BIOLOGICAL BASES OF PARASITISM

Azerbaijan Medical University

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Lecture plan:

1. Subject and problems of medical parasitology
2. Forms of biological interactions in nature
3. Classification of parasitism
4. Development cycle of parasites
5. Specificity in parasites
6. Types of parasitism. Parasites of the first and second degrees
7. Parasite-host relationships
8. Biohelminths
9. Geohelminths
10. Ways of penetration of parasites into the host organism

Subject and tasks of medical parasitology

- **Parasitology** is the study of parasites, their hosts, and the relationship between them.
- **Medical parasitology** traditionally has included the study of three major groups of animals: parasitic protozoa, parasitic helminthes (worms), and those arthropods that directly cause disease or act as vectors of various pathogens.
- **Problems of medical parasitology**: study systematic position of parasites in the living world, their structure, features of life and development cycle; study relationships in the host parasite system; development of methods for the diagnosis, treatment and prevention of parasitic diseases.

Forms of biological interactions in nature

- **Short-term interactions**:
- Predation. In predation, one organism, the predator, kills and eats another organism, its prey. Predators are adapted and often highly specialized for hunting, with acute senses such as vision, hearing, or smell. Many predatory animals, both vertebrate and invertebrate, have sharp claws or jaws to grip, kill, and cut up their prey. Predation has a powerful selective effect on prey, causing them to develop antipredator adaptations such as warning coloration, alarm calls and other signals, camouflage and defensive spines and chemicals.

Forms of biological interactions in nature: predation

Forms of biological interactions in nature

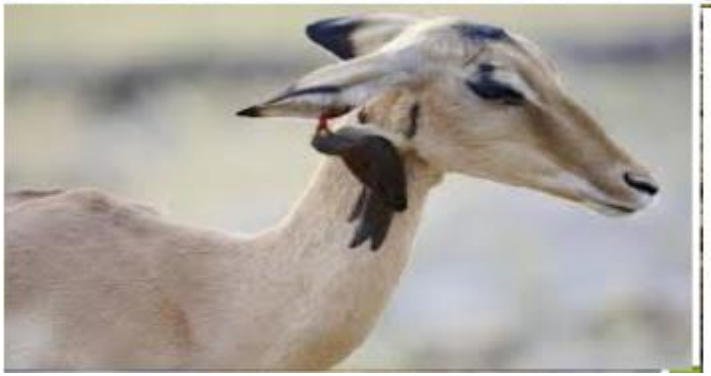
- **Short-term interactions:**
- Pollination: In pollination, pollinators including insects (entomophily), some birds (ornithophily), and some bats, transfer pollen from a male flower part to a female flower part, enabling fertilization, in return for a reward of pollen or nectar.

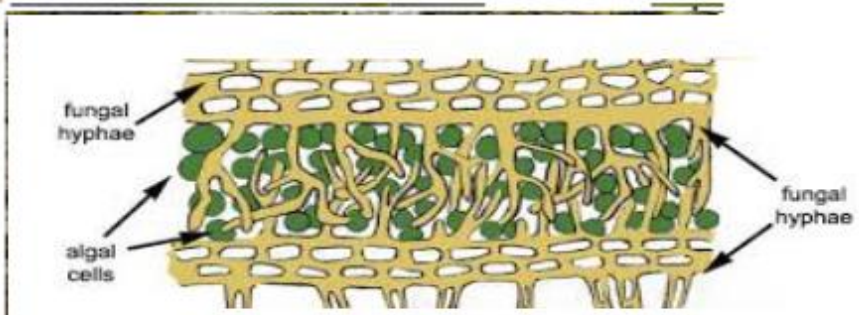
Forms of biological interactions in nature

- **Long-term interactions:**
- Mutualism describes the ecological interaction between two or more species where each species benefits.

Mutualism is often conflated with symbiosis. Symbiosis involves two species living in close proximity and may be mutualistic, parasitic, or commensal, so symbiotic relationships are not always mutualistic.

Forms of biological interactions in nature: mutualism





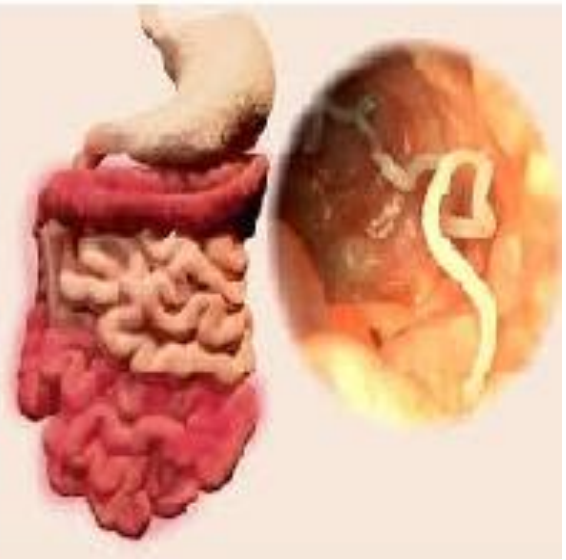
Forms of biological interactions in nature

- **Long-term interactions:**
- Commensalism: one organism benefits and the other organism is neither benefited nor harmed. It occurs when one organism takes benefits by interacting with another organism by which the host organism is not affected.

Forms of biological interactions in nature

- **Long-term interactions:**
- Parasitism is a relationship between species, where one organism, the parasite, lives on or inside another organism, the host, causing it some harm, and is adapted structurally to this way of life. The parasite either feeds on the host, or, in the case of intestinal parasites, consumes some of its food.

Forms of biological interactions in nature: parasitism



Forms of biological interactions in nature

- **Long-term interactions:**
- Neutralism is a type of relationship in which organisms have virtually no effect on each other. For example, the relationship of squirrels and moose in the forest. Pure neutralism does not exist in nature: everything in nature is interconnected and everyone indirectly influences each other.

Forms of biological interactions in nature: neutralism

Forms of biological interactions in nature

- **Long-term interactions:**
- Amensalism is an interaction between organisms in which one organism secretes a chemical that kills the other organism, while the one that secreted the chemical is unharmed. For example, blue-green algae, causing the flowering of water, thereby poison the aquatic fauna, and sometimes even livestock that comes to the watering hole.

Forms of biological interactions in nature

- **Long-term interactions:**
- Competition is a interaction between organisms or species, in which the ability of one is lowered by the presence of another. Competition is often for a resource such as food, water, or territory in limited supply, or for access to females for reproduction.
- Competition among members of the same species is known as intraspecific competition, while competition between individuals of different species is known as interspecific competition. According to the competitive exclusion principle, species less suited to compete for resources should either adapt or die out.

Forms of biological interactions in nature: competition

interspecific competition

intraspecific competition

Classification of parasites

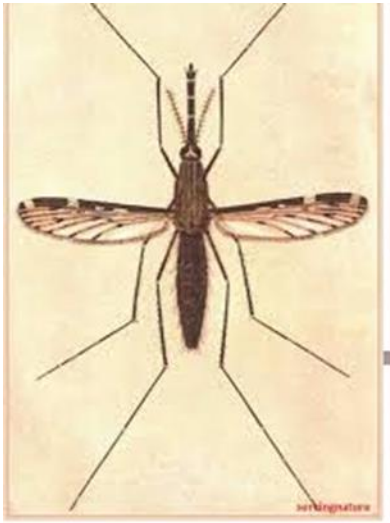
- *Facultative parasite*: lives a parasitic life when opportunity arises i.e., organisms which can live either a parasitic or non-parasitic existence. For example, larvae of synanthropic flies can develop in food products, but, once in the human intestines, they continue their development, causing intestinal myiasis.
- *Obligatory parasite*: Cannot exist without a parasitic life i.e., they are obliged to live a parasitic existence and are incapable of surviving outside the host's environment. Example: plasmodium.

Classification of parasites

- *Ectoparasite* live on the surface of the host body. Example: head louse, blood sucking fleas, flies, lice, mites etc.
- *Endoparasite* live in the inside of the host body: in blood, tissues, body cavities, digestive tract and other organs. Example: Entamoeba, Trypanosoma, Plasmodium, Leishmania, Fasciola etc.

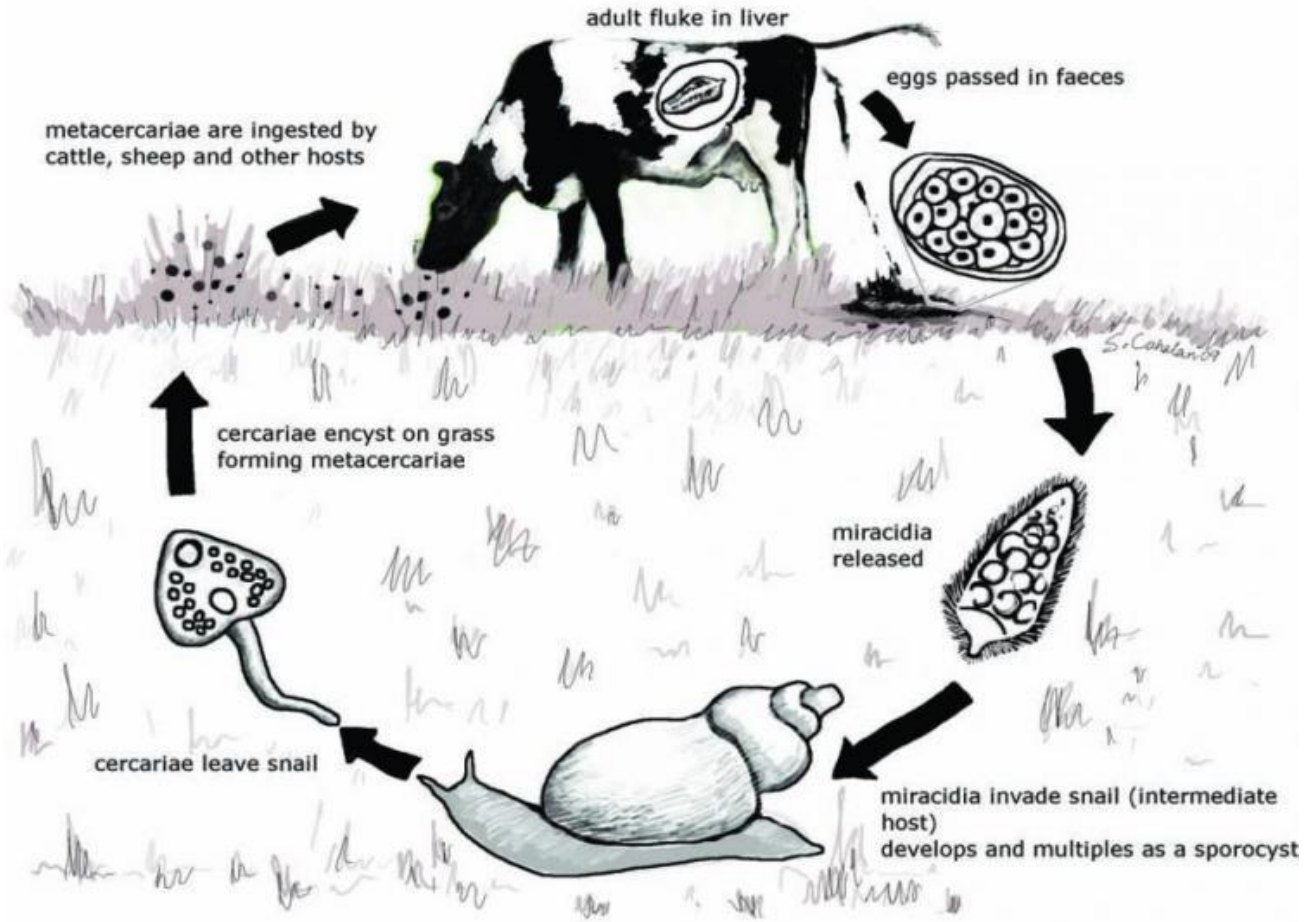
Classification of parasites

- *Permanent parasite*: leads a parasitic condition throughout the whole period of its life. For example, head louse cannot live away from the body of the host.
- *Temporary parasite*: visit host for a short period (ticks, flea).



Life cycle of parasites

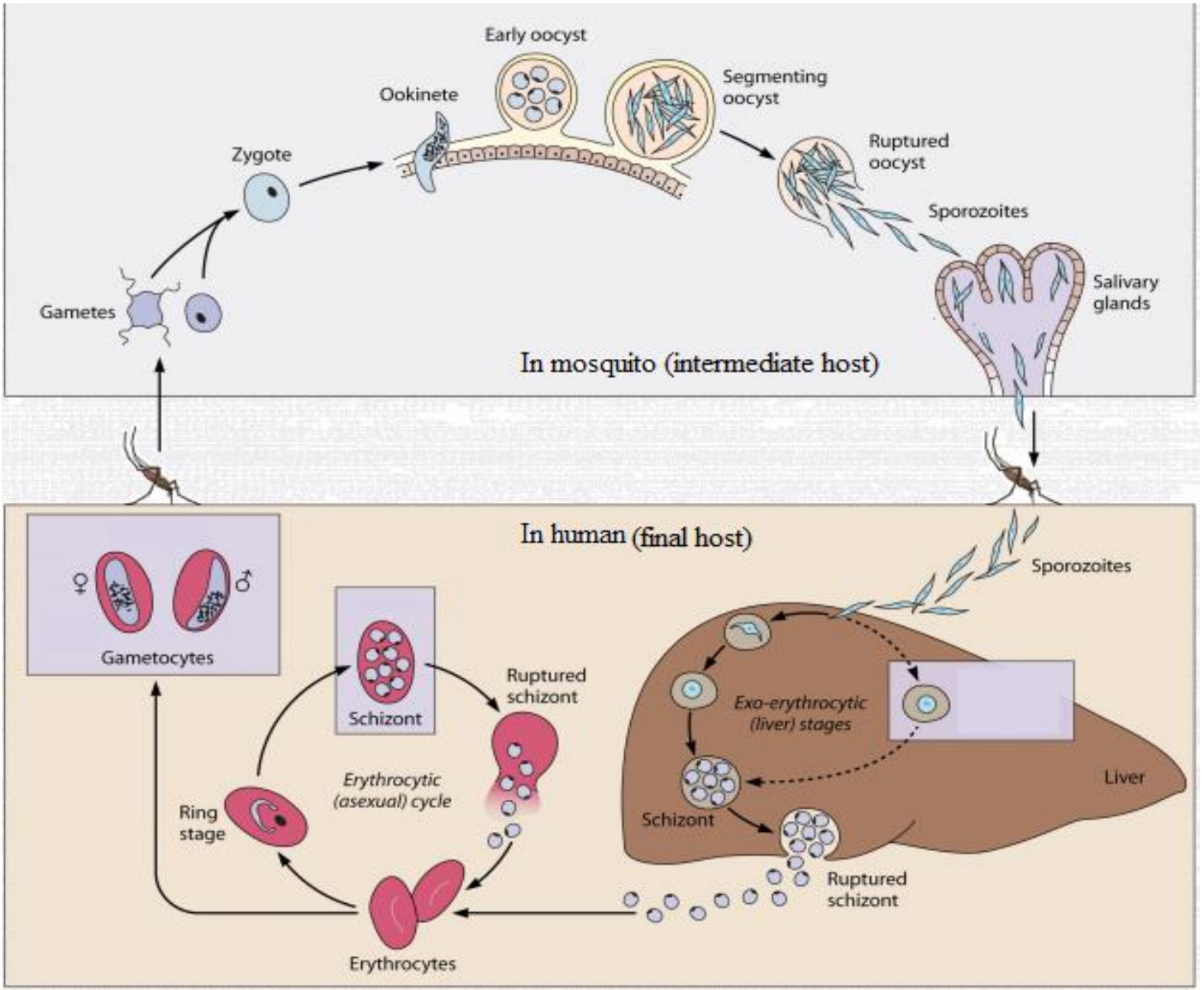
- Life cycle is a set of successive stages of development of a given parasite from the initial stage (egg, cyst) to the final stage (sexually mature stage).
- Some parasites during the life cycle can change hosts.



Life cycle of parasites

- The **main or definitive** host is the organism in which a parasite reaches sexual maturity and undergoes sexual reproduction. For example, a mosquito is the final host, in the life cycle of Plasmodium.
- **Intermediate host** is a host in which the parasite is in the larval stage or reproduces asexually. For example, human is an intermediate host in the life cycle of Plasmodium.

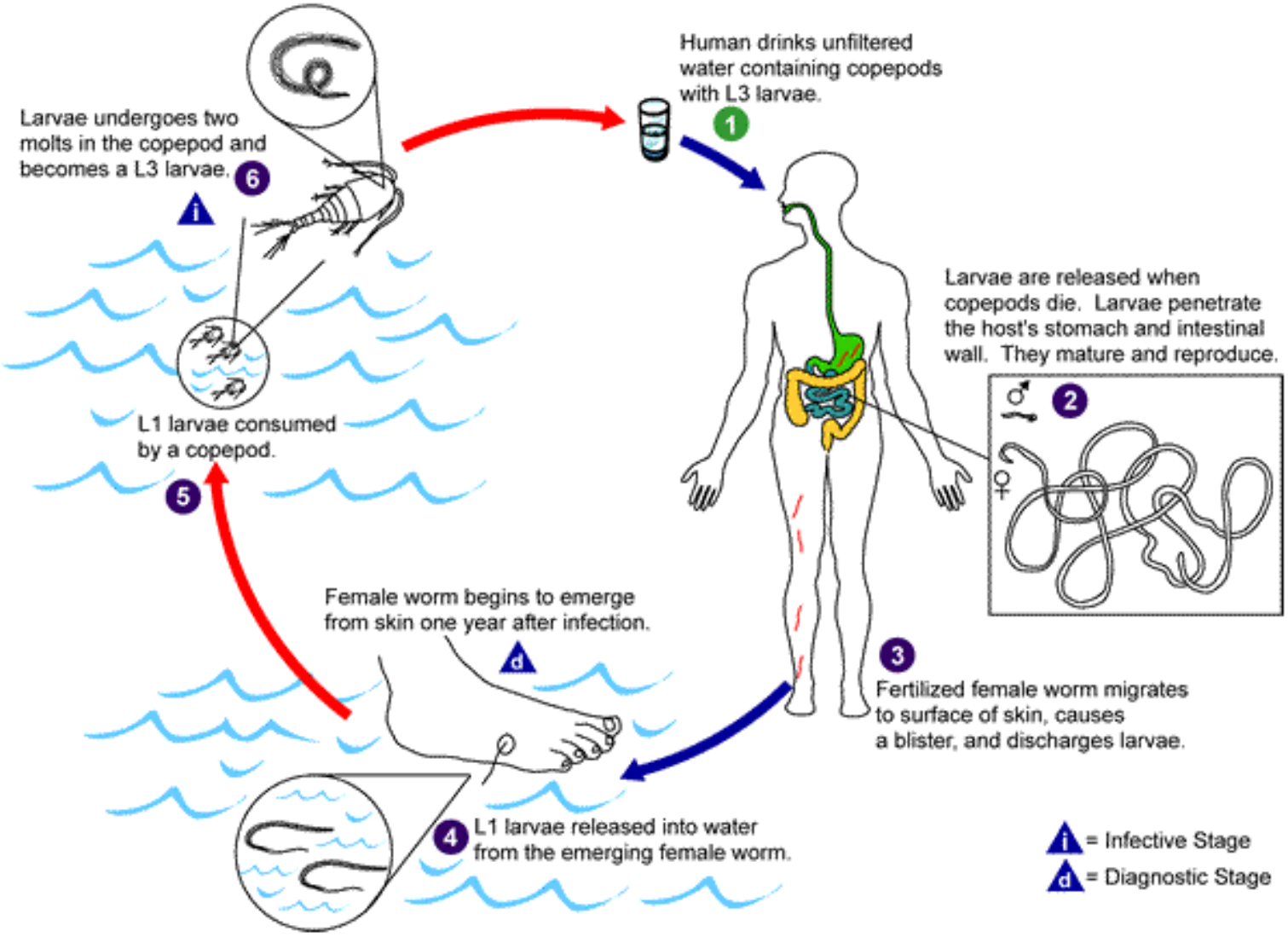
Life cycle of parasites

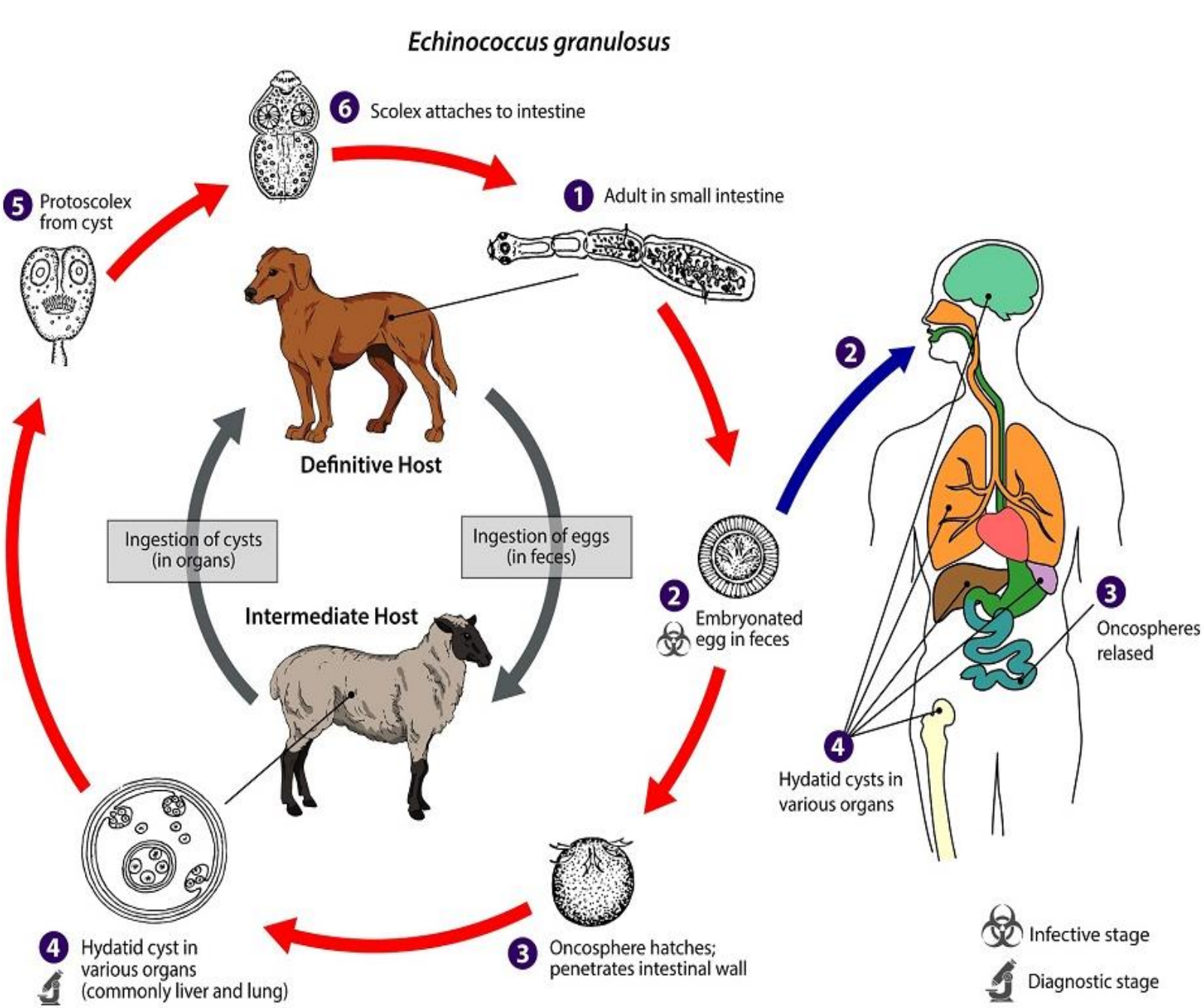


Life cycle of parasites

- Some parasites use two or more various species of intermediate hosts to complete the life cycle. This is due to the fact that each stage completes the development cycle in the organism of a certain species. For example, in the life cycle of the Guinea worm (*Dracunculus medinensis*), there is one intermediate host (copepod) and one final (human).

Life cycle of parasites




Echinococcus granulosus
6 Scolex attaches to intestine
1 Adult in small intestine
5 Protoscolex from cyst
Definitive Host
Ingestion of cysts (in organs)
Ingestion of eggs (in feces)
Intermediate Host
2
2 Embryonated egg in feces
3 Oncospheres relased
4 Hydatid cysts in various organs
3 Oncosphere hatches; penetrates intestinal wall
4 Hydatid cyst in various organs (commonly liver and lung)
Infective stage
Diagnostic stage

Life cycle of parasites

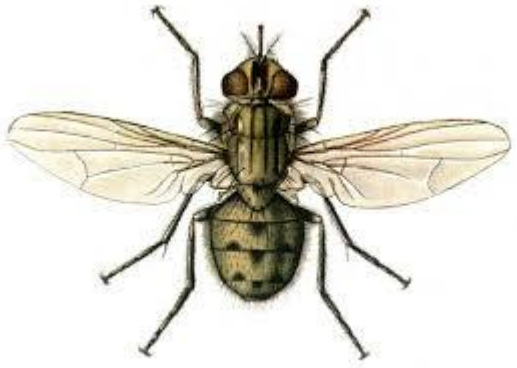
- Paratenic host, also known as transport host or transfer host. Paratenic host - an organism that harbors the sexually immature parasite but is not necessary for the parasite's development cycle to progress. Paratenic hosts serve as "dumps" for non-mature stages of a parasite in which they can accumulate in high numbers. The trematode Alaria americana may serve as an example: the so-called mesocercarial stages of this parasite reside in tadpoles, which are rarely eaten by the definitive canine host. The tadpoles are more frequently preyed on by snakes, in which the mesocercariae may not undergo further development. However, the parasites may accumulate in the snake paratenic host and infect the definitive host once the snake is consumed by a canid. They are believed to bridge the ecological gap between the Definitive and Intermediate host. E.g.-Housefly (contamination agent and disease causing pathogens).

Life cycle of parasites

- Reservoir host, also known as Temporary host is an organism in which the causative agent of the disease can live for a long time, multiply, accumulate and settle. E.g.- Monkey is reservoir host for Plasmodium.
- No development takes place in paratenic hosts, whereas in reservoir host development and multiplication takes place.

Life cycle of parasites

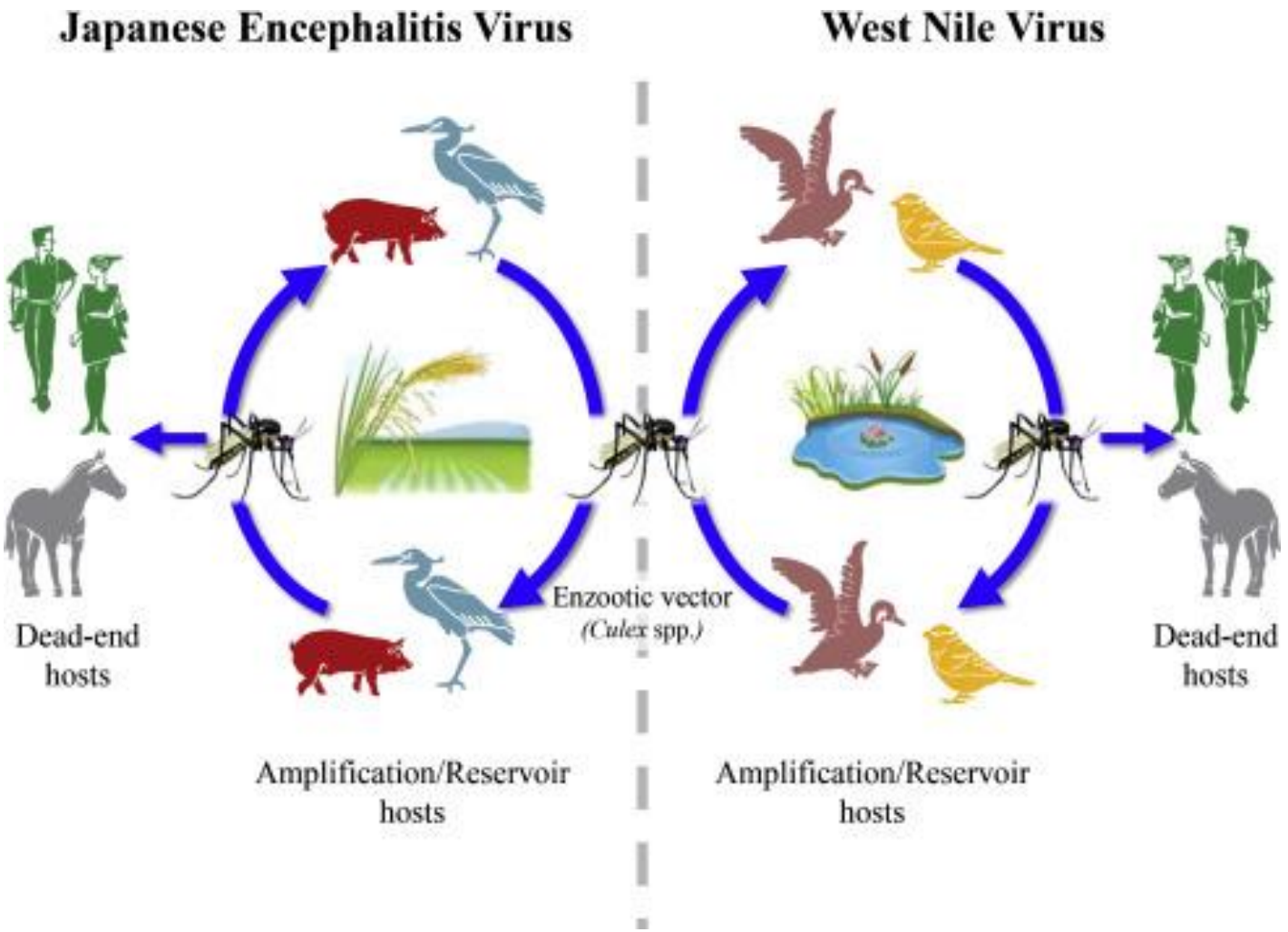
- Vector is the host in which a part of life cycle of a parasite takes place and is also instrumental in the transmission of the parasite from main host to other. Mostly typical Arthropods are the refers to vector hosts.
- There are two types of vector: 1) Biological Vector e.g.- Haematophagous arthropods such as mosqutoes.
- 2) Mechanical Vector e.g.-Flies for transport of Amoebal cysts.



Life cycle of parasites

- Dead-end, incidental, or accidental host is a host from which infectious agents are not transmitted to other susceptible hosts. For example, humans and horses are dead-end hosts for West Nile virus, whose life cycle is normally between mosquitoes and birds. People and horses can become infected, but the level of virus in their blood does not high enough to pass on the infection to mosquitoes that bite them.

Life cycle of parasites



Specificity in parasites

- The parasite's adaptability to existence in a particular form or group of host species is called **specificity**. Specificity is a characteristic property of a parasite that has developed during a long joint evolution of the parasite and the host. It depends on the reactions of both organisms to each other and has a biochemical basis.
- There are 2 types of specificity: wide and narrow.
- In **wide specificity**, parasites can exist in more than one form, genus or family of hosts. For example, parasitic ciliates - chylodonella, ichthyophthyrius - affect various species of fish. A helminth such as botriocephalus can settle in the intestines of carp, as well as grass carp, spotted silver carp, gold and silver crucians, etc.
- Parasites with **narrow specificity** are confined to one species of fish. So, 70% of monogenes species live in one host (carp have their own species, grass carp have their own). Parasitic crustaceans - synergasily - live only in grass carp and silver carp, and each species of fish has its own type of parasite.

Specificity in parasites

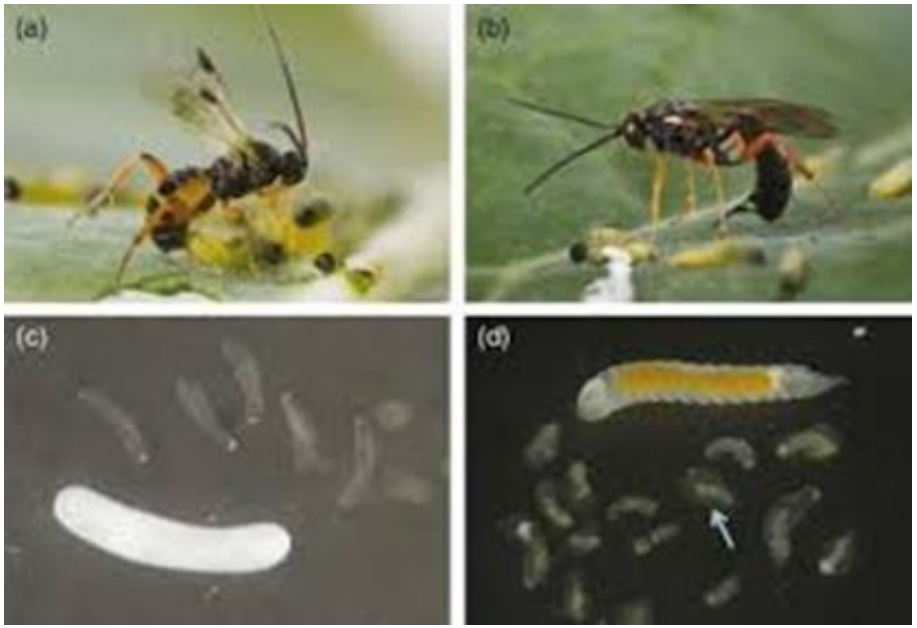
- In almost all cases when a parasite is found in several hosts, it is noted that in one of them it occurs more often, increasing to larger sizes, reaching puberty more quickly, etc. Such hosts are the *main host*.
- In other hosts, the parasite, if even found, is less often and in smaller numbers, lagging behind in growth. Such hosts are called *secondary*.
- In the third hosts, the parasite is very rare and, as a rule, develops poorly in them. They should be considered *random, or nonspecific, hosts*.

Types of parasitism

- **Hyperparasitism**: When a parasite serves as host for another parasite. In this case, the hyperparasite is called a second-level parasite, and its host is called a first-level parasite.

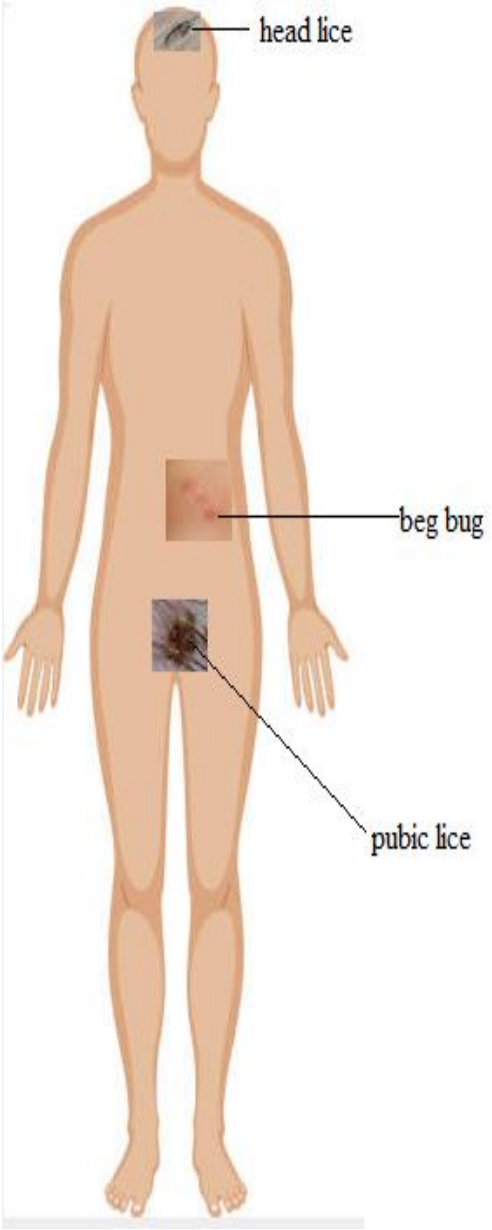
Types of parasitism

- **Superparasitism:** When one organism serves as host for two parasites. For example, caterpillar being infected by Cotesia and Hyposoter.



Types of parasitism

- **Multiparasitism**: When one host is infected by more than one parasite. e.g. Human infected by Head Lice (Pediculus), Pubic Lice (Phthirus), Bed Bug (Cimex) etc. on the same time.



Parasite-host relationships

- **The effects of the parasite on the host are diverse.**

1. Mechanical effects associated with tissue damage, arising from contact with the attachment organs of parasites (suckers, hooks in tapeworms, the mouth apparatus of ticks, etc.). A large accumulation of parasites (roundworm) in the intestine can cause obstruction.

Parasite-host relationships

2. The toxic effect is associated with the effects of vital activity products of parasites. For example, the action of saliva and other digestive juices of ectoparasites secreted during nutrition on the host. The presence of helminths in the intestines of human causes loss of appetite, nausea, vomiting and other phenomena associated with intoxication of the body with the products of parasite vital activity.

Attacks of fever in malaria occur due to rupture of red blood cells and the entry into the blood of the products of parasite dissimilation.

Parasite-host relationships

3. Nutrition of parasites occurs at the expense of the hosts. Parasites, depending on the type and location, are able to absorb tissue fluid, blood, causing harm to the health of the host. For example, hookworm, suckering blood, causes anemia in a human.

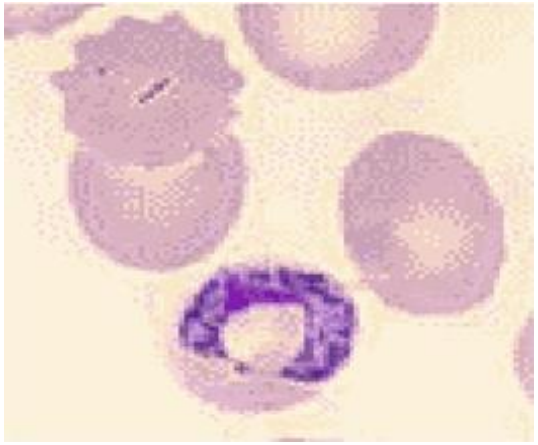
Parasites, as a rule, do not lead to the death of the host, so as not to die themselves.

Parasite-host relationships

- **The effect of the host on the parasite** weakens its vital activity. The host responses can be as a general nature (humoral) and local (cellular and tissue).
- *Humoral reactions* are immune reactions associated with the production of antibodies in response to the receipt of parasite antigens.

Parasite-host relationships

- *Cellular reactions* are manifested in an increase in cell size. Red blood cells affected by malaria plasmodium are larger than those that not affected.



Parasite-host relationships

- *Tissue reaction* is associated with the formation of a connective capsule around the parasite, isolating it from surrounding tissues.

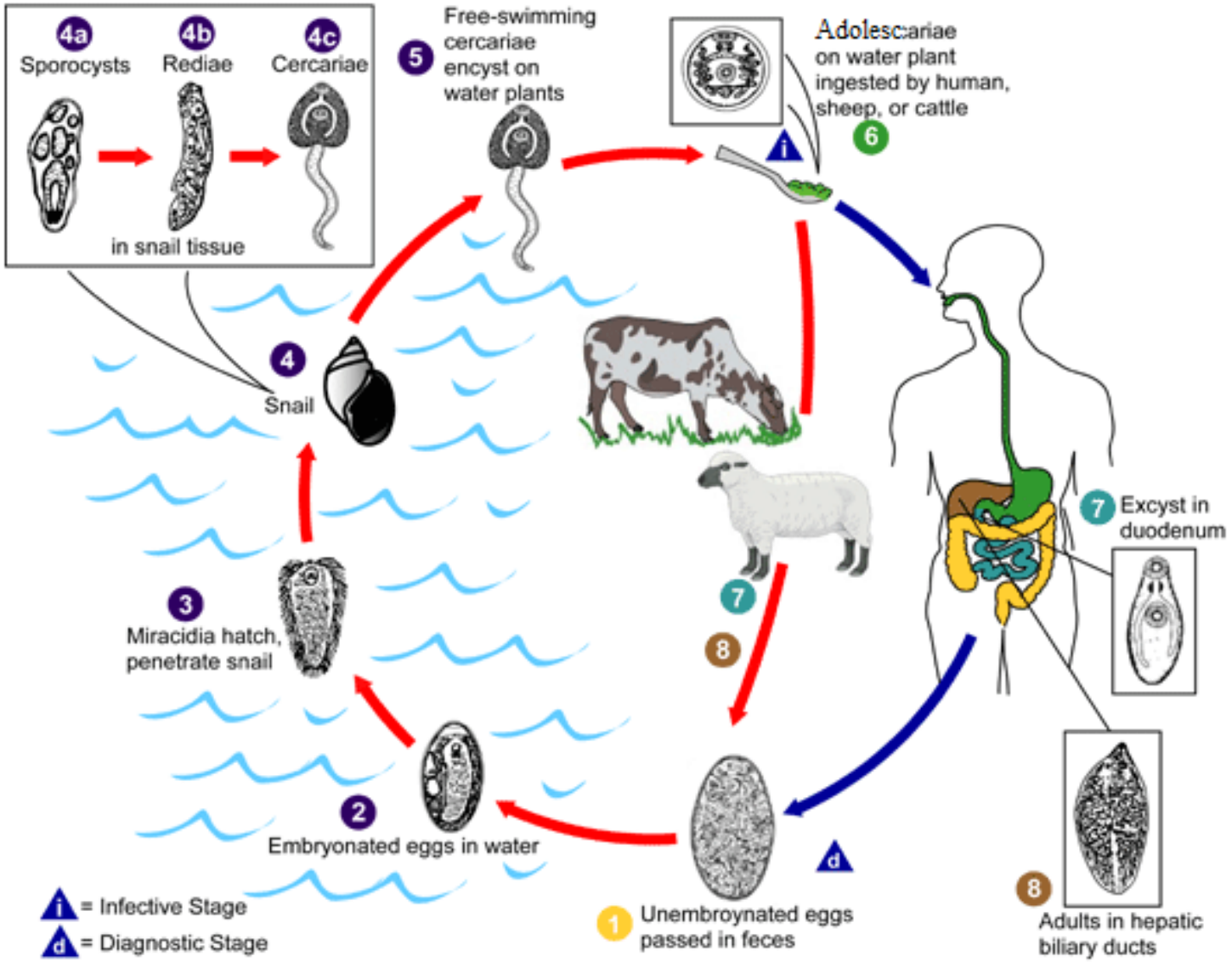
Biohelminths

- **Biohelminths** are the group of parasitic worms that as adults infest the main host (man or animal) and in the larval stage infest the intermediate host (various animals), unlike geohelminths, which develop without an intermediate host. For example, the adult beef tapeworm infests the human intestine, but its larvae, cysticerci, develop in the muscles of cattle. Man becomes infected by eating half-cooked meat infested with cysticerci. The tapeworms also include the broad (fish) tapeworm, liver fluke, trichina, echinococcus, and many other helminths.
- The term "biohelminth" was proposed by the Soviet helminthologist K. I. Skriabin.

Biohelminths

- **Fasciola hepatica**, also known as the common liver fluke or sheep liver fluke, is a parasitic trematode of the class Trematoda, phylum Platyhelminthes. It infects the livers of various mammals, including humans. The disease caused by the fluke is called fasciolosis or fascioliasis.
- Fasciola hepatica occurs in the liver of a definitive host and its lifecycle is indirect. Definitive hosts of the fluke are cattle, sheep, buffaloes and humans. The life cycle of F. hepatica goes through the intermediate host and several environmental larval stages. Intermediate hosts of F. hepatica are air-breathing freshwater snails from the family Lymnaeidae.

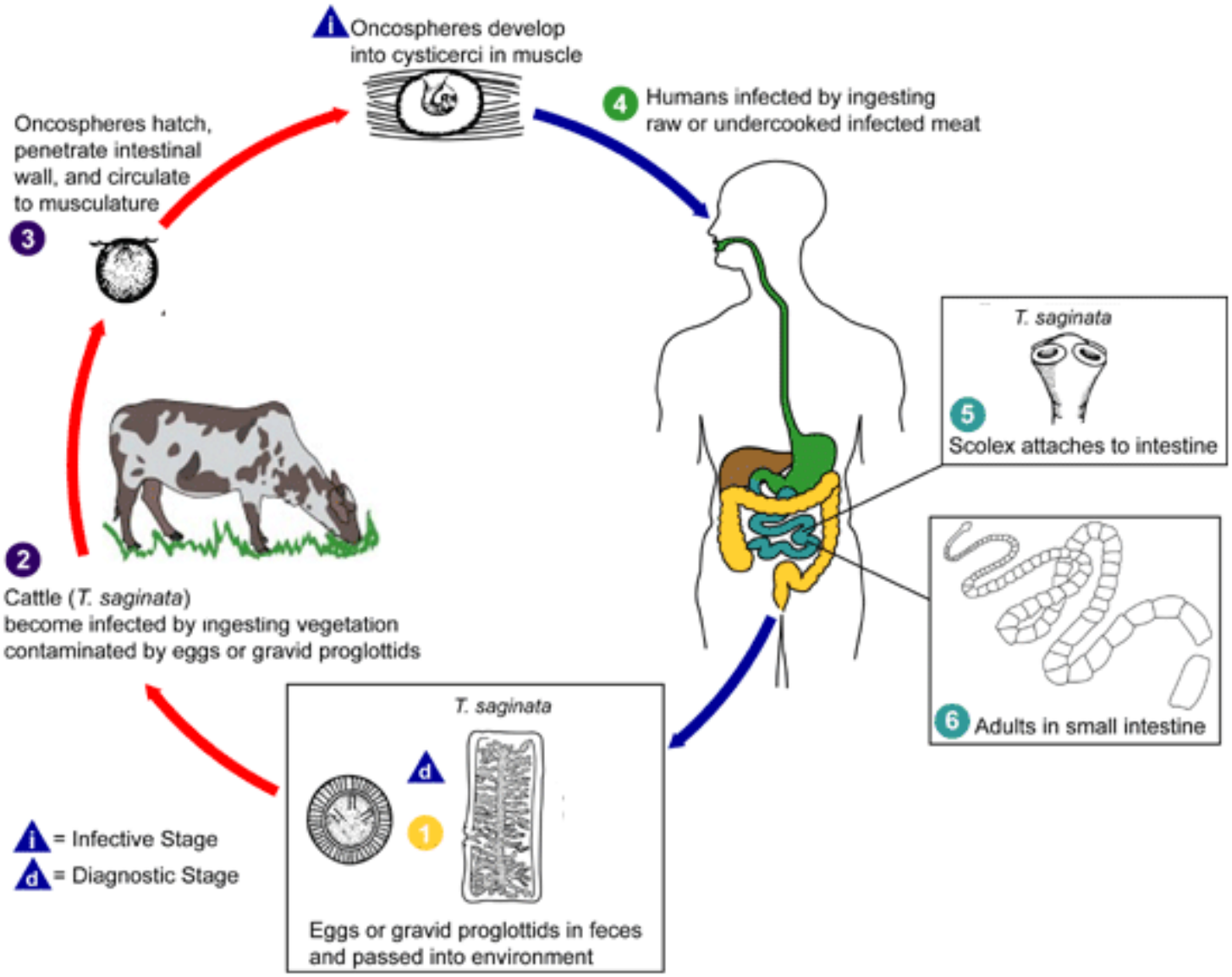
Biohelminths



Biohelminths

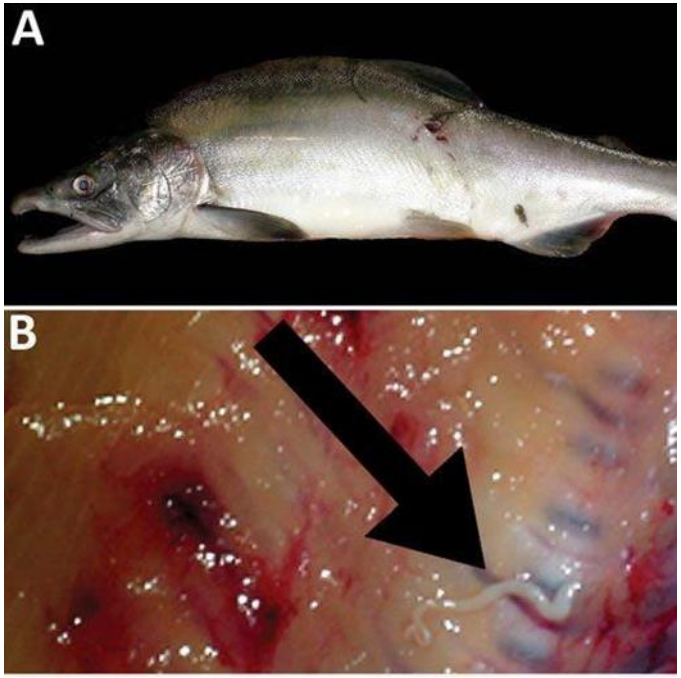
- **Taenia saginata** commonly known as the beef tapeworm, is an intestinal parasite in humans causing taeniasis. Cattle are the intermediate hosts, where larval development occurs, while humans are definitive hosts harbouring the adult worms.

Biohelminths

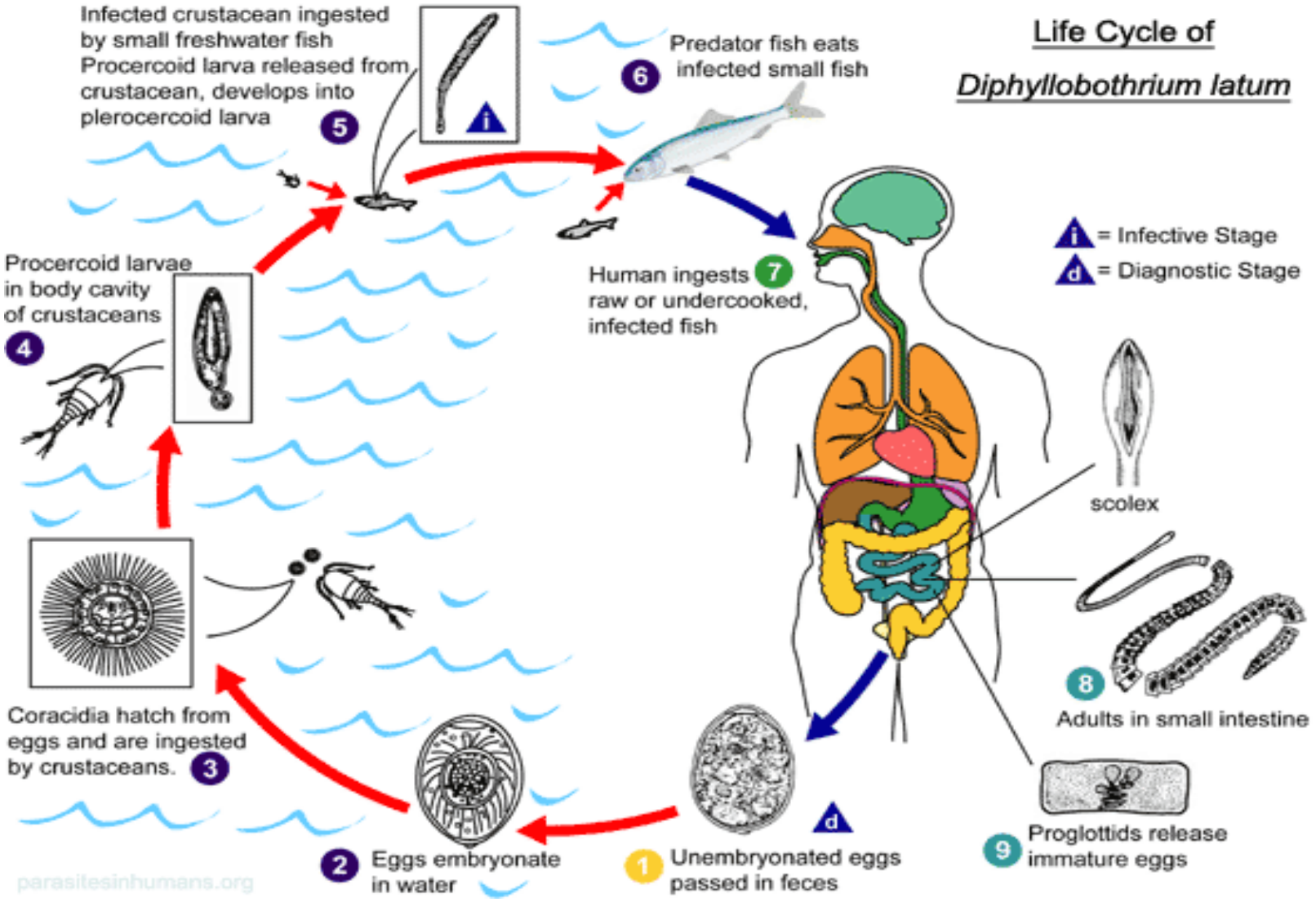


Biohelminths

- **Diphyllobothrium latum**, known as the broad or fish tapeworm, is causing diphyllobothriasis.



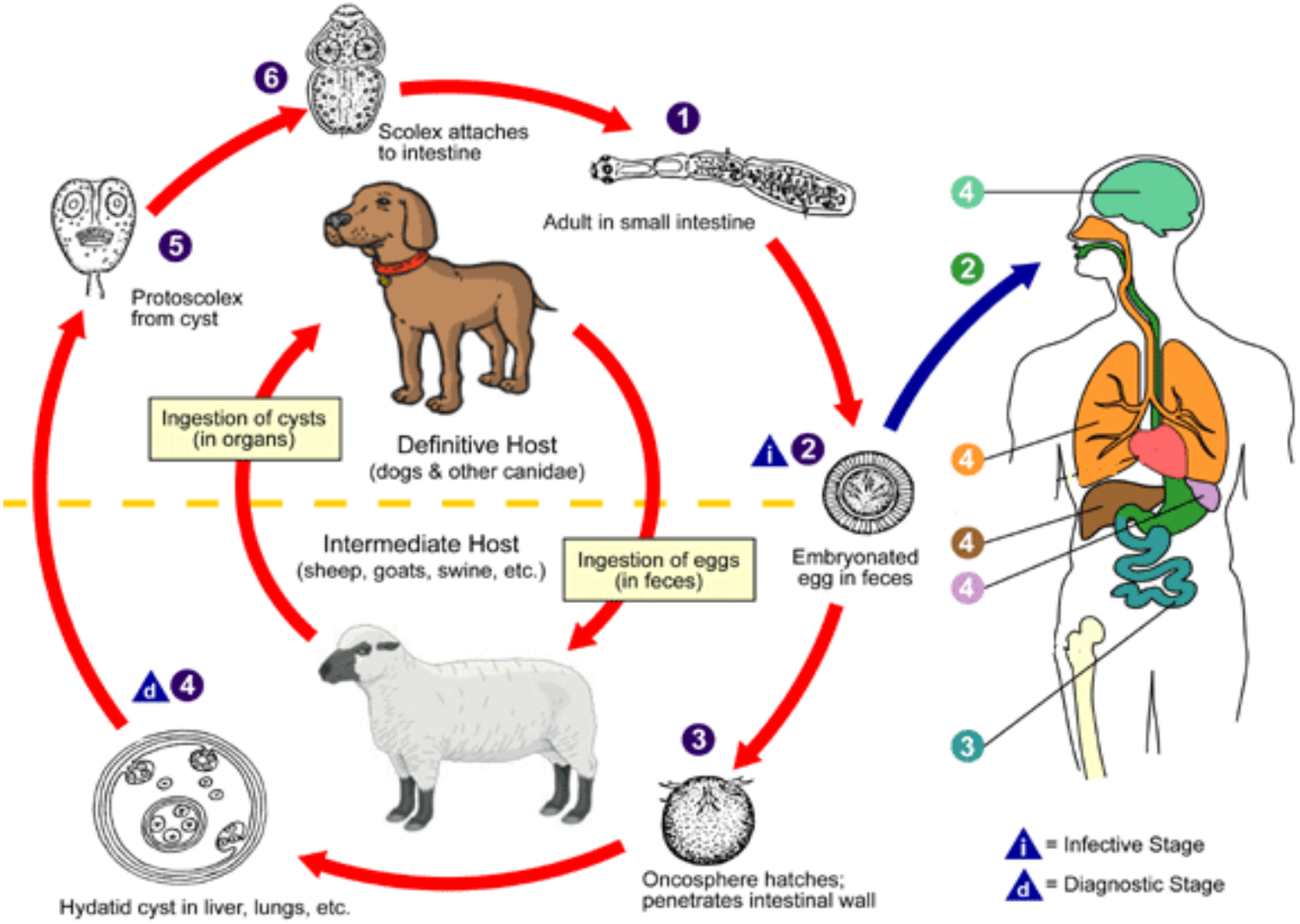
Biohelminths



Biohelminths

- **Echinococcus granulosus**, also called the hydatid worm, dwells in the small intestine of canids as an adult, but which has important intermediate hosts such as livestock and humans, where it causes cystic echinococcosis, also known as hydatid disease.
- The adult tapeworm ranges in length from 3 mm to 6 mm and has three proglottids. The average number of eggs per gravid proglottid is 823. E. granulosus has four suckers on its scolex, and also has a rostellum with hooks.
- The lifecycle of E. granulosus involves dogs and wild carnivores as a definitive host for the adult tapeworm. Wild or domesticated ungulates, such as sheep, and human serve as an intermediate host.

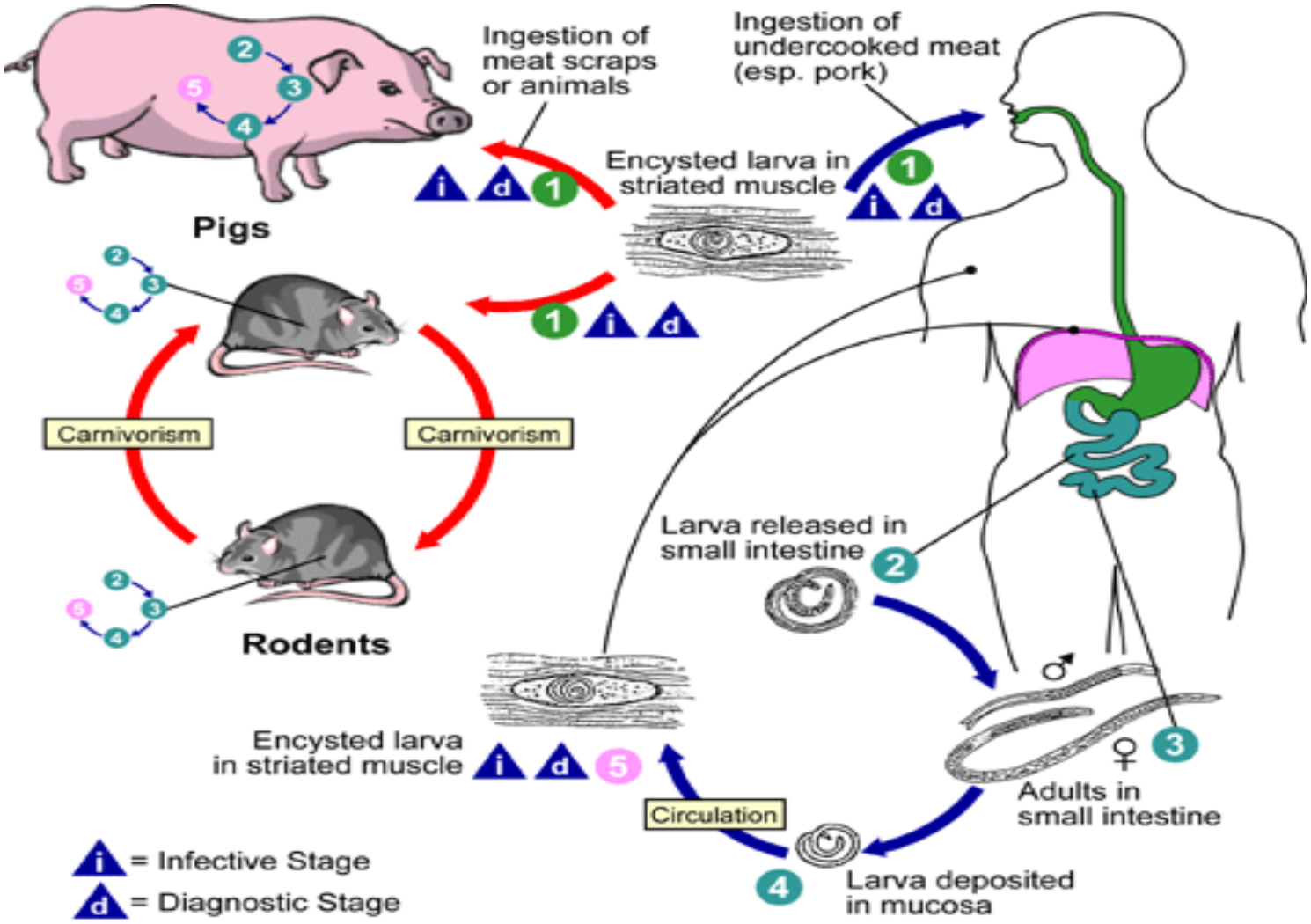
Biohelminths



Biohelminths

- **Trichinella spiralis** is an viviparous nematode parasite, occurring in rodents, pigs, bears, hyenas and humans, and is responsible for the disease trichinosis. It is sometimes referred to as the "pork worm" due to it being typically encountered in undercooked pork products.
- Trichinella spiralis can live the majority of its adult life in the intestines of humans. To begin its life cycle, Trichinella spiralis adults will invade the intestinal wall of a pig, and produce larvae that invade the pig's muscles. The larval forms are encapsulated as a small cystic structure within a muscle cell of the infected host. When another animal (perhaps a human) eats the infected meat, the larvae are released from the meat (due to stomach pH), and migrate to the intestine, where they burrow into the intestinal mucosa, mature, and reproduce.

Biohelminths



Geohelminths

- The **geohelminths**, also called soil-transmitted helminths, are a group of intestinal parasites belonging to the phylum Nematoda that are transmitted primarily through contaminated soil. They are so called because they have a direct life cycle which requires no intermediate hosts or vectors, and the parasitic infection occurs through faecal contamination of soil, foodstuffs and water supplies. The adult forms are essentially parasites of humans, causing soil-transmitted helminthiasis (STH), but also infect domesticated mammals. The juveniles are the infective forms and they undergo tissue-migratory stages during which they invade vital organs such as lungs and liver.

Geohelminths

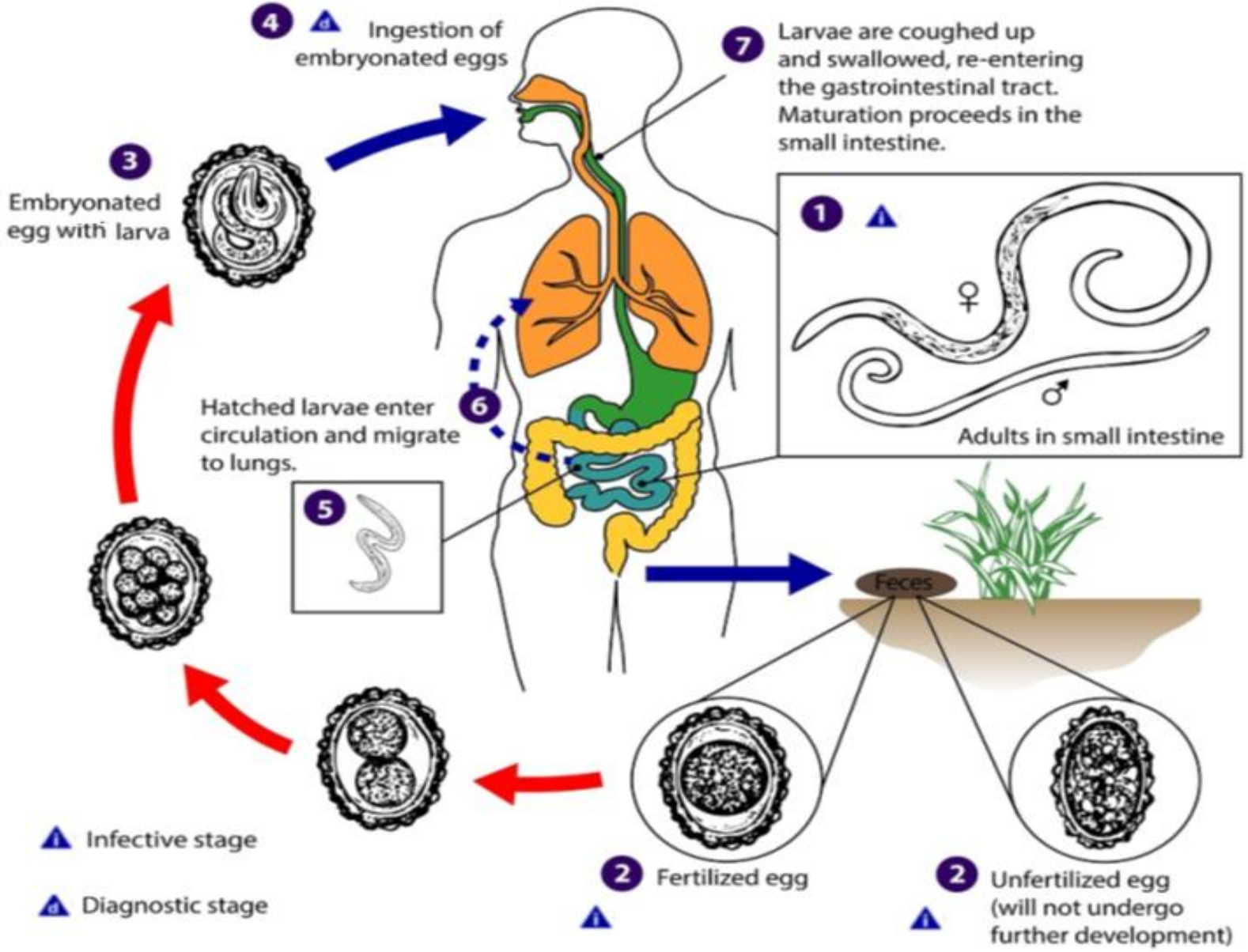
Soil-transmitted helminths are typically from the following families of nematodes, namely:

- *Roundworms* (family Ascarididae), e.g. Ascaris lumbricoides
- *Whipworms* (family Trichuridae), e.g. Trichuris trichiura
- *Hookworms* (family Ancylostomatidae), e.g. Ancylostoma duodenale and Necator americanus
- *Threadworms* (family Strongyloididae), e.g. Strongyloides stercoralis).

Geohelminths

- **Ascaris lumbricoides** is the "large roundworm" of humans, growing to a length of up to 40 cm. Ascaris is responsible for the ascariasis disease. An estimated one-sixth of the human population is infected by A. lumbricoides or another roundworm.
- Males are 2–4 mm in diameter and 15–30 cm long. The male's posterior end is curved ventrally and has a bluntly pointed tail. Females are 3–6 mm wide and 20–40 cm long. The vulva is located in the anterior end and accounts for about one-third of its body length.

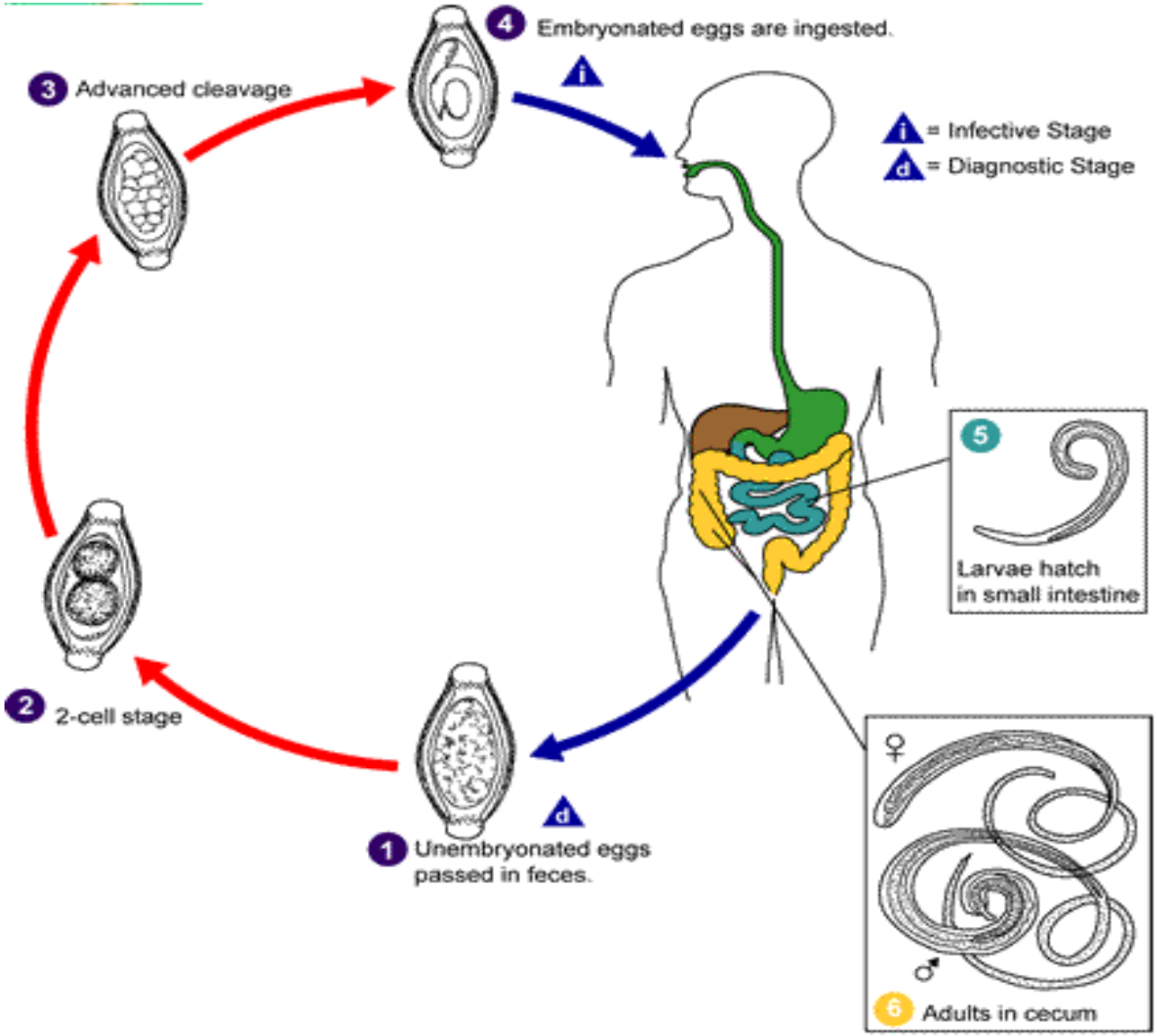
Geohelminths



Geohelminths

- Trichuriasis, also known as whipworm infection, is an infection by the parasitic worm **Trichuris trichiura** (whipworm). If infection is only with a few worms, there are often no symptoms. In those who are infected with many worms, there may be abdominal pain, tiredness and diarrhea. The diarrhea sometimes contains blood. Low red blood cell levels may occur due to loss of blood.

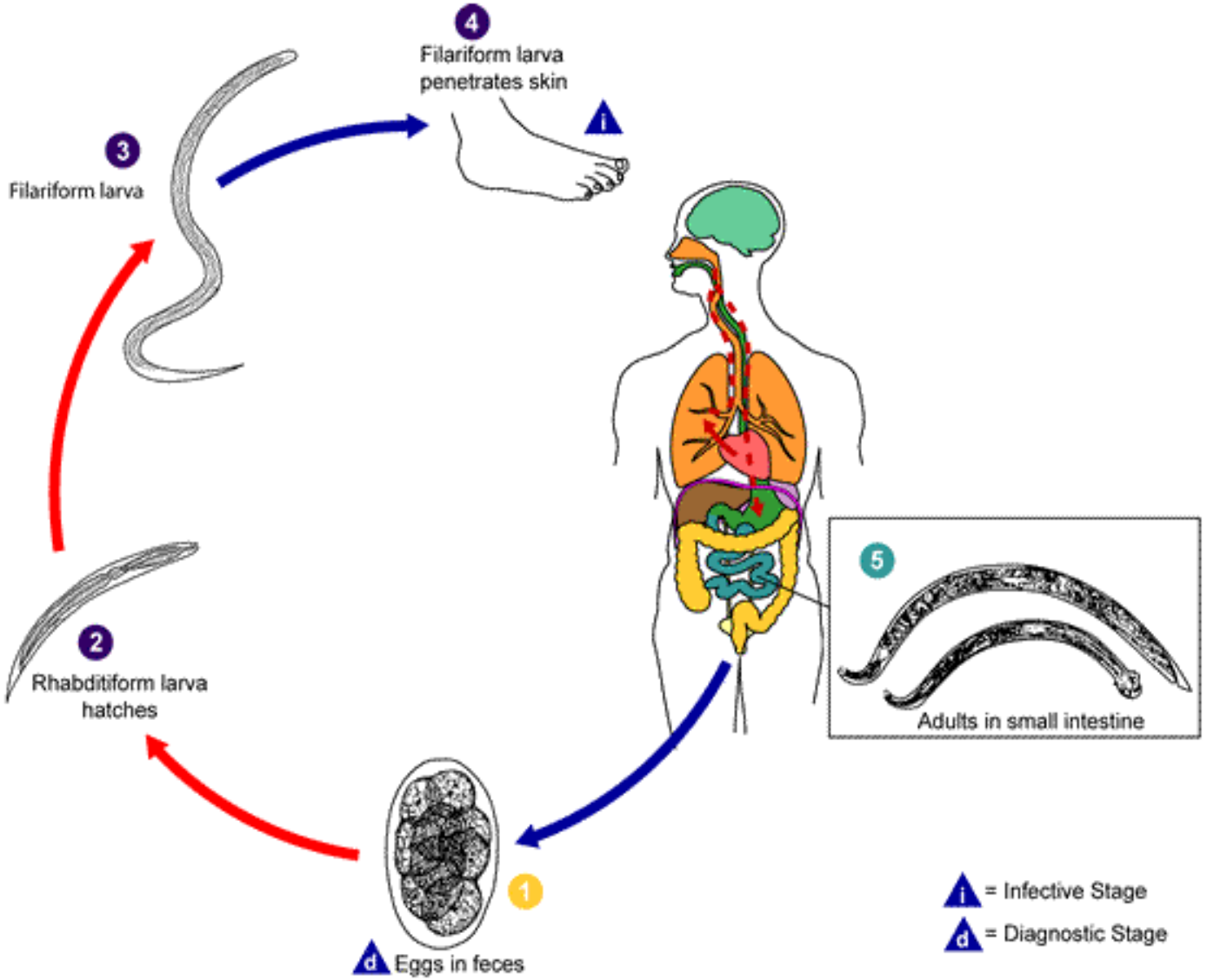
Geohelminths



Geohelminths

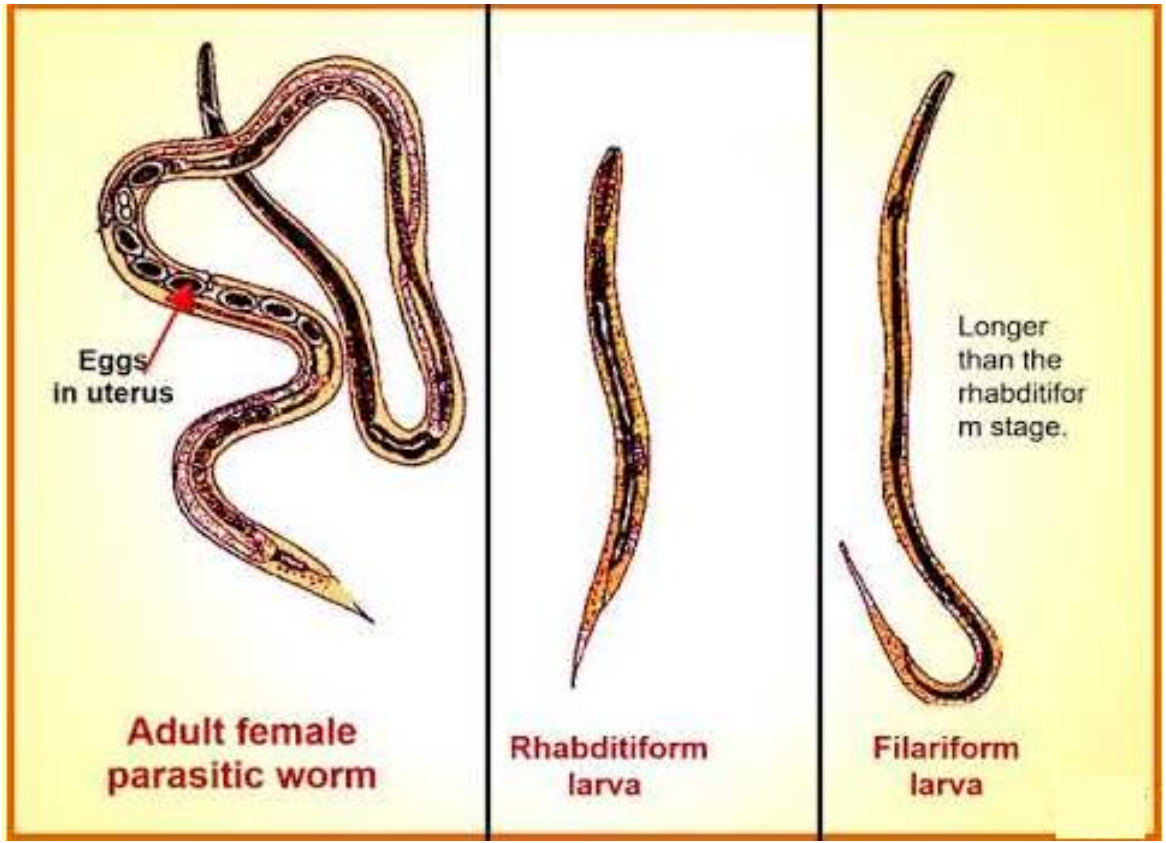
- **Ancylostoma duodenale** is a species of the roundworm genus Ancylostoma. It is a parasitic nematode worm and commonly known as the Old World hookworm. It lives in the small intestine of hosts such as humans, cats and dogs, where it is able to mate and mature. Ancylostoma duodenale and Necator americanus are the two human hookworm species that are normally discussed together as the cause of hookworm infection.

Geohelminths

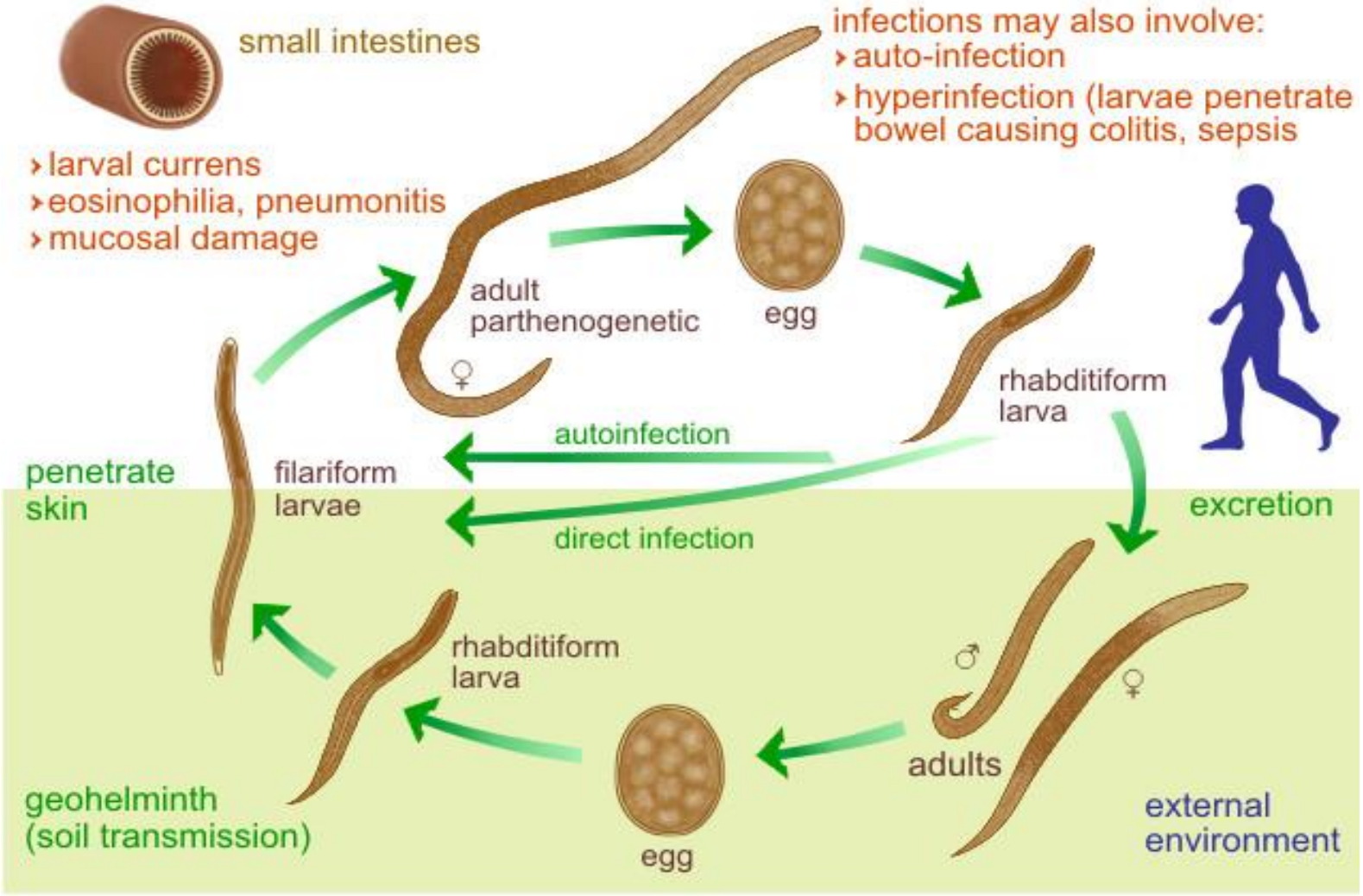


Geohelminths

- **Strongyloides stercoralis**, its common name is threadworm, is a human pathogenic parasitic roundworm causing the disease strongyloidiasis.



Geohelminths



Ways of penetration of parasites into the host organism

- **The peroral** (through the mouth) is the most common. A person can swallow protozoa cysts, eggs and larvae of helminth with infected vegetables, fruits, meat, unwashed hands.

Ways of penetration of parasites into the host organism

- In case of intra-intestinal infection in the intestinal villi, the development of an invasive larva of helminth from a fertilized egg is observed, and then an adult parasite without exit to the external environment. This pathway of infection is observed in dwarf tapeworm and threadworm.

Ways of penetration of parasites into the host organism

- During **transplacental infection**, the invasive stages of the parasite in a pregnant woman can penetrate through placenta into the fetus. Transplacental infection of the fetus is described in case of a disease of a pregnant woman with toxoplasmosis, malaria, African trypanosomiasis, visceral leishmaniasis, hookworm.

Ways of penetration of parasites into the host organism

- **The percutaneous pathway** of infection (active penetration of invasive larvae through intact skin) is characteristic of schistosomes, hookworms, necator and other parasites.

Ways of penetration of parasites into the host organism

- The **contact path** of infection is due to direct transmission of the pathogen from the invaded person to healthy people in contact with contaminated hands, underwear, medical equipment, etc. It is observed when infected with scabies, lice, and vaginal trichomonas (sexual contact).

Ways of penetration of parasites into the host organism

- The **transmissible pathway** of human infection with parasites is carried by carriers - blood-sucking arthropods.
- There are two methods: inoculation and contamination.
- During inoculation, the pathogen is actively introduced into the blood of a person or animal with saliva using the oral organs of the carrier as a result of a violation of the integrity of the skin of the host.
- During contamination, the pathogen is applied by a bloodsucker to the intact human skin, and then it can be actively rubbed by a person when combing itchy places.

Thank you for attention