Common
INTESTINAL
PROTOZOA
of Humans

Life Cycle Charts

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Common Intestinal Protozoa
of Humans*

Life Cycle Charts

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**At the time of this publication the coccidian parasite Cyclospora cayetanensis had not been classified.
Introduction

The intestinal protozoa of humans belong to four groups: amebae, flagellates, ciliates, and coccidia. All of the protozoa are microscopic forms ranging in size from about 5 to 100 micrometers, depending on species. Size variations between different groups may be considerable. The life cycles of these single-cell organisms are simple compared to those of the helminths. With the exception of the coccidia, there are two important growth stages, trophozoite and cyst, and only asexual development occurs. The coccidia, on the other hand, have a more complicated life cycle involving asexual and sexual generations and several growth stages.

Intestinal protozoan infections are primarily transmitted from human to human. Except for Sarcocystis, intermediate hosts are not required, and, with the possible exception of Balantidium coli, reservoir hosts are unimportant.

As listed in the CONTENTS, life cycle charts of the more commonly encountered intestinal amebae and flagellates, and of the ciliate and the intestinal coccidia are presented here. In addition, Trichomonas vaginalis, an inhabitant of the urogenital system, is included with the other flagellates. Less common species of amebae and flagellates (for example, Entamoeba polecki, Enteromonas hominis, and Retortamonas intestinalis) and the species which inhabit the mouth (Entamoeba gingivalis and Trichomonas tenax) are omitted. Blastocystis hominis (identified as a protozoan by Zierdt et al., 1967) is also omitted. The charts are designed as simple, basic cycles that purposely omit details of epidemiology, incubation periods, prepatent and patent periods, and exceptions to the usual pattern. They are intended for use by laboratory and clinical personnel, public health workers, and students who are concerned only with the fundamentals of the life cycles or who need a quick review. Additional information can be obtained from parasitology textbooks, other publications, or lectures.

The design of these charts conforms to the following general rules, insofar as possible:

1. The diagnostic and infective stages are indicated and emphasized. These stages are in proportion with regard to species within a given group (i.e., amebae); average sizes, as recorded in scientific literature, are used. Because of the variations in size between the four groups, no attempt was made to draw all of the organisms to a single scale.
2. Morphologic details are included in a diagrammatic fashion.
3. Survival times, prepatent and patent periods, and modes of transmission are omitted.
4. No general references are listed, since the material incorporated into the charts is commonly found in most parasitology textbooks. Specific references are included where indicated.

Acknowledgements
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Reference


**Amebae**

Five species of amebae live in the intestinal tract of humans: *Entamoeba histolytica*, *Entamoeba hartmanni*, *Entamoeba coli*, *Endolimax nana*, and *Iodamoeba buetschlii*. *Dientamoeba fragilis*, formerly considered an amebae, is now classified as an ameba-flagellate (Camp *et al.*, 1974)(Honigberg, 1974). In this publication of life cycle charts, *D. fragilis* has been placed with the flagellates.

One other species of intestinal amebae, *Entamoeba polecki*, has been found in humans. *Entamoeba polecki* is a parasite of monkeys and pigs and only rarely parasitizes humans. It appears to be nonpathogenic in humans. The trophozoites resemble those of *E. coli* and *E. histolytica*; the mature cysts are uninucleate. The life cycle of *E. polecki* is not included here, but, in general, it is similar to those of other *Entamoeba* species. *Entamoeba gingivalis*, which is located in the mouth, is also omitted from this publication. It is not found in the intestinal contents, since its trophozoites (only known stage), if swallowed, are destroyed by the digestive juices of the intestinal tract.

Although four growth stages (trophozoite, precyst, cyst, and metacystic trophozoite) have been described in scientific literature, only the trophozoite and cyst are included in the cycles presented here. Because the nuclear structure in both stages is a primary differential characteristic, particular attention has been given to this feature in the drawings. The organisms have been drawn to scale with regard to ameba species, but are not necessarily proportional to the other groups.

The motile amebae trophozoites inhabit the lumen of the large intestine, usually on the surface of the intestinal mucosa, where they feed on soluble material, bacteria, and tissue debris. *Entamoeba histolytica* may also ingest red blood cells.) Under certain conditions, the trophozoite "slows down," stops feeding, and "rounds up" into a precyst stage which soon becomes a cyst with a resistant cell wall. Both trophozoites and cysts may be passed in the feces and both are considered diagnostic stages (precysts are also passed but are not considered here). Since the trophozoites are fragile and disintegrate soon after leaving the body, only the cyst is the infective stage. Encystation does not occur outside the body, although immature cysts will mature.
Ingested cysts excyst in the lumen of the small intestine. The exact location and the process involved are not completely known but excystation probably occurs in the lower ileum. After excystation, the trophozoites move into the large intestinal tract, grow, divide repeatedly by binary fission, and become established in the lumen of the caecum and colon. Encystation occurs in the lumen of the colon, probably in the lower levels, but the process and exact conditions are not completely known. Encystation is necessary for survival and propagation of the species, since the cyst stage can survive for some time outside of the body (if the environment is suitable) and can withstand the digestive juices of the upper gastrointestinal tract of the new host.

In *E. histolytica*, *E. hartmanni*, *E. coli* and *E. nana*, multiplication of the nucleus occurs within the cyst. Mature cysts of these species contain either a quadrinucleated organism (*E. histolytica*, *E. hartmanni*, and *E. nana*) or an organism with eight (sometimes more) nuclei (*E. coli*). After excystation, the cytoplasm divides, producing several small amebae (the metacystic trophozoites). In *I. buetschlii*, no multiplication occurs in the cyst and only one trophozoite is produced upon excystation. All species of amebae, however, multiply by binary fission in the trophozoite state.

No intermediate or reservoir hosts are involved in the amebae life cycles and no development outside the body is necessary. The mature cysts are infective upon passage. They are resistant to many external conditions, and in a moist, cool environment may survive for several days or longer. At 0°C in a suitable environment, they can survive for several weeks. Transmission of infections, therefore, may be by ingestion of cysts in contaminated food or water or by direct contact with fecally contaminated items and subsequent ingestion of material containing cysts. Epidemics of *E. histolytica*, for the most part, have been waterborne infections.

Most of the intestinal amebae appear to be commensals, but *E. histolytica* is a recognized pathogen capable of producing both intestinal and extraintestinal lesions. Certain strains seem to be more virulent and in susceptible hosts may produce severe damage. Ulceration of the colon and/or dysentery may occur. Extraintestinal lesions may be found in the liver, lungs, brain, and skin. In some persons, it may exist as a commensal causing no apparent symptoms or pathology (*E. dispar*).
Reference


Life Cycle of *Entamoeba histolytica*

**EXTERNAL ENVIRONMENT**
- Excysts in lower ileum
- Multiplies by binary fission
- Invades wall of colon and multiplies
- Remains in lumen of colon and multiplies
- Extra-intestinal abscesses (liver, lungs, etc.)

**HUMAN**
- Ingested
- Excysts in lumen of colon
- Trophozoite in lumen of colon and multiplies
- Remains in lumen of colon and multiplies
- Returns to lumen
- Encysts
- Encysts in lower ileum
- Multiplies by binary fission
- Trophozoite in lumen of colon and multiplies

**EXTERNAL ENVIRONMENT**
- Trophozoite in lumen of colon and multiplies
- Returns to lumen
- Encysts
- Excysts in lower ileum
- Multiplies by binary fission
- Excysts in lumen of colon

**HUMAN**
- Ingested
- Trophozoite and cysts in feces (diagnostic stages)
- Mature cyst (infective stage)
- Immature cyst (4 nuclei)
- Immature cyst (2 nuclei)
- Disintegrates

**EXTERNAL ENVIRONMENT**
- Immature cyst (1 nucleus)
- Trophozoite
- Disintegrates

**HUMAN**
- Ingested
- Trophozoite and cysts in feces (diagnostic stages)
- Mature cyst (infective stage)
- Immature cyst (4 nuclei)
- Immature cyst (2 nuclei)
- Disintegrates
Life Cycle of *Entamoeba hartmanni*

- **Ingested**
- **Multiplies by binary fission**
- **Remains in lumen of colon and multiplies**
- **Encysts**
- **Trophozoite and cysts in feces**
- **Trophozoite in lumen of colon**
- **Excysts in lower ileum**
- **Immature cyst (2 nuclei)**
- **Immature cyst (4 nuclei)**
- **Immature cyst (1 nucleus)**
- **Trophozoite**
- **Disintegrates**
- **Mature cyst (infective stage)**
- **(diagnostic stages)**
Life Cycle of *Entamoeba coli*

**Immature cyst (4 nuclei)**

**Immature cyst (2 nuclei)**

**Mature cyst (1 nucleus)**

**Mature cyst (8 nuclei)**

**Trophozoite in lumen of colon**

**Excysts in lower ileum**

**Ingested**

**Encysts**

**Disintegrates**

**Multiplies by binary fission**

**Trophozoite and cysts in feces**

**Trophozoite and cysts in feces**

**HUMAN**

**EXTERNAL ENVIRONMENT**
Life Cycle of *Endolimax nana*

- **Excysts in lower ileum**
- **Trophozoite in lumen colon**
- **Encysts**
- **Mature cyst** (4 nuclei)
- **Immature cyst** (1 nucleus)
- **Trophozoite**
- **Multiplies by binary fission**
- **Ingested**
- **Mature cyst** (infective stage)
- **Trophozoite and cysts in feces** (diagnostic stages)

**HUMAN**

**EXTERNAL ENVIRONMENT**

- **Immature cyst** (2 nuclei)
Life Cycle of *Iodamoeba buetschlii*

1. **Ingested**
2. **Excysts in lower ileum**
3. **Encyst**
4. **Trophozoites in lumen of colon**
5. **Multiplies by binary fission**
6. **Trophozoite and cyst in feces**
7. **Cyst**
   - **(infective stage)**
   - **(diagnostic stages)**
8. **Disintegrates**

**EXTERNAL ENVIRONMENT**

**HUMAN**
Flagellates

Four species of flagellates that parasitize the intestinal tract of humans are presented here: *Giardia lamblia*, *Chilomastix mesnili*, *Pentatrichomonas (Trichomonas) hominis*, and *Dientamoeba fragilis*. Recent electron microscope studies have demonstrated that *D. fragilis* is an ameba-flagellate rather than an ameba, and is probably related to *Trichomonas* (Honigberg, 1974). Therefore, its life cycle is included with those of the other flagellates.

In addition to the intestinal flagellates, *Trichomonas vaginalis*, an inhabitant of the urogenital system, is presented in this publication. Three flagellates, however, have been omitted: *Trichomonas tenax*, found in the mouth, and *Enteromonas hominis* and *Retortamonas intestinalis*, intestinal parasites which are encountered only rarely.

Like the amebae, the flagellates have a simple direct life cycle that involves no intermediate hosts. Two of the species included in this publication, *Giardia lamblia* and *Chilomastix mesnili*, have a trophozoite and a cyst stage. Both stages are passed in feces and both are considered diagnostic stages. The trophozoites disintegrate soon after passage so the cyst is the infective stage. *Dientamoeba fragilis* and the *Trichomonas* and *Pentatrichomonas* species, however, have only a trophozoite stage which is both the diagnostic and the infective stage.

Although the drawings of the flagellates are proportional to each other, they are not necessarily in proportion to those of the amebae or other groups. Most of the characteristic morphology, of trophozoites and cysts is included in the diagrams. In the majority of the flagellates, the structural details such as the flagella and the presence of an undulating membrane, sucking disc, or prominent cystostome are used more often than nuclear details for species identification. In *D. fragilis*, which morphologically resembles the amebae, nuclear characteristics are important in species identification.

Although the trophozoite bodies are flexible, they have a characteristic shape, usually elongate or "pear-shaped," which helps to distinguish flagellates from the other groups of protozoa. Furthermore, flagellates, as the name implies, have flagella, the filaments or fibrils that serve as organs of locomotion, and each species has a definite number and arrangement of these. Because of the body shape and specific morphologic features, trophozoites of each flagellate species have a distinctive motility which can be used to identify genera: *Giardia*, *Chilomastix*, and *Trichomonas* and *Pentatrichomonas*. 
*Dientamoeba fragilis* is an exception to the usual flagellate morphology and varies from the others in shape, size, and motility. Morphologically, it resembles the amebae more than the flagellates. It does not have flagella and moves by means of pseudopods. The pseudopods are often angular or serrated and are usually transparent. Movement, for the most part, is nondirectional. *Dientamoeba fragilis* trophozoites usually have two nuclei, although mononucleated forms are frequently seen. As is true of the amebae, *D. fragilis* trophozoites may be identified by nuclear characteristics. The organism occasionally ingests red blood cells.

Unlike most of the intestinal protozoa, *G. lamblia* lives in the small intestine rather than the colon. It is found chiefly in the duodenum and upper levels of the jejunum. The trophozoite is binucleated, has four pairs of flagella, and a large sucking disc which occupies 1/3 to 1/2 of the flattened ventral surface. It attaches to the intestinal mucosa by means of the ventral sucking disc and multiplies by binary fission. *Giardia* trophozoites move with a characteristic "falling-leaf" or tumbling motion.

The ovoidal cysts of *Giardia* are distinctive in appearance and usually are easily recognized. The mature cysts have four nuclei (the organism divides within the cyst) and two trophozoites emerge upon excystation. Cysts are generally shed from the body in "showers" at irregular intervals ranging from a day or two to a week or more.

*Chilomastix mesnili* inhabits the colon. The trophozoites have a stiff caudal end and a spiral groove extending across the ventral surface of the body which contribute to the characteristic stiff, rotary or spiral movement. The organism also has a conspicuous cystostome which extends 1/3 to 1/2 the length of the body. There are three flagella at the anterior end and one lying within the cystostome. The uninucleated cyst is typically lemon shaped. The nucleus of both the trophozoite and cyst frequently has a concentration or a "blob" of chromatin along one side of the nuclear membrane that gives the nucleus a "lop-sided" look."

*Pentatrichomonas (Trichomonas) hominis*, which inhabits the colon, and *T. vaginalis*, which inhabits the urogenital system of both males and females, have an undulating membrane (a cytoplasmic fold with a filament running along the top) extending down the body. The membrane of *P. hominis* extends all the way down the body; that of *T. vaginalis* extends half-way.
Both species have four anterior flagella and *P. hominis* has a fifth flagellum which originates anteriorly, runs along the top of the undulating membrane, and extends posteriorly as a free flagellum. The undulating membrane, together with the flagella, give the trophozoites a nervous, "jerky" type of motion. No cyst is known in the *Trichomonas* species parasitizing humans.

The mode of transmission varies with the species of flagellates. *Giardia lamblia* and *C. mesnili*, which have cyst stages, are transmitted through contaminated food or water. Currently, *Giardia* is the most common waterborne parasite in the United States. *Pentatrichomonas hominis* trophozoites apparently can survive for several hours to several days in moist feces at temperatures of 5°C to 30°C and transmission is probably by fecal contamination from person to person. The mode of transmission of *D. fragilis* is not completely known but presumably is also through contamination and person-to-person fecal spread. The trophozoites apparently can survive for a time in mucus clumps in feces. *Trichomonas vaginalis* is transmitted primarily through sexual intercourse, although, under certain conditions, transmission may be associated with unsanitary surroundings, particularly contaminated toilets. The trophozoites can survive for some time (possibly up to a day or so) in vaginal exudate under favorable environmental conditions.

*Giardia lamblia* and *T. vaginalis* are pathogenic and there is evidence that *D. fragilis* may also be a pathogen. *Giardia* may cause upper abdominal discomfort, steatorrhea, and symptoms referable to gall bladder or duodenal disturbances. Giardiasis appears to be more severe in debilitated or immunosuppressed persons. *Trichomonas vaginalis* may cause vaginitis and occasionally urinary tract infections in women. In men, the infection tends to be asymptomatic although urethritis may occur in severe infections. *Dientamoeba fragilis* may cause a mucous diarrhea and mild intestinal discomfort in some persons. *Pentatrichomonas hominis* and *C. mesnili* are considered nonpathogenic.

**Reference**

Life Cycle of *Dientamoeba fragilis*

**HUMAN**

- **Ingested**
- **Trophozoites** (infective stage)
- **Trophozoites in lumens of colon**

**EXTERNAL ENVIRONMENT**

- **Ingested**
- **Trophozoites in feces** (diagnostic stage)

- **Multiplies by binary fission**
Life Cycle of *Trichomonas hominis*

- Ingested
- Trophozoites in lumen of colon and cecum
- Multiplies by longitudinal binary fission
- Trophozoite (infective stage)
- Trophozoite in feces (diagnostic stages)
Life Cycle of *Trichomonas vaginalis*

- **Trophozoite** in vaginal and prostatic secretions and urine (diagnostic stage)
- **Trophozoite** in vaginal and prostatic secretions and urine
- Placed in vagina or orifice of urethra
- Multiplies by longitudinal binary fission

**EXTERNAL ENVIRONMENT**

**SEXUAL INTERCOURSE**

**HUMAN**
Life Cycle of *Giardia lamblia* (syn. *Giardia intestinalis*)

*Updated from the original printed version in 2001.*
Life Cycle of *Chilomastix mesnili*

- **Ingested**
- **Cyst** (infective stage)
- **Excysts in small intestine**
- **Trophozoites in lumen of colon**
- **Trophozoite and cyst in feces** (diagnostic stages)
- **Cyst**
- **Trophozoite**
- **Disintegrates**

*EXTERNAL ENVIRONMENT*

*HUMAN*
Ciliate

*Balantidium coli*, the only ciliate that parasitizes humans, is distinctive in several respects. It is the largest of the human protozoan parasites (ranging from 50 µm to over 100 µm long), the only one having contractile vacuoles, and the only one possessing both a macronucleus and a micronucleus. Both cyst and trophozoite stages are present in the life cycle, and, like most of the protozoa, either may serve as the diagnostic stage but only the cyst is the infective stage.

*Balantidium coli* multiplies only in the trophozoite stage and divides by transverse binary fission. Conjugation between trophozoites has been described but is not illustrated in the chart. No division occurs in the cyst.

The surface of the trophozoite is covered with longitudinal rows of cilia arranged diagonally, which gives the organisms a rotary, boring type of motion.

*Balantidium coli* is a common parasite of pigs but is found infrequently in humans. Most human infections occur in the tropics. In the United States, the infection is rarely encountered; most cases have been reported from patients in mental institutions. The infection is transmitted by contaminated food and water. Pigs are probably the source of most human infections, but person-to-person spread may occur.
Life Cycle of *Balantidium coli*

- **Ingested**
- **Cyst (infective stage)**
- **Excysts in small external environment**
- **Invades wall of colon and multiplies**
- **Remains in lumen of colon and multiplies**
- **Returns to lumen**
- **Ingested**
- **Trophozoite in lumen of colon**
- **Encysts**
- **Cyst (infective stage)**
- **Trophozoite and cyst in feces** (diagnostic stages)
- **Disintegrates**
**Coccidia**

The coccidia belong to the class Sporozoa and include both intestinal and somatic tissue-inhabiting species. Intestinal parasites of humans include *Isospora, Sarcocystis,* and *Cryptosporidium.*

*Isospora belli* lives within the epithelial cells lining the small intestine, primarily the duodenal and jejunal areas, but occasionally is found in all levels of the small intestine. Histologic studies of human intestine and fecal examination have shown that the developmental stages of *I. belli* are similar to those of other *Isospora* species (Brandborg *et al.*, 1970).

No intermediate host is necessary for *I. belli* to complete its life cycle. Schizogony (the asexual phase) occurs within the epithelial tissue of the human intestinal tract; sporogony (the sexual phase) begins in the intestinal tract with the development of gametes (gametogenesis) and is completed in the external environment. Macrogametes and microgametes develop within intestinal epithelial cells. After fertilization, the macrogamete develops a cyst wall and becomes an oocyst that is passed in feces.

The immature single-cell oocyst is the usual diagnostic stage. (In some late infections, however, developing or even mature oocysts may be seen in stool specimens.) The sporulated or mature oocyst, which develops within a few days under favorable conditions, is the infective stage. The mature oocyst contains two sporocysts with four sporozoites in each.

Humans acquire the infection by ingesting these mature oocysts. In the intestine, the sporozoites are freed, penetrate the epithelial cells, and multiply by schizogony. The merozoites produced penetrate other cells and may repeat the schizogony cycle or they develop into macrogametes and microgametes, which eventually produce oocysts.

*Isospora belli* is considered pathogenic and may cause diarrhea, steatorrhea, abdominal discomfort, fever, weight loss and headaches. However, oocysts may be found in stools from apparently healthy individuals.

Human isosporiasis is only occasionally reported, possibly because the oocysts are not readily detected in stool specimens or because they are often not passed in the feces during the symptomatic period. Mucosal biopsies from the small intestine may demonstrate organisms when oocysts cannot be found in the feces.

Like most of the other intestinal protozoa, *I. belli* is transmitted via contaminated food or water or by person-to-person spread of feces. *Sarcocystis* life cycles involve both a definitive host, in which the sexual development occurs, and an intermediate host in which the asexual development
takes place. Two species parasitize the intestinal tract of humans: *Sarcocystis hominis* and *Sarcocystis suihominis*. These species were previously identified as *Isospora hominis* (Rommel and Heydorn, 1972). The intermediate hosts are cattle for *S. hominis* and swine for *S. suihominis*.

In humans, organisms are present in the subepithelial tissue, specifically the lamina propria, of the small intestine where gametogony and sporogony take place (Dubey, 1976). Macrogametes and microgametes develop, and subsequently, fertilization occurs in the lamina propria. The immature oocyst matures (still in the tissue) and fully sporulated forms (mature oocysts and free sporocysts) are passed in the feces. Generally, free sporocysts or, occasionally, oocysts with collapsed walls, are found in stool examinations. These sporocysts contain four sporozoites each and closely resemble sporocysts of *Isospora*. The exact life cycles of the human species have not been determined but presumably they are similar to those of *Sarcocystis* species in lower animals. The cycle presented here is based on *S. muris* from cats and mice. Since the cycles of *S. hominis* and *S. suihominis* are presumably identical, except for the intermediate host, only *S. hominis* is presented.

The sporulated forms are ingested by the intermediate host (cattle or swine) and, subsequently, the freed sporozoites penetrate the intestinal wall and enter the circulation. Asexual development occurs first in the endothelial cells of blood vessels in most organs. Presumably, there are two asexual generations (Fayer, 1980). Multiplication is by schizogony (similar to that in *Isospora belli*) and merozoites are produced. The second-generation merozoites enter muscle cells and give rise to an elongated, septate cystic structure called a sarcocyst. Rounded or ovoidal metrocytes are formed within the sarcocyst. These divide repeatedly by endodyogeny and finally produce elongate forms called bradyzoites. These bradyzoites are the infective stage for humans and the infection is acquired by eating improperly cooked or raw beef or pork.

Humans may serve as the intermediate host for other species of *Sarcocystis*. In these cases, sarcocysts are present in human muscle tissues.
Cryptosporidium, a coccidian parasite of animals, has recently been found in humans, particularly people with immunologic abnormalities in whom severe chronic diarrhea often develops. People with normal immune responses may also be infected, but the infections are usually asymptomatic or self-limiting.

Unlike Isospora and Sarcocystis, Cryptosporidium lives on the surface of epithelial membranes rather than within the cytoplasm of the epithelial cell. Organisms are enveloped in a membrane attached to the host cell. There is some controversy concerning whether this membrane is formed by the parasite or by the host. If it is of host origin, as recent evidence suggests, then the parasite would be considered intracellular, although it is not actually within the cytoplasm of the epithelial cell (Vetterling et al., 1971; Pohlenz et al., 1978; Bird and Smith, 1980). Although Cryptosporidium has been reported from various levels of the alimentary canal, organisms seem to be most numerous in the jejunum.

The life cycle of Cryptosporidium has not been completely worked out but appears to be similar to that of Isospora. The chart in this manual is based on current knowledge of parasite development and the cycle presented by Navin et al., (1983).

Cryptosporidium undergoes both schizogony and sporogony in a single host. Unlike Isospora, it does not need a period of external development to become infective. Mature oocysts containing four sporozoites (the infective forms) are passed in feces, and humans presumably acquire the infection by ingesting these oocysts in contaminated materials. In the intestinal tract, the oocyst wall is digested. The freed sporozoites attach to the surface of the epithelium, round up, and, in three to four days, become trophozoites. Subsequently, the nucleus divides, initiating the asexual development or schizogony. The multinucleated stage is called a schizont. Three nuclear divisions, occur, and about the seventh to ninth day of infection, a mature schizont with eight falciform merozoites and a central residual mass has developed. This is the first-generation schizont and is the product of the first phase of schizogony. The schizont ruptures, releasing the merozoites, which attach to other host cells and repeat the asexual growth pattern. The second-generation schizont has four merozoites and a residual mass, and can be found in the intestinal tract about two weeks after infection. The second-generation merozoites, after being released, attach to other epithelial cells and develop into macrogametocytes and microgametocytes, initiating the sexual development phase or sporogony.
The macrogametocyte has a single nucleus and a number of tiny granules, and appears to change very little as it matures to the macrogamete stage. As the microgametocyte develops, nuclear divisions occur to form several rod-like microgametes, without visible flagella. The exact number is not known, but probably 12 to 16 microgametes are formed. Subsequently, fertilization of the macrogamete takes place, and the resultant zygote develops into an oocyst. Within the oocyst, four naked sporozoites develop; there is no sporocyst. The sporulated oocysts are passed in the feces and presumably are immediately infective for a new host.

In many species of coccidia, only one complete phase of schizogonous development takes place before sporogony begins. In chronic, long-term cryptosporidiosis, however, the parasite probably undergoes repeated schizogonous cycles. Although this has not been demonstrated, presumably either first- or second-generation merozoites can reinitiate schizogony (Navin and Juranek, 1984). Dotted lines on the chart suggest the possible routes by which this may take place.

† Despite the first human cases of cyclosporiasis being diagnosed in 1977 and 1978, the coccidian parasite *Cyclospora cayetanensis* was not classified until 1994. Please see the Cyclosporiasis chapter in this CD ROM.

References


Life Cycle of *Isospora belli*

* Probable development in intestinal mucosa based upon life cycle of *I. canis*
Simulated life cycle based on that of *S. muris*. 
Life Cycle of Cryptosporidium sp.

**SCHIZOGONY**
- Free merozoite
- First-generation mature schizont with 8 merozoites
- Early (immature) schizont
- Trophozoite
- Attaches to surface of intestinal epithelial cell

**GAMETOGENESIS**
- Macrogamocyte
- Microgametocyte
- Microgamete
- Zygote
- Immature oocyst

**SPOROGONY**
- Mature oocyst in feces
- (diagnostic stage)

**EXTERNAL ENVIRONMENT**

**HUMAN**
- Ingested
- Sporozoite
- Mature oocyst (4 sporozoites) (infective stage)

*Probable development (based on studies in animals and electron microscope examinations of biopsied human intestinal tissue)
Manuals

The following manuals are available from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161
or
Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Laboratory Procedures for the Diagnosis of Intestinal Parasites
D.M. Melvin and M.M. Brooke. 3rd ed., 1982
(HHS Publication N. (CDC) 82-8282)

Morphology of Diagnostic Stages of Intestinal Parasites of Humans
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Part I: Life Cycle of Entamoeba histolytica
Part II: Identification of Intestinal Amebae
Part III: Laboratory Procedures