Introduction to Medical Parasitology

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Human Medical Parasitology

- Human parasitology is the study of those organisms which parasitise humans.

- Taxonomic classification of parasitic organisms:
  The classification of parasites is controversial. Parasites form part of the animal kingdom which comprises some 800,000 identified species categorised into 33 phyla. The parasitic organisms that are of importance for human health are eukaryotes - they have a well defined chromosome in a nuclear membrane.
Parasites are classified into 2 sub-kingdoms: Protozoa (unicellular) and Metazoa (multicellular).

1. **Protozoa** (unicellular-microscopic one-celled organisms) parasites are classified according to morphology and means of locomotion. Most species that cause human disease belong to the first three phyla:
   1. **Sarcomastigophora:** Amoebas and Flagellates (Giardia).
   2. **Apicomplexa:** Sporozoans - Plasmodium.
   3. **Ciliophora:** the Ciliates – Balantidium.
   4. **Microspora:** Enterocytozoa - *M. stagnorum*
Within these great assemblages are found the important human parasites, conveniently listed as subphyla:

1. **Sarcodina**: typically amoeboid. Species:
   * Entamoeba
   * Endolimax
   * Iodamoeba
   * Acanthamoeba

2. **Mastigophora**: flagellates have whip-like flagella and in some cases undulating membrane (trypanosomes).
   * Intestinal & genitourinary flagellates: giardia, trichomonas, dientamoeba, chilomastix.
   * Blood & tissue flagellates: trypanosoma & leishmania.
3. **Sporozoa:**
Undergo a complex life cycle, usually involving 2 different hosts.
* Class Coccidia: isopora, toxoplasma, cryptosporidium.
* Class Haematozoa: malarial parasites (plasmodium), and order Piroplasmida (babesia species).

4. **Ciliophora:**
complex protozoa bearing cilia distributed in rows with 2 kinds of nuclei: *Balantidium coli*,

5. **Microspora:**
microsporidians.
2. **Metazoa** (multicellular) include the worms or the Helminths which belong to two phyla:

1. **Platyhelminths** (flatworms):
   
   * Cestoda (Tapeworms) and Trematoda (Flukes).

2. **Nemathelminths** (Roundworms):
   
   * Nematoda.

3. **Arthropoda** (posses an external skeleton)
   
   * e.g. ticks, lice.

- Note that the genus starts with a capital letter and the species is always written in italics, e.g. *Plasmodium falciparum*, *Giardia lamblia* ..etc.
Life Cycle Stages

- The stages of parasitic protozoa that actively feed and multiply are frequently called **Trophozoites**; in some protozoa, other terms are used for these stages. **Cysts** are stages with a protective membrane or thickened wall. Protozoan cysts that must survive outside the host usually have more resistant walls than cysts that form in tissues.

- Transmission from a patient to another is either direct or through an intermediate host (which is more resistant to the parasite and where the parasite increases in number).
Key definitions

- **Medical parasitology**: “the study and medical implications of parasites that infect humans”

- **A parasite**: “a living organism that acquires some of its basic nutritional requirements through its intimate contact with another living organism”. Parasites may be simple unicellular protozoa or complex multicellular metazoa

- **Eukaryote**: a cell with a well-defined chromosome in a membrane-bound nucleus. All parasitic organisms are eukaryotes
- **Protozoa**: unicellular organisms, e.g. Plasmodium (malaria)

- **Metazoa**: multicellular organisms, e.g. helminths (worms) and arthropods (ticks, lice)

- **An endoparasite**: “a parasite that lives within another living organism” – e.g. malaria, Giardia

- **An ectoparasite**: “a parasite that lives on the external surface of another living organism” – e.g. lice, ticks

- **Host**: “the organism in, or on, which the parasite lives and causes harm”
• **Definitive host:** “the organism in which the adult or sexually mature stage of the parasite lives”

• **Intermediate host:** “the organism in which the parasite lives during a period of its development only”

• **Zoonosis:** “a parasitic disease in which an animal is normally the host - but which also infects man”

• **Vector:** “a living carrier (e.g. an arthropod) that transports a pathogenic organism from an infected to a non-infected host”. A typical example is the female *Anopheles* mosquito that transmits malaria
Taxonomic classification of protozoa

- **Subkingdom**: Protozoa
- **Phylum**: Sarcomastigophora
  - Further divided into Sarcodina
    - move by pseudopodia
    - Entamoeba
      - *E. histolytica*
    - Mastigophora
      - move by flagella
      - Giardia
        - *G. lamblia*
  - Apicomplexa
    - no organelle of locomotion
    - Plasmodium
      - *P. falciparum, P. vivax, P. malariae, P. ovale*
  - Ciliophora
    - move by cilia
    - Balantidium
      - *B. coli*
  - Microspora
    - Spore-forming
    - Enterocytozoa
      - *E. biennis*
Intestinal Flagellates

*Giardia lamblia*:

- A flagellate, the only common pathogenic protozoan found in the duodenum and jejunum of humans, causing irritation & low grade inflammation, with consequent acute or chronic diarrhea, which may be watery, semisolid, greasy, bulky and foul smelling at various times during the course of infection.

**Trophozoite**: heart-shaped, symmetric, 10-20 µm in length, 4 pairs of flagella, 2 nuclei with prominent central karyosomes, and 2 axostyles. A large concave sucking disk in the anterior portion occupies much of the ventral surface. The swaying or dancing motion of trophozoites in fresh preparations is unmistakable.

**Cysts** are found in the stool-often in enormous numbers. As the parasites pass into the colon, they typically encyst. They are thick-walled, highly resistant, 8-14 µm in length, ellipsoid, contain 2 nuclei as immature & 4 as mature cysts.
Giardia lamblia

Trophozoite

Cyst

**Trophozoite, ventral view**
- Anterior flagellum
- Kinetosome
- Region of adhesive disk
- Nucleus
- Ventral groove
- Median body
- Posterior flagellum
- Ventral flagella
- Caudal flagella

**Trophozoite, lateral view**

**Cyst**
- Cyst wall
- Nuclei
- Axonemes
- Retracted flagella
Giardiasis
(\textit{Giardia intestinalis})

Contamination of water, food, or hands/fomites with infective cysts.

Trophozoites are also passed in stool but they do not survive in the environment.

\begin{itemize}
  \item[i] = Infective Stage
  \item[d] = Diagnostic Stage
\end{itemize}
**Giardia lamblia**

- Trophozoites
- Cysts

Cyst of *Giardia lamblia*. Note two nuclei. Two others are not in focus.

Trophozoites of *Giardia lamblia*
Clinical findings:
Malaise, weakness, weight loss, abdominal cramps, distention, and flatulence. Children are more liable to clinical giardiasis than adults. Immunosuppressed individuals are liable to massive infection.

Diagnostic Lab. Tests:
* Finding the distinctive cysts in formed stools, or cysts and trophozoites in liquid stools.
* Stool ELISA: rapid diagnostic tool.
* Duodenal aspirate examination when-negative stool.
A series of 3 or more stool exam. On alternate days is therefore recommended.

Treatment: Metronidazole (Flagyl) will clear >90%. Oral quinacrine HCl (Atabrine) & Furazolidine are alternatives. Tinidazole (Fasigyn) – 1 day treatment. Paromomycin in pregn.
Trichomonas

- Trichomonads are flagellate protozoa with 3-5 anterior flagella.

- *Trichomonas vaginalis* causes trichomoniasis in humans. It is pear-shaped, with a short undulating membrane lined with a flagellum and 4 anterior flagella. It is about 5-30 x 2-14 µm. It moves with wobbling and rotating motion.
  * In females it causes low-grade inflammation limited to vulva, vagina and cervix, causing frothy yellow or creamy discharge.
  * In males it may infect the prostate, seminal vesicles and urethra.

* Treatment: Topical and systemic Metronidazole. Tinidazole & Ornidazole are equally effective with fewer side effects.
General Morphology of the *Trichomonas* trophozoite

*Trichomonas vaginalis* infection
Three types occur in humans

- *Trichomonas hominis*
- *Trichomonas vaginalis*
- *Trichomonas tenax*
Intestinal Amebas

Entamoeba histolytica:

- It is a common parasite in the large intestine of humans, encountering 3 stages: the active ameba, the inactive cyst, and the intermediate precyst.

  - The ameboid trophozoite is the only form present in tissues. It is also found in fluid feces during amebic dysentery. Its size is 15-30 µm. The cytoplasm has 2 zones, a hyaline outer margin and a granular inner region that may contain red blood cells. It has pseudopodia.

  - Cysts are present in the lumen of the colon and in formed feces. Subspherical cysts of pathogenic amebas range from 10-20 µm. Smaller cysts 10 -3.5µm are considered nonpathogenic (E. hartmanni). Cysts may contain 1-4 nuclei, a glycogen vacuole and chromatoidal bodies with characteristic rounded ends.

- Diagnosis in most cases rests on the characteristics of cyst, since trophozoites usually appear in only diarrheic feces for few hours.
Entamoeba histolytica

Trophozoite

Cyst

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Entamoeba histolytica

Trophozoite

Cyst

(by P.W. Pappas and S.M. Wardrop)
Balantidium coli

- It causes balantidiasis or balantidial dysentery, is the **largest** intestinal protozoan of humans.
- The trophozoite is a ciliated, oval organism 60 X 45 μm or larger. It has a **steady progression and rotation around the long axis motion**.
- Most infections are apparently harmless. However, rarely, the trophozoites invade the large bowel and terminal ileum, causing abscesses & ulcerations.
- Treatment: Oxytetracycline may be followed by iodoquinol or metronidazole if necessary.
Balantidium coli – Morphology of 2 stages
The Hemoflagellates

The hemoflagellates of humans include the genera Trypanosoma and Leishmania, casing Trypanosomiasis & Leishmaniasis respectively.

- **Human trypanosomes:**
  - African: *T. brucei rhodesiense* & *T. brucei gambiense*, transmitted by tsetse flies (glossina), causing sleeping sickness.
  - American: *T. (schizotrypanum) cruzi*, transmitted by conenose bugs (triatoma), causing Chagas’ disease.
- **Leishmania:**

  Divided into a number of species infecting humans by sandflies (Phlebotomus) causing:

  - Cutaneous leishmaniasis (Oriental sore or Baghdad boil) – *L. tropica, L. major, L. mexicana, L. braziliensis*.
  - Mucocutaneous or naso-oral leishmaniasis (espundia) – *L. braziliensis braziliensis*.
  - Visceral leishmaniasis (kala-azar) – *L. donovani*.
Typical lesion of cutaneous leishmaniasis

Leishmania spp. amastigotes (1000X) - Giemsa stained tissue impression smear
419 *Trypanosoma brucei* found in blood film. A blood film from a patient with sleeping sickness. The trypomastigotes of *T. brucei* are clearly visible. (*bar = 5 µm*)
Blood Sporozoans

- **The Plasmodia:**

  Sporozoa of genus plasmodium are pigment-producing ameboid intracellular parasites of vertebrates, with one habitat in red cells and another in cells of other tissues. Transmission to humans is by the bloodsucking bite of female anopheles mosquitoes of various sp.

* 4 species infect humans:
  - *Plasmodium vivax*
  - *P. ovale*
  - *P. malariae*
  - *P. falciparum*
Pathogenesis & Clinical Findings:
Infection results from the bite of an infected female anopheles mosquito, in which **sporozoites** (resulting from sexual & sporogonic cycle in mosquito) are injected into blood stream. Sporozoites rapidly (usually within 1 hour) enter parynchymal cells of liver (**1st stage of development in humans - exoerythrocytic phase of life cycle**). Subsequently, numerous asexual progeny – **merozoites** rupture, leave liver cells, enter blood stream & invade erythrocytes, multiply in a species characteristic fashion, breaking out synchronously at 48 or 72 (**P. falciparum**) hours intervals – **erythrocytic cycle**. Incubation period is usually 10-15 days (may be weeks or months). Relapse occurs when merozoites from hypnozoites (resting form) in liver break out, reestablishing a red cell infection (clinical malaria).
• Diagnostic Laboratory Tests:
  - **Thick blood film**: stained with Giemsa’s stain, it concentrates the parasites & permits detection even of mild infections.
  - **Thin blood film**: stained with Giemsa’s stain is necessary for species differentiation.
  - **Antigen – capture tests** using chromatographic methods to detect a trophozoite-derived protein (rapid diagnostic test).

• Treatment:
  - Chloroquine: drug of choice for susceptible forms during the acute attack.
  - Primaquine: eliminates exoerythrocytic forms in the liver (potentially relapsing malaria), permitting radical cure.
*Plasmodium falciparum* ring forms, Giemsa stained thick (left) and thin (right) smears (1000X)
Cryptosporidium

- Cryptosporidium species, typically *C. parvum*, can infect the intestine in immunocompromised persons. *C. parvum* is a protozoal infection which causes an acute diarrhoea in immunocompromised patients. It has probably been an unrecognized cause of self-limited, mild gastroenteritis and diarrhea in humans.
- The parasites are minute (2-5 μm) intracellular spheres found in great numbers just under the outer membrane of the cells lining the stomach or intestine.
- It inhibits the brush border of mucosal epithelial cell of GIT, esp. surface of villi of lower small bowel. The prominent clinical feature is diarrhea (mild & self-limited, 1-2 weeks).
Diagnostic Laboratory Tests: detection of oocysts in fresh stools using a modified acid-fast stain.

Treatment: unnecessary. Spiramycin for immunosuppressed patients.

Cryptosporidium parvum
Acid-fast stain
(oocysts red; yeast and bacteria blue)
Toxoplasma gondii

- It is a coccidian protozoan of worldwide distribution that infects a wide range of animals and birds but does not appear to cause disease in them.
- The normal final hosts are strictly the cat and its relatives, the only host of which the oocyst-producing sexual stage of toxoplasma can develop.
- When oocysts are ingested, can either repeat its sexual cycle in a cat, or-if ingested by humans-can establish an infection in which it can reproduces asexually, where it opens and releases sporozoites in the duodenum then invade various cells esp. macrophages where they form trophozoites which spreads infection to lymph nodes and other organs.
It produces either congenital or postnatal toxoplasmosis. Congenital infection occurs in nonimmune mothers during pregnancy.

Diagrammatic illustration of a *Toxoplasma gondii* trophozoite in a macrophage
Helminths

- **The Nematodes**: (Round worms)
  - They are small round elongated worms, non-segmented, with a body cavity, have separate sexes, usually don’t need an intermediate host, and don’t multiply in the body because eggs don’t hatch unless they leave the body first.
  - They can parasitize either intermediate host (worms in the juvenile, larval, or developmental stages) or final / definitive host (worms occur in the adult or sexually reproductive stage).
  - Infection patterns vary widely. Human intestinal nematodes infect via food-borne, water-borne, and soil-borne routes.
Ascaris lumbricoides:

- Infect by eggs that are strongly resistant to desiccation & environmental conditions.
- Eggs are 75x40 µm, with a thick mamillated brownish shell.
- Freshly passed eggs in feces are not infective, they require 2-3 weeks to develop to be embryonated (contain larva).
Ascaris lumbricoides

Adult worms

Unfertilized egg

Egg containing a larva-infective if ingested

Fertilized Egg
Life Cycle
**Enterobius vermicularis (Pinworm)**

- Small nematode, a common parasite among children, it is unique in that eggs are viable shortly after being laid directly on the perianal skin. They can be accidentally ingested, or passed on fingers, clothing or fecal flecks to others.
- Itching around the anal or vaginal areas are the most common pinworm symptoms. Suspect a pinworm infection if the child shows night time itching in these areas.
Life Cycle Diagram of Pinworms

1. Eggs on perianal folds. Larvae inside the eggs mature within 4 to 6 hours.
2. Embryonated eggs ingested by human.
3. Larvae hatch in small intestine.
4. Adults in lumen of cecum.
5. Gravid female migrates to perianal region at night to lay eggs.

Symbols:
- *i* = Infective Stage
- *d* = Diagnostic Stage
Hookworms

*Ancylostoma duodenale & Necator Americanus*:

- Small nematode 1cm x 1mm, adult worms found in small intestine get hold by teeth resulting in hemorrhages.

- Eggs are oval 60x40 μm. They hatch in 48 hrs to give the rhabditiform larva. After 2 days it moults to filariform larva which is the infective stage that penetrates skin or mucus membrane.

Adult male and female worms of *A. duodenale*

Egg of *A. duodenale* in faecal smear
Cycle Diagram Life of Hookworms

1. Eggs in feces
2. Rhabditiform larva hatches
3. Filariform larva penetrates skin
4. Filariform larva penetrates skin
5. Adults in small intestine

= Infective Stage
= Diagnostic Stage
**Strongyloides stercoralis**

- Minute nematode in the small intestine. Eggs contain fully-developed larva which hatches as soon as laid.
- Rhabditiform larvae are passed in feces where they metamorphose in soil into filariform larvae (the infective stage-by piercing skin).

[Diagram showing the life cycle of Strongyloides stercoralis]
**Trichuris trichiura**

- Whip-worm, adults 3-7cm, live in caecum & colon of man.
- Eggs are barrel-shaped, 50x25 μm with a thick brown shell and a mucoid plug at each pole. They are passed in feces to complete development in soil as in Ascaris. This emryonated egg is the infective stage.
**Trichinella spiralis**

- Very small nematode about 3 mm x 40 µm, lives in small intestine of man, rat, and pig where fertilized female liberate hundred of larvae which circulate in blood stream to the heart, lungs and finally in the muscles where become encysted (Infective stage).

*spiralis Trichinella encysted larva*
Tissue Nematodes

- Adult worms are parasites of the lymphatic system or connective tissue. They are filiform or thread-like.
- Females lay larvae but not eggs.
- Larvae require an intermediate host to complete development resulting in production of the infective stage.
- Family Filariidae, members are:
  - *Wuchereria bancrofti*
  - *Loa loa* (eye worm)
  - *Onchocerca volvulus* (river blindness)
  - *Acanthocheilonema perstans*
• Members may be found in lymphatics, body cavities, subcutaneous tissue.
• Progenies are embryos which are not fully developed (microfilariae), these are between eggs & larvae.
• Microfilariae require an intermediate host which sucks them.
• **Elephantiasis:** True elephantiasis is the result of a parasitic infection caused by three specific kinds of round worms. The long, threadlike worms block the body's lymphatic system. This blockage causes fluids to collect in the tissues, which can lead to great swelling, called "lymphedema." Limbs can swell so enormously that they resemble an elephant's foreleg in size, texture, and colour.
Elephantiasis of the leg
**Dracunculus medinensis (Guinea worm):**

- All adult worms live in the subcutaneous tissue.
- Infection occurs by swallowing water fleas (Copepods) that ingested the larvae.
Onchocerca volvulus

Loa loa microfilaria

Dracunculus medinensis (Guinea worm)

Wuchereria bancrofti microfilaria

Onchocerca volvulus
Plathelminths (Flatworms):
- Flattened, leaf-like, hermaphrodite worms.
- Class Trematoda, Families: Fasciolidae, Heterophyidae, and Schistosomatidae (Bilharzidae).
- Class Cestoda

The Trematodes: (commonly called flukes).
Fertilization occur either cross between 2 worms or self-fertilization (hermaphroditic). All trematodes undergo a complex asexual reproductive phase – larval stages in a nail (their 1st intermediate host). Eggs are oval & operculated, passed to fresh water, develop, hatch, and release a ciliated, snail-seeking 1st larval form – the miracidium, which swims to find its snail host & develop to the final larval stage-the cercariae (infective stage). These swarm out to penetrate the 2nd intermediate host and may encyst as metacercariae (infective stage).
Fasciolidae

- Large-sized trematodes, in which the ventral sucker is near the anterior end.

- Liver Flukes:
  1. *Fasciola hepatica* (liver fluke) - Primarily, a parasite of sheep, humans become infected when they ingest encysted metacercariae that have encysted on watercress. The adult trematode lives in the intrahepatic bile ducts of the liver. “Fascioliasis” can lead to severe anaemia in humans.
  2. *Fasciola gigantica* the parasite of herbivores, causes “Tropical Fascioliasis”.
  3. *Clonorchis sinensis* causes *clonorchiasis* in humans; the Oriental liver fluke.
Intestinal Fluke, *Fasciolopsis buski*

- A common parasite of humans and pigs in South-east Asia.
- This parasite is one of the largest trematodes to infect man and lives in the upper intestine.
- Chronic infection leads to inflammation, ulceration and haemorrhage of the small intestine.

**Adult *Fasciolopsis buski***
• **Lung Fluke, *Paragonimus westermani***

Lung fluke infection can be a serious illness in humans, but it is not transmitted from person-to-person. Symptoms of lung fluke infection can include cough, difficulty breathing, diarrhea, abdominal pain, fever and hives. The parasite, can migrate from the lungs to other organs, and infection can last for years.

• **Fish Fluke, *Heterophyes heterophyes***

Minute intestinal fluke (trematode), hermaphrpdite, remain in the small intestine. Infection occurs by ingestion of the infected fish with the encysted metacercariae-the infective stage.
Schistosomatidae (Bilharzidae).

- *Schistosoma* spp., commonly known as **blood-flukes** and **bilharzia**, cause the most significant infection of humans by **flatworms** (*schistosomiasis*) and are considered by the **World Health Organization** as second in importance only to **malaria**, with hundreds of millions infected worldwide.
- Adult worms parasitize **mesenteric blood vessels**.
- Eggs (140x60 \(\mu\)m) are passed through **urine** (causing terminal haematoria) or **feces** (blood & mucus-dysentery) to **fresh water**, where larval stages (Cercariae) can infect a new host by penetrating the skin.
There are four species of schistosome which are infective to humans:

1- *S. haematobium*, commonly referred to as the *bladder fluke*, originally found in Africa, and the Mediterranean basin. Freshwater snails of the *Bulinus truncatus* are an important host for this parasite. It has round eggs with *terminal* spine.

2- *Schistosoma mansoni*, found in Africa, Brazil, Venezuela. It is also known as *Manson's blood fluke* or *swamp fever*. Freshwater snails of the *Biomphalaria alexandrina* are an important host for this trematode. It has elongated, yellowish eggs with prominent *lateral* spine.
3- **S. japonicum** whose common name is simply *blood fluke* is found widely spread in **Eastern Asia** and the southwestern **Pacific** region. In **Taiwan** this species only affects animals, not humans. Freshwater snails of the **Oncomelania** genus are an important host for *S. japonicum*. Egg has small curved *rudimentary spine*

4- **S. mekongi** is related to *S. japonicum* and affects both superior and inferior mesenteric veins. *S. mekongi* differs in that it has smaller eggs, a different intermediate host, and longer prepatent period in the mammalian host.
Schistosoma mansoni egg

Schistosoma haematobium egg

Schistosoma japonicum egg
Cestoda (Tapeworms)

- General characteristics of Cestodes (tapeworms):
  Flat, ribbon-like chain of segments with no mouth or digestive tract, adult worms are hermaphroditic, have complex life cycle. Humans acquire infection by eating infected flesh.

- Three groups infect humans:
  1. Taenia
  2. Hymenolepis
  3. *Diphyllobothrium latum*
• *Taenia saginata* (beef tapeworm):
  
  - Worldwide, acquired by ingestion of contaminated, uncooked beef (cysticercus), a common infection but causes minimal symptoms.
  - It is about 6 to 7 millimetres in width. The adult *T. saginata* usually grows to be about 4 to 8 meters in length, with about 1000 segments called proglottids.
- **Taenia solium** (Pork Tapeworm):
  - It is very morphologically similar to the *T. saginata*, *T. solium* is slightly shorter and have a modified scolex. The adult tape worm grows to be about 6mm in width and 2-7 m in length with about 800 segments called proglottids.
  - Cysticercosis is the presence of larval stage of *T. solium* (*Cysticercus cellulosae*) in human tissue. It is a systemic disease where cysticerci encyst in muscles and in the brain – may lead to epilepsy.
**Echinococcus granulosus**, also called the Hydatid worm,
- Is a **cyclophyllid cestode** that parasitizes the **small intestine** of carnivores as an adult, but which has important **intermediate hosts** such as **livestock** and humans, where it causes **hydatid disease**. The adult **tapeworm** is about 5 **mm** long and has three **proglottids** ("segments") when intact.
- In humans, cysts containing the larvae develop after ingestion of eggs. Cysts form primarily in the lungs and liver (Hydatid Cyst).
Hymenolepididae

- *Hymelolepis nana*:
  It is the smallest & commonest tape worm found in small intestine of humans. Infection is direct by swallowing eggs. No intermediate host is required.

- *Hymenolepis diminuta*:
  A cestode of rodents, occasionally infects small children, who ingest the larvae in uncooked cereal foods contaminated by fleas and other insects (2nd intermediate host) in which larvae develop. Infection is usually asymptomatic and is diagnosed by the detection of eggs in the stool.
Diphyllobothrium latum

- *Diphyllobothrium latum*, known as the **broad** or **fish tapeworm**, or **broad fish tapeworm**. *D. latum* is the **longest tapeworm** in humans, averaging ten meters long by 2 cm in width. Adults can shed up to a million eggs a day. *D. latum* is a pseudophyllid **cestode** that infects **fish**-the 2nd intermediate host (by eating the cyclops or copepod-a water flea, the 1st intermediate host) and **mammals**.

![Image of D. latum proglottids](image_url)

Proglottids of *D. latum*