Parasitism

- Intimate and obligatory symbiotic relationship between two organisms of different species
- Parasite is metabolically and physiologically dependent on host
- Short term (mosquito) or permanent (tapeworm)
- Very common way of life (50% of animal species)
- “True parasites” include protozoans (single-celled), helminths (worms), and arthropods (ectoparasites)

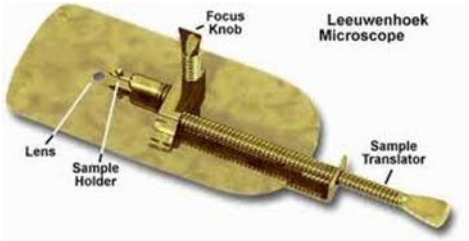
“Success” of parasites defined in terms of:

- prevalence in hosts
- number of host species available
- geographic range
- number of offspring
- available routes of transmission

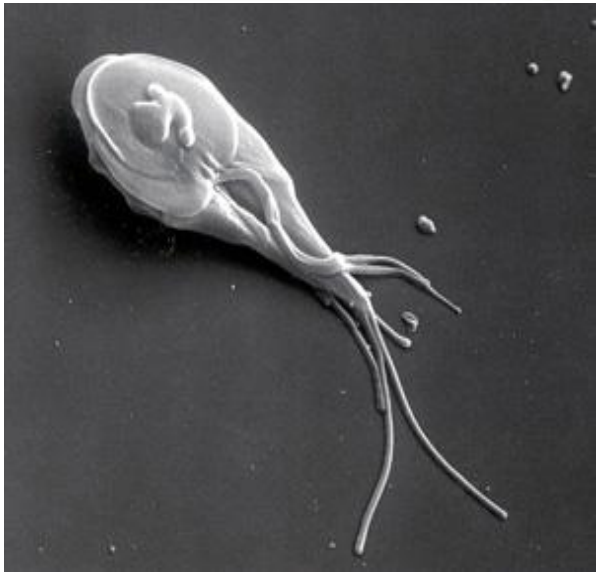
Giardia lamblia (syn. *G. duodenalis*, *G. intestinalis*)

HISTORY

first described by Leeuwenhoek in 1681:



"...I have sometimes also seen animalcules a-moving very prettily, their belly which was flatlike, furnisht with sundry little paws..."



- Demonstrated to be a true pathogen in the early 1900's
- Most frequently identified intestinal parasite worldwide

Symptoms – *G. lamblia*

- Most infections are asymptomatic (carriers)
- acute giardiasis: diarrhea, weight loss, abdominal discomfort, nausea, vomiting
- retardation of growth and development in young children (failure to thrive)

Prevalence - *G. lamblia*

- most common protozoan infection of intestinal tract worldwide
- 2-5% in industrialized world and 20-30% in developing world;
- prevalence rises through infancy and childhood and declines in adolescence (related to faecal-oral route of transmission)
- Other high risk groups include travelers and immunocompromised

Life cycle – *G. lamblia*

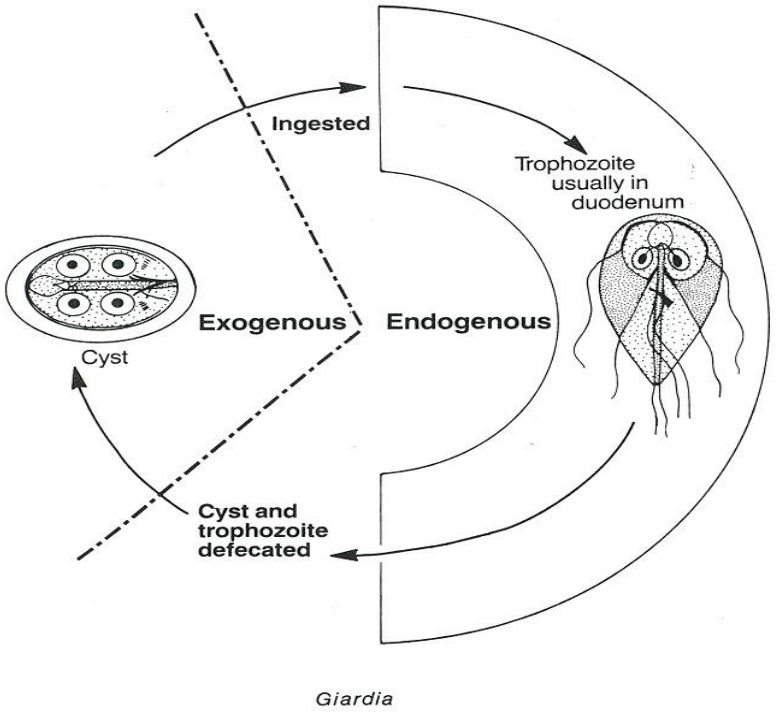
-excystation

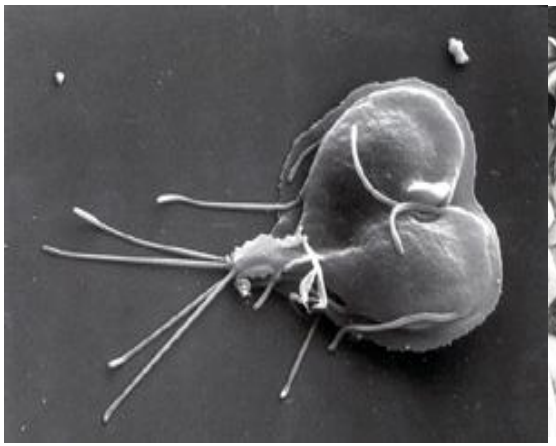
-trophozoites in small intestine

-longitudinal binary fission

-encystation

-cysts shed with faeces





Waterborne Outbreaks of Giardiasis in Canada

LOCATION	YEAR	CASES
100 Mile House, BC	1981	65
Banff, AB	1982	121
Edmonton, AB	1983	895
Penticton, BC	1986	362
Creston, BC	1986	83
Botwood, NL	1991	136
Creston, BC	1991	124
Corner Brook, NL	1992	50
Temagami, ON	1994	?
Deer Lake, NL	1994	9
Muskoka/Parry Sound, ON	1995	37
Camp Tawingo, ON	1995	35(?)
Valemont, BC	1996	10
Swift Current, SK	1996	3(?)
Les Escoumins, QC	1997	?
Ange Gardien, QC	1999	3

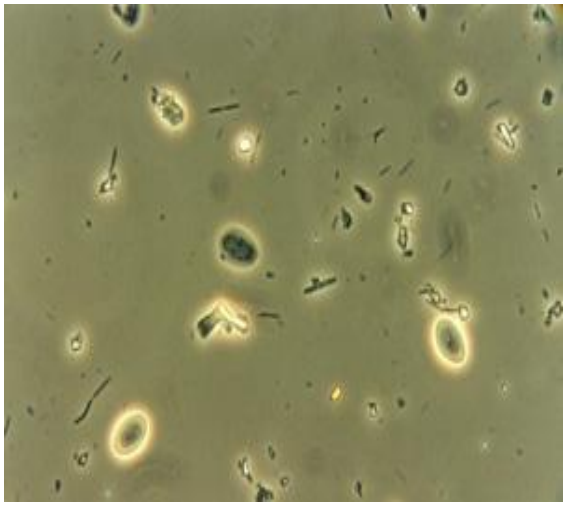
Foodborne Outbreaks in North America

Location	Year	Cases	Food
Goodhue, Minn.	1979	29	canned salmon
Peace River, Alberta	1982	22	ice
Newtown, Conn.	1985	13	noodle salad
Minnesota	1986	88	sandwiches
New Jersey	1986	10	fruit salad
Albuquerque, N.M.	1988	21	lettuce, tomatoes
Washington State	1990	27	ice
Hartford, Conn.	1990	27	raw vegetables
Minnesota	1991	20	fresh fruit
Illinois	1996	6	ice cream
Washington State	1998	3	seafood

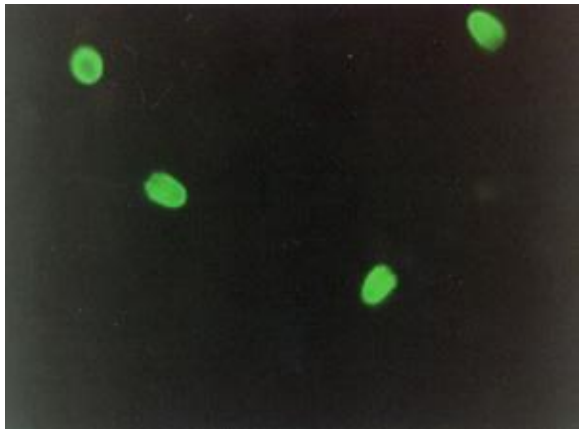
Diagnosis – *G. lamblia*

MICROSCOPY (stool exam)

- cysts concentrated by flotation and identified using bright-field microscopy



- immunofluorecence microscopy using fluorochrome-conjugated mAb's that bind to cyst wall



Diagnosis – *G. lamblia* cont'd

Immunological Testing

- detection of *Giardia*-specific antigens in faeces (eg. ELISA)

Treatment – *G. lamblia*

Nitroimidazole derivatives

- metronidazole and tinidazole are the drugs of choice; 2 g (single dose) daily for 3 days

NB. drug resistance to metronidazole and furazolidone has been described

Control - Water Treatment

- resistance to chlorination
- fewer outbreaks in municipalities using water filtration
- ozone / UV light promising
- EPA method 1623

Control – *G. lamblia*

PUBLIC HEALTH EDUCATION

- increase awareness of person-to-person transmission; improve hygienic practices (e.g., daycares)
- food-borne infections (food handlers, wash produce)
- backpackers drinking raw surface water are at risk (portable filters, boil water)
- Advice to travelers (avoid tap water, peeled fruits)

Trichomonas vaginalis

- Possibly the most common sexually transmitted disease worldwide (200 million cases)

- Transmitted through mucous membrane contact (no resistant cyst stage)

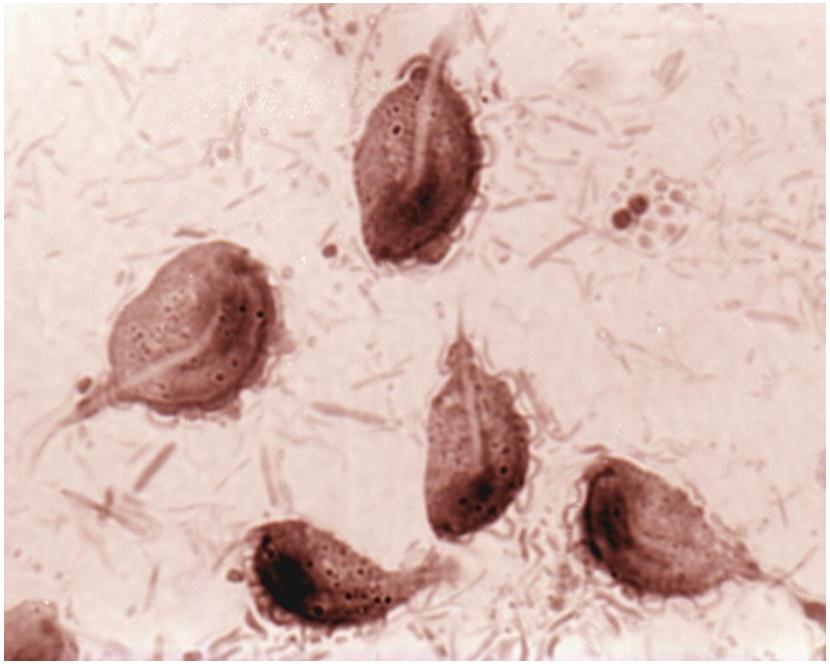
Trichomonas vaginalis - Symptoms

- 40-50% asymptomatic carriage
- Vaginitis (trichomoniasis) with itching, foul-smelling, sometimes frothy discharge
- May increase susceptibility to cervical cancer and HIV infection
- Infection during pregnancy may result in premature delivery and low birth weight
- Males usually asymptomatic; occasionally urethritis, prostatitis

Trichomonas vaginalis - Diagnosis

- Microscopy (wet mounts) to identify trichomonads in vaginal or urethral discharge

- Vary greatly in size (10-30µm)



Trichomonas vaginalis - Treatment

- metronidazole and tinidazole are drugs of choice

- To avoid re-infection, testing and treatment of partners is important

Entamoeba histolytica

- Common in developing tropical countries
- Transmitted through faecal-oral route (person to person), contaminated water, raw produce, food handlers, flies
- Largely related to poor sanitation and hygiene

Entamoeba histolytica - Symptoms

- Typical infections of the large intestine may be asymptomatic, or may result in diarrhea and constipation

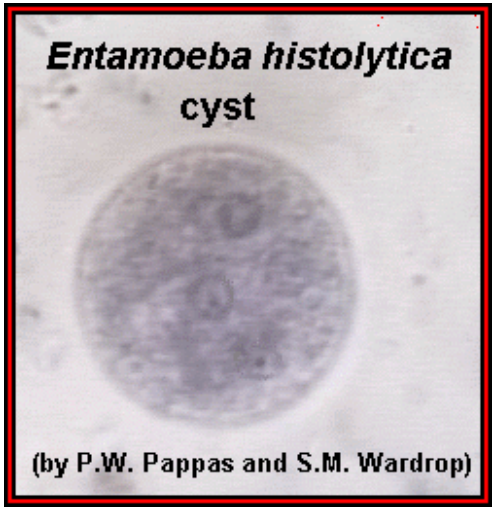
- amoebic dysentery in some patients (bloody/mucoid diarrhea)

Entamoeba histolytica – Symptoms (cont'd)

- May spread through the blood to produce liver, lung or brain abscesses

Entamoeba histolytica - Diagnosis

- Microscopic identification of trophozoites (18-30µm) or cysts in faeces or in lesions



Entamoeba histolytica - Treatment

- Luminal amoebicides (such as paromomycin, diloxanide furoate and iodoquinol) act on organisms in the intestinal lumen

- For symptomatic intestinal disease, or extraintestinal infections (e.g., liver abscess), the drugs of choice are metronidazole or tinidazole, immediately followed by treatment with luminal amoebicides

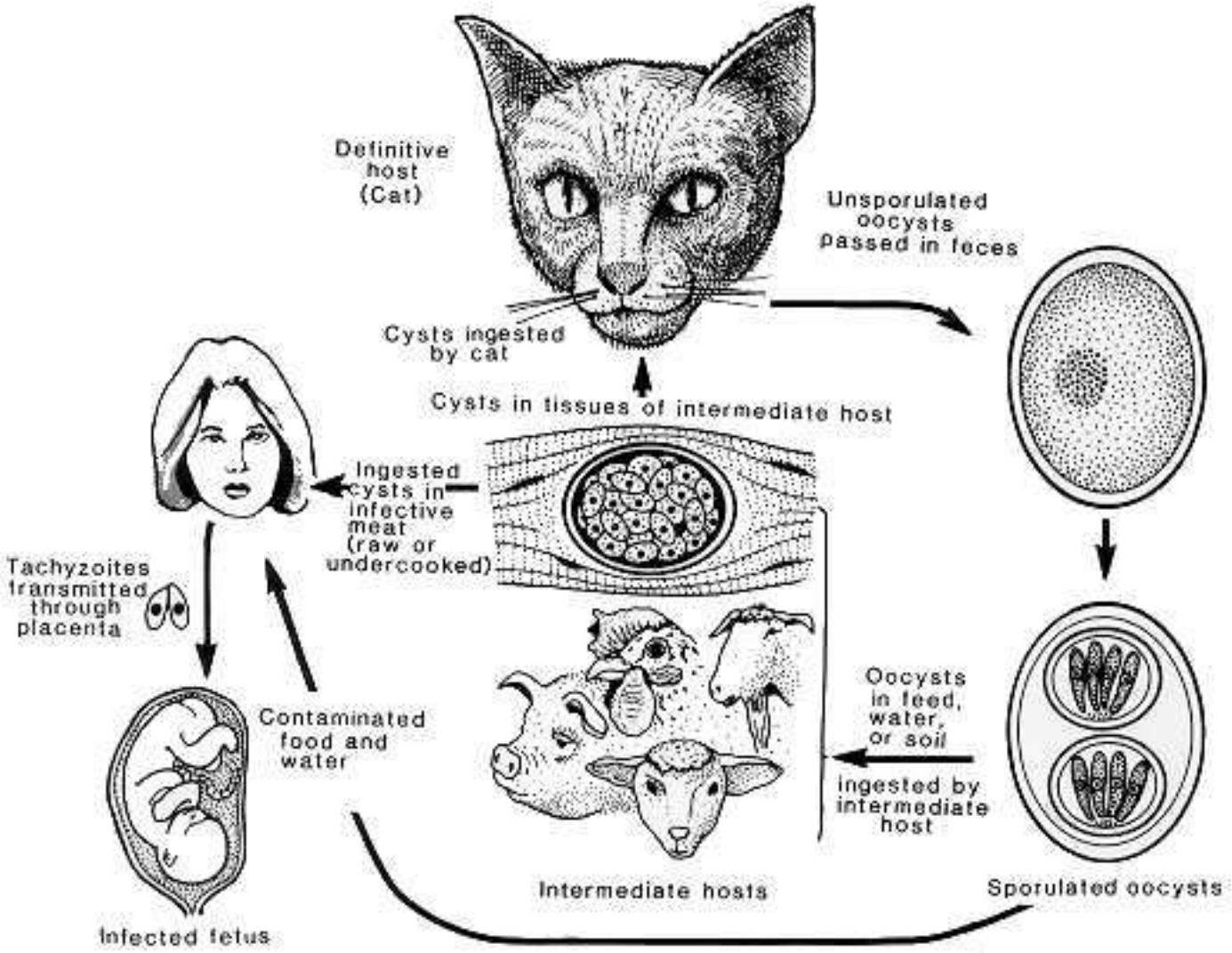
Entamoeba histolytica - Control

- Public health education
- Improved sanitation and water treatment
- Wash fruits and vegetables

Toxoplasma gondii

- Recognized as a human pathogen in early 1900's
- Very high seroprevalence in humans worldwide
- Large number of mammals and birds act as intermediate hosts
- cats are the only definitive hosts (shed oocysts)

Life cycle of *Toxoplasma gondii*



Toxoplasma gondii - Transmission

1. Ingestion of sporulated oocysts (10-12 µm)
   - contaminated soil/sand
   - contaminated fruits and vegetables
   - waterborne outbreaks (Victoria, B.C., 1995)

2. Ingestion of tissue cysts
   - raw or poorly cooked meat

3. Congenital infection of fetus
   - infection acquired during pregnancy (most severe if acquired in first trimester)

Toxoplasmosis - Foodborne Outbreaks

Location	Year	Cases	Implicated Food
New York State	1968	5	rare hamburger
New York, NY	1975	6	rare lamb
California	1978	10	raw goat’s milk
Quebec	1987	4	raw game meats

Symptoms of toxoplasmosis

1. Immunocompetent host

   90% asymptomatic, lymphadenopathy, headaches, muscle aches, fever, malaise

2. Immunocompromised host

   encephalitis, myocarditis, pneumonia

   (AIDS-defining disease)

3. Congenital infection

   hepatosplenomegaly, mental retardation, retinochoroiditis, hydrocephalus

Treatment of toxoplasmosis

- Diagnosis based on serological assays
- Immunocompetent patients normally don’t require treatment unless symptoms become severe or chronic
- Immunocompromised patients require prompt treatment with a combination of pyrimethamine and sulfadiazine
- Congenital infections:
  - Mother/fetus can be treated to reduce incidence and severity of fetal infection
  - Infected newborns can also be treated to minimize sequelae

Malaria
-Transmission

- Anopheline mosquitoes (vectors)
- Blood transfusion / shared needles
- Congenital infection
- “Airport malaria”

Symptoms of Malaria

- Spiking fever and chills
- Flu-like symptoms (myalgias, headaches, abdominal pain, malaise)
- Severe symptoms (*P. falciparum*)

  seizures, coma, renal failure, respiratory failure

Malaria prophylaxis and treatment

- Chloroquine and mefloquine are drugs of choice for prevention and treatment

- drug resistance is a serious problem

Control of Malaria

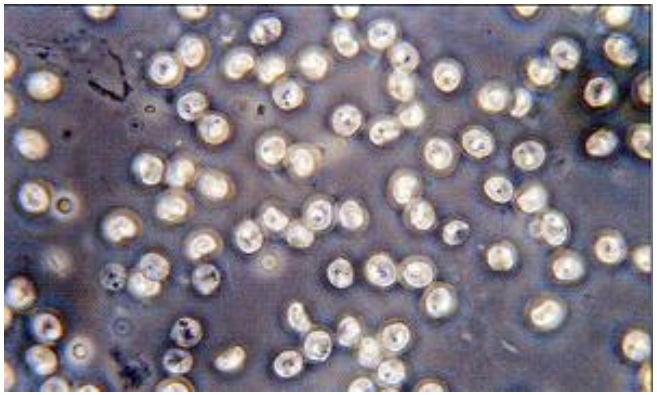
- Largely a man-made disease (clearing of forests, building of irrigation canals)
- Eradication or control of mosquitoes (resistance to insecticides)
- Protection against mosquito bites
  - Avoid rural areas at night
  - Long-sleeved shirts/long pants
  - Insect repellent
  - Bed netting

Cryptosporidium spp.

- recognized as human pathogen (1976)
- reported in humans worldwide
- The most common symptom of cryptosporidiosis is watery diarrhea; other symptoms include dehydration, weight loss, abdominal pain, fever, nausea, vomiting
- chronic, debilitating, and potentially life-threatening symptoms in immunocompromised
- No drug treatment available!

Life cycle – *Cryptosporidium*

- complex life cycle including both sexual and asexual phases (oocysts 4-6 µ)



- obligate intracellular protozoan which infects the intestinal epithelial cells of the host (typically in small intestine)

Transmission - *Cryptosporidium*

WATER

- numerically the most important mode of transmission (contaminated drinking water)

- recently numerous outbreaks associated with water parks/pools

Waterborne Outbreaks of Cryptosporidiosis in Canada

Location	Year	Cases
Kitchener-Waterloo, ON	1993	1,400
Kelowna, BC	1996	15,000
Collingwood, ON	1996	121
Cranbrook, BC	1996	136
Shoal Lake, MB	1997	64
North Battleford, SK	2001	1,907

NB. Milwaukee, Wisconsin, 1993 (400,000 cases, 100 deaths)

Transmission - *C. parvum*

PERSON-TO-PERSON

- ingestion of oocysts due to poor hygiene (e.g., day cares, institutionalized patients)

AUTOINFECTION

- thin-walled oocysts are released into the lumen and cause autoinfection
- responsible for chronic and life-threatening disease in immunocompromised

Transmission - *C. parvum*

ZOONOTIC

- cattle serve as important reservoir hosts
- calves with diarrhea can excrete up to 10^{10} oocysts/day
- environmental contamination; veterinary personnel and animal handlers at increased risk (petting zoo visitors)

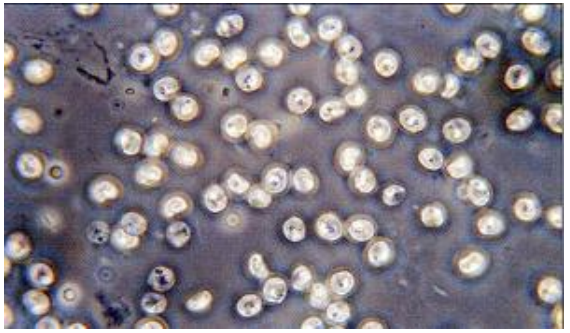
Foodborne Outbreaks – *C. parvum*

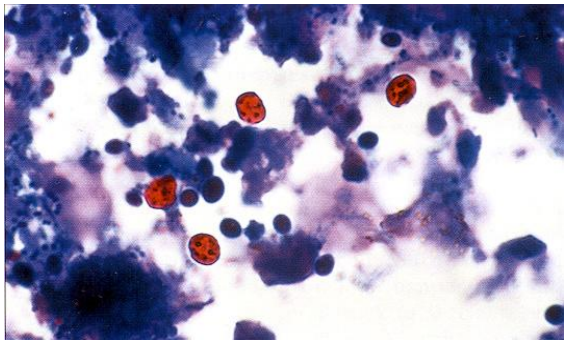
Location	Date	Cases	Food
Maine	1993	160	apple cider
Minnesota	1995	15	chicken salad
New York	1996	31	apple cider
Washington	1997	54	green onions
Washington DC	1998	92	raw produce

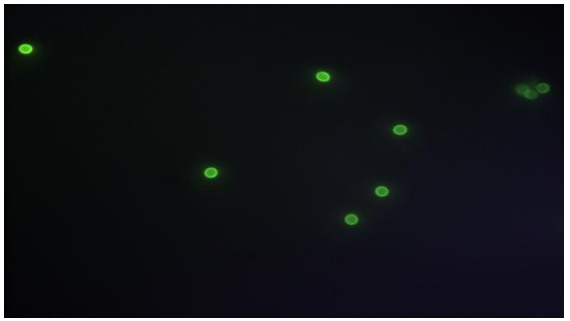
Diagnosis - *C. parvum*

MICROSCOPY

- oocyst shedding intermittent; multiple stools examined
- concentration methods can be used when low oocyst shedding
- wet-mounts or permanent stains are used (acid-fast)
- Fluorescein-labelled IgG mAb is used in immunofluorescence microscopy







Control - Water Treatment

- Watershed management
- Flocculation / Sand filtration
- Resistance to chlorination
- Ozone, UV light
- Water testing (EPA method 1623)

Control - *C. parvum*

PUBLIC HEALTH EDUCATION

- in endemic areas, avoid drinking tap water/ice cubes, raw fruits and vegetables unless you can peel them

- immunocompromised patients should consider bottled water

- exposure to temperatures above 60°C and below -20°C will kill oocysts

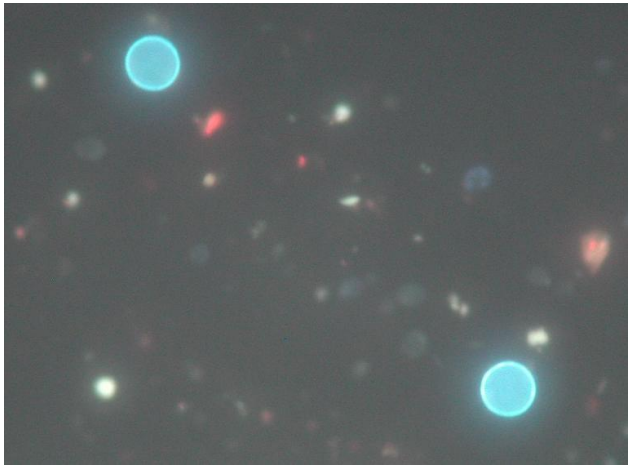
Control - *C. parvum*

PUBLIC HEALTH EDUCATION-cont'd

- because crypto is spread person-to-person, handwashing helps prevent infection

- precautions are required when caring for patients with crypto diarrhea; lack of effective disinfectants against oocysts (nosocomial infections)

Cyclospora cayetanensis



- Identified as a coccidian protozoan parasite and named in 1993
- Cases reported in North, Central, South America, Caribbean, S.E. Asia, Europe, UK, India, Africa
- Endemic countries include Nepal, Haiti, Peru, and Guatemala

Cyclosporiasis - Symptoms

- Low infectious dose
- Incubation period approximately 1 week
- Profuse and prolonged diarrhea
- Abdominal pain, nausea, vomiting, fatigue, fever, loss of appetite
- Effectively treated with bactrim (trimethoprim-sulfamethoxazole)

Cyclosporiasis - Diagnosis

- microscopic examination of wet mount stool for oocysts (brightfield, differential interference contrast, autofluorescence)
- staining methods (e.g. acid-fast)

Cyclosporiasis - Transmission

- Person-to-person transmission unlikely
- Zoonotic transmission unlikely
- Most earlier outbreaks were waterborne
- 90-99% of cases in U.S. are foodborne
- Numerous foodborne outbreaks in recent years

Foodborne outbreaks of cyclosporiasis in North America

U.S. / Ontario	**May-June 1996**	**1,465**	**raspberries/blackberries (Guatemala)**
U.S. / Ontario	**Apr.-May 1997**	**1,012**	**raspberries/blackberries (Guatemala)**
Washington DC	June-July 1997	260	basil
Virginia	Sept. 1997	21	fruit plate
Florida	Dec. 1997	12	mesclun (Peru)
Ontario	May 1998	192	raspberries (Guatemala)
Ontario	May 1999	104	blackberries?
Missouri	July 1999	65	basil (Mexico or U.S.)
Atlanta GA	May 2000	21	raspberries (Guatemala)
Vancouver BC	May 2001	17	Thai basil
Vermont	Jan. 2002	22	raspberries (Chile?)
Vancouver BC	June-July 2003	10	cilantro?
Texas / Illinois	Feb. 2004	95	basil/mesclun?
Vancouver BC	May-June 2004	9	cilantro?
Pennsylvania	June-July 2004	<100	snow peas (Guatemala)
Florida	Mar.-Apr. 2005	>300	basil (Peru)
Ontario	Apr. 2005	40	basil (Peru)
Ontario	Apr. 2005	4	basil (Peru)
Quebec	June 2005	226	basil (Mexico)

Contamination of Foods

Direct contamination

- infected pickers, sorters, inspectors, or other food handlers (poor hygiene, sporulation)

Indirect contamination

- contaminated water used for irrigation, mixing pesticides, washing equipment, washing hands

Enterobius vermicularis (pinworm)

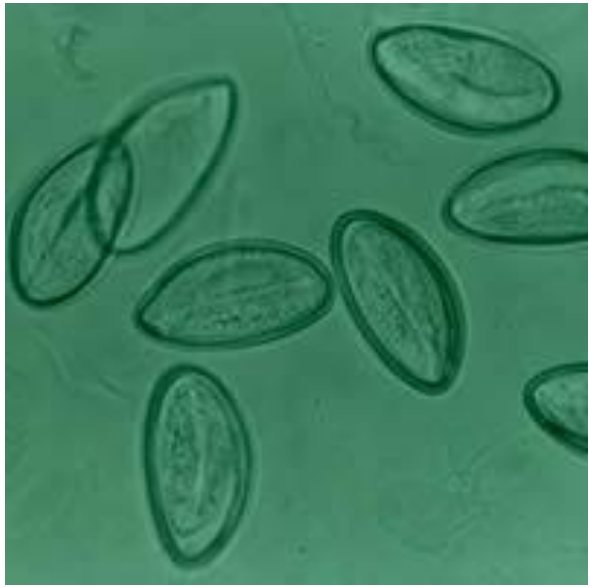
- Prevalent world wide
- Highest incidence in school-age children
- Up to 50% of children in North America
- More of a nuisance than a health problem
- Eggs ingested (faecal-oral route)

Pinworm - Symptoms

- Mild infection of caecum/colon
- May cause itching (pruritus ani) leading to disturbed sleep, irritability
- Scratching may cause secondary infections

Pinworm – Diagnosis/Treatment

- Scotch-tape test of perianal area
- Microscopic identification of eggs; adult female worms may also be present (8-13mm)



- Drug of choice is pyrantel pamoate

Pinworm - Control

- Personal hygiene education for children (wash hands)
- Discourage scratching, nail biting
- Frequent bathing; regular change of underclothing, pajamas, and bedding

Trichinella spp.

- Small roundworm found worldwide in many carnivorous and omnivorous animals, including humans

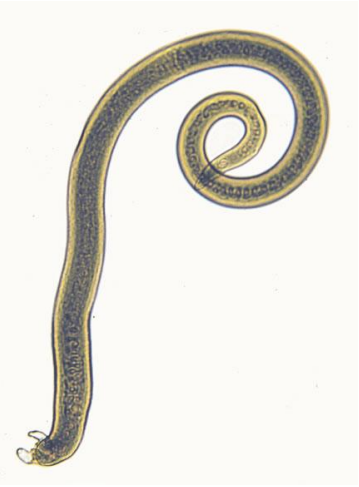
- Transmitted through ingestion of larvae in raw or poorly cooked meat

- Survives as adult in small intestine; as larvae encysted in striated muscle

Trichinella spiralis (domestic form)
- humans, swine, rats (responsible for endemicity)
- horses! (probably fed animal products as supplement)

Trichinella nativa (sylvatic or wild form)
- humans, bears, wild boar, wolf, fox, walrus, etc.

***T. spiralis* adult female**



***T. spiralis* adult male**

Trichinellosis - Symptoms

- Symptoms dependent upon phase of life cycle
- When larvae excyst in small intestine - diarrhea, abdominal pain, vomiting
- When next generation of larvae migrate into muscle tissues - facial edema, conjunctivitis, fever, myalgias
- Occasional life-threatening manifestations include myocarditis, central nervous system involvement, and pneumonitis

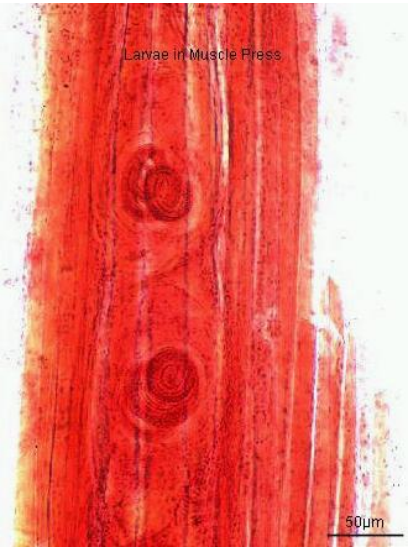
Trichinellosis - Treatment

- Thiabendazole effective against intestinal phase
- Mebendazole and albendazole have some effect on tissue phases
- Steroids may be used to reduce inflammation

Trichinellosis - Control

- Rodent control

- Avoid garbage feeding to livestock

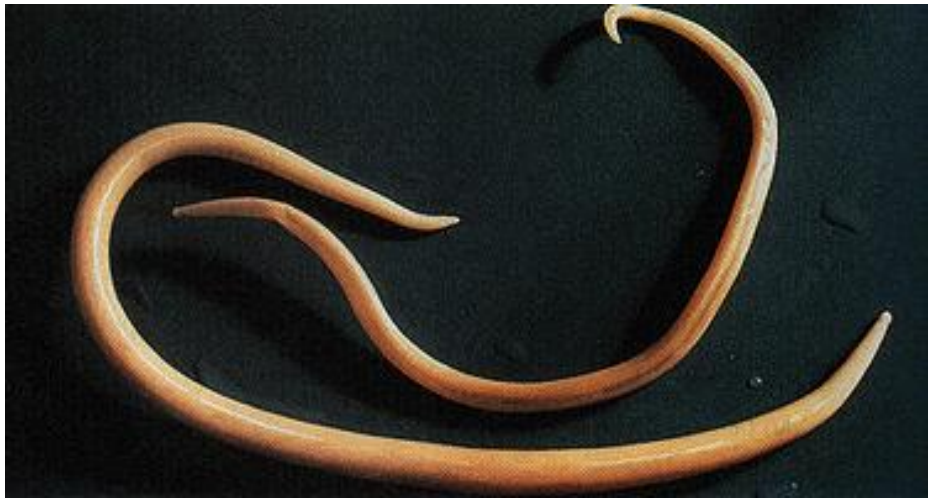


- Inspection programs (trichinoscopy, digestion, ELISA)

- Cooking /freezing (*T. nativa* very resistent to freezing)

Ascaris lumbricoides

- Very large intestinal nematode (adult females 20 to 35 cm; adult male 15 to 30 cm)
- High prevalence worldwide (especially warmer regions); most common human helminth infection (over 1 billion cases)



Ascaris lumbricoides - Transmission

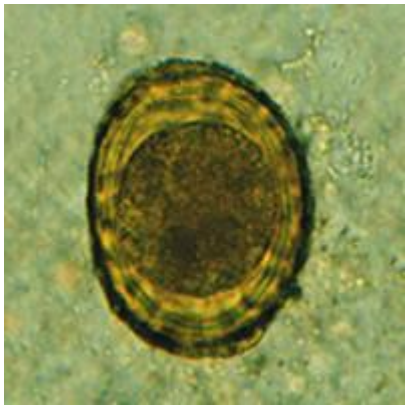
- After shedding with the faeces, eggs mature and become infective after several days
- Transmitted through ingestion of eggs in soil, fruits/veg, or water
- Associated with poor sanitation

Ascaris lumbricoides - Symptoms

- Asymptomatic or vague abdominal discomfort

- Vomiting and/or obstruction may occur

Ascaris lumbricoides – Diagnosis and Treatment



- Stool examination (microscopy) for the presence of eggs
- Mebendazole, albendazole or pyrantel pamoate
- Surgery may be required to clear worm bolus

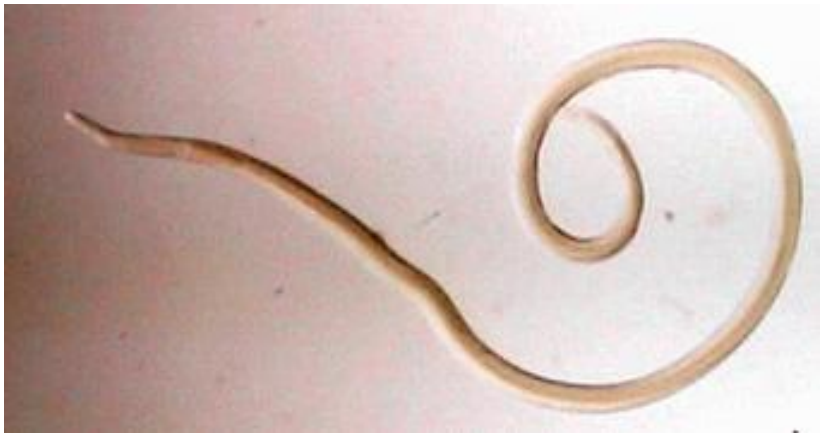
Anisakis simplex (whale worm or herring worm)

- Anisakiasis first reported in the Netherlands in the 1950's
- Highly prevalent in Japan (>1000 cases per year)
- Still quite rare in North America
- most cases arise from home-prepared sushi, sashimi, and ceviche

Anisakis simplex - hosts

- Definitive hosts

- dolphins, porpoises, whales



- First intermediate hosts

- marine crustaceans

- Second intermediate hosts

- salmon, mackerel, cod, herring, tuna, squid

NB. Humans are “dead-end” hosts only

Anisakiasis

Symptoms

- *A. simplex* often invasive (penetrates mucosa)
- abdominal pain, nausea, vomiting

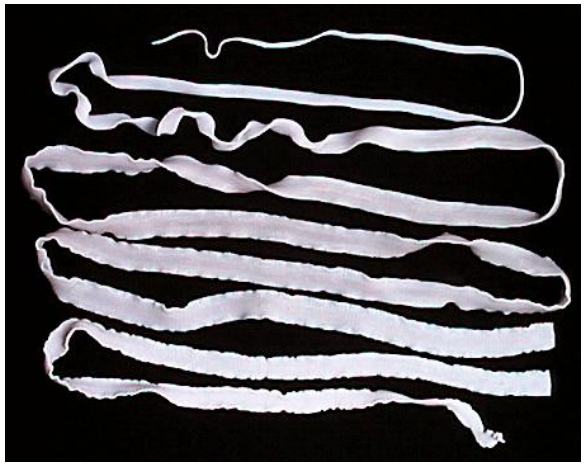
Diagnosis / Treatment

- diagnosis difficult – no eggs in stool
- endoscopic and radiologic examinations may be useful
- symptoms often mistaken for appendicitis; exploratory surgery may reveal larvae which are then removed
- drug treatment is not effective

Anisakiasis - Control

- inspection of fillets at processing plant
- candling on a light table will reveal larvae
- cooking / freezing very effective

Diphyllobothrium spp. (Broad fish tapeworm)



- large tapeworm (10 m long)
- Adult tapeworm inhabits the small intestine of humans and other fish-eating mammals
- Larval stages in freshwater fishes (e.g. pike, trout, perch, whitefish, salmon) which act as intermediate hosts

Diphyllobothrium spp. (Broad fish tapeworm)

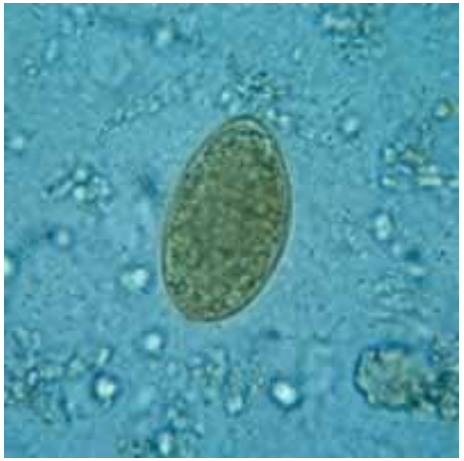
- Transmitted through the consumption of raw or poorly cooked freshwater fish containing infective larvae

Diphyllobothrium spp. - Symptoms

- Most cases are asymptomatic
- Abdominal pain, dizziness, fatigue, vomiting, diarrhea/constipation
- Vitamin B12 deficiency with pernicious anemia

Diphyllobothrium spp. – Diagnosis and Treatment

- Stool examination for eggs (microscopy) or proglottids (segments)



- Anthelmintic drugs effective (Praziquantel)

Taenia spp.

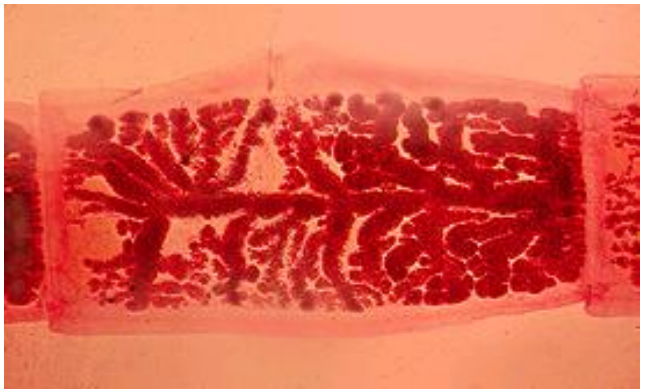
- Large tapeworms (up to 20 m in length)
- Adult stage only found in humans
- Transmitted through ingestion of larvae in raw or poorly cooked meat

Taenia saginata – beef tapeworm

scolex

Gravid proglottid

Taenia solium – pork tapeworm



Taenia spp.

Symptoms (adult tapeworm)

-mild abdominal complaints

Diagnosis

-Eggs or proglottids in stool

-Serological techniques

Treatment

-Anthelmintic drugs (Praziquantel)

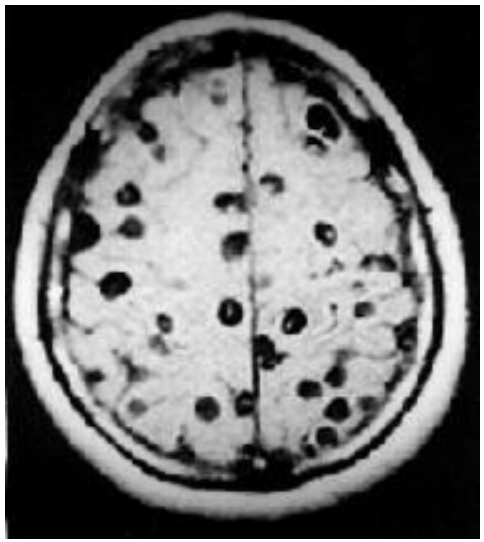
-surgery

T. solium neurocysticercosis

Infection with larval stage following ingestion of *T. solium* eggs (humans act as the intermediate host)

Larvae migrate and develop in brain

intracranial hypertension, hydrocephalus, convulsive seizures



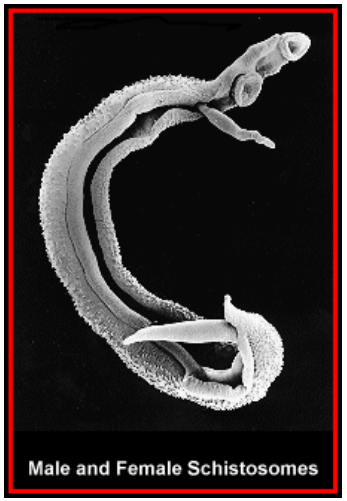
MRI of patient with neurocysticercosis

Control – *Taenia* spp.

- Both species are rare in Canada
- Routine inspections in Canada by CFIA
- Cooking meat readily kills larvae
- In endemic countries - sanitation; prevent access of pigs to human faeces

Schistosoma spp. (Blood flukes)

- Worldwide, 200-300 million cases
- Free-swimming larvae in fresh water penetrate skin and develop in blood vessels surrounding intestine or bladder
- Three main species: *S. haematobium*, *S. japonicum*, and *S. mansoni*



Symptoms of schistosomiasis

- rare except in heavily infected individuals
- Rash, itchyness from penetrating larvae
- fever, lymphadenopathy, hepatosplenomegaly

Diagnosis of schistosomiasis

- Microscopic examination for eggs in faeces or urine

- Treated with praziquantel

S. mansoni egg

Schistosomiasis - Control

- Eliminate habitat for snails which act as intermediate hosts (e.g. drainage channels)
- Spraying with molluscicides

- Improved sanitation
- Avoid contact with fresh water in endemic areas