICAL PHENOMENON

An ecological relationship is the relationship between organisms in an ecosystem. All organisms in the ecosystem are connected. Organisms occupy what are called niches. A niche includes the physical space in which they live, how they use the resources that are in that space, and how they interact with other organisms in that space.

There are ecological relationships in which two are oppositional and six are symbiotic. The oppositional relationships are predation and competition. The symbiotic relationships are amensalism, neutralism, mutualism, cooperation, commensalism, and parasitism.

Table 1 presents different types of relationship of organisms of two populations. Unfavorable influence is shown by the sign «-», and favorable by the sign «+». Therefore mutually beneficial association is marked (+, +), mutually harmful (-, -), indifferent – (0, 0). Moreover there can be associations (+, -), (-, 0) and (+, 0).

Antibiosis means harmful-neutral relationship and it is called **amensalism**. It is marked (-, 0). Therefore, amensalism means that one species is depressed and another species does not receive any advantages. For example light-requiring plants are depressed in the shadow of trees.

Neutralism is marked (0, 0). Neutralism describes the relationship between two species that interact but do not affect each other. But there can be some indirect links between them. For example such forest animals as small rodents, shrews, squirrels, woodpeckers, do not come into contact with each other, however, they depend on the supply of seeds of conifers, that is they depend on the same food resource.

Mutualism is marked (+, +). Mutualism is a relationship in which both species benefit. Mutualistic relationships have three general purposes:

- trophic mutualism is exemplified in lichens, which consist of fungi and either algae or cyanobacteria. The fungus benefits from the algae or cyanobacteria because they produce food by photosynthesis. The algae or cyanobacteria benefit by being protected from the environment by the filaments of the fungus, which also gather moisture and nutrients from the environment;
- defensive mutualism is when one organism provides protection from predators while the other provides food or shelter: an example is ants and

aphids;

- dispersive mutualism is when one species receives food in return for transporting the pollen of the other organism, which occurs between bees and flowers. Bee gets nectar and honey from flower. The bee contributes back to the flower by spreading the pollen so that the flowers can reproduce. This is a very common contribute to both the flower and the bee, they both rely on each other to survive.

Table 1

Different types of relationship between organisms

№	Types of relationship	Species		Characteristic of relationship
		A	B	
1	Amensalism	-	0	The population (A) is suppressed, and the population (B) does not feel any influence
2	Neutralism	0	0	The populations do not influence each other
3	Mutualism	+	+	The interaction is favorable for both populations and it is obligatory
4	Cooperation	+	+	Interrelations are favorable for both species but they are not always obligatory for them
5	Competition	-	-	Each population suppresses another
6	Commensalism	+	0	The population of commensal (A) receives benefit, and the population of the owner (B) is not subjected to the influence of commensal
7	Predation	+	-	The population of a predator (A) destroys and consumes the members of a population of a victim (B)
8	Parasitism	+	-	The population of the parasite (A) maintains the members of a population of the owner (B), which feels adverse influence

The next type of interaction is **Cooperation**. It is marked (+, +). Interrelations are favorable for both species but they are not always obligatory (necessary) for them. For example, plants and animal-carriers of its seeds.

Competition (-, -) is when organisms compete for the same resources which are insufficient. This is a negative relationship because both organisms are harming each other. Any mutually negative relation between species is called competition. Such relations appear during the struggle for space, food,

light, asylum, female, etc. and it is one of the displays of struggle for existence. Competition can be:

- intraspecies competition (more tough). Organisms competing can be from within the same species for example, two male elk fighting for a female mate. Elephants also fight each other for a female mate;
- interspecies competition. Competition can be also found in two different species. A lizard and a frog can compete for a similar food they eat such as a small insect. This type of competition is only found when two different species share an ecological niche that they must compete over.

Commensalism (+, 0) occurs when one organism takes benefits by interacting with another organism by which the host organism is not affected. An example of commensalism is non-pathogenic *Entamoeba gingivalis* (oral amoeba) and *Entamoeba coli* (intestinal amoeba) that live in the human digestive system and feed on bacteria without doing any harm to the human.

Other examples:

- the remora, also called suckerfish, forms a special relationship with sharks and other sea organisms like whales and turtles; it has special suckers attached to its fins; it attaches itself to the bodies of sharks, and uses the shark for transportation as well as protection from its predators; it also eats up the scraps of food that are left over when the shark eats its prey;
- a birds nest in a tree; the bird is benefiting because the tree is giving the bird shelter and the tree is not getting anything in return;
- triggerfish is able to move large rocks that create feeding opportunities for the smaller fish; there is no benefit to the triggerfish.

Predation (+, -) is when one organism hunts and eats the other organism. The organism hunting is called the predator, while the organism being hunted is called the prey.

Predators use representatives of the other species as food only once, killing them. In ecology, predation is a mechanism of population control. Thus, when the number of predators is scarce, the number of prey should rise. When this happens, the predators would be able to reproduce more and possibly change their hunting habits. As the number of predators rise, the number of prey decline. This results in food scarcity for predators that can eventually lead to the death of many predators.

The most important association for medicine is **parasitism.** Parasitism is the type of interspecific relations when one organism uses another as the source

of food and as a habitat. During parasitism parasite population exploit host population that experiences unfavorable influence from the parasites. This is a positive, negative relationship (+,-).

Medical Parasitology is the study of organisms which parasitize humans.

Classification of parasites

According to the nature of relations between a parasite and his host there can be:

a) true parasites. They are organisms of parasitic way of life, that is specific sign of species and is conditioned by phylogenesis (for example intestinal helminthes, lice, and fleas);

b) false or incidental parasites. As a rule these are free living organisms, which, having accidentally got into the organism of another species, can exist in it for some time and do it harm (for example, larvae of house flies in the human intestine).

According to the parasiting time:

a) temporary parasites visit the host only to get food (mostly blood-sucking arthropods, for example, mosquitoes, bugs, some ticks, etc.);

b) constant (or permanent) parasites spend the life cycle in the host organism. They are divided into absolutely permanent and relatively permanent (or periodical):

- absolutely permanent parasites live all their life on the host or inside him (for example lice, itch-mite, trichina worm and some others);
- relatively permanent (or periodical) some part of their life cycle they spend in a parasitic state, the rest of the time they live freely. If a parasitic way of life are only the larvae, the parasitism of this kind are called *larval* parasitism (an example of larval parasitism is gadfly or Wolfart's fly, cavity gadfly of horse). If only the mature stage are parasitic way of life, this kind of parasitism called *imaginal parasitism* (for example Hookworms: *Ancylostoma duodenale* and *Necator americanus*).

According to the localization in the host's organism there are:

a) ectoparasites are parasites that live on the outside of the host, either on the skin or the outgrowths of the skin (lice, fleas and some ticks (mites);

b) endoparasites that live inside the host. Endoparasites are subdivided in-

to:

- cavitary parasites that live in cavitary organs connected with outer environment (digestion, respiratory, urino-vaginal systems);
- tissue parasites are localized in tissues and closed cavities (blood system, connective tissue), for example, the trichina worm (*Trichinella spiralis*) in muscular tissue.
- intracellular parasites are localized in cells (for example malaria *Plasmodium*, *Toxoplasma gondii*).

According to the stage of parasite's development there are:

a) final (definitive, primary) hosts. In their organism a pubertal parasite form lives and has sexual reproduction (for example, a human are definitive hosts for pig tapeworm, malarial mosquito − for malaria pathogens);

b) intermediate hosts. In their organism there is a larvae stage of parasite and there is its asexual reproduction (for an example a pig is an intermediate host for pig tapeworm, a human for malaria pathogens);

c) supplementary (additional) hosts or second intermediate hosts (for example carp fish are second intermediats for the cat liver fluke (*Opisthorchis felineus*).

d) reservoir hosts. In their organism there is an accumulation of invasion stages of a parasite without its development (for example, predatory fish are reservoir hosts for larvae of broad or fish tapeworm, wild rodents for leishmania).

According to the conditions for parasite development there are the following groups of hosts:

a) obligatory (natural) hosts ensure the best conditions for the parasite's development (the best survival rate, quick development, the largest fertility) because there are biocoenotic ties and biochemical conditions (for example a human for *Ascaris lumbricoides*);

b) facultative hosts are characterized by the presence of biocoenotic ties but optimal biochemical conditions are absent, that is why in the organism of these hosts the period of parasite's life is shortened or it does not have a full development cycle (for example, a cat for broad tapeworm (fish tapeworm), a human for pig *Ascaris*);

c) potential hosts ensure biochemical conditions for parasite development but biocoenotic ties are absent (herbivorous animals for trichina worm (*Trichinella spiralis*).

MEDICAL PARASITOLOGY. GENERAL QUESTIONS

The description of a «parasite-host» system

A «parasite-host» system includes one individual host and a group of parasites. **Host** of a parasite is the organism that is used by a parasite as a source of feeding and living. The following conditions are necessary for the formation of a «parasite-host» system:

- a parasite and a host must get into contact with each other;
- a host must ensure the best conditions for parasite's development;
- a parasite must resist reactions from the host's organism.

Stage of parasite in which it can penetrate into the host organism and continue to develop there is called **invasional (or infective) stage**.

The ways of parasite's invasion into host's organism can be different:

a) alimentary (nutritional) way is a way through the mouth (with food, through dirty hands helminths' ova, cysts of Protists can get into host's organisms). When culinary treatment of meat products is insufficient helminths' larvae (trichina worm) and vegetative forms of Protists (*Toxoplasma*) can get into host's organism;

b) contact-domestic way (through direct contact with a patient or animal through bed-clothes and domestic articles). Examples are eggs of contact helminthes (seatworm (*Enterobius vermicularis*), dwarf tapeworm (*Hymenolepis nana*) and many Arthropods (lice, itch mite (*Sarcoptes scabei*), flea). Eggs, which there are on the household articles that surround the sick person may enter the organism of another person through the mouth; lice and itch-mite may go to the body of another person through direct contact with sick person;

c) transmissible way is a way through the skin (or inoculation) with the help of a special blood-sucking carrier (or vector), by the Arthropods (malarial mosquito is a carrier of malarial *Plasmodium*). Blood-sucking arthropods may introduce infected blood at the time of feeding directly into the blood or skin, or skin layers. There are:

- specific vectors. They are arthropods in organism of which a parasite passes stages of development (for example mosquitoes of *Anopheles* genus for malarial *Plasmodium*);
- mechanical vectors. They are arthropods with the help of which an agent only moves in the space (for example cockroaches and flies for

cysts of Protists, eggs of helminthes);

d) contaminative way is a way through the skin, when the human scratches his skin and rubs excrements or haemolymph of the carrier into his skin. In such a way a human can get infected by pediculous typhus, plague;

e) percutaneous way (active invasion into skin) is way through the skin (active invasion of parasite's larvae through non-injured skin). For example, the filarial form larvae of Hookworms (*Ancylostoma duodenale* and *Necator americanus*), which may penetrate the unbroken skin of human; the cercarial form of blood flukes (*Schistosoma haematobium, S. mansoni, S. japonicum*) in infected water, may penetrate the skin of a person coming in contact with such water;

f) intrauterine way is a way through the placenta (for example, merozoites of *Toxoplasma* from the organism of toxoplasmosis-infected mother penetrates into the body of the developing fetus through the placenta);

g) sexual way is a way through the mucous membranes of genital organs. For example *Trichomonas vaginalis* ;

h) transfusional way (malarial *Plasmodium* and trypanosomes penetrates into the body during blood transfusion, use of un-sterile instruments).

Adaptation of parasites in host's organism

Sustaining of host's life demands maximum adjustment to a host from a parasite with the least destructions of its life functions. The closer is the contact between a parasite and a host, the stronger is the regress of some systems of parasite organs and this regress is accompanied by the development of specialized structures (fixation organs) and complication of some systems (for example, sexual system).

Morphological and physiological adaptations are connected with the changes of internal and external structures of parasites and functioning of their organs. They are subdivided into:

- progressive adaptations: the presence of fixation organs (suckers and hooks of intestinal helminthes, mouth apparatus of ticks); complex structure of cover body (cuticle, tegument); molecular mimicry (similarities in the structures of proteins and enzymes of a parasite and a host); discharge of enzyme by intestine parasites for protection from being digested by host's juices; intracellular parasitizing; immunosuppressive action of parasites (endoparasites secrete proteases that destroy immune complexes and cells of a host) and others;

- regressive adaptations: reduction of movement organs and some systems (circulatory, respiratory); simplification of the structure of nervous system and sensory organs.

Biological adaptations are connected with reproduction and life cycles of parasites:

- androgyny (more frequently found in parasites than in free living forms);
- primary development of sexual system and high fertility (pork tapeworm (*Taenia solium*) laying 100 thousand eggs, *Ascaris lumbricoides* – 250 thousand eggs a day, free living flatworms (paramecium) laying only from 5 to 10 eggs a day);
- perfection of different forms of asexual reproduction (schizogony in *Sporozoa*, budding in tapeworms, polyembryony in flukes (fluke worms, tapeworms); one miracidium (the larva of flukes) gives 60 thousand on Cercariae in two months);
- complex development cycles with the presence of several larvae stages and change of hosts (fluke worms);
- migrations in the host's organism (*Ascaris lumbricoides*, trichina worm (*Trichinella spiralis*).

The results of interrelations in the «parasite-host» system can be different; if protective mechanisms of the host's organism are rather strong a parasite dies; if a parasite is strongly pathogenic (this means that it can cause the illness) and protective mechanisms of the host's organism are insufficiently strong then the disease that can cause host's death (frequently the parasite dies with the host); if the relations of a parasite and a host are relatively balanced there **asymptomatic carriers** occur (the presence of pathogenic parasite in the organism without any clinical symptoms of an illness).

Such description of a parasite as **pathogenicity** (an ability to cause illness) is very interesting from the medical point of view. Parasite's pathogenicity is a relative concept. It depends on a big number of factors: host's genotype, host's age (younger organisms are more often subjected to infection), food regime (inferior diet weakens host's organism and leads to the increase of the number of parasites and their laid eggs, shortening the time of their development; the rise of human blood sugar leads to more frequent and serious malaria attacks), the presence of other parasites and diseases in the host's organism.

Virulence of the parasite is a level of its pathogenicity.

A parasite is not always pathogenic. The absence of pathogenicity in parasite is known as carriage (for example cyst carriage for *Entamoeba hystolitica* or dysenteric amoeba).

Pathogenic effect of parasite on the host's organism is determined by its morphological peculiarities.

Mechanical influence on the host appears as an injury of tissues with parasites' fixation organs, blockage of internal organs can be caused by pressure exerted by growing parasites: adult Ascaris, tapeworms can physically block the intestine; migrating larvae of Ascaris may also block the bile ducts, *Opisthorchis felineus*, parasitizing in the human liver can block the bile ducts. Suckers and Hooks of tapeworms can injure intestinal mucous membrane and lead to tissue necrosis. Proboscises of ticks and insects injure dermal integuments.

Toxical influence is intoxication of the host organism with products of the parasite vital activity or decay of dead parasites. When erythrocytolysis takes place products of *Plasmodium* metabolisms get into blood and this causes malaria attacks. Mass death of trichina larvae can cause the death of the patient from anaphylactic shock. When an insect-ectoparasite bites a human there is itching as a result of toxic effect of their saliva on the nerve endings in skin. Dermal eruptions, eosinophilia, headaches are the results of metabolic processes in parasites.

Actions connected with larvae migration are injury of host tissues, inflammatory processes, secondary infection, intoxication, for example migrating larvae of Ascaris break the integrity of intestine walls and alveoli of lungs.

Absorption of nutritives and vitamins from host's organism (feeding due to the host – syndrome of «robbing»). Helminthiasis is usually accompanied by hypervitaminosis (A and C). Broad tapeworm (fish worm) (or *Diphyllobotrium latum*) in the human organism selectively absorbs vitamin B_{12} and this leads to anemia. The bigger the mass of endoparasite body is the bigger is the amount of nutritives it absorbs in the host's organism (for example, broad tapeworm – *Diphyllobothrium latum* and beef tapeworm – *Taeniarhynchus saginatus*).

Opening of ways for secondary infection. Helminthes and their larvae breaking the integrity of dermal integuments and a mucous wall of intestine lead to microorganisms' penetration.

Pathogenic effect may also lead to **breach of metabolism processes** (protein, carbohydrate, fat, etc) in a host, general weakening of an organism, lower-

ing of its resistibility and hypersensitivity to other illnesses (ascariasis is often accompanied by dysentery).

Parasites play a very important role in stimulating human immune system, keeping it at high level and finally in the protection of host's homeostasis.

Host influence on a parasite is manifested as cellular reaction (shows increase of cell sizes), tissue reaction (appearance of connective tissue capsule isolating a parasite from surrounding tissues), humoral reaction (producing antibodies as a reaction on entering parasite antigens).

Responding reactions of host's organism

The first reaction of host's organism is to try to kill a parasite by nonspecific protective means (free radicals, hydrolases), then to try to neutralize factors of its «aggression» (proteases, enzymatic inhibitors) and if these actions are ineffective, different levels of protective reactions of host's organism take place.

Cellular level is characterized by the change of a shape and size of cells affected by parasites (human erythrocytes during malaria).

Tissue level of protective reactions is an ability of host's organism to isolate a parasite from healthy tissue (the trichina worm larvae in muscles, *Toxoplasma* in brain). A connective capsule appears around a parasite, blood vessels widen, there can be seen leukocyte accumulation, deposition of lime salt precipitation. A capsule of the trichina worm larvae is a form of adaptation to tissue parasitism.

Organism level is characterized by immune response to parasite's action (forming antibodies and immune lymphocytes, phagocytosis).

Antigens of many parasites are similar, that is why the hosts have similar protective mechanisms against many parasites. The forms of immunity are different: absolute and relative, active and passive, congenital and innate. The change of development stages of a parasite cause difficulties in developing immunity because antigens of each stage are specific. Larvae stages provoke the strongest immune response. Immune host's reactions are shown in the slowdown of parasites' reproduction and in the delay of their development.

Transmissible and natural focal diseases

Diseases, the pathogenic organisms of which are transmitted from animals to animals are called **zoonoses** (fowl and swine pest). The diseases, the pathogenic organisms of which are transmitted from a human to a human are called **anthroponoses** (measles, diphtheria).

Diseases, the pathogenic organisms of which are transmitted from one organism to another by blood sucking carriers (insects, ticks) are called **transmissible** (malaria, Russian tick-borne encephalitis).

Links of the agent transmission is known as **epidemiological chain**. It consists of the three parts: Reservoir – Vector – Recipient.

According to the geographic distribution there are world-wide and natural focal diseases. **Natural-focal Diseases** are the diseases connected with the complex of natural condition, exist in nature independently of human and are spread on limited territory with certain natural condition. Natural-focal diseases represent a serious hazard for human health. Agents and vectors of such diseases belong to natural landscapes.

The peculiarities of such diseases are as follows. Components of natural focal diseases are:

a) wild animals (carriers of pathogenic organisms) are reservoirs;
b) a pathogenic organism;
c) an organism susceptible to these pathogenic organisms;
d) certain environmental conditions (biotope).

Human is not obligatory component of the natural focus. The majority of transmissible diseases are natural focus. The study of natural focus of transmissible diseases was worked out by Pavlovsky in 1940.

Natural foci are the smallest territories of one or several landscapes, where there is a circulation of pathogenic organisms for quite a long time without them being brought from outside the territory.

Susceptibility is a specific characteristics, that shows ability of individuals of this species to become a habitat for pathogenic parasite and to respond its penetration by specific reactions.

In the focus there is a circulation of pathogenic organisms from sick animals (donors of a pathogenic organism) through a carrier to a healthy organism (recipients) which later become donors of a pathogenic organism. The carriers are blood-sucking Arthropods, while the donors and recipients are rodents and

birds. If a human gets into natural focus of a disease first of all he becomes a recipient and only then a donor of a pathogenic organism. Natural foci exist for a long time but they become epidemiologically important only when a human gets there and becomes infected.

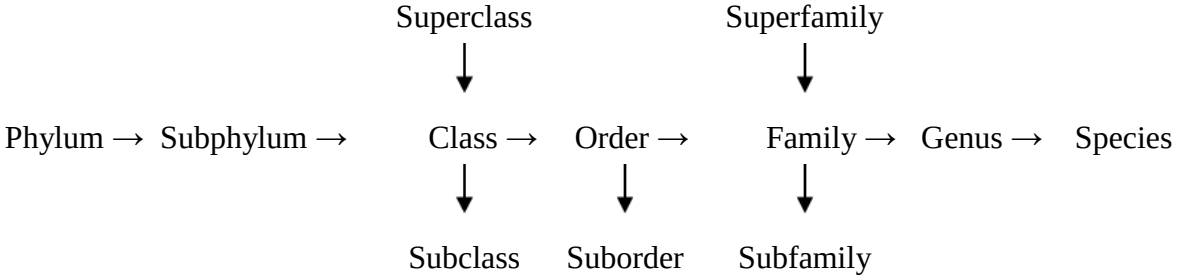
The basic systematization of living organisms

Living organisms occupy biosphere of our planet.

Systematization of living organisms is a section of biology engaged in creation of systems of classification, which in the best way would reflect a various degree of general similarity of living organisms. It is engaged in classification of investigated objects and development of their nomenclature.

Each organism possesses two names, a generic and a specific; the former begins with an initial capital and the latter with an initial small letter, after which comes the designator's name, followed by punctuation and finally the year. The generic and specific names are in italics but not the designator's name. The common intestinal roundworm of a human is named *Ascaris lumbricoides* Linnaeus, 1758. This means that it belongs to the Genus *Ascaris* and the name of the species *lumbricoides* was given by Linnaeus in the year 1758. When the name assigned to the parasite is later transferred, the correct name is written as usual followed by the original name with the year in parenthesis.

While describing animal parasites certain rules of zoological systematization are followed and each phylum may be further subdivided as follows:



The systematization of living things (with an example of *Entamoeba histolytica*): Empire *Cellular*, Kingdom *Animalia*, Subkingdom *Protozoa*, Phylum *Sarcomastigophora*, Class *Sarcodina*, Subclass *Rhizopodea*, Superorder *Lobosia*, Order *Amoebida*, Genus *Entamoeba*, Species according to Linnaeus' nomenclature: *Entamoeba histolytica*.

MEDICAL PROTOZOOLOGY

The general description of *Protozoa* Subkingdom

Medical Protozoology studies morphology and physiology of Protists (which are pathogenic organisms) as well as the questions of epidemiology (prevalence, ways of transmition), pathogenesis, clinic, diagnostics, treatment and prevention of these diseases.

Systematic position in the zoological classification:

Kingdom *Animalia*

SubKingdom *Protozoa*.

Protists are the most primitive living organisms by the cellular level of organization. Subkingdom *Protozo*a includes organisms of the body which consist of one cell performing all the functions of a multicellular organism. More than 10 thousand out of 65 thousand of species of *Protozoa* are parasites. A lot of protists have adapted to parasitizing inside human cells, blood and tissue fluid.

Protists' cell consists of cytoplasm, one or several nuclei and possesses a cell surface. Protists possess the same organelles of general purpose as the eukaryotic cells of multicellular organisms. They have microscopic sizes and inconstant or constant body shape.

Cytoplasm is divided into two layers: external layer is lighter and dense, it's called ectoplasm. Its function is protective, movement and sensory. The second layer is internal granular portion that contains numerous inclusions, this layer is called endoplasm. Its function is nutritive and reproductive.

The cell surface is represented by external membrane that can increase the thickness and density of external layer forming pellicle or thicker cuticle.

The locomotory (movement) organelles can be pseudopods. For example, prolongation of temporary ectoplasmic process, seen in *Sarcodina (Amoeba)*, flagellum is long delicate thread-like filament, seen in *Mastigophora (Leishmania, Trypanosoma*) and cilia are fine needle-like filaments covering the entire surface of the body, seen in *Ciliophora (Balantidium coli)* (Figure 1).

Nutrition. *Protozoa* swallow food:

- with the help of pseudopods (pinocytosis and phagocytosis);
- endoosmotically (absorption of soluble nutritive matters by the cell surface);

- with the help of cell stoma (mouth or cytostome), cell gullet (cytopharynx).

There are food vacuoles for food digestion in the cytoplasm. The contractile (pulsing) vacuole is an excretion, breathing and osmoregulation organelle. Some representatives have an excretory organ represented as a special pore in pellicle known as cytoproct.

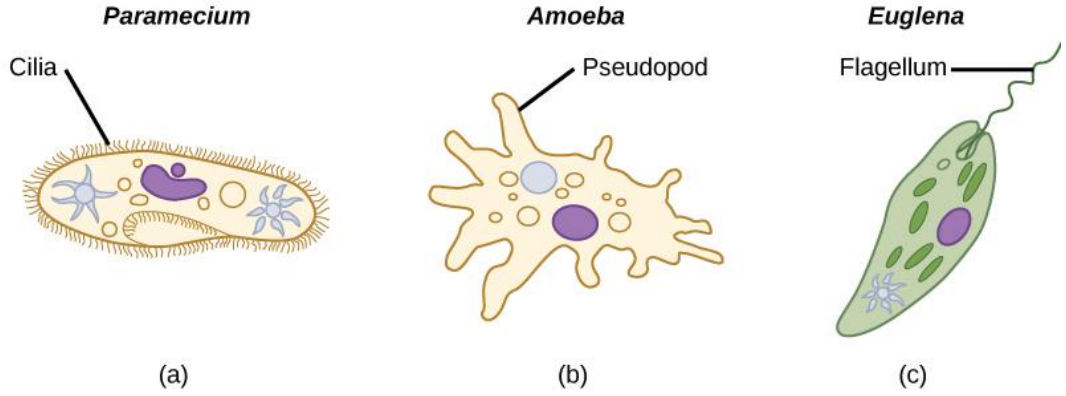


Figure 1. The locomotory organelles of Protists.
(https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcQEC7n8JyIkB_2-cZklTr6Af2QXNRCWcsX93YzODsM2tO152rmv)

Reproduction. *Protozoa* have two types of reproduction: asexual and sexual.

Asexual reproduction involves mitosis (division into two). In this process the individual parasite divides either longitudinally or transversely into two more or less equal parts. Before division all the structures are duplicated.

Multiple fission is called schizogony. In this process more than two daughter cells are produced, as in *Sporozoa* (malarial *Plasmodium*). The nucleus of the parent cell at first undergoes repeated divisions, which are then surrounded by the cytoplasm. When the multiplication is completed, the parasitic body or schizont ruptures and liberates these daughter cells which in their turn repeat their life cycle.

From time to time some *Protozoa* have sexual process in their life cycle that is called conjugation and copulation:

- conjugation. In the process of conjugation, a temporary union of two individuals occurs involving interchange of nuclear material. Later on, the two individuals separate, each being rejuvenated by the process, as in *Ciliophora* (Figure 2).

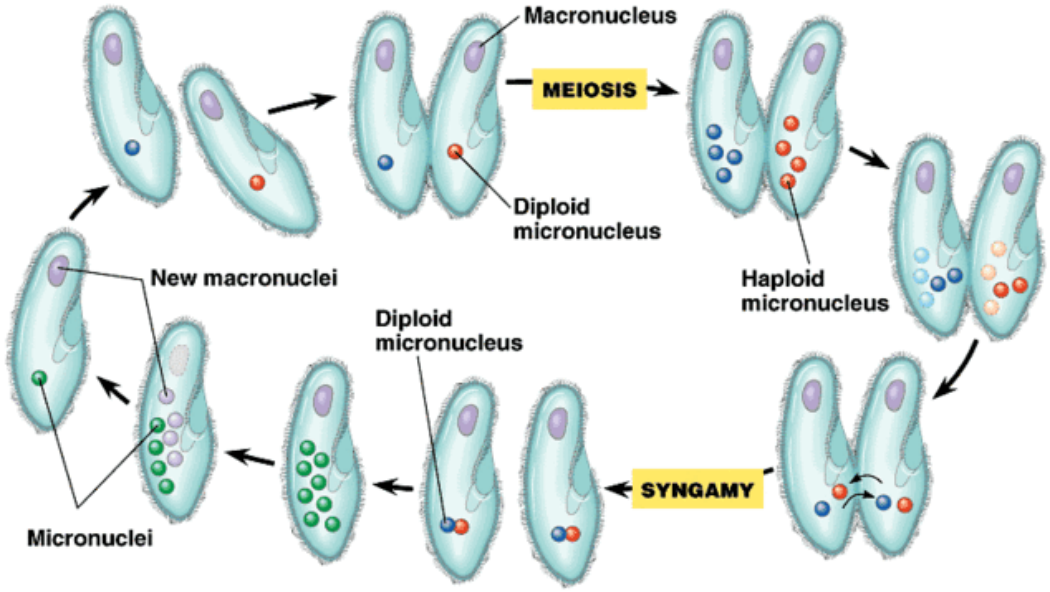


Figure 2. Sexual Reproduction by conjugation of paramecia (https://sharon-taxonomy2009-p2.wikispaces.com/file/view/paramecium.gif/95763626/640x379/paramecium.gif)

Paramecium occasionally reproduces by sexual means, particularly when the cell is exposed to stressful conditions. For this process to take place, two paramecium cells should come together. When this happens, the cells attach to each other. The micronucleus in each of the fused cells divide by meiosis, leading to formation of four haploid nuclei. Out of these, 3 are dissolved and only one survives in each cell. The surviving micronucleus again divides mitotically and forms two nuclei. The two paramecium cells exchange one haploid micronucleus and they separate. It is the meiosis division that leads to exchange of genetic material. This sexual reproduction in paramecium is known as conjugation.

There is no specific paramecium reproduction cycle as such. In favorable conditions, paramecium can undergo asexual multiplication for at least three times a day;

- syngamy or copulation. In this process, sexually differentiated cells, called gametes, unite permanently and a complete fusion of the nuclear material takes place, as in *Apicomplexa*.

Sexual reproduction involves fusion of two haploid (n) cells, the gametes. It produces a diploid (2n) cell called zygote.

It undergoes mitotic divisions to give rise to a number of diploid daughter cells or undergoes meiotic division to form haploid daughter cells.

The process of meiosis is an essential step in sexual reproduction because it reduces the chromosome number to half in gametes.

After fertilization, the diploid number of chromosomes (2n) is restored and is maintained constantly in a species.

Many *Protozoa* have alternated forms of reproduction. There can be seen complex development cycles. Life cycle is a number of stages that follow each. The development cycle starts with zygote, then it is followed by asexual reproduction, then gametes are formed, and the fusion of two of these gametes makes up zygote again. Among the majority of *Protozoa*, especially of parasitizing ones, the transition from one habitat to another takes place during this period.

The life cycle of *Protozoa* includes trophozoite stage (vegetative form) and cyst. Trophozoite is characterized by active nutrition, movement, reproduction. Cyst doesn't feed, move, reproduce; it is covered with a dense membrane. The cyst formation is called encysting. It is a protective reaction of the organism providing survival in unfavorable conditions. Excysting is exit from the state of cyst in favorable conditions.

The shapes, mode of reproduction and type of locomotive organs have been used to divide *Protozoa* into three Phylum: *Sarcomastigophora* (classes *Sarcodina* and *Mastigophora*), *Apicomplexa, Ciliophora*.

Phylum *Sarcomastigophora*

Class *Sarcodina*

Systematic position in the zoological classification:

Kingdom *Animalia*

SubKingdom *Protozoa*

Phylum *Sarcomastigophora*

Class *Sarcodina*

Peculiarities of morphology: The body shape of representatives of *Sarcodina* Class is inconstant. They move from place to place by means of their pseudopods. They can be found in both fresh and salt waters, soil. Nutrition is performed by pinocytosis and phagocytosis and endosmotically (Figure 3).

The cell of representatives of Class *Sarcodina* consists of cytoplasm, one nucleus and it possesses a cell surface. They have the same organelles of general

purpose as the eukaryotic cells of multicellular organisms. They have microscopic sizes and inconstant body form.

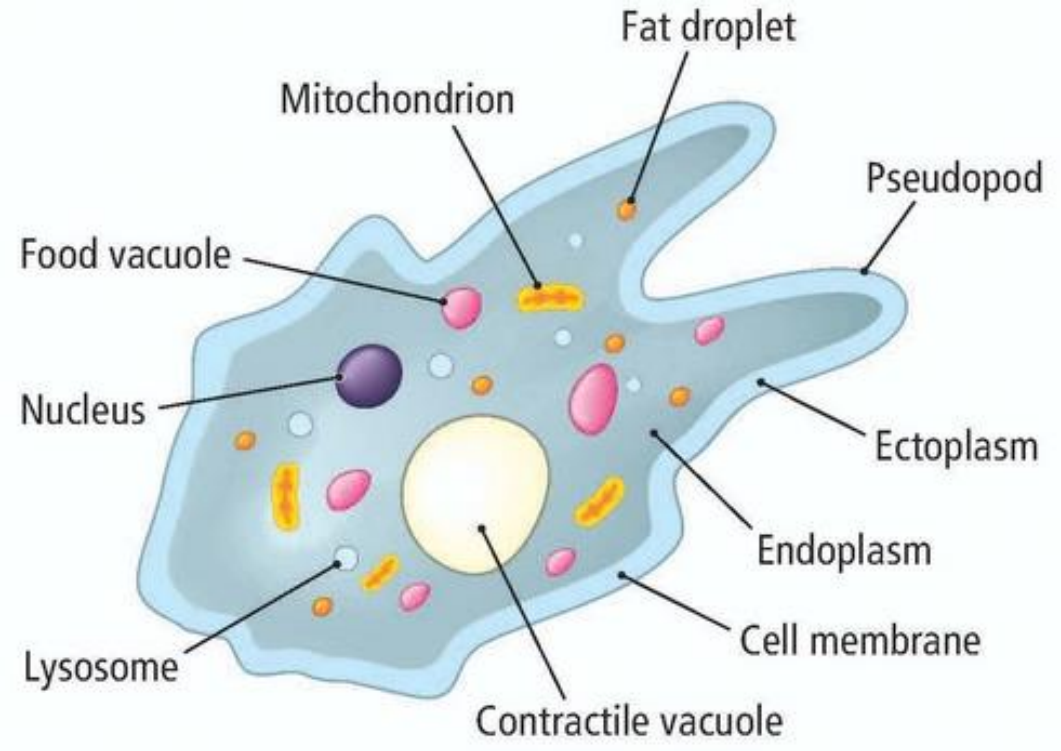


Figure 3. The morphology of Amoeba
(http://www.leavingcertbiology.net/uploads/3/4/3/2/34323540/2212840_orig.jpg)

Cytoplasm is divided into two layers: external layer is lighter and dense, it's called ectoplasm. Its function is protective, movement and sensory. The second layer is internal granular portion that contains numerous inclusions, this layer is called endoplasm. Its function is nutritive and reproductive.

The cell surface is represented by external membrane.

The locomotory organelles are pseudopods.

Nutrition. Amoeba swallows food with the help of pseudopods (pinocytosis and phagocytosis).

Reproduction. Amoeba has asexual type of reproduction. Asexual reproduction involves mitosis (division into two). In this process the parasite divides into two parts. Before division all the structures are duplicated.

The life cycle of Amoeba includes trophozoite stage (vegetative form) and cyst.

The representatives of Class *Sarcodina* that have medical importance: *Entamoeba coli (*amoeba coli*), Entamoeba gingivalis (*amoeba dentalis*), Entamoeba histolytica (*dysentery amoeba*).*

Dysenteric amoeba (*Entamoeba histolytica*)

Systematic position in the zoological classification:

Kingdom *Animalia*

SubKingdom *Protozoa*

Phylum *Sarcomastigophora*

Class *Sarcodina*

Species *Entamoeba histolytica*.

Dysenteric amoeba is pathogenic amoeba, which causes amoebic dysentery or amebiasis (but not dysentery).

Epidemiology (geographical distribution). They are chiefly wide spread in the countries with warm climate but can be found everywhere. Amebiasis is endemic in India, were the prevalence exceeds 30% in some places.

Peculiarities of morphology. There are two stages in the life cycle of the parasite: vegetative stage (Trophozoite) and a cyst. In the outer environment vegetative stages form cysts. The cysts contain four nuclei. Trophozoite (vegetative stage) can exist in three forms: small vegetative form (forma minuta), big vegetative form (forma magna) or erythrophage and tissue form. Forma minuta is commensal, it does not have pathogenic effect.

The mechanism of human infection. Disease sources are sick people and cyst carriers. Invasion stage for human is cyst. The way of penetration is alimentary way (through the mouth). The factors of transmission are dirty hands, unwashed vegetables, fruit, greens, dirty water, contaminated with cysts. Mechanical carrier of cysts are flies and cockroaches. They can carry cysts on their body.

Life Cycle. *Entamoeba histolytica* passes only one life cycle, the human one (Figure 4). The mature cysts are infective form of *Entamoeba histolytica*. They infect humans through the mouth (alimentary way) with contaminated food or water. The factors of transmission are dirty hands, unwashed vegetables, fruit, greens, dirty water, contaminated with cysts. Contamination of food and water with cysts occurs due to feces, flies or unwashed hands. The cysts pass up to the small intestine where they excyst. The cyst with four nuclei rapidly divides to produce eight small vegetative forms (forma minuta). These amoebas

may live in the lumen of large intestine without invading the intestinal mucosa in about 20% of infected persons. They encyst themselves and pass into the feces. Such people do not get sick and they are called asymptomatic carriers (cyst carriers).

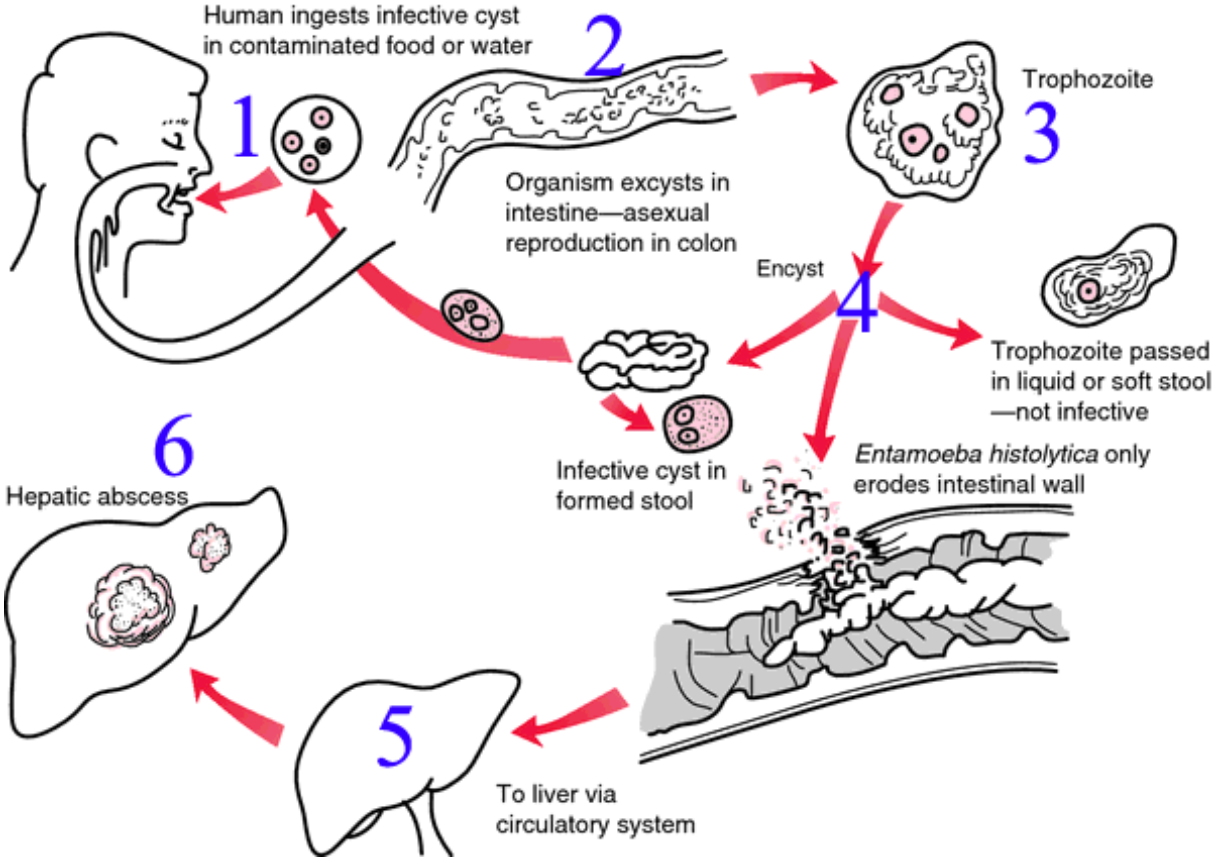


Figure 4. Life Cycle of *Entamoeba histolytica*
(http://www.medical-labs.net/wp-content/uploads/2014/06/500px-Dna2life-life_cycle_of_Entamoeba_histolytica.png)

In unfavorable for humans conditions small vegetative form can turn into big vegetative form. Big vegetative form synthesizes enzymes. It leads to ulceration of intestinal wall. Forms magna (erythrophage trophozoites) are able to engulf erythrocytes appearing in the lumen of intestine.

Some of erythrophage trophozoites can penetrate through intestinal mucosa into tissus of other organs with transformation into tissue form.

Clinical features. Amoebic colitis presents as dysentery. Patients have abdominal pain and they may have blood and mucus in feces. The frequency of stools is 6-8 per day. If the parasite gets into your bloodstream it can spread to other parts of body, including the liver. When this happens, liver abscess develops.

Laboratory diagnosis is based on microscopic study of native faecal smear, smear of the contents from ulcers and tissue and large vegetative forms from these ulcers. A freshly voided sample of faeces (excrements) is used for examination forms magna. Cyst of E.histolytica can be found in faeces during the convalescent stage of amoebic colitis and in asymptomatic carrier.

Preventive measures. Public prevention includes struggle against the pollution of soil and water with faeces, elimination of flies, test on cystcarrying, treatment of patients, sanitary-instructive work. Personal prevention includes good personal hygiene, washing of raw vegetable and fruits before consumption and protection of food from flies and cockroaches. Cysts are resistant to routine chlorination, therefore drinking water should be purified by either boiling or filtration.

Amoeba coli (*Entamoeba coli*)

Systematic position in the zoological classification:

Kingdom *Animalia*

SubKingdom *Protozoa*

Phylum *Sarcomastigophora*

Class *Sarcodina*

Species *Entamoeba coli* (amoeba coli).

Morphology of trohozoite *of Entamoeba coli***.** It is one of the largest amoeba occuring in the human colon and measures 20 to 40 μm in diameter. In the life cycle of parasite there are two stages: vegetative form (trophozoite) and a cyst. In the outer environment vegetative forms make up cysts. The cysts contain eight nuclei (fig. 5).

The mechanism of human infection. Disease sources are cyst carriers. Invasion stage for humans is cyst. The way of penetration is alimentary way (through the mouth). The factors of transmission are dirty hands, unwashed vegetables, fruit, greens, dirty water, contaminated with cysts. Mechanical carrier of cysts are flies and cockroaches.

Clinical features. *Entamoeba coli* are mostly harmless parasites, and do not cause harm to the host (does not have pathogenic effect).

Laboratory diagnosis. Cyst of *E. coli* can be found in faeces of human.

Preventive measures. Public prevention includes struggle against pollution of soil and water with faeces, elimination of flies, sanitary-instructive work. Personal prevention includes good personal hygiene, washing of raw vegetable and fruits before consumption and protection of food from flies and cockroaches.

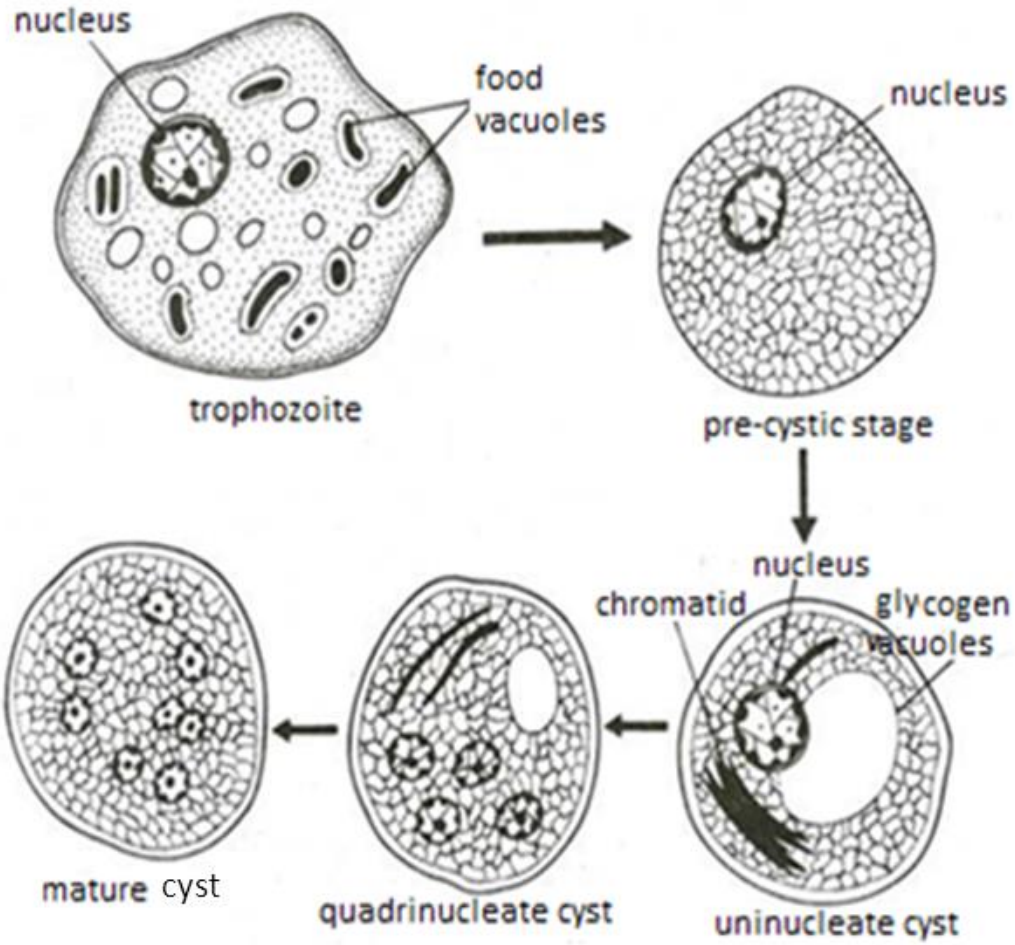


Figure 5. Stages of the *Entamoeba coli*
(https://upload.wikimedia.org/wikipedia/commons/thumb/6/6e/Entamoeba_coli_Stages.png/220px-Entamoeba_coli_Stages.png)

Amoeba dentals or mouth amoeba (*Entamoeba gingivalis*)

Systematic position in the zoological classification:

Kingdom *Animalia*

SubKingdom *Protozoa*

Phylum *Sarcomastigophora*

Class *Sarcodina*

Species *Entamoeba gingivalis.*

Morphology of trophozoite of *Entamoeba gingivalis*. It is an inhabitant of the human mouth, living as a harmless commensal particularly in the unhealthy tissues around the teeth. It is a small amoeba, measuring 10 to 20 μm in diameter. It is actively motile with pseudopods. The cytoplasm is divisible into clear hyaline ectoplasm and granular endoplasm. Cytoplasmic inclusions consist of bacteria and other substances but never red blood cells. In the life cycle there is one stage – vegetative form (trophozoite). There is no cystic stage.

The mechanism of human infection. Invasion stage for human is trophozoite. The way of penetration is alimentary way (through the mouth). Trophozoites are transmitted person-to-person orally by kissing or such as eating utensils, toothbrush. It may be transmitted due to coughing.

Clinical features. *Entamoeba gingivalis* is also considered nonpathogenic, but is found in about 95% of patients with gum disease and about 50% of patients with healthy gums (Figure 6).

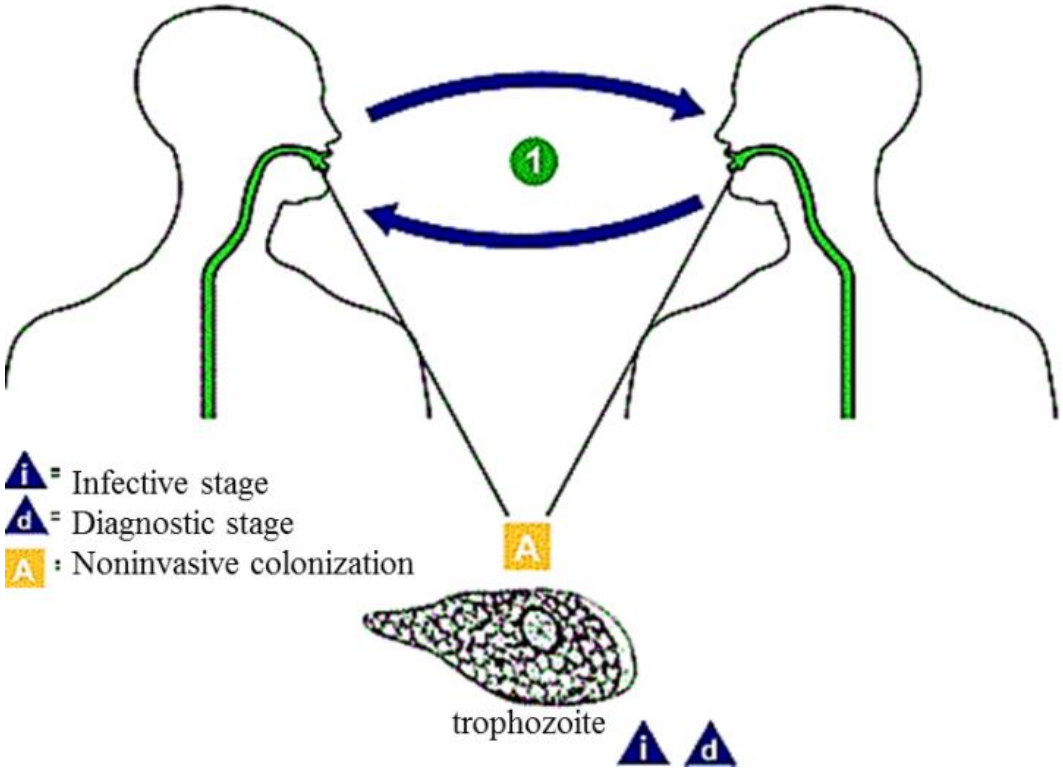


Figure 6. Life Cycle of *Entamoeba gingivalis*
(http://www.cdc.gov/dpdx/images/intestinalAmebae/EgingivalisLifeCycle.gif)

Preventive measures. *Entamoeba gingivalis* is not directly causing harm to the host; there is no specific prevention measure to prevent its occurrence. Proper hygiene may reduce the incidence of *E. gingivalis*.

Class *Mastigophora*

Systematic position in the zoological classification:

Kingdom *Animalia*

SubKingdom *Protozoa*

Phylum *Sarcomastigophora*

Class *Mastigophora*

The cell of representatives of *Mastigophora* Class consists of cytoplasm, nucleus and possesses a cell surface.

They possess the same organelles of general purpose as the eukaryotic cells of multicellular organisms. They have microscopic sizes and constant body form.

Cytoplasm is divided into two layers: external layer is lighter and dense, it's called ectoplasm. Its function is protective, movement and sensory. The second layer is internal granular portion that contains numerous inclusions, this layer is called endoplasm. Its function is nutritive and reproductive.

The cell surface of *Mastigophora* is covered with pellicle and that is why these Protists are not able to change their shape. Some *Mastigophora* have a special supporting organelle (axostyle) in the form of a dense band (cord), coming through the cell.

The locomotory organelles are one or several flagella on one of the development stages. At the base of a flagellum in the body of *Mastigophora* there is a special organelle – kinetoplast or blepharoplast, the function of which is connected with producing the energy for flagellum movement. Some species have a flagellum coming along their body and binding it with a thick undulating membrane that ensures onward movement of the Protist.

Nutrition. They swallow food endoosmotically (absorption of soluble nutritive matters by the cell surface and with the help of cell stoma (mouth or cytostome).

Reproduction. The representatives of *Mastigophora* Class have asexual reproduction. Asexual reproduction involves mitosis (division into two). In this process the parasite divides into two parts. Before division all the structures are duplicated.

***Kinetoplastida* Order. *Trypanosomatidae* family**

Systematic position:

Kingdom *Animalia*

SubKingdom *Protozoa*

Phylum *Sarcomastigophora*

Class *Mastigophora*

Order *Kinetoplastida*

Family *Trypanosomatidae*

Representatives of *Trypanosomatidae* family are the most important ones of this order. They are distinguished by an ability to create several morphologically different forms in the process of development cycle depending on living conditions. There can be following morphological forms (fig. 7)

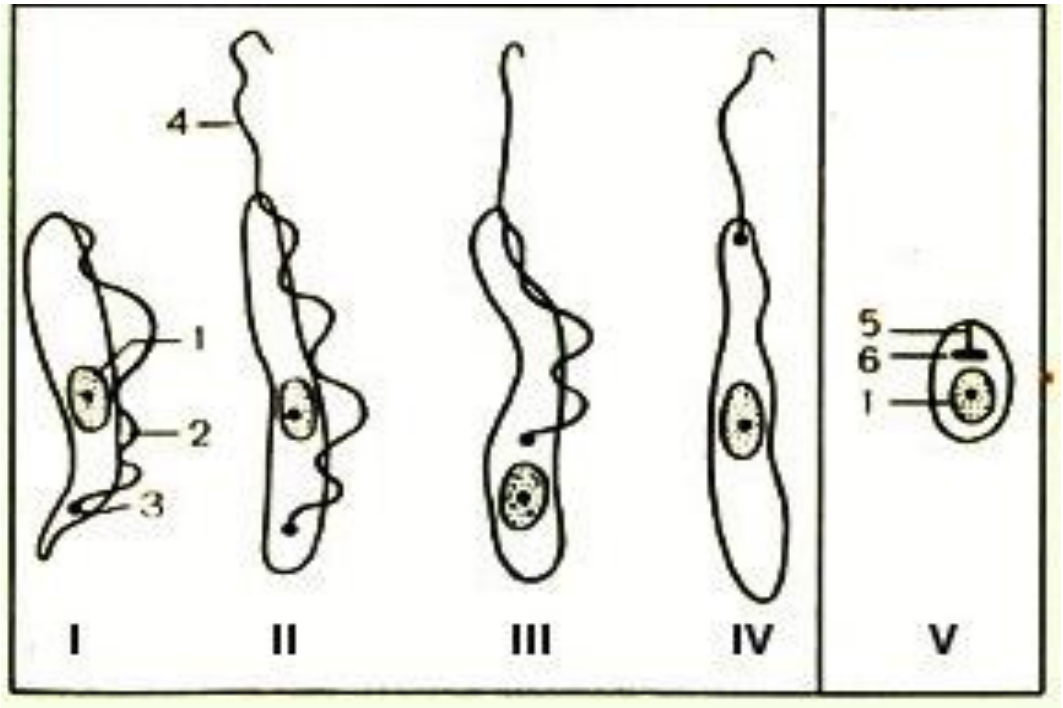


Figure 7. Morphological forms of *Trypanosomatidae:*
I – Metacyclic form, II – Trypomastigote form, III – Epimastigote form,
IV – Promastigote form, V – Amastigote form
1 – nucleus; 2 – undulating membrane;3 – kinetoplast; 4 – a free end of flagellum;
5 – intracellular part of flagellum;6 – kinetoplast
(http://bono-esse.ru/blizzard/img/A/Bio/bio_43.jpg)

Amastigote (leishmanial) form has a spherical shape, a large nucleus. A flagellum is absent or present as its intracellular part.

Promastigote (leptomonadial) form is from 9 to 15 mm long and is slender. The nucleus is located centrally, the flagellum projects from the anterior end (border).

Epimastigote (crithidial) form is from 9 to 15 mm long and is wider than the promastigote, a flagellum begins in front of the nucleus moving forward, forms a short undulate membrane and a free end.

Trypomastigote (trypanosomic) form has an undulating membrane with free flagella, the kinetoplast is placed in the posterior part.

Metacyclic form has the same structure as Trypomastigote but the free flagellum is short.

Leishmania Genus

Systematic position in the zoological classification:

Kingdom *Animalia*
SubKingdom *Protozoa*
Phylum *Sarcomastigophora*
Class *Mastigophora*
Order *Kinetoplastida*
Family *Trypanosomatidae*
Genus *Leishmania*
Species: *Leishmania tropica major*
Leishmania tropica minor
Leishmania donovani
Leishmania brasiliensis

Morphological peculiarities. *Leishmania* have two morphological forms:

a) promastigote or leptomonadial (with flagellum) in the organism of a carrier;

b) amastigote or leishmanial (non-flagella) in the organism of a human and other vertebrates.

Leishmaniasis is a transmissible natural focal disease. The specific carriers of all types of *Leishmania* are Sand Flies. Parasites reproduce in their alimentary canal and accumulate in proboscis. The human is infected by bites of sandflies.

Representatives:

a) *Leishmania tropica* (dermatropic leishmania) is the causative agent of cutaneous (dermal) leishmaniasis.

Life cycle consists of two stages: amastigote in a human and mammalian body, promastigote in Sand Flies of *Phlebotomus* genus. The amastigote is oval. It is placed in skin cells and lymphatic nodes. The promastigote has spindle shape. It also has flagella coming out from the kinetoplast. Invasional stage for human is promastigote form. The mode of infection is transmissive way by the bite of sandflies. They suck blood from the ill human or animal and then become infective in 6-8 days.

Epidemiological chain: reservoir hosts are small rodents; vector is a Sand Fly; recipients are healthy humans.

Clinical features. The typical clinical sign of skin leishmaniasis is the formation of oval, non-healing ulcers on the skin. After healing, they form coarse scars. The immunity against this disease is life-long.

Leishmania tropica major is a cause of rural skin leishmaniasis with acute necrotic forms. It occurs in North and West Africa and Asia.

Leishmania tropica minor is a cause of urban skin leishmaniasis with late onset. It occurs in Middle East, North and West Africa and West India

Laboratory diagnosis is based on the light microscopy of materials taken from ulcers to reveal amastigotes forms.

Prevention of dermal leishmaniosis. Personal protection from Sand Flies bites by using repellents and mosquito-nets. Public prevention includes revealing and treatment of ill people, dressing ulcers by bandages to prevent Sand Flies bites, struggle against vector (sandflies), elimination of reservoir hosts (rodents).

b) *Leishmania donovani* is a pathogene (causative agent) of internal (visceral) leishmaniasis or this disease is called black illness, doom-doom fever, kala-azar. It is wide-spread in India, China, East Africa, South and Central America. It is common along the banks of rivers. Jackals, dogs and sick person can be natural reservoirs. Vector is a Sand Fly (*Phlebotomus papatasii*); recipients are healthy humans.

Life Cycle. The infective forms for humans are promastigotes. They are introduced into tissues in transmissive way by the bite of the infected Sand Flies.

They enter macrophages, lose their flagella and transform to amastigotes. Amastigotes are obligate intracellular forms. Few amastigotes are present free in the peripheral blood. A female Sand Fly needs a blood meal to lay eggs. When it feeds on an infected person, amastigotes are sucked in. The parasite migrates to the pharynx and buccal cavity in large numbers. During the next blood meal of the Sand Fly, mature promastigotes are ready to infect a new host (Figure 8).

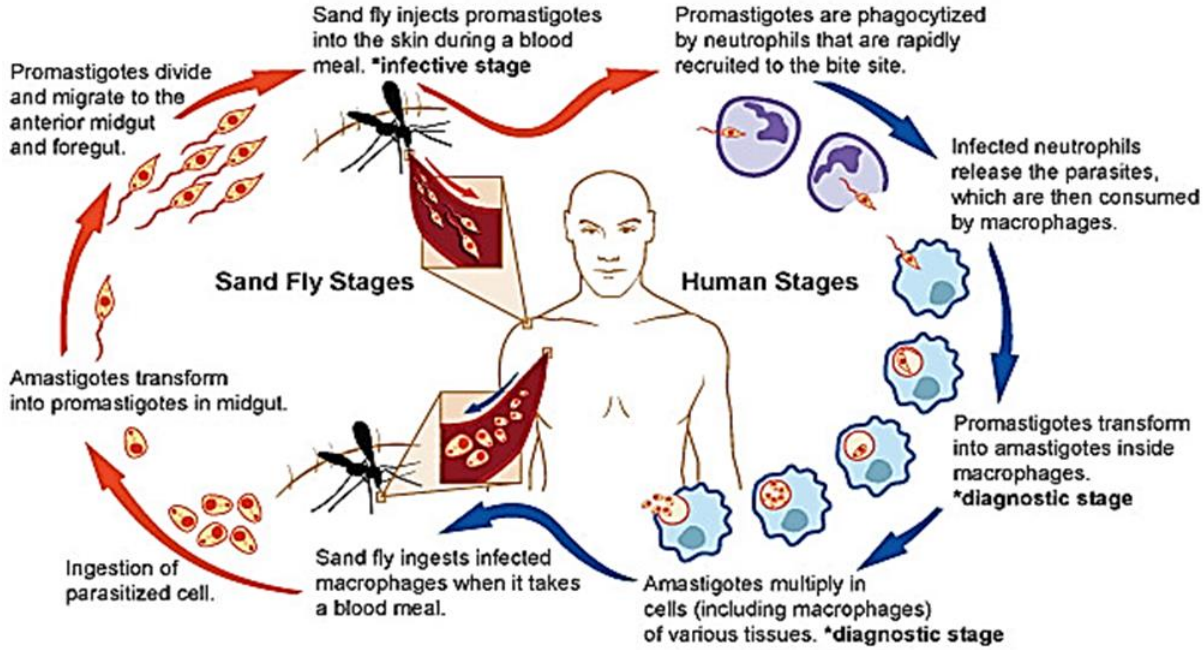


Figure 8. Diagram showing the sandfly and human stages of leishmaniasis (http://4.bp.blogspot.com/-AGZzV1qH9K0/TyeedCo5e6I/AAAAAAAABVs/T-jQWzdTbD4/s1600/leishDiagram1.jpg)

Clinical features. Night irregular fever, diarrhea, enlargement of the spleen, liver and lymph nodes. Edema, weakness and wasting of the body due to severe chronic illness and hyperpigmentation are late manifestations (black disease).

Laboratory diagnosis is based on the microscopical investigation of bone marrow sample from the breast bone (revealing *Leishmania* forms in the cells of bone marrow) as well as microscopical examination of blood.

Prevention of visceral leishmaniasis. Personal protection from Sand Flies' bites by using repellents and mosquito-nets. Public prevention includes revealing and treatment of ill people, struggle against vector (Sand Flies), elimination of reservoir hosts (stray dogs).

***Trypanosoma* Genus**

Systematic position in the zoological classification:

Kingdom *Animalia*
SubKingdom *Protozoa*
Phylum *Sarcomastigophora*
Class *Mastigophora*
Order *Kinetoplastida*
Family *Trypanosomatidae*
Genus *Trypanosoma*
Species: *Trypanosoma brucei gambiense*
Trypanosoma brucei rhodesiense
Trypanosoma cruzi

Trypanosoma brucei gambiense and *Trypanosoma brucei rhodesiense* are pathogens of African trypanosomiasis. *Trypanosoma cruzi* is pathogene of American trypanosomiasis or Chagas' disease

Trypanosomiasis is a transmissible natural focal disease.

Pathogenes of African trypanosomiasis or this disease is called sleeping sickness.

Trypanosoma brucei gambiense. Gambian trypanosomiasis is widespread in Western and Central parts of equatorial Africa. It is spread by tsetse flies *Glossina palpalis*. It affects humans, pigs and neat and small cattle, dogs.

Trypanosoma brucei rhodesiense. Rhodesian trypanosomiasis is distributed in Eastern Africa. It is spread by tsetse flies. It affects antelopes, rhinoceroses, neat and small cattle.

The parasites localize in blood, lymph, lymphonodes, cerebrospinal fluid, brain and spinal marrow of man.

Life Cycle. *Trypanosoma brucei gambiense* and *Trypanosoma brucei rhodesiense* have a complex life cycle. They require two hosts to complete their life cycle.

The mechanism of human infection. Reservoir hosts are some vertebrate animals (antelopes, rhinoceroses, neat and small cattle). Vectors are Tsetse flies. Recipients are healthy humans. The way of infection is transmissive by the vector bite (tsetse flies). The infective forms for humans are the metacyclic form. They are introduced into tissues of the definitive hosts in transmissible way with the bite of an infected tsetse fly (figure 9).

The epidemiological chains of sleeping sicknesses: reservoir is sick human, domestic and wild animals (antelopes); vector is tsetse fly; recipients are healthy humans and vertebrates.

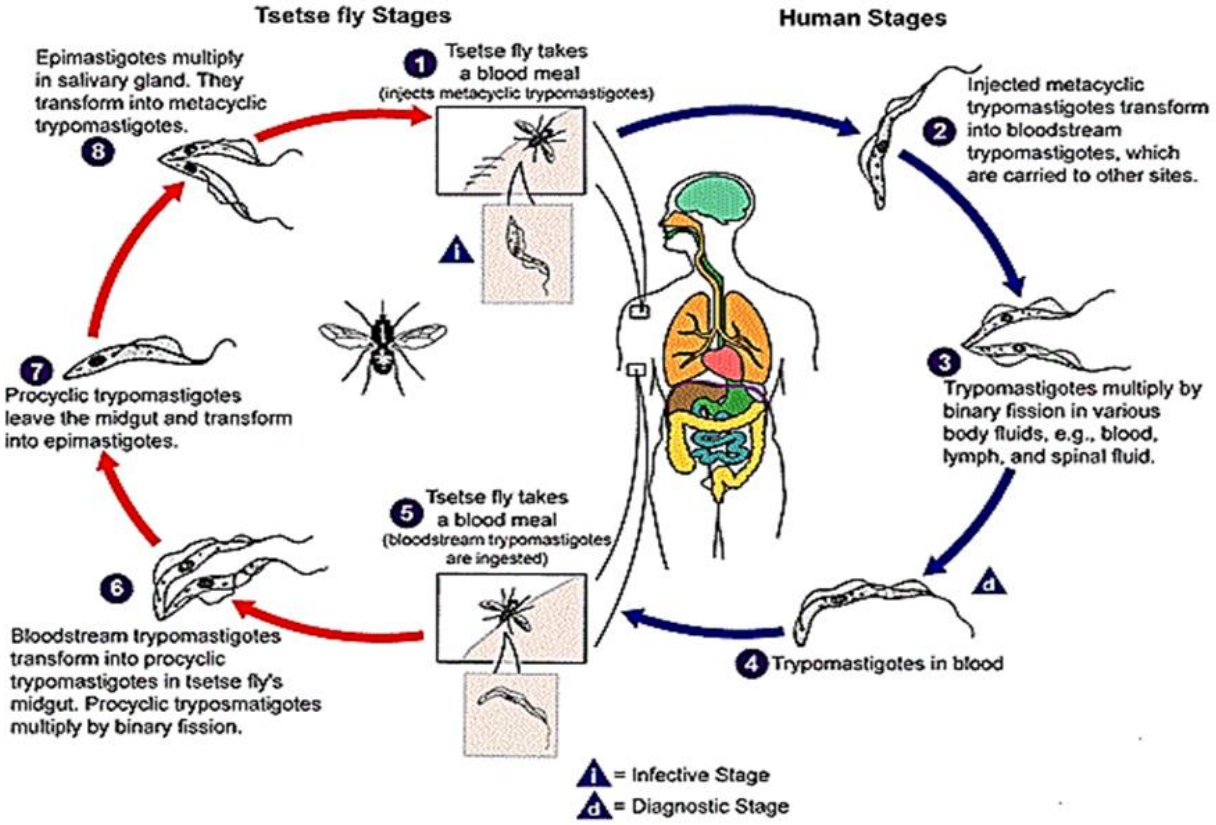


Figure 9. Life Cycle of *Trypanosoma brucei*
(https://upload.wikimedia.org/wikipedia/commons/thumb/d/d7/AfrTryp_LifeCycle.png/220px-AfrTryp_LifeCycle.png)

Clinical signs and symptoms are serious disorders of the nervous system, muscle weakness, depression, drowsiness. During each wave of parasitaemia the patient develops a fever. Anemia also occurs. At the final stage, a progressive neurological disorders lead to coma and death.

Laboratory diagnosis. Parasites in trypomastigote form are easily detected in the lymph nodes and blood aspirate.

Preventive action. Personal prevention of infection to avoid areas harboring the tsetse fly. Use protective clothing and repellents.

Public prevention includes elimination of tsetse flies through the use of insecticides, treatment and vaccination. The latter provides prophylactic effect for at least 6 months.

Trypanosoma cruzi is a pathogene of American trypanosomiasis or Chagas' disease. It is widespread in Central and South America.

In human it exists in 2 forms: amastigotes and trypomastigotes. Amastigotes live in muscles of the heart and the skeleton, nerve cells and cells of the reticulo-endothelial system. Trypomastigotes appear in the peripheral blood from time to time.

Life Cycle. A *Trypanosoma cruzi* has a complex life cycle (figure 10).

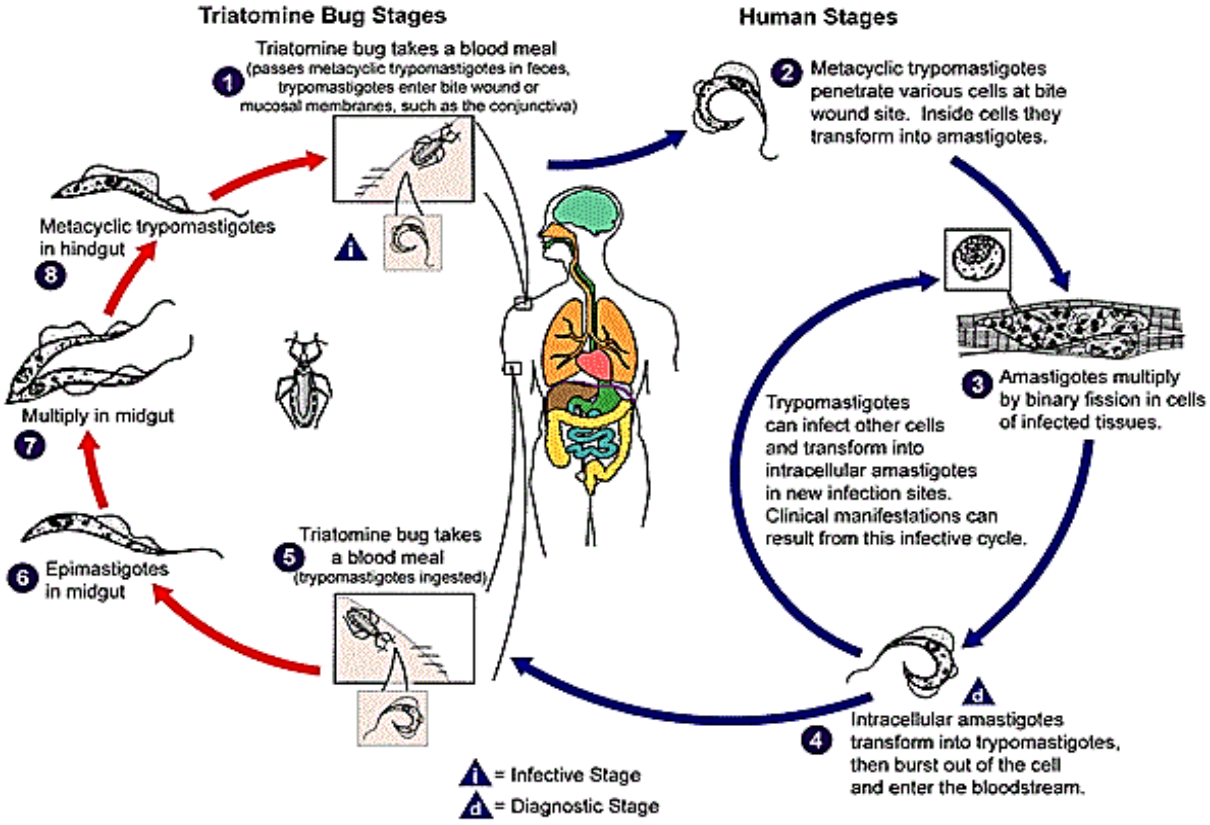


Figure 10. Life Cycle of *Trypanosoma cruzi*
(http://www.dicyt.com/data/51/19951_med.jpg)

The mechanism of human infection. Reservoir hosts are opossums, armadillos, monkeys. Vectors are bugs of *Triatoma* genus *(Triatoma megista).* Recipients are healthy humans. Infective forms of the parasite for humans are metacyclic forms. The way of infection is transmissive by the vector bite (bugs). Metacyclic trypomastigotes are deposited along with the faeces of the bug near the bite wound (mainly around eyes and lips). These infective forms are then rubbed into the wound by the bitten person or transferred to his conjunctiva through contaminated fingers.

Epidemiological chain of Chagas' disease: reservoir hosts are opossums, armadillos, monkeys; vectors are bugs of *Triatoma* genus; recipients are healthy humans and vertebrate animals (armadillo, opossum).

Laboratory diagnosis reveals trypomastigote forms in blood during acute period. Biopsy of involved lymph node or muscle may reveal amastigote forms.

Prevention of Chagas' disease. Personal prevention: protection from bugs' bites using repellents and mosquito-nets. Attack on vector using insecticides as well as avoiding formation of cracks when building houses (these bugs live there). Public prevention is treatment of patients.

Genus *Trichomonas*

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Protozoa*
Phylum *Sarcomastigophora*
Class *Mastigophora*
Genus *Trichomonas*

They are widespread everywhere.

Peculiarities of morphology. The cell of representatives of Genus *Trichomonas* consists of cytoplasm, nucleus and possesses a cell surface. They possess the same organelles of general purpose as the eukaryotic cells of multicellular organisms. They have microscopic sizes and constant body shape.

Cytoplasm is divided into two layers: ectoplasm and endoplasm.

The cell surface is covered by pellicles and that is why these Protists are not able to change their shape. The representatives of Genus *Trichomonas* have a special supporting organelle – axostyle – in the form of a dense band (cord), coming through the cell.

The locomotory organelles are several flagella. They have a flagellum coming along their body and binding it with a thick undulating membrane.

Nutrition. They swallow food with the help of cell stoma (mouth or cytostome).

Reproduction. The representatives of Genus *Trichomonas* have asexual reproduction. Asexual reproduction involves mitosis (division into two). In this process the parasite divides into two parts. Before division all the structures are duplicated.

Trichomonas vaginalis (urogenital trichomonas)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Protozoa*

Phylum *Sarcomastigophora*

Class *Mastigophora*

Genus *Trichomonas*

Species *Trichomonas vaginalis*.

Trichomonas vaginalis is the cause of vaginitis (urogenital trichomoniasis). Geographical distribution is world-wide.

Peculiarities of morphology. The oval-shaped trophozoite has a single nucleus, five flagella. All arise at front end. The undulating membrane reaches up to the middle of the body (figure 11).

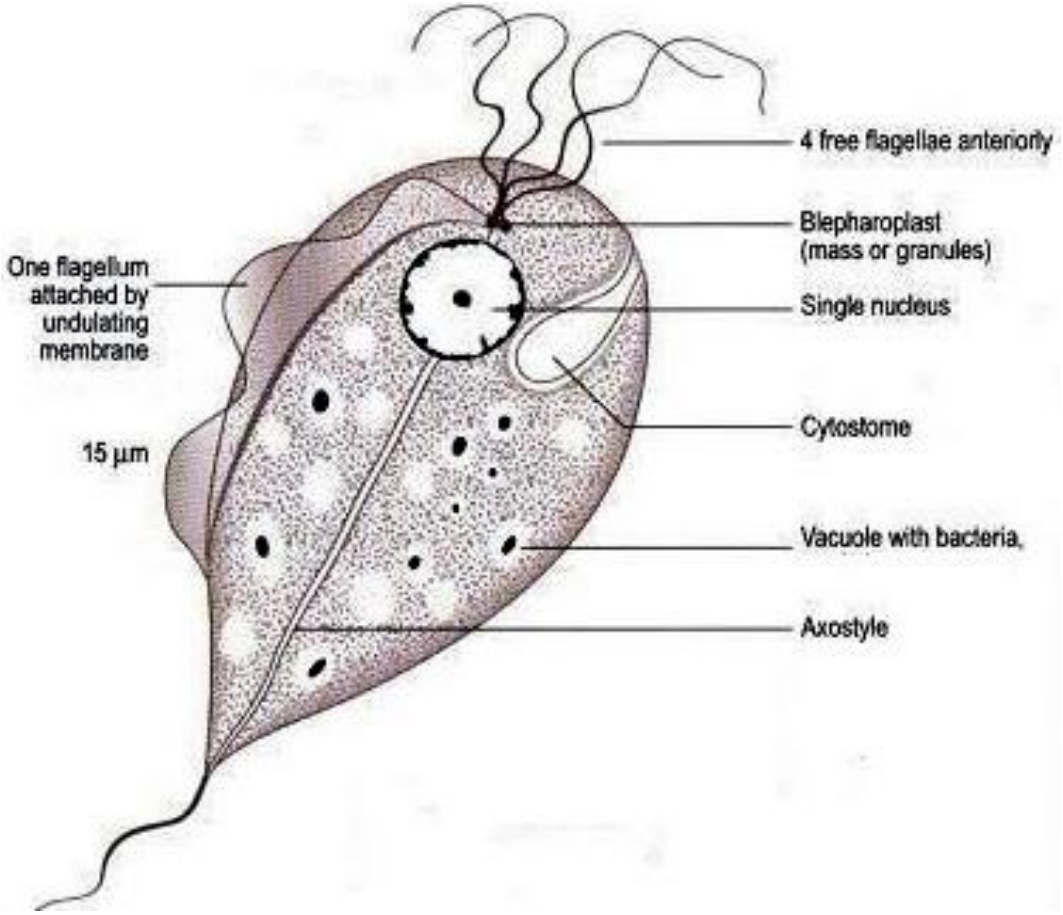


Figure 11. *Trichomonas vaginalis*
(http://microbeonline.com/wp-content/uploads/2016/03/Trophozoite-of-*Trichomonas*.jpg)

It has asexual **reproduction**. Trophozoites divide by binary fission. *Trichomonas vaginalis* lives in the urogenital tract of women and man.

In **the life cycle** it exists only as a flagellate trophozoite (figure 12). Cysts are not formed.

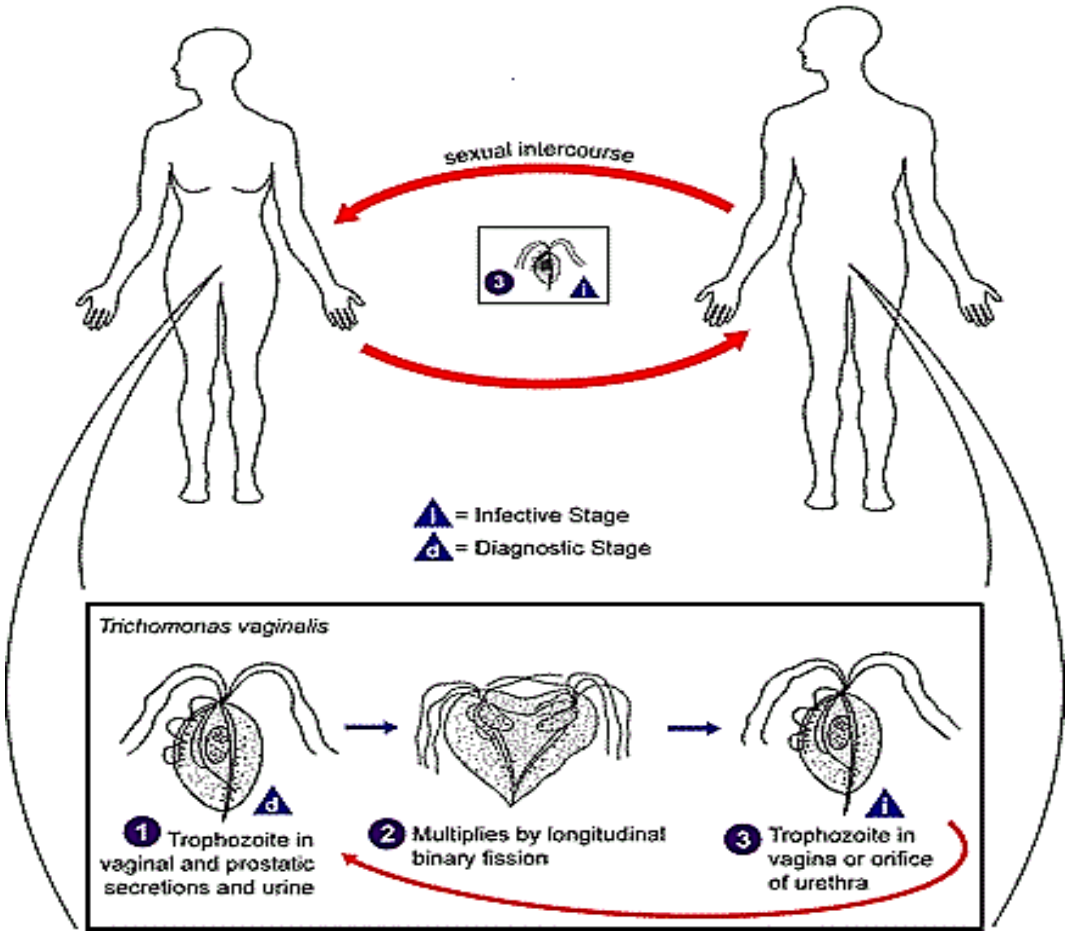


Figure 12. Life cycle of *Trichomonas vaginalis*
https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcTwkn3krOxqMeeq YNpmMyFb9f61F3zIlRce_HAvfJb-nYfpqgWd

The mechanism of human infection. Disease sources are sick humans. The trophozoite is an infective form. They are transmitted by sexual contact and by using other people's personal hygiene items as shared towels or underwear.

Clinical features and symptoms. In women it produces vaginitis. The manifestations are: a yellow malodorous vaginal discharge, vulvar erythema and itching, difficulty or pain when urinating, urinary frequency may also occur. In man the infection is usually asymptomatic. Some patients develop urethritis.

Preventive measures. Personal prevention: the infection can be prevented by the avoidance of casual sex contacts, unprotected sexual intercourse and avoiding sharing of towels and underwear. Individual hygienic articles will also

aid in prevention.Public prevention: sterilization of gynecological instruments and gloves; treatment of patients, sanitary and instructive work.

Trichomonas hominis

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Protozoa*
Phylum *Sarcomastigophora*
Class *Mastigophora*
Genus *Trichomonas*
Species *Trichomonas hominis*

Trichomonas hominis have oval body form, a cytostome representing a rudimentary mouth and axostyle with a spin. An axostyle is a central supporting rod. Parasites possess four flagella, three directed anteriorly and lying free, the fourth is directed backward forming undulate membrane and ending in a free terminal lash. The nucleus is situated at the anterior rounded end.

There is only vegetative form in **life cycle**. These nonpathogenic parasites live as a harmless commensal in the large intestine of men. The high concentration of *T. hominis* in large intestine called intestinal trichomoniasis promotes the development of other intestinal parasites.

The mechanism of human infection. Disease sources are infected people. Invasion stage for people is trophozoite. The way of penetration is alimentary way (through the mouth). The factors of transmission are dirty hands, unwashed vegetables, fruit, greens, dirty water.

Laboratory diagnostics is microscopical investigation of faeces to reveal vegetative forms.

Prevention of intestinal trichomoniasis. Personal prevention: to wash vegetables, fruit, hands, drink boiled water. Public prevention: struggle against soil and water pollution with feces.

Lamblia intestinalis

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Protozoa*
Phylum *Sarcomastigophora*

Class *Mastigophora*

Species *Lamblia intestinalis*

Lamblia intestinalis causes lambliasis. Lambliasis is pervasive.

Peculiarities of morphology. The trophozoites of *Lamblia intestinalis* are pear-shaped. The cell consists of cytoplasm and possesses a cell surface. The dorsal surface is convex. Sticking disk is present on the ventral surface. *Lamblia intestinalis* use it for attachment of the parasite to the intestinal mucosa. There are two nuclei in cytoplasm, two axostyles support the trophozoite. All the organelles are paired (figure 13).

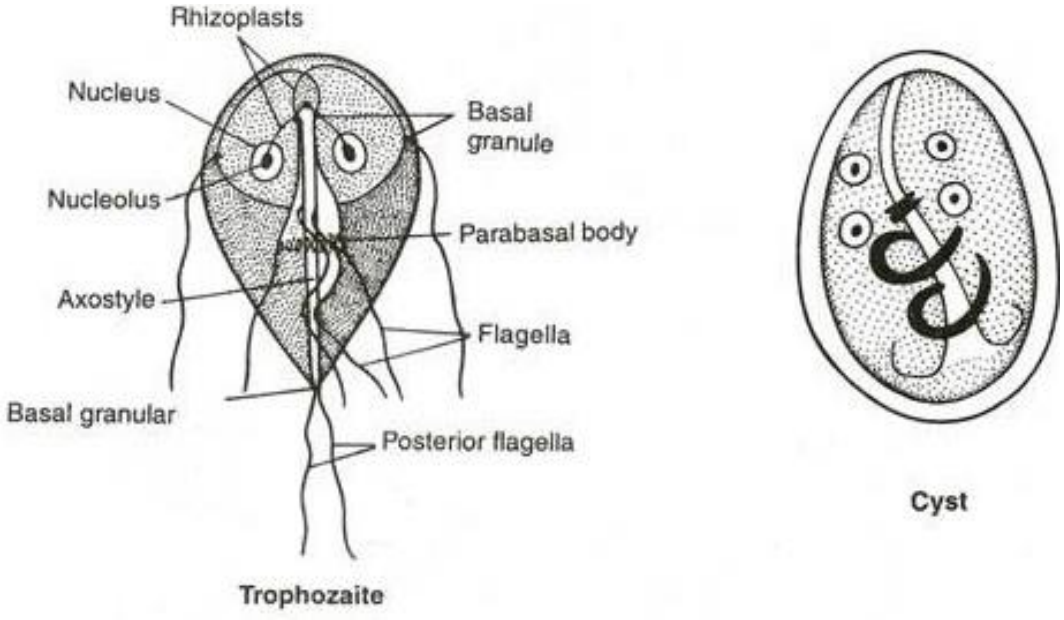


Figure 13. Stages of life cycle *Lamblia intestinalis*
(http://cdn.yourarticlelibrary.com/wp-content/uploads/2014/01/clip_image002172.jpg)

They have microscopic sizes and constant body form.

Cytoplasm is divided into two layers: ectoplasm and endoplasm.

The locomotory organelles are four pairs of flagella.

Nutrition. The parasite feeds with pinocytosis.

Reproduction. *Lamblia intestinalis* have asexual reproduction. Asexual reproduction involves mitosis (figure 14).

Lamblia intestinalis localizes in human duadenum. The infection of *Lamblia intestinalis* is called lambliosis. It is more common in children.

Life Cycle. Lamblia exists in two forms, trophozoite and cyst.

The mechanism of human infection. Disease sources are sick humans and cyst carriers. Invasion stage for people is cyst. The way of penetration is alimentary way (through the mouth). The factors of transmission are dirty hands, un-

washed vegetables, fruit, greens, dirty water, contaminated with cysts. Mechanical carriers of cysts are flies and cockroaches.

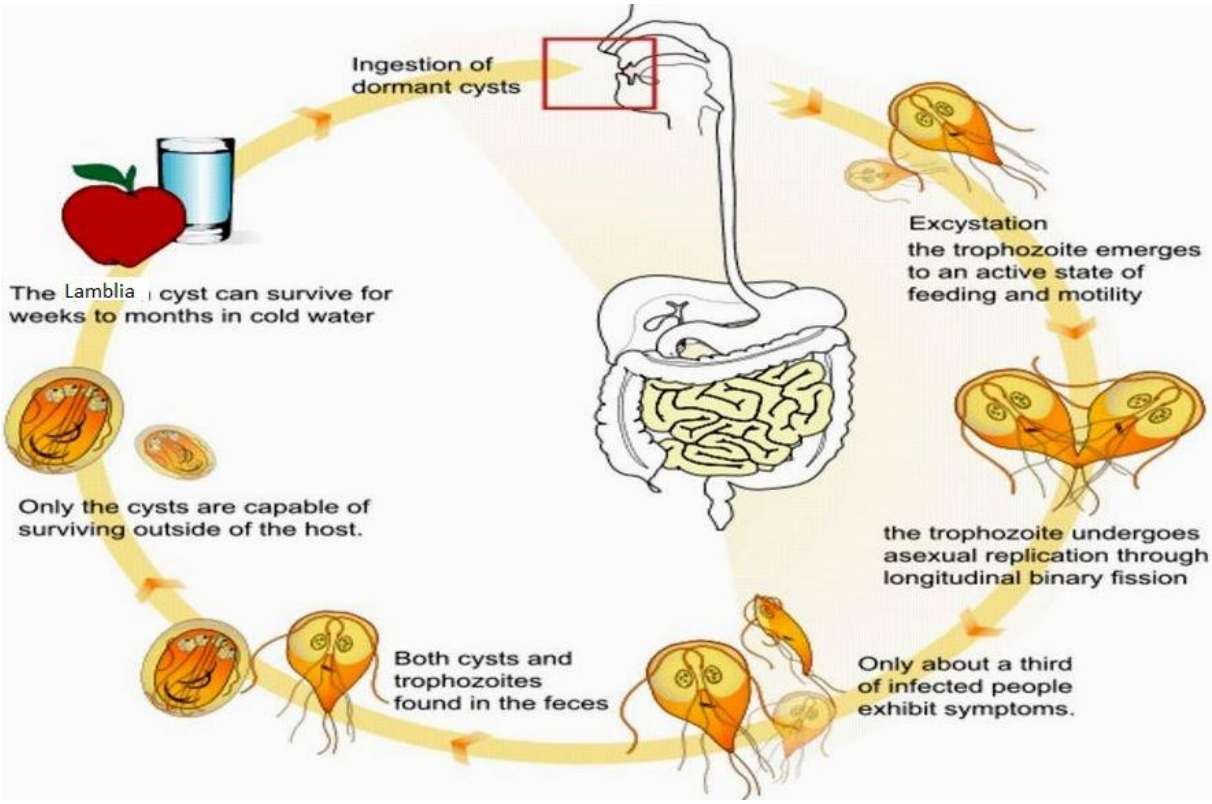


Figure 14. Life cycle of *Lamblia intestinalis*
(http://images.slideplayer.com/33/10148398/slides/slide_12.jpg)

Mature cysts are infective forms of *Lamblia intestinalis*. Transmission of the infection occurs by alimentary way with cyst water, vegetables, fruit, dirty hands. The excystation occurs in the proximal small intestine liberating two trophozoites. The trophozoites attach themselves to the mucosal cells with the help of a sticking disk. They multiply by longitudinal fission every 6-10 hours. *Lamblia intestinalis* completes its life cycle in a single host. The cysts remain viable in soil and water for several weeks.

Clinical features. Most of the infections with *Lamblia intestinalis* are asymptomatic.

Pathogenic effect is provided with disturbance of intestinal function (parietal digestion and absorption) due to attachment of parasite with help of the sticking dick. The parasite is also capable of producing harm by its toxic effect, traumatic and irritative effects. In chronic case the patient may complain of weight loss and diarrhea.

Laboratory diagnosis includes revealing cysts in faeces and vegetative forms in duodenal fluid.

Preventive measures of lambliasis. Personal prevention: to wash vegetables, fruit, drink boiled water, to wash hands before meals. Public prevention: struggle against soil and water pollution with faeces, treatment of patients and cyst-carriers, to hold sanitary and instructive work with people.

Phylum *Apicomplexa*

Systematic position in the zoological classification:
Kingdom *Animalia*
Subkingdom *Protozoa*
Phylum *Apicomplexa*

There are about 3600 species of *Apicomplexa* Phylum that lead parasitic way of life.

The cell of representatives of *Apicomplexa* Phylum consists of cytoplasm and possesses a cell surface. They possess the same organelles of general purpose as the eukaryotic cells of multicellular organisms. They do not have digestive and contractile vacuoles. They have microscopic sizes and constant body form.

Cytoplasm is divided into two layers: ectoplasm and endoplasm.

The cell surface. From the outside *Sporozoa* n body is covered with a three-layer pellicle that consists of external and two internal membranes. Under pellicle there are peripheric fibrillae and microtubes that perform supporting and contractile functions and ensure parasite's movement.

The locomotory organelles are absent.

Nutrition and excretion are osmotic.

Reproduction. The representatives of *Apicomplexa* Phylum have two types of reproduction: asexual or sexual. Asexual reproduction is performed by multiple fission or Schizogony and sporogony:

- in process of schizogony more than two daughter cells are produced. The nucleus of the parent cell at first undergoes repeated divisions which are then surrounded by the cytoplasm. When the multiplication is completed, the parasitic body or schizont ruptures and liberates these daughter cells (merozoites);
- sporogony is the process whereby a single zygote gives rise to many

spores with sporozoites. Sporozoites are small cells that lie within the thick walled resistant spore.

From time to time, they have sexual process in their life cycle that is called copulation or syngamy. In this process, sexually differentiated cells, called gametes, unite permanently and a complete fusion of the nuclear material takes place.

Sexual reproduction consists of gametogenesis (formation of sexual cells), fertilization and forming a zygote (oocyst).

Sporogony occurs immediately after a sexual phase and consists of an asexual reproduction that culminates in the production of sporozoites.

The representatives of *Coccidiomorpha* Class have medical importance. The Class has two orders: *Coccidia* (includes genus *Toxoplasma*) and *Haemosporidia* (includes genus *Plasmodium*).

Order *Coccidia*

Toxoplasma gondii

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Protozoa*
Phylum *Apicomplexa*
Class *Coccidiomorpha*
Order *Coccidia*
Species *Toxoplasma gondii*

Toxoplasma gondii is an obligate intra-cellular parasite. It causes disease called toxoplasmosis. Toxoplasmosis is spread everywhere. *Toxoplasma gondii* infection can be acute or chronic and symptomatic or asymptomatic.

Morphology. *Toxoplasma gondii* exists in a vegetative form (trophozoites), pseudocyst, cyst, oocyst.

Trophozoites of *Toxoplasma gondii* has half-moon shape (figure 15).

In the cell there are all the organelles typical of eukaryotic cell. In front of a nucleus there is a micropore in the pellicle that acts like a cytostome. At the anterior end (rear end) of a cell there is a conoid that has a form of a truncated cone, the walls of which consist of spirally twisted fibrilla. On top of the conoid there are two dense polar rings. Conoid performs a supporting function and takes part in the process of parasite’s penetration into a host’s cell. Near conoid

there are rhoptries – glandular formations eliminating secretion that dissolves the wall of host's cell.

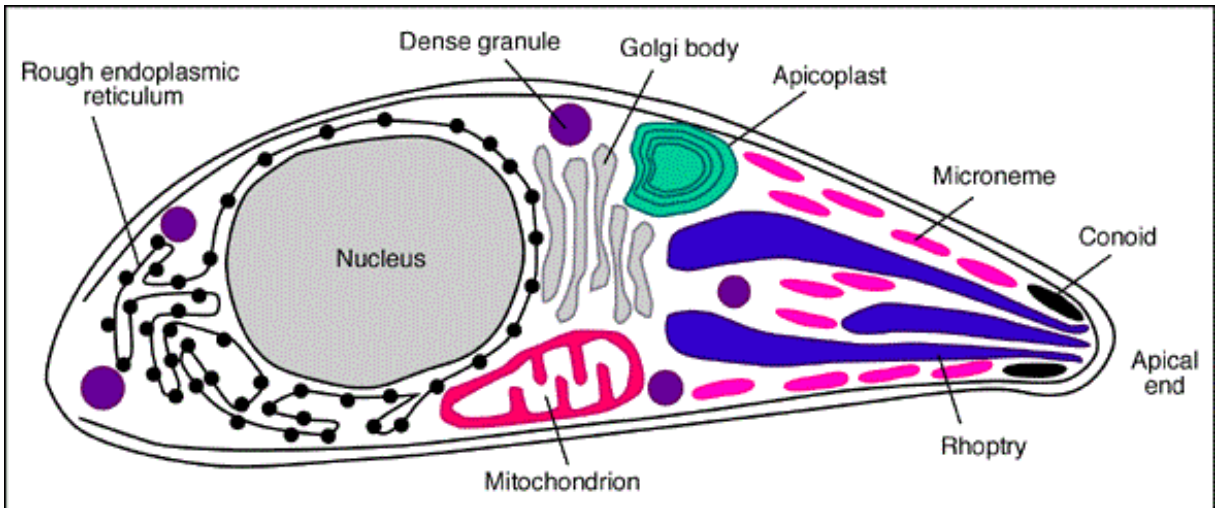


Figure 15. *Toxoplasma gondii*
(https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcSHFxgVI3ShtQgg WFAjpwwhS7CvE1DB3mtttH5GgudPBI8dbOV7Hg)

Life cycle of *Toxoplasma* takes place with the participation of two hosts (figure 16).

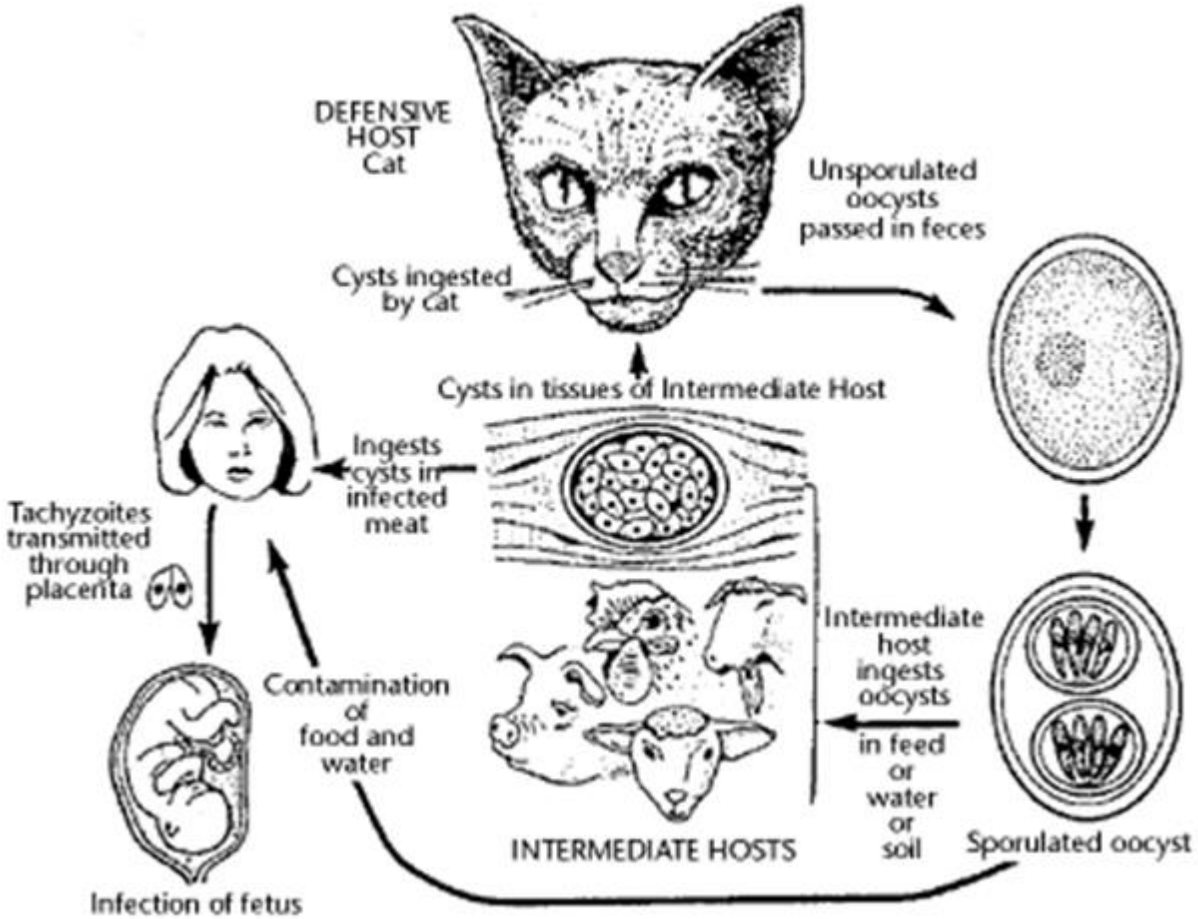


Figure 16. Life cycle of *Toxoplasma gondii*

(http://www.ssi.dk/~/media/Indhold/DK%20-%20dansk/Sygdomsleksikon/toxop-cyclus.ashx)

Final hosts are cats. Intermediate hosts are domestic and wild vertebrates (mice, rats, rabbits, sheep, pigs, cows, some birds) and human beings. The main hosts (cats) are infected by toxoplasmosis when they eat infected mice, rats in the internal organs of which there are pseudocysts and cysts that contain trophozoites (or merozoites). Trophozoites get into epithelial cells of alimentary canal where they reproduce by schizogony with the forming of merozoites. Some merozoites turn into male (microgametes) and female (macrogametes) sexual cells. As a result of copulation (junction) of gametes a zygote is formed. Zygote gets covered by membranes and becomes an oocyst. The oocyst with cat's excrements gets outside. In 1-5 days 2 sporocysts with 4 sporozoites form in each oocyst. They become invasive and can remain viable in the environment for several years.

With food oocysts get into the intestine of intermediate host (for example, human) where sporozoites get out of the oocyst. Sporozoites get into lymphatic nodes with the lymph flow where they grow and turn into trophozoites. Trophozoites get into blood and they are delivered to all tissues and organs and get into cells of liver, spleen, nervous system, eyes, skeletal muscles, myocardium, etc.

Trophozoites reproduce inside the cells by schizogony. During the acute form of disease there is intensive reproduction with forming of pseudocysts.

Pseudocyst is an accumulation of trophozoites (merozoites) in host's cells, which reproduce by schizogony of trophozoites covered by cell membrane. When the cells die merosoites get free and affect other cells. As the immunity that limits reproduction of *Toxoplasma* forms, the disease becomes chronic. At this time cysts form. True cyst is an accumulation of trophozoites in host's cells covered by a thick layer over the cell membrane.

Sources of invasion: Cats that excrete oocysts into environment.

The mechanism of human infection. Infection of an intermediate host (a human) takes place:

- during the contact with sick cats (invasional stage is oocyst, the way of invasion is alimentary);
- when the oocysts get into alimentary canal (alimentary way of invasion), with the hands dirty from soil, dirty food products (vegetables, fruit, greens, etc.); flies and cockroaches can be mechanical transmitters of oocysts on the food products;

- when a human eats meat of infected animals (invasive stages are a trophozoite, pseudocyst, cyst with merozoites); the way of invasion is alimentary;
- with milk and milk products (invasional stages are a trophozoite, pseudocyst, merozoites); the way of invasion is alimentary;
- through skin and mucous membranes during treating sick animals, processing skins and cutting animal raw materials (invasion stages are a trophozoite, merozoites); the way of invasion is percutaneous;
- intrauterine (through the placenta); invasional stages are a trophozoite, merozoites;
- during medical manipulations, transfusion of blood and leukocyte mass (the way of invasion is transfusional).

Clinical features. Toxic-allergic effect lies at the basis of pathogenesis. Nervous, sexual, lymphatic systems, organs of vision are affected. Asymptomatic carriage is also frequent.

Intrauterine infection (congenital toxoplasmosis) in the first months of pregnancy can lead to spontaneous miscarriages, the death of a fetus. Later infection may be the cause for breaches in the development of the fetus' brain (hydrocephalus). Meningoencephalitis is a frequent result of congenital toxoplasmosis, sometimes inflammation of sclera and retina can be observed.

Laboratory diagnosis: immunological reactions and allergic tests. Sometimes the parasites can be found in blood smears, punctures of lymphatic nodes, cerebrospinal fluid.

Prevention of toxoplasmosis. Personal prevention: to wash hands after the contact with cats, to boil milk, to heat meat, to wash vegetables, fruit, to drink boiled water. Public prevention: careful examination of pregnant women, treatment of patients with animal toxoplasmosis, vet control of animal products.

Order *Haemosporidia*

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Protozoa*
Phylum *Apicomplexa*
Class *Coccidiomorpha*

Order *Haemosporidia*

Species: *Plasmodium vivax* is a pathogenic organism of tertian fever;

Plasmodium malariae is a pathogenic organism of quartan fever;

Plasmodium falciparum is a pathogenic organism of tropical malaria;

Plasmodium ovale is a pathogenic organism of ovale-malaria

They are wide spread in the countries with tropical and subtropical climate. Malaria is a transmissible natural focal disease that is transmitted to a human through the bites of specific blood-sucking carriers - mosquitoes of *Anopheles genus*.

Life Cycle. *Plasmodium* have a complex life cycle. They require two hosts to complete their life cycle (figure 17).

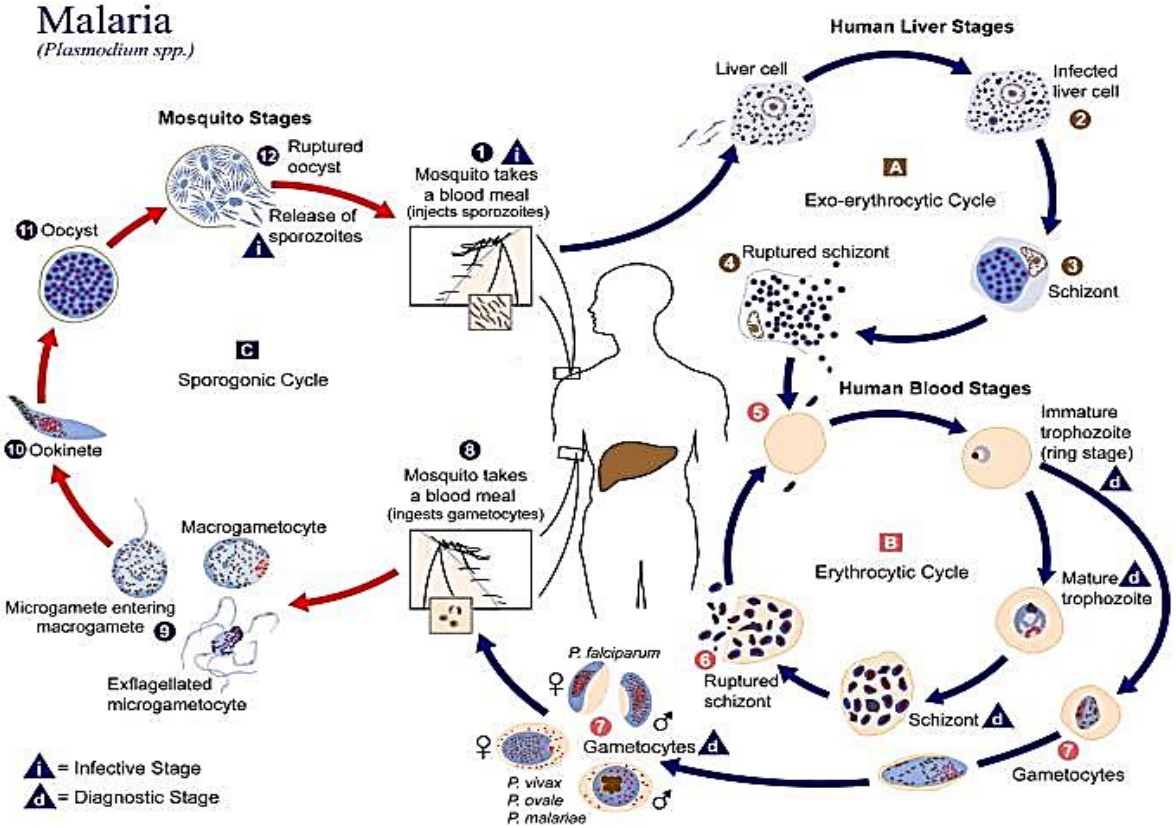


Figure 17. Life cycle of *Plasmodium*
(https://www.cdc.gov/malaria/images/graphs/life_cycle/malaria_lifecycle.gif)

Intermediate hosts are people. Vectors and Definitive hosts are mosquitoes (*Anopheles genus*). The infective form of *Plasmodium* for human is the sporozoite. The mode of infection is transmissive way by the vector bite (malarial mosquito).

Epidemiological chain: reservoirs are sick humans; vector is *Anopheles* mosquito; recipient is a healthy human.

Human cycle starts with the introduction of sporozoites by the bite of an infected mosquito. It comprises the following stages: pre-erythrocytic schizogony, erythrocytic schizogony, gametogony:

- pre-erythrocytic schizogony. The infection of a human takes place when he is bitten by female mosquito which injects the sporozoites of malaria *Plasmodium* mixed with its saliva. Sporozoites make their way through the bloodstream to the liver, where they start intracellular life: grow, and turn into trophozoites. Trophozoites reproduce by schizogony way accompanied by formation of tissue merozoites. All this lasts 15 days and it is incubation period of illness;
- endoerythrocytic schizogony. After liver cells are destroyed tissue merozoites enter the host's bloodstream and invade erythrocytes.

The merozoite that got into erythrocyte is called a **schizont**.

During this phase the parasite passes through some stages. They are the following:

a) schizont in a ring stage (rings-shaped schizonts). The size of schizont is ¼ or ⅓ of erythrocyte, cytoplasm is of bluish color and it is located in a form of a ring around a vacuole, on the background of cytoplasm there is a cherry-red nucleus;

b) young trophozoite. Cytoplasm's volume is increased a little, small pseudopodia are formed;

c) a stage of amoeba schizont (amoeboid schizonts). Parasite is already pretty big and occupies more than a half of erythrocyte. Vacuole's volume decreases, cytoplasm forms pseudopodia. A nucleus grows simultaneously. Grains of dark-brown pigment (gemoin) can be seen in a cytoplasm, they are the results of hemoglobin breakdown;

d) mature schizont;

e) morula stage. Nucleus of *Plasmodium* divides many times and then cytoplasm divides. 16-18 (*Plasmodium vivax*) merozoites are formed and in each of them, there is a nucleus and a cytoplasm. In a formed morule merozoites are located disorderly, pigment is collected in a form of one group and is located outside the parasite's cytoplasm, usually on a side. Number of merozoites in red blood cells varies from 6 to 24 depending on the species of *Plasmodium* (*Plasmodium vivax* – 16-18, *Pl. malaria* – 6-8, *Pl. falciparum* – 22-24, *Pl. ovale* – 8-12 merozoites). Merozoites infect other red

blood cells to repeat schizogony;

f) gamont stage. Macrogamonts of *Plasmodium vivax* are big and round and they fill in the whole erythrocyte. Its nucleus is of cherry-red color, compact, cytoplasm is colored into intensively blue color and contains equally distributed grains of dark pigment. Microgamonts are smaller than macrogamonts. Cytoplasm is light blue, a nucleus is big, crumbly, sometimes long and is more intensively colored in the centre, than in female gamonts. There is more pigment than in macrogamont, it can be located both along the whole cytoplasm and in groups around nucleus. Gamont's size is bigger than the size of a normal erythrocyte.

The duration of trophozoites' development between two periods of schizogony can be different in different species of *Plasmodium*: for *P. vivax* and *P. ovale* – 48 hours, for *P. malariae* – 72 hours, for *P. falciparum* – at first, attacks develop in different periods of time and later in 24 hours. The attack of malaria is connected with merozoites' getting into blood plasma and absorption of products of erythrocytes' metabolism. Then the merozoites penetrate into the erythrocytes again. Gamonts (micro and macrogametocytes) penetrate into mosquito, the further development is possible only in the body of mosquito, turning into mature gamets (micro and macrogamets).

Life cycle of *Plasmodium* in *Anopheles*. Mosquito biting an infected human swallows the gamonts together with blood. In the mosquito's stomach they turn into the mature sexual cells – gametes. Then happens their junction – the mobile microgamete fully penetrates into the macrogamete and as a result a diploid zygote is formed which differentiates into ookinete (mobile stage). Ookinet penetrates into the mosquito's intestinal walls, forms an oocyst, which grows and repeated divisions by sporogony way take place, producing thousands of sporozoites. The cell surface of a mature oocyst ruptures and sporozoites get into mosquito's hemolymph. They migrate and accumulate in salivary glands and from there they are injected into the bloodstream of a human. The infection by malaria can happen during blood transfusion and transplacentally.

Clinical Features. All the pathologies associated with malaria are caused by asexual multiplication of *Plasmodium* in the bloodstream (erythrocytic schizogony). Periodic fever at malaria is characteristic. It is related to the life cycle of the parasite. At the end of each erythrocytic schizogony cycle all the infected red blood cells rupture at the same time. This releases toxic waste products

along with merozoites. The temperature rises (41 °C or higher). The patient at this stage feels cold. Anemia may occur at malaria.

Malaria **diagnosis** is based upon laboratory examination of patient's blood. Different development stages of malaria *Plasmodium* are found in blood during its examination during the different phases of malaria attack.

Prevention of malaria. Public prevention: detecting, diagnosis, registration and treating patients and carriers of parasites; the fight with the carriers of malaria pathogens; destroying and reduction of the places of reproduction of mosquitoes; destruction of larvae in water reservoirs by chemical and biological methods and killing mature mosquitoes in premises and in nature. Personal prevention – individual protection from mosquitoes' attacks (use of repellents, nets).

Phylum *Ciliophora*

Systematic position in the zoological classification:
Kingdom *Animalia*
Subkingdom *Protozoa*
Phylum *Ciliophora*

Ciliophora or *Infusoria* is characterized by the presence of pellicle, they cannot change the shape of their body. Cilia that cover all their body are locomotory organelles (figure 18).

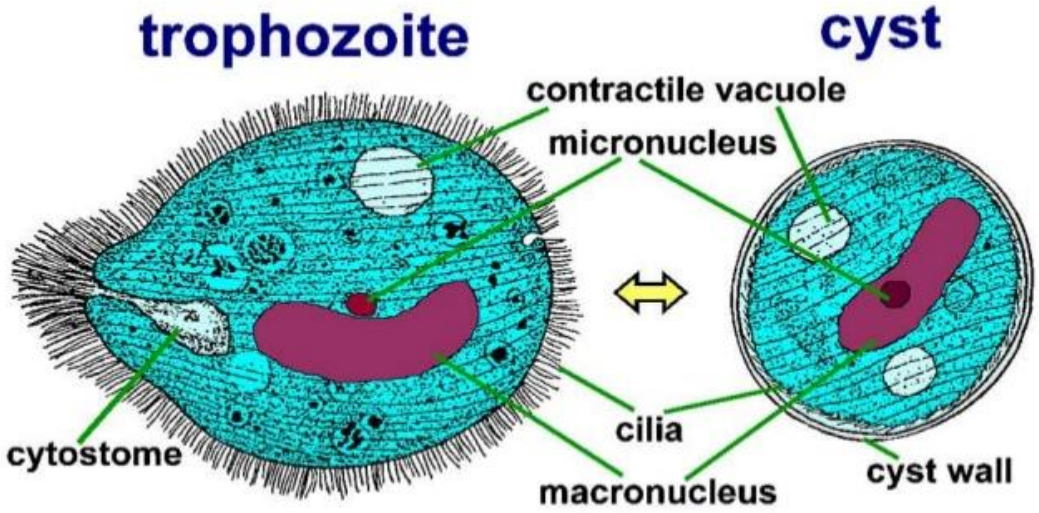


Figure 18. *Balantidium coli*
(http://image.slidesharecdn.com/lecture5-150923063458-lva1-app6891/95/balantidium-coli-4-638.jpg?cb=1442990146)

Ciliophora has two nuclei: macronucleus that regulates metabolism and micronucleus that serves for information exchange during conjugation. They have a complex way of digestion.

They have a cell mouth (stoma) – the cytostoma and a cell gullet – the cytopharynx.

Vacuoles empty their waste contest through a special pore in the pellicle known as the cytoproct. There are also parasitic infusoria – *Balantidium coli* that lives in human digestive system.

The parasite causes dysentery in human (dilate dysentery or balantidiasis).

The parasite exists in two stages: Trophozoite Stage (found in dysenteric stools) and cystic stage.

The mechanism of human infection. *B. coli* passes its life cycle in two stages, but in one host only (fig. 19).

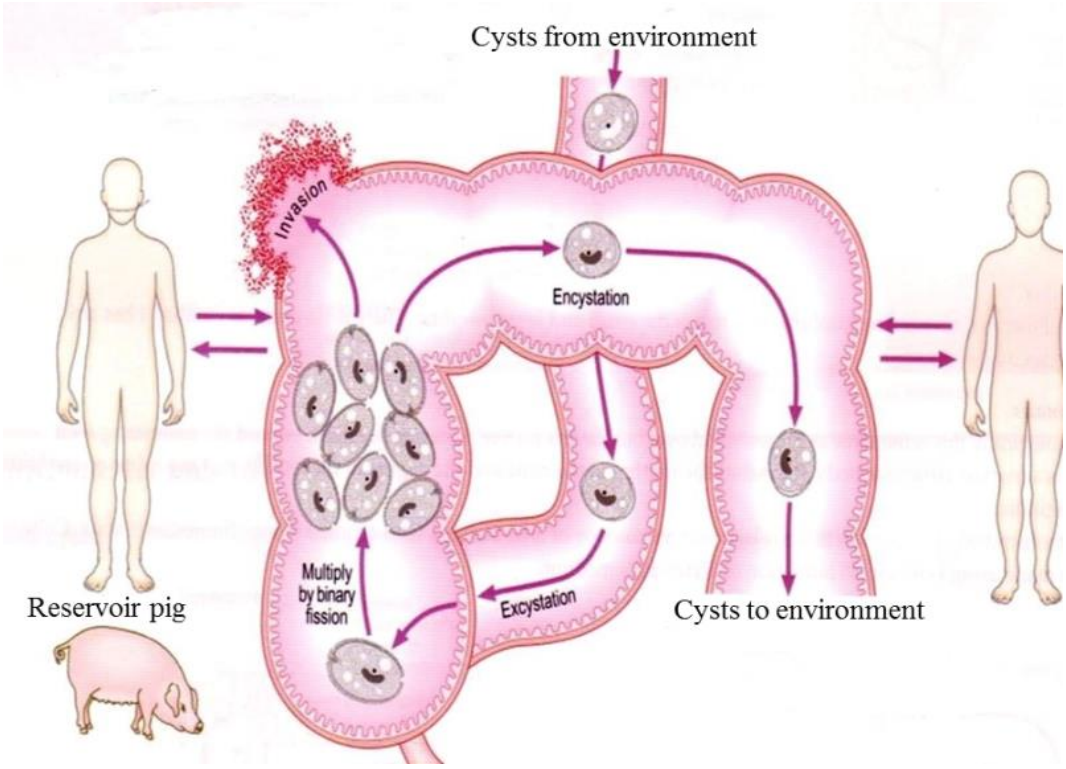


Figure 19. Life cycle of *Balantidium coli*
(http://images.slideplayer.com/23/6885924/slides/slide_27.jpg)

Pig is the reservoir host. Humans are rare and incidental hosts. Transmission occurs from pig to pig, pig to human, human to human and human to pig.

The mechanism of human infection. Disease sources are sick people and cyst carriers, pigs. Invasion stage for human is cyst. The way of penetration is alimentary way (through the mouth). The factors of transmission are dirty hands,

unwashed vegetables, fruit, greens, dirty water, contaminated with cysts. Mechanical carriers of cysts are flies and cockroaches.

Clinical features. Bleeding ulcers in the large intestine, frequent watery, mucous, bloody stools.

Laboratory diagnostics: revealing vegetative forms and cysts in faeces (excrements).

Prevention. Personal prevention of balantidiasis: to wash hands, vegetables, fruit, drink boiled water. Public prevention: includes struggle against pollution of the environment with faeces, proper organization of labor conditions at pig-farms, revealing and treating patients.

MEDICAL HELMINTHOLOGY

The subject and tasks of medical helminthology

Helminthology is one of the sections of parasitology. Helminthology is a science about parasitic worms.

Medical helminthology studies parasitic worms and human diseases caused by them - helminthiasis. The tasks of medical helminthology are study the biology of helminths, epidemiology and prevention of helminthiasis as well as development of measures aimed at elimination of the foci of helminths.

Helminthiasis have been known for a very long time. In some areas 80-90% of people suffer from helminthiasis. The pathogens of human helminthiasis are a very diverse group of animal organisms that lead a parasitic way of life. They are distinguished by a complex and varied development cycle. All the parasitic worms can be divided into two big groups: geohelminths and biohelminths.

The development cycle of geohelminthes is connected with the conditions of environment (ascaris, hookworms, whipworm and others). The development cycle of biohelminthes is connected with different species of vertebrates and invertebrates, with change stages of life cycle: Flukes (*Trematoda*), tapeworms (*Cestoda*), some Round worms (*Nematoda*).

The human, infected by helminths, as rule is not infectious for other people. However there are some helminths (dwarf tapeworm, pinworm) the eggs of which can be infectious (invasional, contagious) for humans right from the moment of their excretion by a sick human.

Representatives of two Phylums can have parasitism in human organism: Flatworms (*Plathelminthes*) and Roundworms (*Nemathelminthes*).

Phylum *Plathelminthes* (Flatworms)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Plathelminthes*

About 10-12 thousands of species are described, the majority of them are parasites. The main characteristics of *Plathelminthes* are:

a) they are multicellular animals (*Metazoa*) with bilateral symmetry;

b) triploblastic animals. They develop from 3 germinal layers: ectoderm, endoderm and mesoderm;

c) their body is taped or leaf shaped and flattened dorso-ventrally. Sizes vary from a few millimeters to several metres.

Body cover. The wall of body is a dermato-muscular (skin-muscular) sac that consists of dermal epithelium (tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal).

The body cavity is absent, intervals between organs is filled with parenchyma.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Alimentary (digestive) system. Digestive system of Flukes is represented by an anterior (front) intestine (mouth, gullet, esophagus) and middle intestine, blindly closed. Back part of intestine and anal opening are absent. Tapeworms lack digestive system. They absorb their food directly through their body walls with the help of microtrichia.

Nervous system is represented by the type of nervous trunks (ladder like). It includes peripharyngeal nerve ganglia and nervous trunks coming out from them. Nerve trunks are joined by commissures (cross connection between trunks).

Excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming a total canal that opens up with excretory pore. Protonephridia remove the products of dissimilation and regulate osmotic pressure.

Sexual system. The Flatworms are hermaphrodites, having both male and female organs. They are characterized by a well-developed sexual system.

The adaptations for parasitic way of life are high fertility, the presence of fixation organs, a complex life cycle with the change of hosts, alternation of stages of their life cycle.

Classification. The representatives of two classes have a particular importance for medicine: Flukes class (Class *Trematoda*) and Tapeworms (Class *Cestoda*).

Class Flukes (*Trematoda*)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Plathelminthes*

Class *Trematoda*

Trematoda (or Flukes) are small helminths. Their size varies from 1 mm to several centimeters in length; they are unsegmented, leaf-shaped flat worms. They have two suckers as organs of attachment. The one surrounding the mouth is called the oral sucker and the other, on the ventral surface of the body, is called the ventral or abdominal sucker.

Body cavity is absent, intervals between organs is filled with parenchyma.

Body cover. The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal) (figure 20).

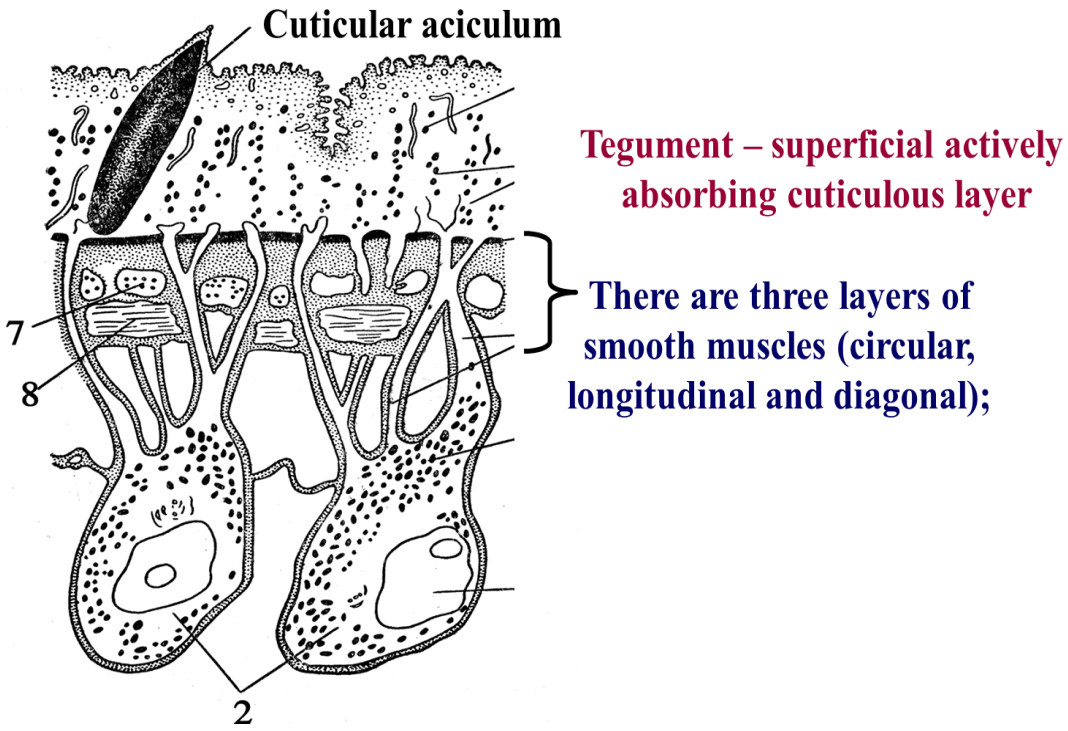
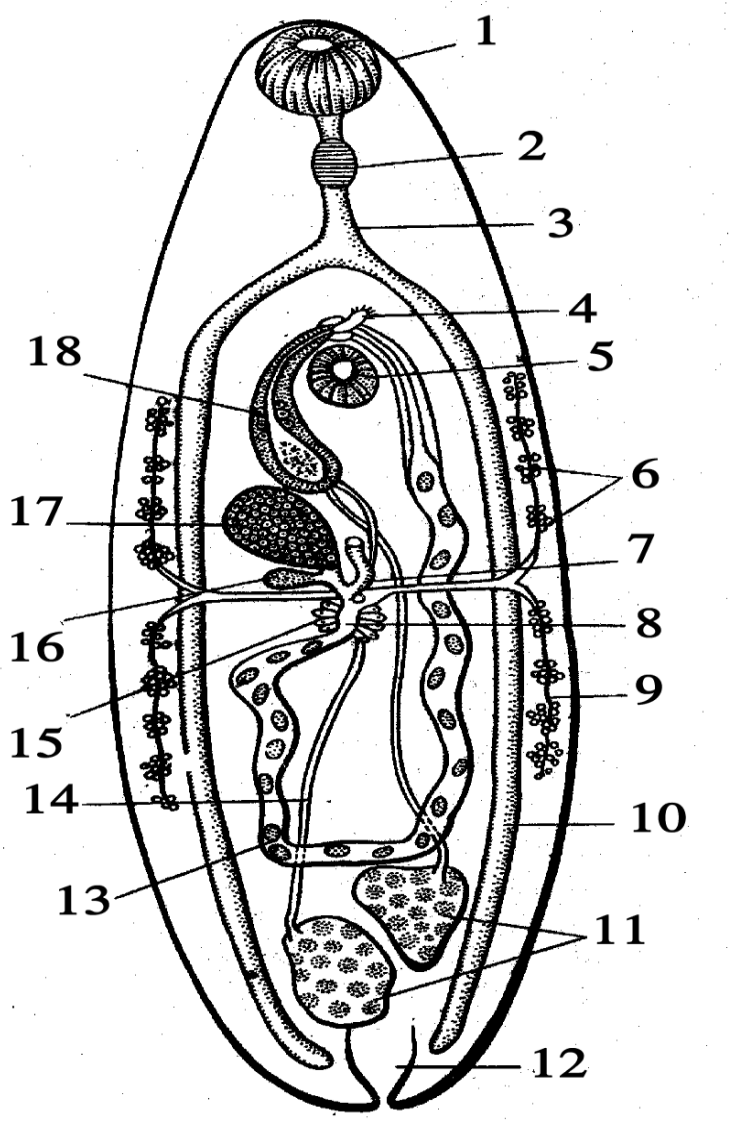


Figure 20. A dermato-muscular sac of *Trematoda*
(http://compendium.su/biology/entering/entering1.files/image244.jpg)

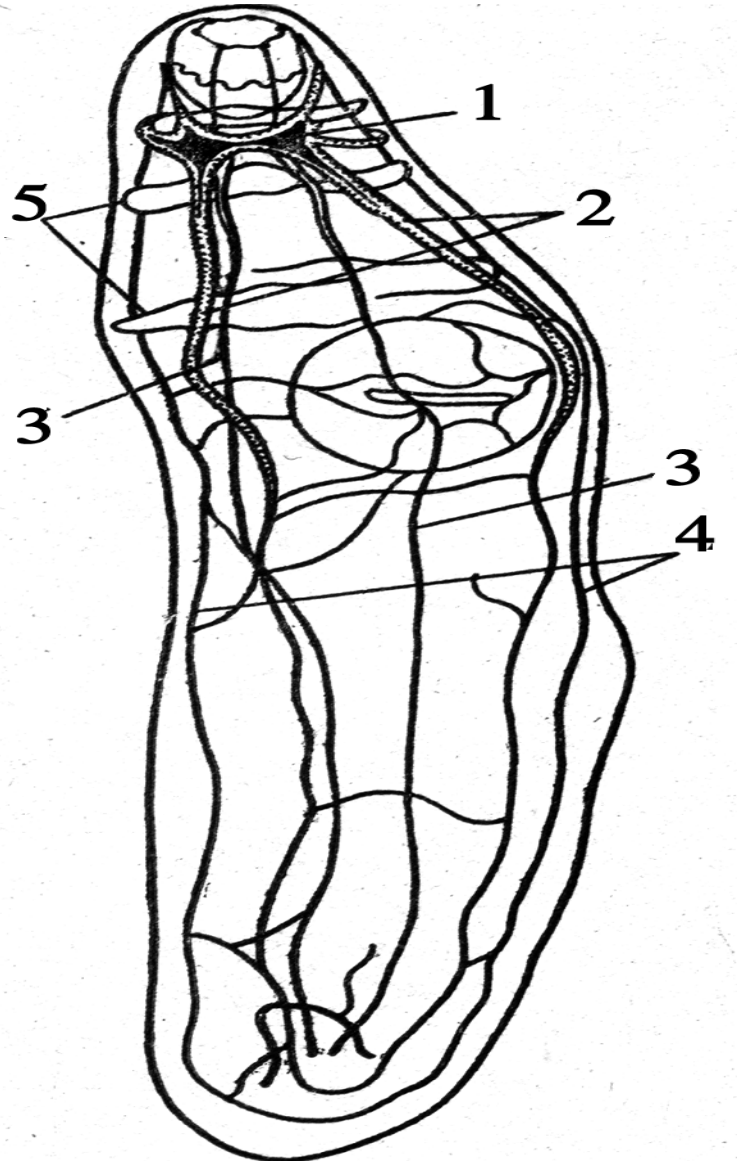
Alimentary (digestive) system has two part of the intestine (front and middle). Back part of intestine and anus are absent. The parts of front (anterior) intestine are mouth, gullet, esophagus. The esophagus bifurcates in front the ventral sucker into a pair of blind intestinal parts which may be simple or branched (fig. 21).



1 – oral sucker
2 – gullet
3 – esophagus
4 – genital pore
5 – ventral sucker
6 – vitelline sacs
7 – Laurer's canal
8 – ootype
9 – vitelline canal
10 – intestinal caeca
11 – testis
12 – excretory bladder
13 – uterus
14 – spermatic vessels
15 – Mehlis' gland
16 – seminal receptacle
17 – ovary
18 – cirrus

Figure 21. Digestive system of *Trematoda*
(Kestner)

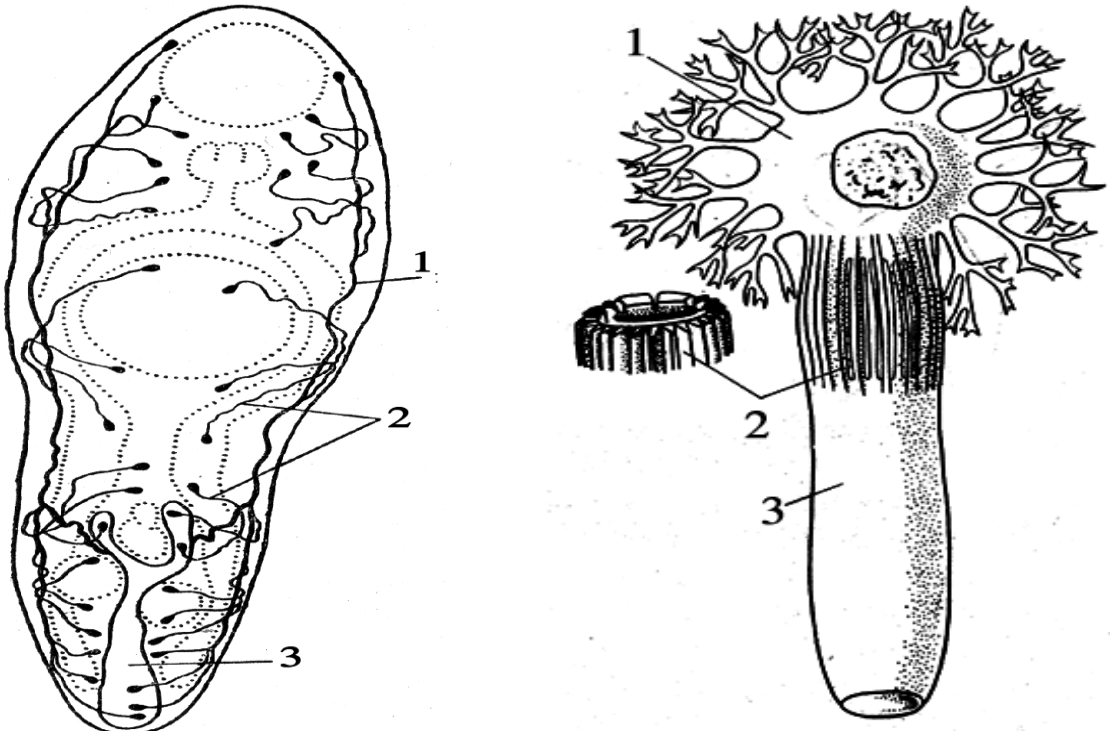
Nervous system is represented by a type of nervous trunks (ladder like). It includes peripharyngeal nerve ganglia and nervous trunks coming out from them. Nerve trunks are joined by commissures (cross connection between trunks) (fig. 22).



1 – neural ganglion
2 – abdominal nerve trunks
3 – dorsal nerve trunks
4 – lateral nerve trunks
5 – comissures

Figure 22. Nervous system of *Trematoda*
(Kotikova)

Excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals leaving them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming total canal that opens up with excretory pore (fig. 23).



1 – lateral canal
2 – terminal stellate-shaped cells and branching coming out
3 – excretory bladder

Protonephridial cell:
1 – stellate-shaped part of cell
2 – canal with cilia flame

Figure 23. Excretory system of *Trematoda*
*(*Odening)

Sexual system. The flukes are hermaphrodites except the blood flukes which are unisexual.

Reproductive system is highly developed and genital organs lie between the two branches of the intestine.

The male sexual system is represented by a pair of testes, pair sperm ducts that join together and form ejaculatory duct (Vas Deferens) that ends by cirrus bursa (cirrus sac) with cirrus. The cirrus is the male copulatory organ.

The female sexual system is represented by ovary, vitelline (yolk) sac, Mehlis' gland and an elongated uterus that opens into the ootype and sperm accepting chamber (seminal receptacle):

- ovary is the sexual organ where formation of female gametes takes place;
- vitelline (yolk) sac provides eggs by nutrients;
- Mehlis' gland excretes an enzyme for formation of eggs outer covering;

- ootype is a chamber where fertilization and eggs formation takes place;
- uterus is straight tube, which arises from the ootype; through the uterus male gametes penetrate into ootype and eggs get outside after formation.

All eggs have a cap on one of poles (except those of blood flukes) and can develop only in water.

Flukes are very fertile. One individual produces about 1 million eggs a week.

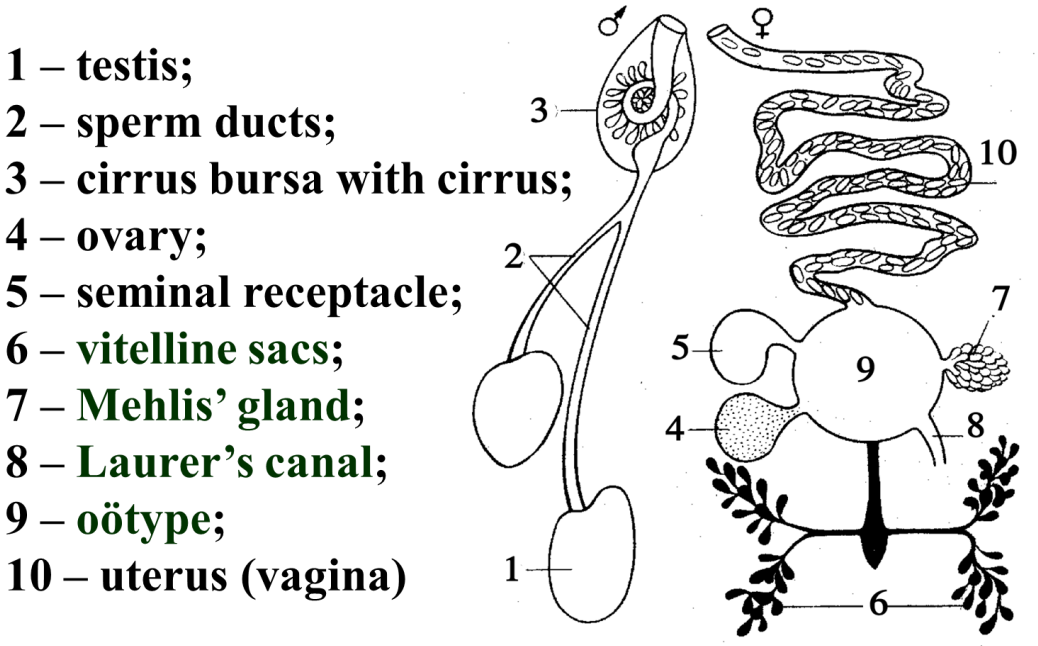


Figure 24. Sexual system of *Trematoda*

The group of illnesses caused by *Trematoda* is called trematodiasis. The following representatives of *Trematoda* have **medical importance**:

a) hepatic Trematodes: *Fasciola hepatica* (the sheep liver fluke), *Opisthorchis felineus* (the cat liver fluke), *Dicrocoelium lanceatum* (the lanceolate fluke);

b) lung Trematodes: *Paragonimus westermani* (the lung) fluke);

c) blood trematodes (blood flukes): in the vesical venous plexus – the vesical blood fluke (*Schistosoma haematobium*), in the rectal venous plexus and portal venous system – Manson's blood fluke (*Schistosoma mansoni*) and the Oriental blood fluke (*Schistosoma japonicum*).

Life Cycle of *Trematoda*. Life cycle is complex with the change of hosts. These worms pass there life cycle in different hosts. Definitive hosts are human beings and some animals. Intermediate host is a fresh-water snail or mollusk. The second Intermediate host (fish or crab or ants) is required for encystment in

some Flukes. The second Intermediate host for *Opisthorchis felineus* (the cat liver fluke) is fish, for *Dicrocoelium lanceatum* (the lanceolate fluke) – ants, for *Paragonimus westermani* (the lung fluke) – crabs (fig. 25).

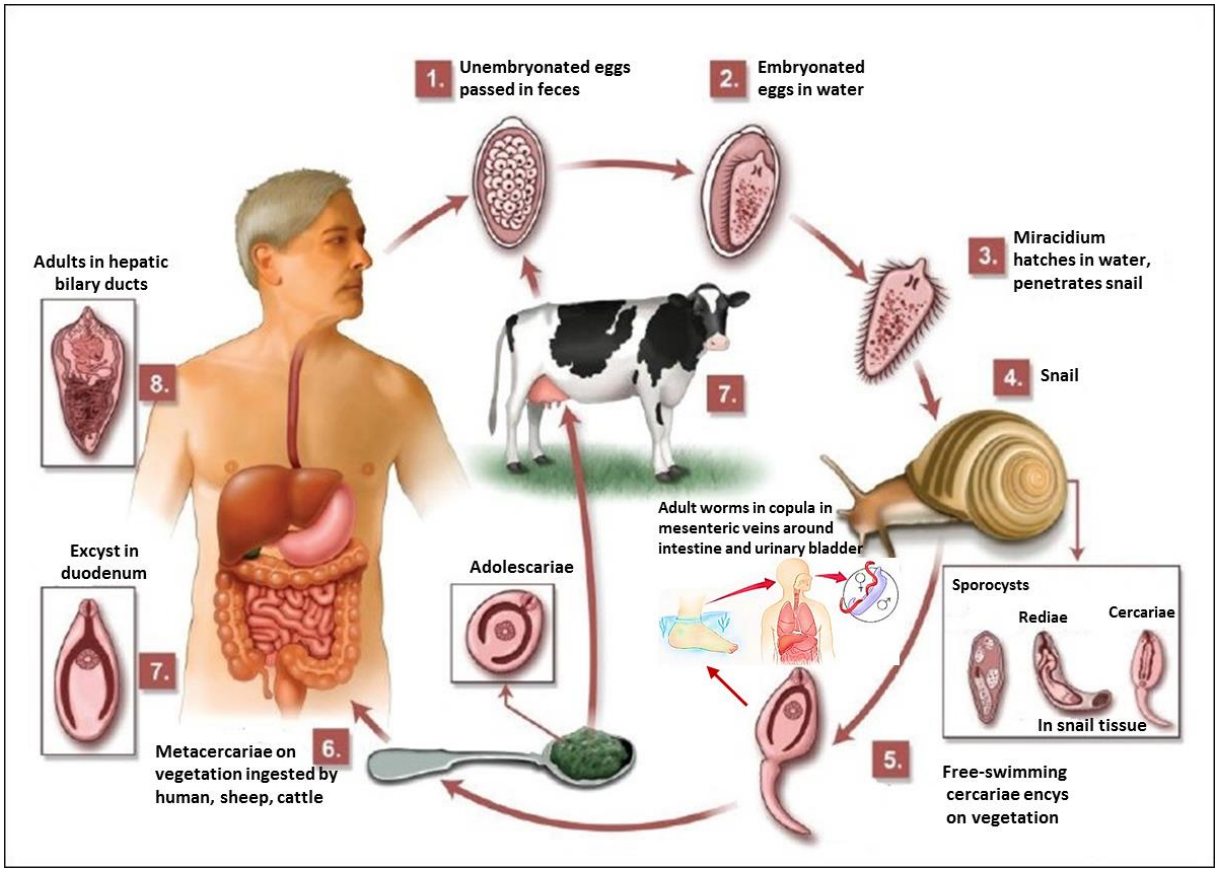


Figure 25. Life cycle of *Trematoda* (http://www.clinicalimagingscience.org/articles/2012/2/1/images/JClinImagingSci_2012_2_1_2_92372_u2.jpg)

Pubertal stage (adult worm) is called **marita**. Marita takes place in the body of a final (or definitive) host. Eggs with faeces (excrement) of a final host are excreted outside. For the further development they have to reach water. A free-swimming ciliated **miracidium** develops inside the egg. There larvae get out of the eggs. In water, miracidium moves and penetrates the body of an intermediate host, a mollusk (a snail), for further development. In the snail's body they shed their cilia and transform into the next larval stage – **sporocyst** that has a sac-like structure. It contains a number of germ cells, out of which the next larval stage - **redia** - is formed. Inside the redia a new crop of germ cells is produced, which develop into the next stage cercaria. The **cercaria** is provided with sackers and has an intestine like that in an adult form. It possesses a tail by

means of which it propels itself in water. Mature cercaria escape from the snail into the water.

The further development of a larva depends on the species of a parasite.

The cercaria of a liver fluke (*Fasciola hepatica*) attach themselves to the plants, lose their tails and transform into **adolescaria** (cysts). Adolescaria are eaten by a final host (cows, human), in the intestine of which the cysts dissolve, a larva with the bloodstream gets into liver and there transforms into adult worm – **puberal stage** or **marita**. It causes fascioliasis, it is localized in the biliary duct of the liver.

In the development cycle of a cat liver fluke (*Opisthorchis felineus*) there are two intermidiate hosts, the first is a fresh-water snail, the second is a carp fish (of the family *Cyprinidae*). **Cercaria** that come out from the mollusks penetrate into a second intermediate host (a fish) and transform into **metacercaria**. The infection of a final host (cat, dog, pig and human) takes place when humans or other animals eat the fish that was not properly cooked. A cat liver fluke causes opisthorchiasis, that is a natural focal disease which is supported by animals who feed on fish. It localizes in the biliary duct of the liver, gallbladder, pancreas.

In the development cycle of a lung fluke (*Paragonimus westermani*) there are also two intermediate hosts: first intermediate hosts are snails, second intermediate hosts are crabs, spiny lobsters, shrimps. Lung fluke causes paragonimiasis (at the Far East). It localizes in the bronchus, lungs.

Blood flukes in the contrast to other flukes are heterosexual. A male is bigger than a female and it has a gutter in which a female is located. The mollusks are intermediate hosts. Blood flukes cause schistosomiasis and parasitize in the veins of organs of the small pelvis, intestine. Marita produces eggs that have a sharp thorn. With the help of this thorn the eggs pierce the walls of the veins and penetrate into the cavities of the urinary bladder or intestine and thus they are excreted outside. Then the eggs must reach the water where they penetrate into the mollusk's body. In the mollusk two generations of sporocysts (first and second stages of sporocysts) develop, then cercaria with a forked tail develops. The infection of a human takes place through the skin (percutaneous way) during bathing or work in the water reservoirs that contain cercariae. After they penetrate into human organism the larvae shed their tails, grow and with the bloodstream get into the places of final localization.

Pathogenic effect. The products of flukes' vital activities cause toxi-allergic effect. And they have mechanical influence. The flukes that localize in the liver destroy liver tissue and cork biliary ducts. They engulf erythrocytes, leucocytes, cells of the walls of biliary ducts. They can lead to the development of liver cirrhosis. The opisthorchiasis patients suffer from pancreas damage, more frequently they suffer from primary carcinoma of the liver.

1. *Paragonimus westermani*. In the lungs the parasites are located by pairs. They are covered with granular tissue forming a capsule. In the lung the worm stimulates an inflammatory response. These capsules can ulcerate and heal over time. If the worm becomes disseminated and gets into the spinal cord, it can cause paralysis; capsules in the heart can cause death. The symptoms are localized in the pulmonary system, which include a bad cough, bronchitis, and blood in sputum (hemoptysis).
2. *Schistosoma haematobium*. The pathogen of urogenital schistosomiasis has toxi-allergic effect, mechanical influence on the tissues of urinogenital system and the possibility of secondary infection. The mucous membrane of the urinary bladder often suffers from inflammatory processes, ulcers.
3. *Schistosoma mansoni* is the pathogene of intestinal schistosomiasis.
4. *Schisostoma japonicum* is the pathogene of intestinal (japaneses) schistosomiasis. They have toxi-allergic effect, mechanical influence on the tissues of intestine and the possibility of secondary infection. The mucous membrane of the intestine often suffers from inflammatory processes, ulcers.

Laboratory diagnosis of fascioliasis, opisthorchiasis and dicrocoeliasis is based on detecting the eggs in feces and in contents of the duodenum. The diagnosis of paragonimiasis is based on detecting the eggs in sputum or in faeces. The diagnosis of urogenital schistosomiasis is based on the microscopic examination of the urine, intestinal schistosomiasis – on the microscopic examination of the faeces. Immunological tests are becoming more and more important.

The sheep liver fluke (*Fasciola hepatica*)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Plathelminthes*
Class *Trematoda*

Species *Fasciola hepatica*

Fasciola hepatica is a cause of fascioliasis.

Geographical Distribution. *Fascioliasis* is widespread everywhere.

Fasciola hepatica is a parasite of herbivorous animals (sheep, goat and cattle), living in the bile ducts of liver. It is occasionally found in human.

Morphology of Adult Worm (Marita). It is a large leaf-shaped fluke. Its sizes vary from 3 to 5 cm (fig. 26). They are grey or brown. There are two suckers: oral and ventral (abdominal), the oral sucker is smaller. The anterior end bearing the oral sucker forms a conical projection. The posterior end is rounded. Structure of inner organs is branched. The genital system follows the same general pattern of *Trematodes.*

Body cavity is absent, intervals between organs are filled with parenchyma.

The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (tegument is superficial actively absorbing cuticulous layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal).

1 – oral sucker
2 – ventral sucker
3 – both the intestinal caeca bear a number of lateral compound branches
4 – cirrus
5 – ovary
6 – vitelline sacs
7 – vitelline canal
8 – testis
9 – spermatic vessels
10 – uterus

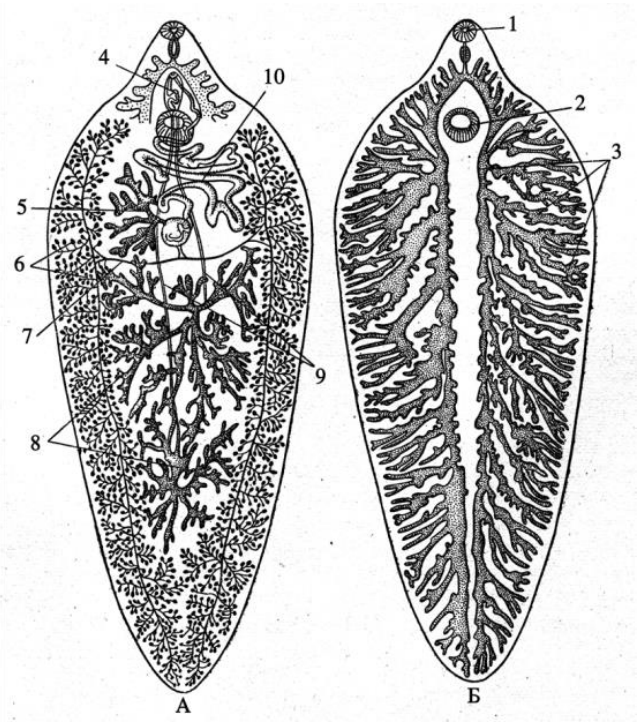


Figure 26. The structure of *Fasciola hepatica* (Chandler)

Alimentary (digestive) system has two part of the intestine (front and middle). The parts of front (anterior) intestine are mouth, gullet, esophagus. Middle intestine bifurcates in front the ventral sucker into two of blind intestines. Both

intestines bear a lot of lateral branches. Back part of intestine and anal opening are absent.

Nervous system is presented by the type of nervous trunks (ladder like). It includes peripharyngeal nerve ganglia and nervous trunks coming out from them. Nerve trunks are joined by commissures (cross connection between trunks).

Excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming total canal that opens up with excretory pore.

Sexual system makes up the main part of worm's body. *Fasciola hepatica* has hermaphroditic sexual system. The male sexual system is represented by two strongly branching testes, occupying the whole middle part of fluke's body; pair sperm ducts that join together and form ejaculatory duct that ends by cirrus bursa (cirrus sac) with cirrus. The female sexual system is represented by ovary, vitelline (yolk) sac, Mehlis' gland and an elongated uterus that opens into the ootype and sperm accepting chamber (seminal receptacle).

Life Cycle. *Fasciola hepatica* is biohelminth. It passes its life cycle in two different hosts (fig. 27).

Definitive (or Final) Hosts: Sheep, goat, cattle or human.

Intermediate Host: Mollusks (Snails) of the genus *Lymnaea*. Larval development proceeds in this snail.

Stages of life cycle: marita (adult worm), eggs with miracidium, sporocyst, redia, cercaria, adolescaria.

The mechanism of human infection. Invasion stage (Infective form) for the definitive host is the adolescaria. The way of penetration is alimentary way. The factors of invasion are water, greenstuf, fruit, vegetables, contaminated with adolescariae. Organ for the localization are bile ducts of liver.

The eggs passed out in the faeces of definitive hosts, mature in water; inside each egg a ciliated miracidium is developed. There larvae get out of the eggs. In the water miracidium moves and penetrates the body of an intermediate host is a mollusk (a snail) for further development. In the snail's body they shed their cilia and transform into the next larval stage - sporocyst that have a sac-like structure. It contains a number of germ cells, out of which the next larval stage -

redia - is formed. Inside the redia a new crop of germ cells is produced, which develops into the next stage cercaria. The cercaria is provided with sackers and has an intestine like that adult form. It possesses a tail by means of which it propels itself in water. Mature cercaria escape from the snail into the water.

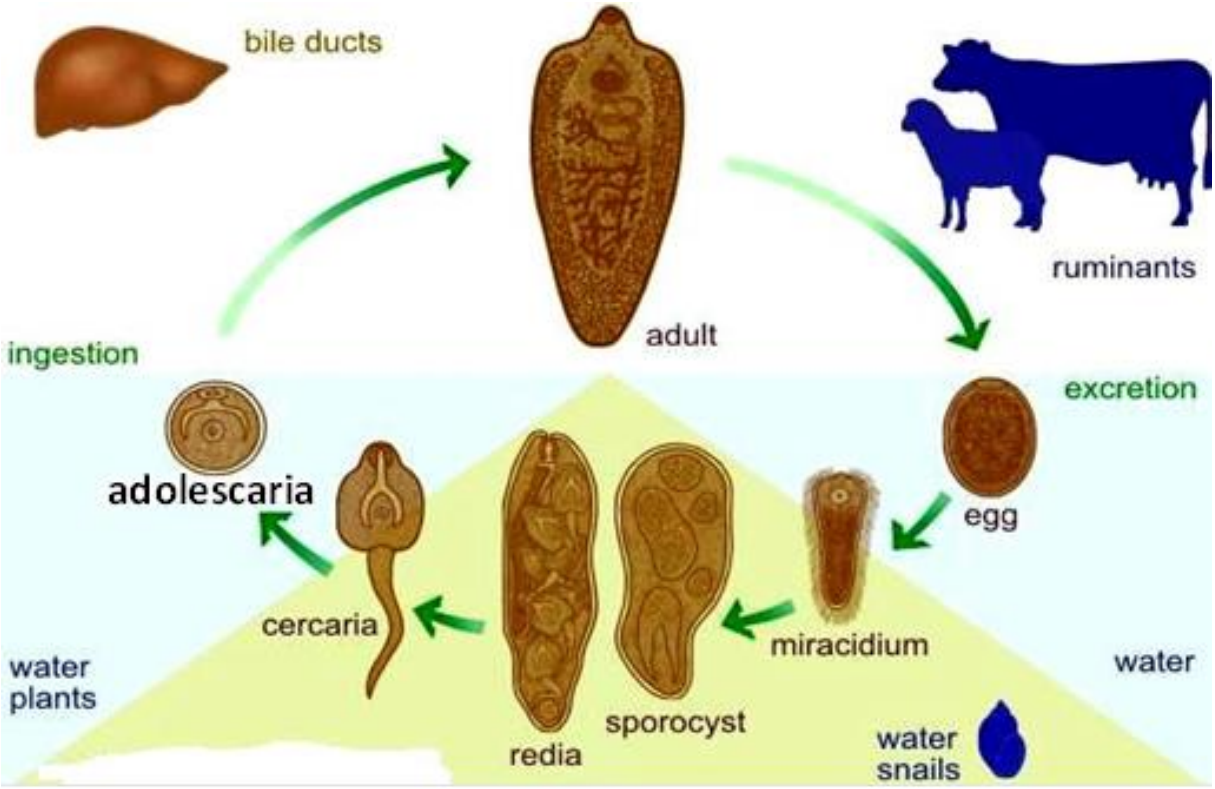


Figure 27. Life Cycle of *Fasciola hepatica*
(http://www.gridgit.com/postpic/2011/06/fasciola-hepatica_532115.jpg)

The cercaria of a *Fasciola hepatica* attach themselves to the plants, lose their tails and transform into adolescaria. Adolescariae are eaten by a final host (sheep, goat, cattle, human), in the intestine of which the cysts dissolve, a larva with the bloodstream gets into liver and there transforms into an adult worm – puberal stage or marita. It causes fascioliasis.

Pathogenic effect of *Fasciola hepatica*. The products of the sheep liver flukes' vital activities cause toxi-allergic effect. And they also have mechanical influence: destroy liver tissue and cork bile ducts. They engulf erythrocytes, leukocytes, cells of the walls of bile ducts. They can lead to the development of liver cirrhosis.

Clinical features (Pathogenesis) of fascioliasis. Fever (due to toxic and allergic effects), abdominal pain occur in acute fascioliasis. Nausea, diarrhea and cough are also present. The mechanical arrest of the bile flow leads to inflammatory processes and cirrhosis of the liver.

Laboratory diagnosis of fascioliasis is based on the finding of eggs in faeces or in bile obtained by duodenal intubation. The egg of *Fasciola hepatica* has an oval form, of yellow colour; two-contour membrane and they have an operculum (or cap) on one of the poles and protuberance (or tubercle) on antipole. Its sizes are 150 μm by 80 μm.

Preventive measures. Personal prevention of human infection can be achieved by wash with boiled water of greenstuff, fruit, vegetables and boiling water before consumption. Public prevention include treatment of humans, treatment of cattle, change of pastures, where infected snails live, destruction of mollusks. Sanitary-instructive work.

The cat liver fluke (*Opisthorchis felineus*)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Plathelminthes*
Class *Trematoda*
Species *Opisthorchis felineus*

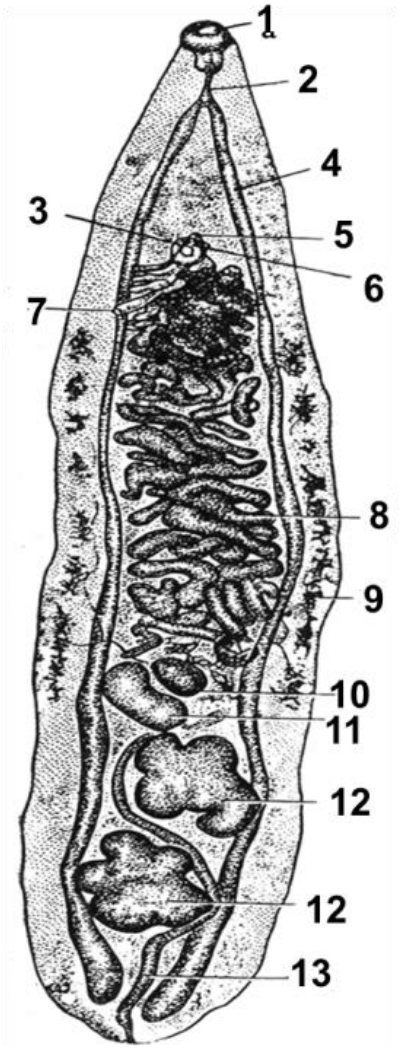
Opisthorchis felineus is a cause of opisthorchiasis. It is a natural-focal disease.

Geographical distribution. The cat liver fluke is a common fluke infection of human in Russia, Poland and Siberia; it has also been reported from Japan. Chandler found that 60% of cats in Calcutta (India) were infected with the parasite and human cases have also been reported from India.

Morphology of Adult Worm (Marita). *Opisthorchis felineus* is a leaf-shaped fluke. Its sizes are from 10 to 12 mm in length (fig. 28). There are two suckers: oral and ventral or abdominal suckers. Digestive canal has two unbranched tubes. In the centre of the body there is a uterus. There is an oval ovary behind it and two rosette-shaped testes on back part of the body. The genital system follows the same general pattern of Trematodes.

Body cavity is absent, intervals between organs are filled with parenchyma.

The wall of the body is a dermato-muscular (skin-muscular) sac that consists of dermal epithelium (tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal).



1 – oral sucker
2 – esophagus
3 – ventral sucker
4 – intestinal caeca
5 – female genital pore
6 – male genital pore
7 – vas deferens
8 – uterus
9 – vitelline sacs
10 – ovary
11 – seminal receptacle
12 – testis
13 – excretory bladder

Figure 28. The structure of *Opisthorchis felineus*
(Skryabin A.N.)

Alimentary (digestive) system has two part of the intestine (front and middle). Back part of intestine and anal opening are absent. The parts of front (anterior) intestine are mouth, gullet and esophagus. The esophagus bifurcates in front the ventral sucker into two of blind unbranched intestines.

Nervous system is represented by type of nervous trunks (ladder like). It includes peripharyngeal nerve ganglia and nervous trunks coming out from them. Nerve trunks are joined by commissures (cross connection between trunks).

Excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the

movement of liquid in the canals. Canals interflow, forming total canal that opens up with excretory pore.

Opisthorchis felineus has hermaphroditic sexual system. The Male sexual system is represented by pair testes, pair sperm ducts that join together and form ejaculatory duct that ends by cirrus bursa (cirrus sac) with cirrus. There are two rosette-shaped testes on back part of the body. The female sexual system is represented by ovary, vitelline (yolk) sacs, Mehlis' gland, an elongated uterus that opens into the ootype and sperm accepting chamber (seminal receptacle). In the centre of the body there is a uterus. There is an oval ovary behind it.

Life cycle. *Opisthorchis felineus* is biohelminth. Its life cycle is in three hosts (fig. 29).

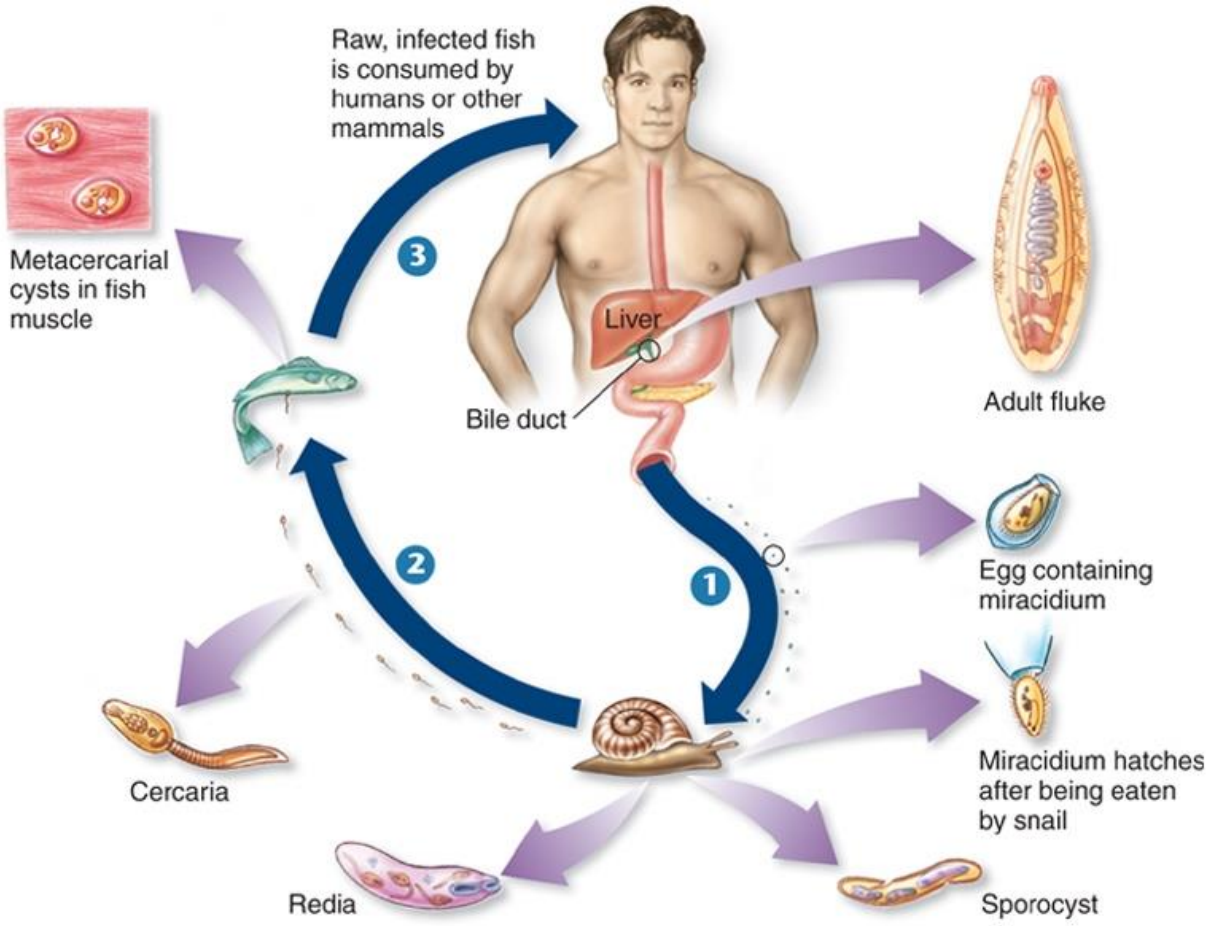


Figure 29. Life cycle of *Opisthorchis felineus*
(http://schoolbag.info/biology/living/living.files/image608.jpg)

The definitive (or final) hosts are cat, dog, fox, pig and human. The first intermediate host is a fresh-water snail (mollusk). Second intermediate host is carp fish of the *Cyprinidae genus*. Stages of life cycle: marita (adult worm), eggs with miracidium, sporocyst, redia, cercaria, metacercaria.

The mechanism of human infection. Invasion stage (Infective form) for the definitive host is metacercarium. The mode of invasion (the way of penetration) is alimentary way. The factors of invasion are badly heat-treated fish. Organs for the localization are the bile duct of the liver, gallbladder, pancreas.

Eggs containing miracidium are passed out with faeces of definitive hosts and on entering water, are ingested by intermediate host (a fresh-water snail).

In the body of mollusk miracidium transforms into sporocyst. The latter give rise to redia. Redia divide and transform to cercaria which escape into the water, where they swim about. If they are eaten by fish, they will bore into the muscles, lose their tails and transform into the metacercaria (the cyst in the muscle tissue). Thus, fish are second intermediate host for this fluke. If a human or other animals eat raw infected fish, the metacercareae migrate to the bile ducts or pancreatic duct, where they mature.

Pathogenic effect of *Opisthorchis felineus*. The products of cat liver flukes' vital activities cause toxi-allergic effect. And they have mechanical influence: destroy liver and pancreas tissue, cork bile ducts. They engulf erythrocytes, leukocytes, cells of the walls of bile ducts, pancreas. They can lead to the development of liver cirrhosis.

Clinical features (Pathogenesis) of opisthorchiasis. Fever (due to toxic and allergic effects), abdominal pain occur in acute opisthorchiasis. Nausea, diarrhea and cough are also present. The opisthorchiasis patients suffer from the affection of pancreas, they more frequently suffer from primary carcinoma of the liver.

Laboratory diagnosis of opisthorchiasis is based on the finding of eggs in faeces or in bile obtained by duodenal intubation.

Definitive diagnosis is established by demonstration of operculated eggs in faeces or bile. The egg of *Opisthorchis felineus* has an oval and asymmetrical form, it is of light yellow colour; it posesses two-contour membrane and an operculum (or cap) on one of the poles and protuberance (or tubercle) on antipole. Its sizes are 30 μm by 15 μm.

Preventive measures. Personal prevention: to avoid eating raw or uncooked fish, to follow the technology of fish cooking. Public prevention include treatment of human, treatment of cats, disinfection of faeces, sanitary-instructive work.

Other species:

- *Opisthorchis Viverrini.* This is an important human infection in Thai-

land. The normal host is the civet cat (*Felis Viverrus*). It is distinguished from O. felineus by the greater proximity of its ovary and testis and few clusters of «Vitellaria». During early phase of heavy infection, diarrhoea, pain in the right hypochondrium and mild jaundice may be encountered. Fibrosis of liver, inflammation of biliary canaliculi with epithelial hyperplasia develop in chronic stage of illness;

- *Opisthorchis noverca.* This has been recovered from Pariah dog and pig in India and also from humans;
- *Clonorchis sinensis* (The Chinese liver fluke; Oriental liver fluke, «Distome of China»). A parasite of the Far East. The endemic areas include Japan, Korea, Formosa, Southern China, Indochina and North Vietnam.

The lanceolate fluke (*Dicrocelium lanceatum*)

Systematic position of in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Plathelminthes*
Class *Trematoda*
Species *Dicrocelium lanceatum*

Dicrocelium lanceatum is the cause of dicrocoeliasis.

Geographical distribution. Dicrocoeliasis is widespread everywhere. *Dicrocoelium lanceatum* is common parasite of sheep and other herbivores. It is also known as «lancet fluke» because of its shape.

Morphology of Adult Worm (Marita). *Dicrocoelium lanceatum* is a leaf-shaped fluke, having lancet-shaped form. Its sizes are from 10 to 12 mm in length (fig. 30). There are two suckers: oral and ventral or abdominal suckers. Digestive canal has two unbranched tubes. In the centre of the body there are two testes and uterus on back part of the body.

Body cavity is absent, intervals between organs are filled with parenchyma.

The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal).

Alimentary (digestive) system has two part of the intestine (front and middle). Back part of intestine and anal opening are absent. The parts of front (ante-

rior) intestine are mouth, gullet, esophagus. The esophagus bifurcates in front the ventral sucker into two of blind unbranched intestines.

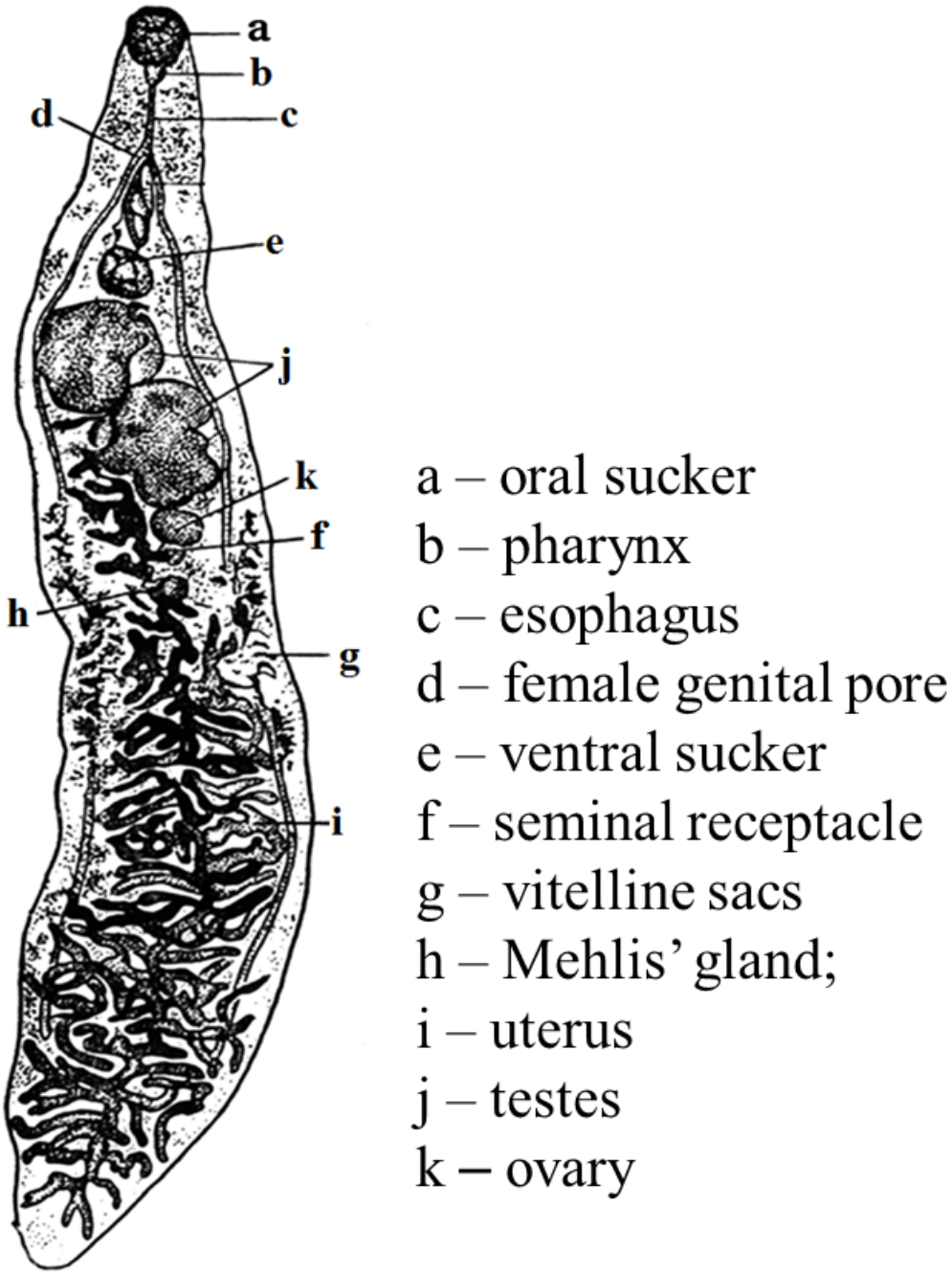


Figure 30. The structure of *Dicrocelium lanceatum* (Skryabin A.N.)

Nervous system is represented by the type of nervous trunks (ladder like). It includes peripharyngeal nerve ganglia and nervous trunks coming out from them. Nerve trunks are joined by commissures (cross connection between trunks).

Excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these

terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming total canal that opens up with excretory pore.

Dicrocelium lanceatum has hermaphroditic sexual system. The male sexual system is represented by pair oval testes, pair sperm ducts that join together and form ejaculatory duct that ends by cirrus bursa (cirrus sac) with cirrus. The testes are located behind ventral sucker. The female sexual system is represented by ovary, vitelline (yolk) sacs, Mehlis' gland, an elongated uterus that open into the ootype and sperm accepting chamber (seminal receptacle). Uterus is on the back part of body.

Life cycle. *Dicrocelium lanceatum* is biohelminths. Its life cycle is in three hosts (fig. 31).

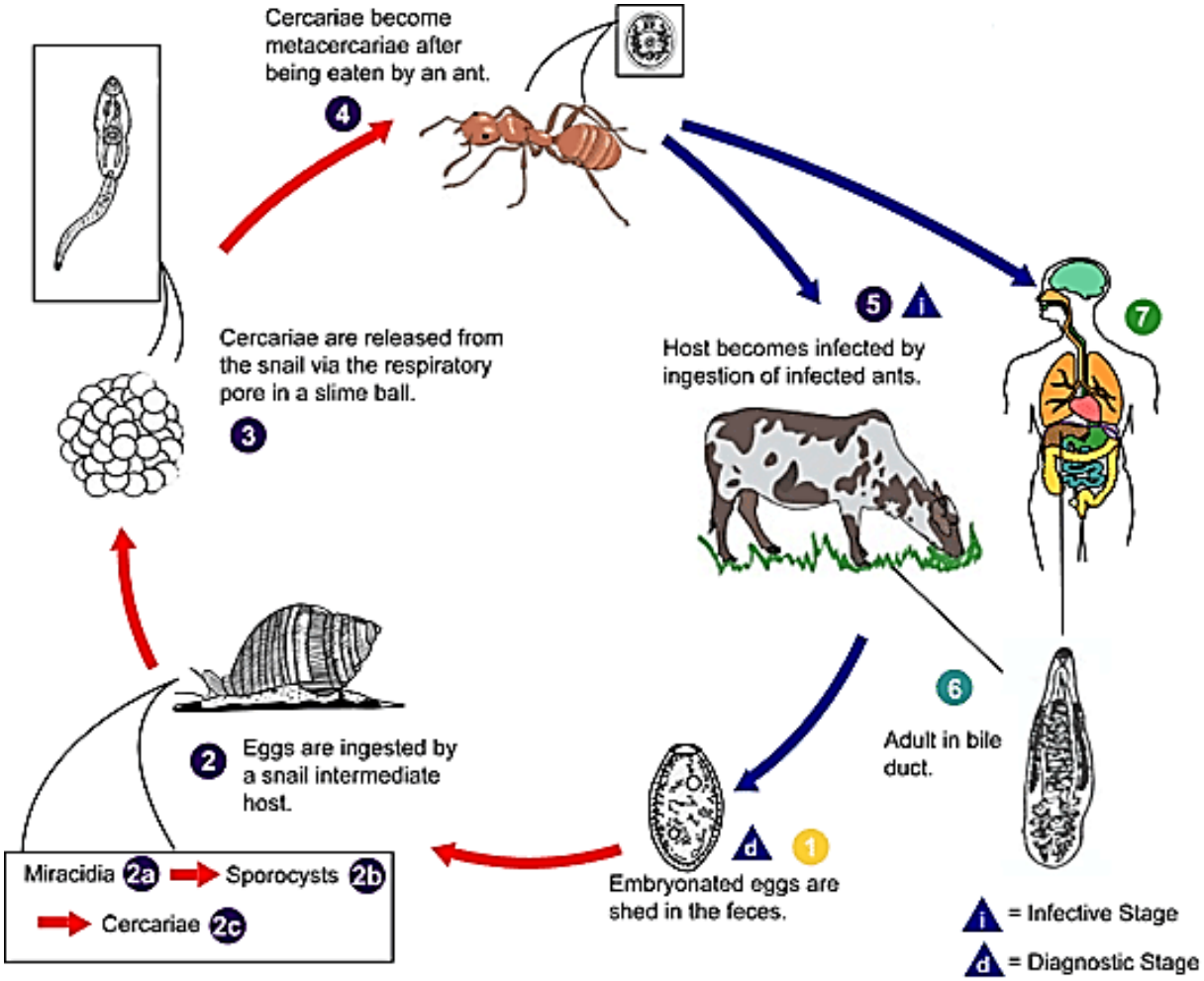


Figure 31. Life cycle of *Dicrocelium lanceatum*
(http://www.cdc.gov/dpdx/images/dicrocoeliasis/Dicrocoelium_LifeCycle.gif)

The definitive (or final) hosts are herbivorous animals and human. Human infection is rare. The first intermediate hosts are Land Snails. Second intermedi-

ate hosts are Ants. Stages of life cycle: marita (adult worm), ova (eggs) with miracidium, first range sporocyst, second range sporocyst, cercaria, metacercaria. Redia is absent.

The mechanism of human infection. Invasion stage (Infective form) for the definitive host is metacercarium. The mode of invasion (the way of penetration) is alimentary way. The factors of invasion are ants infected by metacercaria. Organ for the localization are the bile duct of the liver.

Herbivorous animals accidentally ingest ants while grazing. Eggs are excreted from final host with faeces.

Eggs have to be ingested by first intermediate host (Land Snail). Within snail liver, an egg transforms into the first range sporocyst. Than it transforms into the second range sporocyst. This larva continues growing within the snail, giving rise to the cercaria. The cercaria travel to mollusk's lungs. There they congregate and make congregated cysts. Those cysts escape into plants. Here they can be ingested by second intermediate host (ants). In ants cercaria leave defensive shell and transform into metacercaria. Human invasion occurs with occasional swallowing of ants with vegetation.

Pathogenic effect of *Dicrocelium lanceatum*. The products of the lanceolate flukes' vital activities cause toxi-allergic effect. And they have mechanical influence: destroy liver tissue and cork bile ducts. They engulf erythrocytes, leukocytes, cells of the walls of bile ducts. They can lead to the development of liver cirrhosis.

Clinical features (Pathogenesis) of dicroceliasis. Fever (due to toxic and allergic effects), abdominal pain occur in acute dicroceliasis. Nausea, diarrhea and cough are also present. The mechanical arrest of the bile flow leads to inflammatory processes and cirrhosis of the liver.

Laboratory diagnosis of dicroceliasis is based on the finding of eggs in faeces or in bile obtained by duodenal intubation.

Definitive diagnosis is established by demonstration of operculated eggs in faeces or bile. The egg of Dicrocelium lanceatum is of oval asymmetrical shape (bean shaped), it has two-contour membrane and an operculum (or cap) on one of the poles and protuberance (or tubercle) on antipole. Its sizes are 45 μm by 30 μm. The colour of eggs is from light-yellow to dark-brown depending on maturation.

Prevention. Personally prevention to avoid ant's penetration with food. Public prevention include treatment of human, treatment of cattle, change of

pastures, where infected snails live, destruction of mollusks. Sanitary-instructive work.

Pulmonary or lung fluke (*Paragonimus westermani*)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Plathelminthes*
Class *Trematoda*
Species *Paragonimus westermani*

Paragonimus westermani is pathogen of paragonimiasis.

Geographical distribution. Far East, especially in Japan, Korea, Formosa and China; in India, reported from Bengal, Assam and South India. Also reported from Nepal and some parts of Africa and South America.

Morphology of Adult Worm (marita). *Paragonimus westermani* is a leaf-shaped fluke, thick, fleshy and egg-shaped (fig. 32). It measures 8 to 12 mm in length. There are two suckers: oral and ventral or abdominal suckers. The excretory vesicle is large and extends from the back part to the front region, dividing the body into two equal halves. The two blind intestinal caeca are unbranched and extend to the back region.

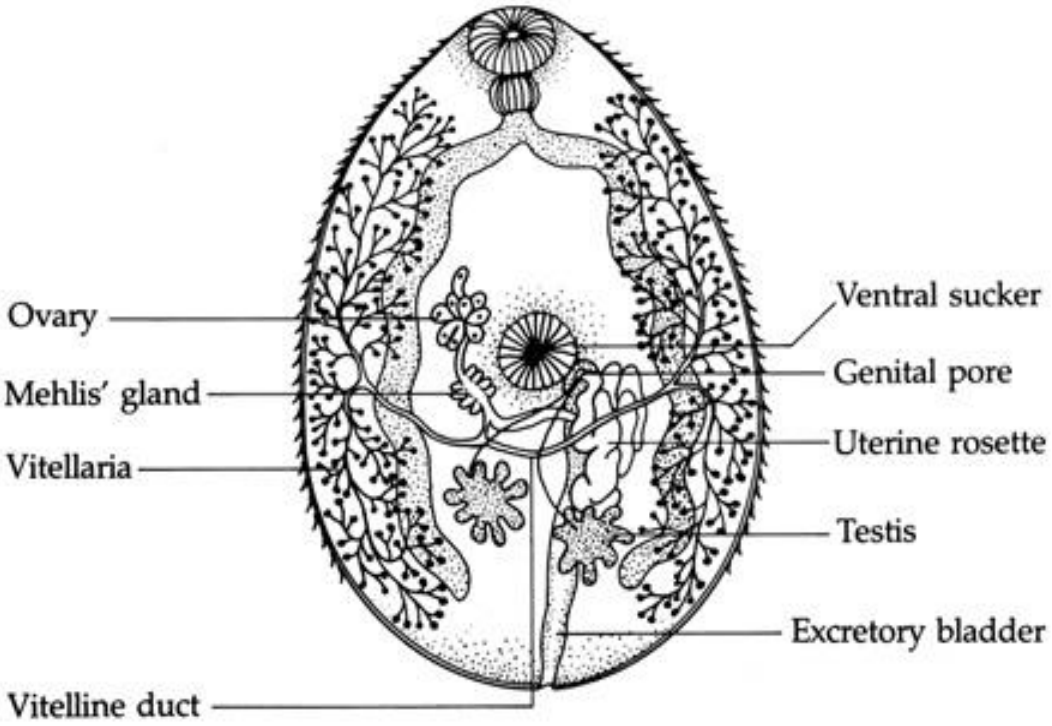


Figure 32. The structure *Paragonimus westermani*
(http://rowdysites.msudenver.edu/~churchcy/BIO3270/Images/Worms/paragonimus.jpg)

Body cavity is absent, intervals between organs are filled with parenchyma.

The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal).

Alimentary (digestive) system has two parts of the intestine (front and middle). Back part of intestine and anal opening are absent. The parts of front (anterior) intestine are mouth, gullet, esophagus. The esophagus bifurcates in front the ventral sucker into two of blind unbranched intestines.

Nervous system represented by the type of nervous trunks (ladder like). It includes peripharyngeal nerve ganglia and nervous trunks coming out from them. Nerve trunks are joined by commissures (cross connection between trunks).

Excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming total canal that opens up with excretory pore.

Paragonimus westermani has hermaphroditic sexual system. The male sexual system is represented by a pair of oval testes, a pair of sperm ducts that join together and form ejaculatory duct that ends by cirrus bursa (cirrus sac) with cirrus. There are two oval testes. They are located behind ventral sucker. The female sexual system is represented by ovary, vitelline (yolk) sac, Mehlis' gland, an elongated uterus that opens into the ootype and sperm accepting chamber (seminal receptacle).

Life Cycle. *Paragonimus westermani* is biohelminth. Its life cycle proceeds in three hosts.

Definitive Hosts: Human and carnivorous animals. Common hosts in Asia are the tiger and the leopard (fig. 33).

First intermediate hosts are snails. Second intermediate hosts are crabs, spiny lobsters, shrimps. Stages of life cycle: marita (adult worm), eggs with miracidium, sporocyst, redia, cercaria, metacercaria.

The mechanism of human infection. Invasion stage (the infective form) for definitive hosts is metacercaria. The mode of invasion (the way of penetration) is alimentary way. The factors of invasion are undercooked crabs, spiny

lobsters, shrimps. Organ for the localization: the adult worms live in the respiratory tract (alveolar sac) of definitive hosts.

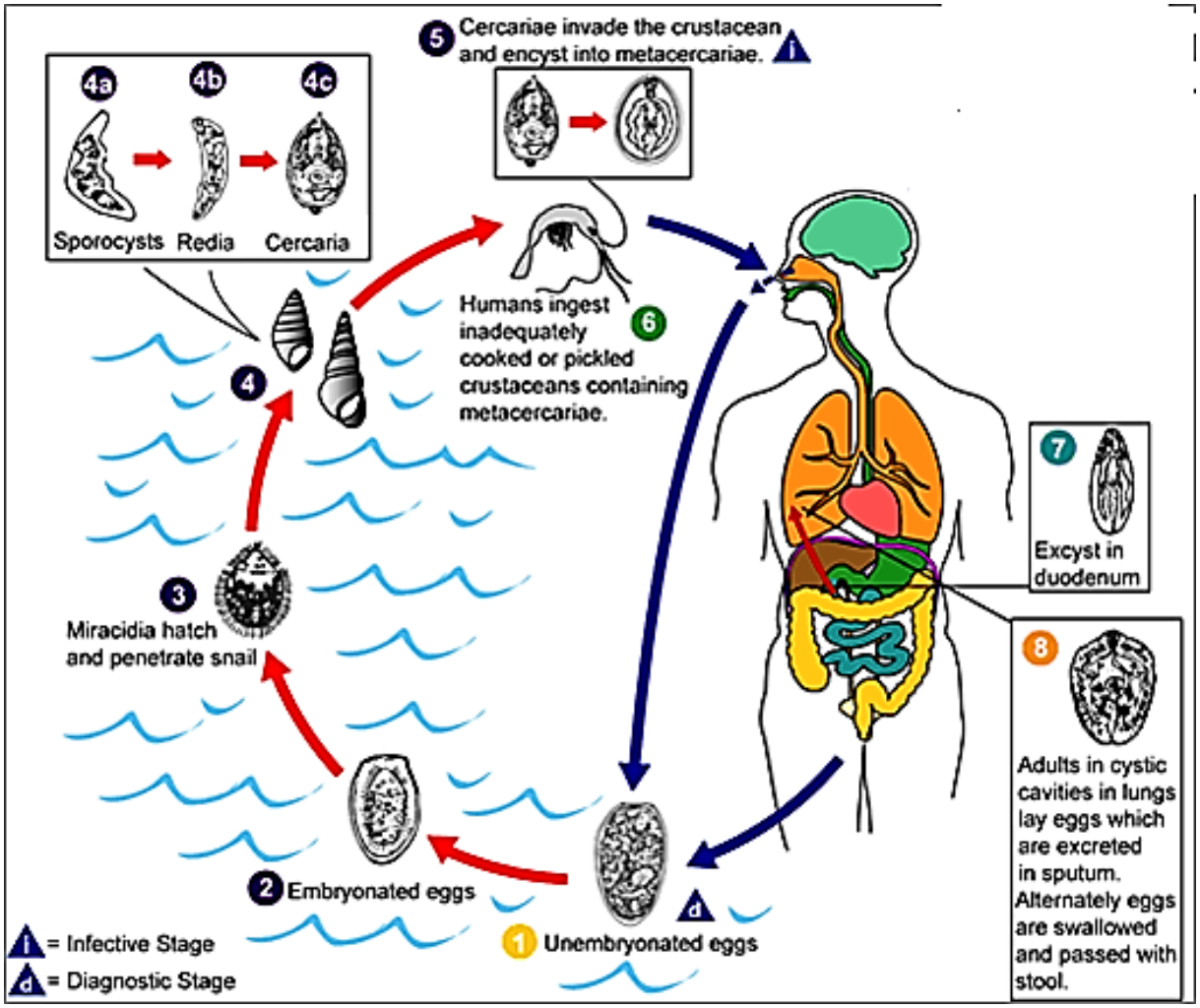


Figure 33. Life Cycle of *Paragonimus westermani*
(http://www.parasitesinhumans.org/pictures/paragonimus-westermani-life-cycle.gif)

The eggs generally escape with the sputum and some are excreted in the faeces. In water, a ciliated embryo (miracidium) develops inside the egg. On attaining maturity, the miracidium escapes into water and swims about in search of its snail host. Inside the soft tissue of the snail the miracidium casts off its tail and passes through the stages of sporocyst and two generations of redia being finally transformed into cercaria. The mature cercaria escape from the snail into water and enter into its second intermediate host, crabs, spiny lobsters, shrimps. Inside the *Crustacea*n host they become encysted (metacercaria) in the viscera, muscles and gills. When the raw flesh of infected crabs, spiny lobsters, shrimps are eaten by human and other susceptible hosts, the cyst-wall is dissolved by the gastric juice and the metacercaria is released in the duodenum. These young

worms penetrate the wall of the small intestine and enter the abdominal cavity. Later, they migrate upwards, piercing through the diaphragm and the two layers of the pleura, to gain entrance into the lungs where they finally settle and grow to sexual maturity (taking a period of two weeks for such migration). Eggs are discharged into bronchiole and are coughed out with the sputum. The cycle is thus repeated.

Clinical Features (Pathogenesis). This may be divided into 2 groups: pulmonary and extrapulmonary paragonimiasis. In the lungs the parasites are located by pairs. It is covered with granulation tissue forming a capsule. In the lung the worm stimulates an inflammatory response. These capsules can ulcerate and heal over time. The symptoms of pulmonary paragonimiasis are clinic cough with recurring attacs of haemoptysis, simulating a case of pulmonary tuberculosis. The clinical manifestations in extrapulmonary cases depend on the organs involved. If the worm becomes disseminated and gets into the spinal cord, it can cause paralysis; capsules in the heart can cause death.

Laboratory diagnosis of paragonimiasis is based on examination of faeces and sputum for the eggs.

Prevention measures. Personal prevention: avoid eating raw, undercooked or salted crabs, spiny lobsters, shrimps. Public prevention: the measures include disinfection of the sputum and faeces; eradication of molluscan host; control of paragonimiasis in nature focus (to prevent contamination of reservoirs, to conduct dehelminthization of sick people and animals, sanitary-instructive work).

Family Blood Flukes (*Schistosomatoidea*)

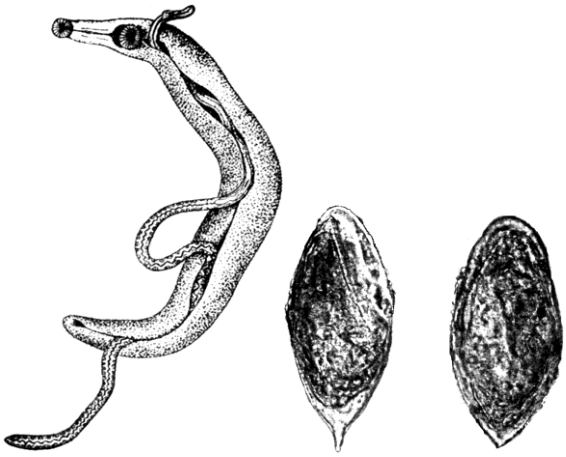
Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Plathelminthes*
Class *Trematoda*
Family *Schistosomatoidea*
Species Infecting Man: *Schistosoma haematobium* (The vesical blood fluke),
Schistosoma mansoni (Manson's blood fluke),
Schistosoma japonicum (The Oriental blood fluke) (fig. 34).

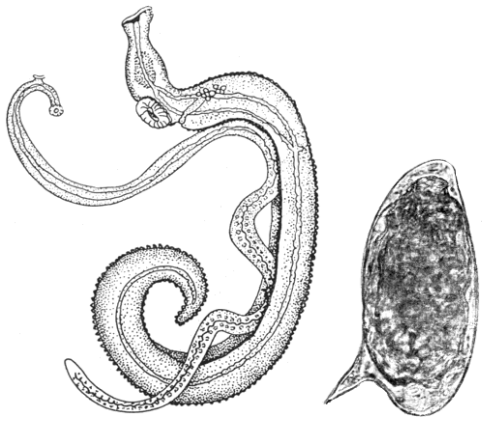
Schistosoma mansoni and *Schistosoma japonicum* cause intestinal schistosomiasis.

Schistosoma haematobium causes urinary schistosomiasis.

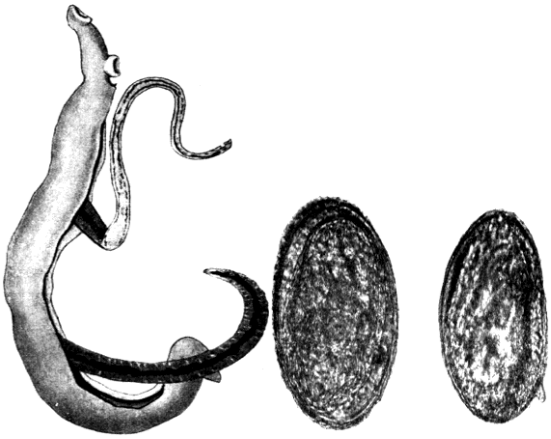
Schistosomiasis is also known as bilharzia, snail fever, and Katayama fever.



Male, female and eggs of *Schistosoma haematobium*.



Male, female and egg of *Schistosoma mansoni*



Male, female and eggs of *Schistosoma japonicum*

Figure 34. Flukes of family *Schistosomatoidea*
(Loos, Faust)

Geographical distribution. The disease is found in tropical countries in Africa, the Caribbean, eastern South America, Southeast Asia and in the Middle East. *Schistosoma mansoni* is found in parts of South America and the Caribbean, Africa, and the Middle East; *Schistosoma haematobium* in Africa and the Middle East; and *Schistosoma japonicum* in the Far East.

The disease is common in about 75 developing countries and mainly affects people living in rural agricultural and peri-urban areas.

Morphology of Adult Worm (marita). They are dioecious flukes having narrow cylindrical body. Males are shorter and wider than females; lateral margins of males are folded ventrally to form a gynaecophoric canal in which the females are situated. There are two suckers: oral and ventral or abdominal suckers. Suckers have delicate spines. Intestinal caeca reunite behind the ventral sucker to form a single canal; the length of the reunited intestine varies in different species. The number of testes in the male varies from 4 to 8.

Body cavity is absent, intervals between organs are filled with parenchyma.

The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal).

Alimentary (digestive) system has two parts of the intestine (front and middle). Back part of intestine and anal opening are absent. The parts of front (anterior) intestine are mouth, esophagus. The muscular pharynx is lacking. The esophagus bifurcates in front the ventral sucker into two intestines which join together behind the ventral sucker to form a single canal; the length of the reunited intestine varies in different species.

Nervous system represented by the type of nervous trunks (ladder like). It includes peripharyngeal nerve ganglia and nervous trunks coming out from them. Nerve trunks are joined by commissures (cross connection between trunks).

Excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming total canal that opens up with excretory pore.

The schistosomes are diecious trematodes, i.e., the sexes are separate. The male sexual system is represented by testes (the number of testis varies from 4 to 8), sperm ducts that join together and form vas deferens that ends by cirrus. The female sexual system is represented by ovary, vitelline (yolk) sacs, Mehlis' gland, an elongated uterus that opens into the ootype and sperm accepting chamber (seminal receptacle).

Life Cycle. Schistosomes are biohelminths. Its life cycle is in two hosts (fig. 35).

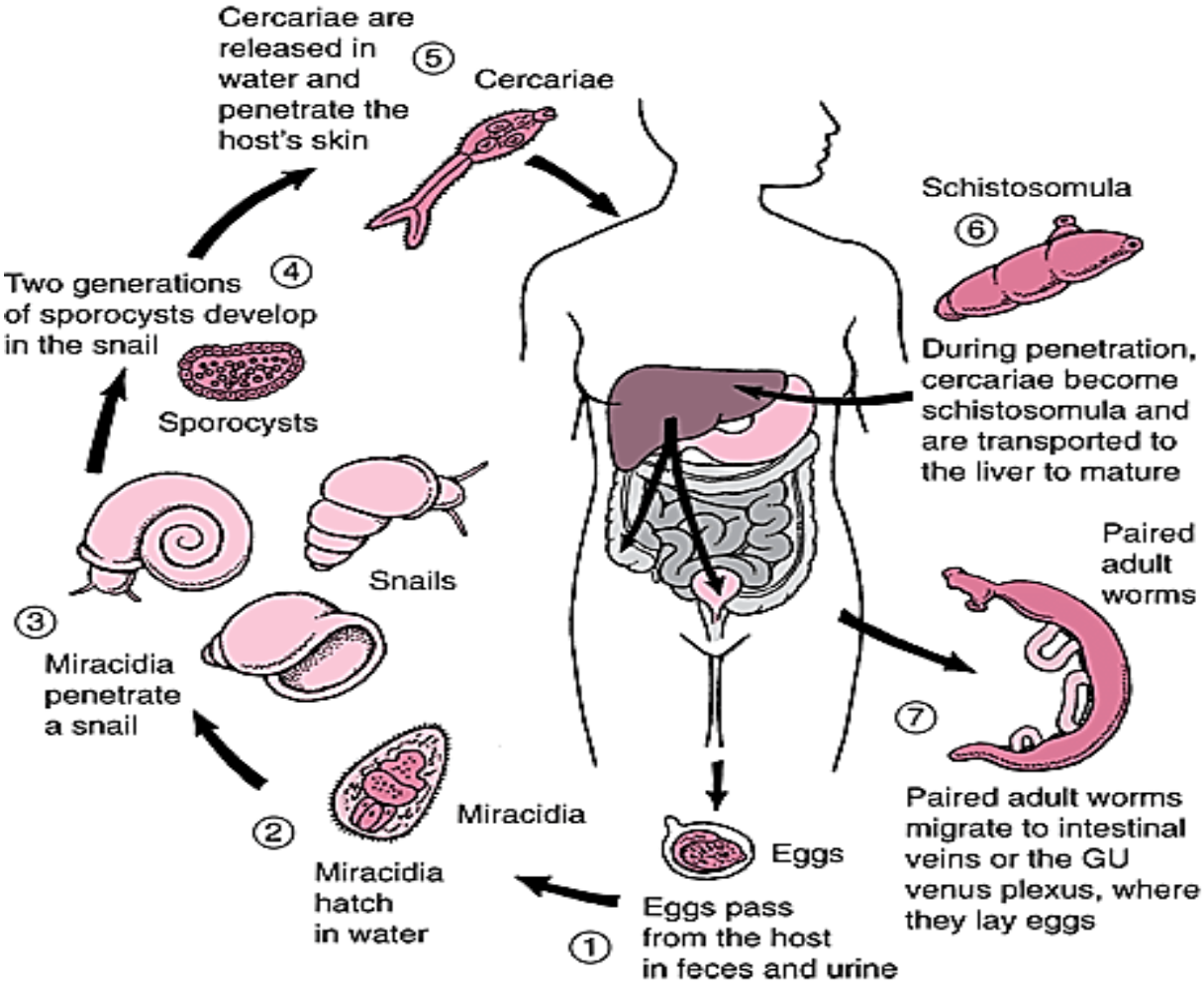


Figure 35. Life Cycle of Schistosomes (http://www.articlesweb.org/blog/wp-content/gallery/schistosomiasis-2/Schistosomiasis-1.png)

Definitive Hosts are Humans. First intermediate hosts are fresh water snails. Second intermediate host is absent. Stages of life cycle: marita (adult worm), eggs with miracidium, first range sporocyst, second range sporocyst, cercaria, metacercaria. Redia is absent.

The mechanism of human infection. Invasion stage (the infective form) for human is cercaria. The mode of invasion (the way of penetration) is percutaneous way (through the unbroken skin). The factors of invasion: humans are infected by cercaria while swimming or working in contaminated fresh water.

Marita produces eggs that have a sharp thorn. With the help of this thorn the eggs pierce the walls of the veins and penetrate into the cavities of the urinary bladder or intestine and thus they are excreted outside. Then the eggs must

reach the water where they penetrate into the molusk's body. In the mollusk two generations of sporocysts (first and second stages of sporocysts) develop, then cercaria with a forked tail develop. The infection of a human takes place through the skin (percutaneous way) during bathing or work in the water reservoirs that contain cercaria.

Cercaria penetrate through unbroken skin of human, cast off their tails, convert into schistosomules and enter the bloodstream. Schistosomules develop in portal veins, male and female worms migrate:

Schistosoma haematobium migrate to the venous plexus of the pelvic organs (bladder, ovaries, uterus) and cause urogenital schistosomiasis

Schistosoma mansoni and *Schistosoma japonicum* migrate to the venous plexus of the intestine and excite intestinal schistosomiasis (schistosomal dysentery).

Clinical features (Pathogenesis). Pathogenic effect of *Schistosoma haematobium*. The pathogen of urogenital schistosomiasis has the toxi-allergic effect, mechanical influence on the tissues of urinogenital system and the possibility of a secondary infection. The mucous membrane of the urinary bladder often suffers from inflammatory processes, ulcers. Signs and symptoms may include abdominal pain, diarrhea and blood in the urine. In those who have been infected for a long time, liver damage, kidney failure, infertility, bladder cancer may occur.

Schistosoma mansoni is the pathogene of intestinal schistosomiasis. *Schisostoma japonicum* is the pathogene of intestinal (japaneses) schistosomiasis. They have the toxi-allergic effect, mechanical influence on the tissues of intestine and the possibility of a secondary infection. The mucous membrane of the intestine often suffers from inflammatory processes, ulcers. Signs and symptoms may include abdominal pain, diarrhea and blood in the stool.

Laboratory diagnosis. The diagnosis of urogenital schistosomiasis is based on the microscopic examination of the urine, intestinal schistosomiasis – on the microscopic examination of the faeces. Diagnosis is established by demonstration of characteristic eggs. Eggs are non-operculated and when laid are fully embryonaled (containing a ciliated embryo, miracidium). Immunological tests are becoming more and more important.

Prevention measures. Personal prevention: in disease foci not to use water from natural reservoirs, not to drink unboiled infiltrated water. Public preven-

tion: health education and proper sanitary methods to prevent water contamination with urine and faeces, eradication of snails and treatment of infected persons.

Class Tapeworms (*Cestoda*)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Plathelminthes*

Class *Cestoda*

Now about 1800 species of tapeworm are known. They are wide-spread everywhere.

Morphology. *Cestoda* have a flat tape-like body that flattens dorsoventrally. The length of different species of tape worms ranges from a few millimeters to several meters. Tapeworms body have three parts: a head, a neck and a body. Another term for their head is scolex. On the scolex the following organs of fixation are present:

- hooks and suckers are found in representatives of Teniidae family: the pig tapeworm (*Taenia solium*) or the armed tapeworm; the dog tapeworm (*Echinococcus granulosus*) or the hydatid worm; alveolar or multilocular hydatid worm (Echinococcus multilocularis); the dwarf tapeworm (*Hymenolepis nana*);
- suckers are present in beef tapeworm or unarmed tapeworm (*Taeniarhynchus saginatus*);
- slit-like sucking grooves or bothria are observed in fish tapeworm or the broad tapeworm (*Diphyllobothrium latum*).

Adult tapeworms attach to the intestinal wall.

The region of the growth behind the scolex is the neck. The part after the neck is the body. The body of a tapeworm is also called strobila. The strobila is made of segments which are called proglottids. Proglottids are formed from the neck continuously during the entire life of the adult worm.

The strobila consists of immature (or young), mature (or hermaphroditic) and gravid (pregnant) segments:

1) the young (immature) segments are the nearest to the neck and have only excretory organs and nervous system, reproductive organs (male and female organs) are absent;

2) hermaphroditic segments (mature segments): reproductive organs (male and female organs) have become differentiated (male organs appear first);

3) gravid (pregnant) segments possess a uterus with fertile eggs, other organs atrophied or disappeared.

The general caracteristics of tapeworms

The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (or tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal) (fig. 36). The tapeworms have adapted to absorbing the food through the tegument.

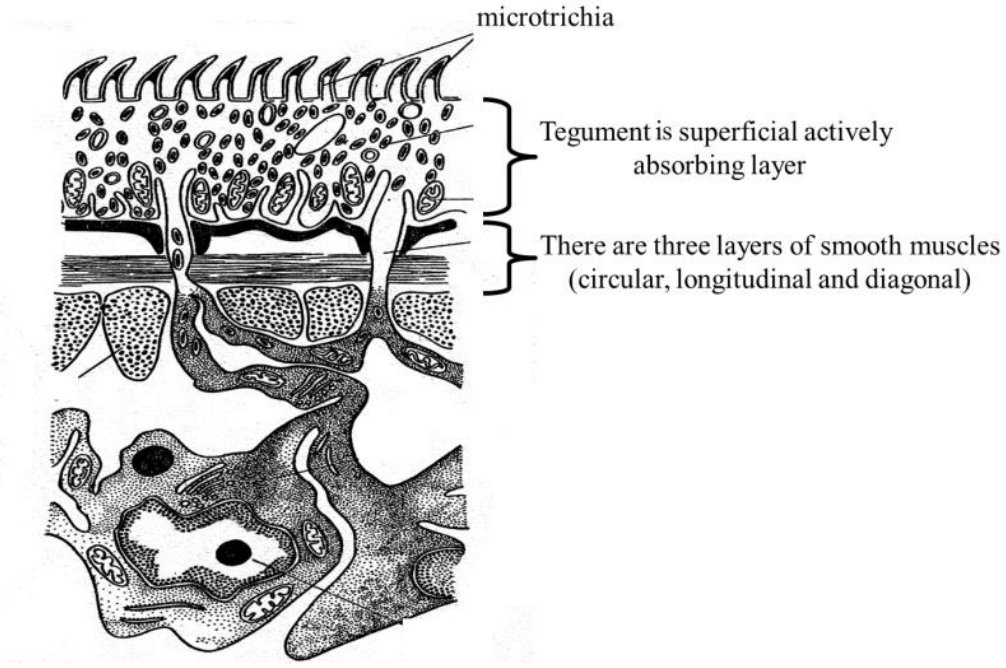


Figure 36. A dermato-muscular sac of *Cestoda*
http://www.licey.net/bio/img/zoology/cestoda1.png

In order to increase the absorbing surface there are microscopic microtrichia, the forms of which are the same as the cilia of the small intestine of the final host. That is why all the food goes through the worm's body.

Body cavity is absent, intervals between organs are filled with parenchyma.

Digestive, circulatory and respiratory systems are absent.

The pattern of nervous systems is nervous trunk type. It includes head ganglion and nervous trunks coming out from them. Nerve trunks are joined by comissures. Among the sense organs tactile organs and chemical senses are developed.

The pattern of excretory system is of protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them.

Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming two total canals that open up with two excretory pores.

The sexual system is hermaphroditic (fig. 37). Each mature segment of the tapeworm has a complete set of internal organs, male and female sexual systems.

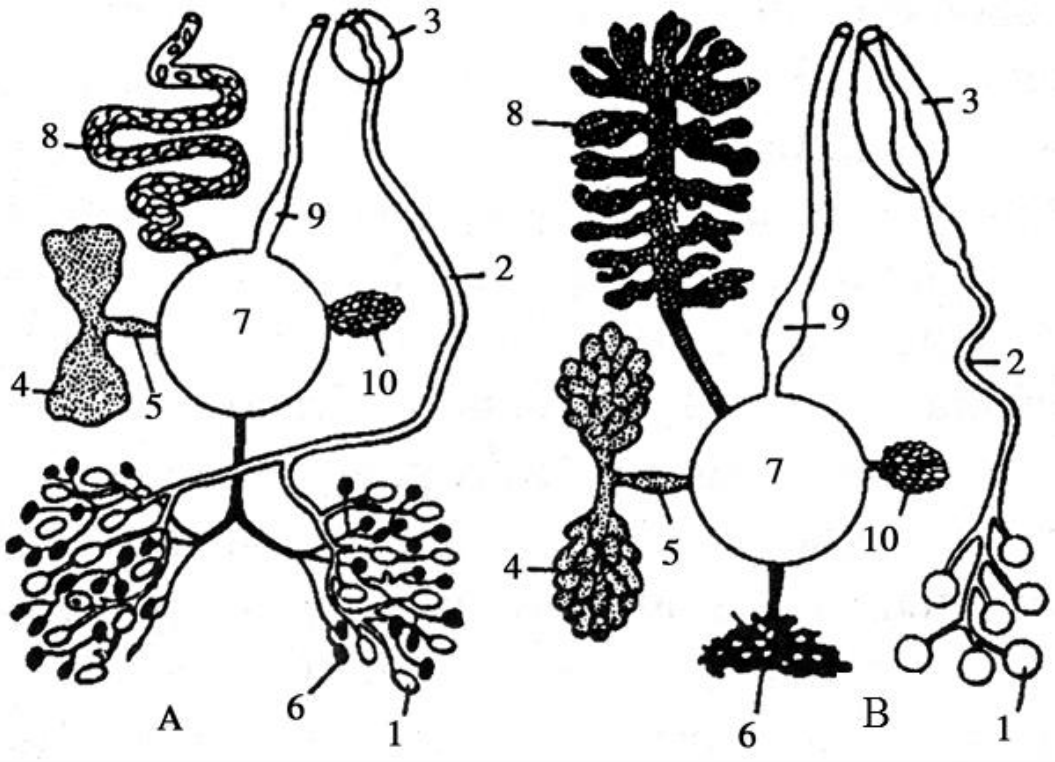


Figure 37. The sexual system of *Cestoda* Class
(http://www.doctoribolit.ru/images/Vermes/Vermes11.gif)
1 – testes; 2 – ejaculatory duct; 3 – cirrus sac; 4 – ovary; 5 – oviduct; 6 – vitelline (yolk) sac; 7 – ootype; 8 – uterus; 9 – vagina; 10 – Mehlis' gland

Male sexual system matures before the female sexual system. It consists of the following:

- testes are usually multiple follicles and are scattered throughout the parenchyma. Sperm ducts coming out from them join and form ejaculatory duct (vas deferens) that ends by cirrus bursa (cirrus sac) with cirrus;
- Cirrus Sac is a sac at the end of vas deferens containing a coiled-up muscular organ which is called cirrus (penis), the cirrus and vagina open into a common cup-shaped chamber (common genital pore).

Female sexual system lies on the ventral surface of each segment and comprises the following:

- ovary may be single or paired, it is usually a bilobed organ; it discharges ova through the oviduct into ootype;
- vagina extends from the genital pore to the ootype and is meant for the entrance of sperms;
- uterus is a straight tube, which arises from the ootype and when gravid, becomes filled with eggs, it may be open as in *Diphylobotrium latum* (the fish tapeworm or the broad tapeworm), or it may remain as a blind sac, as in family *Teniidae*: *Taeniarhynchus saginatus* (the beef tapeworm or unarmed tapeworm), *Taenia solium* (the pig tapeworm or the armed tapeworm), *Hymenolepis nana* (the dwarf tapeworm), *Echinococcus granulosus* (the dog tapeworm or the hydatid worm), *Echinococcus multilocularis* (alveolar or multilocular hydatid worm);
- ootype is a chamber where the ovum is fertilised and all the components of the egg are collected;
- Vitelline (yolk) Sac provides eggs with nutrients;
- Mehlis' Gland excretes the enzyme for formation of eggs surface.

Fertilization takes place between the segments; it may be a self-fertilization or a cross-fertilization between segments of the same or other worm.

The eggs are formed in the ootype where they are surrounded by protective coverings.

In *Taeniidae* family the egg is not operculated and has two coverings. The outer covering is called the egg-shell and the inner one surrounding the embryo is called the embryophore (fig. 38).

The space between the embryophore and the egg-shell is taken up by the yolk material. The egg contains an embryo. The embryo has six hooks and is called oncosphere. From the outside oncosphere is covered with a thick layer that has a radial striation.

The egg of *Diphyllobothrium Latum* is ovoid, with an operculum at the one end and a knob at the other, it has a single covering (fig. 39).

The membrane covering the embryo (which is formed outside) has a ciliated epithelium. The embryo is called coracidium. The size of egg is 58-76 mm in length and 40-51 in diameter.

All the Tapeworms (*Cestoda*) are biohelminths.

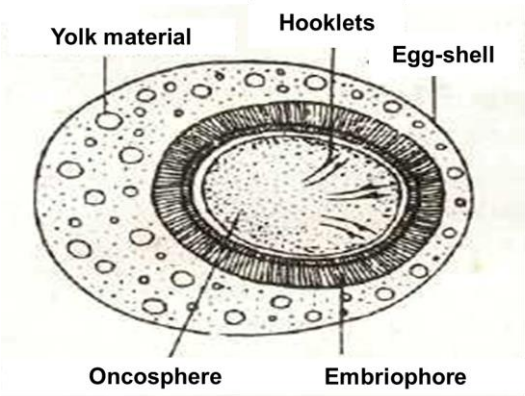


Figure 38. Egg of tapewors of the family *Taeniidae* (Chatterejee K.D.)

Figure 39. The egg of *Diphyllobothrium Latum* (http://images.myshared.ru/17/1047402/slide_59.jpg)

Life cycles of *Cestoda* are complex. Stages of life cycle: egg with larva (oncosphere or coracidium) and different forms of larval (or cystic) stages (cysticercus, cysticercoid, hydatid cyst, multilocular hydatid cyst, plerocercoid), pubertal form.

Cestoda are characterized by the presence of the final and intermediate hosts. In the organism of the final host (for example a human) a pubertal or tape stage develops.

Eggs in the gravid segments are excreted with faeces and get into the body of an intermediate host. In the egg a larva (oncosphere or coracidium) develops.

In the intestine of an intermediate host the larva gets out of its coats, with the help of the hooks it is delivered to different tissues, muscles and organs, where it transforms into the next larval or cystic stage.

Larvocystic stage can have different morphological variants:

- cysticercus is larval stage of *Taeniarhynchus saginatus* (the beef tapeworm or unarmed tapeworm) and *Taenia solium* (the pig tapeworm or the armed tapeworm). It is a hollow vesicle with the invaginated scolex on its wall and central cavity containing little fluid. It is grossly visible in meat (fig. 40);
- cysticercoid is a hollow vesicle with the invaginated scolex on its wall and central cavity containing a little fluid head and it have tail appendage. It is larval stage of *Hymenolepis nana* (the dwarf tapeworm) (fig. 41);
- hydatid cyst is larval stage of *Echinococcus granulosus* (the dog tapeworm or the hydatid worm). It is a large vesicle full of fluid, its wall consists of two layers (chitinous or laminated and germal), the inner layer produces protoscolices and brood capsules and form daughters' and granddaughters' vesicles

inside of the cyst (fig. 42);

- multilocular (or alveolar) hydatid cyst is a larval stage of *Alveococcus multilocularis* (alveolar or multilocular hydatid worm). The cyst contains little fluid and is multilocular, the germinal membrane proliferates outward, to create new cysts;
- plerocercoid is a larva of *Diphyllobothrium latum* (the fish tapeworm or the broad tapeworm). Plerocercoid is a wormshaped larva of white colour, there are two suction grooves (bothria) on the front end (fig. 43).

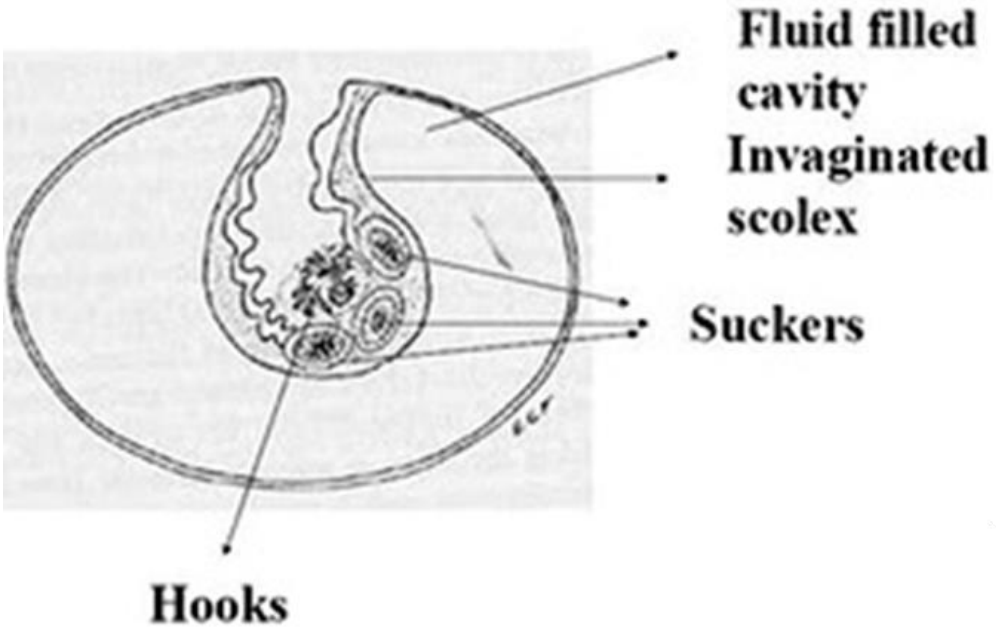


Figure 40. Cyscticercus (Chatterejee K.D.)

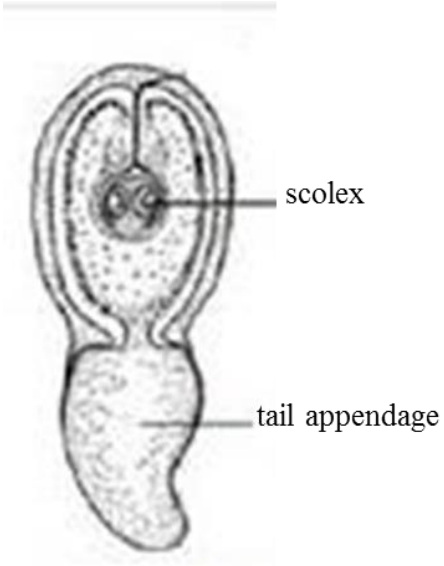


Figure 41. *Hymenolepis nana.* Cysticercoid.
(https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcRVvqxcUNID-PaIVNhl1X8dEG6KBLoPcS7wsibdB6Ew7bpAGLvhnw)

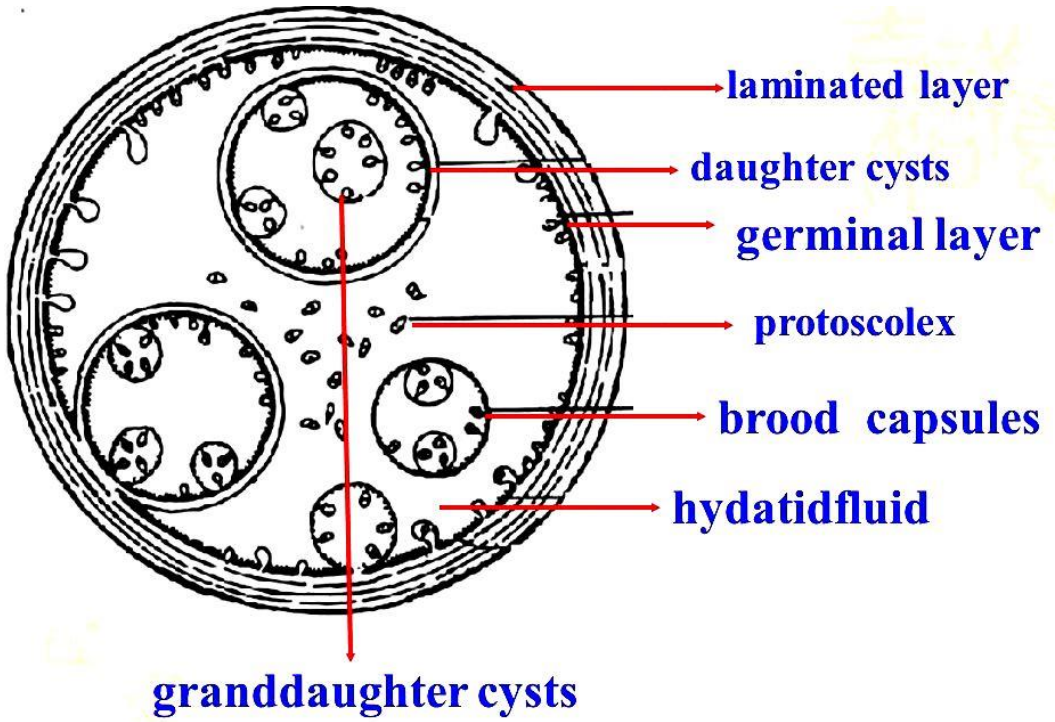


Figure 42. Hydatid cyst
(http://images.slideplayer.com/24/7468144/slides/slide_34.jpg)

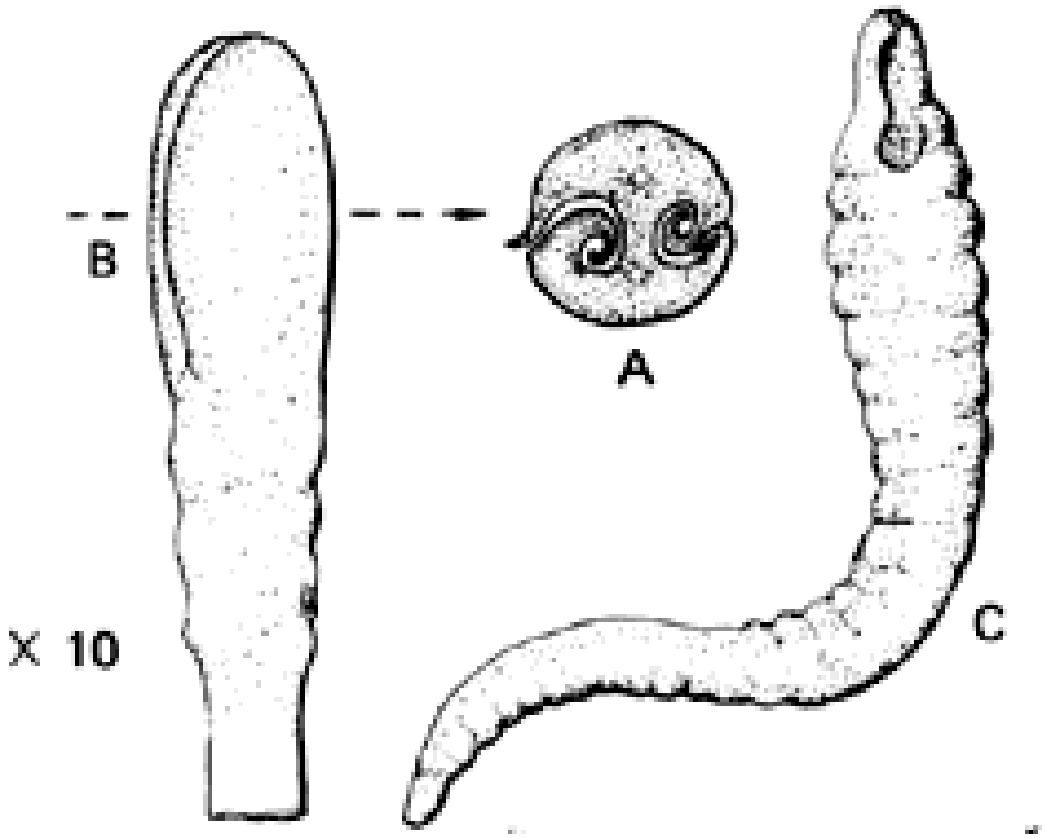


Figure 43. *Diphyllobothrium latum:*
A – cross section through a scolex, B - scolex and beginning of the strobili, C – plerocercoid.
(http://accessmedicine.mhmedical.com/data/books/1843/cmdt17_ch35_ef036.png)

Larvae develop into a puberal stage in the intestine of the final hosts, the infection of which takes place during eating meat of the infected by larvocysts intermediate hosts. Because of the digestive juice the scolex turns out and attaches itself to the intestinal wall, and proglottids start to bud from the neck.

Several dozens of species of *Cestoda* are parasites of human. Some of them can parasitize in the human in pubertal stage. They are *Taenia solium* (the pork tapeworm or the armed tapeworm), *Taeniarhynchus saginatus* (the beef tapeworm or unarmed tapeworm); *Diphyllobothrium latum* (the fish tapeworm or the broad tapeworm). They localize in the small intestine, there gravid segments in the feces can be found. The shape of the uterus in the gravid segments is a diagnostic characteristic. The uterus of beef and pork tapeworms has no outlet that is why eggs cannot be found in faeces of final hosts, in the broad tapeworm there is an outlet in the uterus so eggs as well as segments can be found in the faeces of final hosts.

In the larval stage the following helminthes parasitize in the human organism: *Echinococcus granulosus* (the dog tapeworm or the hydatid worm), *Echinococcus multilocularis* (alveolar or multilocular hydatid worm). They localize in the liver, lungs, brain, seldom in spleen, kidneys, bones, muscles. The methods of specific and additional diagnosis of alveococcossis and echinococcosis are immunologic metods, allergy tests, X-ray method; tomography.

For a dwarf tapeworm (*Hymenolepis nana*) the human is at the same time a final and an intermediate host. Laboratory diagnosis of hymenolepiasis is based upon detecting of eggs in the faeces.

The illnesses caused by *Cestoda* are called cestodiasises.

Pathogenic effect of *Cestoda* is toxi-allergic and mechanical (breach of the integrity of the intestine walls by suckers, hooks, strangulation by bothria of the broad tapeworm, the pressure on organs and tissues by larvocysts of the dog tapeworm and multilocular hydatid worm), absorbing of vitamins and food digested by the host (broad tapeworm).

***Taeniarhynchus saginatus* (Beef tapeworm)**

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Plathelminthes*
Class *Cestoda*

Species *Taeniarhynchus saginatus* (the beef tapeworm, unarmed tapeworm)

Taeniarhynchus saginatus is the pathogen of taeniarhynchiasis.

Geographical distribution. A human infection with *Taeniarhynchus saginatus* occurs worldwide. It is common in areas where cattle ranches are the major occupation and beef is a common meal for people (beef tapeworm). In some countries like Egypt, camel is a major source of infection.

Morphology of adult worm. *Taeniarhynchus saginatus* has a flat tape-like body that is flattened dorso-ventrally. The adult worm is from 5 to 7 meters in length. The strobila consists of 1000 to 2000 proglottids.

The body has three parts: a head (scolex), a neck and a body. The scolex has four cup-shaped suckers. *Taeniarhynchus saginatus* is an «unarmed» tapeworm as it lacks hooks. The scolex is followed by the unsegmented neck and further there is a flat tape-like body (strobila) that consists of segments (proglottids). «Neck» is the region of growth behind the scolex.

The strobila consists of immature (or young), mature (or hermaphroditic) and gravid (pregnant) segments:

- the young (immature) segments are the nearest to the neck and have only excretory organs and nervous system, reproductive organs (male and female organs) are absent;
- hermaphroditic segments (mature segments): reproductive organs (male and female organs) have become differentiated (male organs appear first);
- the length of a gravid segment is 3 to 4 times its breadth and possess a uterus with fertile eggs, other organs are atrophied; the uterus consists of a central longitudinal stem with 17 to 35 lateral branches on each side. The gravid segments show active movement.

The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (or tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal). *Taeniarhynchus saginatus* absorbs the food through the tegument with the help of microtrichia.

The Body cavity is absent, intervals between organs are filled with parenchyma.

Digestive, circulatory and respiratory systems are absent.

The pattern of nervous systems is nervous trunk type. It includes head ganglion and nervous trunks coming out from them. Nerve trunks are joined by comissures. As sense organs tactile organs and chemical senses are developed.

The pattern of excretory system is protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming two total canals that open up with two excretory pores.

The sexual system is hermaphroditic. Each segment of the tapeworm has a complete set of internal organs, male and female sexual systems. Male sexual system matures before the female sexual system. It comprises the following:

- testes are usually multiple follicles and are scattered throughout the parenchyma. Sperm ducts come out from them joining and forming ejaculatory duct (vas deferens) that ends by cirrus bursa (cirrus sac) with cirrus;
- Cirrus Sac is a sac at the end of vas deferens containing a coiled-up muscular organ which is called cirrus (penis). The cirrus and vagina open into a common cup-shaped chamber (common genital pore).

Female sexual system lies on the ventral surface of each segment and consists of the following:

- ovary is a bilobed organ, it discharges ova through the oviduct into ootype;
- vagina extends from the genital pore to the ootype and is meant for the entrance of sperms;
- uterus is a blind sac, which arises from the ootype and when gravid, becomes filled with eggs; the gravid uterus consists of a central longitudinal stem with 17 to 35 lateral branches on each side;
- ootype is a chamber where the ovum is fertilized and all the components of the egg are collected.
- Vitelline (yolk) Sac provides eggs with nutrients.
- Mehlis' Gland excretes the enzyme for ova surface formation.

Life cycle. *Taeniarhynchus saginatus* is biohelminth (figure 44).

The definitive (final) hosts are Human. The intermediate hosts are cattle (cow or buffalo). Stages of the life cycle: egg (in the egg, when it is still in the uterus, an oncosphere develops); oncosphere (in the intestine of an intermediate

host); larval stage (Cyscticercus) (in the muscles of an intermediate host); adult worm (in the intestine of a final host).

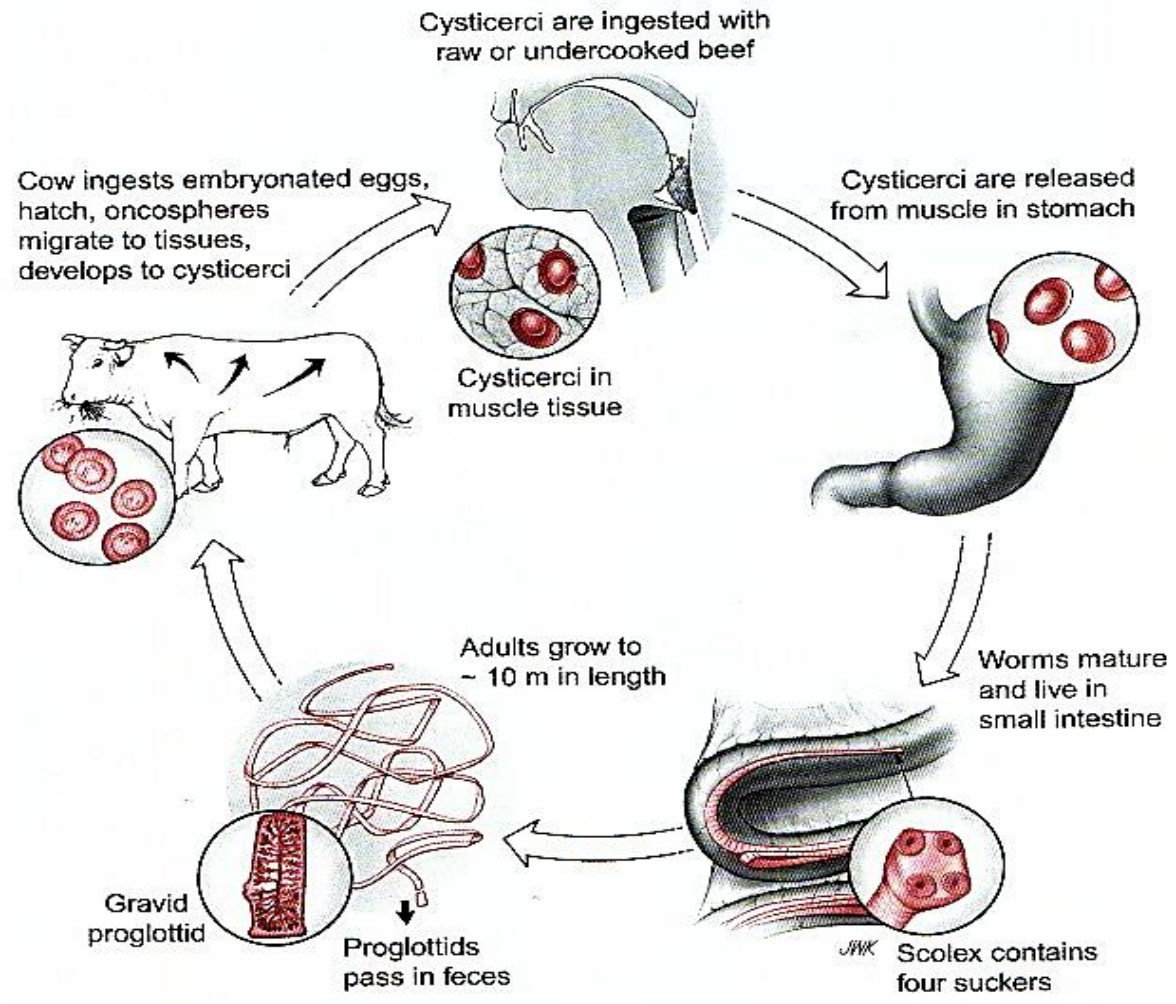


Figure 44. Life cycle of *Taeniarhynchus saginatus* (https://o.quizlet.com/93Fy3L3062YoEKRxAibR4g_m.jpg)

The mechanism of human infection. Invasion stage for final host (human) is Cyscticercus that presents in the muscles of the cattle. Invasion stage for intermediate host is egg. The way of penetration is alimentary way. The factors of invasion for human is raw or undercooked beef. Localization organ – an adult worm lives in the human intestine, their larval forms live in tissues of cattle (cow or buffalo).

Human is infected with *Taeniarhynchus saginatus* by alimentary way, after consuming raw or undercooked beef containing cysticercus. The scolex of cysticercus evaginates in the small intestine and attaches to the mucosa with its suckers. The process of strobilization starts and an adult worm forms. Eggs are produced in the gravid system of the worm. Gravid segments detach and pass along

with the faeces. These segments are capable to move and migrate to the grazing sites and rupture to release eggs on the grass. Gravid segments can also migrate through the anus of the host and rupture to release eggs on the perianal skin. Cattle while grazing, ingest eggs along with their food (grass). The ingested eggs hatch to liberate oncospheres in the animal's duodenum.

The hooked oncospheres penetrate the mucosa to invade the bloodstream or lymph to reach muscles. The oncospheres are filtered out from the circulating blood into the muscular tissues where they ultimately settle down and undergo further development. The muscles most commonly selected are those of the tongue, neck, shoulder and hip; the cardiac muscle is also involved. The oncospheres lose their hooks on reaching their destination and each oncosphere forms cysticercus. When the beef infected with cysticercus is consumed raw or undercooked by humans, the life cycle of *Taeniarhynchus saginatus* completes.

Pathogenic effect. The products of worm's vital activities cause toxi-allergic effect. Manifestations of intestinal obstruction may occur.

Clinical features. The name of disease is taeniarhynchiasis. When it is symptomatic: a vague abdominal discomfort, nausea, change in the appetite, weakness and weight loss may be present. Patients become aware of the disease by either noticing passage of proglottids in their faeces or after experiencing a discomforting perianal sensation when a proglottid forces its way through the anus.

Laboratory diagnostics. Detection of gravid segments in the feces (fig. 45). The uterus of beef tapeworms has no outlet that is why eggs cannot be found in their feces. The shape of the uterus in the gravid segment is a diagnostic characteristic. The height of segments is bigger than width. The definitive diagnosis can be made by the demonstration of the gravid segments of *Taeniarhynchus saginatus* showing uterus branches from 17 to 35 on each side.

Prevention measures. Personal prevention: not to use poorly thermally treated beef or beef failed the vet control. Public prevention: control of meat quality, treatment of patients, prevention of enviromental pollution.

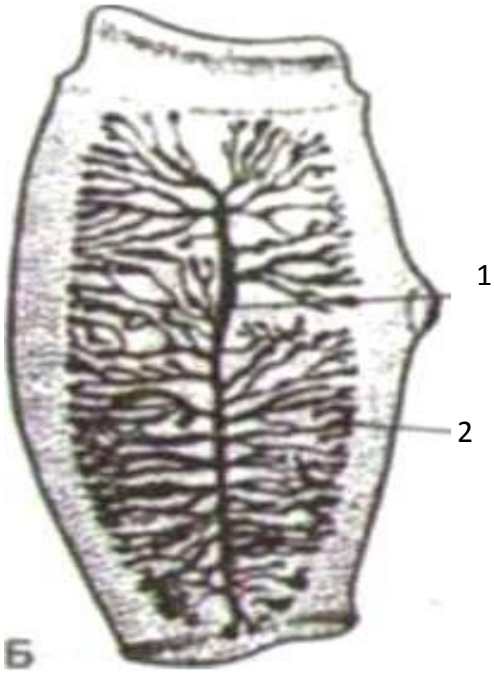


Figure 45. Gravid segment of *Taeniarhynchus saginatus*
1 - central longitudinal stem of uterus; 2 – branches of uterus

***Taenia solium* (Pig tapeworm)**

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Plathelminthes*

Class *Cestoda*

Species *Taenia solium* (the pig tapeworm, the armed tapeworm)

Taenia solium is the pathogen of taeniasis.

Geographical Distribution. Taeniasis is found world-wide. The infection is common amongst those eating raw or insufficiently cooked pork.

Morphology of adult worm. *Taenia solium* has a flat tape-like body that is flattened dorso-ventrally. The adult worm is from 2 to 3 meters in length. The body has three parts: a head (scolex), a neck and a strobila.

The scolex («head») has 4 circular suckers. It is "armed" with two rows hooks on the top of the scolex. The scolex is followed by the unsegmented neck and further there is a flat tape-like body (strobila) that consists of segments (proglottids). «Neck» is the region of growth behind the scolex. The «neck» is short.

The strobila consists of immature (or young), mature (or hermaphroditic) and gravid (pregnant) segments:

- the young (immature) segments are the nearest to the neck and have only excretory organs and nervous system, reproductive organs (male and female organs) are absent;
- hermaphroditic segments (mature segments): reproductive organs (male and female organs) have become differentiated (male organs appear first);
- the length of a gravid segment is 3 to 4 times its breadth gravid and possess a uterus with fertile eggs, other organs disappeared; the uterus consists of a central longitudinal stem with 7 to 12 lateral branches on each side and it do not move actively.

The wall of body is a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium (or tegument is superficial actively absorbing layer) that has lost its cellular structure under which there are three layers of smooth muscles (circular, longitudinal and diagonal). *Taenia solium* absorbs the food through the tegument with the help of microtrichia.

The Body cavity is absent, intervals between organs are filled with parenchyma.

Digestive, circulatory and respiratory systems are absent.

The pattern of nervous systems is nervous trunk type. It includes head ganglion and nervous trunks coming out from them. Nerve trunks are joined by comissures. Among the sense organs tactile organs and chemical senses are developed.

The pattern of excretory system is protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming two total canals that open up with two excretory pores.

The sexual system is hermaphroditic. Each segment of the tapeworm has a complete set of internal organs, male and female sexual systems. Male sexual system matures before the female sexual system. It comprises the following:

- testes are usually multiple follicles and are scattered throughout the parenchyma, sperm ducts coming out from them that join together and form ejaculatory duct (vas deferens) that ends by cirrus bursa (cirrus sac) with cirrus;
- Cirrus Sac is a sac at the end of vas deferens containing a coiled-up muscular organ which is called cirrus (penis). The cirrus and vagina open into a

common cup-shaped chamber (common genital pore).

Female sexual system lies on the ventral surface of each segment and comprises the following:

- ovary is a trilobed organ, posessing one extra lobule. It discharges ova through the oviduct into ootype;
- vagina extends from the genital pore to the ootype and is meant for the entrance of sperms;
- uterus as a blind sac, which arises from the ootype and when gravid, becomes filled with eggs; the gravid uterus consists of a central longitudinal stem with 7 to 12 lateral branches on each side;
- ootype is a chamber where the ovum is fertilized and all the components of the egg are collected;
- Vitelline (yolk) Sac provides eggs with nutrients;
- Mehlis' Gland excretes the enzyme for ova surface formation.

Life cycle. *Taenia solium* is a biohelminth (figure 46).

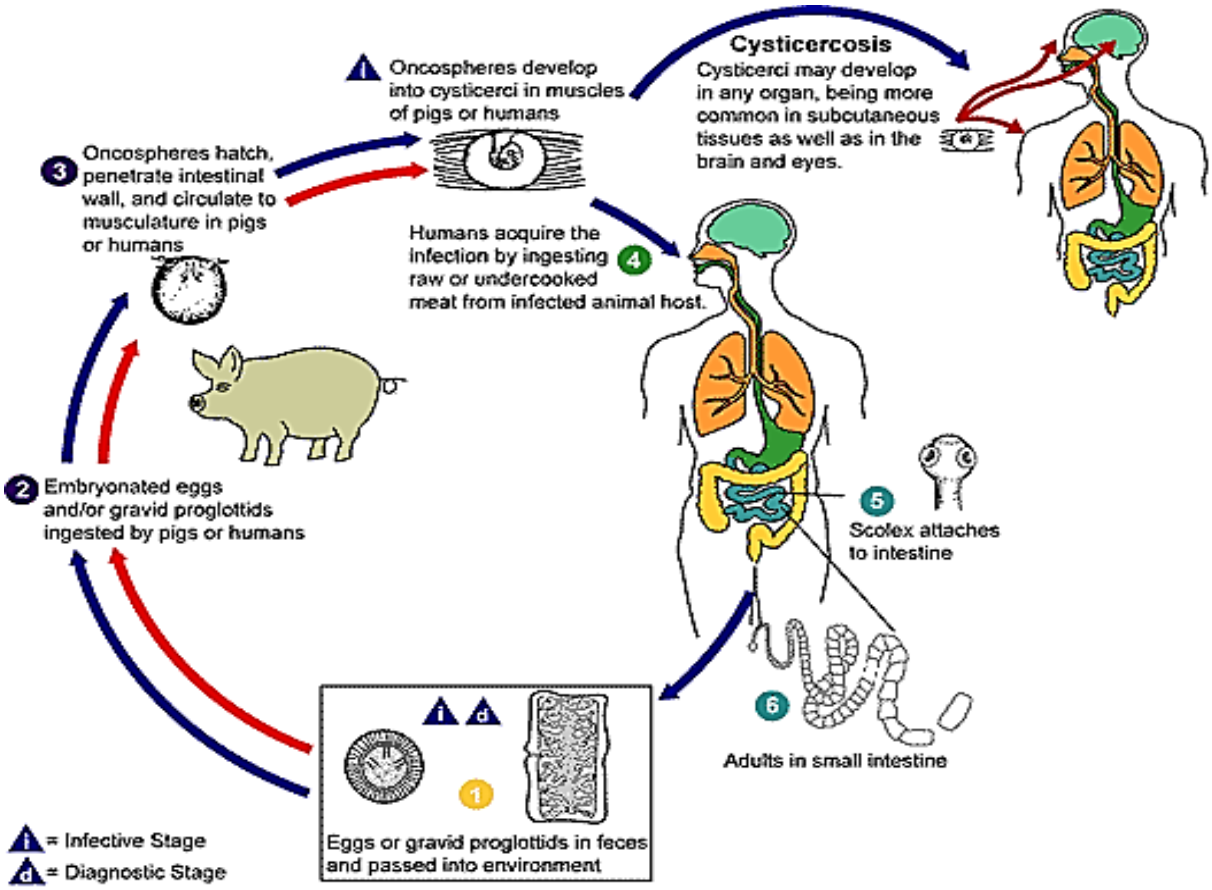


Figure 46. Life cycle of *Taenia solium*
(http://www.phsource.us/PH/PARA/Chapter_4_files/image001.jpg)

The definitive (final) hosts are Humans. The intermediate hosts are pigs.

Stages of the life cycle: egg (in the egg, when it is still in the uterus, an oncosphere develops); oncosphere (in the intestine of an intermediate host); Cyscticercus (in the tissues of an intermediate host); adult worm (in the intestine of a final host).

The mechanism of human infection. Invasion stage for final host (human) are eggs and Cyscticercus that present in the muscles of the pigs. Eggs of *Taenia solium* reach the stomach with:

- consumption of contaminated water and vegetables;
- autoinfection by unhygienic habits;
- the process of reverse peristalsis in the human intestine.

Invasion stage for intermediate host is egg. The way of penetration is alimentary way. The factors of invasion for human are raw or improperly cooked pork, containing cysticercus.

Localization organ – an adult worm lives in the small intestine of human, their larval forms live in tissue of pigs. However, the larvae can also develop in human tissues. In this case eggs are an invasion form of *Taenia solium* for humans.

Human is infected with *Taenia solium* by alimentary way, after consuming raw or undercooked pork containing cysticercus. In the intestine of human the scolex evaginates and attaches to the intestinal mucosa with the help of suckers and hooks. The process of strobilization starts and an adult worm forms. Eggs are produced in the gravid system of the worm. Gravid segments detach and pass along with the faeces.

The life cycle is continued by the pig ingesting viable eggs. In the pig intestine the oncosphere is released, penetrates the gut-wall with the help of its hooklets to reach the bloodstream, and is filtered in muscles of the neck, shoulders, legs and the tongue. It develops into cysticercus.

Pathogenic effect. Toxi-allergic and mechanical (breach of the integrity of the intestine walls by suckers, hooks), absorbing of vitamins and food digested by the host.

Clinical features. There are two forms of diseases caused by pig worm.

Taeniasis is caused by adult parasite. When it is symptomatic: a vague abdominal discomfort, nausea, change in the appetite, weakness and weight loss

may be present. Patients become aware of the disease by either noticing passage of proglottids in their faeces.

Human cysticercosis is caused by cysticercus. Manifestations of human cysticercosis depend on the site of the location of cystecercus. Serious manifestations may accompany the involvement of brain and eye.

Laboratory diagnostics of taeniasis is based on revealing gravid segments in the faeces. The uterus of pig tapeworms has no outlet that is why eggs cannot be found in their faeces. The shape of the uterus in the gravid segment is a diagnostic characteristic (fig. 47). The height of segments is bigger than width. Within gravid segment there is uterus with branches from 7 to 12 on each side. However, efforts should be made to distinguish them during the laboratory diagnostics because of the potential risk of cysticercus developing in *Taenia solium* infection. Laboratory diagnostics of cysticercosis are immunologic reactions.

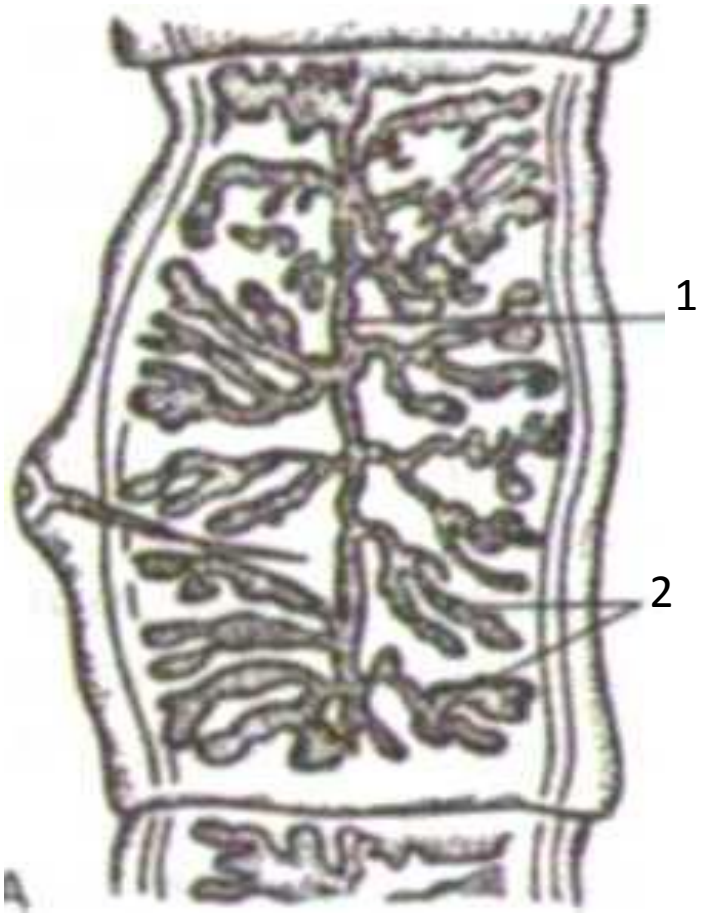


Figure 47. Gravid segment of *Taenia solium*
1 - central longitudinal stem of uterus; 2 – branches of uterus

Differences between *Taeniarynchus saginatus* and *Taenia solium* to be noted during the laboratory examination (Table 2)

Table 2

Differences between *Taeniarynchus saginatus* and *Taenia solium*

The part of body	***Taeniarynchus saginatus***	***Taenia solium***
Scolex	4 suckers, no hooks, rhomboid	4 suckers, hooks, globular
Mature segment	Ovary: 2 large lobes	Ovary: 2 large and 1 small lobe
Gravid segment	Uterine branches: from 17 to 35 on each side.	Uterine branches: from 7 to 12 on each side.

Prevention of taeniasis. Personal prevention is not to use insufficiently thermally treated pork failed the vet control. Public prevention are sanitary examination of pig carcasses, dehelminthization of sick people.

Prevention of cysticercosis. Personal prevention is to follow personal hygiene. Public prevention includes detection of sick with taeniasis; avoiding vomiting and dissolving segments by medicaments.

***Echinococcus granulosus* (Hydatid worm)**

Systematic position of in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Plathelminthes*

Class *Cestoda*

Species *Echinococcus granulosus* (The dog tapeworm; the hydatid worm)

Echinococcus granulosus is a pathogen of echinococcosis.

Geographical Distribution. Although the hydatid disease is world-wide in distribution, it is most commonly found in those countries where sheep and cattle-raising constitutes an important industry and consequently there is a close association between human, sheep and dog. It is more a disease of temperate climates than of tropical areas.

Morphology of adult worm. *Echinococcus granulosus* is a small tapeworm, measuring 3 to 6 mm in length (fig. 48). It consists of a scolex («head»), «neck» and strobila consisting of 3 segments (occasionally 4). The scolex

(«head») bears four suckers and two circular rows of hooks. The «neck» is short and thick.

The first segment is young, the second one is hermaphrodite (mature) and the last one (as well as the fourth one, when present) is gravid. The young (immature) segment has only excretory organs and nervous system, reproductive organs (male and female organs) are absent. Male and female sexual organs in mature segment have become differentiated (male organs appear first). Gravid (pregnant) segments possess a uterus with fertile eggs, other organs disappeared. The gravid segments show active movement.

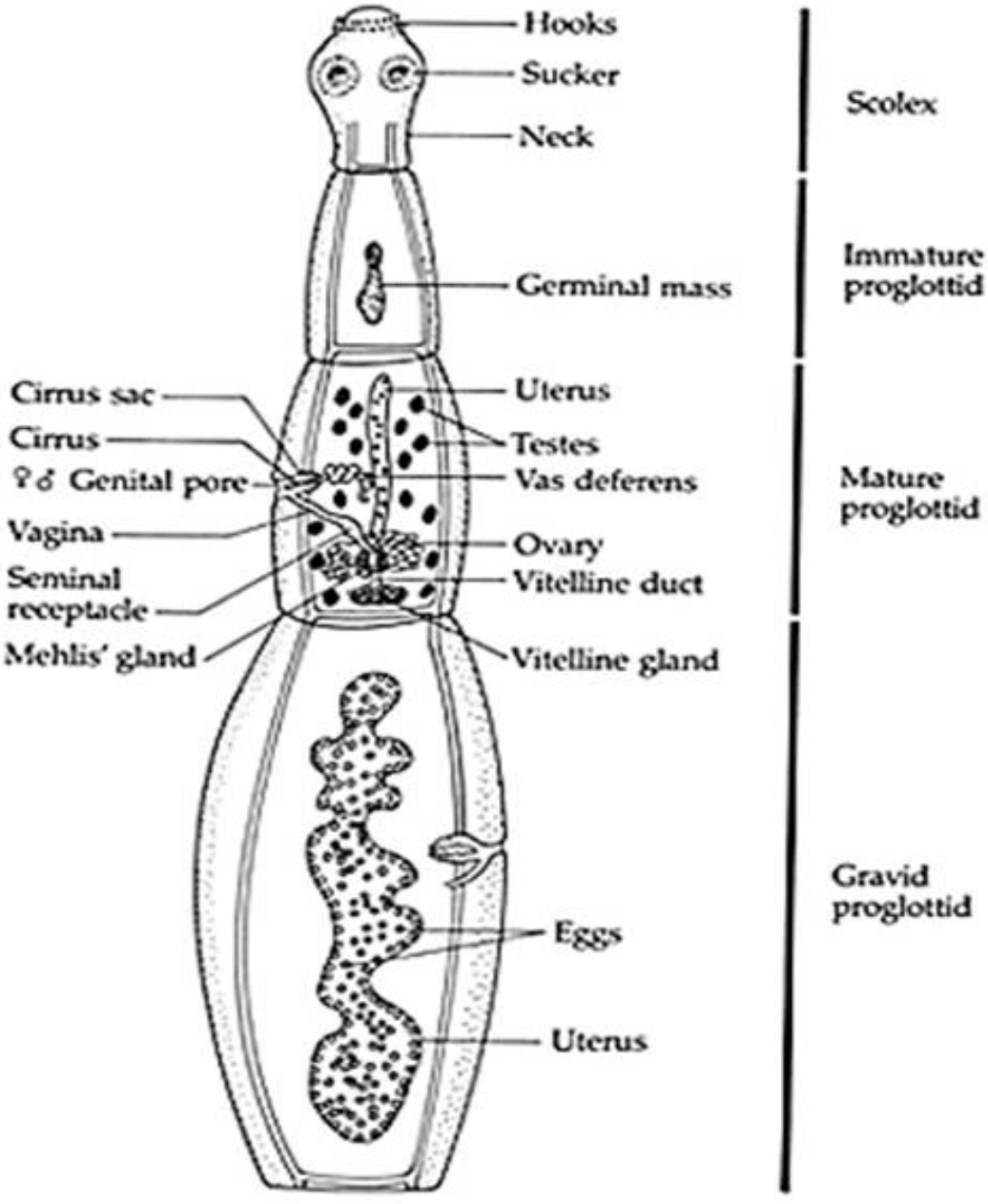


Figure 48. Morphology of *Echinococcus granulosus*
(http://rowdysites.msudenver.edu/~churchcy/BIO3270/Images/Worms/Echinococcusps.jpg)

They possess a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium that has lost its cellular structure (tegument is superficial actively absorbing layer) under which there are three layers of smooth muscles (circular, longitudinal and diagonal). They have adapted to absorbing the food through the tegument's microtrichia. The Body cavity is absent, intervals between organs are filled with parenchyma.

Digestive, circulatory and respiratory systems are absent.

The pattern of nervous systems is nervous trunk type. It includes head ganglion and nervous trunks coming out from them, lateral nervous trunks are well developed. Nerve trunks are joined by comissures.

The pattern of excretory system is protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming two total canals that open up with two excretory pores.

The sexual system is hermaphroditic. Male sexual system consists of the following:

- testes are usually multiple follicles and are scattered throughout the parenchyma. Sperm ducts coming out from them that join together and form ejaculatory duct (vas deferens) that ends by cirrus bursa (cirrus sac) with cirrus;
- Cirrus Sac is a sac at the end of vas deferens containing a coiled-up muscular organ which is called cirrus (penis). The cirrus and vagina open into a common cup-shaped chamber (common genital pore).

Female sexual system consist of:

- ovary discharges ova trough the oviduct into ootype;
- vagina extends from the genital pore to the ootype and is meant for the entrance of sperms;
- uterus is a blind sac, which arises from the ootype and when gravid, becomes filled with eggs;
- ootype is a chamber where fertilization and eggs formation take place;
- Vitelline (yolk) Sac provides eggs with nutrients;
- Mehlis' Gland excretes the enzyme for eggs surface formation.

Life Cycle. *Echinococcus granulosus* is biohelminths. The worm passes its life cycle in two hosts (fig. 49).

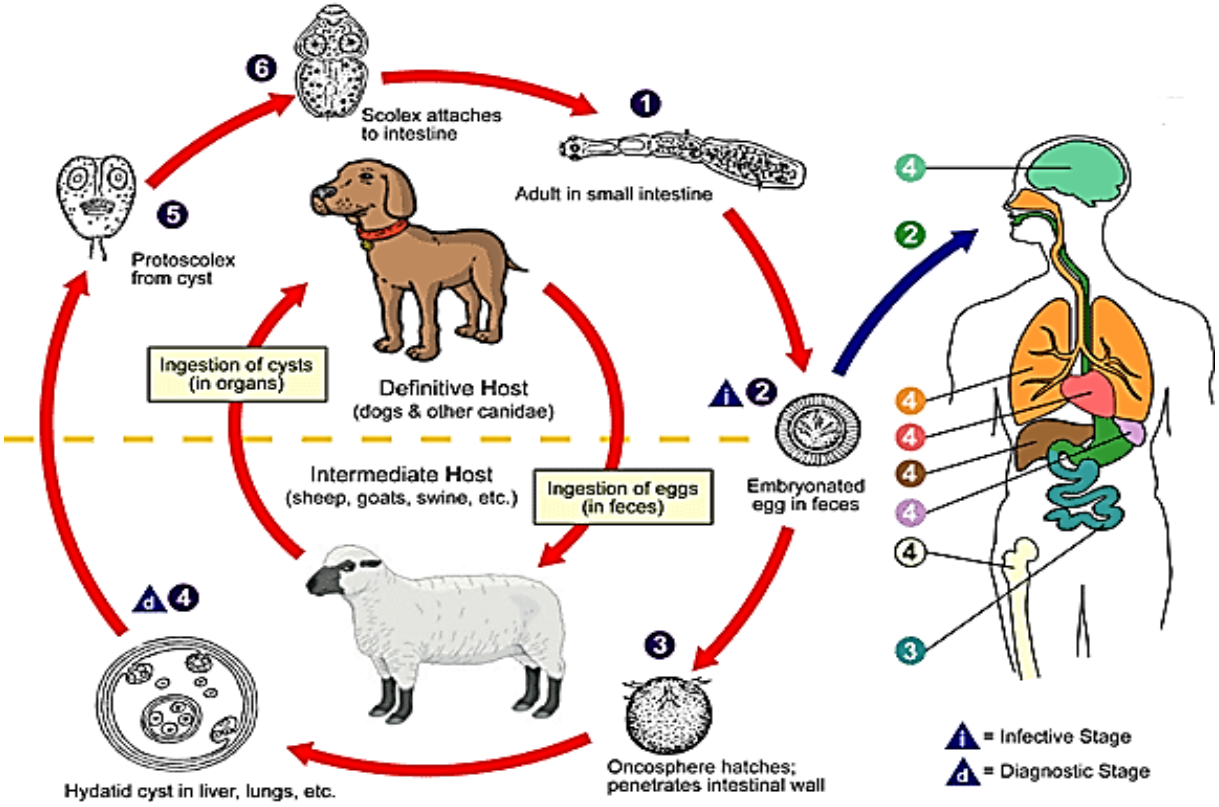


Figure 49. Life cycle of *Echinococcus granulosus*
(http://www.cdc.gov/parasites/images/echinococcosis/echinococcus_lifecycle.gif)

Definitive (final) hosts are dog, wolf, fox and jackal. Intermediate hosts are sheep, pig, cattle, horse, goat and human.

Stages of the life cycle: egg (in the egg, when it is still in the uterus, an oncosphere develops); oncosphere (in the intestine of an intermediate host); hydatid cysts (in the liver, lungs, brain, muscles, tubular bones, in any organ of an intermediate host); adult form (in the intestine of a final host).

The mechanism of human infection. Invasional stage for final host (dog) is hydatid cysts, which are present in the organism of sheep (also cattle, pigs, goats and camels). Humans are accidental intermediate hosts. Invasional stage for intermediate host (humans) is egg. The way of penetration is alimentary way. The factors of invasion for human are dirty hands, contaminated with egg.

Localization organs: An adult worm lives in the small intestine of final hosts. The hydatid cysts are mainly located in the liver and lungs. Rarely, the cysts may be found in the brain, eye, kidney, muscles and bones of Intermediate hosts.

Natural life cycle of *Echinococcus granulosus*. Sheep are infected by eggs consumed with the contaminated grass → an embryo releases from the egg in

the duodenum (oncosphere), penetrates the mucosa to enter the portal circulation → oncosphere settles down in the liver and other organs to develop into hydatid cysts → dogs are infected consuming infected tissues of a sheep → scolex is released from hydatid cyst in the dog's intestine → scolexes evaginate and attach themselves to the intestinal mucosa → strobilization ensues and adult worms are formed in the dog's intestine. An auto-fertilization or a cross-fertilization of eggs occurs in the gravid segment. This gravid segment ruptures to release eggs. They contain an oncosphere surrounded by the thick radially striates embryophore. Eggs are passed out with dog's faeces.

Incomplete life cycle of *Echinococcus granulosus* in a human being. Humans are infected when eggs of *Echinococcus granulosus* reach their gastrointestinal tract either as a result of hands or food contamination with infected dog's faeces. → Oncospherae are released from the eggs in the duodenum. They penetrate the mucosa and enter the portal circulation. Then oncosphere settle down in the liver and other organs. → Oncosphere turns into hydatid cysts during one month to a year’s time.

Pathogenic effect. *Echinococcus granulosus* causes hydatid cyst disease in humans (echinococcosis). Slowly enlarging hydatid cysts are usually asymptomatic. As the cyst enlarges symptoms of space occupying lesion develop.

Allergic reactions and sometimes anaphylactic shock may occur if the cyst ruptures (the hydatid fluid is antigenic and toxic). Rupture of the cyst may also lead to the escape of protoscolices into the surrounding tissues, these can then develop into further cysts.

It manifests in the liver with the abdominal pain. Pathogenic effect is toxi-allergic and mechanical, the pressure on organs and tissues by larvocysts of the dog tapeworm. The compression of the bile duct may result in obstructive jaundice. In lungs, a hydatid cyst manifests with the cough, chest pain or haemoptysis. In bones, the growing hydatid cyst leads to bone erosion and pathological fractures.

Laboratory diagnostics must apply a combination of tools that involve imaging techniques, histopathology and nucleic acid detection (polymerase chain reaction) and serology. The main method is serology tests. The imaging technique is ultrasonography, MRI (magnetic resonance imaging) and CT (computerized (or computed) tomography).

Preventive measures. Personal prevention includes personal hygiene especially after dealing with dogs, washing hands before eating. Public prevention is prevention of the infection of dogs and dehelminthization of dogs in endemic areas, examination of cattle, sanitary-instructive work.

Alveococcus multilocularis

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Plathelminthes*

Class *Cestoda*

Species *Alveococcus multilocularis*

Geographical Distribution. The larval worm causes alveolar or multilocular hydatid disease in human (alveococcosis). The disease is prevalent in certain parts of Europe.

Morphology of adult worm. *Alveococcus multilocularis* is a small tapeworm, measuring 3 to 6 mm in length. It consists of a scolex («head»), «neck» and strobila consisting of 3 (occasionally 4) segments.

The scolex («head») bears four suckers and two circular rows of hooks. The «neck» is short and thick. The first segment is young, the second one is hermaphrodite (mature) and the last one (as well as the fourth one, when present) is gravid. The young (immature) segment has only excretory organs and nervous system, reproductive organs (male and female organs) are absent. Male and female sexual organs in mature segment have become differentiated (male organs appear first). Gravid (pregnant) segments possess a uterus with fertile eggs, other organs disappeared. The gravid segments show active movement.

They possess a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium that has lost its cellular structure (tegument is superficial actively absorbing layer) under which there are three layers of smooth muscles (circular, longitudinal and diagonal). They have adapted to absorbing the food through the tegument's microtrichia. The Body cavity is absent, intervals between organs are filled with parenchyma.

Digestive, circulatory and respiratory systems are absent.

The pattern of nervous systems is nervous trunk type. It includes head ganglion and nervous trunks coming out from them, lateral nervous trunks are well

developed. Nerve trunks are joined by comissures. Among the sense organs tactile organs and chemical senses are developed.

The pattern of excretory system is protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming two total canals that open up with two excretory pores.

The sexual system is hermaphroditic.

Male sexual system consists of the following: testes are usually multiple follicles and are scattered throughout the parenchyma, sperm ducts leave them joining and forming ejaculatory duct (vas deferens) that ends by cirrus bursa (cirrus sac) with cirrus; Cirrus Sac is a sac at the end of vas deferens containing a coiled-up muscular organ which is called cirrus (penis). The cirrus and vagina open into a common cup-shaped chamber (common genital pore).

Female sexual system consist of:

- ovary discharges ova trough the oviduct into ootype;
- vagina extends from the genital pore to the ootype and is meant for the entrance of sperms;
- uterus is a blind sac, which arises from the ootype and when gravid, becomes filled with eggs;
- ootype is a chamber where fertilization and eggs formation take place;
- Vitelline (yolk) Sac provides eggs with nutrients;
- Mehlis' Gland excretes an enzyme for eggs surface. formation

Life Cycle. *Alveococcus multilocularis* is biohelminth. The worm passes its life cycle in two hosts (fig. 50, 51). Definitive hosts are dog, wolf, fox and jackal. Intermediate hosts are sheep, pig, cattle, horse, goat and human being.

Stages of the life cycle: egg (in the egg, when it is still in the uterus, an oncosphere develops); oncosphere (in the intestine of an intermediate host); alveolar or multilocular hydatid cysts (in the liver, lungs, brain, muscles of an intermediate host); adult form (in the intestine of a final host).

The mechanism of infection. Invasional stage for final host is multilocular hydatid cysts that are present in the organism of sheep (also cattle, pigs, goats and camels). Humans are accidental intermediate hosts. Invasional stage for in-

termediate host (humans) is egg. The way of penetration is alimentary way. The factors of invasion for human are dirty hands, contaminated with eggs.

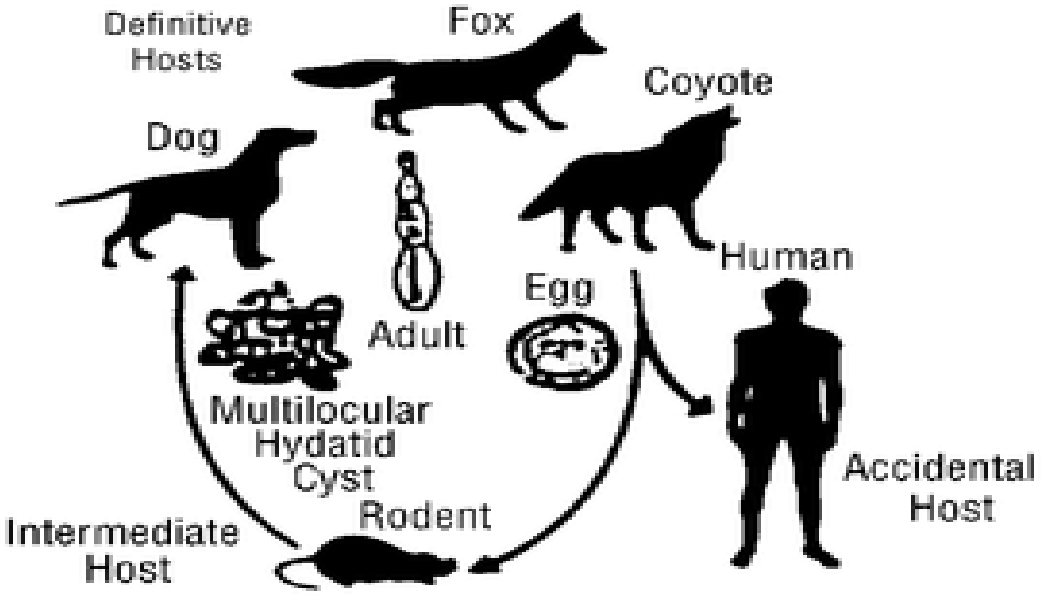


Figure 50. Life cycle of *Alveococcus multilocularis*
(https://vetlabel.com/lib/images-vet/praziquantel-1/image-01.jpg)

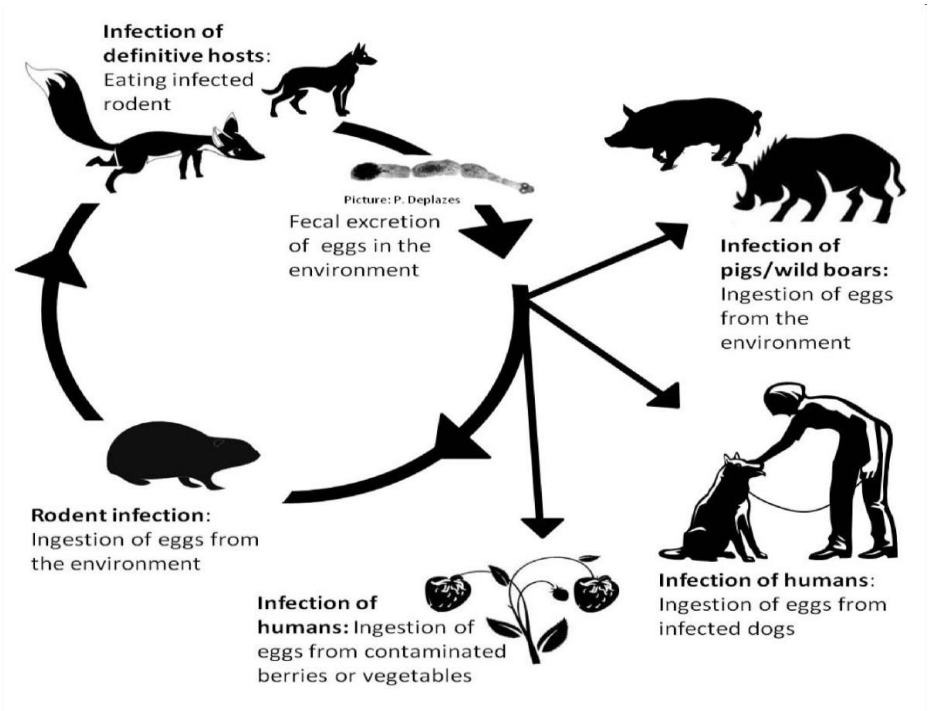


Figure 51. Life cycle of *Alveococcus multilocularis*
(https://www.researchgate.net/profile/Dan_Christensson/publication/49830104/figure/fig1/AS:214063603818508@1428048149002/Life-cycle-of-Echinococcus-multilocularis.png)

Localization organs: the adult worm lives in the small intestine of dog and other canine animals, their larval forms live in the liver, lungs, brain, muscles in any organ of human. The most commonly involved organ is the liver.

Pathogenic effect. The slowly enlarging alveolar or multilocular hydatid cysts are usually asymptomatic. The most common localization of larvocysts is the liver and lungs. However, a multilocular hydatid cyst can develop in any organ. It manifests in the liver with the abdominal pain. Pathogenic effect is toxi-allergic and mechanical, with the pressure on organs and tissues by larvocysts of *Alveococcus multilocularis*. The compression of the bile duct may result in obstructive jaundice. In lungs, a multilocular hydatid cyst manifests with the cough, chest pain or haemoptysis.

Laboratory diagnostics must use a combination of tools that involve imaging techniques, histopathology and nucleic acid detection (polymerase chain reaction) and serology. The main method is serology tests. The imaging technique is ultrasonography, MRI (magnetic resonance imaging) and CT (computerized (or computed) tomography).

Preventive measures. Personal prevention: personal hygiene especially after dealing with dogs, washinghands before eating. Public prevention: prevention of the infection of dogs and dehelminthization of dogs in endemic areas, examination of cattle, sanitary-instructive work.

***Hymenolepis nana* (Dwarf tapeworm)**

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Plathelminthes*
Class *Cestoda*
Species *Hymenolepis nana*

Hymenolepis nana is pathogen of hymenolepiasis.

Geographical distribution. Hymenolepiasis is found worldwide.

Morphology of adult worm. An adult form of *Hymenolepis nana* is one of the small intestinal cestodes infecting the human. It is from 1 to 4 cm in length (fig. 52). It consists of a scolex, neck and strobila. The number of segments is about 200. The scolex has 4 suckers and is provided with a shot retractile rostellum armed with a single row of hooks. The «neck» is long. The young (imma-

ture) segments have only excretory organs and nervous system, reproductive organs (male and female organs) are absent. Male and female sexual organs in mature segment have become differentiated (male organs appear first). Gravid (pregnant) segments possess a uterus with fertile eggs. Other organs disappeared.

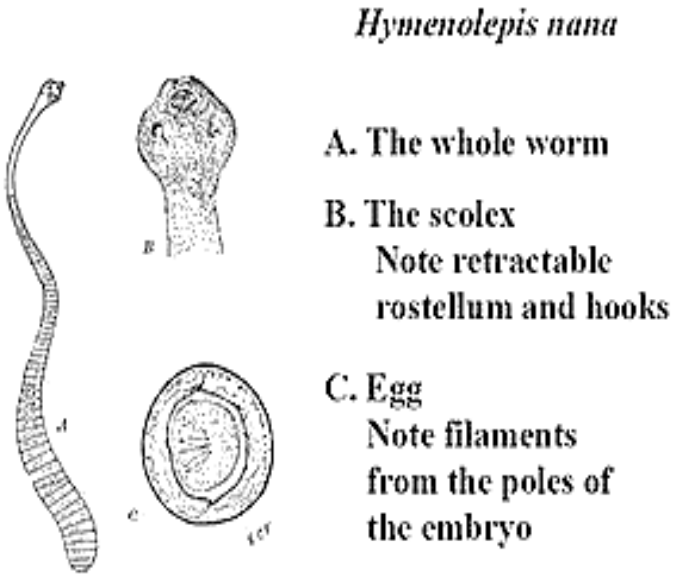


Figure 52. The structure of *Hymenolepis nana*
(http://www.medicalrealm.net/uploads/1/2/7/3/12737542/4010308_orig.jpg)

They possess a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium that has lost its cellular structure (tegument is superficial actively absorbing layer) under which there are three layers of smooth muscles (circular, longitudinal and diagonal). They have adapted to absorbing the food through the tegument's microtrichia.

The Body cavity is absent, intervals between organs are filled with parenchyma.

Digestive, circulatory and respiratory systems are absent.

The pattern of nervous systems is nervous trunk type. It includes head ganglion and nervous trunks coming out from them, lateral nervous trunks are well developed. Nerve trunks are joined by comissures. Among the sense organs tactile organs and chemical senses are developed.

The pattern of excretory system is protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that

ensure the movement of liquid in the canals. Canals interflow, forming two total canals that open up with two excretory pores.

The sexual system is hermaphroditic. Each segment of the dwarf tapeworm has a complete set of internal organs, male and female sexual systems. Male sexual system consists of the following: testes are usually multiple follicles and are scattered throughout the parenchyma, sperm ducts leave them joining and forming ejaculatory duct (vas deferens) that ends by cirrus bursa (cirrus sac) with cirrus; Cirrus Sac is a sac at the end of vas deferens containing a coiled-up muscular organ which is called cirrus (penis); the cirrus and vagina open into a common cup-shaped chamber (common genital pore).

Female sexual system is represented by:

- ovary discharges ova trough the oviduct into ootype;
- vagina extends from the genital pore to the ootype and is meant for the entrance of sperms;
- uterus is a blind sac, which arises from the ootype and when gravid, becomes filled with ova;
- ootype is a chamber where fertilization and ova forming take place;
- Vitelline (yolk) Sac provides eggs by nutrients;
- Mehlis' Gland excretes an enzyme for ova surface formation.

Eggs are released in the faeces by gradual disintegration of the terminal segments.

The characteristics of the eggs are as follows: spherical or oval in shape measuring 30 to 45 μm in diameter; there are two distinct membranes: the outer membrane is thin and colorless, the inner embryophore encloses an oncosphere with three pairs of lancet-shaped hooklets; the space between the two membranes is filled with yolk granules and polar filaments (4 to 8) emanating from little knobs at either end of embryophore.

Life Cycle. *Hymenolepis nana* is biohelminth. Hymenolepiasis is contact helminthiasis (fig. 53, 54).

Human is Definitive and Intermediate host. The peculiarities of the life cycle are that intermediate and final hosts are one and the same organism, being at first final and then an intermediate host.

Stages of the life cycle: egg (in the egg, when it is still in the uterus, an oncosphere develops); oncosphere (in the intestinal lumen of an intermediate host

– human); cysticercoids (in mucous membrane villi of the intermediate host (human) intestine); adult form (in the intestinal lumen of a final host – human).

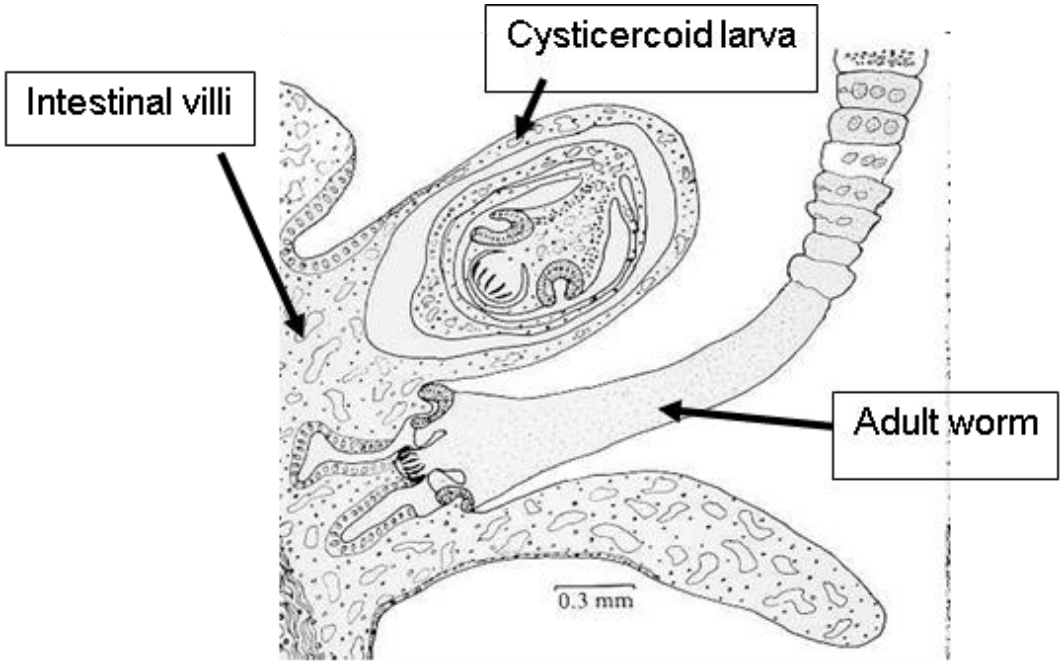


Figure 53. Life Cycle of *Hymenolepis nana* in mucous membrane villi of intestine (https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQd7r_6T6oHgDEbI0_KsdT5LNep1LXiv0qw-JUY7efPvPHypLT1)

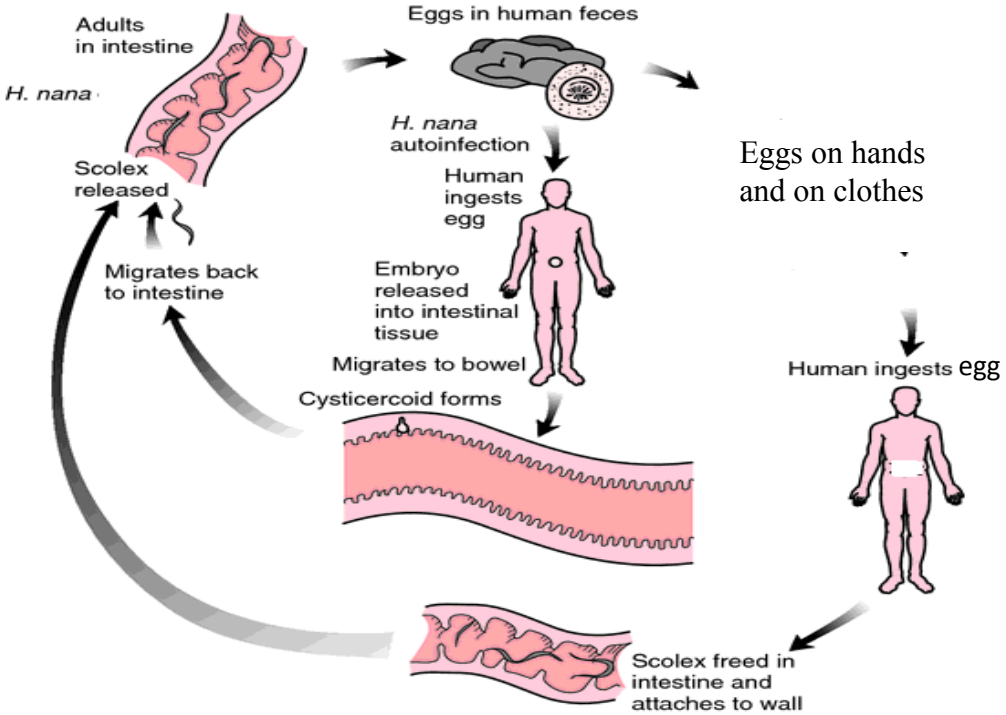


Figure 54. Life Cycle of *Hymenolepis nana* (http://img2.tfd.com/mk/H/X2604-H-45.png)

The mechanism of human infection. Invasional stage for humans is egg. The way of penetration is alimentary way. The factors of invasion for human are dirty hands and clothes infected with eggs.

The eggs are immediately infective to humans. They do not survive for more than 10 days in the external environment. The way of penetration is alimentary way. The oncosphere discharges in the intestine. It penetrates the intestinal villi and transforms into a cysticercoid larva. Cysticercoid is a hollow vesicle with the invaginated scolex on its wall and central cavity containing a little fluid head and tail appendage. The larva migrates back into the intestinal lumen, attaches to the mucosa, and matures in 10-12 days into an adult worm. The eggs pass into faeces to infect a new host. An alternate mode of infection consists of internal autoinfection, where the eggs release their hexacanth embryo, which penetrates the villus continuing the infective cycle without passage through the external environment.

Clinical features of hymenolepiasis. Even with a large number of intestinal worms the infection is usually asymptomatic. When it is symptomatic, patients have anorexia, abdominal pain, diarrhea, toxic and allergic reactions. Epileptiform attacks are possible.

Laboratory diagnostics. *Hymenolepis nana* infection is diagnosed by detecting eggs in faeces.

Prevention measures.: Personal prevention is personal hygiene. Public prevention includes fight against rodents, sanitary-instructive work, revealing and treating patients.

***Diphyllobothrium latum* (Fish tapeworm)**

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Plathelminthes*

Class *Cestoda*

Species *Diphyllobothrium latum* (The fish tapeworm; the broad tapeworm (Russian).

Diphyllobothrium latum is pathogen of diphyllobothriasis.

Geographical Distribution. Central Europe, America, Japan and Central Africa. It has not yet been reported from India.

Morphology of adult worm. *Diphyllobothrium latum* measures 10 to 18 meters in length. It consistsof a scolex, neck and strobila. The segments are greater in width than in length. On the dorsal and ventral surfaces of the scolex there are two slit-like grooves (bothria). The «neck» is thin and unsegmented and is much longer than the «head».

The young (immature) segments have only excretory organs and nervous system, reproductive organs (male and female organs) are absent. Male and female sexual organs in mature segment have become differentiated (male organs appear first). Uterus is open. Gravid (pregnant) segments are greater in width than in length and are filled with male and female reproductive organs. Later the dried-up segments break off from the body, not singly but in chains, and are passed off in the host's faeces. The uterus is large and remains coiled in the centre of each segment in the form of a rosette.

They possess a dermato-muscular (skin-muscular) sac that consists of the dermal epithelium that has lost its cellular structure (tegument is superficial actively absorbing cuticulous layer) under which there are three layers of smooth muscles (circular, longitudinal and diagonal). They have adapted to absorbing the food through the tegument’s microtrichia. The Body cavity is absent, intervals between organs are filled with parenchyma.

Digestive, circulatory and respiratory systems are absent.

The pattern of nervous systems is nervous trunk type. It includes head ganglion and nervous trunks coming out from them. Nerve trunks are joined by comissures. Among the sense organs tactile organs and chemical senses are developed.

The pattern of excretory system is protonephridial type. It is represented by terminal stellate-shaped cells and branching canals coming out from them. Inside these terminal cells there are fascicles of vacillating cilia (cilia flame) that ensure the movement of liquid in the canals. Canals interflow, forming two total canals that open up with two excretory pores.

The sexual system is hermaphroditic. Each segment of the tapeworm has a complete set of internal organs, male and female sexual systems.

Male sexual system consists of:

- testes are usually multiple follicles and are scattered throughout the parenchyma; sperm ducts leave them joining and forming ejaculatory duct (vas deferens) that ends by cirrus bursa (cirrus sac) with cirrus;

- Cirrus Sac is a sac at the end of vas deferens containing a coiled-up muscular organ which is called cirrus (penis). The cirrus and vagina open into a common cup-shaped chamber (common genital pore).

Female sexual system is represented by:

- ovary discharges ova trough the oviduct into ootype;
- vagina extends from the genital pore to the ootype and is meant for the entrance of sperms;
- uterus is a straight tube, which arises from the ootype and when gravid, becomes filled with eggs. Uterus is open. The uterus is large and remains coiled in the centre of each segment in the form of a rosette;
- ootype is a chamber where fertilization and ova formation take place;
- Vitelline (yolk) Sac provides eggs with nutrients;
- Mehlis' Gland excretes an enzyme for ova surface formation.

Life cycle. *Diphyllobothrium latum* is biohelmith. The worm passes its life cycle in one definitive host and two intermediate hosts (fig. 55).

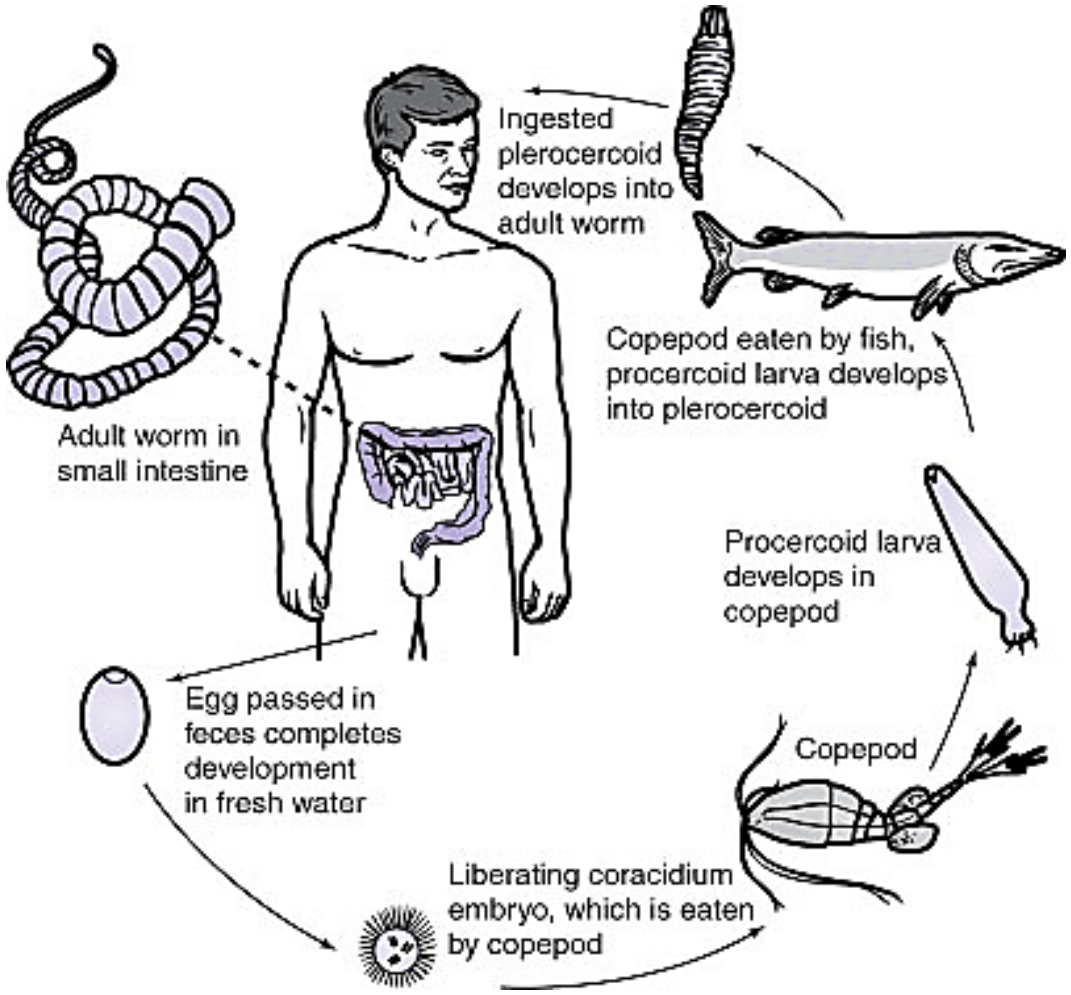


Figure 55. Life cycle of *Diphyllobothrium latum*
(http://medicine.academic.ru/pictures/medicine/457.jpg)

Definitive Hosts are human, carnivorous animals (dog, cat, etc); human is the definitive host. The first Intermediate hosts are fresh-water lower *Crustacea*ns – copepods (cyclops). The second Intermediate (supplementary) host is a fresh-water fish.

Human organ for localization: the adult worms are found in the small intestine.

Stages of the life cycle: egg, coracidium (in external medium); procercoid (in the intermediate host); plerocercoid (in the supplementory and reservoir host); pubertal form (in the final host).

The mechanism of human infection. Invasional stage for Definitive Hosts (human) is plerocercoid. Invasional stage for first intermediate host (cyclop) is coracidium. Invasional stage for second Intermediate hosts (fish) is procercoid. The way of penetration is alimentary way. The factors of invasion for human are insufficiently cooked fish or raw roe.

Adult worm lives in the small intestine of human; also in dog, cat, fox and other fish-eating mammals. Immature *Diphyllobothrium latum* eggs are passed in the feces of the human host. These eggs then complete development in fresh water.

Life Cycle continues in crustaceans: small, ciliated coracidium larvae hatch from mature eggs, and swim about until ingested by crustaceans.The second larval stage is completed in the crustacean with the development of the procercoid.

Life Cycle then moves to fish: infected crustaceans are the ingested by small freshwater fish. The procercoid larva are then released from the crustacean into the fish. The larvae continue to develop in the flesh of the fish, developing into the plerocercoid stage, which is the infective stage for humans.

If humans ingest this fish, they will become infected. However, the fish ingesting an infected crustacean is small and usually not prey for any mammals. Thus, a larger predator fish ingests the smaller infected fish. The plerocercoid may infect the larger fish, but will not continue to grow as the fish is only a transport host.

Life Cycle completes itself in Human or other suitable Mammal: Human (or other mammal) ingests raw or undercooked infected fish. Plerocerciod larva is not digested, but instead remains in the small intestine of its new host and grows to adulthood. Proglottids release immature eggs, completing the cycle.

Pathogenic effect of *Diphyllobothrium latum* is toxi-allergic and mechanical (breach of the integrity of the intestine walls by bothria of the broad tapeworm, intestinal obstruction and cholangitis caused by migrating proglottids may occur), absorption of vitamins and food digested by the host.

Clinical features. Manifestations are gastrointestinal disturbances, acute abdominal pain. *Diphyllobothrium latum* absorbs large quantities of vitamin B_{12} and interferes with its absorbtion through the intestinal mucosa leading to anemia.

Laboratory diagnosis is based on detection of eggs and Gravid (pregnant) segments in faeces. The characteristic of eggs: The egg is ovoid, with an operculum at one end and a knob at the other, it has a single covering (fig. 39). The membrane covering the embryo (which is formed outside) has a ciliated epithelium. The embryo is called coracidium. The size of egg is 58-76 mm in length and 40-51 in diameter.

Gravid (pregnant) segments are greater in width than in length and are filled with male and female reproductive organs. Later the gravid segments break off from the body, not singly but in chains, and are passed in the host's faeces. The uterus is large and remains coiled in the centre of each segment in the form of a rosette.

Preventive measures. Personal prevention: do not to eat poorly thermally treated or unsalted fish and caviar. Public prevention is revealing and treatment of sick people, prevention of water pollution by eggs of fish tapeworm, fish examination, sanitary-educational work.

Round Worms Phylum (*Nemathelmintes*)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Nemathelmintes*

Class *Nematoda*

Round worms live in different habitats: in soil, fresh and sea water. A lot of them lead a parasitic way of life. The phylum is divided into four classes. The *Nematodae* Class (nematode, hookworms) is medically important, these worms cause illnesses that are called nematodiasis.

The distinguishing features. *Nemathelminthes* are bilaterally symmetrical. They develop from three germinal (embryonic) layers (ectoderm, endoderm and mesoderm).They have a body of elongated, cylindrical, unsegmented shape, round in cross-section.

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue is cuticle (it protects from chemical and physical influence and serves as a skeleton), under which there is epidermal syncytium; epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles (fig. 56, 57). Epidermal syncytium performs metabolic and barrier functions.

They have primary body cavity – a pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is represented by nervous trunk type. It consists of nervous ring and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands with canals opening into a pore behind the oral hole. Their canals pass into lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus.

Round worms are dioecious animals. Sexual system is of tubular structure. The Female sexual system consists of paired convoluted tubes. Each part of the tube is differentiated into one pair ovaries, oviducts, uterus and common vagina. The Male sexual system consists of a long convoluted tube which can be differentiated into testis, sperm duct and Vas Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent.

In round worms the character of sexual dimorphism is rather pronounced: females are larger than males, back end of males is curved to abdominal side.

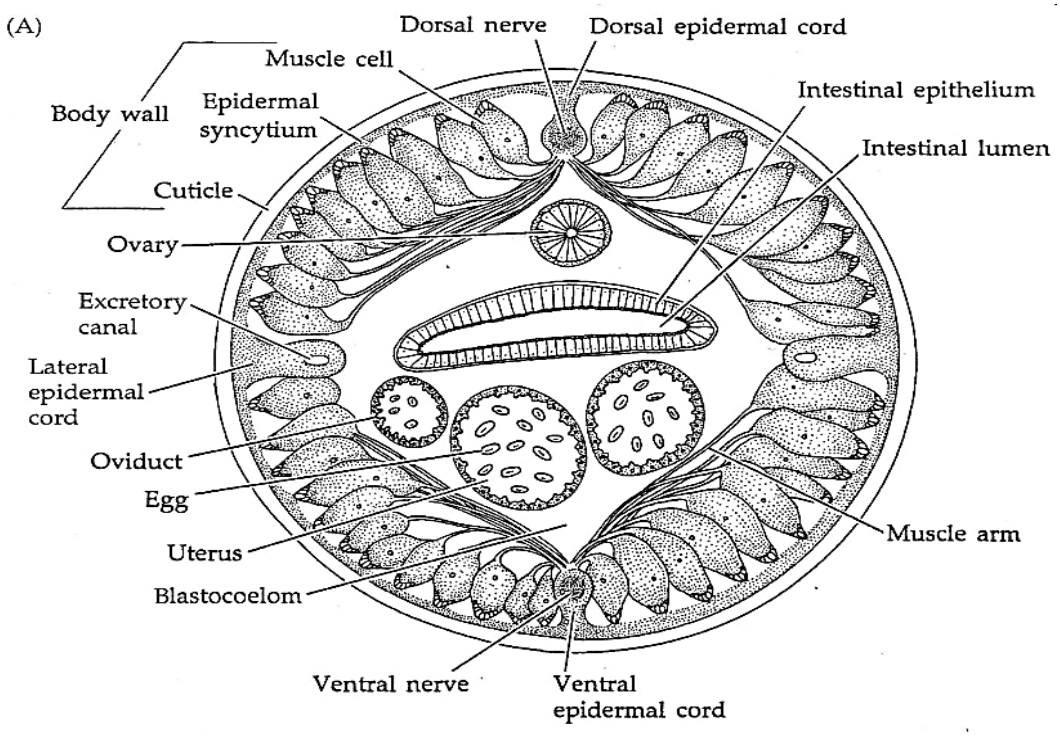


Figure 56. The structure of *Nematoda* (https://commons.wikivet.net/images/thumb/d/dc/Female_nematode_xsection.jpg/200px-Female_nematode_xsection.jpg)

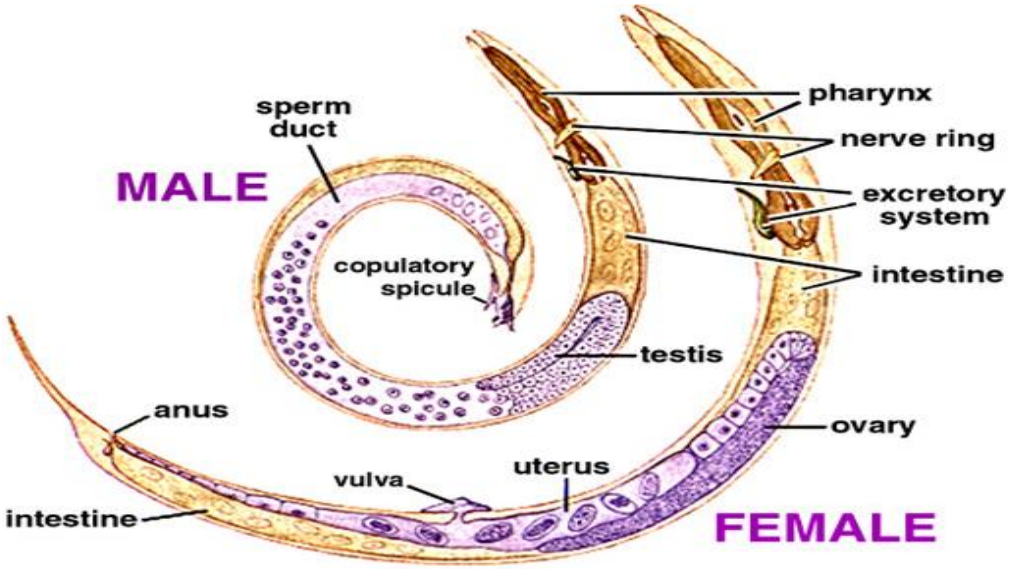


Figure 57. The structure of *Nematoda* (https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcQC3QJdM0FHEtEsMaCH45hPw--NWXAAMc8DoFSOs0VzVHNRIvtKVg)

There are two kinds of helminthes:

- geohelminths (fig. 58) are parasitic worms, one stage of their development is spent in soil and biohelminths are parasitic worms, whose cycle of development is spent in living organisms. The majority of *Nematoda* are geohelminths. Geohelminths are *Ascaris lumbricoides*, pinworm or oxyurid (*Enterobius vermicularis*), whipworm (*Trichocephalus trichiurus*), hookworm (*Ancilostoma duodenale, Necator americanus*). Only infected people serve as the sources of invasion;

- biohelminths include trichina worm (*Trichinella spiralis*), guinea worm (*Dracunculus medinensis)*, Bancroft's filaria (*Wuchereria bancrofti*). All the representatives are viviparous.

Dehelminthization is the complex of measures in treating a patient with helminthiasis. **Devastation** is the complex of measures on eliminating helminths as a zoological species. Devastation includes treating a patient and elimination of invasive material from the environment.

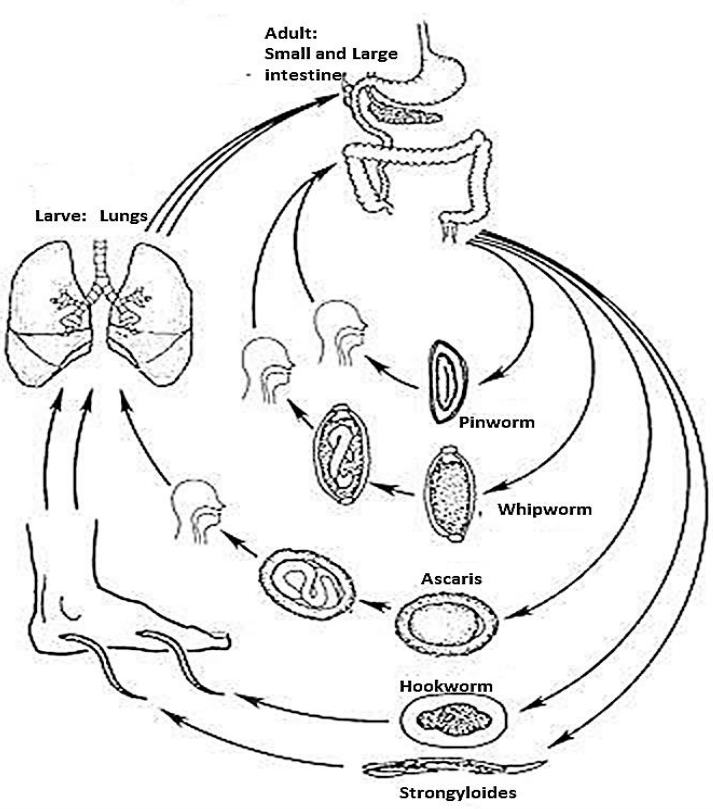


Figure 58. Life cycle of Round worms-geohelminths
(https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcTr8OxCgB2U2pf0lEZ97jxPHcihAogWIFe7EMhbjeFnoF2NNahQ8w)

Round Worms – geohelminths

Ascaris lumbricoides

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Nemathelmintes*

Class *Nematoda*

Species *Ascaris lumbricoides*

Ascaris lumbricoides causes ascariasis (geohelminthiasis).

Geographical Distribution. Ascariasis is distributed worldwide.

Adult Worm. *Ascaris lumbricoides* is the largest intestinal nematode parasitizing in human (fig. 59). They have a body of elongated, cylindrical shape with tapers at both ends, unsegmented, round in cross-section. Adult male's size is 15 to 20 cm in length. Their posterior (back) end is curved to abdominal side. Adult female's size is 20 to 40 cm in length.

Their posterior end is straight and conical. The mouth opens at the anterior (front) end and is surrounded by three finely toothed lips, one dorsal and two ventral (fig. 60). The mouth opens at the anterior end and possesses three finely toothed lips, one dorsal and two ventral.

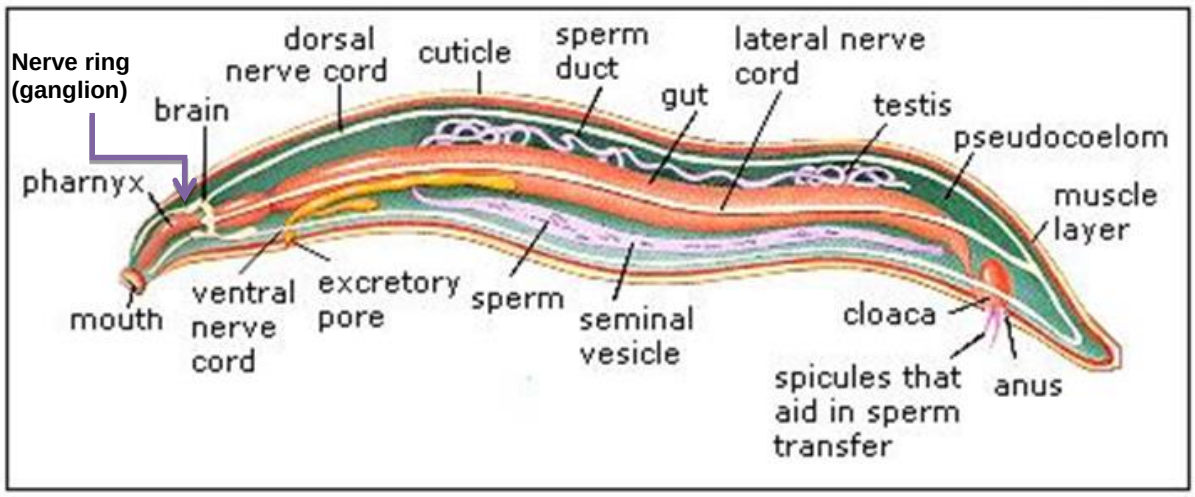


Figure 59. The structure of *Ascaris lumbricoides*
(https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcSalPaH8HWVB5cHimtpBNcSz2J2j6pWQ4AvKr9sTsQI0bu_z70w-g)

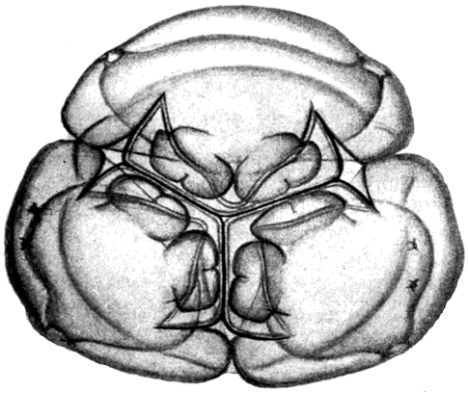


Figure 60. Lips of *Ascaris lumbricoides*.

The digestive and reproductive organs float inside the body cavity containing an irritating fluid. The life span of the adult worm in the human host is less than a year.

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue called cuticle performing protective function, under which there is epidermal syncytium; epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles. Epidermal syncytium performs metabolic and barrier functions.

Primary body cavity is a pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is of nervous trunk type. It consists of nervous ring and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands with canals, which open into a pore behind the oral hole. Their canals pass into lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus.

Ascaris lumbricoides is dioecious animal. Sexual system is of tubular structure. The Female sexual system consists of the paired convoluted tubes. Each part of the tube is differentiated into one pair ovaries, oviducts, uterus and common vagina. The Male sexual system consists of a long convoluted tube which

can be differentiated into testis, sperm duct and Vas Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent.

Life Cycle. *Ascaris lumbricoides* is geohelminth. Its life cycle is migrative. The worm passes its life cycle in one host and no intermediate host is required. Species existence is provided by human-to-human transmission. Definitive host of *Ascaris lumbricoides* is human.

Stages of life cycle in humans are:

- stage 1 – Eggs in Faeces. Fertilized eggs are passed out with the faeces. They are not infective to human when freshly passed;
- stage 2 – Development in Soil. A larva develops inside the egg during 2 to 3 weeks, depending on temperature and humidity of the atmosphere. This takes place in soil (that is outside the human host). The conditions for egg maturation in external medium are: temperature 26-28 °C, humidity more than 50%, oxygen. The ripe egg containing the coiled-up embryo is infective to human;
- stage 3 – Infection by Ingestion and Liberation of Larvae. When ingested with food, drink or raw vegetables, the embryonated egg passes down to the duodenum where the digestive juices weaken the egg-shell and in small intestine larvae hatch out;
- stage 4 – Migration through the Lungs. The larvae released in the small intestine do not directly develop into mature worms. These motile worms penetrate mucosa to enter the portal circulation and reach liver. After 3-4 days in liver, the larvae enter systemic circulation to heart and lungs. After 10 to 15 days of development in lungs, larvae penetrate through the capillaries and enter alveoli. From here the larvae ascend the bronchial tree, trachea, larynx and pharynx. Larvae then crawl over the epiglottis and are swallowed;
- stage 5 – Re-entry into the Stomach and the Small Intestine. The larvae pass down the esophagus to the stomach and localize in the upper part of the small intestine;
- stage 6 – Sexual Maturity and egg Liberation. They finally reach small intestine and grow into adult worms in 6 to 10 weeks. After that female worms lay fertilized eggs. Eggs embryonate in soil to repeat the life cycle.

The mechanism of human infection. The way of penetration is alimentary way. Factors of invasion are food products, hands, water, contaminated with eggs. The invasional stage for human is egg with a larva.

Clinical features. There are two clinical forms of the disease: pneumonia that caused by larva; abdominal form (is caused by puberal form).

The migrating larvae produce symptoms and signs related mainly to the lungs. Patients develop non-productive cough and typical symptoms of pneumonia. These features are the result of larvae penetrating alveoli. The adult worm may cause toxic, allergic, intestinal obstruction (verminous ileus), especially in children. Single worm may migrate into aberrant sites to produce serious manifestations.

With massive infection some larvae may reach the general circulation to be filtered out in various organs and tissues. When they happen to lodge in such aberrant sites as kidneys, brain, spinal cord and other organs, they are unable to grow to maturity and perhaps most of them are destroyed. In a heavy infection the larvae may even be excreted in the urine.

Laboratory diagnosis. Intestinal ascariasis is diagnosed by detection of characteristic eggs in faeces (material for laboratory diagnosis). Eggs are round oval with three coats: tuberous (external), lustrous (middle) and fibrous (internal) and are 50 μm × 40 μm in size.

Prevention measures. Personal prevention consists of personal hygiene (to wash hands, vegetables, fruits, greens). Public prevention includes dehelmintization of sick people, desinfection of faeces, struggle against mechanical eggs carriers (flies, cockroaches).

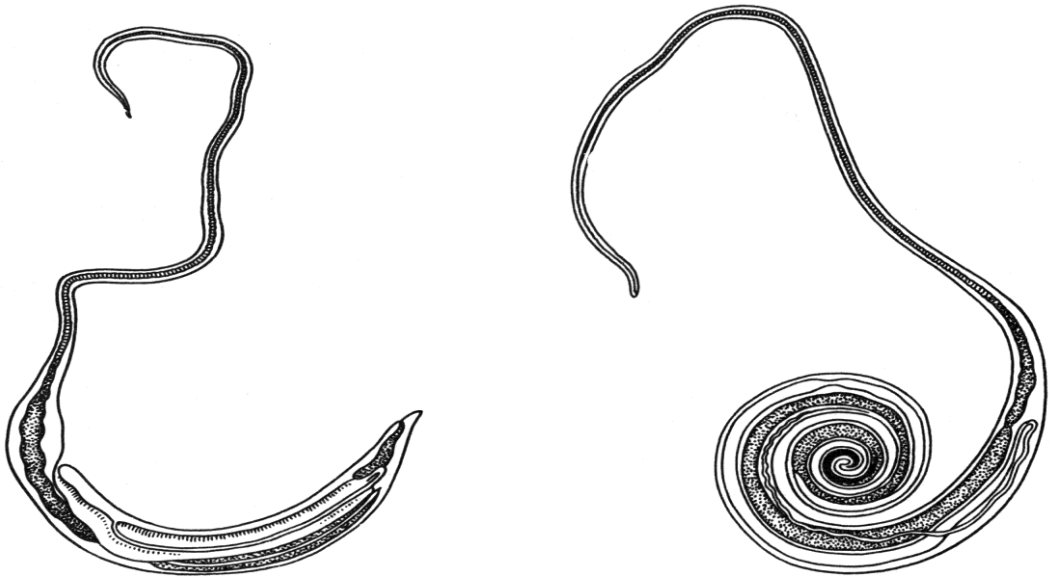
Whipworm (*Trichocephalus trichiurus*)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Nemathelmintes*
Class *Nematoda*
Species *Trichocephalus trichiurus*

Geographical Distribution. *Trichocephalus trichiurus* is a cause of trichocephaliasis (geohelminthiasis). Trichocephaliasis is distributed worldwide.

Morphology of adult worm. Whipworm is a grey thread-like nematode. Its front end is elongated, back part is thickened, alimentary canal stretches along a thin front end and it becomes intestine in a widened part of the body. A male is 30-40 mm long. Their posterior (back) end curves to abdominal side. A female is 40-50 mm long. Their posterior end is straight and conical (fig. 61).



Female Male

Figure 61. *Trichocephalus trichiurus*

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue named cuticle (it protects from chemical and physical influence and serves as a skeleton), under which there is epidermal syncytium; epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles. Epidermal syncytium performs metabolic and barrier functions.

They have primary body cavity - pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is of nerve trunk type. It consists of nervous ring and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands, with outgoing canals which open into a pore behind the oral hole. Their canals pass in lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus.

Trichocephalus trichiurus is dioecious animal. Sexual system is of tubular structure. The Female sexual system consists of paired convoluted tubes. Each part of the tube is differentiated into one pair ovaries, oviducts, uterus and com-

mon vagina. The Male sexual system consists of a long convoluted tube which can be differentiated into testis, sperm duct and Vas Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent.

Life cycle. *Trichocephalus trichiurus* is geohelmith (fig. 62). It leads a life cycle without migration. It requires only one host (humans). Definitive host of *Trichocephalus trichiurus* is human.

The mechanism of human infection. The way of penetration is alimentary way. Factors of invasion are dirty vegetables, fruit, hands, water, contaminated with eggs. The invasional stage for humans is egg with a larva (embryonated egg). Mature *Trichocephalus trichiurus* live in caecum and appendix of humans.

The eggs hatch in small intestine. Here the released larvae develop into adults. They migrate to blind gut and appendix. The worms then mature sexually. The anterior portion of the adult worms' lies embedded in mucosa while the posterior end projects in the lumen. The fertilized female lays characteristic eggs that pass along with faeces. Eggs mature in soil to become infective to a new host. The conditions for egg maturation in external environment are temperature 26-28 °C, humidity more than 50%, oxygen and time for maturation 3-4 weeks.

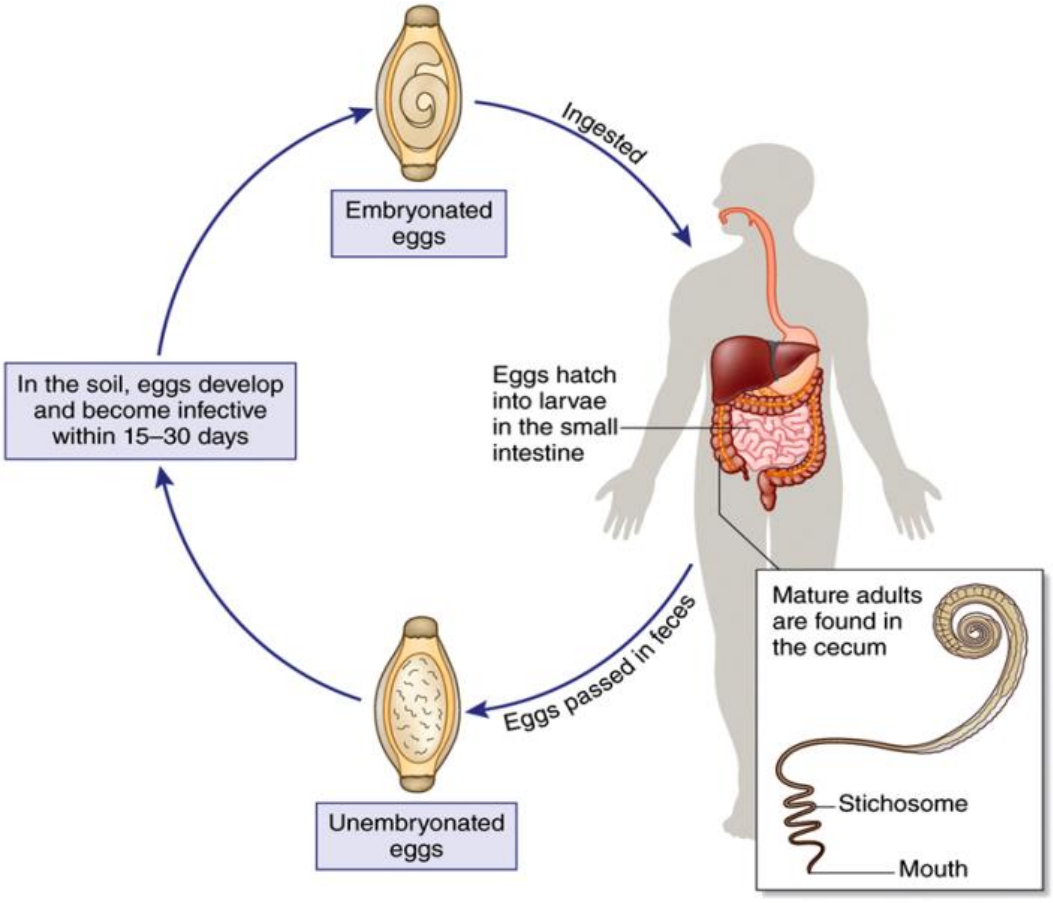


Figure 62. Life cycle of *Trichocephalus trichiurus*
(http://www.nature.com/ng/journal/v46/n7/images/ng.3018-F1.jpg)

Pathogenic effect and Clinical features. Heavy infections may result in abdominal pain, bloody or mucoid diarrhea. *Trichocephalus trichiurus* infection can contribute to anemia, malnutrition and growth retardation. Massive infection in children can lead to disorder of alimentary and nervous systems, epileptiform attacks. Rarely appendicitis may occur.

Laboratory diagnostics. The material for laboratory diagnosis are faeces. The eggs in faeces are of lemon form (barrel shaped) with corks on the poles and size of 50 μm × 22 μm. The eggs are brown (bile-stained).

Prevention measures. Personal prevention consists of personal hygiene (to wash hands, vegetables, fruits, greens). Public prevention includes dehelminthization of sick people, desinfection of faeces, struggle against mechanical eggs carriers (flies, cockroaches). Social preventive measures are health care education.

Pinworm, or oxyurid (*Enterobius vermicularis*)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Nemathelmintes*

Class *Nematoda*

Spacies *Enterobius vermicularis* (threadworm, pinworm, seatworm).

Geographical Distribution. *Enterobius vermicularis* causes enterobiasis (contact helminthiasis). Enterobiasis is spread everywhere. *Enterobius vermicularis* can often be found in kids' groups.

Morphology of adult worm. *Enterobius vermicularis* has a body of elongated, cylindrical form with tapers at both ends, unsegmented, round in cross-section. There are wing-like expansions at the anterior end of the worm called cervical alae (vesicula). It is small and white in color (fig. 63).

A Male is 2-5 mm long. Their posterior end is curved to abdominal side. It usually dies after fertilizing the female.

A Female is 8 to 13 mm long. An adult female has a sharply pointed posterior end. Egg filled-uterus occupies the entire body. A female is an oviparous worm. A gravid female dies within 2 to 3 weeksnafter oviposition.

The infection of a human takes place on swallowing the eggs.

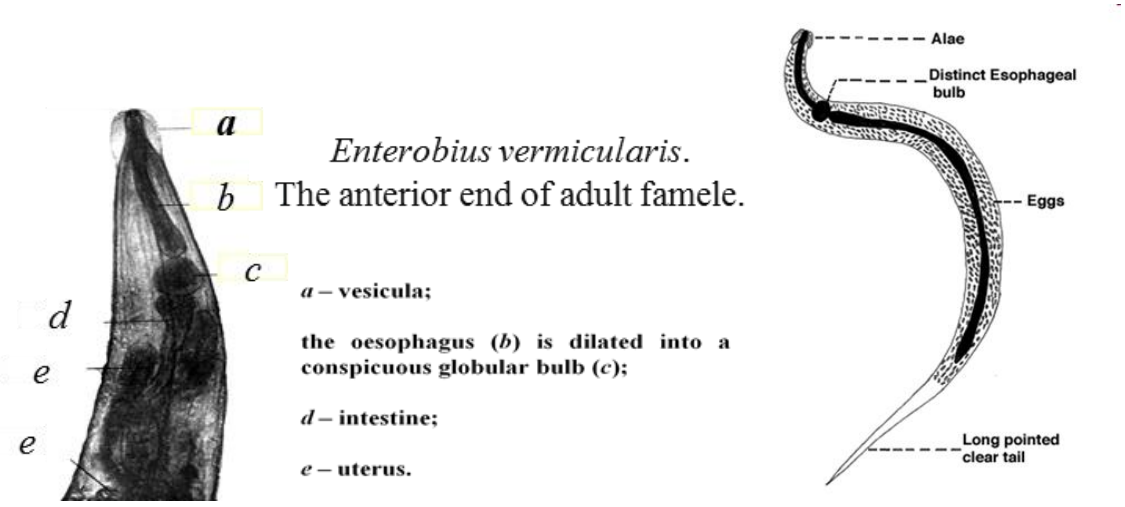


Figure 63. The structure of *Enterobius vermicularis*
(http://fce-study.netdna-ssl.com/images/upload-flashcards/back/0/9/38690482_m.jpg)

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue - cuticle (it protects from chemical and physical influence and serves as a skeleton), under which there is epidermal syncytium; epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles. Epidermal syncytium performs metabolic and barrier functions.

They have primary body cavity - a pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is of nerve trunk type. It consist of nervous ring and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands, leading away the canals which open into a pore behind the oral hole. Their canals pass in lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus. Double-bulled esophagus (bulb) is a characteristic feature of pinworm.

Enterobius vermicularis is dioecious animal. Sexual system is of tubular structure. The Female sexual system consists of paired convoluted tubes. Each part of the tube is differentiated into one pair ovaries, oviducts, uterus and com-

mon vagina. The Male sexual system consists of a long convoluted tube which can be differentiated into testis, sperm duct and Vas Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent.

Life Cycle. *Enterobius vermicularis* is geohelmith. It has a simple life cycle without migration. It requires only one host (humans) to complete its life cycle. No intermediate host is required. Enterobiasis is contact helminthiasis (fig. 64).

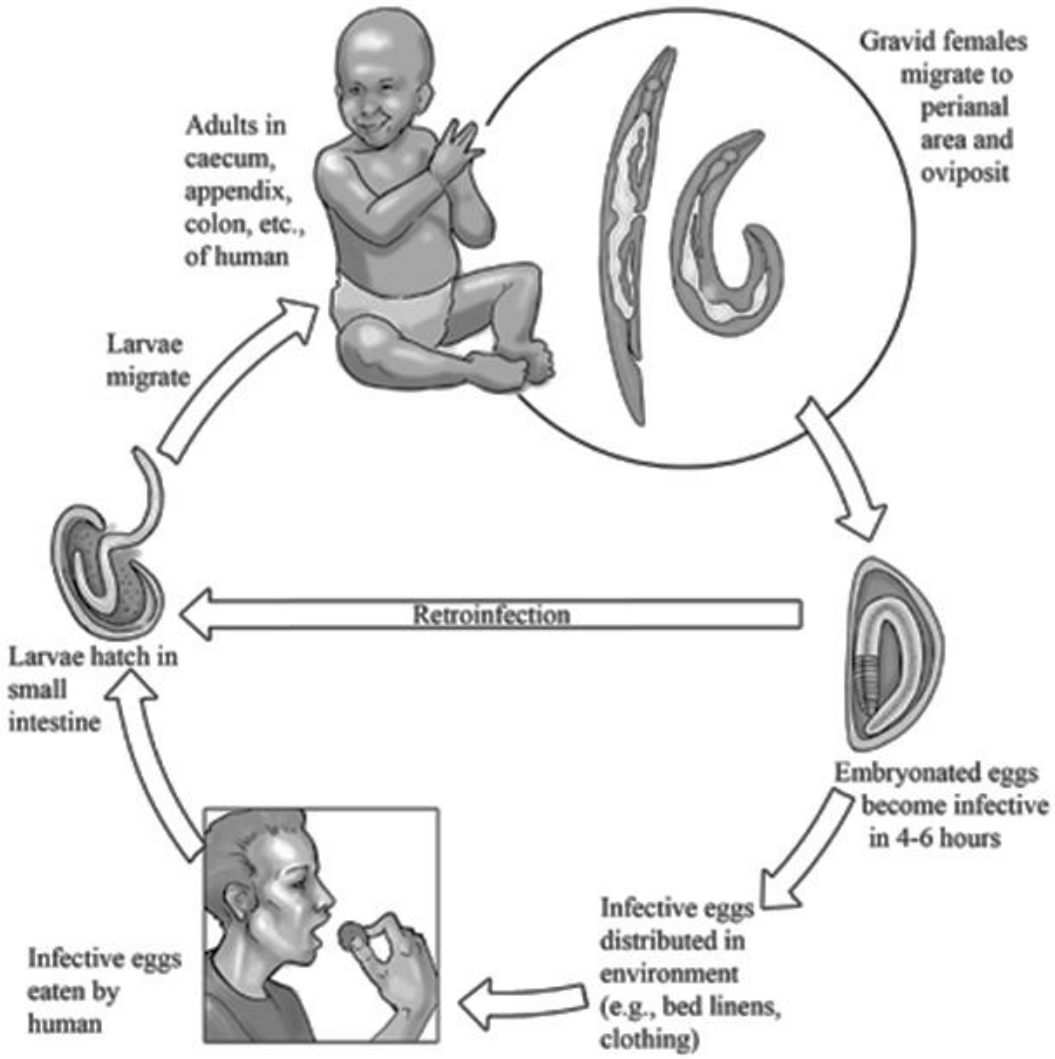


Figure 64. Life cycle of *Enterobius vermicularis*
(https://s-media-cache-ak0.pinimg.com/originals/
9d/4e/4b/9d4e4b553a4c852178662ca9e550db47.jpg)

The mechanism of human infection. The invasional stage for humans is egg with a larva. The way of penetration is alimentary way. Factors of invasion are dirty hands or clothes contaminated with eggs. Adult worm live in caecum, appendix and adjacent parts of ascending colon.

The larvae develop into mature worms in large intestine and live there. The male worm fertilizes the female worm and dies. The gravid female worm migrates out of the anus and lays up immature eggs on perianal skin. The worm generally lays eggs at night. The larvae in the eggs develop in 6 hours. Such mature eggs are infective (invasional stage). Conditions necessary for eggs maturation: temperature 34 to 36 °C; humidity 70% to 90%; oxygen, time of maturation 4 to 6 hours.

Enterobius vermicularis eggs can reinfect the same host; autoinvasion occurs by hand-to-mouth passage. The eggs laid on the perianal skin contaminate, night clothes or during bed making, the infection be transmitted.

Pathogenic effect and Clinical features. Perianal itching (pruritus) is a characteristic feature of enterobiasis. This itching is due to eggs-laying activity of the worm. Itching is worse at night. Excoriation and bacterial super infection may occur at the site, nocturnal enuresis may occur. Pinworms may rarely invade female genital tract, causing vulvo-vaginitis, this worm may also cause appendicitis.

Thus, the main symptoms of enterobiasis are toxic effect, allergic reactions, itching, loss of appetite, diarrhea, sleep disorder, inflammatory processes in vulva.

Laboratory diagnostics. Diagnosis is established by detection of eggs in scraping from perianal folds. Adult worms can be detected in faeces. But perianal swab method is better (the material for laboratory diagnosis is scraping from perianal folds). General characteristics of the egg: colorless, asymmetrical in shape, 50 to 20 mm in length, surrounded by colorless cover.

Prevention measures. Personal preventive measure is to follow personal hygiene rules, especially by children: keeping hands, body, linen, room clean. Public preventive measures include cleanup, separation of ill and healthy children, systematic ovohelminthoscopic control in children's institutions, dehelminthization, regular humid cleaning in public places, sanitary-instructive work.

Hookworms

Two species of hookworms infect humans: *Ancylostoma duodenale* and *Necator americanus.*

Ancylostoma duodenale

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

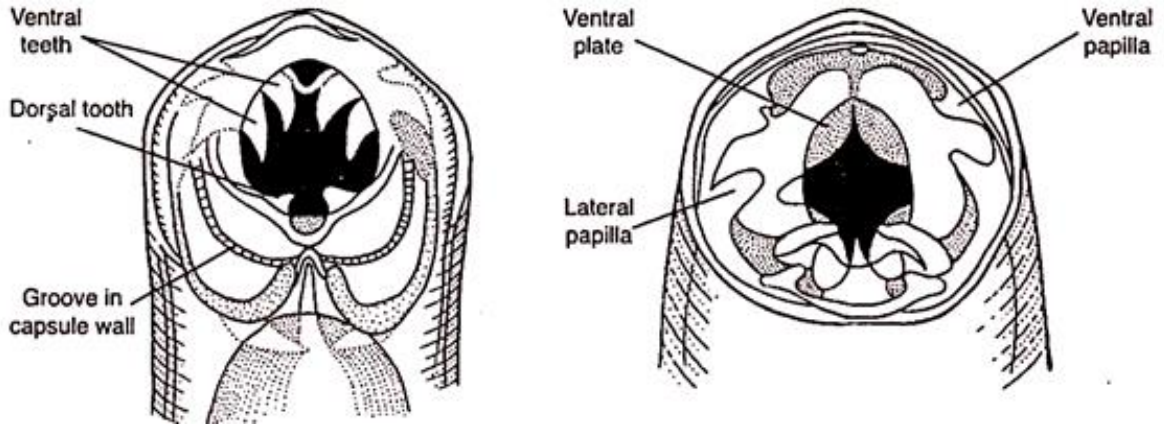
Phylum *Nemathelmintes*

Class *Nematoda*

Species *Ancylostoma duodenale* (The Old World hookwoorm).

Geographical Distribution. *Ancylostoma duodenale* causes ancylostomiasis or hookworm disease. Ancylostomiasis is widely distributed in all tropical and subtropical countries, occurring in places wherever humidity and temperature are favorable for the development of larvae in the soil. It is found in Europe, North Africa (specially prevalent in, Egypt), India (Punjab and Uttar Pradesh), Sri Lanka, Central and North China, Pacific Islands and Southern States of America.

Morphology of adult worm. *Ancylostoma duodenale* exists in two forms: adult and larval. The sizes of female is 10-13 мм, the size of male is 8-10 mm. It is small, greyish white, cylindrical worm. When freshly passed, the worm is a reddish brown color due to the ingested blood in its intestinal tract. The anterior end of the worm is bent slightly dorsally, hence the name is hookworm. This bend is in the same direction as the general body curvature. The oral aperture is not terminal but directed towards the dorsal surface. The large buccal capsule is provided with 4 teeth on the dorsal surface (fig. 65). They attach themselves by teeth to the mucous membranes of the intestine, secrete anticoagulant and use blood for food.



A B

Figure 65. *Ancylostoma duodenale* (A) and *Necator americanus* (B) (http://cdn.biologydiscussion.com/wp-content/uploads/2016/11/image-136.png)

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue – cuticle (it protects from chemical and physical influence and serves as a skeleton), under which there is epidermal syncytium; epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles. Epidermal syncytium performs metabolic and barrier functions.

They have primary body cavity – a pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is of nerve trunk type. It consists of nervous ring and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands, leading away canals, which open into a pore behind the oral hole. Their canals pass in lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus. There are five glands connected with the digestive system; one of them, called the esophageal gland, secretes a ferment which prevents blood clotting.

Ancylostoma duodenale is dioecious animal. Sexual system is of tubular structure. The Female sexual system consists of paired convoluted tubes. Each part of the tube is differentiated into one pair ovaries, oviducts, uterus and common vagina. The Male sexual system consists of a long convoluted tube which can be differentiated into testis, sperm duct and Vas Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent.

Life cycle. *Ancylostoma duodenale* is geohelminth and has a life cycle with migration (fig. 66, 67). It requires only one host (humans). Freshly passed eggs are not infective to humans. Further development of eggs occurs in soil. Rhabditiform larvae hatch out. Rhabditiform larvae moult twice to develop into infective filariform larvae to complete the life cycle. The time needed for the development of filariform larvae is 8 to 10 days.

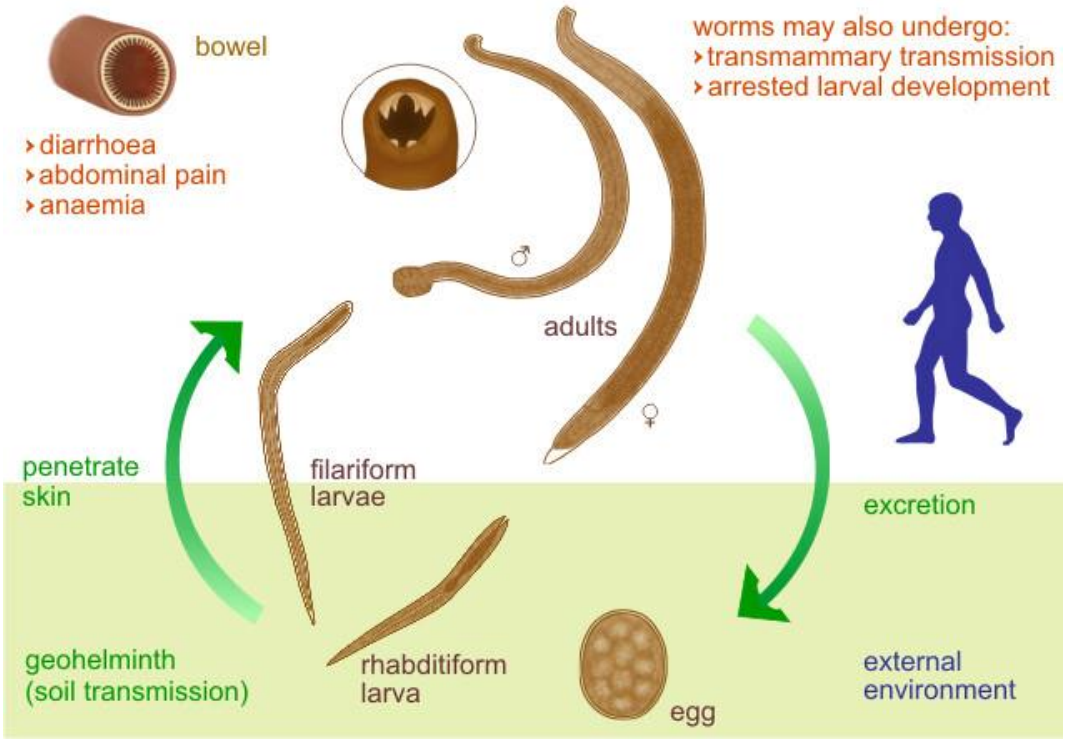


Figure 66. Life cycle of *Ancylostoma duodenale*
(http://parasite.org.au/para-site/images/ancylostoma-mode.jpg)

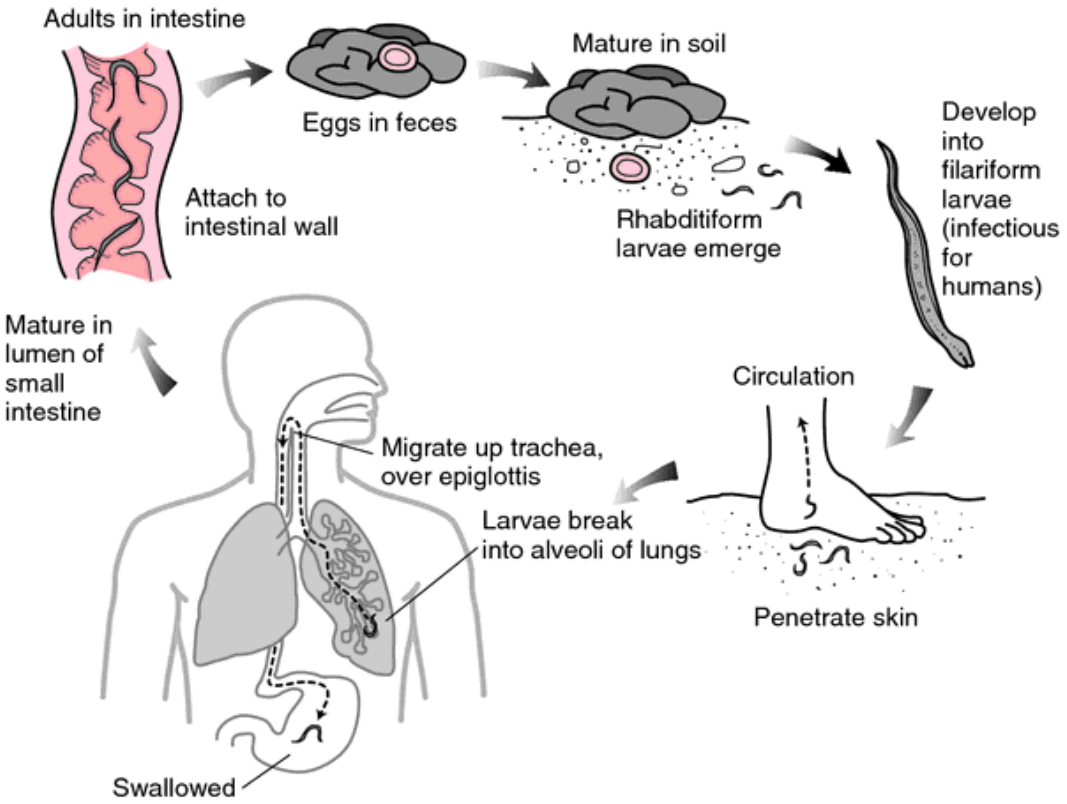


Figure 67. Life cycle of Hookworms
(http://img2.tfd.com/mk/H/X2604-H-38.png)

The mechanism of human infection. The invasional stage for humans is the filariform larvae. There are two ways of penetration:

- percutaneous way (active invasion through the skin). Larvae infect humans by penetrating the skin. They invade the blood stream to heart and reach the lungs. In the lungs they penetrate through the capillaries to reach alveoli. From here the larvae ascend the bronchial tree, trachea, larynx, and pharynx. The larvae then crawl over the epiglottis and are swallowed with saliva. On reaching small intestine they attach to the mucosa and grow into adults during 3-4 weeks;
- alimentary way. Larvae that got into human body through the mouth don't migrate. They localize in the duodenum and there they become mature in 4-5 weeks. This way is met seldom.

Ancylostoma duodenale worms live in small intestine of human.

Pathogenic effect and Clinical features. Symptomatic hookworm infections are due to either larvae or adults. Larvae produce pruritic maculopapular dermatitis (ground itch) at the site of skin penetration. Larvae migrating through the lungs can produce a mild pneumonitis.

Adult hookworms produce epigastric pain, diarrhea and vomiting during early phase of infection. The most important manifestation of hookworm infection is hypochromic anemia. An adult worm sucks blood. A single adult *Ancylostoma duodenale* sucks 0,2 ml blood a day.

Laboratory diagnostics. The material for laboratory diagnosis are faeces. The diagnosis is established by finding the characteristic eggs in the faeces. The eggs are oval and measure 60 × 40 mm. They are colorless with a thin transparent hyaline shell membrane.

Prevention measures. Personal prevention – adequate footwear and gloves provide physical barriers to the entry of larvae through feet and hands respectively (to wear boots, not to lie on the ground). Not to drink unboiled water. Public prevention – prevention of soil pollution with human faeces (night soil) is important in control of hookworm infection, dehelminthization of population, sanitary control of soil, sanitary-instructive work. Treatment of persons infected with hookworms limits the source of infection. These preventive measures are particularly important for farm workers.

***Necator americanus* (The American hookworm or the New World hookworm).**

Geographical Distribution. Necotoriasis is the most common species in Sri Lanka and India (except in Punjab and Uttar Pradesh). Although first discovered in America, it is more likely of African origin. From its original focus (Tropical and South Africa), it has spread to India, Far East, Australia and America.

The life cycle, general morphology, pathogenicity, diagnosis and treatment are the same as described for *Ancylostoma duodenale*.

Peculiarities of structure. The mouth of *Necator americanus* has cutting plates (fig. 65). The back end of the body has copulative bursa.

Round worms – biohelminths

The trichina worm (*Trichinella spiralis*)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Nemathelmintes*

Class *Nematoda*

Species *Trichinella spiralis* (The trichina worm)

Trichinella spiralis causes trichineliasis. Trichiniasis is biohelminthiasis.

Geographical Distribution. *Trichinella spiralis* is widely found in variety of carnivorous and omnivorous animals. It's common in Europe and United States. Also reported from some parts of Africa, China and Syria. Natural infection with this helminth has not yet been reported from India (So far three reports are available where trichina larvae were found from animals in India).

Morphology of adult worm. *Trichinella spiralis* exists in two forms: adult and larvae. Adult worms have reddish-color, spindle-shaped (fusiform) body; females 4 mm in length, males 1,5 mm in length.

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue – cuticle (it protects from chemical and physical influence and serves as a skeleton), under which there is epidermal syncytium; epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles. Epidermal syncytium performs metabolic and barrier functions.

They have primary body cavity – a pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is of nerve trunk type. It consists of nervous ring and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands, leading away canals which open into a pore behind the oral hole. Their canals pass in lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus.

Trichinella spiralis is dioecious animal. Sexual system is of tubular structure. The Female sexual system consists of a long convoluted tube. Each part of the tube is differentiated into one ovary, oviduct, uterus and vagina. *Trichinella spiralis* females are viviparous. The Male sexual system consists of a long convoluted tube which can be differentiated into testis, sperm duct and Vas Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent.

Life cycle. *Trichinella spiralis* is biohelminth, it has life cycle with migration (fig. 68). The natural life cycle of *Trichinella spiralis* takes place in pigs and rodents. In the wild, the life cycle is maintained in carnivorous animals. Humans are accidental hosts. Both the adult and larvae forms occur in the same host.

Humans are definitive (final) and intermediate hosts. Natural reservoirs are wild carnivorous. They are both intermediate and final hosts. A human is a blind branch. The way of penetration is alimentary way. Factors of invasion are meat (of pig, bear, badger, etc) infected with encysted larvae. Most cases of human trichinosis are caused by ingestion of infected pork.

It starts as an intestinal parasite, remaining buried in the duodenal or jejunal mucosa, where its adult life is passed but its stay there is relatively short. The fertilized female discharges larvae into the circulating blood, which ultimately encyst in the striated muscles of the animal harboring the adult worm, such as the pig, rat or human. Encysted larvae occur in striated muscles. The cysts lie longitudinally along the muscle fibers.

The invasional stage for humans is the encysted larvae.

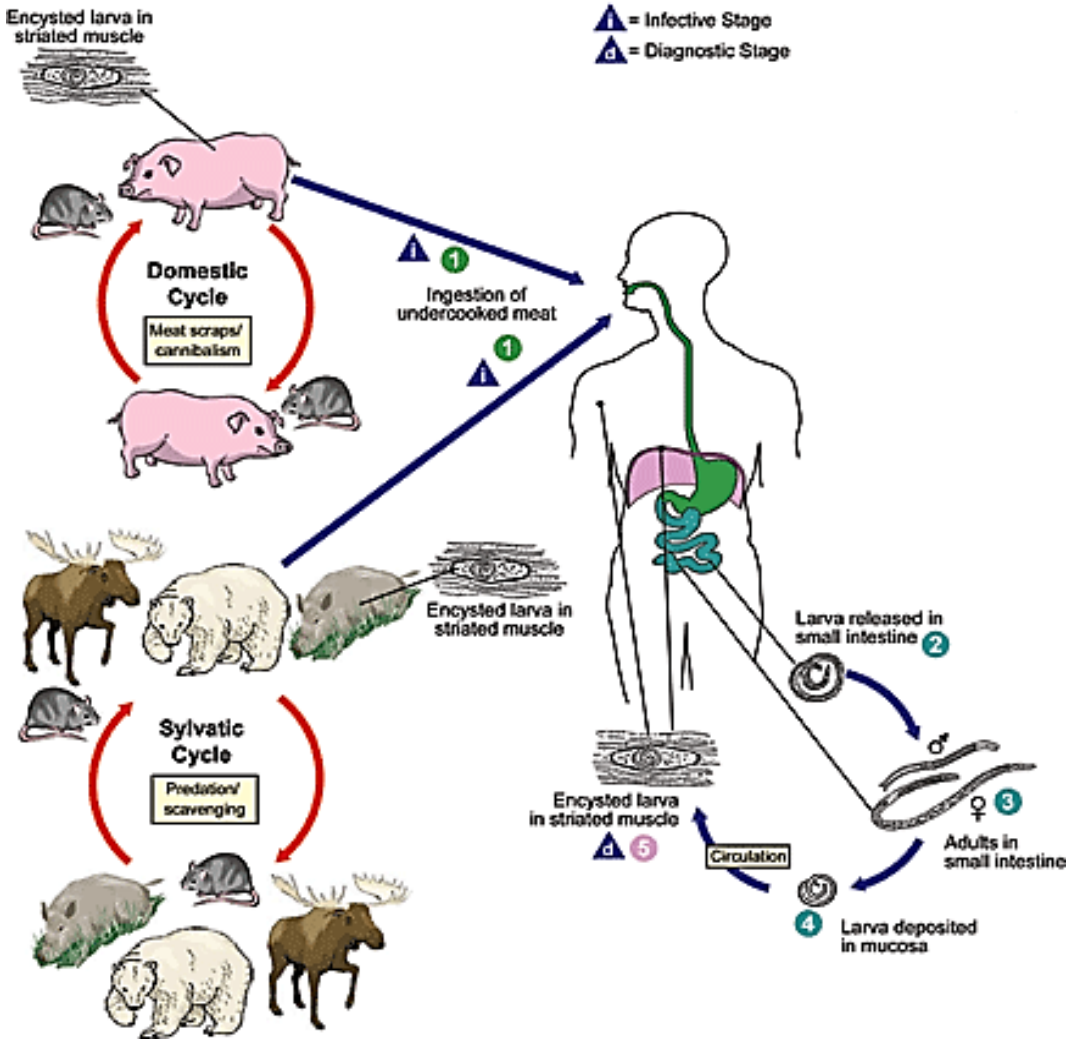


Figure 68. Life cycle of *Trichinella spiralis* (http://1.bp.blogspot.com/-IPWN5Ck2ToY/UPNxOLoGITI /AAAAAAAAAbs/3vnQPdOhmVM/s1600/Trichinella_LifeCycle_2011.jpg)

After ingestion of contaminated pork, the cyst wall of the encysted larvae is digested in small intestine. The larvae mature into adults in 40 hours. The males fertilize the females and die (fig. 69).

The gravid female burrows into the intestinal mucosa to deposit larvae. The larvae find their way to the blood stream to be distributed all over the body.

They encyst preferentially in striated muscles of eye, tongue, mastication muscles, diaphragm, intercostals and finally the muscles of upper and lower extremities. The larvae may live encysted for several years. This is the dead end for the parasite.

Pathogenic effect and Clinical features. Clinical features may arise in three phases: during enteric invasion; larval migration; encystations of larvae.

Manifestation of enteric invasion includes pain in abdomen, nausea, vomiting and diarrhea.During larval migration hyper sensitivity reactions occur. These include fever, eosinophilia, periorbital edema, facial edema, in heavy infections fatal myocarditis, encephalitis or pneumonitis may develop during larval migration. Both these phases occur in first 2 weeks of infection. In the phase of larval encystation the manifestations are myalgias and weakness.

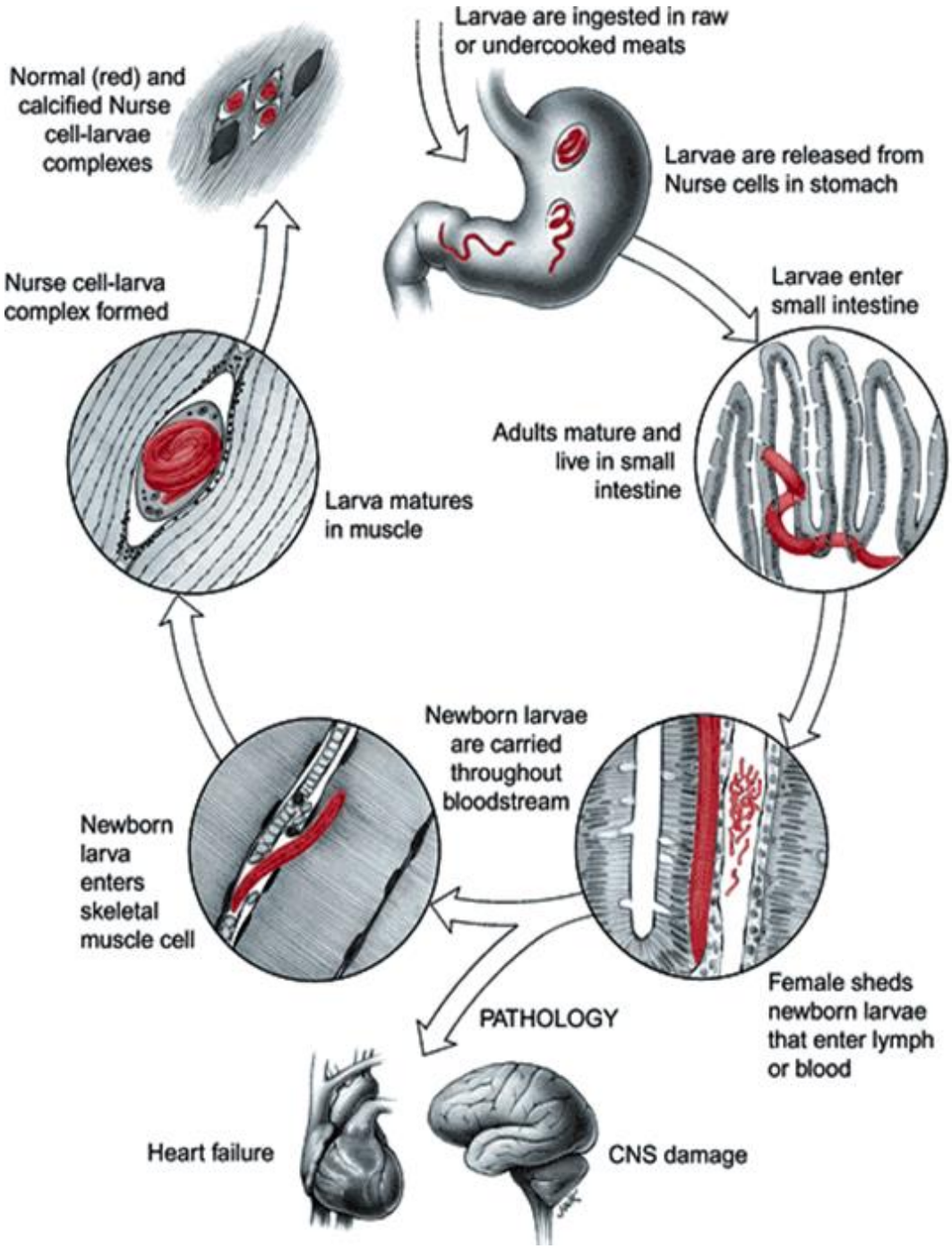


Figure 69. Life cycle of *Trichinella spiralis* in human.
(http://www.trichinella.org/images/biology/lifecycle.gif)

Laboratory diagnostics. Immunologic reactions can be used to detect specific antibodies against *Trichinella spiralis* in acute condition.

In suspected cases of trichinosis definitive diagnosis requires biopsy of involved muscle – revealing spiral larvae in muscles (fig. 70).

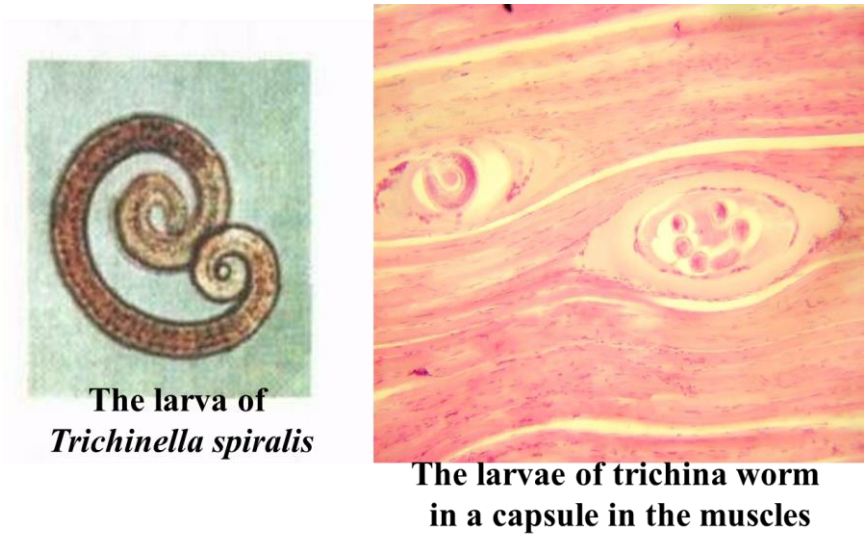


Figure 70. *Trichinella spiralis*

Prevention measures. Personal prevention is not to use meat without sanitary examination. The infected meat of animals should be eliminated. Public prevention includes sanitary-veterinary examination of meat, zoohygienic keeping of pigs, destruction of rats.

Guinea worm (*Dracunculus medinensis*)

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Nemathelmintes*

Class *Nematoda*

Species *Dracunculus medinensis* (Guinea worm, serpent worm or dragon worm, Medina worm).

Dracunculus medinensis causes dracunculiasis.

Geographical Distribution. India, Pakistan (Sind & Lahore), Burma, Saudi Arabia, Iraq, Iran, Turkestan, Africa (East, West and Central), West Indies and South America. In India the parasite is limited to Punjab, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra and South India. It has not yet been found in Bengal, Assam, Bihar and Orissa.

Morphology of adult worm. *Dracunculus medinensis* exists in two forms: adult and larval. The male is much smaller than the female and measures 2 to 4 cm in length. Female is a slender long worm, measuring 70 cm to 120 cm in length, resembling a piece of long twine thread. The body is cylindrical, smooth and milk-white in color. The posterior extremity is tapering and is bent to form a hook. The body fluid is toxic and causes blister if it escapes into the tissues.

Larvae are 5-7 mm long and have a rounded anterior end. The tail is long (one third of the body length) and pointed. Larvae are actively motile.

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue - cuticle (it protects from chemical and physical influence and serves as a skeleton), under which there is epidermal syncytium; epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles. Epidermal syncytium performs metabolic and barrier functions.

They have primary body cavity – a pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is of nerve trunk type. It consists of nervous ring and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands, leading away canals which open into a pore behind the oral hole. Their canals pass in lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus.

Dracunculus medinensis is dioecious animal. Sexual system is of tubular structure. The Female sexual system consists of a long convoluted tube. Each part of the tube is differentiated into one ovary, oviduct, uterus and vagina. *Dracunculus medinensis* females are viviparous and discharges larvae (microfilariae) in successive batches for a period of about 3 weeks until the gravid female completely empties its uterine contents. The Male sexual system consists of a long convoluted tube which can be differentiated into testis, sperm duct and Vas

Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent. A male worm dies after fertilizing a female worm.

Life cycle. The worm passes its life cycle in two hosts: human and copepods cyclops (fig. 71).

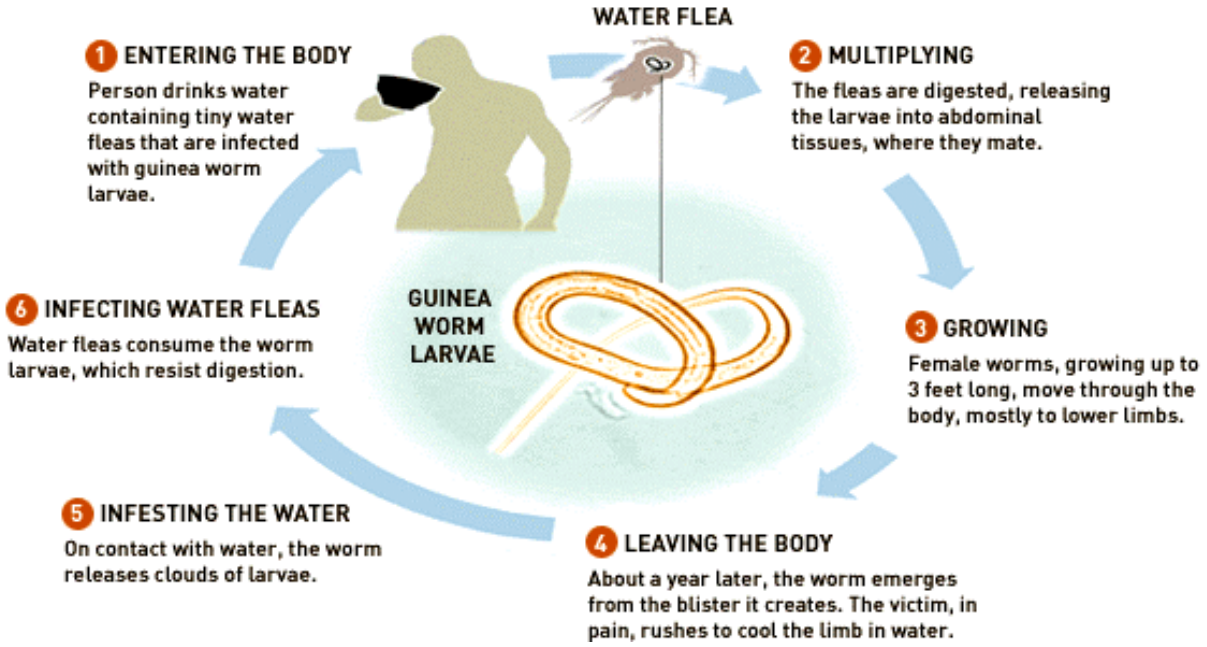


Figure 71. Life cycle of *Dracunculus medinensis* (http://3.bp.blogspot.com/-Sbgb4YqnrV0/UP7Pcaps-_I/AAAAAAAAD2k/S2E075wdXTw/s1600/life-cycle-of-the-guinea-worm.gif)

Definitive Host is Human. Intermediate Hosts are fresh-water lower *Crustacea*ns (Cyclops or water flea), in which the microfilariae (embryos) undergo certain developmental changes before they become infective to human.

The mechanism of human infection. The way of penetration is alimentary way. Factors of invasion is water which is neither boiled nor filtered, that contains the cyclops (water flea) infected with larva (microfilariae). The cyclops containing the infective larvae are swallowed by human with raw drinking water. The invasional stage for humans is the larva (microfilariae). The place for localization in human organism is subcutaneous tissues, especially of the legs, arms and back.

On reaching the stomach the cyclops are digested by the gastric juice and the larvae are released. They then penetrate through the gut-wall and enter the retroperitoneal connective tissues where they grow to sexual maturity. The larvae in human become adult males and females. The males die after fertilizing the females and disappear within 6 months after infection.

A gravid female worm preferably migrates to the subcutaneous tissue of the leg because this part of the body is most likely to meet water. About 10-14 months after infection the uterus of the gravid female fills up with larvae.

The female worm releases certain substances from its anterior, which lead to formation of a blister on the overlying skin. This blister breaks open to leave an ulcer. When the affected part of the infected individual comes in contact with water the worm releases a milky fluid containing a large number of larvae. These actively motile larvae are ingested by Cyclops.

Larvae penetrate the gut wall to reach the body cavity of the Cyclops where they mature to the third infective stage in two weeks. When ingested by a new host such Cyclops complete the life cycle of *Dracunculus medinensis*.

Pathogenic effect and Clinical features. Clinical manifestations of *Dracunculus medinensis* infection appear after a female worm migrates to the subcutaneous tissue of the leg (fig. 72).

These manifestations are allergic and include rash, diarrhea, nausea, dizziness, wheezing and periorbital edema. Later the worm tries to come out through the skin to discharge larvae. It leads to pain, swelling and a blister on the skin overlying the anterior end of the worm.

When the infected leg comes in contact with water the blister breaks open leaving behind a shallow ulcer with a tiny hole in the centre.

Figure 72. An attempt is made to extract the female guinea worm by rolling it round a stick (http://medicine.slovaria.ru/me/drakunkulyoz.jpg)

The individual gets some relief with the break down of the blister. The worm continues to release larvae through this hole every time the leg comes across the water.

Such act of the female worm lasts till the stock of larvae is exhausted. Then the female worm shrivels up and dies. It is soon absorbed in the tissue. The ulcer heals over weeks to months. The ulcer may become secondarily infected and cellulitis, abscess or rarely tetanus may occur.

Laboratory diagnostics. The worm can be detected visually.

The old method of treatment is the gradual extraction of the worm with winding of a few centimeters on a stick every day, over 3-4 weeks. The worm can also be removed surgically.

Prevention measures. Personal prevention is not to drink unboiled and infiltrated water. Public prevention includes guarding places of water intake, prohibition to bathe in water intakes, planning and organization of public services, eliminating cyclops, revealing and treating patients.

***Wuchereria bancrofti* (Bancroft's filaria)**

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Nemathelmintes*
Class *Nematoda*
Species *Wuchereria bancrofti* (Bancroft's filaria).

Geographical Distribution. The parasite is largely confined to the tropics and subtropics, occurring in India, the West Indies, Puerto Rico, Southern China, Japan, Pacific Islands, West and Central Africa and South America. In India, it is distributed chiefly along the sea coast and along the banks of big rivers (except Indus); it has also been reported from Rajasthan, Punjab, Uttar Pradesh and Delhi.

Morphology of Adult Worm. These are long hair-like transparent nematodes (often creamy-white in color). They are filiform in shape and both ends are tapering, the head end terminating in a slightly rounded swelling.

The male measures 2 to 4 cm in length. Its tail-end is curved ventrally and contains two spicules of unequal length (fig. 73). The female measures 8 to 10 cm in length. Its tail-end is narrow and abruptly pointed.

Body wall is a dermato-muscular sac. Their dermato-muscular sac consists of integumentary tissue – cuticle (it protects from chemical and physical influence and serves as a skeleton), under which there is epidermal syncytium.

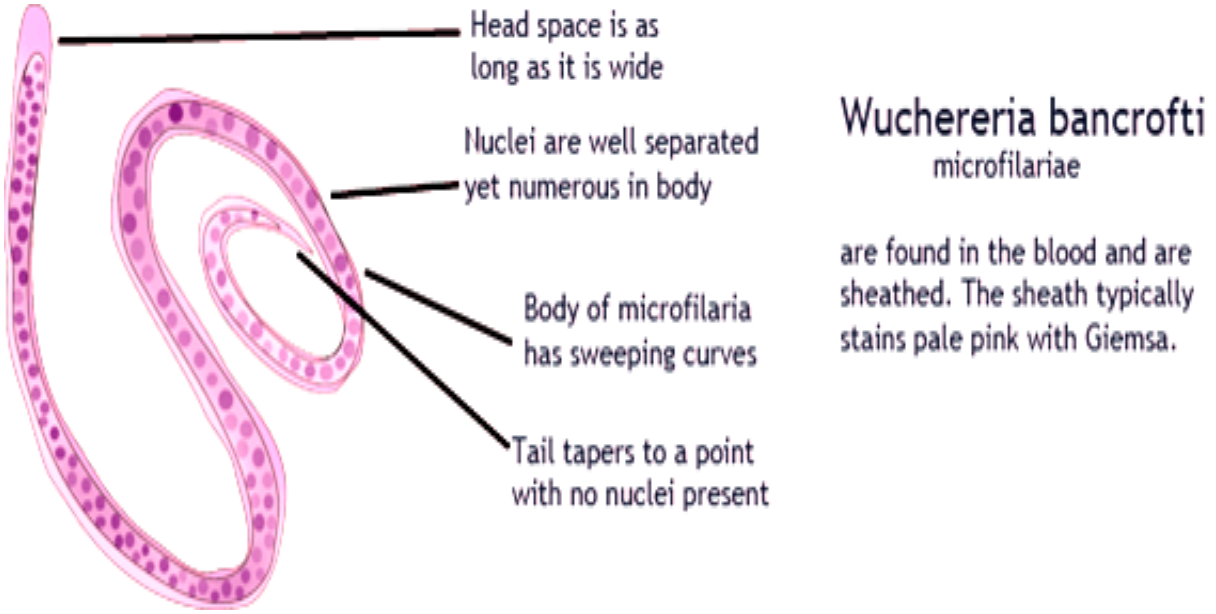


Figure 73. *Wuchereria bancrofti*
(http://parasitologyillustrated.com/images/parasitology%20website%20images/ Nematodes/wuchereria/wuchereria%20bancrofti%20drawing.png)

Epidermal syncytium has four epidermal cords (two lateral epidermal cords, ventral and dorsal epidermal cords) and four swellings of longitudinal smooth muscles. Epidermal syncytium performs metabolic and barrier functions.

They have primary body cavity - a pseudocoelom or blastocoelom, filled with fluid under high pressure which serves as a hydroskeleton.

Blood and respiratory systems are absent, respiratory metabolism is performed through the body surface.

Nervous system is of nerve trunk type. It consist of nervous ring (ganglia) and nervous trunks (4-8 pairs) that are connected by commissures. They are located in dorsal and ventral epidermal cords of epidermal syncytium.

Excretory system is represented by dermal glands, leading away the canals, which open into a pore behind the oral hole. Their canals pass in lateral epidermal cords of epidermal syncytium.

Digestive system (alimentary canal) is complete, it has three parts of the intestine, represented by an anterior (front) intestine (mouth, gullet, esophagus), middle intestine and back intestine, it finishes with anus.

Wuchereria bancrofti is dioecious animal. Sexual system is of tubular structure. The Female sexual system consists of a long convoluted tube. Each part of the tube is differentiated into one ovary, oviduct, uterus and vagina. Wuchereria bancrofti females are viviparous. The Male sexual system consists of a long convoluted tube which can be differentiated into testis, sperm duct and Vas Deferens (ejaculatory duct), that opens into back part of intestine. Cirrus is absent. A male worm dies after fertilizing a female worm.

Life Cycle. *Wuchereria bancrofti* is a biohelminth (fig. 74). It passes its life cycle in two hosts: human and mosquito. Wuchereriasis is transmissible natural focal disease.

Definitive Host is Human. Intermediate Hosts (vector) is a mosquito. A large number of species of mosquito belonging to the genus *Culex*, *Aedes* and *Anopheles* act as intermediate hosts for *Wuchereria bancrofti*.

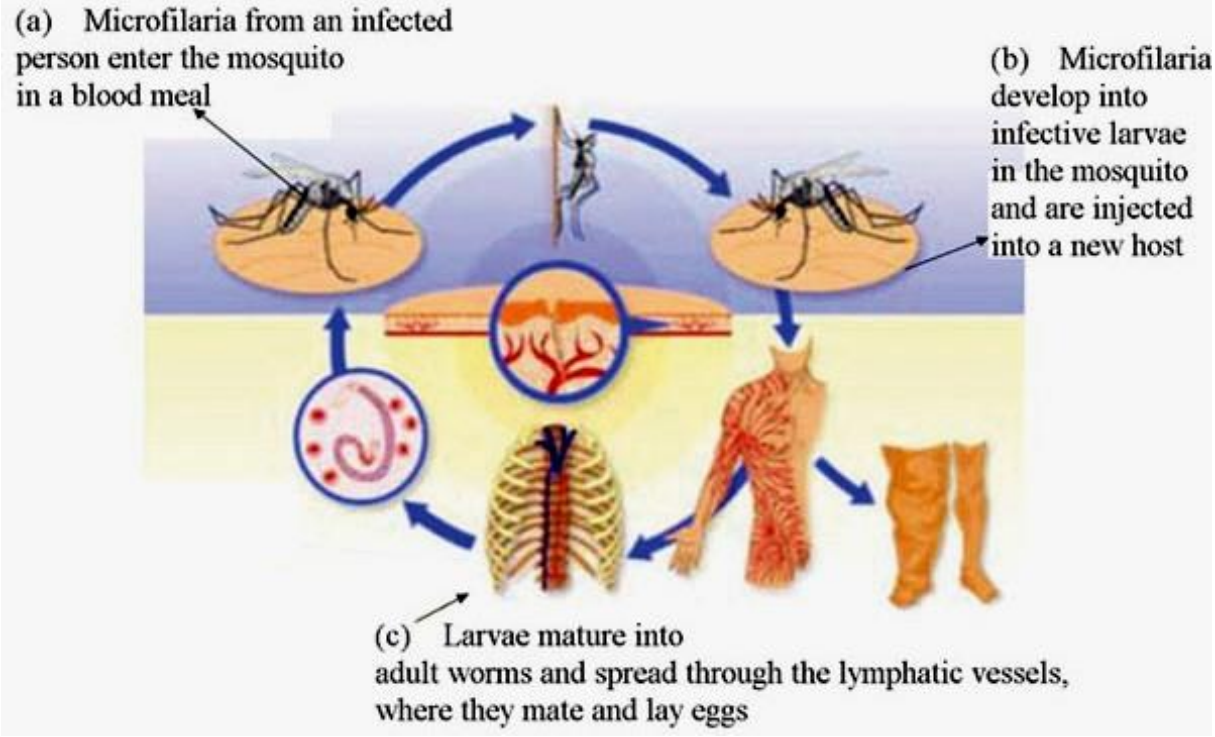


Figure 74. Life Cycle of *Wuchereria bancrofti*
(http://www.open.edu/openlearnworks/pluginfile.php/4590/mod_oucontent/oucontent/86/none/none/cd_session37_fig20.jpg)

The mechanism of human infection. The way of penetration is transmissible way. Factors of invasion. When the infected mosquito bites a human being, the larvae penetrate through the skin. The invasional stage for humans is the larva (microfilariae). Adult worms live in the lymph nodes.

Males and females remain coiled together and can only be separated with difficulty (females are usually more numerous than males and the latter are difficult to find). The life span of the adult worms is long, probably several years (5 to 10 years).

Females give birth to active larvae (microfilariae). Passing through the lymph nodes, these embryos find their way by the main lymphatic trunks into the circulating blood. They are very active in their habits and can move both with and against the blood stream. The larval forms do not undergo any further development in the human body unless they are taken up by their appropriate intermediate host (mosquito). If these microfilariae are not sucked up by the mosquito, they die in course of time. The life span of microfilariae in the human body has been found to be as long as 70 days.

The microfilariae of Oriental countries (India and China) are not constantly found in the peripheral blood but appear periodically at night mostly between 10 p.m. and 4 a.m. thus showing a nocturnal periodicity. It has been suggested that during daytime they retire principally inside the capillaries of lungs, kidneys (glomerular tufts), heart and the big arteries, such as the carotid one. When the infected mosquito bites a human being, the larvae penetrate through the skin.

Infective larvae, having penetrated the skin, reach the lymphatic channels, settle down at some spot (inguinal, scrotal or abdominal lymphatics) and begin to grow into adult forms. In course of time, probably after a period of 5 to 18 months they become sexually mature.

The male fertilizes the female and the gravid females give birth to larvae.

A new generation of microfilariae is emitted which passes either through the thoracic duct or the right lymphatic duct, to the venous system and pulmonary capillaries and then to the peripheral circulation (capillaries of the systemic circulation), thus completing the cycle.

Pathogenicity and Clinical Features. The morbid change initiated by *Wuchereria bancrofti* is essentially confined to the lymphatic system. Infection with this parasite is called wuchereriasis (commonly called «filariasis»).

The pathogenic effects is an inflammatory reaction of the lymphatic system, lymphangitis which forms the basic lesion in classical filariasis.

The metabolites of the growing larvae may give rise to allergic manifestations, such as urticaria (painful, red areas of the skin at the extremities) and lymphedema (elephantiasis).

Causes of lymphangitis are mechanical irritation caused by the movement of the adult parasite inside the lymphatic system, release of metabolites of the growing larvae, «toxic» products released from dead worms.

The factors which cause an obstruction to the lymph flow are mechanical blocking of the lumen by dead-worms, inflammatory thickening of the walls of lymphatic vessels.

Effects of lymphatic obstruction is varicosity of lymphatic vessels, elephantiasis – hypertrophy of the affected part.

Laboratory diagnostics. Laboratory diagnostics is based on finding microfilariae in the peripheral blood, urine, lymph; adult worms in the biopsied lymph node and calcified worm by X-ray. Immuno-allergic tests.

Prevention consists of the following: destruction of mosquitoes, reducing the rate of infection amongst insect vectors; treatment of carriers; protection against mosquito bites.

The laboratory diagnosis of parasitosis

For many years, microscopy has been the only available tool for the detection of parasites through inspection of blood smears, tissue specimens, feces, lymph node aspirates, bone marrow, and even cerebrospinal fluid. All major intestinal helminth infections are still solely dependent on microscopy for diagnosis. As for other parasite infections, many are confirmed by the use of microscopy in combnation with other methods of diagnosis including serology-based assays and more recently molecular-based assays.

Direct and indirect methods are used for the laboratory diagnosis of helminthiasis.

Direct methods are based on finding a helminth at the different stages of development (an egg, larvae, segments). Faeces, urine, sputum, duodenal contents are used to discover helminths and their fragments, larvae or eggs.

Direct methods are macroscopic methods (helminthoscopy – with a naked eye) and microscopic (ovoscopy – to discover eggs), X-ray photography, ultrasound.

Microscopic methods are method of Native smear; method of Thick smear (Kato method), which is used when there is a big amount of eggs.

The enrichment method (the method of floating) is based on using a 40% solution of sodium chloride, in which the eggs either float or settle on the bottom of the flask (or glass). The use of this solution can help to detect the eggs of all fluke worms, broad tapeworms, beef and armed tapeworms, unfertilized eggs of askaris.

The sedimentation method is the special methods of analysis for enterobiasis. The scraping from perianal folds and the method of scotch tape.

Indirect methods: Immune-enzyme analysis, polymerase chain reaction.

The principles of fighting against parasitosis

Fight against parasitosis is based on knowledge of life cycles of the parasites and application of measures that interrupt the life cycle of the parasite (ecological prevention). It can be made in two directions: public and personal.

Public prevention: sanitary improvement of the dwellings; sanitary control of the products; water purification; handling of food (thermal, chemical); neutralization of faeces; systematic medical examination of the workers of food industry.

Personal prevention: it depends on the peculiarities of a life cycle of the parasite.

For example: The representatives of the cat family are the source of invasion of the human by the following helminthiasises (Alveococcosis).

MEDICAL ARACHNOLOGY

The general description of *Arthropoda* Phylum

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Arthropoda*

The phylum of arthropods includes more than 1,5 million species. It is the most numerous phylum in the animal world. This diversity is determined by the appearance of a number of progressive features – aromorphosis and idioadaptation, which are common for *Arthropoda* phylum.

The importance of arthropods in nature, in the cycle of matter in nature and biosphere is great. They are also very economically important as the vermin and pollinators of cultivated plants, as the animals used as food, etc.

The majority of such arthropods are from the *Arachnoidea* Class (they are studied by arachnology) and *Insecta* Class (they are studied by entomology). Arachnids and insects that have medical importance are the subjects of the study of medical arachnoentomology, which is one of the sections of medical parasitology.

The characteristic features of Arthropods. They are multicellular animals with bilateral symmetry.

They are Triploblastic animals (develop from 3 germinal layers: ectoderm, endoderm and mesoderm).

The body is segmented. Segments have different structure and perform different functions. This type of segmentation is called heteronomous metamerism. It has three body parts: head, thorax and abdomen. Some arthropods have two body parts: head-thorax (cephalothorax) and abdomen.

The body is covered with a cuticle made of chitin, which plays the role of external skeleton and performs protective function.

They have segmented extremities (legs).

They show the presence of striped muscles and isolation of separate groups of muscles.

The body cavity is mixocoel (mixed) that is formed during embryonic development as a result of junction of the primary and secondary body cavities.

They develop all systems of organs: digestive, respiratory, nervous, excretory, circulatory, endocrinal, sexual.

The Digestive system consists of three parts of the intestine (anterior, middle and posterior). It starts with oral apparatus and ends with an anus. Channels of digestive glands (salivary, hepatopancreas) open into the digestive tract.

Respiratory organs are represented by gills (in water forms), lungs sacs, trachea. Lungs sacs and trachea are adapted to use the oxygen of air. The gills use oxygen, dissolved in water.

Arthropods have a excretory system that they use and get rid of wastes through their anus. The Arthropods have malpighian tubes and coxal glands that collect wastes from their blood and lead it into the intestines. This allows all wastes to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus.

The Circulatory system is open (unclosed). A pulsating organ is the heart, located at the spinal part of the body. Blood is taken into the body cavity by one artery leading from the heart. The mix of blood and cavity fluid is called hemolymph.

The Nervous system is characterized by abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body. All the organs of sense are developed.

The arthropods are dioecious (unisexual).

There are two ways of the arthropods' development: direct and indirect. Indirect development or development with metamorphosis may be complete or incomplete.

The complete metamorphosis includes the stages of egg, larva, pupa (or chrysalis) and imago (fig. 75).

The incomplete metamorphosis includes the stages of egg, larva and imago. The pupa is absent.

The first stage in this development, after the egg, is that of the larva. The pupa is the next stage of development of an insect, which does not eat and as a rule is incapable of locomotion. Under a thick covering of chitin a reconstruction of all the organs of the larva occurs within the body of the pupa. In the adult stage an insect is called an imago.

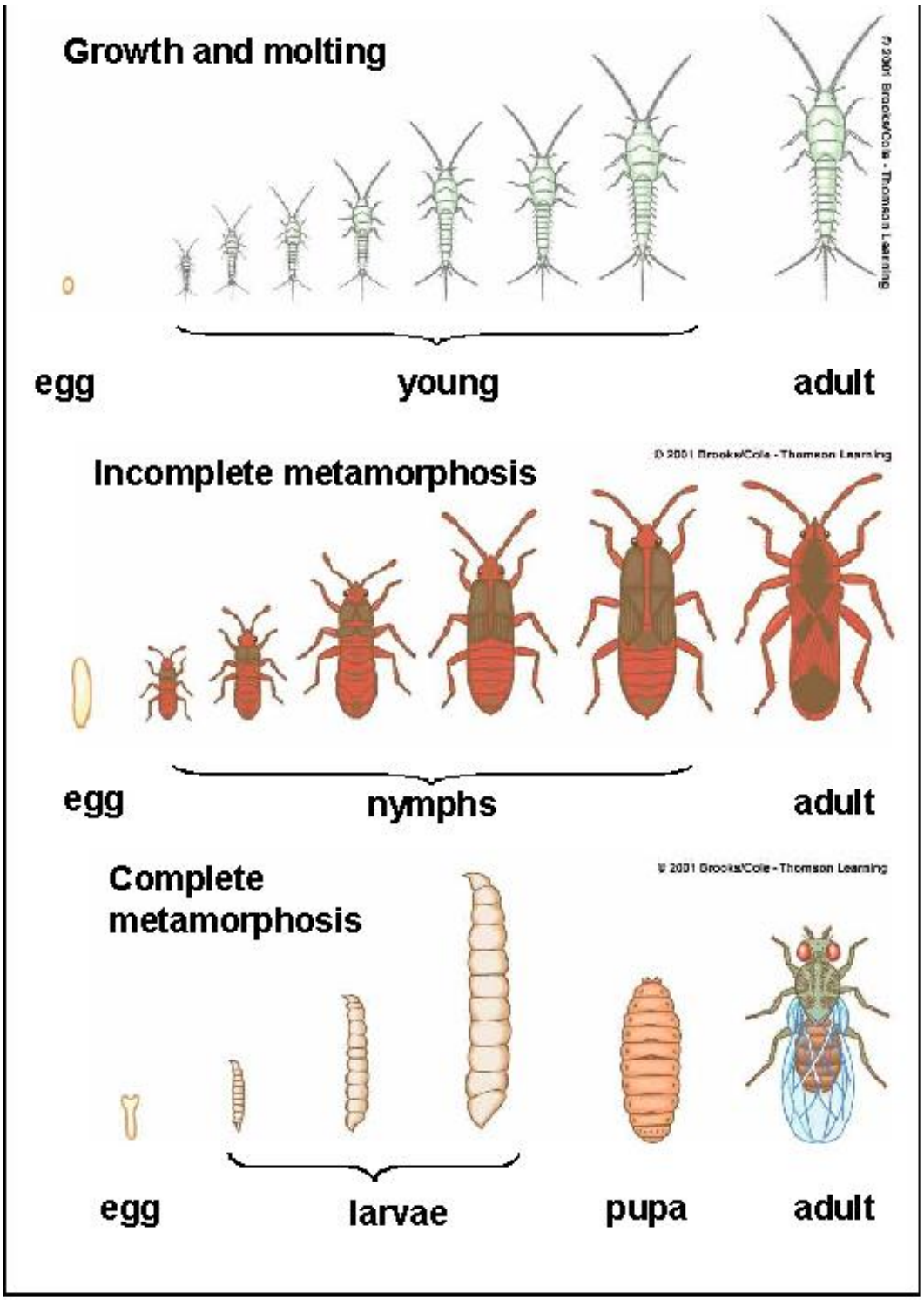


Figure 75. Development of arthropods
(http://siera104.com/school/biology/arthro/insect%20development.png)

Medical importance of arthropods:

- mechanical carriers of pathogenic organism (cockroaches, flies);
- specific carriers of pathogenic organism (ticks, bugs, flies, fleas, mosquito);
- pathogenic organisms (itch tick, lice);
- intermediate hosts of helminthes (crabs, lobsters, shrimps and lower *Crusta-*

*cea*ns – Cyclops);

- venomous (poisonous) animals (spiders, scorpions).

Classification. There are three subphylum in the *Arthropoda* Phylum: *Branchiata* (Class *Crustacea*), *Chelicerata* (Class *Arachnoidea*) and *Tracheata* (Class *Insecta*).

Class *Crustacea*

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Branchiata*
Class *Crustacea*

Most *Crustacea*ns live in water, but some live on land. *Crustacea*ns are the most numerous animals in the oceans, but some *Crustacea*ns live in fresh water. There are about 30 500 known species of *Crustacea*ns around the world.

*Crustacea*ns are a group of animals that have a hard exoskeleton (the body covered with a cuticle made of chitin), jointed legs, and a segmented body that is bilaterally symmetrical. They have two body parts: head-thorax (cephalothorax) and abdomen.

The *Crustacea*n body is protected by the hard exoskeleton, which must be moulted for the animal to grow. The shell around each body segment can be divided into a dorsal tergum, ventral sternum and a lateral pleuron. Various parts of the exoskeleton may be fused together (fig. 76).

*Crustacea*ns have a pair of legs attached to each segment that are specialized for different functions: antennules (sensory appendages for taste, touch, and equilibrium), antennae (sensory appendages for taste and touch),mandibles (move up and down to crush food), maxillae (move side to side to tear food; also act as «gill bailers» that pass water over gills), maxillipeds (hold the prey), chelipeds (defend crayfish and capture prey), walking and swimming legs. In males one of these legs is used to deposit sperm in the female. Uropod and telson allow the crayfish to move backwards.

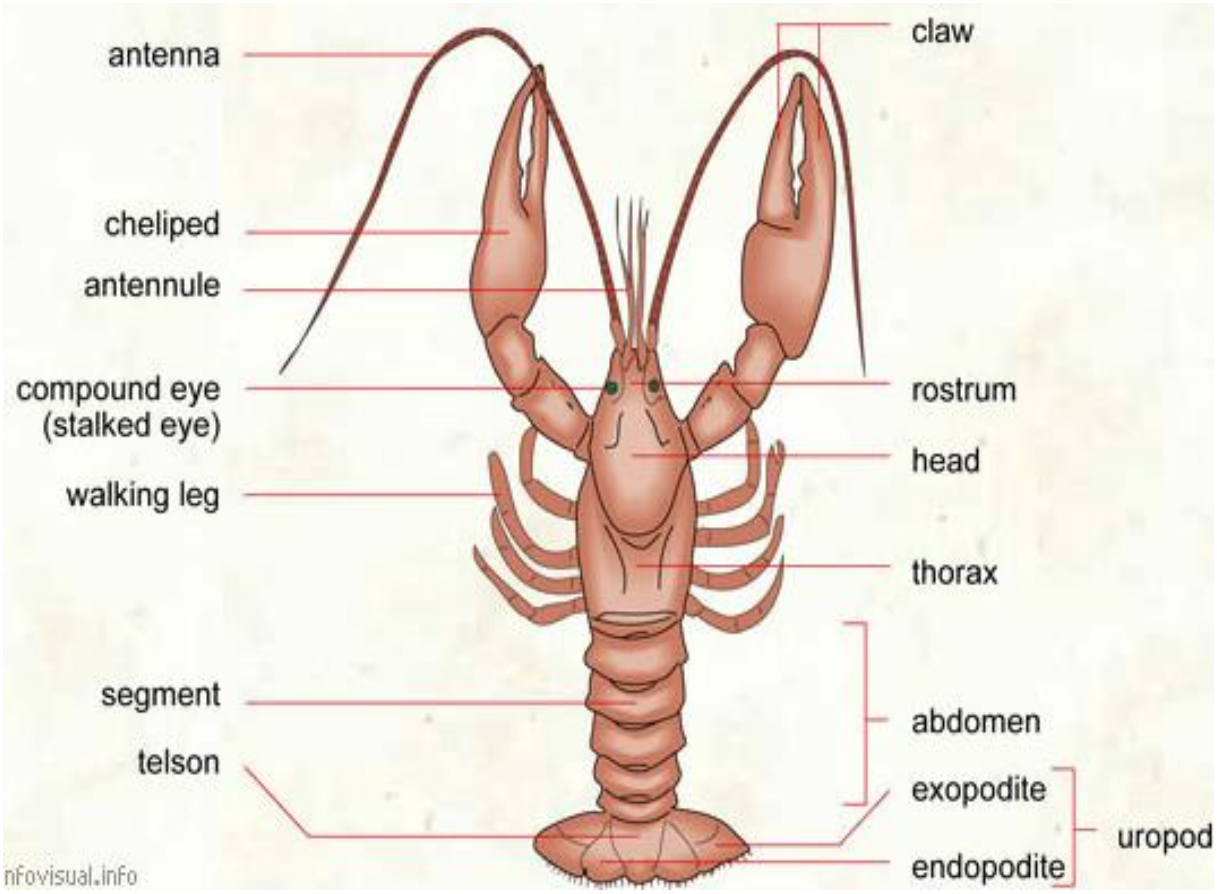


Figure 76. Morphology of crayfish
(https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcT4LW1gtPq4IpREzdgpseTIxKKLw8iXH8yQkLzSsiyMpUQh1mD0EQ)

The Digestive system consists of three parts of the intestine (anterior, middle and back). It starts with oral apparatus and ends with an anus. Channels of digestive glands (salivary, hepatopancreas) open into the digestive tract. Chelipeds capture food, food is grasped and cut by maxillae and maxillipeds; food is chewed by mandibles, passes into the mouth and enters the esophagus; stomach; digestive glands secrete enzymes that digest food; nutrients are absorbed in the intestine into the blood; undigested food exits through the anus (fig. 77).

Respiratory organs are represented by gills. The gills use oxygen, dissolved in water.

The Excretory system are green glands.

The Nervous system consists of a primitive ventral nerve cord and ganglia system. Brain exists in the form of ganglia close to the antennae, and a collection of major ganglia is found below the gut.

The Circulatory system is open (unclosed). Blood is pumped into the body cavity from blood vessels. The pulsating organ is the heart, located at the spinal part of the body.

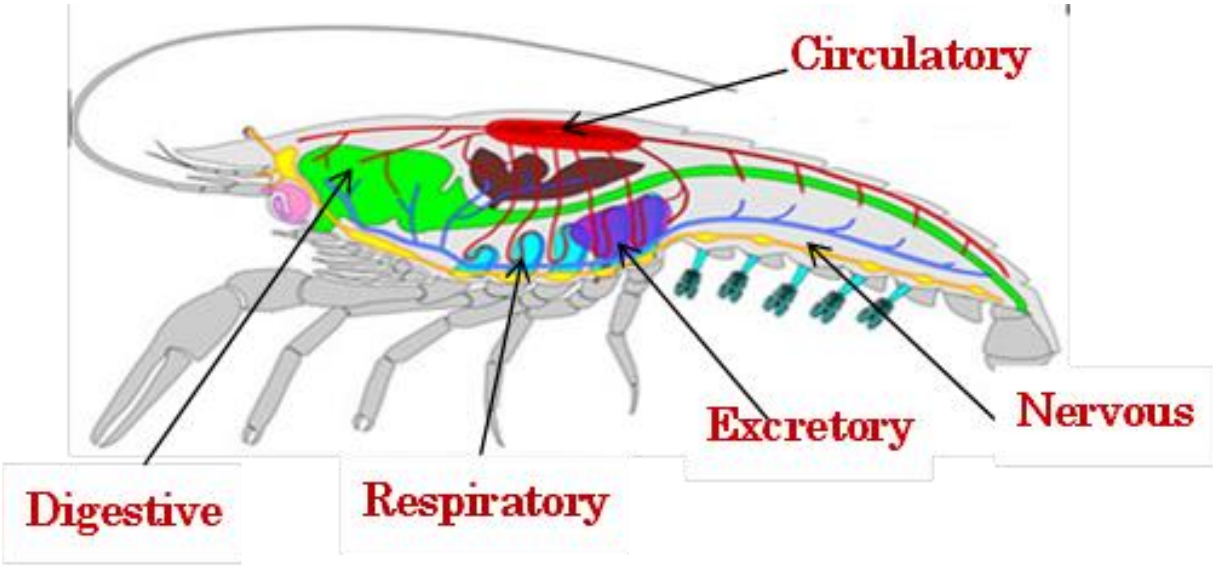


Figure 77. The system organs of crayfish
(http://bazis-ufa.ru/upload/iblock/ee9/ee90ff997abaa063e0b48bbb2672e261.jpg)

*Crustacea*ns have separate sexes, and reproduce sexually. The first one or two pairs of swimming legs are specialised for sperm transfer by the males and the females hold the eggs until they hatch into free-swimming larvae. In many species the fertilized eggs are just released into the water or attach to objects in water. The larvae metamorphose through a number of stages before they become adults.

The class of *Crustacea*ns (*Crustacea*) includes two subclasses: lower *Crustacea* (class *Entomostraca*) and higher *Crustacea* (class *Malacostraca*). Lower *Crustacea*ns usually live in water thickness and are the part of plankton.

Cyclops (or ware flea) are the intermediate hosts of a fish tapeworm (*Diphyllobotrium latum*), guinea worm (*Dracunculus medinensis*). The higher cancers live in the sea and fresh waters. The river crayfish, crabs, lobsters are eaten by human. A lot of cancers (necrophags) are sanitary important because they free the water reservoirs from animals' dead bodies. Crabs, spiny lobsters, shrimps are the intermediate hosts of a lung fluke (*Paragonimus westermani*).

Class *Arachnoidea*

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Arthropoda*

Subphylum *Chelicerata*

Class *Arachnoidea*

The subphylum of *Chelicerata* includes the class of arachnids (*Arachnoidea*) that numbers about 40 thousands of species. The representatives of this class are scorpions, spiders, mites (ticks). These arthropods are adapted to living on land that is why they are characterized by the presence of organs of air respiration.

The representatives of *Arachnoidea* are group of animals that have a hard exoskeleton (the body covered with a cuticle made of chitin), jointed legs, and a segmented body that is bilaterally symmetrical. They have two body parts: head-thorax (cephalothorax) and abdomen. The cephalothorax is derived from the fusion of the cephalon (head) and the thorax, and is usually covered by a single, unsegmented carapace. The abdomen is segmented in the more primitive forms, but varying degrees of fusion between the segments occur in many groups. It is typically divided into a preabdomen and postabdomen, although this is only clearly visible in scorpions, and in some orders, such as the *Acari*, the abdominal segments are completely fused.

The Arachnids have 6 pairs of extremities (legs). The first two pairs of legs (chelicerae and pedipalps) are adapted for feeding, defense, and sensory perception. The first pair, the chelicerae, serve for feeding and defense. The next pair of legs, the pedipalps, are adapted for feeding, locomotion, and reproductive functions. They have four pairs of walking legs. Arachnids do not have antennae or wings.

The digestive system is adapted to eat liquid food. The pharynx performs a sucking function. Arachnids produce digestive juices in their stomachs, and use their pedipalps and chelicerae to pour them over their dead prey. The digestive juices rapidly turn the prey into a broth of nutrients, which the arachnid sucks into a pre-buccal cavity located immediately in front of the mouth. Behind the mouth is a muscular pharynx, which acts as a pump, sucking the food through

the mouth and on into the esophagus and stomach. Arachnids are mostly carnivorous, feeding on the pre-digested bodies of insects and other small animals. Several groups secrete venom from specialized glands to kill prey or enemies.

The respiratory system is represented by leaf-shaped lungs (lungs sacs) or tracheae, which open outside by means of stigma (special opening). The lungs are homological to the gills of Crustacean gills. The tracheae are tubes, which branch and come to every organ and tissue where the exchange of gases takes place.

The excretory system of arachnids include up to four pairs of coxal glands and one or two pairs of Malpighian tubules, emptying into the intestine. Many arachnids have only one or the other type of excretory gland, although several do have both.

The circulatory system is unclosed. Arachnids with an efficient tracheal system do not need to transport oxygen in the blood, and may have a reduced circulatory system. The heart is located at the spinal part of the body. Some ticks have no heart at all.

The nervous system is a double chain of segmented ganglia running along the animal ventral surface. This chain gives up peripheral nerves (type of abdominal nervous chain). The sense organs are: eyes, fine sensory hairs that cover the body and give the animal its sense of touch. Slit sense organs are believed to be involved in hearing.

Reproduction and development. The Arachnids have separate sexes, and reproduce sexually. The sexual dimorphism is expressed a lot. Arachnids may have one or two gonads, which are located in the abdomen. The genital opening is usually located on the underside of the second abdominal segment. In most species, male transfers sperm to the female in a package, or spermatophore. Complex courtship rituals have evolved in many arachnids to ensure the safe delivery of the sperm to the female.

Arachnids usually lay eggs. Scorpions, however, are either ovoviviparous or viviparous, depending on species.

The class *Arachnoidea* includes three orders: order *Scorpionidae* (Skorpions), order *Aranei* (Spiders) and order *Acari* (Ticks and Mites). The representatives of order *Acari* have the most important medical value. Many of them are sanguivorous. They may parasite on birds, mammals and human beings. They

can be vectors of transmissive diseases. Spiders, scorpions are venomous (poisonous) animals.

Order *Scorpionidae*

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Scorpionidae*

Scorpions are group of animals that have a hard exoskeleton (the body is covered with a cuticle made of chitin), jointed legs, and a segmented body that is bilaterally symmetrical (fig. 78). The scorpion's exoskeleton is thick and durable, providing good protection from predators.The cuticle of scorpions is covered with hairs in some places that act like balance organs.

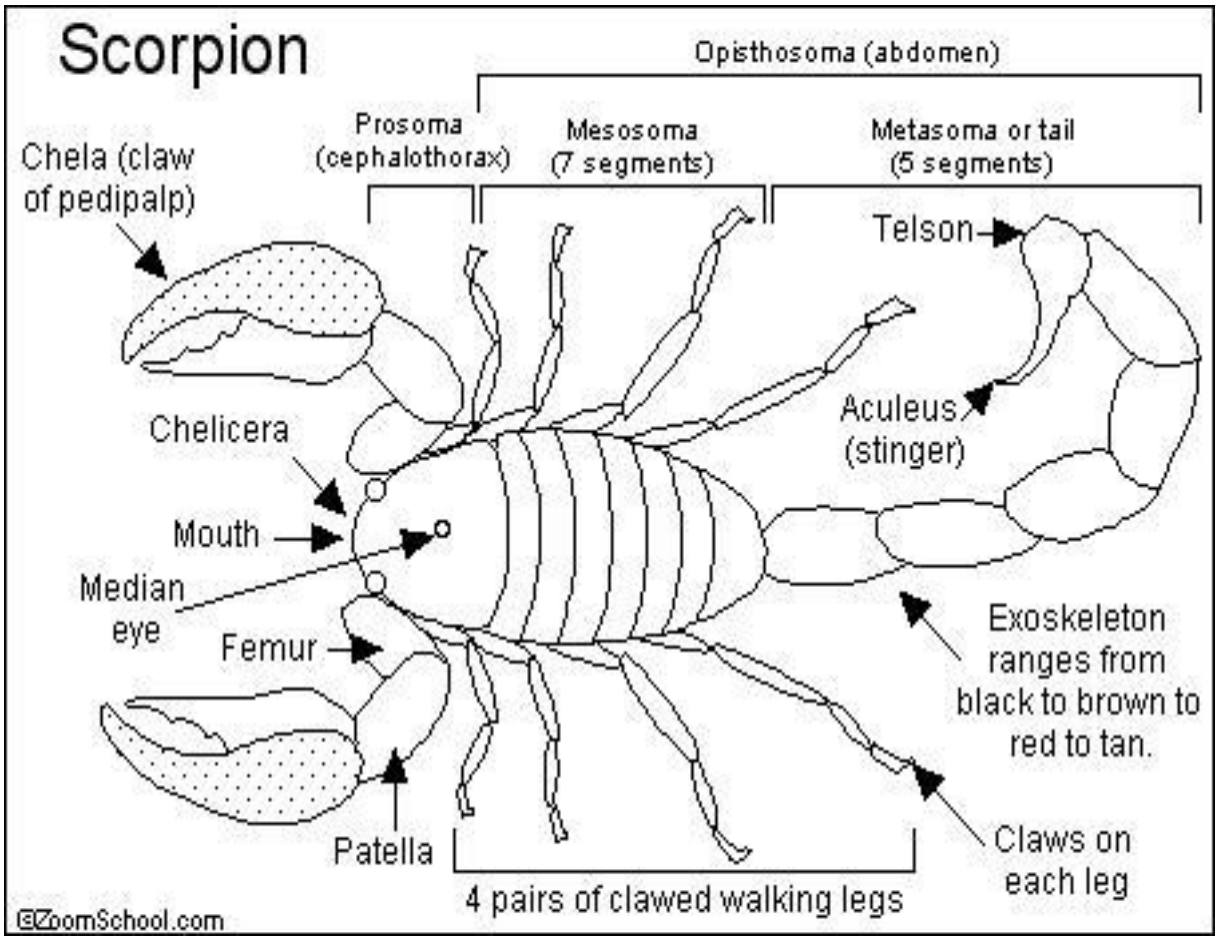


Figure 78. The structure of scorpion
(http://www.enchantedlearning.com/sgifs/Scorpion_bw.GIF)

They have two body parts: head-thorax (cephalothorax) and abdomen. The cephalothorax is derived from the fusion of the cephalon (head) and the thorax. The abdomen is typically divided into a preabdomen (mesosoma) and postabdomen (metasoma or tail). The scorpions have 6 pairs of legs.The first pair, the chelicerae, serve in feeding and defense. The next pair of legs, the pedipalps, have chelae, commonly called claws.

The rest 4 pairs are walking legs. The last abdominal segment of a scorpion carries a sting, in the bases of which there are venom glands. All known scorpion species possess venom and use it primarily to kill or paralyze their prey so that it can be eaten. It is also used as a defense against predators.

The Digestive system consists of three parts of the intestine (anterior, middle and back). It starts with oral apparatus and ends with an anus. Channels of digestive glands (salivary, hepatopancreas) open into the digestive tract. Digestive glands secrete enzymes that digest food; nutrients are absorbed in the intestine into the blood; undigested food exits the anus.

The respiratory system is represented by leaf-shaped lungs (lungs sacs). Each of the final four segments of abdomen contains a pair of lungs sacs. The excretory system is Malpighian tubules, emptying into the intestine.

Scorpions have open circulatory systems. The heart is a tube in the upper part of the body. Blood is discharged into the hemocoel by one artery.

The nervous system is a double chain of segmented ganglia running along the animal ventral surface. This chain gives up peripheral nerves (type of abdominal nervous chain). Scorpions have two eyes on the top of the cephalothorax, and usually two to five pairs of eyes along the front corners of the cephalothorax.

Scorpions have separate sexes, and reproduce sexually. Scorpions are viviparous. The young are born one by one, and the brood is carried about on its mother's back until the young have undergone at least one moult. The young generally resemble their parents, requiring between five and seven moults to reach maturity.

Medical importance of scorpions. Scorpions use their venom to kill or paralyze their prey so that it can be eaten; in general, it is fast acting, allowing for effective prey capture. Most scorpions are relatively harmless to humans; stings produce only local effects (such as pain, numbness or swelling). A few

scorpion species can be dangerous to humans. The fat-tailed scorpion of North Africa is the most deadly to humans.

The venom is a mixture of compounds (neurotoxins, enzyme inhibitors, etc.). In humans, if the scorpion's neurotoxin is lethal, symptoms before the onset of death can include pain and swelling at the site of the sting, numbness, respiratory paralysis, muscle twitching, and convulsions.

They can be found in the Crimea, Caucasus, Middle Asia. The stings of the scorpions that live in these areas are not fatal for the human but they cause painful feeling, edema of the extremity. As a specific medicine the serum against poison of scorpion is used.

Order *Aranei* (Spiders)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Aranei*

Spiders are found in all terrestrial habitats and some have even adapted to a semi-aquatic lifestyle. They are common in scrubland, desert regions, caves and around human habitation. Spiders can commonly be found in leaf litter and under rocks, logs or the bark of trees. Many dig burrows in the soil.

Spiders come in a variety of shapes, colors and sizes. The representatives of Order *Aranei* are group of animals that have a hard exoskeleton (the body covered with a cuticle made of chitin), jointed legs, and a segmented body that is bilaterally symmetrical (fig. 79). They have two body parts: head-thorax (cephalothorax) and abdomen. The cephalothorax is derived from the fusion of the cephalon (head) and the thorax. The abdomen are unsegmented. The spiders have 6 pairs of legs. The first two pairs are chelicerae and pedipalps. chelicerae are used to deliver venom to kill prey, for defence, to capture and crush prey and to dig and excavate burrows. Pedipalps are pair of sensory palps (often much larger in males) between the first pair of legs and the chelicerae, used for sperm transfer during the mating season, prey manipulation during feeding and detection of smells and vibrations. The rest 4 pairs are walking legs.

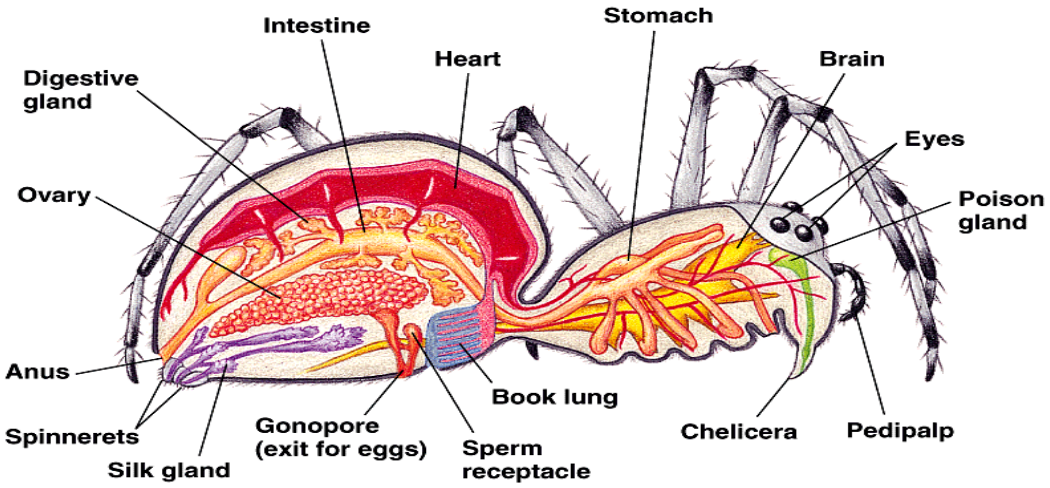


Figure 79. The structure of spider
(http://www.everythingology.com/wp-content/uploads/2011/08/33-30b-SpiderAnatomy-L.gif)

Their abdomens bear appendages that have been modified into spinnerets that extrude silk from up to six types of silk glands within their abdomen. Spider webs vary widely in size, shape and the amount of sticky thread used.

The digestive system is adapted to eat fluid food. They have external digestion. The pharynx performs a sucking function. Spiders produce digestive juices in their stomachs. The final sections of spiders' chelicerae are fangs, and the great majority of spiders can use them to inject venom into prey from venom glands in the roots of the chelicerae. The digestive juices rapidly turn the prey into a broth of nutrients. The insides of the victim are then consumed and the hard outer body discarded. A muscular pharynx acts as a pump, sucking the food through the mouth and on into the esophagus and stomach.

Most species of spider are active at night and all are predators. Several groups secrete venom from specialized glands to kill prey or enemies.

The respiratory system is represented by leaf-shaped lungs (lungs sacs) or tracheae, which open outside by means of the stigma (special opening).

The excretory system is Malpighian tubules.

The circulatory system is unclosed. Hence spiders have open circulatory systems. The heart is a tube in the upper part of the body. Blood is discharged into the hemocoel by one artery. The blood of many spiders that have lung sacs (book lungs) contains the respiratory pigment hemocyanin to make oxygen transport more efficient.

Spiders have a more centralized nervous system. The cephalothorax is largely filled with nervous tissue and there are no ganglia in the abdomen.

Most spiders have four pairs of eyes on the top-front area of the cephalothorax. Chemical sensors provide taste and smell by means of setae.

Spiders have separate sexes, reproduce sexually and their fertilization is internal but indirect. The male spider will transfer its sperm to the female via syringe-like pedipalps. After mating the male will either die or be eaten by the female. A short time later the female will lay her eggs into a silken sac. On hatching the spiderlings resemble adults and are generally lighter in color. Growth occurs by shedding their skin (moulting) and several moults are required before spiders reach adulthood.

Medical importance of spiders. A few species of spiders are dangerous to people. For example, Widow spiders (Black Widow, Brown Widow, Red Widow). Widow spiders (*Latrodectus spp.*) are venomous, and can be harmful to people. Widow spiders bite only in self-defense when they accidentally contact humans. The bite from the widow spider causes a set of symptoms.

Local swelling and redness at the site may be followed in one to three hours by intense spasmodic pain, which can travel throughout the affected limbs and body, settling in the abdomen and back (intense abdominal cramping, described as similar to appendicitis), and can last 48 hours or longer. Elderly patients or young children run a higher risk of severe reactions, but it is rare for bites to result in death. Other symptoms can include nausea and profuse perspiration. If left untreated, tremors, convulsions and unconsciousness may result. When death does occur, it is due to suffocation.

The coloration of the female can vary by species (brown, black, red), but all females (of the species found in the United States and Canada) are shiny black, brown-black, or red with possibly a row of red spots on the top of the ab-

domen along the midline. Two reddish triangles resembling an hourglass are present on the underside of the abdomen of all species except the Red Widow (*L. bishopi*). Females are sedentary, staying on or near their web. They will bite if molested.

The male's abdomen usually has red spots along the upper midline and white lines or bars radiating out to the sides. (The number of bars can indicate species type.) Males almost exclusively wander in search of females.

Mediterranean black widow (European black widow, or steppe spider), (binomial name Latrodectus tredecimguttatus), is a species of widow spiders in the genus Latrodectus. Latrodectus tredecimguttatus has different names in different regions. For example, in Southern France it is called Malmignatte and in Italy - malmignatta. Throughout the Central Asia and Eastern Slavic region, the name karakurt is most often applied. The words kara, meaning "black", and kurt, meaning "worm", come from the Turkic languages.

Tarantulas comprise a group of very large and often hairy arachnids belonging to the *Theraphosidae* family of spiders. Most species of tarantulas are not dangerous to humans, and some species have become popular in the exotic pet trade. Sometimes bites of tarantulas are regarded as the probable source of infections. Medical advice regarding prophylaxis may be helpful in that regard. In addition, there is considerable evidence indicating that the venoms of some species can produce symptoms so severe that medical treatment would be appropriate. Medical intervention is also regarded as appropriate when symptoms such as breathing difficulty or chest pain develop, since these conditions may indicate an anaphylactic reaction.

Precautions. To be very careful when working around areas where widow spiders may be spread. Take proper precautions-wear gloves and pay attention to where you are working. The reaction to a widow bite can be painful, and the victim should refer to the doctor immediately for treatment.

Order *Acari*

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

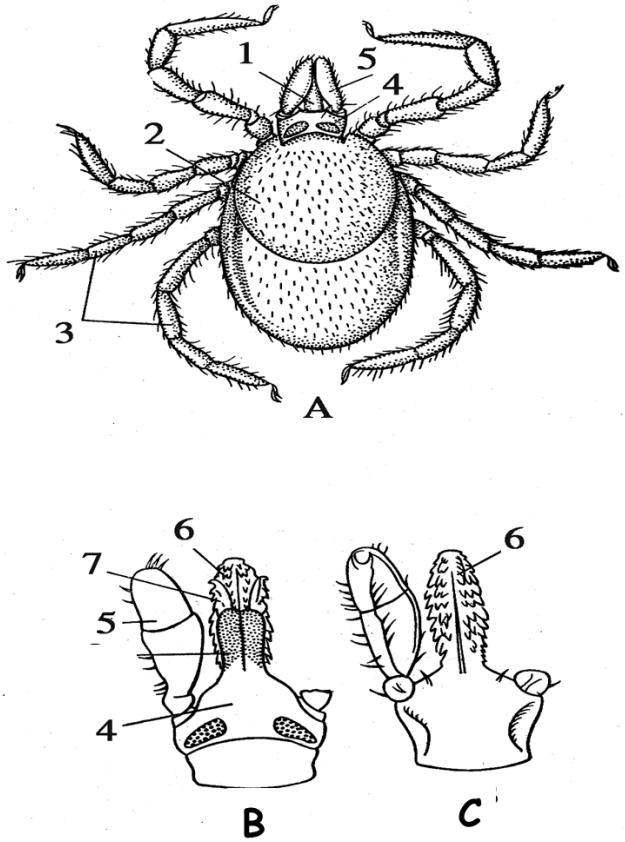
Phylum *Arthropoda*

Subphylum *Chelicerata*

Class *Arachnoidea*

Order *Acari*

The parasites belonging to order *Acari* have small sizes. They have a hard exoskeleton (the body covered with a cuticle made of chitin), jointed legs, and unsegmented body that is bilaterally symmetrical. They have head-thorax (cephalothorax) and abdomen. The typical feature of them is fusing of the cephalothorax and the abdomen to the one unit (unsegmented body). There are 6 pairs of legs: 2 pairs form an oral apparatus chelicerae and pedipalps, 4 pairs are used for moving. The representatives of family *Ixodidae* (or hard tick) have thick dorsal shells made of chitin, which is called dorsal shield (corselet). In males, the dorsal shield (corselet) covers the entire back, whereas in females it covers only the neck. The representatives of *Argasidae* family (or soft ticks) have a membranous outer surface (fig. 80).



A – female.
B, C – mouth apparatus.
1 – proboscis
2 – body;
3 – walking legs;
4 – base of proboscis;
5 – pedipalp
6 – hypostome;
7 – chelicerae.

Figure 80. *Ixodes persulcatus* (Dogel)

The Digestive system consists of three parts of the intestine (anterior, middle and back). It starts with oral apparatus and ends with an anus. The intestine is branched to keep sucked blood. The oral organs include chelicerae and pedipalps. They have proboscis with hooklets. This proboscis is for biting and fixa-

tion in the host body. On being attached to the host, the mites can suck the blood for several days. The females can enlarge their sizes in 3-4 times while sucking.

The respiratory system is presented by trachea.

Representative of order *Acari* have well-developed central nervous system. It is single ganglion. Many ticks are eyeless.

The excretory system is malpigian tubules.

They posess well expressed sex dimorphism. In males, the dorsal shield covers the entire back, whereas in females it covers only the neck. The females are very fertile. The development (fig. 81) is presented by incomplete metamorphosis (egg-larva-nymph-imago). Nymphs do not have sexual opening. The transformation to next stage is connected with blood feeding. There are one-, two- and threehosted ticks. The female lays its egg into the soil. Larval stages feed on the small vertebrates (rodents, birds, hedgehogs). Then a larva goes to the soil and there it casts its coat (moulting). Nymphs feed on chipmunks, squirrels, hares, the adult forms – on horned cattle, deer, elks and humans.

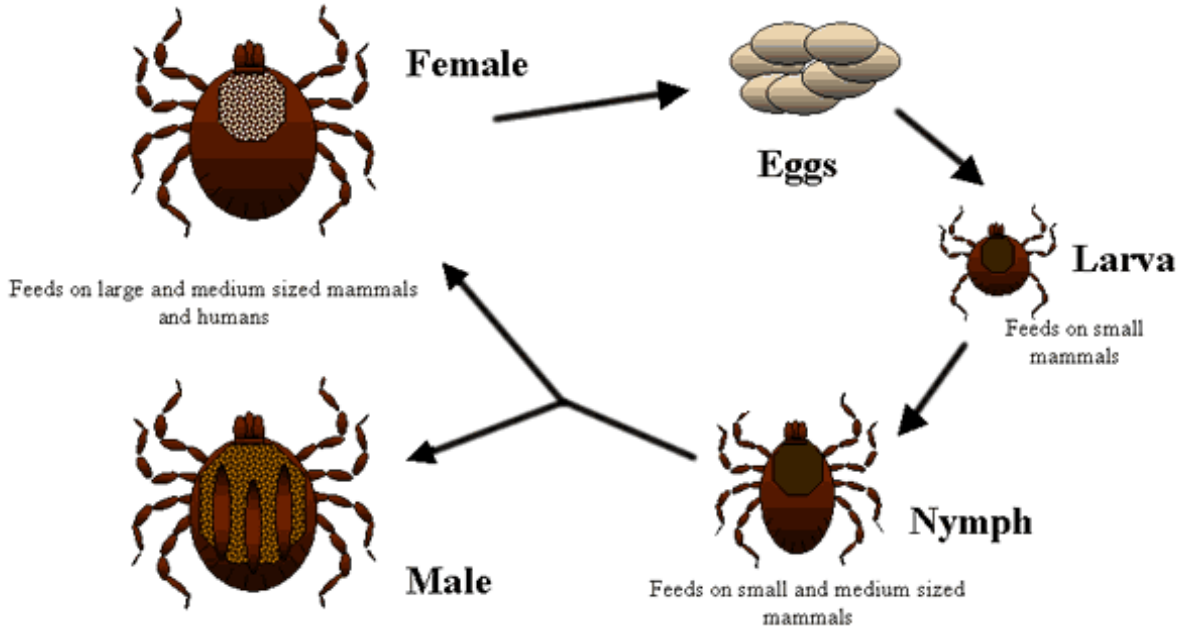


Figure 81. Life cycle of ticks
(https://classconnection.s3.amazonaws.com/22/flashcards/99022/png/pharm-142913484196AE6FFB0.png)

Acari are ectoparasites, causative agents and vectors of diseases. Their characteristics is transovarial transmission of a causative agent (by ovum). The order *Acari* includes Family *Ixodidae* (taiga tick, dog follicle tick, *Dermacentor*

tick or hard ticks), Family *Argasidae* (settlement tick), Family *Acariformes* (itch mite) and Family *Demodicidae (Demodex folliculorum).*

Family *Ixodidae*

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Acari*
Family *Ixodidae*

The parasites belonging to family *Ixodidae* live in the forests and bushes. They have a hard exoskeleton (the body covered in a cuticle made of chitin), jointed legs, and unsegmented body that is bilaterally symmetrical. Their cephalothorax and abdomen are fused to the one unit (unsegmented body). There are 6 pairs of legs: 2 pairs form an oral apparatus chelicerae and pedipalps, 4 pairs are used for moving. The representatives of family *Ixodidae* (or hard tick) have thick dorsal shells made of chitin, that called dorsal shield (corselet). In males, the dorsal shield (corselet) covers the entire back, whereas in females it covers only the neck. The oral apparatus is visible from the dorsal side (is located terminally). The body is brown color.

The Digestive system consists of three parts of the intestine (anterior, middle and back). It starts with oral apparatus and ends with an anus. The intestine is branched to keeping of sucked blood. The oral organs include chelicerae and pedipalps. They have proboscis with hooklets. This proboscis is for biting and fixation in the host body. On being attached to the host, the mites can suck the blood for several days. The females can enlarge their sizes in 3-4 times while sucking.

The respiratory system is presented by trachea.

The nervous ganglia are fused in single ganglion.

The excretory system is malpigian tubules.

They have good expressed sex dimorphism. In males, the dorsal shield covers entire back, whereas in females it covers only neck. The females are very fertile. They can lay up to 3000 eggs. The development includes the following

stages: egg → larva → nymph → imago (fig. 82). The transformation to the next stage is connected with blood feeding. A larva has small sizes, 3 pairs of extremities; underdeveloped respiratory and sexual systems. A nymph has 4 pairs of walking extremities, tracheal respiratory system, underdeveloped sexual system without a genital orifice. An imago is a pubertal stage of the development having 4 pairs of walking legs, stigmas and the genital orifice.

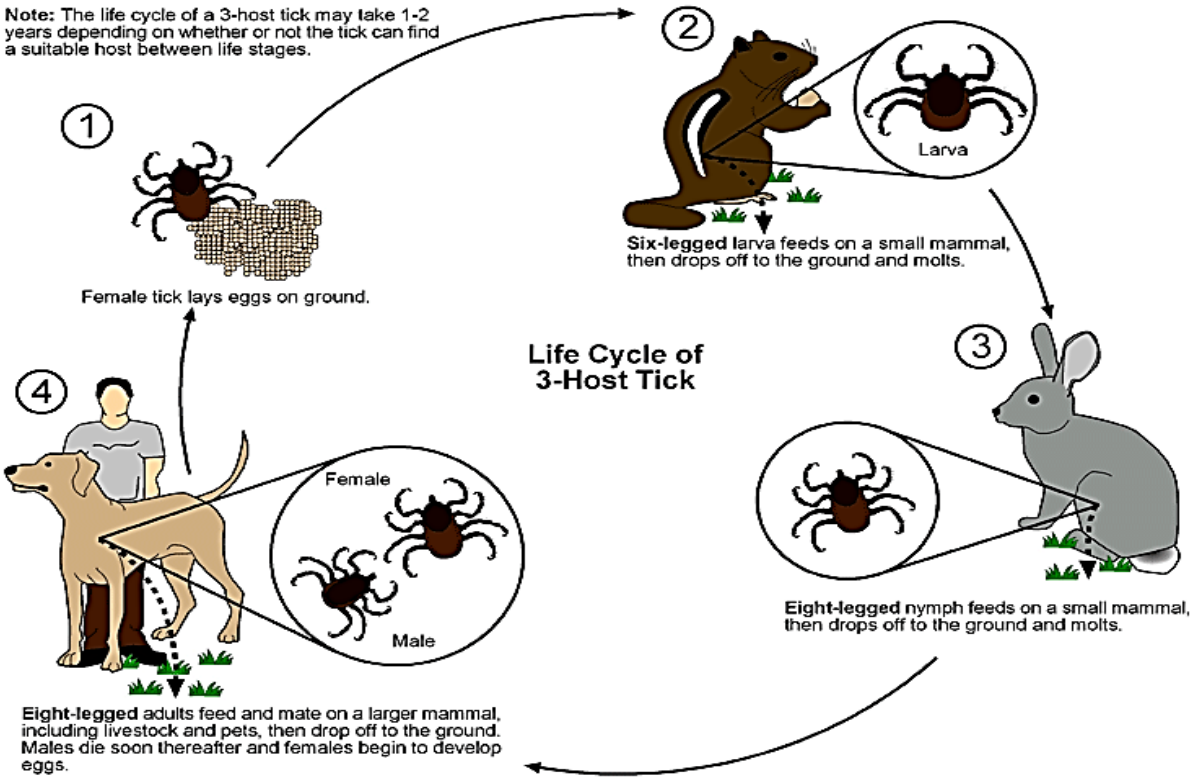


Figure 82. Life cycle of ticks
(https://encrypted-tbn2.gstatic.com/images?q=
tbn:ANd9GcSomVEPZzChVSlbyrYiGuJDl4e8uQjEl9Fcxt0cucpgWt-SZytYrA)

Ixodid ticks require three hosts, and their life cycle takes at least one year to complete.

Adult female lay eggs on the ground. When larvae emerge, they feed primarily on small mammals and birds. After feeding, they detach from their host and molt to nymphs on the ground, which then feed on larger hosts and molt to adults. Female adults attach to larger hosts, feed, and lay eggs.

Medical importance of representatives of family *Ixodidae*. They are ectoparasites of mammalian and human being. Specific carriers of pathogenic organism.

Ixodes persulcatus (the taiga tick)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Acari*
Family *Ixodidae*
Genus *Ixodes*
Species *Ixodes persulcatus* (the taiga tick)

The taiga tick (*Ixodes persulcatus*) occurs in the Taiga (siberian) forests of Europe and Asia. It lives as parasite on many species of birds and mammalian. They have a hard exoskeleton (the body covered in a cuticle made of chitin), jointed legs, and unsegmented body that is bilaterally symmetrical. There are 6 pairs of legs: 2 pairs form an oral apparatus chelicerae and pedipalps, 4 pairs are used for moving.

Ixodes persulcatus has oval body, with shield on the dorsal surface. In males, it covers entire back, whereas in females it covers only neck. The males are brown colored with size up to 2,5 mm long. Hungry female is also brown in color with size up to 4 mm long.

Medical importance of taiga tick. It is reservoir and vector of Taiga encephalitis virus among wild animals (chipmunk, hedgehog, mouse). Taiga or spring-summer encephalitis is acute infectious disease with affection of the central nervous system. The mode of infection is transmissible way – by a bite of taiga tick. Epidemiological chain: reservoir – wild Mammalia and birds; vector – taiga tick, recipient – healthy man. This virus can be transmitted by transovarial way (between generations).

Ixodes ricinus (the dog tick)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*

Class *Arachnoidea*
Order *Acari*
Family *Ixodidae*
Genus *Ixodes*
Species *Ixodes ricinus* (the dog tick)

The dog tick (*Ixodes ricinus*) is externally similar to the taiga tick. They live in forests and bushes in Europe.

Medical importance of dog tick. The dog tick supports rabbit fever circulation among rodents. It also transmitted this exciter to human being. It is as well as vector for West-European encephalitis virus and tularemia.

Genus hard ticks (*Dermacentor*)

Systematic position of in the zoological classification:
Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Acari*
Family *Ixodidae*
Genus *Dermacentor*

The ticks of *Dermacentor* genus (*Dermacentor pictus* (meadow tick), *Dermacentor marginatus* (the Ornate sheep tick), *Dermacentor nuttalli*) are spread in foliage and mixed forests of Western Siberia.

They have a hard exoskeleton (the body covered in a cuticle made of chitin), jointed legs, and unsegmented body that is bilaterally symmetrical. Their cephalothorax and abdomen are fused to the one unit (unsegmented body). There are 6 pairs of legs: 2 pairs form an oral apparatus (chelicerae and pedipalps), 4 pairs are used for moving (fig. 83).

The ticks of *Dermacentor* have oval body, with shield on the dorsal surface. In males, it covers entire back, whereas in females it covers only neck and dorsal shield with enamel picture. The males are brown colored with size up to 8 mm long. Hungry female is also brown in color with size up to 5 mm long.

The Digestive system consists of three parts of the intestine (anterior, middle and back). It starts with oral apparatus and ends with an anus. The intestine

is branched to keeping of sucked blood. The oral organs include chelicerae and pedipalps. They have proboscis with hooklets. This proboscis is for biting and fixation in the host body. On being attached to the host, the mites can suck the blood for several days. The females can enlarge their sizes in 3-4 times while sucking.

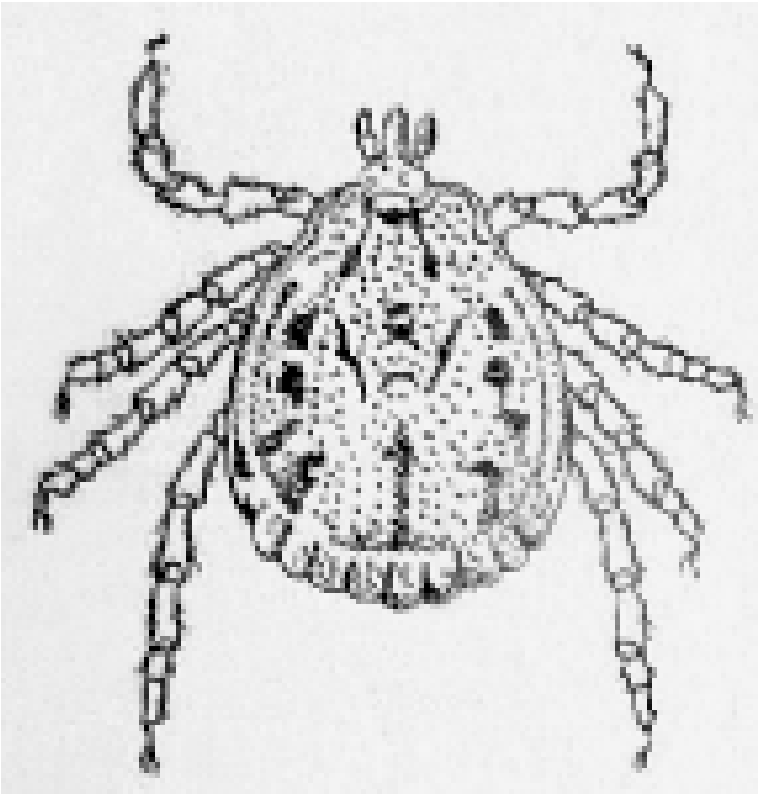


Figure 83. The ticks of *Dermacentor genus*
(http://rudocs.exdat.com/data/83/82791/82791_html_25dcb3e8.png)

The respiratory system is presented by trachea.

The nervous ganglia are fused in single ganglion. They have eyes.

The excretory system is malpigian tubules.

They have good expressed sex dimorphism. In males, the dorsal shield covers entire back, whereas in females it covers only neck. The females are very fertile.

Larvae and nymphs attack only small animals, whereas mature mites can attack big animals and human being.

Medical importance. They are reservoirs and vectors of causative agents of encephalitis, tularemia, rickettsia of European typhus and haemorrhagic fevers.

Prevention. Personal prevention of diseases carried by *Ixodidae* ticks is protection against tick bites: special clothes, examination of the body and clothes on returning from the forest, using repellents. Public prevention includes sanitary-instructive work and preventive injections.

***Argasidae* family (soft ticks)**

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Acari*
Family *Argasidae*
Species *Ornithodorus papillipes* (settlement or village tick)

The places of preferable living are caves, burrows, sheds. The geographical distribution is countries with arid climate: Middle Asia, Iran, Afghanistan, India, Syria. The life span is about 20 years.

They have a exoskeleton (the body covered in a cuticle made of chitin), jointed legs, and unsegmented body that is bilaterally symmetrical (fig. 84). There are 6 pairs of legs: 2 pairs form an oral apparatus chelicerae and pedipalps, 4 pairs are used for moving.

They are known as «soft» ticks because lack of dorsal shield (no corselet). They have large sizes (about 10 mm) and are grey in color. The oral apparatus is visible only from the ventral side. The side parts are parallel, the front end is sharp.

The Digestive system consists of three parts of the intestine (anterior, middle and back). It starts with oral apparatus and ends with an anus. The intestine is branched to keeping of sucked blood. The oral organs include chelicerae and pedipalps. There are no accessories for attachment to the host. The time of blood sucking is about 3-30 minutes. The females can enlarge their sizes in 3-4 times while sucking.

The respiratory system is presented by trachea.

The nervous ganglia are fused in single ganglion. Usually they have no eyes.

The excretory system is malpigian tubules.

There is almost no sex dimorphism. The cycle of development includes from 2 to 7 stages of nymph. Providers for *Ornithodorus papillipes* are different Mammals (rodents, bats, jackals, wolves, domestic cattle).

Medical importance. The parasite is a reservoir and a vector of spirochaeta (from Borrelia genus) which is exciter of tick-borne relapsing fever (recurrent typhus) in natural focus. Borrelia can be transmitted to the next generation of ticks transovarially. The disease signs are fever, inflammatory events in the respiratory system, affection of the nervous system. The mode of infection is transmissible way through bite of a settlement tick. Epidemiological chain: reservoir (wild Mammalia) – vector (a settlement tick) – recipient – healthy man.

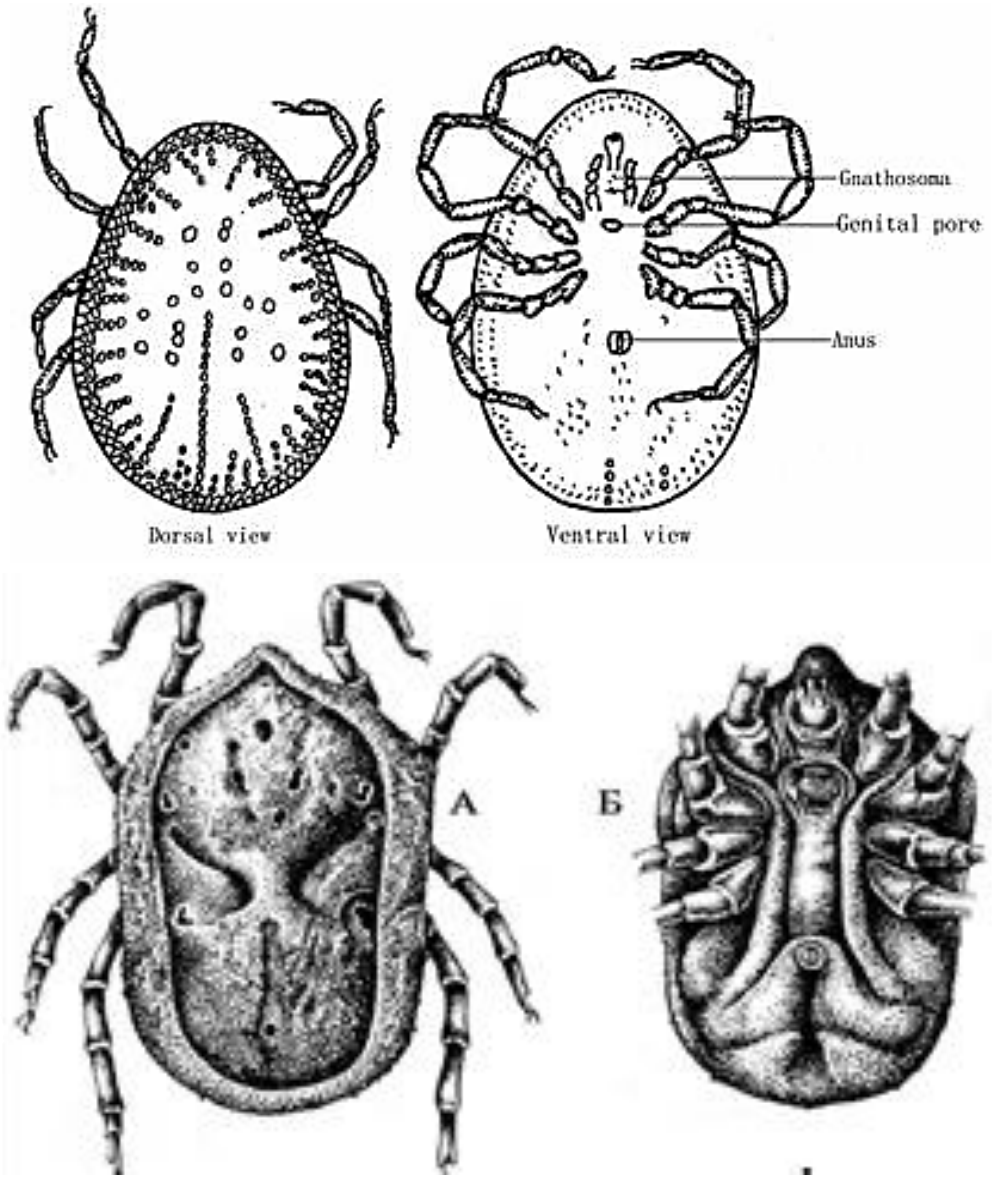


Figure 84. *Ornithodorus papillipes*
(https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcQlsgFCRqXicNRLxujdOxud26yXgoaEmEDB1baz8IvBlrQMF0lP_Hi2iQ)

Prevention. Personal prevention – protection against tick bites. Public prevention – destroying deserted buildings, disinfection in rooms and places of cattle living.

Family *Sarcoptidae*

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Acari*
Family *Sarcoptidae*
Species *Sarcoptes scabiei*

Sarcoptes scabiei (itch-mite) are skin parasites of many mammalians species, including people. These ectoparasites are exciters of scabies. *Sarcoptes scabiei* is spread worldwide. *Sarcoptes scabiei* is a skin parasite causing severe itching and infections. All ages of men and women especially in crowded and unhygienic conditions are at risk.

The body of mite is wide, oval with bristles. The female is up to 0,4 mm long whereas male is about 0,3 mm long. The body covered by chitin, has legs. Unsegmented body is bilaterally symmetrical. There are 6 pairs of legs: 2 pairs form an oral apparatus (chelicerae and pedipalps), 4 pairs are used for moving. The legs are shortened and they have 6 legs. The two pairs of legs are on anterior part of the body while the other two pairs are shifted to back part of the body.

The Digestive system consists of three parts of the intestine (anterior, middle and back). It starts with oral apparatus and ends with an anus. The oral apparatus is adapted to gnawing in human skin.

The respiratory system is absent. Breathing occurs through the body surface.

The nervous ganglia are fused in single ganglion. Eyes are absent.

The excretory system is malpigian tubules.

They have sex dimorphism. The females are larger than males.

Sarcoptes scabiei goes through four stages in its life cycle: egg, larva, nymph and adult. The life cycle starts, when an adult female gets in contact with

your skin. It crawls to crevices such as elbows, feet, fingers and genital area. It penetrates the skin and burrows a tunnel. It can slice skin with its sharp front legs and mouthparts. The other legs it uses for holding on to the skin with suckers on each leg. It takes about 30 minutes for it to burrow into the skin. It then continues to drill horizontally across the skin laying eggs along the way. The tunnels are usually shaped in a zigzag on the skin surface. It lays 2-3 eggs per day for two months. Then it dies. The larvae hatch from the eggs within a few days. They find hair follicles where they feed and molt into nymphs. In order for the nymph to become an adult male it molts once. This takes about ten days. To become a female it has to molt twice which takes about 17 days. Males do not usually burrow into the skin but only crawl and feed on it (fig. 85).

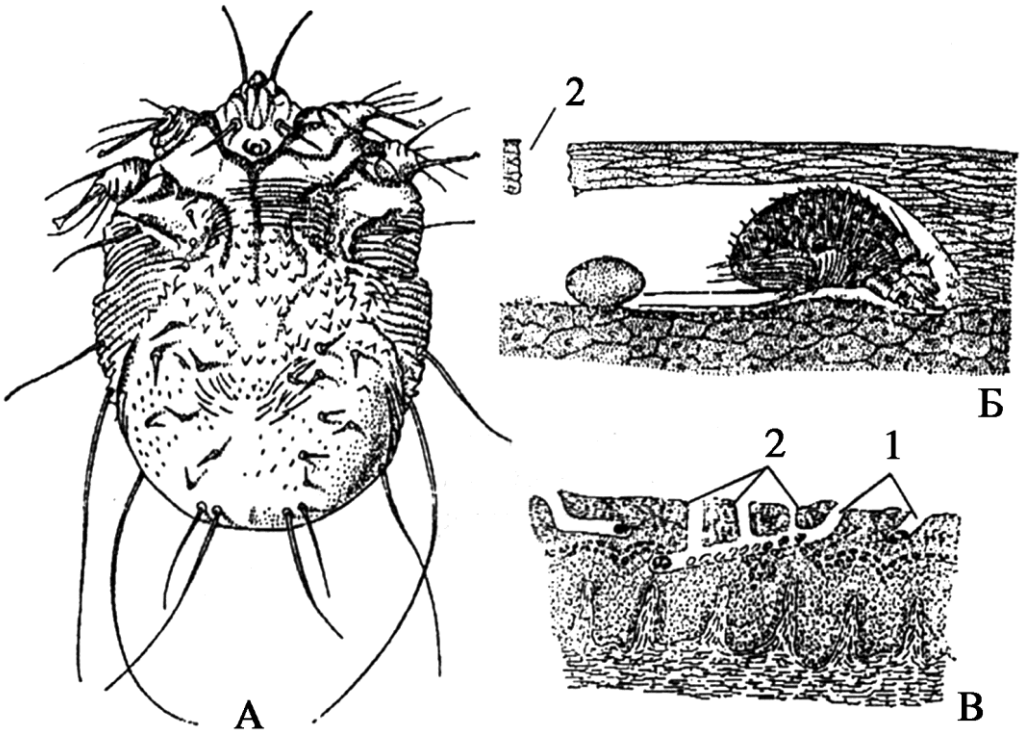


Figure 85. *Sarcoptes scabiei*
(Pavlovsky, Dubinin)

The human being can be infected through the contact with infected people in baths, through clothes and linens. The human can be infected by horses, sheep's goats, dog's itch-mites. *Sarcoptes scabiei* can survive on the human skin for a long time.

Clinical features. The movement of *Sarcoptes scabiei* and eggs inside the tunnels cause local inflammation. This allergic reaction causes very intense rashes. People who have never been exposed to scabies develop allergic response within six weeks.

Those who have had scabies previously will get the rash within a few days. On average there are only a few fertile female mites per infected person. These kind of infections can be harmless and the victim might not even notice it.

The diagnostics. The visual diagnosis can by suspected on the base of topical dermatological picture. The channels of an itch mite are straight and winding thin strips of dirty-white color, 5-8 mm long. They rise over the skin a little bit and look like a healed scratch. Along the channel there are dark spots – holes. In order to see it clearer the skin may be painted with iodine and then wiped. At the blind end of such a channel there is a vesicle which is the location of an itch mite. For the diagnosis of scabies the vesicle and cover of a scabiosa channel are opened by scalpel, the received material is examined with a microscope.

The personal **preventive measures** are in following personal hygiene rules (cleanliness of the body and clothes, avoiding the contact with a sick man and his things).

The public preventive measures are treatment of patients, disinfection of wearing, stations, hotels, transport, sanitary-instructive work.

Family *Demodicidae*

Demodex folliculorum

Systematic position in the zoological classification: Kingdom Animalia
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Chelicerata*
Class *Arachnoidea*
Order *Acari*
Family *Demodicidae*
Genus *Demodex*
Species *Demodex folliculorum*

The *Demodex folliculorum* has worm-like body (female up to 0,38 mm; male up to 0,3 mm) (fig. 86). *Demodex folliculorum* is a parasite of human skin. They causes demodecoses. They are very fertile. The ticks can be found in sebaceous glands and hair follicles of face, neck, shoulders (fig. 87). They can be found in healthy people. In the weak people who are inclined to allergies worm-like ticks can reproduce intensively causing the obstruction of sebaceous glands ducts. It causes the appearance of pink pimples with pus. The infection takes

place during the contact with a patient. 40-60% of the population have worm-like ticks that live like commensals.

The diagnostics is based on revealing of mites while microscoping in drop of 50% glycerin solution.

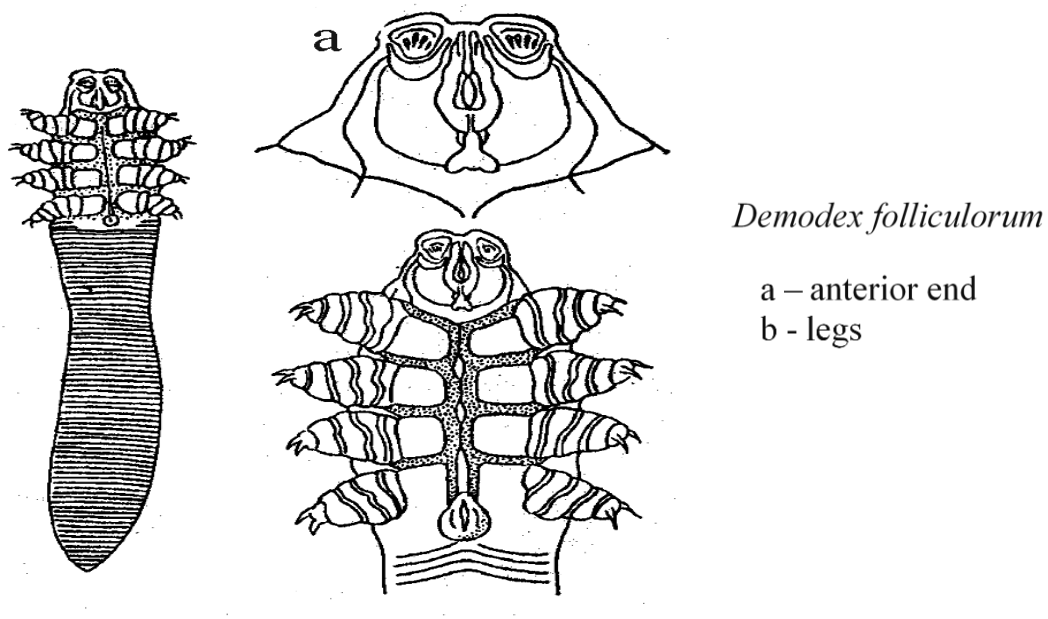


Figure 86. *Demodex folliculorum* (Berlese)

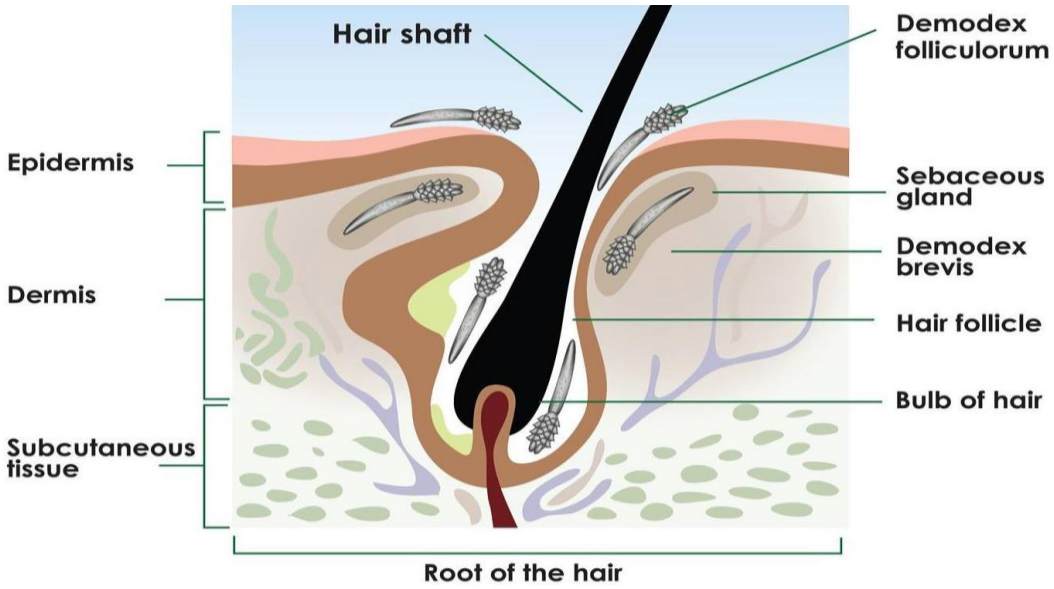


Figure 87. *Demodex folliculorum* (http://blog.rosacea-info.de/wp-content/uploads/2015/10/Fotolia41532281Scopyright_Demodex.jpg)

Preventive measure. The personal preventive measure is in following personal hygiene rules and treating diseases, which make organism weaker. The social preventive measures are treatment of ill, disinsection of wearing, sanitary-instructive work.

MEDICAL ENTOMOLOGY

Subphylum *Tracheata*
Insecta Class

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Arthropoda*

Subphylum *Tracheata*

Class *Insecta*

Insects are the highest class of arthropods. This class includes about 1 million of species.

Morphology. Their body consists of head, thorax and abdomen (fig. 88, 89).

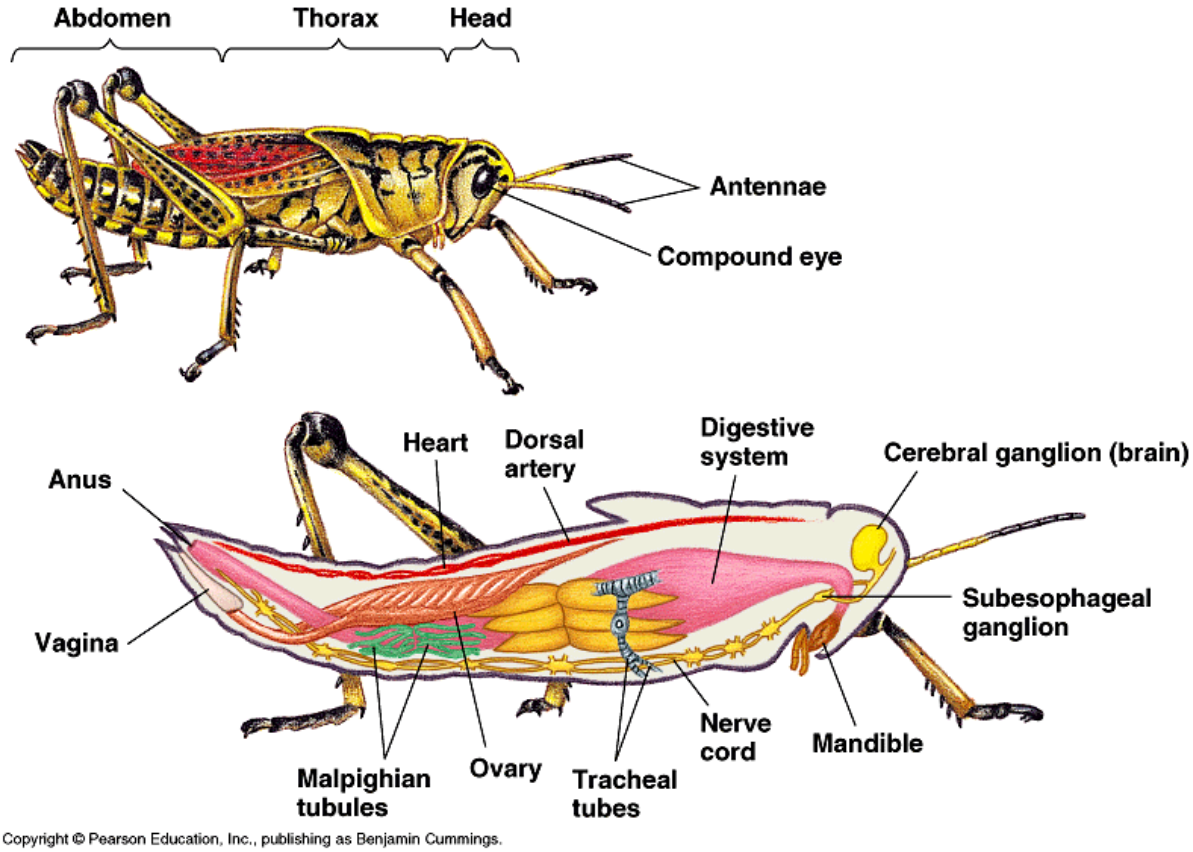


Figure 88. The structure of Insects
(https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcSyps06dWHj555Zh_ofttAXH2BbqWGaCIBPEcClvv9CY1Hl_PUW)

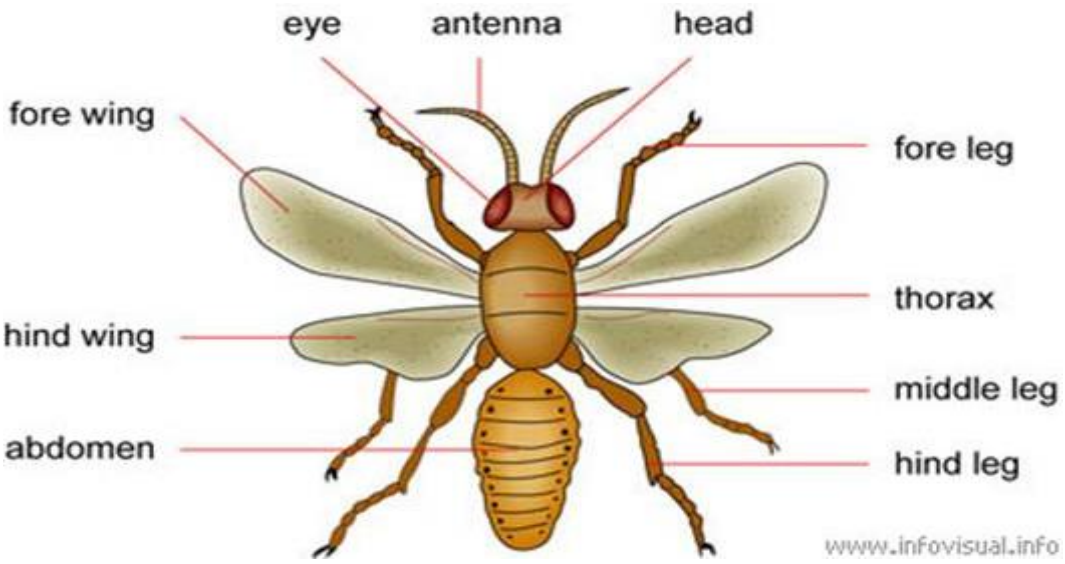


Figure 89. Morphology of flying insect

The organs of sense are at the head, they are one pair of antennae, simple or compound eyes and a complex mouth apparatus.

The *Insecta* have 6 pairs of legs. The thorax consists of three segments, to each of which one pair of legs is attached (three pairs of walking legs). The majority of insects have two pairs of wings on the thorax. Some of the members of class *Insecta* are wing-less (louses, flea and bed bugs). The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw (mandibula), the second pair to lower jaw (maxilla), the third pair to the lower lip. Upper lip is an outgrowth of chitin. The types of mouth apparatus: gnawing-masticating, licking-sucking, piercing-sucking. The organs of sense are at the head, they are antennae, compound eyes (facets).

The abdomen does not have legs.

The rest systems of organs correspond to the organization of arthropods.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, esophagus. Esophagus has dilatation, called craw. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpigian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body. The eyes are compound, but they can be simple too. The organs of balance, taste, smell and, sometimes, hearing are present.

The insects are dioecious (unisexual). They have good expressed sex dimorphism. The females are larger than males.

There are two way of development: direct and indirect. Indirect development or development with metamorphosis may be complete or incomplete.

The complete metamorphosis includes the stages of egg, larva, pupa (or chrysalis) and imago.

The incomplete metamorphosis includes the stages of egg, larva and imago. The pupa is absent.

The first stage in this development, after the egg, is that of the larva. The pupa is the next stage of development of an insect, does not eat and as a rule is incapable of locomotion. Under a thick covering of chitin a reconstruction of all the organs of the larva occurs within the body of the pupa. In the adult stage an insect is called an imago.

The medical importance of insects consists first of all in the fact that they are the carriers of dangerous epidemiological illnesses that affect big masses of people. Besides, there are a lot of ectoparasites and venom forms among the insects.

Medical importance of insects:

- mechanical carriers of pathogenic organism (cockroaches, flies);
- specific carriers of pathogenic organism (bugs, flies, fleas, mosquito);
- among the insects that have medical importance there are the following groups;

- temporary blood-sucking ectoparasites (mosquito);
- constant blood-sucking parasites (lice);
- tissue and cavity larval parasites (Wohlfahrtia fly or Blowfly);
- synantropic species that are not parasites (flies, cockroaches).

The *Blattodea* Order

Systematic position in the zoological classification:
Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Blattodea*

Cockroaches are domestic parasites (fig. 90). They spoil foodstuffs, causing economic damage.

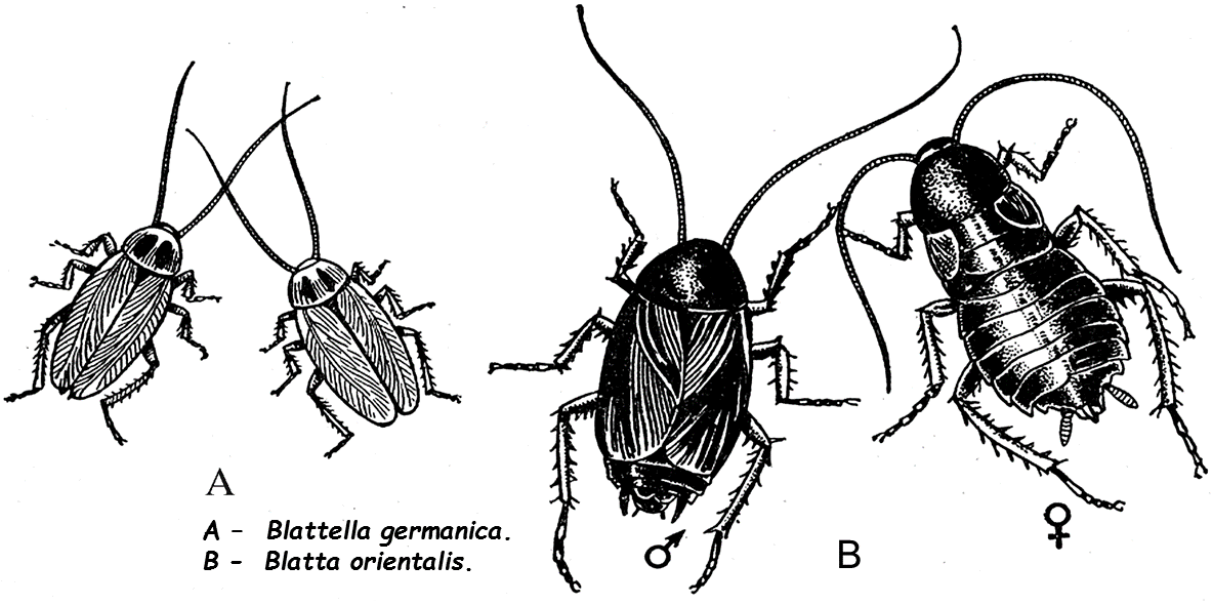


Figure 90. Cockroaches

It is known about 3,5 thousands of species in this Order. In the human dwelling, the *Blatta orientalis* (black cockroach), *Blatta germanica* (red cockroach), *Polyphaga saussurei* (Egypt's cockroach), *Periplaneta Americana* (American cockroach) occur. They are active at nighttime.

Peculiarities of structure. Their body consists of head, thorax and abdomen.

The organs of sense are at the head, they are feelers (two antennae), compound eyes and a complex mouth apparatus.

The cockroaches have 6 pairs of legs. The thorax consists of three segments, to each of which one pair of legs is attached (three pairs of walking legs). They have two pairs of wings on the thorax. The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw, the second pair to lower jaw, the third pair to the lower lip. Upper lip is an outgrowth of chitin. The types of mouth apparatus: gnawing-masticating.

The abdomen does not have legs.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, oesophagus. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: gnawing-masticating.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpigian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body. The eyes are compound. The organs of balance, taste, smell and hearing are present.

The insects are dioecious (unisexual). They have good expressed sex dimorphism. The females are larger than males. They have incomplete metamorphosis, that includes the stages of egg, larva and imago. The pupa is absent.

Medical importance. They are mechanical vectors of different infections and invasions. They can infect foodstuffs by bringing infection on their legs. Thus, the exciters of diphtheria, typhoid, cholera, cysts of *Protozoa*, helminthes eggs can be transmitted. The bacteria of typhoid and dysentery can survive in the cockroach gut for 2-4 days.

There are several methods of killing cockroaches. The most effective is poisoned bait. The intensive disinsection only decrease their number. It is due to having special valves, which close tracheae in presence of poisons. In addition, they have wide genetical polymorphism and good ability to adapt in any situation.

Order *Hemiptera*

Systematic position in the zoological classification:
Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Hemiptera*

There are about 40 thousands species of chinches. The size of a female is 4,8-8,4 mm, of a male – 4,9-6,4 mm. The body of the bed-chinch is brown, flattened in a dorsal ventral direction and is divided into the head, thorax and abdomen. The organs of sense are at the head, they are feelers (two antennae), compound eyes and a complex mouth apparatus. The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw, the second pair to lower jaw, the third pair to the lower lip. Upper lip is an outgrowth of chitin. The types of mouth apparatus: piercing-sucking. The oral apparatus forms two canals. One of them is for sucking fluid food (blood); the other is for excretion of salivary glands secret. Mesothorax has the rudiments of the front pair of wings. The chinches have 6 pairs of walking legs. The thorax consists of three segments, to each of which one pair of legs is attached. The abdomen does not have legs.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, esophagus. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: piercing-sucking.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpigian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body. The eyes are compound. The organs of balance, taste, smell and hearing are present.

The insects are dioecious (unisexual). They have good expressed sex dimorphism. The females are larger than males. They have incomplete metamorphosis, that includes the stages of egg, larva and imago. The pupa is absent.

Only representatives of *Cimicidae* and *Reduviidae* families have medical importance.

Bed-chinch (*Cimex lectularius*) is world spread. It is most adapted to parasite being. The body is flat; the wings are reduced. They attack human being at night. They have rest at daytime. Bed-chinch sucks blood throughout whole life.

Medical importance of *Cimex lectularius* (fig. 91). The role in transmitting exciters of diseases was not proved.

The kissing chinches (*Triatoma genus*) are spread in South and Central America (fig. 92). They can fly. They are sanguivorous on all development stages. They bite painless. They bite prevalently near the lips, therefore they was named «kissing chinches».

Medical importance of kissing chinches. They are specific vectors of Chagas's disease exciters – *Trypanasoma cruzi*.

Figure 91. *Cimex lectularius*
(https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcTTo0YMw5oF9IivlCJwNzyPfD2_w-7JpJdoMXAAHpJ99uEGxpuiCw)

Figure 92. Kissing chinch
(https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcSH904Uemkz4MFKTEXhNnDahw--RpGU2Ud0Ufi2OXdCvb60gX5jog)

Order *Anoplura*

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Arthropoda*

Subphylum *Tracheata*

Class *Insecta*

Order *Anoplura*

Lice are permanent ectoparasites of the human and are seen in all parts of the world.

Peculiarities of structure. Their body consists of head, thorax and abdomen. The organs of sense are at the head, they are feelers (two antennae), simple eyes and a complex mouth apparatus.The Lice have 6 pairs of legs. The thorax consists of three segments, to each of which one pair of legs is attached (three pairs of walking legs). Their walking legs have the apparatus of fixation to the skin, hair, clothes and they cannot provide quick movement. Wings are absent. The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw, the second pair to lower jaw, the third pair to the lower lip. Upper lip is an outgrowth of chitin. The type of mouth apparatus is piercing-sucking.

The abdomen does not have legs.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, esophagus. The saliva contains cementing substance. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: piercing-sucking and adapted for blood sucking.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpigian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body. The eyes are simple.

They are dioecious (unisexual). They have good expressed sex dimorphism. The females are larger than males. They have incomplete metamorphosis, that includes the stages of egg, larva and imago. The pupa is absent.

The lice are characterized by adaptations to ectoparasiting. All the stages of life cycle take place on the organism of one host.

Human lice are of three types (fig. 93): head louse (*Pediculus humanus capitis*), body louse (*Pediculus humanus humanus*), pubic or crab louse (*Phtirus pubis*).

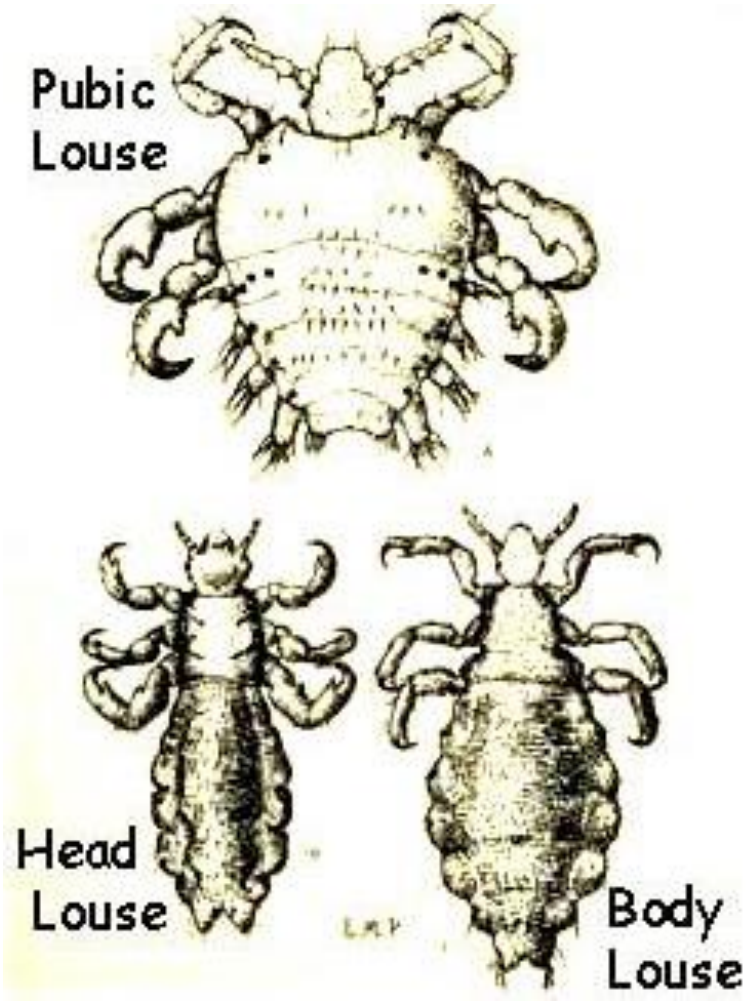


Figure 93. Human lice
(https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcT-_FtUIqQSpTSVrmZx7FqgsxPDQU0PaaHoC19CBDaw3q9yGBeO)

Life cycle. Stages of life cycle: egg, larvae, puberal form (adult). Eggs (nits) are laid on the hair and seams of clothes. They are attached there by a cementing substance. Larvae come out of the eggs after 6-9 days. They look like adults, but are smaller. They moult three times in 10-15 days. Lice are transmit-

ted by a direct contact or through clothing, combs, hair brushes. The transmission is the highest in crowded, institutionalized conditions or during the war or prisons. Lice are known to leave their host if the host's body temperature rises above or falls below norm.

***Pediculus humanus capitis* (Head louse)**

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Anoplura*
Species *Pediculus humanus capitis*

Peculiarities of structure. The size is 2-3 mm. Louse's body grayish color, it is flattened in a dorsal-ventral direction and is divided into the head, thorax and abdomen. Its head is oval, narrowed to the front. On the head there are a pair of simple eyes and a pair short antenna (feelers). The type of mouth apparatus is piercing-sucking and adapted for blood sucking. On the sides of the thorax there are dark pigment spots. The thorax is not segmented, it is significantly narrower than the abdomen and sharply separated from it. On the sides of the thorax there are three pairs of legs, which end with small claws. The abdomen has 9 segments. There are deep cuts between the segments of the abdomen.

In females the end of the abdomen is bifurcated, in males it is rounded. Lice do not have wings.

The place of location of Head louse is the hair part of a head.

Medical importance. Head louse is ectoparasite and causative agent of pediculosis (the lice' saliva has toxic effect, causes itching and burning pain). Infection with the lice is called pediculosis. The way of pediculosis invasions is contact. The bites of lice lead to red papules which exude and itch. Scratching in response to intense pruritus (itch) leads to dermatitis and secondary infection. Head louse is carrier of causative agents of louse-borne typhus.

***Pediculus humanus humanus* (Body louse)**

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*

Phylum *Arthropoda*

Subphylum *Tracheata*

Class *Insecta*

Order *Anoplura*

Species *Pediculus humanus humanus* (Body louse) (fig. 94).

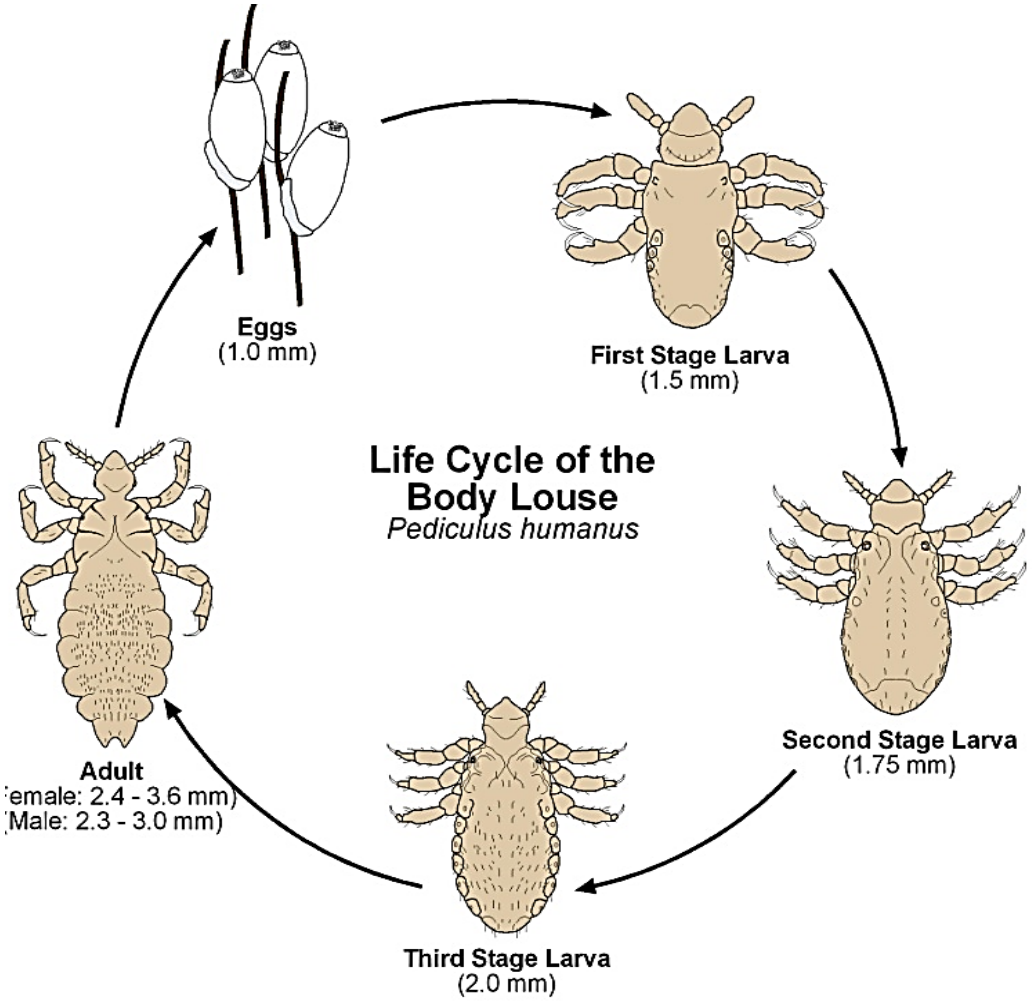


Figure 94. Life cycle of *Pediculus humanus humanus* (https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQxzb_chZ4LoMhibowxubcNJpjAOM2sC_Xc0NpdZkgN25B9lko7)

Peculiarities of structure. Size is 3-5 mm. The body consists of head, thorax, abdomen and flattened dorsoventrally. Antennae are thinner and longer. The type of mouth apparatus is piercing-sucking and adapted for blood sucking.

The thorax is almost square and has three pairs of legs with claws at their ends. The abdomen has 9 segments. *Pediculus humanus humanus* has light color. The cuts between the segments of the abdomen are less deep, there are no pigment spots on the sides of the body. Lice do not have wings.

The place of location of body louse is on the body and clothes of man.

Medical importance. *Pediculus humanus humanus* is carrier of causative agents of louse-borne (epidemic) typhus and recurrent (relapsing) fever.

***Phtirus pubis* (crab louse)**

Systematic position of in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Anoplura*
Species *Phtirus pubis*

Crab lice (also known as «crabs» and «pubic lice») are parasitic insects notorious for infesting human genitals (fig.93, 95).

The species may also live on other areas with hair, including the eyelashes. They feed exclusively on blood. Humans are the only known hosts of this parasite.

It has a short and wide body with a length of 1-1,5 mm. The thorax is wider then the abdomen and is vaguely separated from it. The head is square-shaped and is relatively big. It has piercing-sucking mouth apparatus.

Infestation with pubic lice is called phthiriasis pubis, while infestation of eyelashes with pubic lice is called phthiriasis palpebrarum.

Pubic lice usually infect a new host only by close contact between individuals, usually through sexual intercourse. Parent-to-child infestations are more likely to occur through routes of shared towels, clothing, beds or closets. Adults are more frequently infested than children. As with most sexually transmitted pathogens, they can only survive a short time away from the warmth and humidity of the human body.

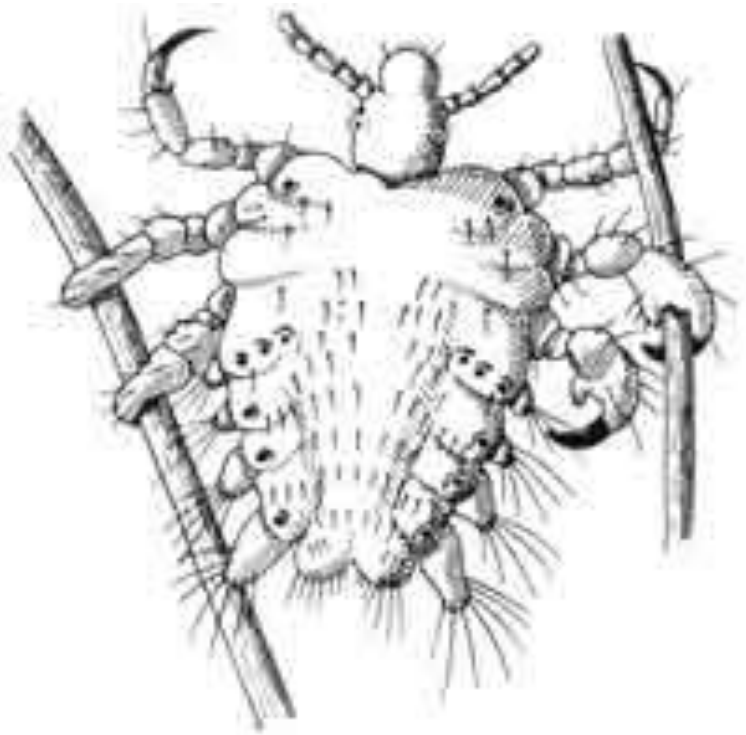


Figure 95. *Phtirus pubis*
(https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9Gc
R1wRrepDrYzo3ThLigvaAzvmNVrN1ledDqqBWEddlP1bT2RVag)

Symptoms. The main symptom is itching, usually in the pubic-hair area, resulting from hypersensitivity to louse saliva, which can become stronger over two or more weeks following initial infestation.

Medical importance is a crab louse is not known as a vector of any disease.

Prevention of pediculosis and infectious diseases which are earned by lice. Personal prevention are regular washing of the head and body, change of clothes; for eliminating insecticides are used. Public prevention are obligatory hospitalization and treatment of patients.

Order *Aphaniptera*

Systematic position in the zoological classification:
Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*

Class *Insecta*

Order *Aphaniptera*

Species *Pulex irritans* (Human flea)

Xenopsylla cheopis (Oriental rat flea)

The fleas are wingless, sanguivorous ectoparasites of human, animals and birds.

Peculiarities of structure of Human flea. The size is 1-5 mm. The body is yellow or brown, flattened from the sides and covered by thin hairs. The head is rounded and has a pair of ocelli, a pair of short clavate antennae and piercing-sucking mouth apparatus. The thorax has three segments and three pairs of legs, the third pair is long and is used for jumping. The abdomen consists of 10 segments.

The body is covered by chitinous exoskeleton. Their bodies are laterally compressed, permitting easy movement through the hairs or feathers on the host's body (or in the case of humans, under clothing). The flea body is hard, polished, and covered with many hairs and short spines directed backward, which also assist its movements on the host.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, oesophagus. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: piercing-sucking and adapted for blood sucking.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpighian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body. The eyes are simple.

They are dioecious (unisexual). They have good expressed sex dimorphism. The females are larger than males.

Life cycle. Development occurs with complete metamorphosis. Life cycle passes through stages of egg, larva, crysalis (pupa) and adult (imago). Eggs are laid in the floor slots, dust, rat holes. Adult fleas can live for 1 to 4 years. Both sexes can bite and suck blood (fig. 96).

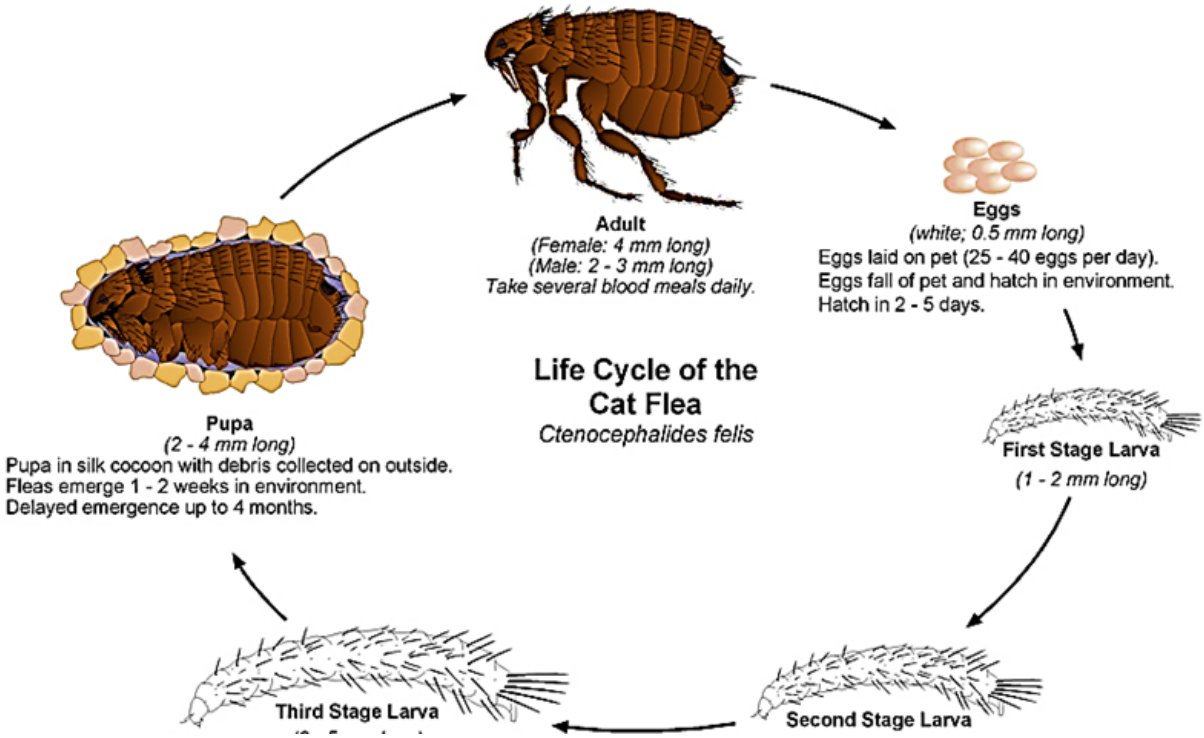


Figure 96. Life cycle of Cat Flea
(https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcSU3aTvCOqjNq-CoNO2q7s9bILRStTDe1PHvion8CX5I2ToL0RG)

Medical importance. It is ectoparasite and specific carrier of plague agents. Causative agent of plague is plague bacillus.

Epidemiological chain of plague: reservoir (mammalia, birds and sick people); carrier (flea); recipient (healthy man).

Bites of infected *Pulex irritans* or *Xenopsylla cheopis* transmit plague bacillus (causative agent). They transmit disease more effectively when their food passage is blocked by multiplying bacteria of plaque. To overcome this block,

the flea regurgitates the stomach contents into the bite wound before it can suck blood. The regurgitated fluid contains many bacteria causing infection.

Measures of struggle against fleas are maintaining cleanliness in rooms, moist tidying, elimination of floor cracks, use of insecticides.

Order *Diptera*

Systematic position in the zoological classification:
Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Diptera*

This order has largest number of species among insects (more than 80 thousands of species). The body of Order *Diptera* consists of head, thorax and abdomen. Ball shaped head is very mobile. The organs of sense are at the head, they are feelers (two antennae), simple or compound eyes and a complex mouth apparatus. They have 6 pairs of legs. The thorax consists of three segments, to each of which one pair of legs is attached (three pairs of walking legs). The second segment of thorax bears one pair of wings. The typical feature of them is absence of second pair of wing and the third segment of the thorax bears the halteres, which help to balance the insect during flight. The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw (mandibula), the second pair to lower jaw (maxilla), the third pair to the lower lip. Upper lip is an outgrowth of chitin. The types of mouth apparatus are licking-sucking or piercing-sucking. The abdomen does not have legs.

The rest systems of organs correspond to the organization of arthropods.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, esophagus. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: licking-sucking or piercing-sucking.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpighian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body.

They are dioecious (unisexual). They have complete metamorphosis, that includes the stages of egg, larva, pupa and imago.

Family *Culicidae*

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Diptera*
Family *Culicidae*
Genus *Anopheles*, *Culex*, *Aedes*

The body of Family *Culicidae* consists of head, thorax and abdomen. Ball shaped head is very mobile. The organs of sense are at the head, they are feelers (two antennae), compound eyes and a complex mouth apparatus. They have 6 pairs of legs. The thorax consists of three segments, to each of which one pair of legs is attached (three pairs of walking legs). The second segment of thorax bears one pair of wings. The typical feature of them is absence of second pair of wing and the third segment of the thorax bears the halteres, which help to balance the insect during flight. The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw (mandibula), the second pair to lower jaw (maxilla), the third pair to the lower lip. Upper lip is an outgrowth of

chitin. The types of mouth apparatus: piercing-sucking. The feeding structure of the mosquito is the proboscis. The mandibles and the maxillae are used for piercing the skin. Lips gripping the upper and lower jaws and form a proboscis. The hypopharynx and the upper lip are both hollow. Saliva with anticoagulant is pumped down the hypopharynx to prevent clotting. The abdomen does not have legs.

The rest systems of organs correspond to the organization of arthropods.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, oesophagus. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: piercing-sucking. The Family *Culicidae* are sanguivorous insects. The thin proboscis of females can pierce to capillaries. Many species suck blood at twilight, at night or at sunrise.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpigian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side. Eyes are compound.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body.

They are dioecious (unisexual). They have complete metamorphosis, that includes the stages of egg, larva, pupa and imago (fig. 97).

In this family, there are three important genera *Anopheles, Culex,* and *Aedes*. They are spread worldwide.

The eggs of *Anopheles* mosquitoes differ from eggs of *Culex* and *Aedes* Mosquitoes.

The *Anopheles* mosquitoes lay eggs separately on the water surface. Each egg has a curved inward belt. It also has swimming chambers. Eggs of *Culex* have no belt and chambers. They lay eggs by groups on water surface. The *Aedes* lay eggs on wet land near intermittent rivers and ponds by groups or separately.

The *Anopheles* larvae have one pair of breathing openings on next to last segment of abdomen. They lay horizontally in the water. The *Culex* and *Aedes* larvae have breathing tubes (siphon) on next to last segment of abdomen. They lay at an angle to the water surface.

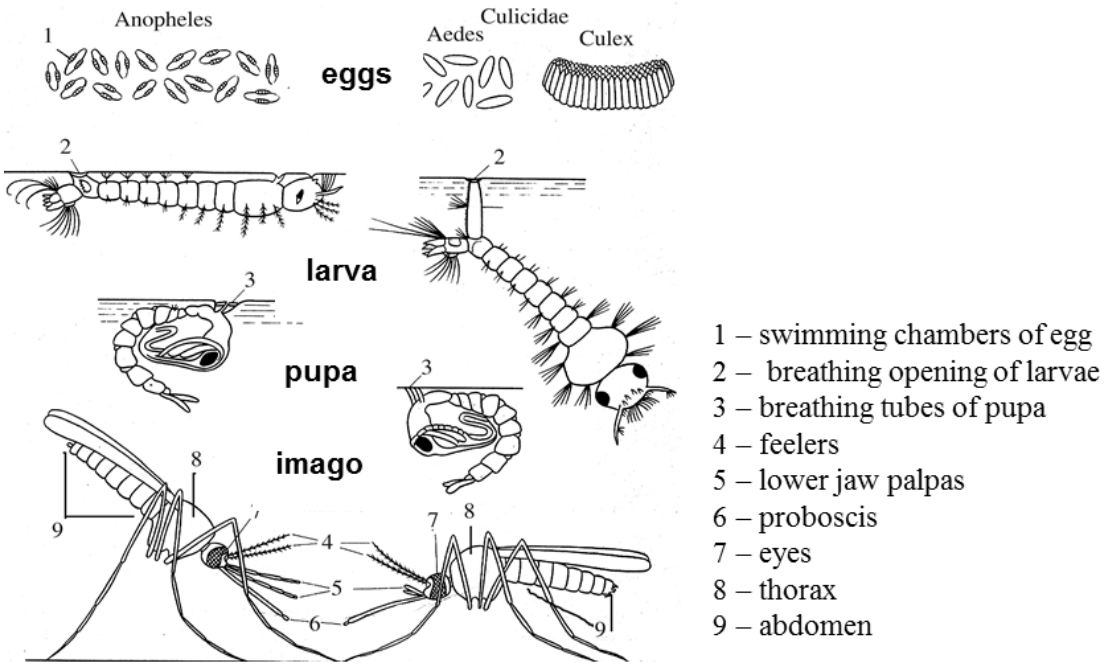


Figure 97. Life cycle of mosquitoes

The *Anopheles* pupa has breathing tubes of conical shape, whereas *Culex* pupa has cylindrical breathing tubes.

The mature mosquitoes have differences in head appendages structure, wings color, and landing pattern. The *Anopheles* females have lower jaw tentacles or palps (maxillary tentacles or palps) as long as proboscis is. The *Culex* females have lower jaw palps (maxillary palps) which smaller than proboscis in four times.

The *Anopheles* males have lower jaw palps (maxillary palps) with mace-shaped bulge on the end. It is as long as proboscis is. The *Culex* males have lower jaw palps (maxillary palps) longer than proboscis and without mace-shaped bulge on the end (fig. 98).

The *Anopheles* mosquitoes have dark spots on the wing, which are absent in *Culex*. Landing on the skin, the *Anopheles* mosquitoes keep their body at the angle to the skin surface. They direct their abdomen outward. The *Culex* mosquitoes keep their body parallel to the skin or directed to the skin.

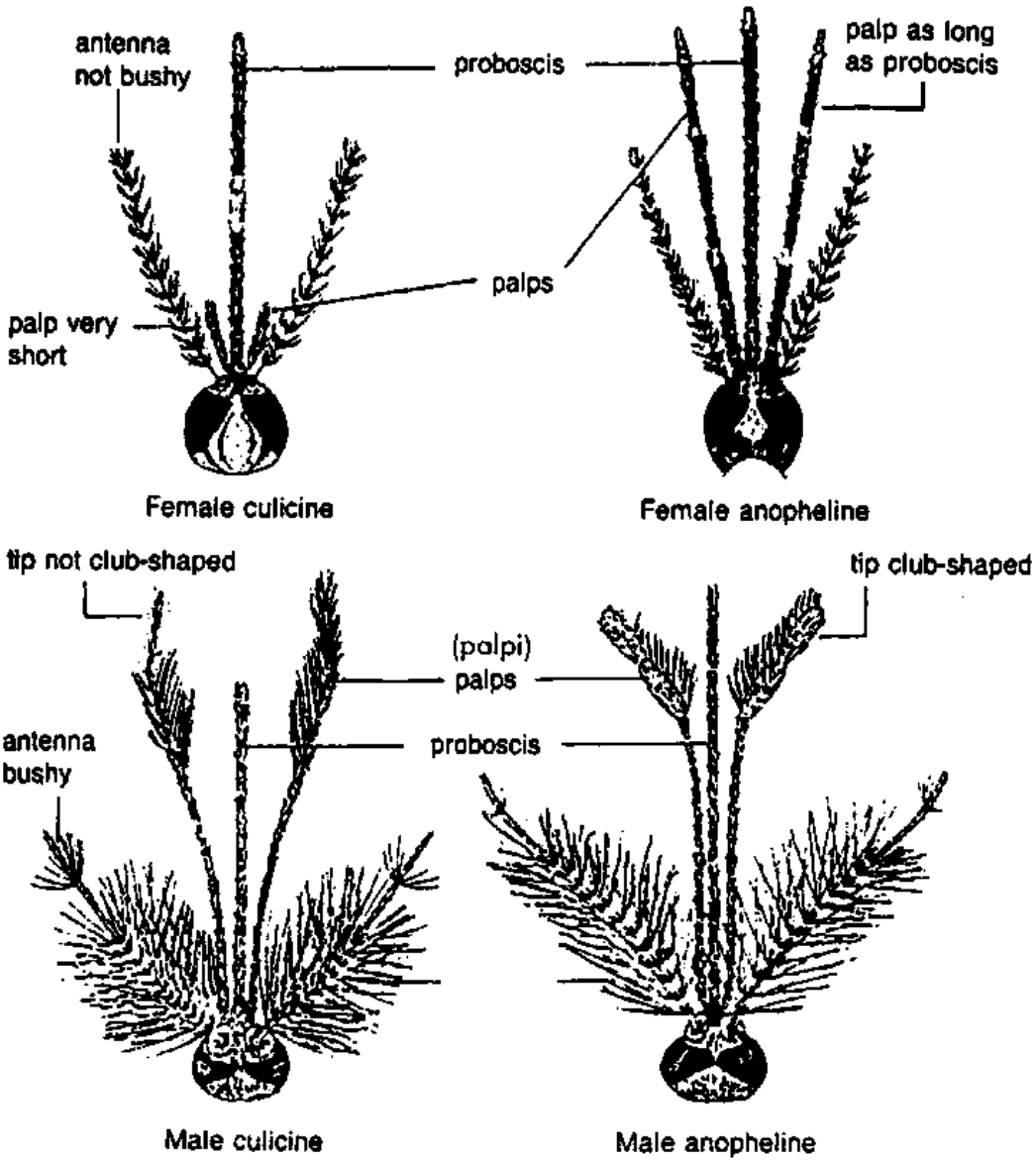


Figure 98. Difference between Male and female mosquitoes
(http://www.nzdl.org/gsdl/collect/who/archives/HASH017f.dir/p008.gif)

Medical importance. The mosquitoes of *Anopheles* genus are definite hosts and specific vectors for malaria exciters. They transmit it to the human being by specific inoculation. The oral apparatus of female is of piecing-sucking type (because of blood sucking), the oral apparatus of male is of sucking type (feeding by nectar).

The *Anopheles* mosquitoes live near human dwelling. They start to fly at twilight. The female sucks blood after fertilization. It is needed for eggs development. Then, the females fly to the dark places. There, they stay for 2-12 days digesting food. At spring and summer, the eggs are formed. Then, females fly to the nearest pond and lay ova on the water surface. At autumn, the blood is used for fat body formation to survive at winter. It can spend a winter in vaults and basements. At spring, these females lay the eggs. Later, after blood sucking, the spring and summer females lay their eggs. After laying the eggs, the females fly searching new food. They can lay eggs several times during one season.

In tropics, the *Anopheles* mosquitoes are specific vectors for exciters of lymphatic filiariasis (*Wuchereria bancrofti, Brugia malai*).

The *Culex* mosquitoes are specific vectors for exciter of Japanese encephalitis, West Nil encephalitis, wuchereriasis and brugiasis.

The *Aedes* mosquitoes maintain circulation of yellow fever virus, Japanese encephalitis virus, exciters of lymphatic filiariasis (*Wuchereria bancrofti, Brugia malai*) in the nature.

For individual protection from mosquitoes biting, the repellents and mechanical devices (nets) are used. The fight against mosquitoes is directed to interrupting life cycle on a stage of water larvae. For this purpose, the wild pond should be filled up by sand. It is possible to use insecticides to kill larvae in small pond with high concentration of larvae. The biological methods are also effective. Thus, in Transcaucasia, it was successful rearing of gambusia fish, which eat mosquito larvae. It results in decreasing mosquito population in several times.

The family Sandfly (*Phlebotomidae*)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Diptera*
Family *Phlebotomidae*
Species *Phlebotomidae pappatasii* (Sandfly)

Sandflies are small (1,2-3,7 mm long) insects, golden-brown or grey color of body. The body of Family *Phlebotomidae* consists of head, thorax and abdomen (fig. 99). Ball shaped head is very mobile. The organs of sense are at the head, they are feelers (two antennae), compound eyes and a complex mouth apparatus. They have 6 pairs of legs. The thorax consists of three segments, to each of which one pair of legs is attached (three pairs of walking legs). The second segment of thorax bears one pair of wings. The typical feature of them is absence of second pair of wing and the third segment of the thorax bears the halteres, which help to balance the insect during flight. Wings and body is covered by setae. The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw (mandibula), the second pair to lower jaw (maxilla), the third pair to the lower lip. Upper lip is an outgrowth of chitin. The types of mouth apparatus: piercing-sucking. The feeding structure of the mosquito is the proboscis. The mandibles and the maxillae are used for piercing the skin. Lips gripping the upper and lower jaws and form a proboscis. The hypopharynx and the upper lip are both hollow. Saliva with anticoagulant is pumped down the hypopharynx to prevent clotting. The abdomen does not have legs.

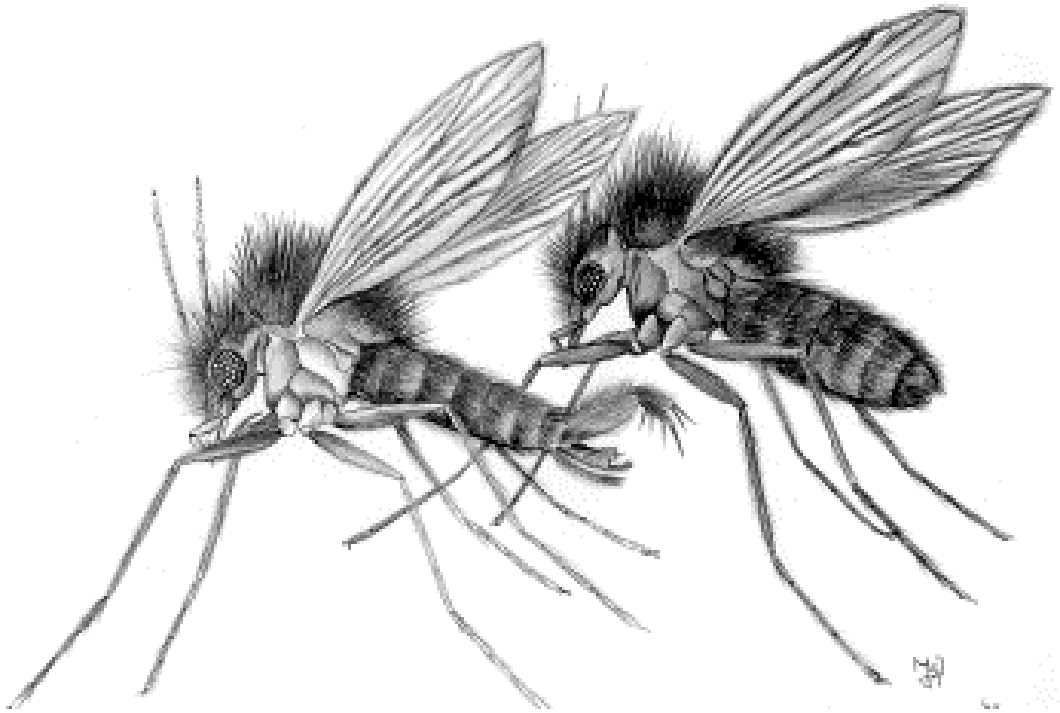


Figure 99. Sandfly of Family *Phlebotomidae*
(https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcQlBqy-_rRwJF7GmNUvoJglcqnuRu5VVqKRjUpTVZViv_vpKKrS)

The rest systems of organs correspond to the organization of arthropods.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, esophagus.The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: piercing-sucking. The Family *Phlebotomidae* are sanguivorous insects. The thin proboscis of females can pierce to capillaries. Many species suck blood at twilight, at night or at sunrise.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes that will collect wastes from their blood and put it into the intestines. The Malpighian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side. Eyes are compound.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body.

The insects are dioecious (unisexual). They have complete metamorphosis, that includes the stages of egg, larva, pupa and imago.

They lay eggs in rodent burrows, where is high humidity and many organics. The larvae develop two months. Then, they transform to pupa for 10-12 days. The pupa gives rise to imago.

They are twilight insects. They are very active during several hours after sunset. They fly near the land with many landings. If wind rise over two meters per second, they cancel flying. They live in villages (in farm buildings where is conditions for arthropods development), as well as, in rural areas (rodent burrows, caves, tree hollows).

Medical importance. The Sandflies' biting is very painful. It causes itching with inflammatory reaction. If a human being was bitted many times, he can

have troubled sleep, risen temperature, and fatigue. Such type of Sandflies is specific vectors for exciters of leishmaniasis and phlebotomic fever. The virus of phlebotomic fever is transmitted by transovarial way.

For individual protection, the repellents and nets are applied. The fighting against Sandflies is performed with help of insecticides.

Family *Muscidae* (real flies)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Diptera*
Family *Muscidae*

The sizes of flies can vary from 6-8 mm to 18 mm. The body of Family *Muscidae* consists of head, thorax and abdomen. Ball shaped head is very mobile. The organs of sense are at the head, they are two antennae, compound eyes and a complex mouth apparatus. They have 6 pairs of legs. The thorax consists of three segments, to each of which one pair of legs is attached (three pairs of walking legs). The second segment of thorax bears one pair of wings. The typical feature of them is absence of second pair of wing and the third segment of the thorax bears the halteres, which help to balance the insect during flight. The first three pairs of legs transformed into part of the mouth apparatus: one pair to the upper jaw (mandibula), the second pair to lower jaw (maxilla), the third pair to the lower lip. Upper lip is an outgrowth of chitin. The types of mouth apparatus: licking-sucking. The abdomen does not have legs.

The body is covered by chitinous exoskeleton.

The muscles are striated.

The Digestive system consists of three parts of the intestine (anterior, middle and back). The digestive system starts from mouth. It continued by mouth cavity, in which ducts of salivary gland open, oesophagus. The digestion and absorption occurs in the middle intestine. The posterior intestine opens outside by anus. The types of mouth apparatus: licking-sucking.

The respiratory organs are presented by tracheae, which deliver air to all organs.

The excretory organs are malpighian tubes and coxal glands that will collect wastes from their blood and put it into the intestines. The Malpigian tubules are slender projections of the digestive tract. These are attached at the junction of the midgut and hindgut. This allows all waste to leave out of the anus. Thus in these animals both excretory and digestive wastes exit from the anus. The dissimilation products are crystals of uric acid.

The circulatory system is not well developed. It has no function of oxygen transportation. It is open. The heart and aorta are on the dorsal side.

The Nervous system is abdomen nervous chain type. It consists of a large ganglia, located in the head and small ganglia located in each segment of body. Eyes are compound.

The sexual system. The insects are dioecious (unisexual). They have complete metamorphosis, that includes the stages of egg, larva, pupa and imago.

The typical representatives of *Muscidae* are house fly (*Musca domestica*), market fly (*Musca sorbens*), biting fly (*Stomoxys calcitrans*) and tsetse flies (*Glossina palpalis, Glossina morsitans*).

Musca domestica

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Diptera*
Family *Muscidae*
Species *Musca domestica*

Peculiarities of structure. House flies are non-biting. Of these *Musca domestica* is the commonest house frequenting fly. It is 8 mm long. *Musca domestica* has a pair of compound eyes, a pair of antennae and a single retractile proboscis on its head. The types of mouth apparatus: licking-sucking. Its thorax has 2-4 dark longitudinal stripes (these are characteristic of the genus Musca), a pair of wings and 3 pairs of legs. Its abdomen is segmented and shows light and dark markings (fig. 100, 101).

Life cycle. Egg. About 150 eggs are laid on the decaying organic matter. Eggs hatch in about 8-24 hours to liberate larvae. The larvae (maggots) moult twice and increase from 2 mm to 12 mm in a week. These larvae then convert into pupae. Pupa (crysalis) is the resting stage and lasts for 3-6 days, after which an adult house fly comes out of the pupa. Adult house flies live for 15-25 days.

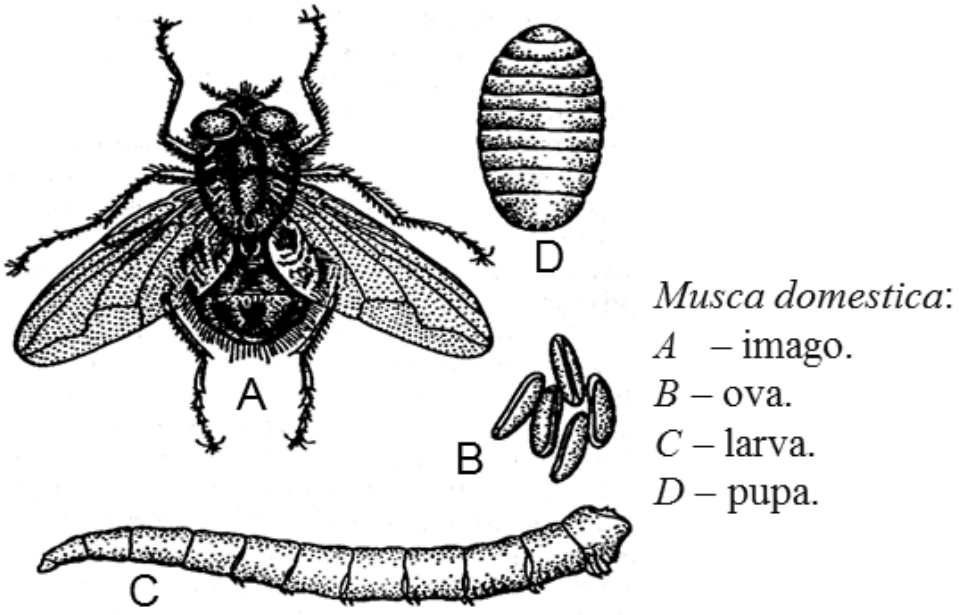


Figure 100. *Musca domestica* (Derbeneva-Uchova)

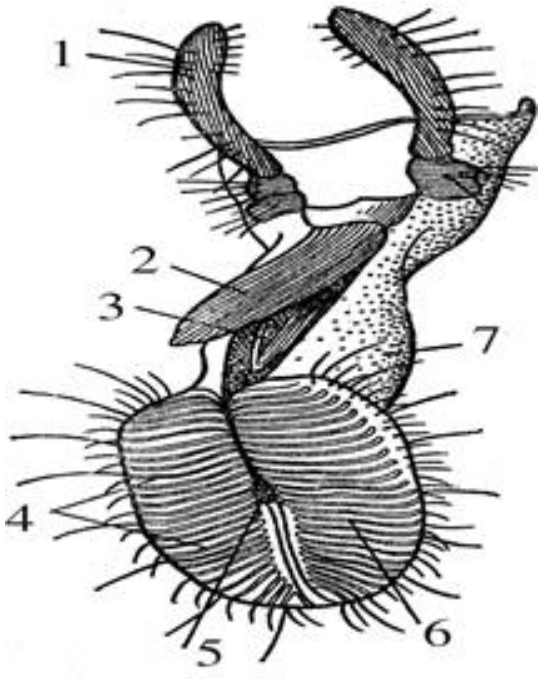


Figure 101. Mouth apparatus of *Musca domestica* (Schvanevich):
1 – palps; 2 – upper lip; 3 – hypopharynx (language); 4, 6 – the blades of the lower lip; 5 - channels of proboscis; 7 – lower lip

Medical importance. It is mechanical carrier of causative agents of several diseases: enteric fever, diarrhea, dysentery, cholera, amoebiasis, intestinal helminthiasis, poliomyelitis, trachoma, hepatitis. A housefly transports the infective agents on its feet from contaminated faeces to food. They cannot eat solid food. Therefore, they vomit on their food to dissolve and then suck it. The vomit drop is a rich bacterial culture. Their excrement contains bacteria, eggs, and cysts of intestinal parasites.

Control measures. Environmental measures are most important. A clean house with clean surroundings is the best fly control measure, using insecticides for eliminating of larva and flying forms.

Glossina palpalis (Tsetse fly)

Systematic position in the zoological classification:

Kingdom *Animalia*
Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Diptera*
Family *Muscidae*
Genus *Glossina*
Species *Glossina palpalis*

Peculiarities of structure. Tsetse flies inhabited in much of midcontinent Africa between the Sahara and the Kalahari Desert. They are yellow or dark brown and measure half an Inch length. A Tsetse fly has mouth apparatus adapted for skin piercing and blood sucking. It has a pair of wings that are folded on the back while resting (fig. 102).

Life cycle. A female Tsetse fly does not lay eggs. Larvae are produced. Larvae crawl beneath the soil surface and pupate within few hours. Adults emerge after 20 to 40 days. Adult Tsetse flies live for less than 100 days. Both sexes bite mainly during day. They attack humans, animals as well as birds. Tsetse flies do not enter houses.

Medical importance. Tsetse flies act as intermediate hosts of African trypanosomiasis (sleeping sickness). *Glossina palpalis* is the primary vector of

Gambian sleeping sickness and Glossina morsitans principally transmits Rhodesian sleeping sickness.

Measures of struggle against Tsetse fly: using of repellents; cutting down bushes; using insecticides for eliminating of imagoes.

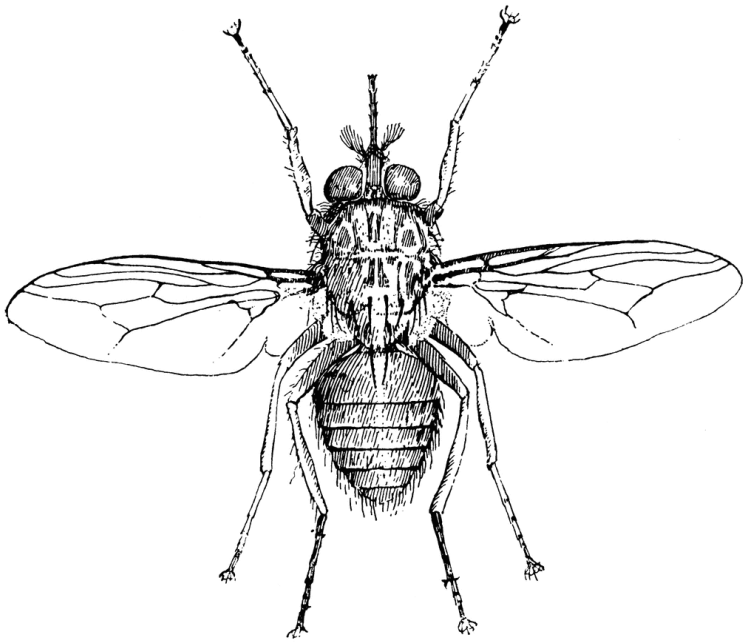


Figure 102. *Glossina palpalis*
(http://etc.usf.edu/clipart/47800/47873/47873_tsetse_fly_lg.gif)

Insects as causative agents of Myiasis

Myiasis is defined as the infestation of live vertebrates (humans and/or animals) with dipterous larvae. In mammals (including humans), dipterous larvae can feed on the host's living or dead tissue, liquid body substance, or ingested food and cause a broad range of infestations depending on the body location and the relationship of the larvae with the host.

Some species of dipterous insects (including the most common myiatic flies, the botfly, blowfly and screwwormfly or Wohlfarhtia magnifica) can create an infestation even on unbroken skin.

Insects as causative agents of cutaneous myiasis

Wohlfahrtia fly (*Wohlfarhtia magnifica)*

Systematic position in the zoological classification:

Kingdom *Animalia*

Subkingdom *Metazoa*
Phylum *Arthropoda*
Subphylum *Tracheata*
Class *Insecta*
Order *Diptera*
Family *Muscidae*
Species Wohlfahrtia fly (*Wohlfarhtia magnifica*).

Wohlfarhtia magnifica is found in southern Europe, Central Asia, the Middle East, North Africa, and China. Their range is increasing, believed to be because of spread of intensive sheep rearing (fig. 103).

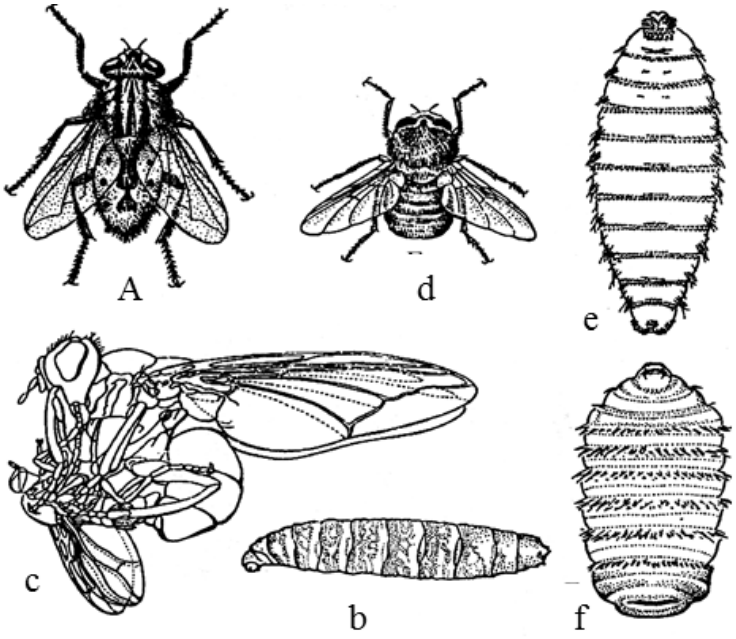
Wohlfahrtia magnifica, the spotted flesh fly, or sometimes called the screwworm fly. Adult flies have a dark color and reach about 10 mm length. The life cycle needs 4 to 6 weeks to be completed. Adult females are larviparous, i.e. they do not deposit eggs, but larvae that have already hatched inside the uterus before deposition. One female lays about 150 larvae in her lifetime. Larvae cause *cutaneous myiasis* in mammals, mainly in sheep, but also in cattle, goats, horses, and rarely in humans. In sheep, larvae chiefly infest genitalia or open wounds. In humans, larvae of Wohlfartia magnifica may infest the ear, eye, mouth or nose, damaging living tissues; they may also infest open wounds, including after surgery. Larvae feed for 4 to 8 days on the host's superficial tissues, which are progressively destroyed. Feeding larvae burrow deeply in the hosts flesh and may not be noticed when superficially examining the wounds. Mature larvae are up to 20 mm long. They drop to the ground for pupation. Adults emerge 4 to 12 days later.

Dermatobia hominis (human botfly)

It has a distribution ranging from northern Argentina to southern Mexico, and is usually found in warm, humid lowland forests. The larva of *Dermatobia hominis* causes cutaneous myiasis in humans and other mammals. Infestation of cattle has important economic consequences. Adult females deposit eggs on blood-sucking arthropods, which transmit the infectious larvae to the host (fig. 104).

Oestrus ovis (sheep bot fly)

It is a widespread species of fly of the genus Oestrus. It is known for its parasitic predation and damage to sheep, deer, goats and sometimes cattle. There have also been many records of horse, dog and human infestation. In some areas of the world it is a significant pest which affects the agricultural economy (fig. 103).



A – *Wohlfahrtia magnifica;*
b – larva of *Wohlfahrtia magnifica;*
c – female of *Dermatobia hominis*;
d – horse botfly *Gastrophilus intestinalis;*
e – larva of cavitary botfly *Oestrus ovis;*
f – larva of horse botfly *Gastrophilus intestinalis.*

Figure 103. Tissue and cavity larval parasites

Insects as causative agents of intestinal myiasis

Intestine myiasis take place when a human accidentally swallows the food containing small larvae of flies. The larvae that get into the intestine, especially in persons with low acidity of gastric juice can stay alive there and even develop. This leads to irritating and inflammation of the mucous membrane of the intestine, stomach ache, vomiting. Larvae are excreted with the stools.

Intestinal myiasis is usually an accidental phenomenon which is transient and asymptomatic.

More than 50 fly species to cause myiasis in human worldwide. Common species are *Musca domestica* (house fly), *Funnia* spp. (latrine fly), *Eristalis tenax* (rat tailed maggots) and *Muscina* spp.

Eristalis tenax is the most common species involved in intestinal myiasis and has a worldwide distribution, while *Musca domestica* common in India. Life cycle of fly is about 10-14 days. Adult fly lays its eggs on decaying food materi-

al and sometimes in an open wound, and these hatch into larvae which through one or more larval stage develop into pupa and finally converted to adult fly.

Clinical symptoms are variable ranging from asymptomatic cases to symptoms like abdominal pain, nausea vomiting, anal pruritis and rectal bleeding. It can manifest with severe clinical symptoms and invasive disease as in the present case, depending on the number and species of fly and their location in the intestinal tract.

The prevention of myiasis is by reducing the number of flies with sanitary measures and insecticides. Repellents, screening and protective clothing are useful. There is no specific treatment as larvae are insensitive to drugs. The source of infestation should be identified and eliminated. Vermicide purgative along with anti-inflammatory drugs are used. The correct diagnosis and eradication of flies can avoid the unnecessary treatment. Thorough washing, adequate cooking and proper storage of food or vegetables, fruits before consumption are preventive measures.

PROGRAM CONTROL

Examples of test items

1. INVASIONAL STAGE OF *ENTAMOEBA COLI* FOR A HUMAN IS
    1) trophozoites
    2) gametes
    3) pseudocysts
    4) cysts

2. THE WAY OF PENETRATION OF *ENTAMOEBA HISTOLYTICA* INTO HOST'S ORGANISM IS
    1) transmissible
    2) percutaneous
    3) alimentary
    4) contact-domestic

3. INVASIONAL STAGE OF *ENTAMOEBA GINGIVALIS* FOR A HUMAN IS
    1) trophozoites
    2) cyst
    3) pseudocyst
    4) gamete

4. THE TYPE OF REPRODUCTION OF *BALANTIDIUM COLI* IS
    1) conjugation
    2) budding
    3) schizogony
    4) sporogony

5. REPRESENTATIVES OF *APICOMPLEXA PHYLUM* DO NOT HAVE
    1) nucleus
    2) locomotory organelles
    3) endoplasmic reticulum
    4) Golgi apparatus

6. THE CAUSATIVE AGENT OF TROPICAL MALARIA IS

1) *Plasmodium falciparum*
2) *Plasmodium vivax*
3) *Plasmodium malariae*
4) *Acanthamoeba castellani*

7. THE NUMBER OF MEROZOITES IN MORULA STAGE OF *PLASMODIUM MALARIAE* IS

1) 6-8
2) 8-12
3) 12-18
4) 18-24

8. PATHOGENIC EFFECT OF *PLASMODIUM FALCIPARUM* ON THE HUMAN ORGANISM IS

1) ulceration on intestinal wall
2) ulceration on the skin
3) periodic fever
4) inflammation of the mucous membranes of the urogenital tract

9. THE FACTORS OF INVASION WITH *PARAGONIMUS WESTERMANI* ARE

1) water, contaminated with cysts
2) vegetables, fruit, greens, contaminated with ova
3) insufficiently cooked fish
4) insufficiently cooked crabs

10. INVASIONAL STAGE OF LUNG FLUKE FOR A HUMAN IS

1) miracidium
2) sporocyst
3) cercariae
4) metacercariae

11. THE WAY OF PENETRATION OF VESICAL BLOOD FLUKE INTO HUMAN ORGANISM IS

1) inoculation
2) percutaneous
3) transmissible
4) contact-domestic

12. INTERMEDIATE HOSTS OF MANSON'S BLOOD FLUKE ARE

1) bugs
2) dogs
3) snails
4) rodents

13. THE CAUSATIVE AGENT OF SCABIES IS

1) settlement tick
2) dog tick
3) itch-mite
4) taiga tick

14. THE DEVELOPMENT OF HUMAN ASCARIS OCCURS

1) with the change of hosts with migration
2) without the change of hosts with migration
3) with the change of hosts without migration
4) without the change of hosts and without migration

15. THE MEDICAL SIGNIFICANCE OF A COCKROACH IS THAT IT IS

1) mechanical carrier of cysts of Protists
2) carrier of a malarial *Plasmodium*
3) causative agent of myiasis
4) causative agent of trypanosomiasis

16. THE TYPE OF MOUTH APPARATUS OF BED BUG IS

1) piercing-sucking
2) licking-sucking
3) gnawing-licking
4) lapping

17. THE MEDICAL SIGNIFICANCE OF A WOHLFAHRTIA FLY IS THAT IT IS

1) mechanical carrier of cysts of Protists
2) carrier of a malarial *Plasmodium*
3) causative agent of myiasis
4) causative agent of trypanosomiasis

18. THE DEVELOPMENT OF HUMAN WHIPWORM OCCURS

1) with the change of hosts with migration
2) without the change of hosts with migration
3) with the change of hosts without migration
4) without the change of hosts and without migration

19. INVASIONAL STAGE OF CAT LIVER FLUKE FOR A HUMAN IS

1) miracidium
2) sporocyst
3) cercariae
4) metacercariae

20. THE FACTORS OF INVASION WITH *OPISTHORCHIS FELINEUS* ARE

1) water, contaminated with cysts
2) vegetables, fruit, greens, contaminated with ova
3) insufficiently cooked fish
4) insufficiently cooked crabs

21. PATHOGENIC EFFECT OF *ENTAMOEBA HISTOLYTICA* ON THE HUMAN ORGANISM IS

1) ulceration on intestinal wall
2) ulceration on the skin
3) periodic fever
4) inflammation of the mucous membranes of the urogenital tract

22. PATHOGENIC EFFECT OF *LEISHMANIA TROPICA* ON THE HUMAN ORGANISM IS

1) ulceration on intestinal wall
2) ulceration on the skin
3) periodic fever
4) inflammation of the mucous membranes of the urogenital tract

23. PATHOGENIC EFFECT OF *TRICHOMONAS VAGINALIS* ON THE HUMAN ORGANISM IS

1) ulceration on intestinal wall
2) ulceration on the skin
3) periodic fever
4) inflammation of the mucous membranes of the urogenital tract

24. INVASIONAL STAGE OF VESICAL BLOOD FLUKE FOR A HUMAN IS

1) miracidium
2) sporocyst
3) cercariae
4) metacercariae

25. THE CAUSATIVE AGENT OF TERTIAN FEVER IS

1) Plasmodium falciparum
2) Plasmodium vivax
3) Plasmodium malariae
4) Acanthamoeba castellani

26. THE CAUSATIVE AGENT OF QUARTAN FEVER IS

1) Plasmodium falciparum
2) Plasmodium vivax
3) Plasmodium malariae
4) Acanthamoeba castellani

27. THE MEDICAL SIGNIFICANCE OF A KISSING CHINCHES IS THAT IT IS

1) specific vectors of Chagas's disease exciters
2) carrier of a malarial *Plasmodium*
3) causative agent of myiasis
4) causative agent of trypanosomiasis

28. THE TYPE OF MOUTH APPARATUS OF SANDFLY IS

1) piercing-sucking
2) licking-sucking
3) gnawing-licking
4) lapping

Situational tasks

Problem № 1

A patient referrs to a hospital, he is suffering from a frequent liquid stool with blood and pain in an iliac region. He thinks that he got infected when he went on a trip to Middle Asia countries a month ago. He ate unwashed fruit and vegetables several times in a bus.

What kind of a disease can it be?

What is the laboratory diagnosis?

Problem № 2

A sick person comes to a doctor, complaining of a high fever and fatigue. The skin is pale (anemia), liver, spleen and lymph nodes are enlarged. According to the history we know that he made a business trip to Samarkand and after mosquito bites, he discovered an ulcer in the skin. The doctor suggested that the patient had a visceral leishmaniasis.

What kind of laboratory examinations it is necessary to conduct for diagnosis specification?

Write English and Latin names of the visceral leishmaniasis agent.

What disease group does visceral leishmaniasis belong to?

Describe epidemiological chain of visceral leishmaniasis.

Problem № 3

A sick man has pain in the right side of abdomen. In feces and duodenal contents eggs were found. Eggs are oval-shaped, brownish yellow in colour. In one of poles there is operculum, on the opposite pole – protuberance (knob). Its size is 150 μm by 80 μm.

About what disease can we speak in this case?

What type of parasite is its pathogenic organism?

Name systematic position of the pathogenic agent in Latin.

What can be the way of penetration?

Describe personal and public preventive measures of this illness.

Problem № 4

During the sanitary-epidemiological control of beef at the market the bubbles in the size of a pea in the amount of 8 - 10 pieces per 1 dm^2 were found in meat.

What is the diagnosis?

What are the actions of sanitary doctor?

Give recommendations how to use the meat.

ANSWERS TO PROGRAM CONTROL

Test items

№	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
answers	4	3	2	1	2	1	1	3	4	4	2	3	2	1
№	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
answers	1	3	3	4	4	3	1	2	4	3	2	3	1	1

Situational tasks

Problem № 1

Amebiasis. Laboratory diagnosis: examination of feces. In a direct smear there are mobile vegetative forms of amoeba and cysts. Feces should be examined as soon as possible, because in 10-20 minutes amoeba loose mobility and this makes reliable diagnosis impossible. Cysts of Amoeba can be also found in faeces.

Problem № 2

Examination of smears of surface ulcers is made to diagnose dermal leishmaniasis. In stained smears there can be found amastigotes of parasites both inside and outside the cells. Leishmaniasis is a transmissible natural focal disease. Epidemiological chain: reservoir hosts are small rodents; vector is a sandfly: recipients are healthy humans.

Problem № 3

In this case we can speak about fascioliasis. The pathogene of fascioliasis is Fasciola hepatica. Systematic position: Kingdom ZOO, Phylum *Plathelminthes*, Class *Trematoda*, Species *Fasciola hepatica* (The sheep liver fluke). The way of penetration is alimentary. The factors of invasion are unboiled water, badly washed greenery. Personal prevention of human infection can be achieved by proper disinfection of water plants and boil water before consumption. Public prevention includes treatment of human, treatment of cattle, change of pastures, where infected snails live, destruction of mollusks. Sanitary-instructive work.

Problem 4

The diagnosis is cysticercosis. The bubbles found in meat are cysticercus (larvae) of beef tapeworm (*Taeniarhynchus saginatus*). The doctor should not allow this meat for sale.

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TABLE OF CONTENTS

Introduction……. 3
Different types of relationship between organisms.
Parasitism as an ecological phenomenon……. 4
Classification of parasites……. 7
Medical parasitology. General questions…….. 9
The description of a «parasite-host» system…… 9
Adaptation of parasites in host's organism…….. 10
Responding reactions of host's organism…… 13
Transmissible and natural focal diseases…… 14
The basic systematization of living organisms…… 15
Medical Protozoology……..... 16
The general description of *Protozoa* Subkingdom……... 16
Phylum *Sarcomastigophora*…….... 19
Class *Sarcodina*…… 19
Class *Mastigophora*…….. 26
Phylum *Apicomplexa*…… 40
Phylum *Ciliophora*……... 48
Medical helminthology……. 51
The subject and tasks of medical helminthology…….. 51
Phylum *Plathelminthes* (Flatworms) ……... 51
Class Flukes (*Trematoda*) …… 53
Class Tapeworms (*Cestoda*) …… 80
Phylum *Nemathelmintes* (Round Worms)..…….. 113
Round worms – giohelminths……... 117
Round worms – biohelminths……... 131
The laboratory diagnosis of parasitosis…… 143
The principles of fighting against parasitosis……... 144
Medical arachnology……. 145
The general description of *Arthropoda* Phylum……... 145
Class *Crustacea*……..... 148
Class *Arachnoidea*…… 151
Order *Scorpionidae*……... 153

Order *Aranei* (Spiders)…… 155
Order *Acari*…….. 158
Medical Entomology…….... 172
Subphylum *Tracheata*. *Insecta* Class. …… 172
Order *Blattodea* …….. 175
Order *Hemiptera*…….... 177
Order *Anoplura*…….... 179
Order *Aphaniptera*…… 185
Order *Diptera* …….. 188
Insects as causative agents of Myiasis……. 200
Program Control…… 204
Examples of test items…….. 204
Situational tasks…… 209
Answers to program control ……. 210
Recommended Literature…….. 212

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