

## SECTION 19 HELMINTHIC INFECTIONS

## 255e Introduction to Helminthic Infections

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The word *helminth* is derived from the Greek *helmins* (“parasitic worm”). Helminthic worms are highly prevalent and, depending on the species, may exist as free-living organisms or as parasites of plant or animal hosts. The parasitic helminths have co-evolved with specific mammalian and other host species. Accordingly, most helminthic infections are restricted to nonhuman hosts, and only rarely do these zoonotic helminths accidentally cause human infections.

Helminthic parasites of humans belong to two phyla: Nematelminthes, which includes nematodes (roundworms), and Platyhelminthes, which includes cestodes (tapeworms) and trematodes (flukes). Helminthic parasites of humans reside within the human body and hence are the cause of true infections. In contrast, parasites of other genera that reside only on mucocutaneous surfaces of humans (e.g., the parasites causing myiasis and scabies) are considered to represent infestations rather than infections.

Helminthic parasites differ substantially from protozoan parasites in several respects. First, protozoan parasites are unicellular organisms, whereas helminthic parasites are multicellular worms that possess differentiated organ systems. Second, helminthic parasites have complex life cycles that require sequential stages of development outside the human host. Thus, most helminths do not complete their replication within the human host; rather, they develop to a certain stage within the mammalian host and, as part of their obligatory life cycle, must mature further outside that host. During the “extra-human” stages of their life cycle, helminths exist either as free-living organisms or as parasites within another host species and thereafter mature into new developmental stages capable of infecting humans. Thus, with only two exceptions (*Strongyloides stercoralis* and *Capillaria philippinensis*, which are capable of internal reinfection), increases in the number of adult helminths (i.e., the “worm burden”) within the human host require repeated exogenous reinfections. In the case of protozoan parasites, a brief, even singular exposure (e.g., a single mosquito bite transmitting malaria) may lead rapidly to intense parasite loads and overwhelming infections; in contrast, for all but the two helminths noted above, increases in worm burden require multiple and usually ongoing exposures to infectious forms, such as ingestion of eggs of intestinal helminths or waterborne exposures to infectious cercariae of *Schistosoma mansoni*. This requirement is germane both to the consideration of helminthic infections in individuals and to ongoing global efforts to interrupt and/or minimize the acquisition of helminthic infections by humans.

Third, helminthic infections have a predilection toward stimulation of host immune responses that elicit eosinophilia within human tissues and blood. The many protozoan infections characteristically do not elicit eosinophilia in infected humans, with only three exceptions (two intestinal protozoan parasites, *Cystoisospora belli* and *Dientamoeba fragilis*, and tissue-borne *Sarcocystis* species). The magnitude of helminth-elicited eosinophilia tends to correlate with the extent of tissue invasion by larvae or adult helminths. For example, in several helminthic infections, including acute schistosomiasis (Katayama syndrome), paragonimiasis, and hookworm and *Ascaris* infections, eosinophilia is most pronounced during the early phases of infection, when migrations of infecting larvae and progression of subsequent developmental stages through the tissues are greatest. In established infections, local eosinophilia is often present around helminths in tissues, but blood eosinophilia may be intermittent, mild, or absent. In helminthic infections in which parasites are well contained within tissues (e.g.,

echinococcal cysts) or confined within the lumen of the intestinal tract (e.g., adult *Ascaris* or tapeworms), eosinophilia is usually absent.

**NEMATODES**

Nematodes are nonsegmented roundworms. Species of nematodes are remarkably diverse and abundant in nature. Among the many thousands of nematode species, few are parasites of humans. Most nematodes are free-living, and these species have variably evolved to survive in diverse ecologic niches, including saltwater, freshwater, or soil. The well-studied organism *Caenorhabditis elegans* is a free-living nematode. Nematodes can be either beneficial or deleterious parasites of plants. Parasitic nematodes have co-evolved with specific mammalian hosts and have no capacity to live their full life cycles in other hosts. Uncommonly, humans are exposed to infectious stages of nonhuman nematode parasites, and the resultant zoonotic nematode infections can elicit inflammatory and immune responses as larval forms migrate and die in the unsuitable human host. Examples include pulmonary coin lesions due to mosquito-transmitted infections with the dog heartworm *Dirofilaria immitis*; eosinophilic meningoencephalitis due to ingested eggs of the raccoon ascarid *Baylisascaris procyonis*; and eosinophilic meningitis due to ingestion of larvae of the rat lungworm *Angiostrongylus cantonensis*.

Nematode parasites of humans include worms that reside in the intestinal tract or localize in extraintestinal vascular or tissue sites. Roundworms are bisexual, with separate male and female forms (except for *S. stercoralis*, whose adult females are hermaphroditic in the human intestinal tract). Depending on the species, fertilized females release either larvae or eggs containing larvae. Nematodes have five developmental stages: an adult stage and four sequential larval stages. These parasites characteristically are surrounded by a durable outer cuticular layer. Nematodes have a nervous system; a muscular system, including muscle cells under the cuticle; and a developed intestinal tract, including an oral cavity and an elongated gut that ends in an anal pore. Adults may range in size from minute to >1 meter in length (with *Dracunculus medinensis*, for example, at the long end of this spectrum).

Humans acquire infections with nematode parasites by various routes, depending on the parasitic species. Ingestion of eggs passed in human feces is a major global health problem with many of the intestinal helminths (e.g., *Ascaris lumbricoides*). In other species, infecting larvae penetrate skin exposed to fecally contaminated soil (e.g., *S. stercoralis*) or traverse the skin after the bite of infected insect vectors (e.g., filariae). Some nematode infections are acquired by consumption of specific animal-derived foods (e.g., trichinellosis from raw or undercooked pork or wild carnivorous mammals). As noted above, only two nematodes, *S. stercoralis* and *C. philippinensis*, can internally reinfect humans; thus, for all other nematodes, any increases in worm burden must be due to continued exogenous reinfections.

**CESTODES**

Tapeworms are the cestode parasites of humans. Adult tapeworms are elongated, segmented, hermaphroditic flatworms that reside in the intestinal lumen or, in their larval forms, may live in extraintestinal tissues. Tapeworms include a head (*scolex*) and a number of attached segments (*proglottids*). The worms attach to the intestinal tract via their scolices, which may possess suckers, hooks, or grooves. The scolex is the site of formation of new proglottids. Tapeworms do not have a functional gut tract; rather, each tapeworm segment passively and actively obtains nutrients through its specialized surface tegument. Mature proglottids possess both male and female sex organs, but insemination usually occurs between adjacent proglottids. Fertilized proglottids release eggs that are passed in the feces. When ingested by an intermediate host, an egg releases an oncosphere that penetrates the