

Protozoa

Did you know that protozoa causes the following threats to public health?

- **Cryptosporidiosis (*Cryptosporidium*)**
- **Giardiasis (*Giardia lamblia*)**
- **Encephalitis**

Objectives of This Lesson

After completing this lesson, you will be able to:

- Describe the general characteristics of a basic protozoan
- Recall the 7-phyllum classification scheme for protozoans
- Differentiate between pathogenic and non-pathogenic protozoans
- Gain familiarity with the disease-causing characteristics of a protozoan
- Gain familiarity with important coccidians such as *Cryptosporidium*, *Cyclospora*, and *Isospora*
- Gain familiarity with and recognize the importance of *Microsporidia*
- State at least one pathogenic disease associated with protozoans

Protozoa: The Basics

Protozoa are unicellular eukaryotes, meaning that they have characteristic organelles. They are relatively large and some are visible with the naked eye. They occupy a vast array of habitats and niches and have organelles similar to those found in other eukaryotic cells as well as specialized organelles. Protozoa usually reproduce asexually by binary fission.

- Eukaryotic
- Can be both free-living (can live outside of a host) or parasitic (colonize host cell tissues)
- Usually single-celled organisms
- Divided into seven phyla
- Large - some are visible with the naked eye
- May have one or more nuclei
- Typically lack cell walls
- Complex life cycles and diverse. There are approximately 65,000 known protozoa. By way of comparison, only about 4,500 bacteria are known.
- May have both sexual and asexual reproductive phases
- Found in nearly all terrestrial and aquatic or moist environments and are thought to play a valuable role in ecological cycles
- Many are able to exist in extreme environments, from polar regions to hot springs and desert soils
- *Giardia*, *Cryptosporidium* and *Microsporidium* have become major concerns in the drinking water industry

Traditional Classification

Diverse structures of protozoa have developed to aid in movement and feeding in a great many environments. Traditional classifications of protozoa are based mainly on their structural morphology and ways of moving.

The traditional four phyla classification, based largely on movement, includes the following groups:

- **Flagellates** – use flagella
 - Flagellates are protozoa that move by means of flagellar action. Some flagellates have their flagella attached in a structure called an undulating membrane. Flagellates tend to have symbiotic relationships with multicellular organisms.

- **Amoebae** – uses pseudopodial structures, flowing cytoplasm
 - Amoebas are protozoa that move by employing pseudopodia, which are membrane-covered cytoplasmic extensions. Many amoebas also employ their pseudopodia to engulf food. Amoebas live in moist terrestrial or aquatic environments. Amoebas include among their members various protozoa which form calcium-based or silicon-based shells (the foraminiferous and the radiolarians, respectively.)

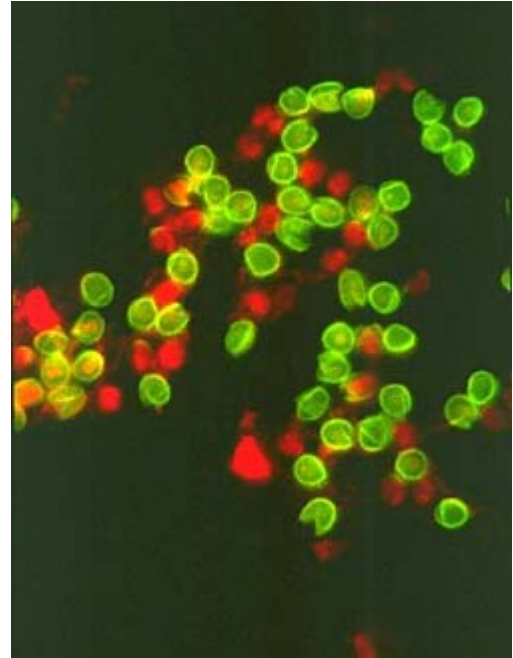
- **Sporozoans** – bending, creeping or gliding
 - The sporozoans are parasitic spore formers that do not move under their own power. *Plasmodium*, the cause of malaria, is a sporozoan. *Microspora* are an extremely ancient eukaryote lineage also classified as sporozoan.

- **Ciliates** – use cilia
 - The ciliates are protozoa that move by means of cilia action. Recall that the difference between eukaryotic flagella and cilia is one of size and number. Cilia are small and numerous; flagella are large and few. Because of the tremendous variety in ciliary arrangements and functions, ciliates are among the most diverse and awesome cells in the biological world.

Oocysts

Oocysts are encapsulated zygotes of sporozoan protozoa, occurring as a life-cycle stage. Further development in an oocyst stage produces small individual infective organisms called sporozoites.

Sporozoites, products of meiotic division of zygotes in parasitic protozoa, are infective cells that invade the host and undergo asexual reproduction.



Oocysts of *Cryptosporidium parvum*

The Seven-Phyla

The traditional four-phyla classification is still used today but a more recent, seven-phyla classification scheme is more appropriate for parasitology or for public health practitioners who are interested in pathogenic protozoa.

The seven-phyla classification includes the following groups:

- Apicomplexa
- Sarcomastigophora
- Microspora
- Ciliophora
- Acetosphora
- Myxospora
- Labyrinthomorpha

Pathogenic Protozoa

Not all protozoa are of concern to public health. Within the seven-phyta classification, there are only four that are pathogens:

Phylum	Pathogenic
Apicomplexa	Yes
Sarcomastigophora	Yes
Microspora	Yes
Ciliophora	Yes
Acetospora	No
Myxospora	No
Labyrinthomorpha	No

We will briefly discuss each of the pathogenic protozoa in the next few pages.

Apicomplexa

Apicomplexa are characterized by the presence of complex apical organelles generally consisting of a conoid that aids in penetrating host cells, rhoptries that possibly secrete a proteolytic enzyme, and subpellicular microtubules that may be related to motility.

- All species parasitic
- No organelles for movement
- Characteristic apical complex
- Reproduction by spores and cysts

Examples:

- *Toxoplasma*
- *Cryptosporidium*



Toxoplasma



Cryptosporidium

Apicomplexa: Coccidians

The coccidia are classified as members of the phylum *Apicomplexa*, class *Sporozoa*, and subclass *coccidia*.

Six genera of coccidia infect humans:

- *Toxoplasma*
- *Isospora*
- *Cryptosporidium*
- *Cyclospora*
- *Sarcocystis*
- *Plasmodium*

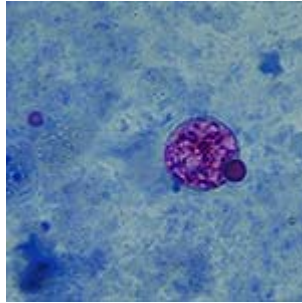
The six coccidians have some features in common, but also differ markedly. The infective stage for all coccidia is a sporozoite, which is very similar in form and function among all coccidians. All produce an oocyst stage following the sexual cycle, and this environmentally hardy oocyst stage is excreted in the stool.

Important Coccidians: *Cryptosporidium*, *Cyclospora* and *Isospora*

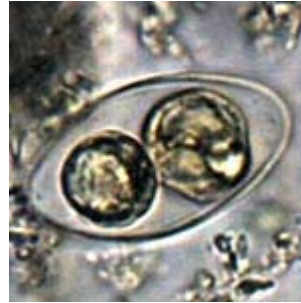
Cyclospora, *Cryptosporidium*, and *Isospora* all infect the gut of the host, and both asexual and sexual stages occur in the epithelial cells of a single host. Oocysts of *Cyclospora* and *Isospora* require a period in the environment to sporulate and become infectious, while *Cryptosporidium* oocysts are infectious immediately upon being passed.



Cryptosporidium



Cyclospora



Isospora

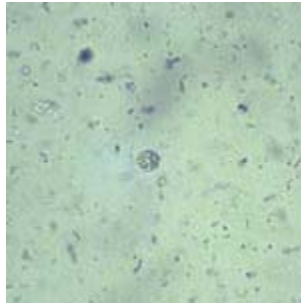
Important Coccidians: *Cryptosporidium*

Cryptosporidium is a very common coccidian. Animals and humans are equally infected and about 25% of Americans show serologic evidence of previous infection. It can cause outbreaks of diarrhea from contaminated municipal water sources. It can cause outbreaks of diarrhea in infants in day care centers, and sporadic cases can occur in travelers.

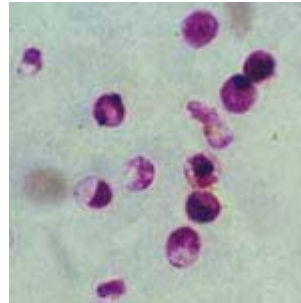
Cryptosporidium is ingested as a round oocyst that contains four motile sporozoites. Its life cycle occurs within the intestinal epithelial cells, and it causes diarrhea or abdominal pains.



Cryptosporidium
(fluorescently stained - the most common staining method)



Cryptosporidium
(unstained)

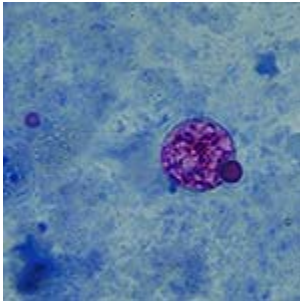


Cryptosporidium (modified Kinyoun's acid-fast)

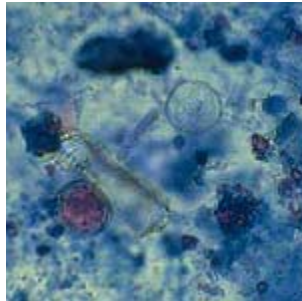
Important Coccidians: *Cyclospora*

Cyclospora can cause watery diarrhea, nausea, vomiting, and fever. *Cyclospora* is spread by ingestion of water or food that was contaminated with infected stool. For example, outbreaks of cyclosporiasis have been linked to various types of fresh produce. *Cyclospora* needs time (days or weeks) after being passed in a bowel movement to become infectious. Therefore, it is unlikely that *Cyclospora* is passed directly from one person to another. It is unknown whether animals can be infected and pass infection to people.

Cyclospora is ingested as an oocyst that contains two sporocysts with two sporozoites.



Modified acid-fast smears - oocysts stain from a light pink to a deep red



There are two oocysts of *Cyclospora* in this field, one shows the typical acid fast reaction and the other is a ghost

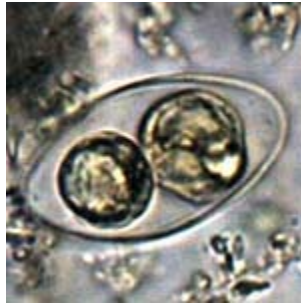
Important Coccidians: *Isospora*

Isospora belli (*I. Belli*) causes human coccidiosis or isosporiasis and is one of the four intestinal coccidia that parasitize humans. It is spread by the fecal-oral route. *Isospora belli* infects the mucosal epithelium of the small intestine and can cause diarrhea that may last for only a few days or a chronic infection that may persist for months. It can be life threatening to patients with weak immune systems. Although infection with *I. Belli* occurs worldwide, it tends to be a very uncommon infection.

Isospora is ingested as a mature oocyst that contains two sporocysts each with four nucleated sporozoites.



Immature *Isospora* oocyst with one sporocyst



Infective stage - mature *Isospora* oocyst with 2 sporocysts

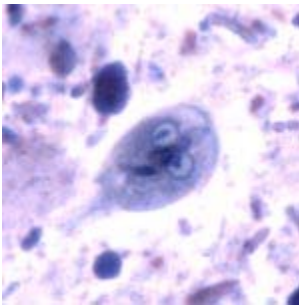
Sarcomastigophora

Sarcomastigophora is characterized by a single-type nucleus and movement by flagella, pseudopodia, or both. It comprises the subphyla *mastigophora*, *opalinata*, and *sarcodina*.

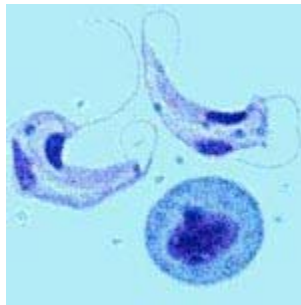
- Locomotory organelles are pseudopodia and flagella
- Only one type of nucleus

Examples:

- *Giardia*
- *Cryptobia* spp.



Giardia



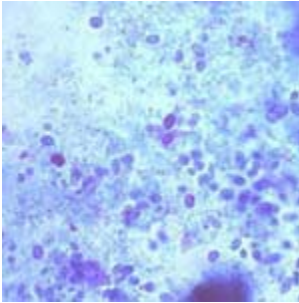
Cryptobia spp.

Microspora

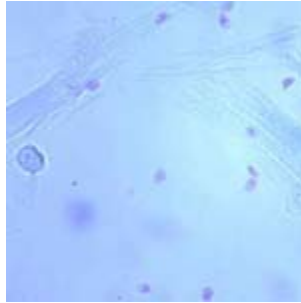
Microspora, or *Microsporidia*, is a phylum made of tiny intracellular parasites with spores of unicellular origin.

Examples:

- *Enterocytozoon bieneusi*
.....
- *Pleistophora* spp.
.....



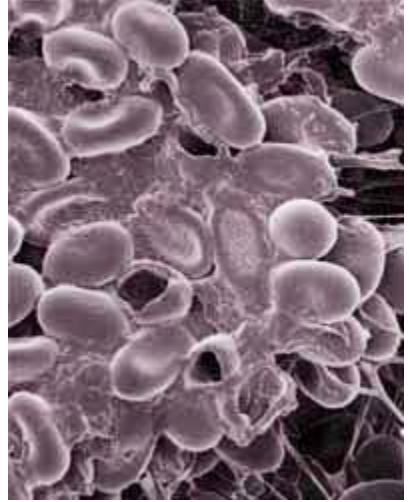
Enterocytozoon bieneusi



Pleistophora spp.

***Microspora* (cont'd)**

The *Microsporidia* are obligate intracellular parasites that have been recognized in a variety of animals, particularly vertebrates. Typical sizes of the spores range from 0.5 to 2.0 μ m in humans. The infectious stage, the spore, contains a coiled polar tubule, which is an extrusion mechanism for injecting the infective spore contents into host cells. Demonstration of the coiled polar tubule within spores is diagnostic for microsporidial infections.

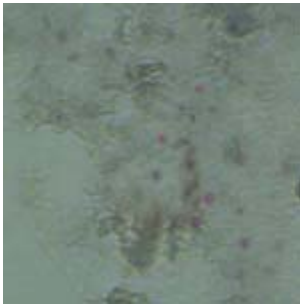


Microspora: Five Genera

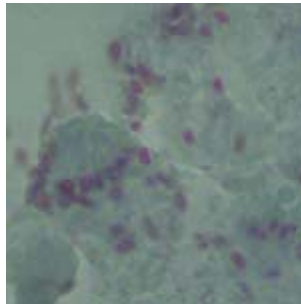
Currently, there are five genera of *Microsporidia* that can infect humans:

- *Enterocytozoon bieneusi*
- *Encephalitozoon hellem*
- *Encephalitozoon cuniculi*
- *Encephalitozoon intestinalis*
- *Pleistophora* spp.

The first four have the potential to be waterborne because they are shed in feces and urine. *E. bieneusi*, *E. hellem*, and *E. intestinalis* are the most common cause of microsporidian infections in patients with AIDS. In addition, they are much smaller than other parasites and potentially more difficult to remove by water treatment filtration.



Enterocytozoon species
(*Enterocytozoon bieneusi*)



Encephalitozoon species
(*Encephalitozoon cuniculi*)

Microspora: Infections

Human infections occur through ingestion, inhalation, and probably direct inoculation of infectious spores from the environment. Infection occurs with the introduction of infective sporoplasm through the polar tubule into the host cell.

Ciliophora

Ciliophora is characterized by the presence of cilia at some time during the life cycle.

Examples:

- *Paramecium*
- *Tetrahymena*



Paramecium



Tetrahymena

Putting Pathogenic Protoza in thier Place

Protoza are organized into seven different phyla. Use the arrow buttons to sort the phyla below based on whether they are pathogenic or not. If a phylum is sorted incorrectly, the system will encourage you to try again.

Pathogenic		Non-pathogenic
	« Acetospora »	
	« Apicomplexa »	
	« Ciliophora »	
	« Labyrinthomorpha »	
	« Microspora »	
	« Myxospora »	
	« Sarcomastigophora »	

Question 1 of 6

All protozoan are pathogenic for humans.

- A. True
- B. False

Submit Answer

Question 2 of 6

Protozoan may have both sexual and asexual reproductive phases.

- A. True
- B. False

Submit Answer

Question 3 of 6

Protozoa are traditionally classified by morphology and movement.

- A. True
- B. False

Submit Answer

Question 4 of 6

Microspora, also called microsporidians, have cysts as small as bacteria.

- A. True
- B. False

Submit Answer

Question 5 of 6

Cryptosporidium, a coccidian apicomplexan, has one of the simplest protozoan life cycles.

- A. True
- B. False

Submit Answer

Question 6 of 6

Which of the following is a non-pathogenic phylum of protozoa?

- A. Acetospora
- B. Apicomplexa
- C. Ciliophora
- D. Microspora

Submit Answer