

Review Article



# An Overview of the Science of Parasitology Simply for the General Public

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## Abstract

Every year, millions of people in the world are infected with parasitic diseases, and the main conflict with parasitic diseases is in countries with hot and humid climates and low levels of hygiene. Parasites can damage human and animal communities in different ways, and these damages can be highly extensive. Parasites exist in microscopic and macroscopic forms, which are transmitted to humans and animals through different ways, including water, food, or insect bites. Controlling and examining the transmission ways of parasites is the most important way to prevent parasitic diseases. Although these control programs are being implemented today, one of the extremely important points in controlling parasites is that parasites are eukaryotic organisms, and treatment and control of these organisms is much more difficult compared to prokaryotic organisms. Accordingly, increasing public knowledge is the best way to deal with parasites.

**Keywords:** Parasitology science, Arthropoda, Protozoa, Helminthes, General public

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## Introduction

Parasitology is composed of two Greek words, namely, Para meaning next to and Situs meaning food (1). Parasites are eukaryotic organisms that spend all or part of their lives in contact with living organisms (2). Parasitic diseases are less common in European and North American countries because of the high level of health in these societies, but in African countries, East Asia, tropical regions, and the Indian peninsula, the prevalence of parasitic diseases is high due to the low level. Public health and climate are suitable for the growth and reproduction of parasites. The World Health Organization (WHO) has included five parasitic diseases among the most dangerous human infectious diseases, which are malaria, leishmaniasis, trypanosomiasis, onchocerciasis, and schistosomiasis (3). These parasitic infections can cause death, anemia, fever, malnutrition, iron deficiency, and even death in humans and animals (Figures 1 and 2).

One of the simplest classifications divides parasites into three main categories as follows:

1. *Arthropoda*: Their body is segmented, has bilateral symmetry, and is made of a large number of body cells [Metazoan], and the male and female sexes are separate from each other.
2. *Worms or Helminthes*: Their body is made of many cells [Metazoan], and they belong to five different groups.
3. *Protozoa*: Whose body is made of only one cell, and all biological actions are performed by the same cell.

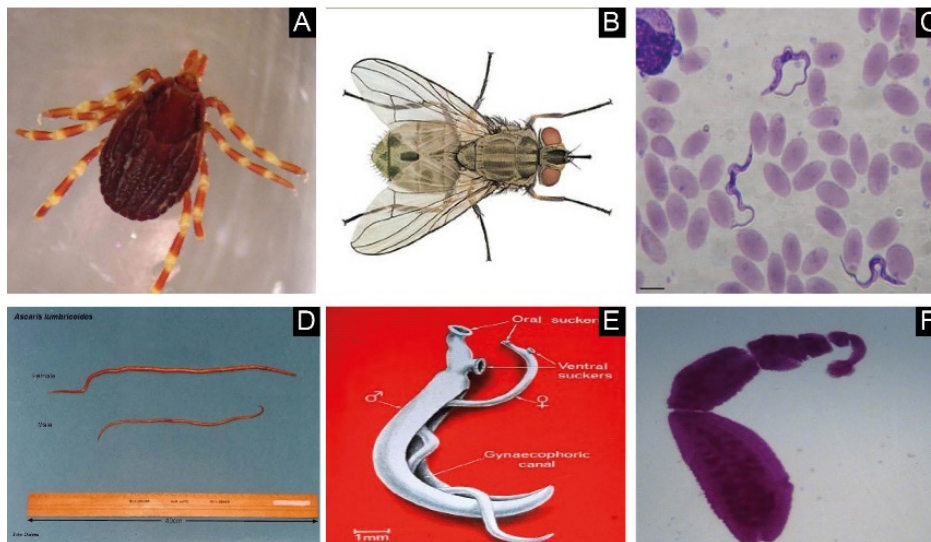
The science of parasitology considers a parasite from the following points:

1. The structure and morphology of the parasite
2. Symptoms of parasitic diseases
3. The life cycle of parasites
4. Treatment (antiparasitic medicine)
5. Geographic distribution of the parasite
6. Epidemiological and health sciences related to the prevention of parasitic diseases

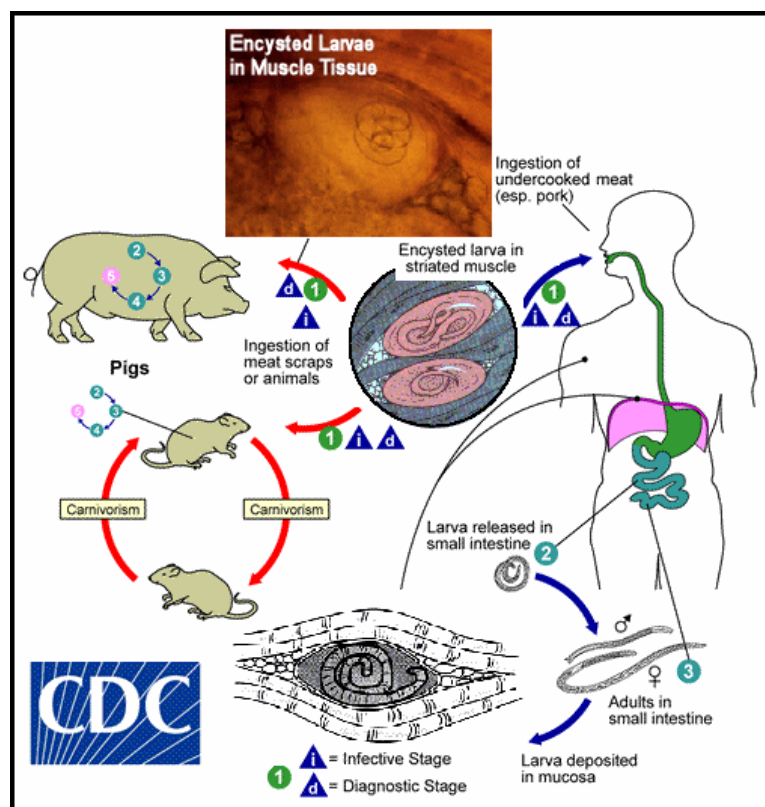
Some important terms of parasitology are mentioned as follows:

- External parasite: It is a parasite that lives outside the host's body (e.g., lice, ticks fleas, and bugs).
- Internal parasite: It is a parasite that lives inside the host's body (e.g., worms and protozoa).
- Carrier host: It is a host that carries part of the parasite's life cycle (e.g., eggs or larvae). The shape of the parasite does not change in the carrier host, and it is only transferred from one host to another. The carrier host makes the parasite safe from climate change.
- Intermediate host: It is a host in which part of the parasite's life cycle is spent. The difference between the intermediate host and the carrier host is that the sexual cycle of the parasite does not change in the carrier host, but part of the sexual cycle and growth of the parasite takes place in the intermediate host.
- Final host: It is the host in whose body the parasite reaches sexual maturity and is ready for sexual





**Figure 1.** Images of Different Parasites Living in the Body of Humans and Different Animals: (A) Hyalomma, (B) Wolfartia, (C) Trypanosoma, (D) Ascaris, (E) Schistosoma, and (F) Echinococcus.



**Figure 2.** Life Cycle of *Trichinella spiralis*.

reproduction or asexual reproduction.

**Arthropoda**

Arthropods make up more than 80% of all organisms on the planet, but many arthropods are useful, and the environment will suffer if they are not there; however, some arthropods are themselves parasites or play a role in the transmission of parasites.

Arthropods are creatures whose bodies have bilateral symmetry, their male and female sexes are separate,

and some of them have the ability to fly. Two classes of arthropods are important in parasitology, and some arthropods have wings.

**Class Insecta:** Some of them have wings, while some are wingless, including mosquitoes, flies, bed bugs, lice, and fleas.

**Class Arachnida:** They are wingless and include ticks and scabies.

All humans and animals face many parasites during the day, but one of the most important creatures dealt

with during the day and around the places where humans and animals sleep and eat are insects, which are the most essential carriers of blood parasites that transmitted by blood-sucking insects. The most vital characteristic of insects is their ability to fly, which can move parasites for several kilometers and may even transfer parasites from one city to another. However, not all insects can fly.

Flies and mosquitoes are insects, and mosquitoes can transmit blood parasites mostly through biting, but flies mostly transmit digestive parasites through their legs and their babies.

The *malaria* parasite is one of the blood parasites that is transmitted through the bite of the *Anopheles* mosquito and is mostly found in tropical regions such as countries on the equator and the Indian peninsula. In recent years, extensive scientific research has been performed to eradicate this disease, but it is still spreading in some places. For example, according to the research conducted between 2013 and 2018 in Burkina Faso, the average monthly visits of children under 5 years old with malaria parasites to health centers has increased (4).

Children and the elderly are always two groups of people who are more at risk of contracting parasitic diseases than the other age groups.

*Leishmania* is also another prominent disease in the world. This parasite is also transmitted by mosquitoes, is mostly found in tropical regions, and exists in about 90 countries of the world (5). Due to the activity of the body's immune system to destroy this parasite, wounds are created at the site of the mosquito bite. In ancient Mesopotamia, in Iraq, inscriptions and signs have been discovered that refer to painless wounds, and in South America, vessels have been discovered that have inscriptions on them that are similar to leishmaniasis infections. It was concluded that this parasitic disease has existed throughout history (6).

About 350 million people are exposed to *Leishmania* every year (7). Most of the infected people are from tropical regions and countries such as Brazil, Ethiopia, Somalia, Sudan, South Sudan, Yemen, Algeria, Iraq, Libya, Pakistan, Syria, Bolivia, Peru, and Kenya. This parasite kills 70 000 people every year, and after malaria, it is one of the diseases that the WHO is thinking of eradicating (8). There are different types of *Leishmania*, and the vectors of this disease are also different. In addition to humans, *Leishmania* exists in animals as well, and *Leishmania* in animals is called visceral *Leishmania*. There are more than 20 different species of *Leishmania* parasites, the most important *Leishmania* vectors are ground mosquitoes belonging to the *Phlebotomus* family. Old World *Leishmania* or cutaneous *Leishmania*, which is known as eastern sore, is mostly found in the Middle East and North Africa. It is *Leishmania tropica*, which is transmitted by the ground mosquito or *Phlebotomus*, and the reservoirs of this type of *Leishmania* are dogs

and rodents. However, New World *Leishmania* with mucocutaneous *Leishmania* is more common in the Americas, some of its important species are as follows:

*Leishmania mexicana*, most of the reservoirs of this type of *Leishmania* are wild cats, and the mosquito of the genus *Lutzomyia* transmits it, which has been reported in Guatemala and the state of Texas in the United States (9).

Another type of *Leishmania* is *Leishmania panamensis*. This type of *Leishmania* parasite is found mostly in Central America and in countries such as Colombia, Costa Rica, and Panama. Most of those infected with this parasite are tourists who have traveled to this region from European and North American countries for fun. In general, when traveling to rainy and tropical countries, safety tips should be observed to prevent mosquito bites (10).

Flies mostly play a role in the physical transmission of parasites, but in the African continent, there is a fly called *Glossina*, which is known as the tsetse fly. *Glossina morsitans* is the most widespread species of tsetse fly that exists in many regions of West Africa - South Sudan - Sudan - Angola - Tanzania - Congo - Zaire - Uganda, and Mozambique and has become a serious problem for these regions. This fly introduces African *trypanosomiasis* into the human body with its bite, which can even cause death (11).

However, as it was mentioned, the baby of some flies is considered a parasite, which is called *Myiasis*, and causes many disorders, especially in domestic animals, including damage to the skin of the body, face, and genital area. Their four important families are *Calliphoridae*, *Oestridae*, *Sarcophagidae*, and *Hippoboscidae* families.

For example, the parasite *Hypoderma bovis* in cattle can cause great economic damage in the livestock industry. This parasite, which is an external parasite and is caused by the larvae of flies, can cause a change in the shape of the skin and beef by damaging the cow's skin, which damages the leather industry and reduces milk and meat production, among the most important damages of this external parasite (12).

The distribution of parasites is different. Some parasites exist only in some countries or some geographical areas such as bed bugs, which are wingless insects and cause disease mostly in the Americas. Identifying the foci of involvement in the disease and its control is one of the basic principles of epidemiology in parasitology. For example, in the United States, the rate of infection with diseases transmitted by bed bugs is higher in the western and southwestern regions, but the most important focus is in the state of Ohio. These bed bugs, which are mostly from the *Reduviidae* family, are found in the sleeping area of humans and are known as kissing bugs. They can cause Chagas disease, which occurs due to bites. *American trypanosomiasis* is transmitted to humans by the bite of bed bugs and can cause allergies, anemia, inflammation of the digestive system, and heart failure. Bed bugs

themselves are considered external parasites, but they transmit other parasites and even transmit bacterial and viral diseases such as hepatitis B (13).

Therefore, it is highly important to be familiar with the centers of disease and it is better for tourists to be familiar with the diseases of that country and region before entering any country, especially countries with hot and humid climates.

However, the danger of lice is one of the problems that all the people of the world are probably facing, especially children between 7 and 12 years old in schools. Lice are extremely specific creatures that can affect both humans and animals. This high specificity has made human and animal lice different, and animal lice cannot affect humans or human lice cannot involve animals. The most important louse in the world, *Pediculus humanus capitis*, is the human head louse. These lice do not play a role in the transmission of protozoan diseases, but cause itching and sensitivity of the scalp surface; thus, the best way to deal with lice is to follow hygiene principles and prevent the use of shared equipment between children and people (14).

Fleas are extremely small and blood-sucking insects that, according to historical studies, originated in Egypt and then spread to other parts of the world. Fleas can transmit the plague and cause widespread deaths; nonetheless, today, the plague has been greatly reduced with the spread of sanitation, but India is one of the countries where the plague still exists (15).

Their third leg is longer than the other legs, which makes the insect jump, and these insects are more important in pets such as dogs and cats.

*Ctenocephalides canis* is known as the dog flea and is mostly found in dogs that live freely, but domestic dogs can become infected with this parasite if they come in contact with infected dogs or contaminated places (16). This type of flea can even transmit the tapeworms of *Dipylidium caninum* to dogs and cause serious damage to dogs.

*Ctenocephalides felis* is a cat flea that is less important in the transmission of pathogens but can cause severe skin allergies in cats (17).

In the Arachnida class, two categories of ticks and mites are worth examining. Ticks are more important in veterinary medicine and make humans less sick. Ticks are the second largest group of parasite carriers and feed on blood, which includes hard and soft ticks (18). To date, about 800 types of ticks have been identified, most of which are hard ticks, and the number of soft ticks is extremely less. Male ticks are smaller than female ticks because male ticks feed on plant nectar rather than feeding on blood, but female ticks are larger due to blood feeding.

Hard ticks are larger than soft ticks. These ticks can feed on blood for a long time, and their body size increases up to 4 times after feeding on blood. They spend most of their lives on the bodies of animals or

humans and must constantly feed on blood. *Hyalomma anatolicum anatolicum* and *Rhipicephalus bursa* are two species of hard ticks that are involved in the transmission of *Theileria* and *Babesia*, respectively, in sheep, goats, and cattle. *Theileria lestoquardi* and *Theileria hirci* species in sheep and *Theileria annulata* species in cattle cause disease. *Babesia ovis* and *Babesia motasi* species in sheep and *Babesia bigemina* and *Babesia bovis* in cattle also cause disease, which is also known as *Babesia* disease. However, according to global research, it has been found that these two parasites cause abortion in livestock and as a result, livestock communities can face population decline.

Soft ticks suck less blood and can stay away from the animal's body and survive for a longer period of time. Soft ticks do not live permanently on the body; they are separated from the body surface after feeding on blood and are mostly found in animal stables and chicken farms. In general, ticks can cause skin inflammation in animals.

An important group of parasites is scabies. These types of parasites can cause serious diseases for humans and pets can also get scabies. This group of parasites creates tunnels under the skin of the body and cause severe damage to the skin tissue and severe itching of the body. Scabies is more common in poor areas of cities and areas that do not respect hygiene (19).

Human contact with animals such as dogs and cats that have mange may also cause this disease. Therefore, it is recommended that humans should not be on the outskirts of cities and polluted areas and not near street dogs and cats.

### Helminthes

Worms are one of the important parasites that are transmitted to humans and animals through contaminated food and water. Most worms are found in the small intestine, but their eggs or larvae can be found in various body tissues. In addition, the eggs or filaria of some worms are transmitted to humans and animals through arthropods (20).

Most worms are macroscopic parasites that can be detected without the use of a microscope. Two important groups of these parasites are tapeworms/cestodes and roundworms/nematodes, which have fundamental differences. The body of cestodes is striped. They do not have a digestive system, and their nutrition is performed through skin absorption. Further, cestodes are parasites in which the male and female sexes are placed in the same band and do not have two males and females. The body of nematodes is one piece. Furthermore, nematodes have a mouth and gut, which forms a weak digestive system. In nematodes, the reproductive system has male and female sexes.

There is another group called leaf-shaped worms or trematodes, which are of lower importance, and the intermediate hosts of these worms are snails.



Additionally, the most important parasitic disease caused by trematodes is *Fasciola*, which can affect the digestive system of animals such as sheep, harm goats, and cows.

In terms of classification and epidemiology, cestodes and nematodes are also divided into several groups, but here the purpose of classification is to get to know the basic principle of parasitology.

One of the cestodes that is pathogenic for humans is *Taenia solium*, which can be infected with this worm due to the consumption of raw or half-cooked human meat or direct contact with contaminated feces of humans. Eating habits are highly important in parasitology and in communities where raw or consumed semi-cooked foods have higher rates of helminthic diseases. Worm diseases have a direct relationship with human and animal nutrition.

Another important cestode in medicine and veterinary medicine is *Echinococcus granulosus*, which can cause cysts in the human body. The intermediate hosts of this parasite are humans and herbivores, who get hydatid cyst if humans or herbivores come in direct contact with infected dog feces or consume food and vegetables contaminated with eggs of this parasite. This worm is one of the most common worms in the Middle East, especially in Iran, which causes serious damage to the liver in most cases (21).

However, most nematodes are worms that live freely in nature, but some nematodes can be pathogenic for humans and animals. Humans become infected with nematodes by coming in contact with feces contaminated with worm eggs or consuming raw food and water contaminated with nematodes. Fishes are one of the most important sources of human nutrition, and especially Scandinavian and East Asian countries are heavily dependent on the fishing industry, but one of the foods that can be eaten raw is sushi, which is made from raw fish meat. If this food is prepared with raw fish meat infected with *Anisakis* larvae, humans can be infected with this parasite, which may damage the throat and stomach (22).

The most fish that may transmit *Anisakis* to humans are salmon, tuna, squid, codfish, sardines, and anchovies (23).

One of the most important helminthic diseases and one of the most common helminthic diseases is *ascariasis*, which can affect both humans and pigs (24).

*Ascaris lumbricoides* is the most widespread species that infects about 33% of the world's population (25).

However, nematodes in pets such as dogs can also cause lesions in the skin and heart. *Dirofilaria immitis* is an example of nematode known as dog heartworm.

The most essential principles in preventing worm diseases are to use clean food and water and refuse to eat raw food.

Protozoa are microscopic organisms that can be transmitted to different hosts both directly and indirectly. These parasites exist in two forms; the first category

includes parasites that enter the blood cells of the body and are called blood protozoa, and the second one contains parasites that enter the digestive system, which are called digestive protozoa. It is claimed that Protozoan parasites are highly dangerous.

### Protozoa

One of the most important pathogenic protozoa is *Trichomonas vaginalis*, which can cause many problems in women. The parasite has declined with improved sanitation but is still present in communities where unprotected sex is practiced. *Trichomonas vaginalis* causes foul-smelling secretions in the vagina and provides a suitable substrate for the growth of viruses and bacteria (26).

*Giardia lamblia* is a protozoan that is probably one of the oldest protozoa in the world. This parasite was first observed by Lion Hook in 1681. It is mostly found in tropical and hot and humid areas. In general, this parasite is more common in children and can cause severe diarrhea.

The next important protozoan is *Toxoplasma gondii*. The ultimate host of this parasite is cats, but it can affect humans and animals such as sheep. *Toxoplasma* is found worldwide and is one of the most successful parasites in causing disease. Humans can get infected with this parasite through direct contact with cat feces or contaminated food and water or consumption of meat infected with parasite cysts (27).

One of the extremely important points of this parasite is that it causes abortion in humans or animals. If pregnant women are infected with *T. gondii*, their baby may miscarry. Abortion can cause many problems for mothers and affect their mental health. Parasitologists advise pregnant women to attempt not to approach cats that are on the street.

There is also a protozoan called *Neospora caninum*, which is highly similar to *T. gondii*, and this parasite can be called the younger brother of *T. gondii*. The ultimate host of *N. caninum* is dogs, but humans and cattle can also be infected with this parasite. This parasite can cause abortion in cows, but the risk of contracting this disease in humans is low. This parasite is extremely problematic for the livestock industry. *N. caninum* can reduce the number of cows by causing abortions and deal a heavy blow to the livestock industry of countries. *N. caninum* can be transmitted through milk, and one should be highly careful in drinking milk and avoid drinking unsanitary milk. If this parasite enters an area, the production of milk and meat in that area may suffer problems (28).

There are many parasites around us humans, thus humans must observe hygiene, which is one of the best ways to prevent parasites. Some highly important points in preventing parasites are as follows:

1. Use of sanitary water

2. Meat should be consumed cooked because of cysts or parasite eggs present in the meat
3. If we travel to rainforests or humid areas such as sea and ocean coasts, we should be careful about insect bites and use insect-repellent ointments
4. Do not sleep outdoors when traveling to humid tropical areas
5. If you have pets, be sure to check their body hair and have your pet's stool tested by a parasitologist or veterinarian several times a year
6. Before traveling, we should familiarize ourselves with the pathogenic conditions of that region or country. African countries, Central and South America, and the Indian peninsula have the highest number of parasitic diseases. Likewise, humid and tropical regions of Southeast Asia are widely affected by parasites.

### Conclusion

Parasitic diseases have always been at the top of infectious diseases in the world. As previously mentioned, the people of countries that are located on the equator and have a hot and humid climate are more at risk of contracting parasitic diseases. The highest number of parasitic diseases is related to blood protozoa and, in the next stage, there are helminthic diseases. Unfortunately, today, drug resistance is one of the serious problems in the treatment of parasitic diseases, and parasites have become resistant to many treatment methods. The level of health in the world community is increasing and this is highly promising. Parasitology is a broad science, and it is impossible to explain all its contents, but a parasitologist must be familiar with the most basic issues. We attempted to familiarize even people who are not familiar with the science of parasitology by reading this article.

### Ethical Approval

Not applicable.

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