NATURAL FOCI DİSEASES: TRANSMİSSİBLE DİSEASES

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Lecture plan:

1. *Properties and classification of natural foci diseases*
2. *Components of the natural foci*
3. *Classification of vector-borne (transmissible) diseases*
4. *Disease vectors*
5. *Plague: natural foci, human infection routes*
6. *Tularemia: natural foci, human infection routes*
7. *Leishmaniasis: natural foci, human infection routes*
8. *Trypanosomiasis: natural foci, human infection routes*
9. *Malaria: natural foci, human infection routes*
10. *Toxoplasmosis: natural foci, human infection routes*
11. *Filariasis*

Properties and classification of natural foci diseases

- A large group of parasitic and infectious diseases is characterized by natural foci. They are characterized by the following properties:

1) pathogens circulate in nature from one animal to another irrespective of a human;

2) animals serve as a reservoir of the pathogen;

3) diseases are widespread in a limited area with a certain landscape, climatic factors and biogeocenosis.

Properties and classification of natural foci diseases

- The pathogens of natural focal diseases can circulate with the participation of carriers (natural foci vector-borne diseases) and without the participation of carriers (natural foci non-vector-borne diseases).
- Natural focal vector-borne diseases include leishmaniasis, trypanosomiasis, spring-summer tick-borne encephalitis, plague, etc. Natural focal non-transmissible diseases include toxoplasmosis, opisthorchiasis, paragonimiasis, diphyllobothriasis, trichinosis, etc.

Classification of natural foci vector-borne diseases

Classification of natural foci of vector-borne diseases is possible according to several criteria:

1) According to the systematic affiliation of the pathogen:

- **Viral - taiga encephalitis, Japanese encephalitis;**
- **Bacterial - plague, anthrax;**
- **Protozoal - leishmaniasis, trypanosomiasis;**
- **Helminth infections - filariasis.**

2) By species diversity of animal reservoirs

- **Monogostal - one type of reservoir animal;**
- **Polygostal - several types of reservoiranimals (gophers, jerboas, hamsters in the natural focus of cutaneous leishmaniasis);**

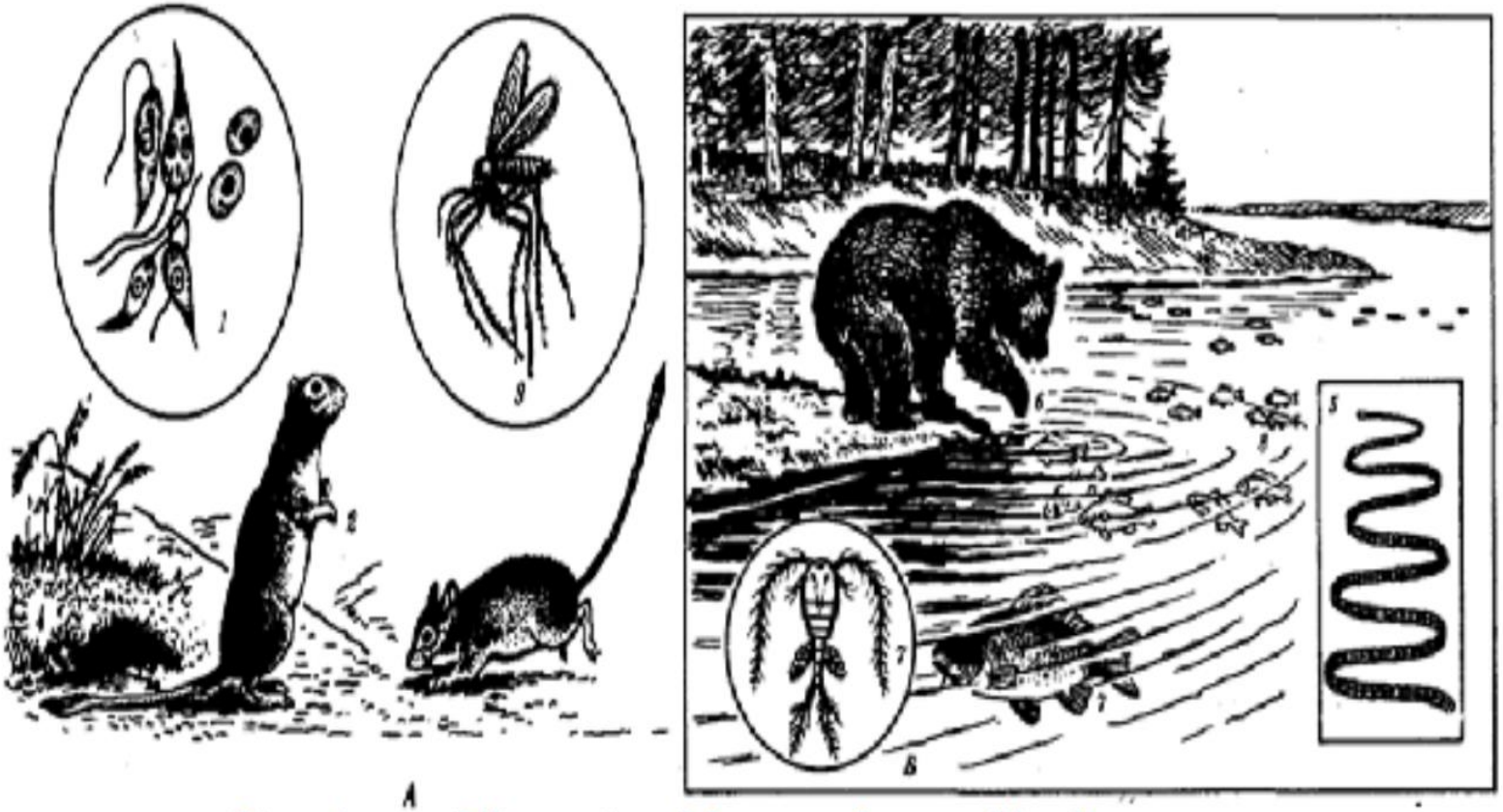
3) By the generic variety of carriers

- **Single-vector - the pathogen is transmitted by only one genus of the carrier (pathogens of visceral leishmaniasis are transmitted only by mosquitoes of the genus Phlebotomus);**
- **Multivector - pathogens are transmitted by carriers of different genera (tularemia pathogens are transmitted by ixodid ticks, ordinary mosquitoes, etc.).**

Classification of parasitic diseases

- Parasitic diseases (parasitoses), depending on the nature of the pathogen, are divided into several groups.
- Diseases at which pathogens are transmitted from animals to animals are called **zoonosis** (plague of chickens and pigs).
- Diseases at which pathogens are transmitted from human to human are called **anthroponosis** (measles, diphtheria).
- Diseases at which pathogens are transmitted from animal to human are called **anthropozoonosis** (brucellosis, Ebola).
- Diseases at which pathogens are transmitted from one organism to another through blood-sucking vectors (insects, ticks) are called **vector-borne (transmissible) diseases** (malaria, taiga encephalitis).

Classification of parasitic diseases



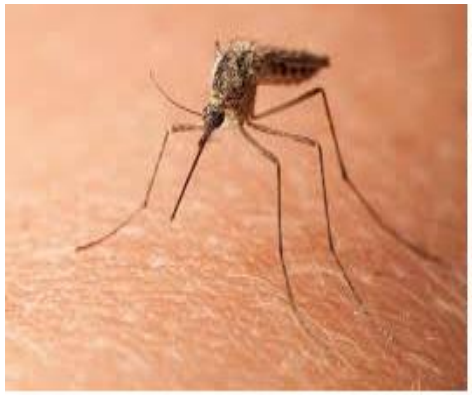
Structure of the natural focus of parasitic disease.
A - leishmaniasis (vector-borne disease); B - diphyllobothriasis (non-transmissible disease)

Classification of vector-borne diseases (transmissible) diseases

- Transmissible diseases are divided into:

1) **obligate-transmissible,** the causative agents of which are transmitted through specific carriers (malaria - by mosquitoes of the genus Anopheles, taiga encephalitis - taiga ticks);

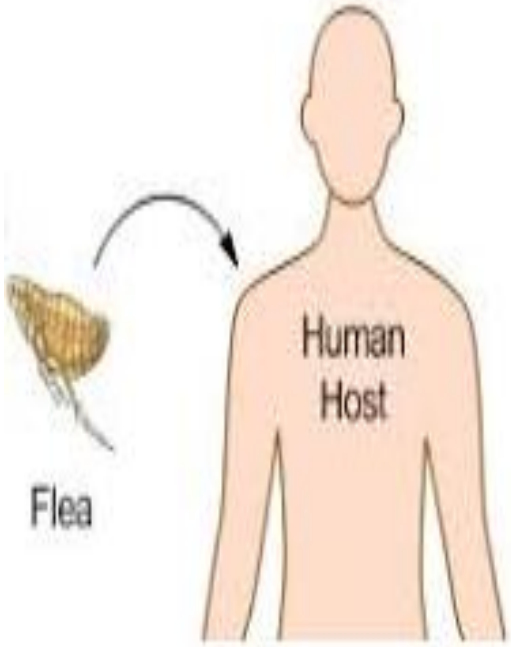
2) **facultative-transmissible,** the causative agents of which can be transmitted through carriers, or in other ways (infection with tularemia and anthrax is possible through numerous carriers and when cutting carcasses of sick animals).

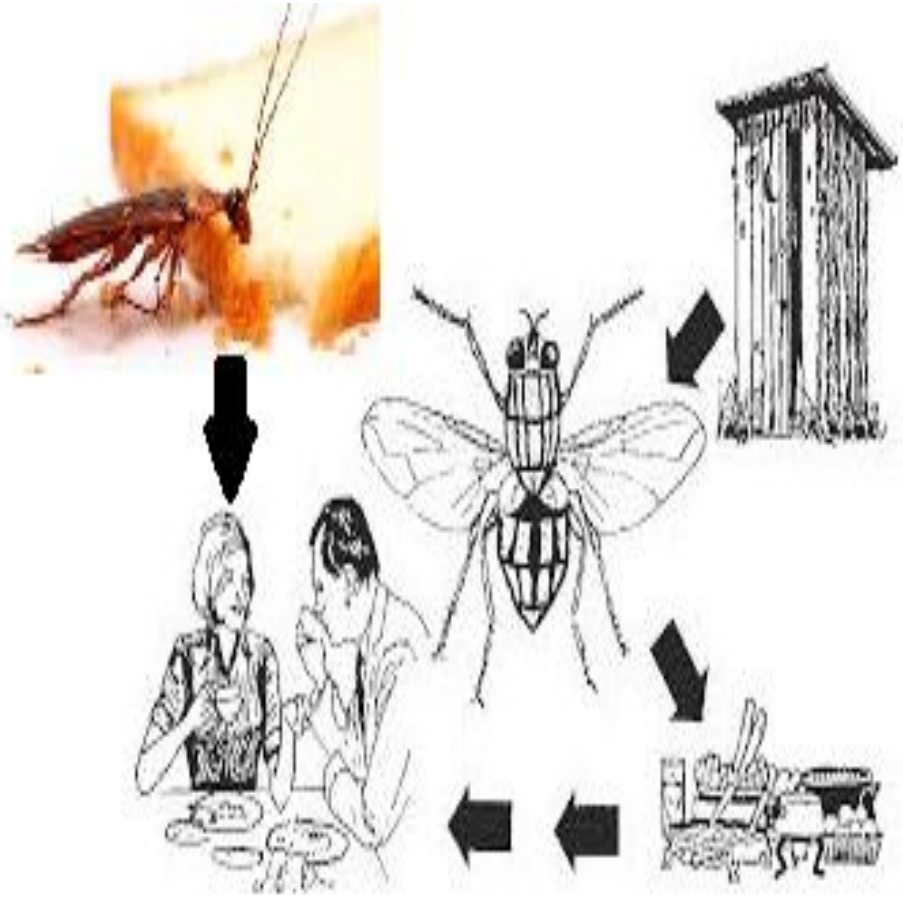


Vectors of diseases

- Vectors of vector-borne diseases for pathogens can be specific and mechanical.
- In the organism of a **specific vector**, the pathogen passes part of the life cycle (plague bacillus multiplies in the digestive tract of fleas; malarial plasmodia undergo the sexual development cycle in mosquitoes of the Anopheles genus).
- The causative agents of diseases in **mechanical vectors** (flies, cockroaches) located on the surface of the body, on the limbs and on the parts of the oral apparatus.

Vectors of diseases





Plague: natural foci, human infection routes

- Plague is an infectious disease caused by the bacterium *Yersinia pestis*.

- *Symptoms* include fever, weakness and headache. Usually this begins one to seven days after exposure.

Plague: natural foci, human infection routes

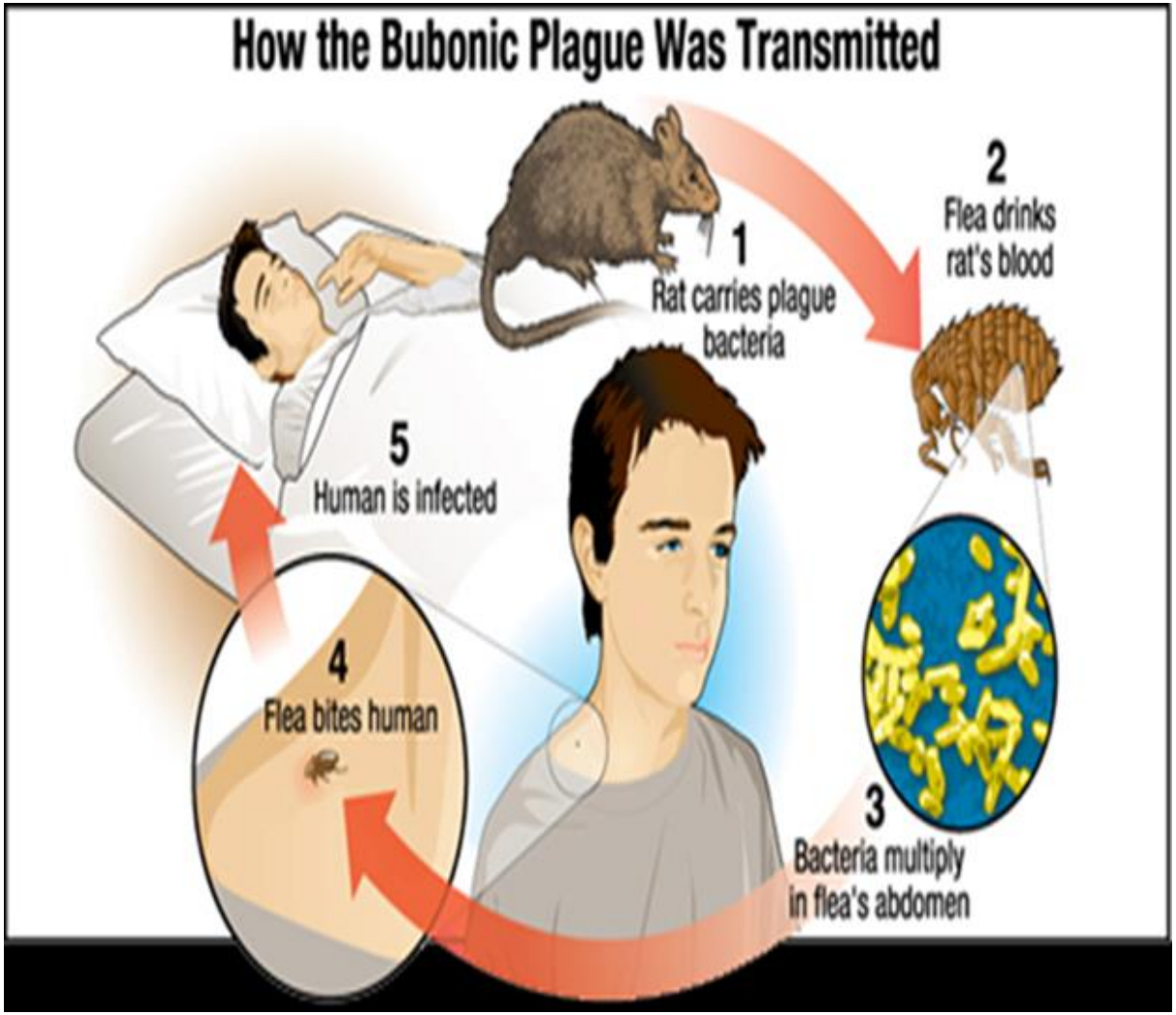
Transmission of *Y. pestis* to an uninfected individual is possible by any of the following means:

- droplet contact – coughing or sneezing on another person,
- direct physical contact – touching an infected person, including sexual contact,
- indirect contact – usually by touching soil contamination or a contaminated surface,
- airborne transmission – if the microorganism can remain in the air for long periods,
- fecal-oral transmission – usually from contaminated food or water sources.

Plague: natural foci, human infection routes

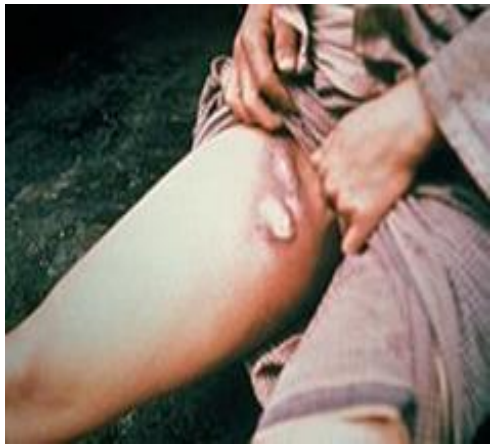
- *Yersinia pestis* circulates in animal reservoirs, particularly in rodents, in the natural foci of infection found on all continents except Australia. The natural foci of plague are situated in a broad belt in the tropical and sub-tropical latitudes and the warmer parts of the temperate latitudes around the globe, between the parallels 55 degrees North and 40 degrees South.
- Contrary to popular belief, rats did not directly start the spread of the bubonic plague. It is mainly a disease in the fleas (*Xenopsylla cheopis*) that infested the rats, making the rats themselves the first victims of the plague. Infection in a human occurs when a person is bitten by a flea that has been infected by biting a rodent that itself has been infected by the bite of a flea carrying the disease. The bacteria multiply inside the flea, sticking together to form a plug that blocks its stomach and causes it to starve. The flea then bites a host and continues to feed, even though it cannot quell its hunger, and consequently the flea vomits blood tainted with the bacteria back into the bite wound. The bubonic plague bacterium then infects a new person and the flea eventually dies from starvation.

Plague: natural foci, human infection routes



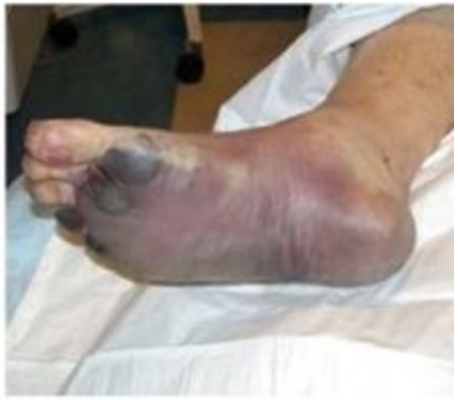
Plague: natural foci, human infection routes

- **Bubonic plague**
- When a flea bites a human and contaminates the wound with regurgitated blood, the plague carrying bacteria are passed into the tissue. *Y. pestis* can reproduce inside cells, so even if phagocytosed, they can still survive. Once in the body, the bacteria can enter the lymphatic system, which drains interstitial fluid. Plague bacteria secrete several toxins, one of which is known to cause beta-adrenergic blockade.
- *Y. pestis* spreads through the lymphatic vessels of the infected human until it reaches a lymph node, where it causes acute lymphadenitis.



Plague: natural foci, human infection routes

- If the lymph node is overwhelmed, the infection can pass into the bloodstream, causing secondary septicemic plague and if the lungs are seeded, it can cause secondary pneumonic plague. In septicemic plague, bacterial endotoxins cause disseminated intravascular coagulation (DIC), causing tiny clots throughout the body and possibly ischemic necrosis (tissue death due to lack of circulation/perfusion to that tissue) from the clots.



Tularemia: natural foci, human infection routes

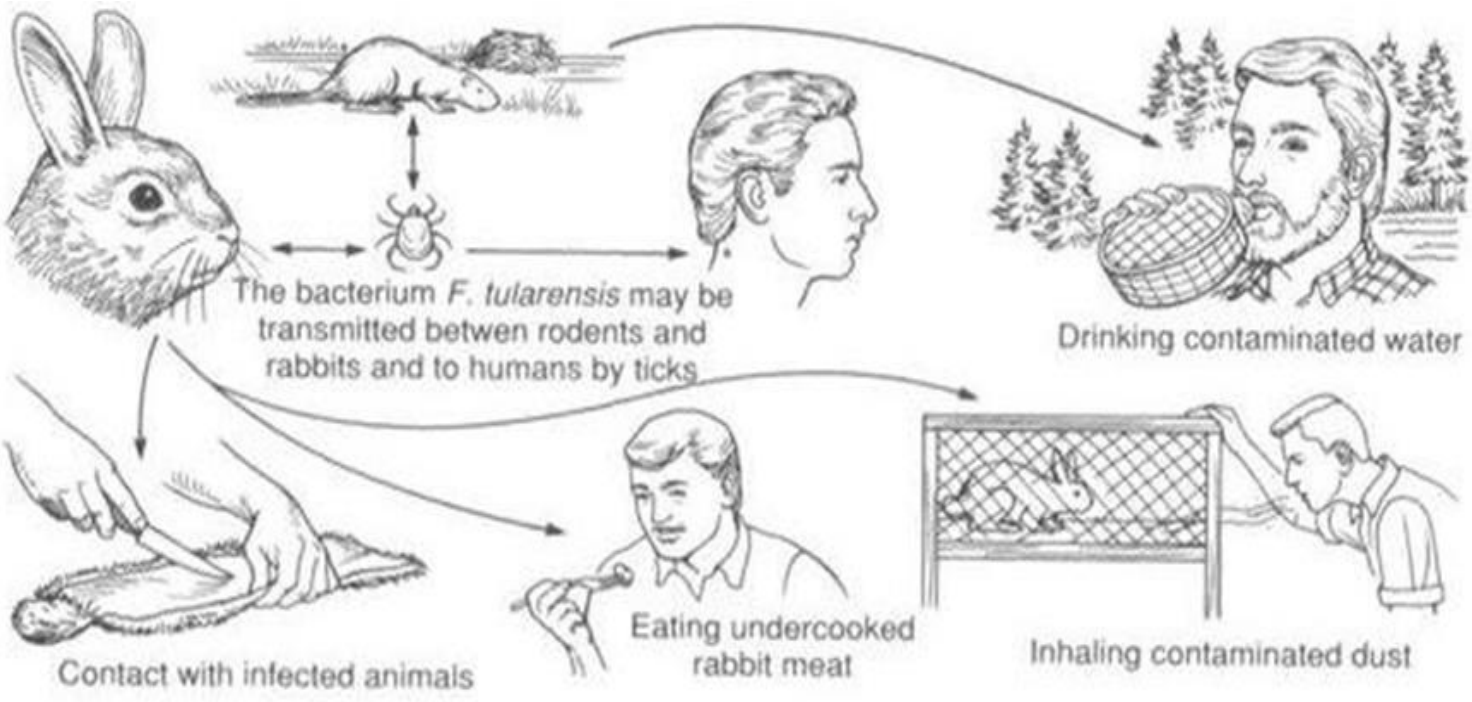
- Tularemia, also known as rabbit fever, is an infectious disease caused by the bacterium Francisella tularensis.
- Diagnosis is by blood tests or cultures of the infected site.

Tularemia: natural foci, human infection routes

- Tularemia is most common in the northern Hemisphere, including North America and parts of Europe and Asia (Russia). It occurs between 30° and 71° north latitude.
- Symptoms may include fever, skin ulcers, and enlarged lymph nodes. Occasionally, a form that results in pneumonia or a throat infection may occur.

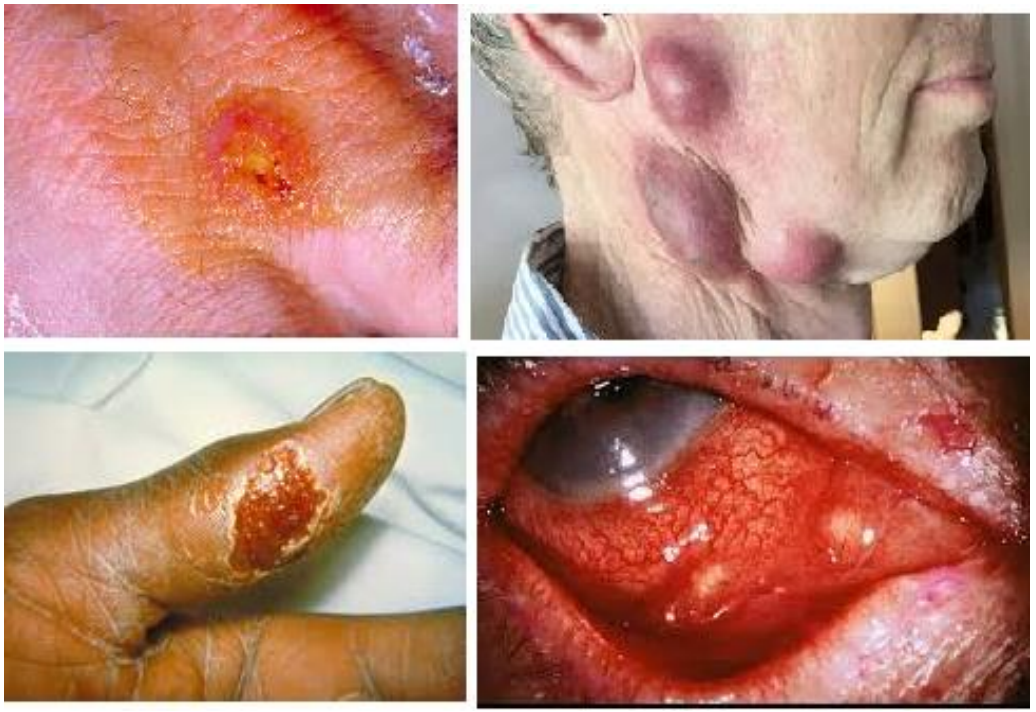
Tularemia: natural foci, human infection routes

- The bacterium is typically spread by ticks, deer flies, or contact with infected animals. It may also be spread by drinking contaminated water or breathing in contaminated dust. It does not spread directly between people.



Tularemia: natural foci, human infection routes

- The incubation period for tularemia is one to 14 days; most human infections become apparent after three to five days. In most susceptible mammals, the clinical signs include fever, lethargy, loss of appetite, signs of sepsis, and possibly death.
- Fever is moderate or very high, and tularemia bacilli can be isolated from blood cultures at this stage. The face and eyes redden and become inflamed. Inflammation spreads to the lymph nodes, which enlarge and may suppurate (mimicking bubonic plague). Lymph node involvement is accompanied by a high fever.



Tularemia: natural foci, human infection routes

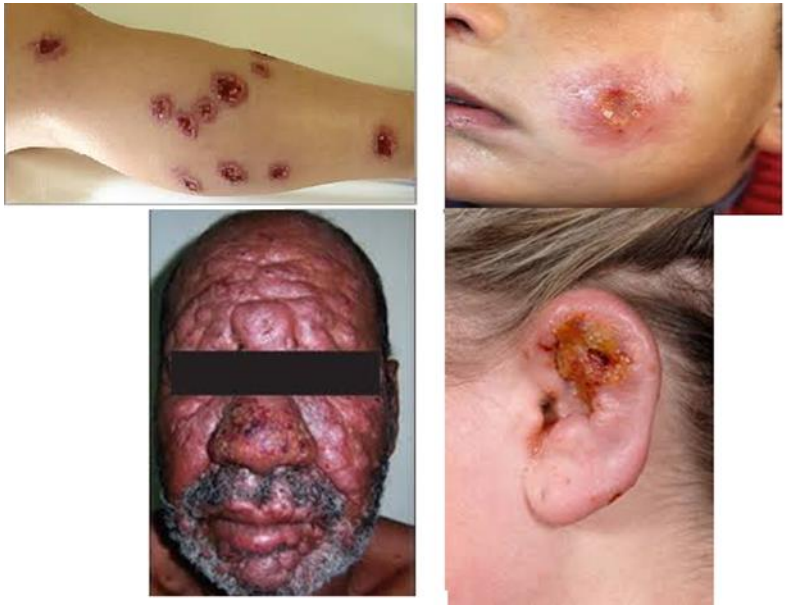
- The most common way the disease is spread is via arthropod vectors. Ticks involved include Amblyomma, Dermacentor, Haemaphysalis, and Ixodes. Rodents, rabbits, and hares often serve as reservoir hosts. Tularemia can also be transmitted by biting flies, particularly the deer fly Chrysops discalis.

Leishmaniasis: natural foci, human infection routes

- Leishmaniasis is a disease caused by parasites of the Leishmania type.
- It is spread by the bite of infected female *Phlebotomine* sandflies.

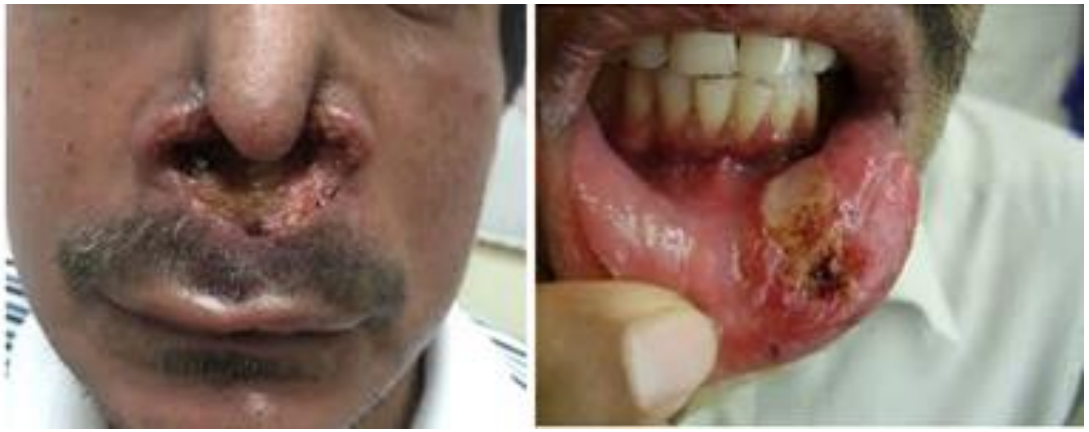
Leishmaniasis: natural foci, human infection routes

- The disease can present in three main ways: cutaneous, mucocutaneous, or visceral leishmaniasis.
- The *cutaneous* form presents with skin ulcers,



Leishmaniasis: natural foci, human infection routes

- while the mucocutaneous form presents with ulcers of the skin, mouth, and nose,



Leishmaniasis: natural foci, human infection routes

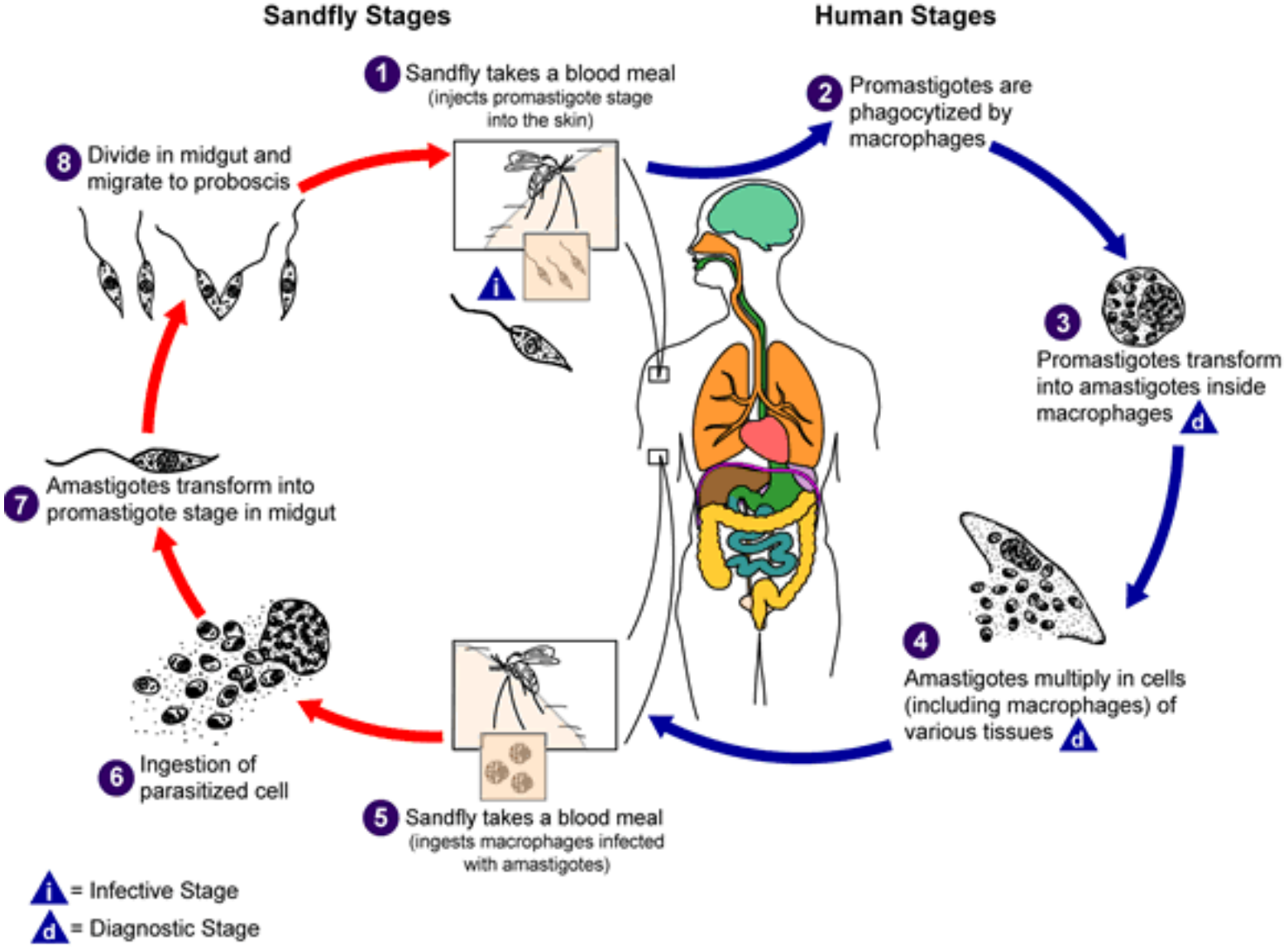
- and the visceral form or kala-azar ('black fever') starts with skin ulcers and then later presents with fever, low red blood cells, and enlarged spleen and liver.

Leishmaniasis: natural foci, human infection routes

- **Life cycle of Leishmania**

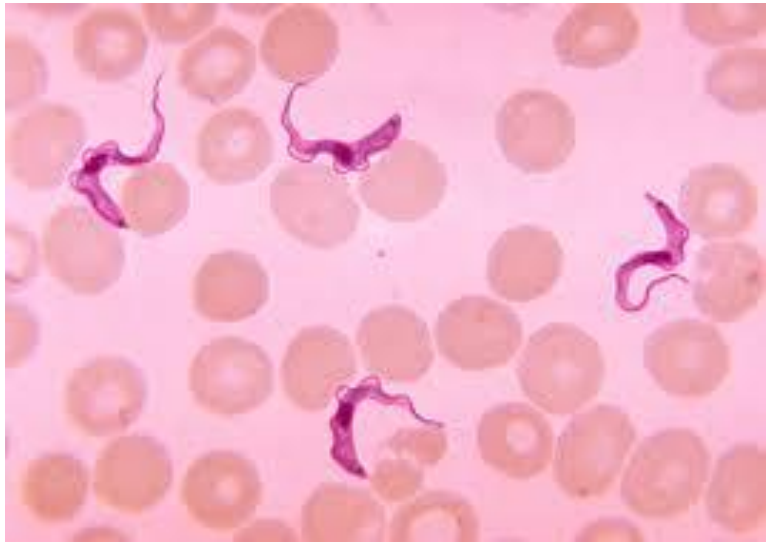
(1)The sandflies inject the infective stage, metacyclic promastigotes, during blood meals. (2) Metacyclic promastigotes that reach the puncture wound are phagocytized by macrophages, and (3) transform into amastigotes. (4) Amastigotes multiply in infected cells and affect different tissues, depending in part on the host, and in part on which Leishmania species is involved. These differing tissue specificities cause the differing clinical manifestations of the various forms of leishmaniasis. (5,6) Sandflies become infected during blood meals on infected hosts when they ingest macrophages infected with amastigotes. (7) In the sandfly's midgut, the parasites differentiate into promastigotes, (8) which multiply, differentiate into metacyclic promastigotes, and migrate to the proboscis.

Leishmaniasis: natural foci, human infection routes



Trypanosomiasis: natural foci, human infection routes

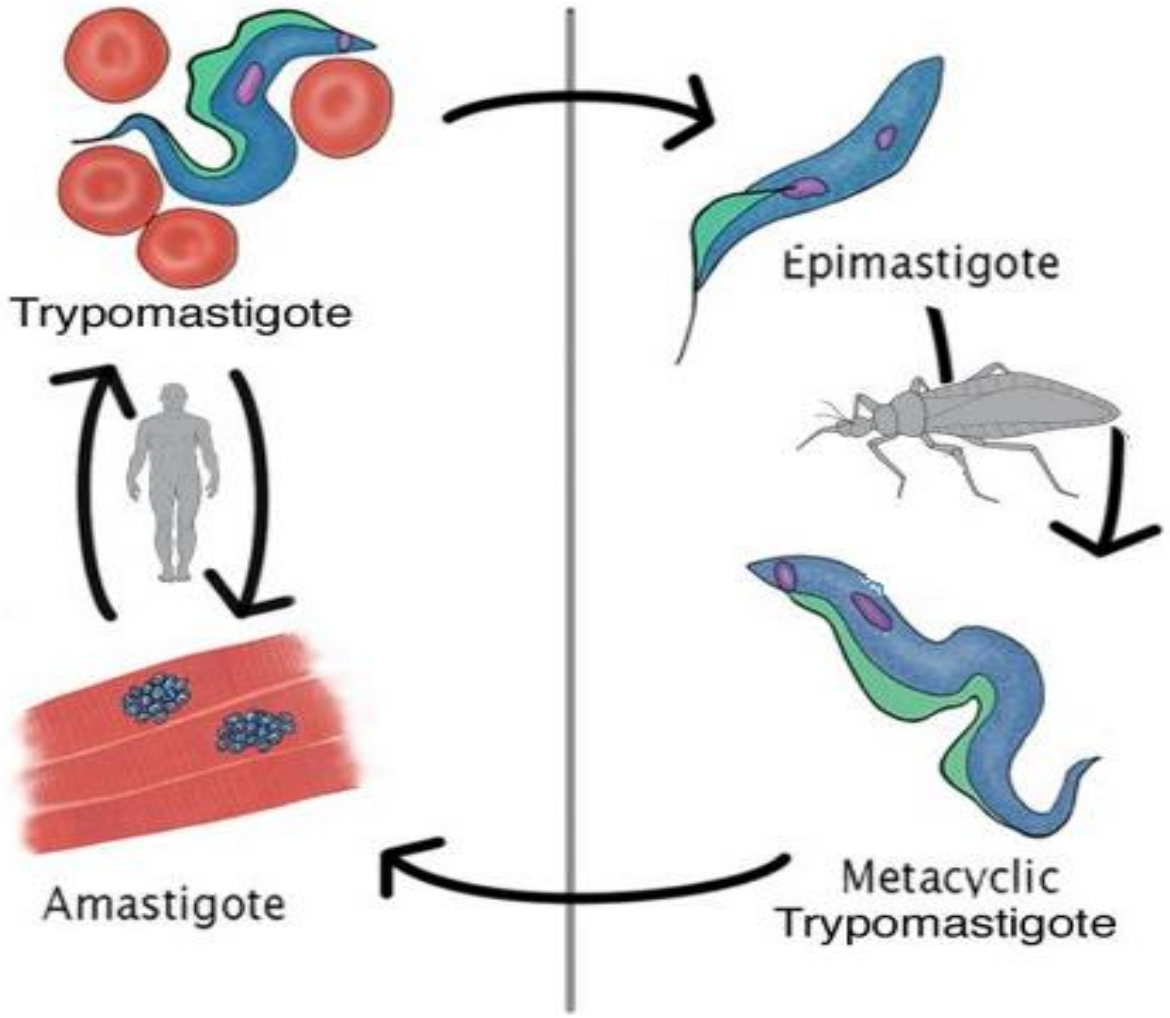
- Trypanosomiasis or trypanosomosis is the name of several diseases in vertebrates caused by parasitic protozoan trypanosomes of the genus Trypanosoma.
- In humans this includes Chagas disease and African trypanosomiasis which is caused by Trypanosoma cruzi and Trypanosoma brucei gambiense or Trypanosoma brucei rhodesiense. A number of other diseases occur in other animals.



Trypanosomiasis: natural foci, human infection routes

- **Life cycle Trypanosoma cruzi (Chagas disease)**
- The life cycle of T. cruzi is relatively complex, as there are different forms of the parasite in both the insect vector (triatomine bugs) and mammals (including humans).
- T. cruzi has a rather unique way of infecting mammals. Rather than being transmitted by the bite of its insect vector, metacyclic trypomastigotes are extruded as the infected insect feed – leaving them deposited on the skin of victim. The parasites themselves have no way of invading through the unbroken skin and thus must be mechanically introduced – e.g. through scratching the bite site or rubbing the feces into the mouth or eyes, where the parasites can find hospitable cells to invade.
- The trypomastigotes circulate in the blood, where they do not divide, but can enter various types of cells in the host. Once inside a host cell, T. cruzi trypomastigotes move to the cytoplasm and transform into a more rounded form without a flagellum – known as amastigotes. Amastigotes are the dividing form of T. cruzi in mammals.
- Following multiple rounds of division over 4-5 days, all within the cytoplasm of the host cells, amastigotes convert back to trypomastigotes and leave the now dying host cell. These released trypomastigotes can then infect other host cells locally or enter the blood circulation where they may invade cells in other tissues in the body or be transmitted to the insects during the course of its feeding. In the insect, these trypomastigotes convert to rapidly dividing epimastigotes which remain in the insect gut. Ultimately, after weeks of replication in the gut, the epimastigotes differentiate into metacyclic trypomastigotes, a stage similar to the blood-form trypomastigotes and capable of initiating infection in mammals.

Trypanosomiasis: natural foci, human infection routes

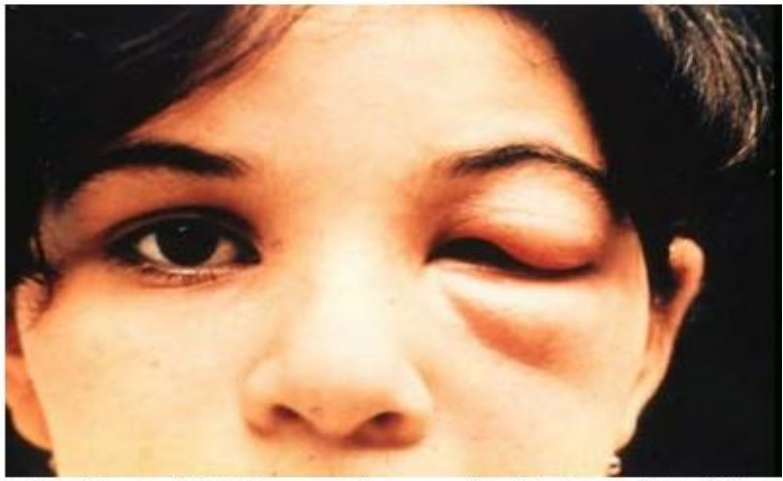


Trypanosomiasis: natural foci, human infection routes

SYMPTOMS OF CHAGAS DISEASE

ACUTE PHASE

- Redness and swelling at the site of infection
- Fever
- Fatigue
- Body aches
- Nausea, diarrhea or vomiting
- Swollen glands



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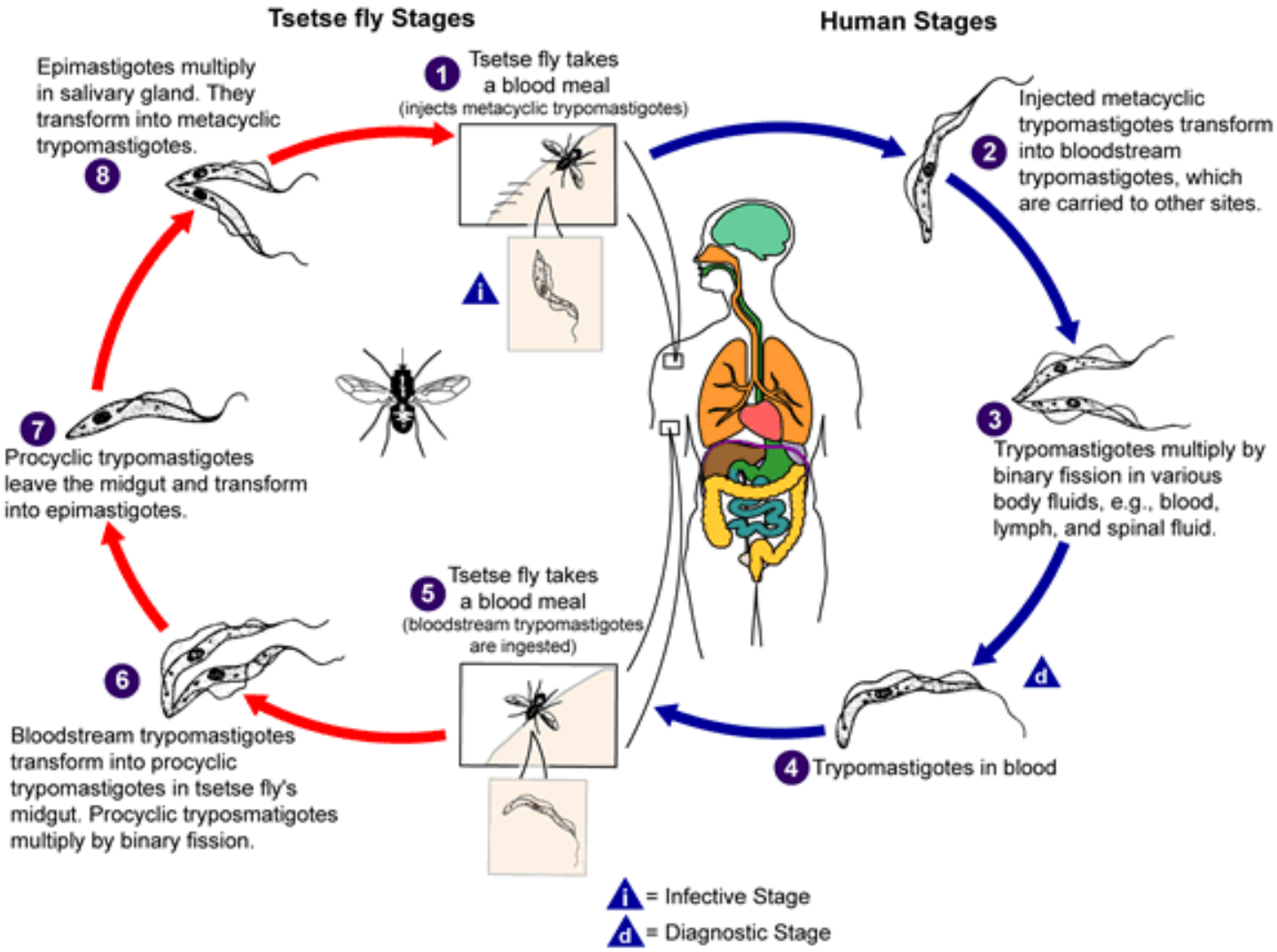
CHRONIC PHASE (10-20 years later)

- Irregular heartbeat
- Inflamed, enlarged heart (cardiomyopathy)
- Congestive heart failure
- Enlarged esophagus and colon

Trypanosomiasis: natural foci, human infection routes

- **African trypanosomiasis**, also known as sleeping sickness, is an insect-borne parasitic disease of humans and other animals. It is caused by protozoa of the species Trypanosoma brucei. There are two types that infect humans, Trypanosoma brucei gambiense (TbG) and Trypanosoma brucei rhodesiense (TbR). TbG causes over 98% of reported cases. TbG causes the diseases in west and central Africa, whereas TbR has a limited geographical range and is responsible for causing the disease in east and southern Africa. Both are usually transmitted by the bite of an infected tsetse fly and are most common in rural areas.

Trypanosomiasis: natural foci, human infection routes



Trypanosomiasis: natural foci, human infection routes

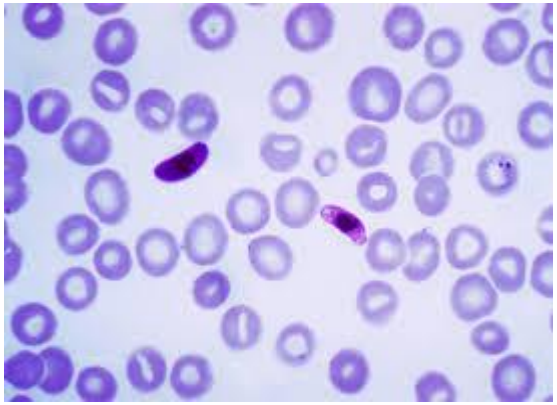
African trypanosomiasis symptoms occur in two stages.

- The first stage, known as the **hemolymphatic phase**, is characterized by fever, headaches, joint pains, and itching, swelling of lymph nodes.
- The second phase of the disease, the **neurological phase**, begins when the parasite invades the central nervous system by passing through the blood–brain barrier. Disruption of the sleep cycle is a leading symptom of this stage and is the one that gave the disease the name 'sleeping sickness.' Infected individuals experience a disorganized and fragmented 24-hour rhythm of the sleep-wake cycle, resulting in daytime sleep episodes and nighttime periods of wakefulness.

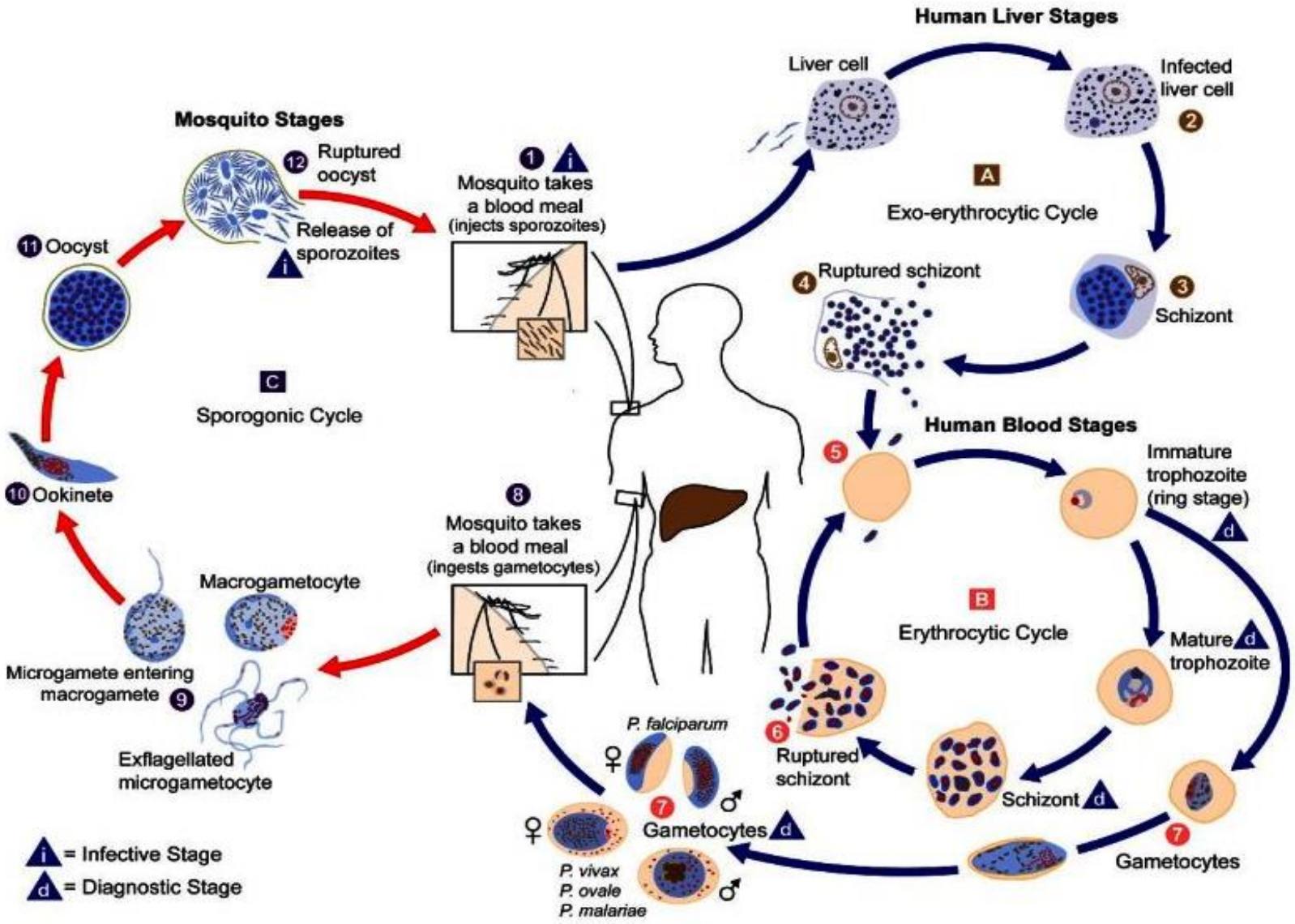
Tse-tse fly

Malaria: natural foci, human infection routes

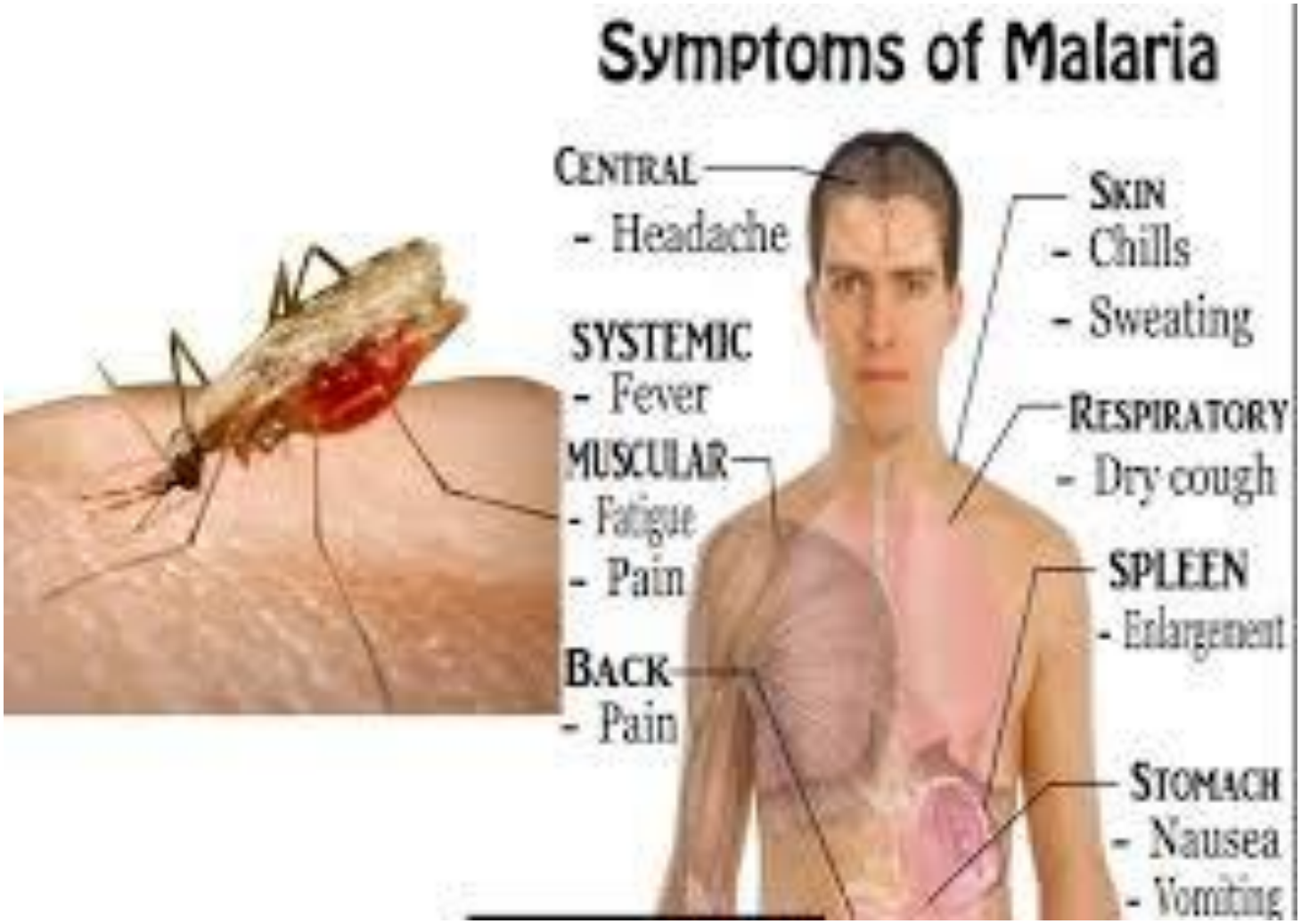
- Malaria is a mosquito-borne infectious disease that affects humans and other animals.
- Malaria is caused by single-celled microorganisms of the Plasmodium group. Five species of Plasmodium can infect and be spread by humans. Most deaths are caused by P. falciparum because P. vivax, P. ovale, and P. malariae generally cause a milder form of malaria. The species P. knowlesi rarely causes disease in human.



Malaria: natural foci, human infection routes

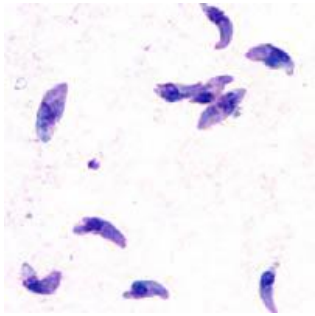


Malaria: natural foci, human infection routes



Toxoplasmosis: natural foci, human infection routes

- Toxoplasmosis is a parasitic disease caused by Toxoplasma gondii.
- Infections with toxoplasmosis usually cause no obvious symptoms in adults. Occasionally, people may have a few weeks or months of mild, flu-like illness such as muscle aches and tender lymph nodes. In a small number of people, eye problems may develop. In those with a weak immune system, severe symptoms such as seizures and poor coordination may occur. If infected during pregnancy, a condition known as congenital toxoplasmosis may affect the child.

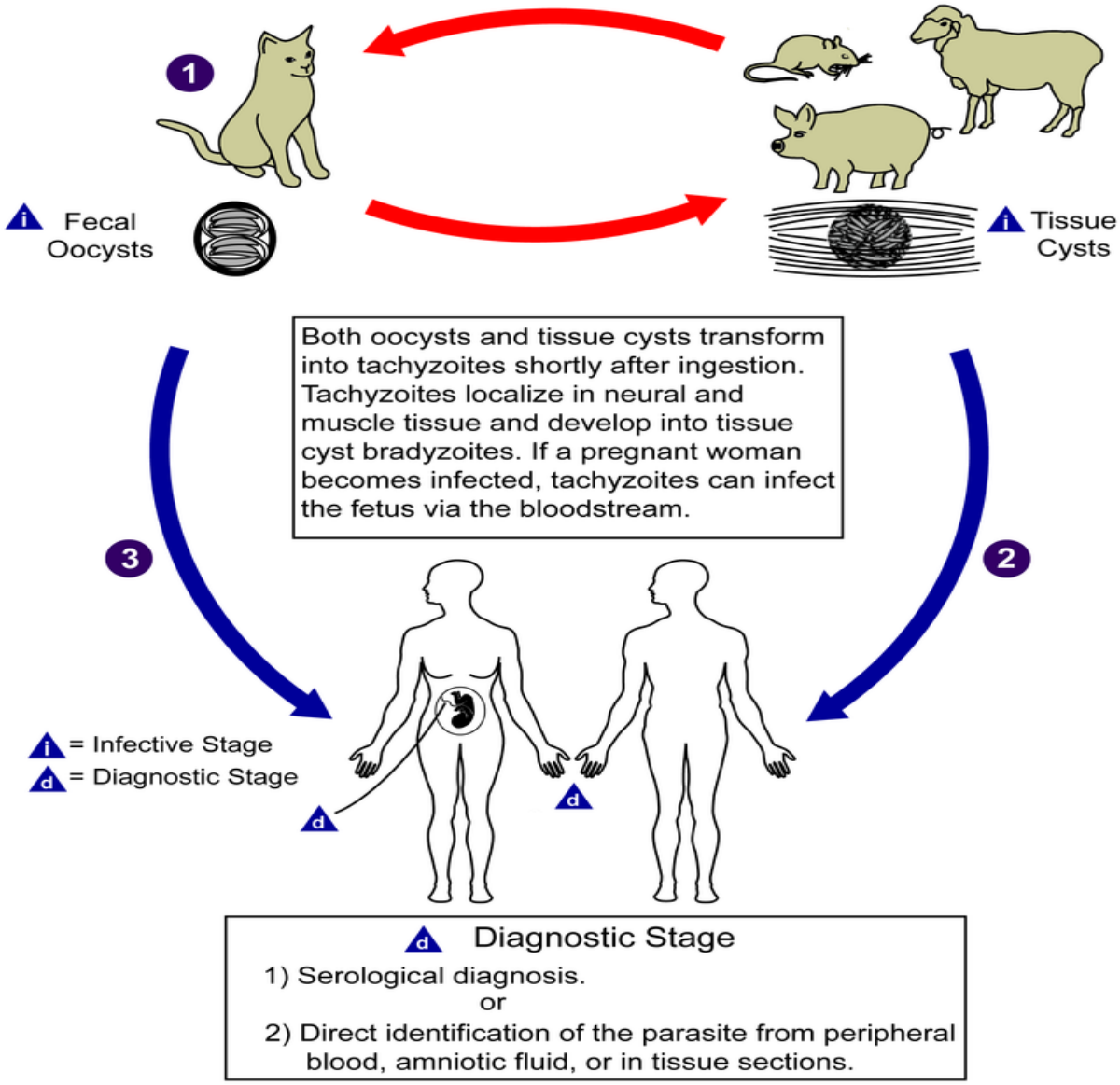


Toxoplasmosis: natural foci, human infection routes

Life cycle of Toxoplasma gondii consists of two phases:

- 1. The sexual part of the life cycle takes place only in individuals of some species of the Canidae family (wild and domestic cats), which become the primary host of parasites.
- 2. The asexual part of the life cycle can take place in any warm-blooded animal, for example, in mammals (including human) and in birds, reptiles.
- 3. Parasite invades the cells of the intermediate hosts, forming intercellular vacuoles containing bradyzoites. Vacuoles can develop in the internal organs, including the lungs, liver, and kidneys, but they are more common in nerve and muscle tissues - such as the brain, eye, skeletal and cardiac muscle. Inside these vacuoles, T. gondii reproduce by a sequence of divisions into two parts until the infected cell finally bursts and the tachyzoites exit. Tachyzoites are motile and reproduce asexually, producing new parasites. Unlike bradyzoites, free tachyzoites are easily eliminated by the host's immune system, but they can infect cells and form bradyzoites, thereby supporting the infection.
- 4. Tissue cysts are swallowed by a cat (for example, when it eats an infected mouse). Cysts survive in the cat's stomach, and parasites infect the epithelial cells of the small intestine, where they begin sexual reproduction and the formation of oocysts. Oocysts are excreted with feces into the external environment, where under favorable conditions, after 1-5 days, two sporocysts with four sporozoites form in each oocyst.
- 5. The distribution period is 3-10 days after ingestion of tissue cysts and 18 days or more after ingestion of tachyzoites or oocysts.
- 6. Animals (including humans) swallow oocysts (for example, eating unwashed vegetables, etc.) or tissue cysts (in poorly prepared meat) and become infected.

Toxoplasmosis: natural foci, human infection routes



Filariasis

- **Filariasis** is a parasitic disease caused by an infection with roundworms of the Filarioidea type. These are spread by blood-feeding diptera such as black flies and mosquitoes.

Filariasis

- Filarial nematodes use human as their definitive hosts. These are divided into three groups according to the niche they occupy in the body:
- Lymphatic filariasis
- Subcutaneous filariasis
- Serous cavity filariasis

Filariasis

- **Lymphatic filariasis,** also known as elephantiasis, is a human disease caused by filarial worms.
- The worms are spread by the bites of infected mosquitoes. Three types of worms are known to cause the disease: Wuchereria bancrofti, Brugia malayi, and Brugia timori, with Wuchereria bancrofti being the most common (for 90% of the cases).

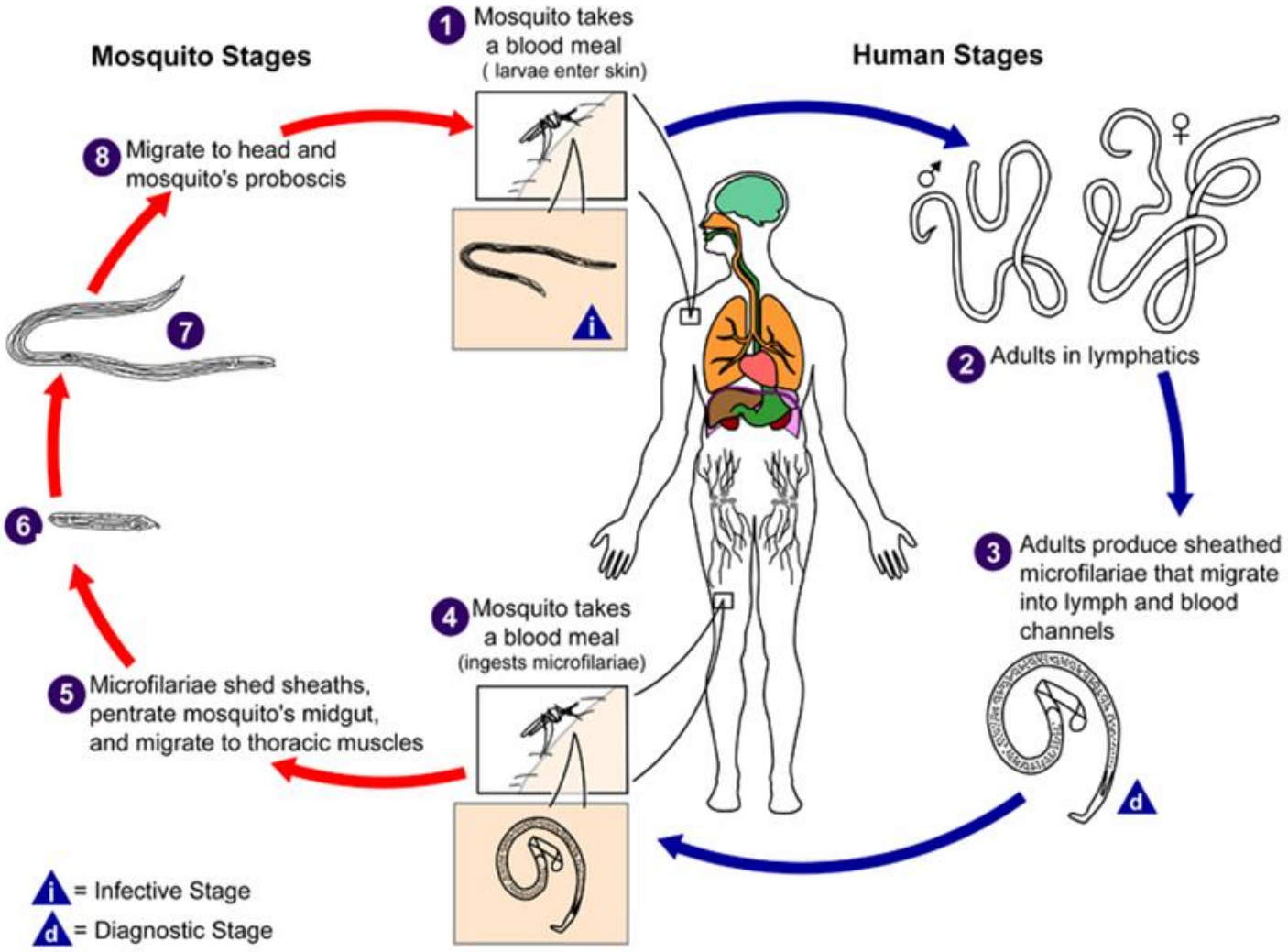
Filariasis

- *Wuchereria bancrofti*: The female has a thin hairy body, white, reaching a length of 5-10 cm. The dimensions of the male are 2-4 cm in length. Usually, males and females are intertwined, forming a ball. The female gives birth to live larvae.

Filariasis

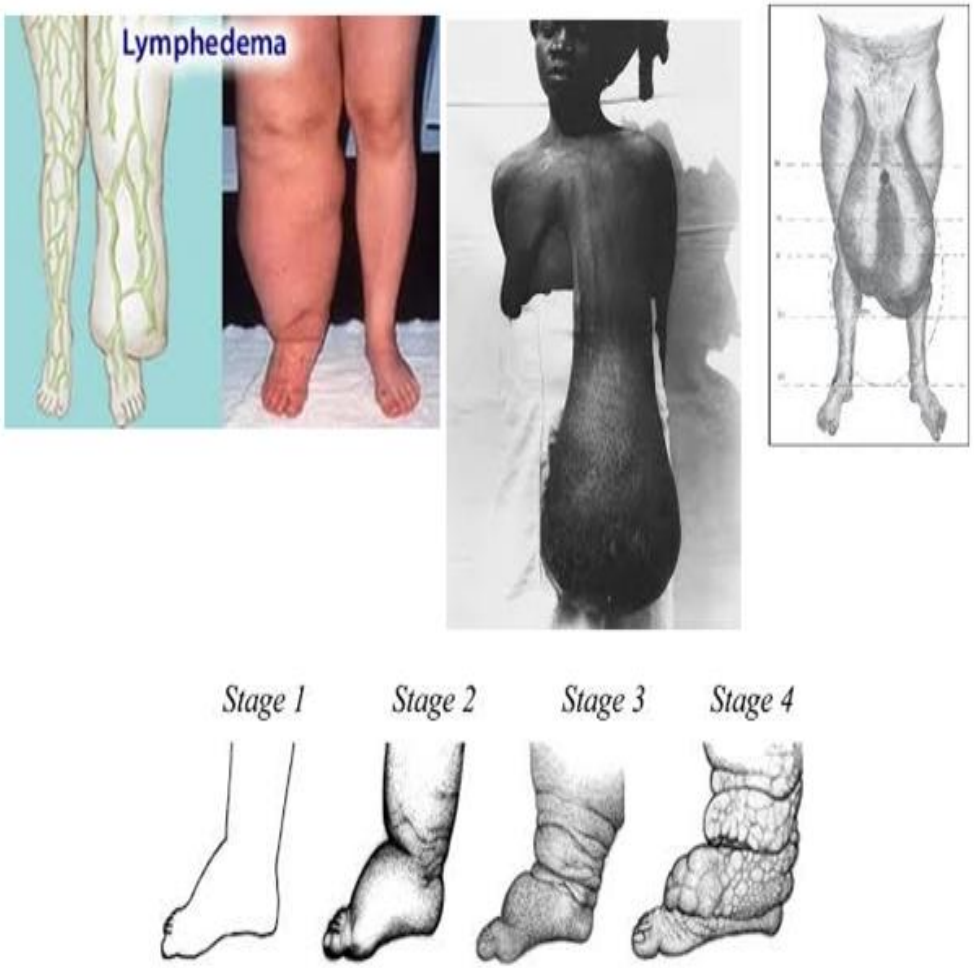
- The life cycle occurs with a change of hosts. The definitive host is only human, the intermediate host is mosquitoes of the genus Anopheles, Aedes, Mansonia.
- In the lymphatic vessels and nodes, the female gives birth to larvae- microfilariae, which pass into the circulatory system. During the day, the larvae are located in large blood vessels and vessels of the internal organs, and at night they exit into the peripheral blood vessels. When a mosquitoa bites sick person, the larvae can get into the stomach of the insect. From the digestive tract they migrate to the thoracic muscle and after to the proboscis. At the time of a bite a human by mosquito, microfilariae tear the proboscis, fall on the skin and aggressively invade it. Then they are entered into the lymphatic system and there develop into sexually mature forms. Life expectancy in the human body is about 17 years.

Filariasis


Mosquito Stages
Human Stages
1 Mosquito takes a blood meal (larvae enter skin)
2 Adults in lymphatics
3 Adults produce sheathed microfilariae that migrate into lymph and blood channels
4 Mosquito takes a blood meal (ingests microfilariae)
5 Microfilariae shed sheaths, pentrate mosquito's midgut, and migrate to thoracic muscles
6
7
8 Migrate to head and mosquito's proboscis
i = Infective Stage
d = Diagnostic Stage

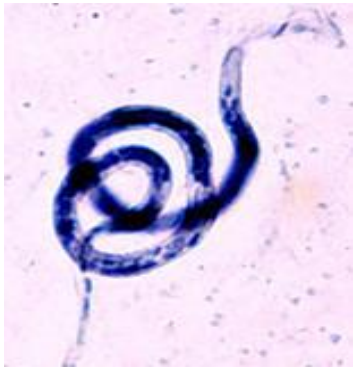
Filariasis

- The adult worms only live in the human lymphatic system. The parasite infects the lymph nodes and blocks the flow of lymph throughout the body; this results in chronic lymphedema, most often noted in the lower torso (typically in the legs and genitals).



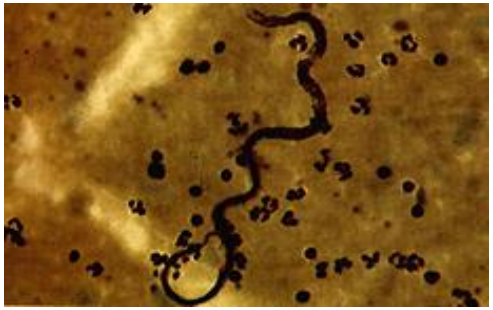
Filariasis

- *Brugia malaji*: Very similar to the above worms, it is large in size - up to 5 cm.
- The definitive host is also human, but may be cats, dogs. The intermediate host can be the same mosquito species, but more often mosquitoes of the Mansonia genus. Larvae are detected at night in peripheral blood, but at other times.



Filariasis

- *Brugia timori* is a human filarial parasitic nematode (roundworm) which causes the disease "Timor filariasis", or "Timorian filariasis". While this disease was first described in 1965, the identity of Brugia timori as the causative agent was not known until 1977. In that same year, Anopheles barbirostris was shown to be its primary vector.
- Like other human filariasis infections, Brugia timori filariasis causes acute fever and chronic lymphedema. The life cycle of Brugia timori is very similar to that of Wuchereria bancrofti and Brugia malayi, leading to nocturnal periodicity of the disease symptoms.

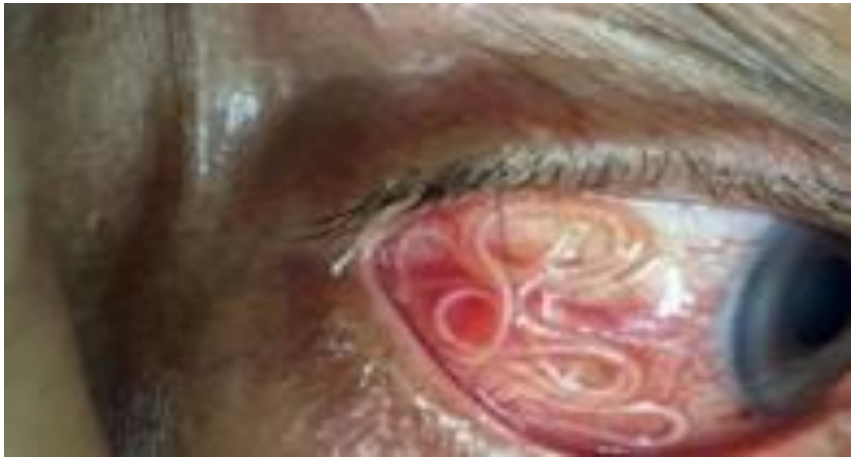


Filariasis

- **Subcutaneous filariasis**: The roundworms that have been associated with subcutaneous filariasis are Loa loa, Mansonella streptocerca, and Onchocerca volvulus.
- *Loa loa filariasis* is a skin and eye disease caused by the nematode worm Loa loa. Humans contract this disease through the bite of a deer fly or mango fly (Chrysops spp), the vectors for Loa loa.

Filariasis

- Loa loa does not normally affect one's vision but can be painful when moving about the eyeball or across the bridge of the nose.



Filariasis

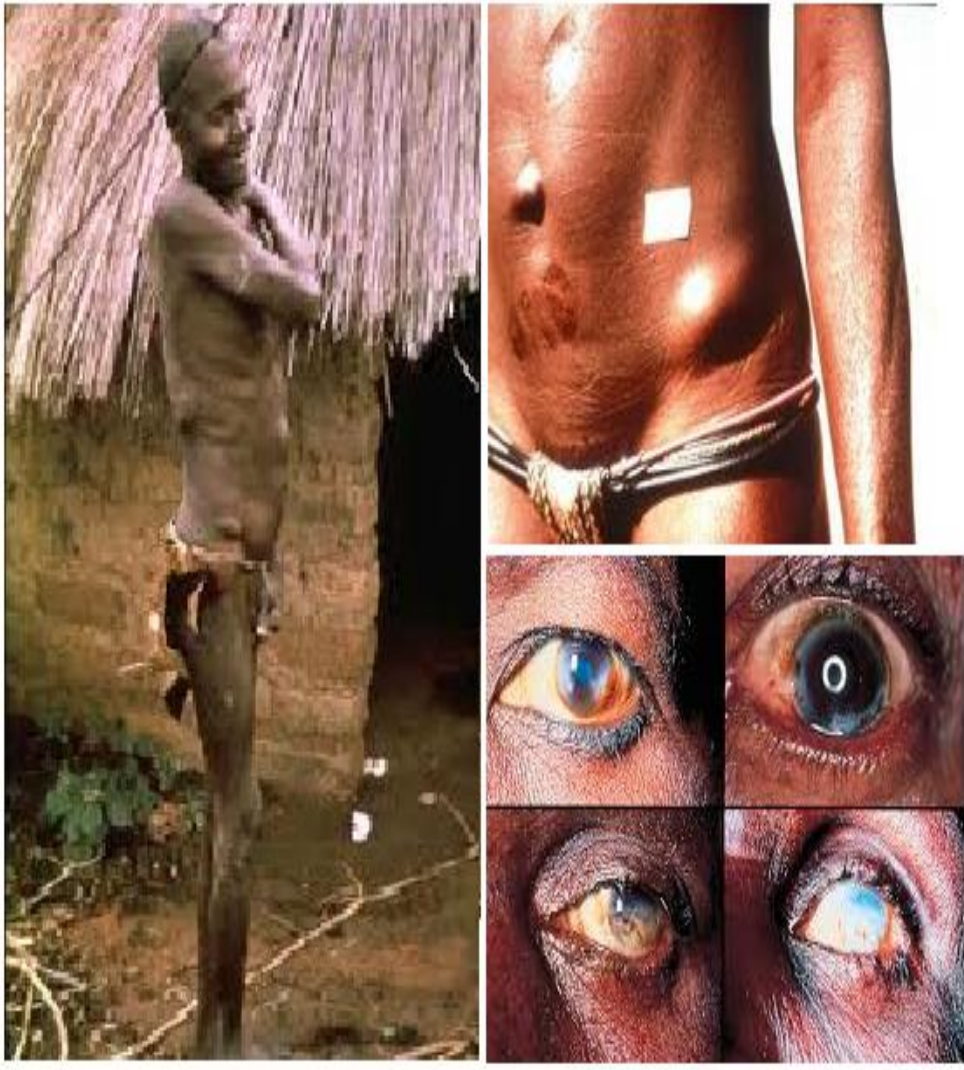
- *Mansonella streptocerca* is mostly found in West and Central Africa. Its intermediate host is a midge insect (Culicoides sp.). The definitive hosts are humans and chimpanzees.

Filariasis

- *Onchocerca volvulus* is a filarial nematode that can cause river blindness (onchocerciasis) and is found mostly in Africa. They have a white filamentous body, pointed at both ends of the female of significantly larger sizes - up to 50 cm in length, giving rise to small microfilariae.
- The intermediate host of this worm is the black fly. The definitive host is human. Infestation with this worm results in blindness when the corneal stroma thickens due to chronic corneal inflammation.

Filariasis

- Adult parasites are located in nodes located under the skin, ranging in size from a pea to a pigeon egg. The nodes are usually located in the armpit, near the joints (knee, femoral).



Filariasis

- **In serous cavity filariasis**, the filariasis is caused by Mansonella perstans and Mansonella ozzardi. These roundworms occupy the serous cavity of the abdomen. They are transmitted by midges. Midges are small flies that feed on blood and therefore are important vectors of diseases. One of these diseases is filariasis. Mansonella perstans is found in sub-Saharan Africa, certain parts of Central and South America, and the Caribbean.

THANK YOU FOR ATTENTION!