CHAPTER 208

# Classification and Nomenclature of Human Parasites

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Although common names frequently are used to describe parasitic organisms, these names may represent different parasites in different parts of the world. To eliminate these problems, a binomial system of nomenclature in which the scientific name consists of the genus and species is used.[1-3,8,12,14,17] These names generally are of Greek or Latin origin. In certain publications, the scientific name often is followed by the name of the individual who originally named the parasite. The date of naming also may be provided. If the name of the individual is in parentheses, it means that the person used a generic name no longer considered to be correct.

On the basis of life histories and morphologic characteristics, systems of classification have been developed to indicate the relationship among the various parasite species. Closely related species are placed in the same genus, related genera in the same family, related families in the same order, related orders in the same class, and related classes in the same phylum, one of the major categories in the animal kingdom. As one moves up the classification schema, each category becomes more broad; however, each category still has characteristics in common.

Parasites of humans are classified in a number of major divisions. They include the Protozoa (amebae, flagellates, ciliates, sporozoans, and coccidia), the Fungi (microsporidia), the Platyhelminthes or flatworms (cestodes, trematodes), the Acanthocephala or thorny-headed worms, the Nematoda or roundworms, and the Arthropoda (insects, spiders, mites, ticks, and so on). Although these categories appear to be well defined, often considerable confusion occurs in attempting to classify parasitic organisms. One of the primary reasons is the lack of known specimens. Some organisms recovered from humans are very rare; thus, difficulty arises in determining morphologic and physiologic variation among such groups. Type specimens must be deposited for study before a legitimate species name can be given. Even when certain parasites are numerous, they may represent strains or races of the same species with slightly different characteristics.

In general, reproductive mechanisms are a valid concept in determining definitions of species, but so many exceptions exist within parasite groups that taking into consideration properties such as sexual reproduction, parthenogenesis, and asexual reproduction is difficult. Another difficulty in recognition of species is the ability and tendency of the organisms to alter their morphologic forms according to age, host, or nutrition, which often results in several names being given to the same organism. An additional problem involves alternation of parasitic and free-living phases in the life cycle. These organisms may be very different and difficult to recognize as belonging to the same species. Despite these difficulties, newer, more sophisticated molecular methods of grouping organisms often have confirmed taxonomic conclusions reached hundreds of years earlier by experienced taxonomists.

As investigations continue in parasitic genetics, immunology, and biochemistry, the species designation will be defined more clearly. Originally, these species designations were determined primarily by morphologic differences, resulting in a phenotypic approach. With the use of highly sophisticated molecular techniques, the approach will continue to be more genotypic. Benefits of these studies also include the development of highly specific and sensitive diagnostic tests and the ability to diagnose parasitic infections on the basis of molecular parameters rather than merely phenotypic characteristics.

Although gaps in our knowledge concerning classification of all human parasites remain, the binomial system has allowed the classification of 1.5 million species of organisms in the animal kingdom such that all published information can be retrieved, regardless of the language spoken. The difficulty for the clinician arises when one considers the rapid increase in information concerning microbiology during the past few years and changing considerations, such as the role of immunosuppression in the host-parasite interaction and the modified definitions of "normal flora" and "nonpathogenic" in this population of patients.

The classification of parasites is presented in tabular form. Although certain designations of species may be somewhat controversial, this classification scheme is designed to provide some order and meaning to a widely divergent group of organisms. No attempt has been made to include every possible organism, and only those considered clinically relevant in the context of human parasitology are listed. The main groups that are presented include protozoa, fungi, nematodes (roundworms), cestodes (tapeworms), and trematodes (flukes). Some relevant information on arthropods is presented in Tables 208-1 and 208-2. The hope is that this information will provide some insight into the parasite groupings, thus leading to a better understanding of parasitic infections and the appropriate diagnostic and clinical approach.

TABLE 208-1 **Human Vector-Borne Infections**

| Infection (Disease) | Causative Agent | Vector (Common Name) |
|---|---|---|
| **Protozoal** | | |
| Malaria | *Plasmodium* spp. | Mosquitoes |
| Leishmaniasis | *Leishmania* spp. | Sandflies |
| Chagas disease | *Trypanosoma cruzi* | Triatomid bugs |
| East African trypanosomiasis | *Trypanosoma brucei rhodesiense* | Tsetse flies |
| West African trypanosomiasis | *Trypanosoma brucei gambiense* | Tsetse flies |
| Babesiosis | *Babesia* spp. | Ticks |
| **Helminthic** | | |
| Filariasis | *Wuchereria bancrofti* | Mosquitoes |
| Filariasis | *Brugia malayi* | Mosquitoes |
| Filariasis | *Dirofilaria* spp. | Mosquitoes |
| Filariasis | *Mansonella perstans* | Biting midges |
| Filariasis | *Mansonella streptocerca* | Biting midges |
| Filariasis | *Mansonella ozzardi* | Biting midges |
| Onchocerciasis | *Onchocerca volvulus* | Black flies |
| Loiasis | *Loa loa* | Deer flies |
| Dog tapeworm infection | *Dipylidium caninum* | Dog lice and fleas, human fleas |
| Rat tapeworm infection | *Hymenolepis diminuta* | Rat fleas, beetles, grain beetles |
| Dwarf tapeworm | *Hymenolepis nana* | Grain beetles (rare) |

# PROTOZOA

## Amebae—Intestinal

These organisms are characterized by having pseudopods (motility) and trophozoite and cyst stages in the life cycle and include some exceptions in which a cyst form has not been identified. Amebae usually are acquired by humans through fecal-oral transmission or mouth-to-mouth contact (*Entamoeba gingivalis*).

### *Current Name*

*Entamoeba histolytica**
*Entamoeba dispar**
*Entamoeba hartmanni*†
*Entamoeba coli*
*Entamoeba polecki*
*Entamoeba moshkovskii*
*Entamoeba gingivalis*
*Endolimax nana*
*Iodamoeba bütschlii*
*Blastocystis hominis**

## Flagellates—Intestinal

These organisms move by means of flagella and are acquired by fecal-oral transmission. With the exception of *Dientamoeba fragilis* (internal flagella) and those in the genera *Trichomonas* and *Pentatrichomonas*, they have the trophozoite and cyst stages in the life cycle. *D. fragilis*, *Trichomonas*, and *Pentatrichomonas* species do not have a cyst stage.

### *Current Name*

*Giardia lamblia*†
*Chilomastix mesnili*
*Dientamoeba fragilis*
*Pentatrichomonas hominis*
*Trichomonas tenax*

**Entamoeba histolytica* is being used to designate the true pathogen, whereas *Entamoeba dispar* now is being used to designate a nonpathogen. Unless trophozoites containing ingested red blood cells (*E. histolytica*) are seen during microscopic examination, the two organisms cannot be differentiated on the basis of morphologic features seen in permanent stained smears of fecal specimens and will be reported as *E. histolytica/E. dispar*. Fecal immunoassays for antigen detection are available commercially for differentiation of *E. histolytica* from *E. dispar* and for detection of the *E. histolytica/E. dispar* group.[7] Because the differences in pathogenicity are genetic and not just phenotypic, the decision to treat is one that must be determined by the physician. The finding of organisms in the *E. histolytica/E. dispar* group in patient specimens must continue to be reported to state and county Departments of Public Health (follow your particular state reporting regulations).

†*Entamoeba hartmanni* is nonpathogenic and is totally different from *E. histolytica*. "Small race *E. histolytica*" is incorrect and should not be used at any time to designate *E. hartmanni*.

*The taxonomic position of *Blastocystis* has always been somewhat confusing, but it is now clear that this organism exists as a number of serotypes or species. It has been recommended that all isolates from birds and mammals, including humans, be designated in the future as *Blastocystis* spp., serotypes ST1 to ST10 plus ST Unknown. This organism has now been placed in the Stramenopila.[21]

†Although some individuals have changed the species designation for the genus *Giardia* to *G. duodenalis* or *G. intestinalis*, no consensus exists. Therefore, for this listing, the name *Giardia lamblia* is retained. However, molecular and epidemiologic evidence suggests that at least two assemblages of *Giardia* infect humans, one of which is *Giardia duodenalis* and the other, possibly a new species, *Giardia enterica*.[16]

TABLE 208-2 **Medically Important Arthropods**

| Local or Systemic Problems | Vector (Common Name) |
|---|---|
| Skin reaction to bites | Sucking lice |
| | Bedbugs |
| | Kissing bugs |
| | Biting midges |
| | Sandflies |
| | Black flies |
| | Mosquitoes |
| | Deer flies |
| | Tsetse flies |
| | Soft ticks |
| | Hard ticks |
| Painful bite | Horseflies |
| | Fire ants |
| | Centipedes |
| Intense itching | Human itch mites |
| | Chiggers |
| Painful sting, potential anaphylaxis | Honeybees |
| | Bumblebees |
| | Wasps, hornets, yellow jackets |
| | Fire ants |
| | Scorpions |
| Dermatitis, ulcerations | Fleas |
| Nodular ulceration with subsequent secondary infection | Chigoe flea |
| Blistering of skin after contact with adult beetles | Blister beetles |
| Bite, usually painless, delayed systemic reaction | Black widow spiders |
| Initial blister followed by extensive necrosis and slow healing | Brown recluse spiders |
| | South American brown spider |

*Enteromonas hominis*
*Retortamonas intestinalis*

## Ciliates—Intestinal

These organisms, which move by means of cilia, are acquired by humans through fecal-oral transmission. They have both the trophozoite and cyst forms in the life cycle.

### *Current Name*

*Balantidium coli*

## Apicomplexa, Sporozoa (Coccidia)—Intestinal

These organisms are acquired by humans by ingestion of various meats or through fecal-oral transmission through contaminated food or water.

### *Current Name*

Coccidia
*Cryptosporidium hominis*
*Cryptosporidium parvum*
*Cryptosporidium* spp.
*Cyclospora cayetanensis*[18,19]
*Isospora (Cystoisospora) belli*
*Sarcocystis hominis*
*Sarcocystis suihominis*
*Sarcocystis bovihominis*

## Fungi (Microsporidia*)—Intestinal

*Enterocytozoon bieneusi*
*Encephalitozoon (Septata) intestinalis*†

## Amebae, Flagellates—Other Body Sites

The amebae are pathogenic, free-living organisms that may be associated with warm, freshwater areas. They have been found in the central nervous system, the eye, and other sites. *Trichomonas vaginalis* usually is acquired by sexual transmission. This particular flagellate is found in the genitourinary system.

### *Current Name*

Amebae
*Naegleria fowleri*
*Acanthamoeba* spp.
*Hartmannella* spp.
*Balamuthia mandrillaris*
*Sappinia diploidea*
Flagellates
*Trichomonas vaginalis*

## Apicomplexa, Sporozoa (Coccidia)—Other Body Sites

The coccidia are particularly important in the compromised patient. They also may infect many individuals who have no apparent symptoms.[6,7] On the basis of molecular studies, the microsporidia are linked more closely to the fungi and have been reclassified with those organisms. However, during this transition phase, the listing will remain with the parasites.

### *Current Name*

Coccidia
*Toxoplasma gondii*

*The microsporidia are now thought to be more closely related to fungi than to protozoa; however, parasitologists have been reluctant to part with this group, whereas mycologists have been equally reluctant to accept it. Consequently, the microsporidia will be retained within this list for parasites, although they are classified within the Fungi.[11,22,23]
†Formerly called *Septata intestinalis*.[10,15]

## Fungi (Pneumocystis,* Microsporidia)—Other Body Sites

Microsporidia
- *Nosema ocularum*
- *Anncaliia (Brachiola) connori*
- *Anncaliia (Brachiola) algerae*
- *Anncaliia (Brachiola) vesicularum*
- *Vittaforma corneae*
- *Pleistophora ronneafiei*
- *Trachipleistophora hominis*
- *Trachipleistophora anthropophthera*
- *Encephalitozoon hellem*
- *Encephalitozoon cuniculi*
- *Encephalitozoon (Septata) intestinalis*†
- *Enterocytozoon bieneusi*‡
- *Microsporidium africanum*§
- *Microsporidium ceylonensis*
- *Tubulinosema acridophagus*¶

## Sporozoa, Flagellates—Blood and Tissues

All of these organisms are arthropod borne. Diagnosis may be somewhat more difficult to make than is that of the intestinal protozoa, particularly if automated blood differential systems are used. The *Leishmania* have undergone extensive revisions in classification. However, from a clinical perspective, recovery and identification of the organisms still are related to body site. Recovery of the organisms is limited to the site of the lesion in infections other than those caused by the *Leishmania donovani* complex (visceral leishmaniasis).

### *Current Name*

Apicomplexa, Sporozoa (malaria, babesiosis)
- Malaria
  - *Plasmodium vivax*
  - *Plasmodium ovale*
  - *Plasmodium malariae*
  - *Plasmodium falciparum*
  - *Plasmodium knowlesi***
- Babesiosis*
  - *Babesia microti*
  - *Babesia divergens*
  - *Babesia duncani*
  - *Babesia* spp.

Flagellates (leishmaniasis, trypanosomiasis)
- Leishmaniasis
  - *Leishmania tropica* complex (cutaneous leishmaniasis)
  - *Leishmania infantum* complex (cutaneous leishmaniasis)
  - *Leishmania major* complex (cutaneous leishmaniasis)
  - *Leishmania mexicana* complex (cutaneous leishmaniasis)
  - *Leishmania braziliensis* complex (mucocutaneous leishmaniasis)
  - *Leishmania donovani* complex (visceral leishmaniasis)
  - *Leishmania infantum/Leishmania chagasi* group (visceral leishmaniasis)
- Trypanosomiasis
  - *Trypanosoma brucei gambiense* (West African trypanosomiasis)
  - *Trypanosoma brucei rhodesiense* (East African trypanosomiasis)
  - *Trypanosoma cruzi* (American trypanosomiasis)
  - *Trypanosoma rangeli*

# NEMATODES

## Nematodes—Intestinal

These organisms normally are acquired by ingestion of eggs or penetration of the skin by larval forms from the soil.

### *Current Name*

- *Ascaris lumbricoides*
- *Enterobius vermicularis* (pinworm)
- *Ancylostoma duodenale*
- *Necator americanus*
- *Strongyloides stercoralis*
- *Strongyloides fuelleborni*
- *Trichostrongylus* spp.
- *Trichuris trichiura* (whipworm)
- *Capillaria philippinensis*
- *Oesophagostomum* spp. (*O. bifurcum* most common in humans—West Africa)
- *Ternidens diminutus* (as high as 80% in Zimbabwe)

## Nematodes—Tissue

For the most part, these organisms rarely are seen within the United States; however, the first three are more important.

**Pneumocystis carinii* has been reclassified with the fungi and renamed *Pneumocystis jiroveci*.[5,20] Consequently, it will be removed from future parasite listings.

†Formerly called *Septata intestinalis.*

‡*Enterocytozoon bieneusi* has been recovered from sites other than the intestinal tract.

§This designation is now written as a true genus but remains a "catch-all" for those organisms that have not been (or may never be) identified to the true genus or species levels.

¶New human pathogen, disseminated infection in a patient with multiple myeloma (severely immunosuppressed, allogeneic stem cell transplant recipient).[13]

***Plasmodium knowlesi*, a malaria parasite of macaque monkeys in Southeast Asia that is now established as a naturally transmitted parasite of humans in Malaysia and other parts of Southeast Asia, has been responsible for a number of deaths.[4] Thus, there are now five species of malaria that infect humans.

*Molecular studies confirm that humans can also harbor a number of *Babesia* parasites that have not yet been identified.[9]

***Current Name***

*Trichinella spiralis*
*Trichinella* spp.
*Toxocara canis* or *Toxocara cati* (visceral or ocular larva migrans)
*Ancylostoma braziliense* (cutaneous larva migrans)
*Ancylostoma caninum* (eosinophilic enteritis)
*Baylisascaris procyonis* (severe systemic visceral larva migrans, neural larva migrans)
*Dracunculus medinensis*
*Angiostrongylus cantonensis*
*Angiostrongylus costaricensis*
*Gnathostoma spinigerum*
*Gnathostoma* spp.
Anisakiasis (larvae from saltwater fish)
*Anisakis* spp.
*Phocanema* spp.
*Contracaecum* spp.
*Pseudoterranova* spp.
*Hysterothylacium* spp.
*Porrocaecum* spp.
*Capillaria hepatica*
*Thelazia* spp.

## Nematodes (Filarial Worms)—Blood, Other Body Fluids, Skin

These organisms also are arthropod borne. The adult worms tend to live in the tissues of lymphatics. Diagnosis is made on the basis of the recovery and identification of the larval worms (microfilariae) in the blood, other body fluids, or skin. Elephantiasis may be associated with some of the organisms listed.

***Current Name***

*Wuchereria bancrofti*
*Brugia malayi*
*Brugia timori*
*Loa loa*
*Onchocerca volvulus*
*Mansonella ozzardi*
*Mansonella streptocerca*
*Mansonella perstans*
*Dirofilaria immitis* ("coin" lesion in the lung) (dog heartworm)
*Dirofilaria* spp. (may be found in subcutaneous nodules)

# CESTODES

## Cestodes—Intestinal

The adult form of these organisms is acquired by humans through ingestion of the larval forms contained in poorly cooked or raw meats or freshwater fish. In the case of *Dipylidium caninum*, infection is acquired by the accidental ingestion of dog fleas. Both *Hymenolepis nana* and *Hymenolepis diminuta* are transmitted by ingestion of certain arthropods (fleas, beetles). Also, *H. nana* can be transmitted through egg ingestion (life cycle in the human can bypass the intermediate beetle host). Humans can serve as both the intermediate and definitive hosts in *H. nana* and *Taenia solium* infections.

***Current Name***

*Diphyllobothrium latum* (broad, fish tapeworm)
*Dipylidium caninum* (dog tapeworm)
*Hymenolepis (Rodentolepis) nana* (dwarf tapeworm)
*Hymenolepis diminuta* (rat tapeworm)
*Taenia solium* (pork tapeworm)
*Taenia saginata* (beef tapeworm)
*Taenia asiatica* (Taiwanese variant of *T. saginata*)

## Cestodes (Larval Forms)—Tissue

The ingestion of certain tapeworm eggs or accidental contact with certain larval forms can lead to the diseases shown in parentheses.

***Current Name***

*Taenia solium* (cysticercosis)
*Echinococcus granulosus* (hydatid disease)
*Echinococcus multilocularis* (alveolar hydatid disease)
*Echinococcus oligarthrus* (polycystic hydatid disease)
*Multiceps multiceps* (coenurosis)
*Diphyllobothrium* spp. (sparganosis)
*Spirometra mansonoides* (sparganosis)

# TREMATODES

## Trematodes—Intestinal

These organisms are uncommon within the United States, except for four species of *Alaria*, which are endemic within North America.

***Current Name***

*Fasciolopsis buski* (giant intestinal fluke)
*Echinostoma ilocanum*
*Eurytrema pancreaticum*
*Heterophyes heterophyes*
*Metagonimus yokogawai*
*Alaria* spp.

## Trematodes—Liver, Lung

These organisms are not seen commonly within the United States; however, some Southeast Asian refugees do harbor some of these parasites.

***Current Name***

*Clonorchis (Opisthorchis) sinensis* (Chinese liver fluke)
*Opisthorchis viverrini*
*Opisthorchis felineus*
*Fasciola hepatica* (sheep liver fluke)
*Paragonimus westermani* (lung fluke)

*Paragonimus kellicotti* (lung fluke endemic in the United States)
*Paragonimus* spp.
*Metorchis conjunctus* (North American liver fluke)

## Trematodes—Blood

The schistosomes are acquired by penetration of the skin by the cercarial forms that are released from freshwater snails. Although they are not endemic within the United States, occasionally patients are seen who may have these infections.

### *Current Name*

*Schistosoma mansoni*
*Schistosoma haematobium*
*Schistosoma japonicum*
*Schistosoma intercalatum*
*Schistosoma mekongi*

## ARTHROPODS

See Tables 208-1 and 208-2.

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