

## Human Intestinal Parasites

Parasitic infections, caused by intestinal helminths and protozoan parasites, are among the most prevalent infections in humans. Protozoan parasites more commonly cause gastrointestinal infections compared to helminths. Intestinal parasites cause a significant **morbidity and mortality** in endemic countries. Helminths are worms with many cells. **Nematodes** (roundworms), **cestodes** (tapeworms), and **trematodes** (flatworms) are among the most common helminths that inhabit the **human gut**. Usually, helminths cannot multiply in the human body. **Protozoan** parasites that have only one cell can multiply inside the human body. There are four species of intestinal helminthic parasites, also known as **geohelminths** and soil-transmitted helminths : *Ascaris lumbricoides* (roundworm), *Trichiuris trichiuria* (whipworm), *Ancylostoma duodenale*, and *Necator americanicus* (hookworms). These infections are most prevalent in **tropical** and **subtropical regions** of the developing world where adequate water and sanitation facilities are lacking. Recent estimates suggest that *A. lumbricoides* can infect over a billion, *T. trichiura* 795 million, and hookworms 740 million people. Other species of intestinal helminths are not widely prevalent. Intestinal **helminths rarely cause death**. The most common intestinal protozoan parasites are: *Giardia intestinalis*, *Entamoeba histolytica*, *Cyclospora cayentanensis*, and *Cryptosporidium* spp. The diseases caused by these intestinal protozoan parasites are known as **giardiasis**, **amoebiasis**, **cyclosporiasis**, and **cryptosporidiosis** respectively, and they are associated with **diarrhoea**.

<u>Symptoms</u>	<u>Parasite</u>
Abdominal pain and distension	<i>Giardia, Cryptosporidium, Amoebiasis, Ascaris, hookworm, taenia</i>
Diarrhoea +/- malabsorption	<i>Giardia, Cryptosporidium, Strongyloides</i>
Diarrhoea with blood loss	<i>Amoebiasis, Trichuris, Hookworm</i>
Tenesmus, prolapsed rectum	<i>Trichuris</i>

### Infections & Diagnosis

The following list of parasites and what to look for may be of help in identifying some of the most common parasitic infections:

**Amoebiasis:** Amoebas cause **irregular ulcers** in the **rectum with red borders** and **gray bases**. They can be found in fresh stool specimens and on biopsy specimens **taken from rectal ulcers**.

**Balantidiasis:** **Diarrhea, dysentery**, and occasional **ulceration** of the large **intestine** characterize this disease. *Balantidium coli* **cysts found in stools are diagnostic**.

**Fascioliasis:** Fasciola organisms can cause an enlarged and **painful liver accompanied** by fever. **Eggs of these organisms** can be found in **stools**.

**Giardiasis:** Infection with *Giardia lamblia* can cause **diarrheic** and/or **dysenteric symptoms**. **Cysts and trophozoites** can be found in **stools**.

**Hookworm:** Severe symptoms such as **iron-deficiency anemia, physical and mental retardation**, and **cardiac complication** sometimes occur. Diagnosis is made by the **finding of ova in stools**.

**Pinworm:** Although the most **common complaint** caused by pinworms is **perianal itching**, they may also cause **intestinal abscesses** and **bleeding**. **Eggs** may be found in the perianal area; they can be transferred with a **cellophane tape swab** to a slide for microscopic inspection. Worms may also be seen **in stools**, and sometimes **around the anus**.

**Roundworm:** Severe symptoms-such as **intestinal, biliary, or pancreatic obstruction**; or **appendicitis**-may occur. Eggs may be diagnosed by a simple **smear of stools**.

**Strongyloidiasis:** The infectious agent is the nematode *Strongyloides stercoralis*. It causes diarrhea. Larvae can be found in stools.

**Tapeworm:** Segments of beef, pork, and fish tapeworms can be found in stools. Eggs can be swabbed from perianal areas and examined.

**Trichinosis:** Severe trichinosis infestation may result in death within six weeks. Muscle biopsy, to determine the presence of encysted larvae of *Trichinella spiralis*, is the only reliable diagnostic procedure, since neither eggs nor worms occur in stools.

**Whipworm:** Blood-streaked stools, rectal prolapse, iron-deficiency anemia, and malnutrition may occur. Stool examination for eggs and parasites is indicated for an accurate diagnosis.



## Helminths

### *Cestodes*

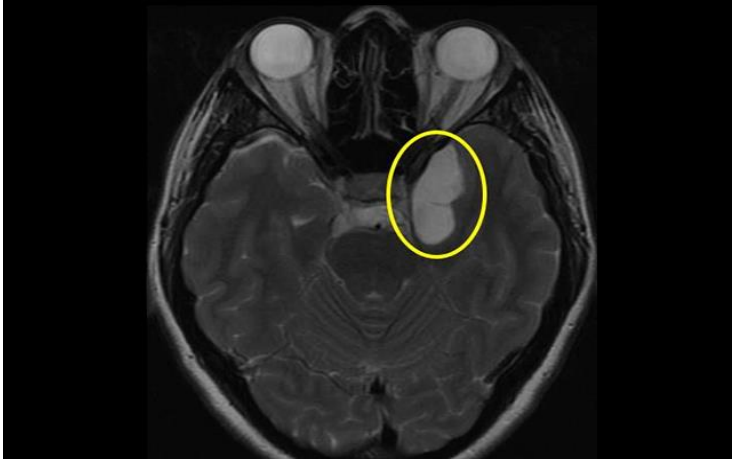
Tapeworms are long, segmented worms of the class Cestoda, which includes the genera *Taenia*, *Diphyllobothrium*, *Hymenolepis*, *Dipylidium*, *Echinococcus*, and *Spirometra*. Adult tapeworms lack an intestinal tract and absorb **all nutrients through their integument**. The adults have a head (termed a **scolex**), a **neck**, and a **segmented body** with both male and female **gonads**. Tapeworms require one or more intermediate hosts in their life cycle. Typically, the eggs are passed from the **host** into the **environment**, where they are ingested by an intermediate host. In the intermediate host, the eggs hatch, and the larvae enter the host tissues and encyst. The primary host then ingests the cysts by consuming the flesh of the intermediate host.

**Humans** are the **primary** hosts for *Taenia*, *Diphyllobothrium*, and *Hymenolepis*, but they may be **intermediate** hosts for *Echinococcus* and *Spirometra*. Infection is typically from either **fecal-oral transmission** or the ingestion of **contaminated**, undercooked meat. *Hymenolepis nana* the most commonly diagnosed parasitic intestinal infection with helminths and/or protozoa can lead to significant morbidity and mortality if not recognized and treated appropriately.

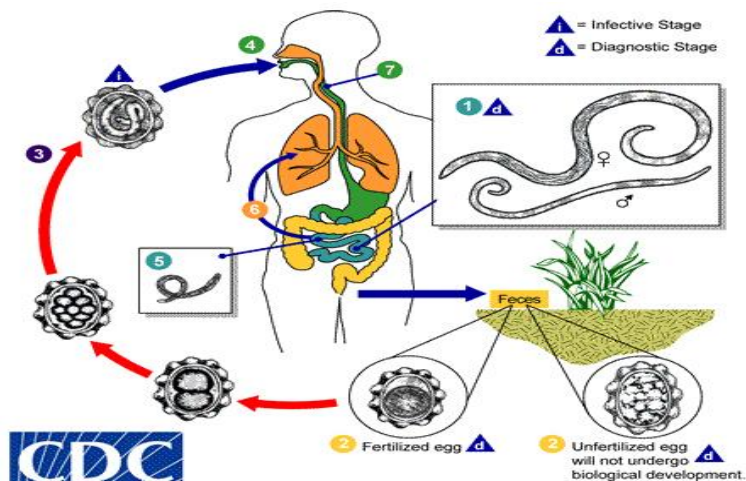


Many **cestode** infestations are **asymptomatic**. The most common symptoms are **abdominal pain, anorexia, weight loss, and malaise**. *Diphyllobothrium* **absorbs** large quantities of vitamin **B12**, causing **megaloblastic** anemia in hosts. *Taenia solium* may deposit cysts in the central nervous system, leading to the development of **seizures** from neurocysticercosis.

*Echinococcus granulosus* (shown) may deposit cysts slowly over years, eventually precipitating a mass effect on the involved organ; the alveolar form of the disease may not manifest until 5-15 years after infection. Rupture of these cysts may cause fever, pruritus, urticaria, eosinophilia, and anaphylaxis. Untreated symptomatic liver involvement carries a fatality rate greater than 2%-4%; untreated alveolar echinococcosis has an estimated mortality rate above 90% at 10-15 years.



Tapeworm infections can typically be diagnosed by **collecting two to three stool samples and checking for ova and parasites**. Enzyme-linked immunosorbent assay (**ELISA**), immunoblot, and polymerase chain reaction (**PCR**) assay may help confirm a diagnosis; sensitivities and specificities vary, depending on the species involved.



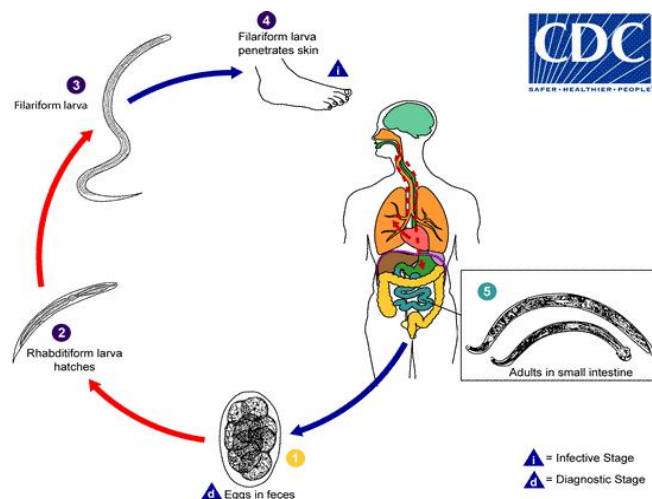
## *Ascaris*

Ascariasis is the most **common** helminthic infection worldwide. *Ascaris lumbricoides* is the **largest** of the roundworms that infect humans, growing as long as 35 cm, and it may live for up to 2 years in the small intestine. Its life cycle is **complex** and involves multiple human organs.

Every day, a female worm will produce about 200,000 eggs, which are fertilized by nearby male worms. Fertilized eggs may remain **viable** for up to **17 months** in soil, where they cause infection through ingestion and subsequent hatching in the small intestine. **Second**-stage larvae pass through the **intestinal wall** and migrate through the portal system to the liver and lungs. Larvae may be expectorated and then swallowed into the digestive tract, where they mature into adults. Adults will feed on **digestive products**, which can **lead to protein, calorie, or vitamin A deficiency** in children at risk for malnutrition. Because pinworms do not multiply in the host, infection is limited to 2 years unless reexposure occurs. Although most infected individuals are asymptomatic, patients may develop growth retardation, pneumonitis, pneumonia, eosinophilia, intestinal or pancreatic obstruction, and hepatobiliary injury.



The diagnosis of **ascariasis** is typically made by means of **stool ova and parasite examination**. Abdominal **x-rays** may show signs of bowel obstruction, and ultrasonography may reveal a single worm or a mass of the worms with segmented sections and curling movements. Treatment with a single dose of albendazole, mebendazole, or ivermectin is usually effective for eradication. Medical therapy during active pulmonary infection is not indicated, not only because pulmonary ascariasis is a self-limited disease but also owing to the high risk of developing pneumonitis from the dying larvae. Endoscopic retrograde cholangiopancreatography may be used both to diagnose and to treat infection of the biliary system. Most worms will spontaneously migrate from the intestines and biliary system, but surgery may be needed for refractory cases. Preventive chemotherapy may be used as a short-term strategy, but improvements to water, sanitation, and hygiene are needed to prevent long-term reinfection



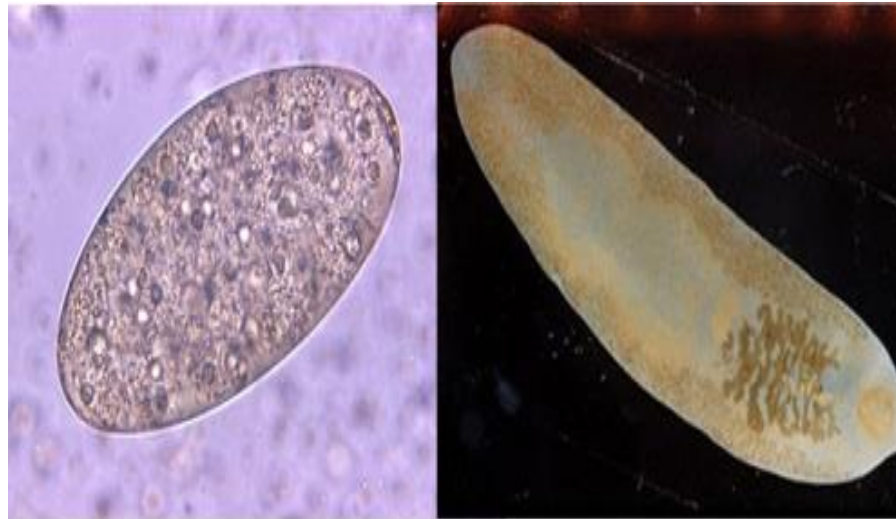
## Hookworms

Human hookworms, predominantly *Ancylostoma duodenale* and *Necator americanus*, infect hundreds of millions of people (576-740 million) worldwide. They are the second most common cause of helminthic infections after ascariasis.

Hookworm larvae rapidly penetrate the skin of humans who are exposed to soil contaminated by human feces (life cycle shown). "Ground itch" (local skin manifestations involving severe allergic itching) at the site of penetration is common. The larvae then burrow into venules and embolize into the lungs, where they penetrate into alveoli and cause an asymptomatic alveolitis with eosinophilia. Coughing and then

swallowing transport the larvae into the intestines, where they mature into adults. Adult worms feed on blood from the mucosal capillaries. About 5 weeks after initial infection, female worms release thousands of eggs into the stool daily. If no reexposure occurs, the infection will disappear once the worms die; the lifespan of *Necator* is 3-10 years, and that of *Ancylostoma* is 1-3 years

Patients may report diarrhea, vague abdominal pain, colic, or nausea. The diagnosis is made by means of stool ova and parasite examination. Both iron-deficiency anemia and eosinophilia may be present on a complete blood cell count. Treatment with iron therapy is used to manage the anemia; a single dose of albendazole or mebendazole, or one dose daily of pyrantel pamoate for 3 days, is typically sufficient to eradicate the infection



### ***Intestinal trematodes***

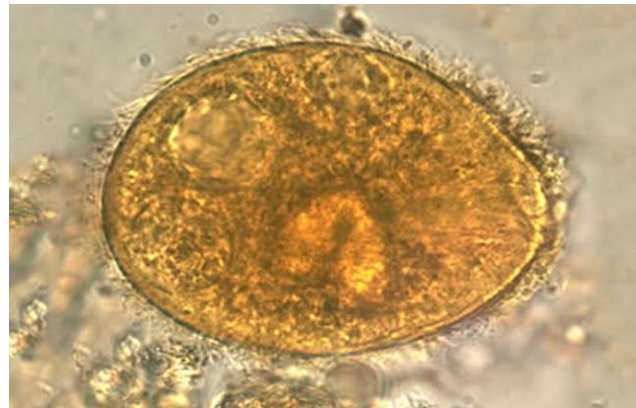
Intestinal flukes are flat hermaphroditic worms (class Trematoda) that range in length from a few millimeters to several centimeters. The species that most commonly infect humans are *Fasciolopsis buski* (shown), which is the largest and most common human intestinal fluke, *Heterophyes heterophyes*, *Metagonimus yokogawai*, and *Echinostoma* species.

The life cycle of each species is very complex and can involve a number of intermediate hosts, such as snails, fish, tadpoles, or vegetables. Humans are typically



infected after ingesting a raw or undercooked intermediate host. Developmental forms will attach to the small intestinal walls, where they develop into adults over a period of several months. Adult flukes will cause inflammation, ulceration, and mucus secretion at the site of attachment.

Most infected persons are asymptomatic, but some may develop loose stools, weight loss, malaise, and nonspecific abdominal pain. In severe infection, alternating diarrhea and constipation; edema of the face, abdominal wall, and lower extremities; anorexia; nausea; and vomiting may occur. The diagnosis is made by means of stool ova and parasite examination. Treatment with three doses of praziquantel over 1 day is typically sufficient to clear infection



## Protozoa

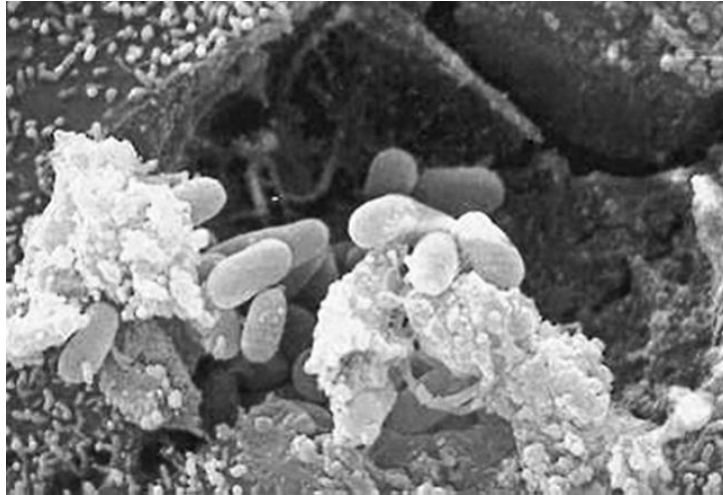
### *Balantidium coli*

Balantidiasis is an intestinal infection caused by the **ciliated** protozoan *Balantidium coli* (shown). The primary reservoir is thought to be pigs. Thus, those who handle pigs or pig byproducts are at increased risk for infection.

After human ingestion of infective cysts via **contaminated food** or water, *B. coli* organisms migrate to the large intestine, cecum, and terminal ileum. There, they develop into trophozoites, which replicate by binary fission and conjugation while consuming bacteria. They reside primarily within the intestinal lumen but may penetrate the mucosa and cause ulcers. Although most immunocompetent individuals will be asymptomatic, patients may develop bloody, mucoid diarrhea; nausea; vomiting; abdominal pain; anorexia; weight loss; fever; colitis; and dehydration.

The diagnosis is made on the basis of wet smears of stool specimens (shown at 1000× magnification). Trophozoites can be recognized by their large size, ciliary covering,

and spiraling motility. Treatment includes volume and electrolyte replacement, as well as antimicrobial coverage with tetracycline, metronidazole, or iodoquinol. There are no large-scale reports of antimicrobial resistance.

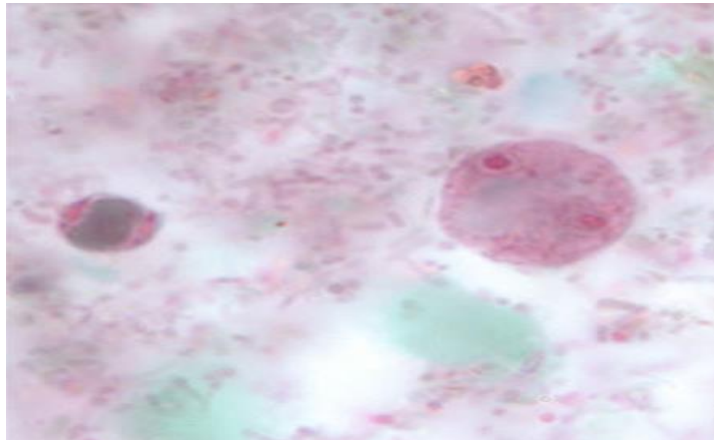


### ***Microsporidia***

Microsporidia are obligate, intracellular, spore-forming parasites. The phylum Microsporidia contains over 1200 fungal species, a large number of which cause infection in humans. Two of the most important of these species are *Encephalitozoon hellem* and *E. intestinalis*. Most cases of infection are associated with human immunodeficiency virus (HIV) or other immunosuppressing illness, including organ transplant recipients, diabetics, children, and the elderly. Microsporidiosis occurs through ingestion or inhalation of microsporidial spores from human-to-human or waterborne transmission. The spores will extrude a polar tubule and inject an infective sporoplasm into the host cell. Within the cell, the sporoplasm multiplies by binary fission and eventually ruptures the cell, releasing more spores (shown). Patients with intestinal microsporidiosis may develop chronic nonbloody diarrhea, weight loss, abdominal pain, nausea, vomiting, and malnourishment. With dissemination,

cholecystitis and renal failure as well as infections of the muscles, brain, and respiratory tract may occur.

The diagnosis is made via stool microscopy, but this does not allow species identification. Cytologic and histologic examination may also be helpful; additionally, immunofluorescence assays (IFA) and PCR are available. Typically, treatment with albendazole for 2-4 weeks is effective for most ocular, intestinal, and disseminated microsporidiosis.



### ***Dientamoeba fragilis***

*Dientamoeba fragilis* is a nonflagellated protozoan (shown) that infects the large intestine. Transmission is thought to be via human-to-human fecal-oral spread or via coinfection with the eggs of *E. vermicularis* (human pinworm); however, the life cycle is incompletely understood, and no cystic stage has been definitively identified.

Trophozoites infect the mucosal crypt cells of the large intestine, invoking an eosinophilic inflammatory response. Abdominal pain and nonbloody diarrhea are the most common symptoms, but anorexia, weight loss, nausea, vomiting, flatulence, headaches, fever, malaise, and fatigue may also develop.

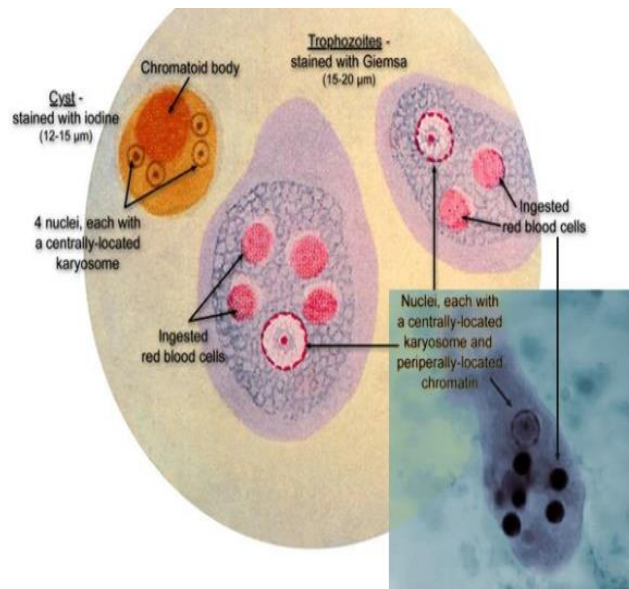
The diagnosis is typically made through microscopic evaluation of permanently stained fresh fecal smears (trichrome), which show a characteristic pleomorphic trophozoite with up to four nuclei (most commonly binucleate [shown]) that are distinctive for their

clumped chromatin granules. Treatment typically involves the use of an anthelmintic medication such as iodoquinol (drug of choice), metronidazole, tetracycline, or paromomycin.



### ***Giardia***

Giardiasis is a major diarrheal illness found worldwide; in the United States, it is the most frequently diagnosed intestinal parasitic disease. It is most commonly caused by the flagellate protozoan *Giardia lamblia* (also known as *G intestinalis*). Infection is via the ingestion of *Giardia* cysts, typically from contaminated water, which then excyst, multiply, and colonize the upper small bowel. Cysts are able to retain viability for 2-3 months in cold water, and the infective dose is as low as 10-25 cysts. The exact pathophysiology is unclear. Most infections are asymptomatic, and asymptomatic carriage is quite common. Person-to-person transmission from poor hygiene and sanitation is a primary means of infection. Symptomatic individuals may report explosive, watery diarrhea; abdominal cramps; foul flatus; vomiting; fever; malaise; anorexia; lactose intolerance; and weight loss. Symptoms may last for up to 3 weeks, and more than 50% of patients lose an average of 10 lb. Physical findings are typically unremarkable, and stools are usually heme negative. The diagnosis is made by means of stool examination for cysts or trophozoites, stool antigen detection with ELISA or IFA, or, rarely, duodenal sampling. Treatment typically involves aggressive fluid and electrolyte replacement plus administration of an antimicrobial agent such as albendazole or metronidazole.



### ***Entamoeba histolytica***

Amebiasis is caused by infection with the protozoan *Entamoeba histolytica*; this occurs after ingestion of cystic protozoa, typically in fecally contaminated soil, food, or water. Excystation into trophozoites occurs in the cecum, terminal ileum, or colon. The trophozoites then penetrate the colonic mucosal barrier and, with severe invasive disease, produce tissue destruction, secretory bloody diarrhea, and colitis. Hematogenous spread can cause trophozoite deposition into the liver, brain, and lungs, leading to abscess formation

The diagnosis can be made by means of stool microscopy for cysts and trophozoites, ELISA, IFA, indirect hemagglutination, or PCR. Treatment for asymptomatic amebiasis is with iodoquinol or paromomycin. Symptomatic intestinal and extraintestinal disease is treated with metronidazole or tinidazole, followed by administration of iodoquinol or paromomycin. Extraintestinal abscesses generally require both drainage and metronidazole or tinidazole administration.

### ***E. vermicularis***

*E. vermicularis*, commonly referred to as the pinworm or seat worm, is a nematode, or roundworm, with the largest geographic range of any helminth. It is the most prevalent nematode in the United States. Humans are the only known host, and about 209 million persons worldwide are infected. More than 30 percent of children worldwide are infected.

Adult worms are quite small; the males measure 2 to 5 mm, and the females measure 8 to 13 mm. The worms live primarily in the cecum of the large intestine, from which the gravid female migrates at night to lay up to 15,000 eggs on the perineum. The eggs can be spread by the fecal-oral route to the original host and new hosts. Eggs on the host's perineum can spread to other persons in the house, possibly resulting in an entire family becoming infected. Ingested eggs hatch in the duodenum, and larvae mature during their migration to the large intestine. Fortunately, most eggs desiccate within 72 hours. In the absence of host autoinfection, infestation usually lasts only four to six weeks.

Disease secondary to *E. vermicularis* is relatively innocuous, with egg deposition causing perineal, perianal, and vaginal irritation. The patient's constant itching in an attempt to relieve irritation can lead to potentially debilitating sleep disturbance. Rarely, more serious disease can result, including weight loss, urinary tract infection, and appendicitis.

Pinworm infection should be suspected in children who exhibit perianal pruritus and nocturnal restlessness. Direct visualization of the adult worm or microscopic detection of eggs confirms the diagnosis, but only 5 percent of infected persons have eggs in their stool. The "cellophane tape test" can serve as a quick way to clinch the diagnosis.

