The image is a microscopic view of tissue, likely stained with hematoxylin and eosin (H&E). The background is a dense field of cells with various shades of purple and pink. The text "Human African Trypanosomiasis" is overlaid in the center in a white, serif font. The text is arranged in two lines: "Human African" on the top line and "Trypanosomiasis" on the bottom line. The background shows a complex cellular structure with many small, dark purple spots and larger, lighter purple areas, suggesting a high magnification of a tissue section.

# Human African Trypanosomiasis

Human African Trypanosomiasis (HAT)  
is commonly known as sleeping sickness



HAT proceeds rapidly from  
lethargy through coma to death



HAT is caused by a parasitic protozoan



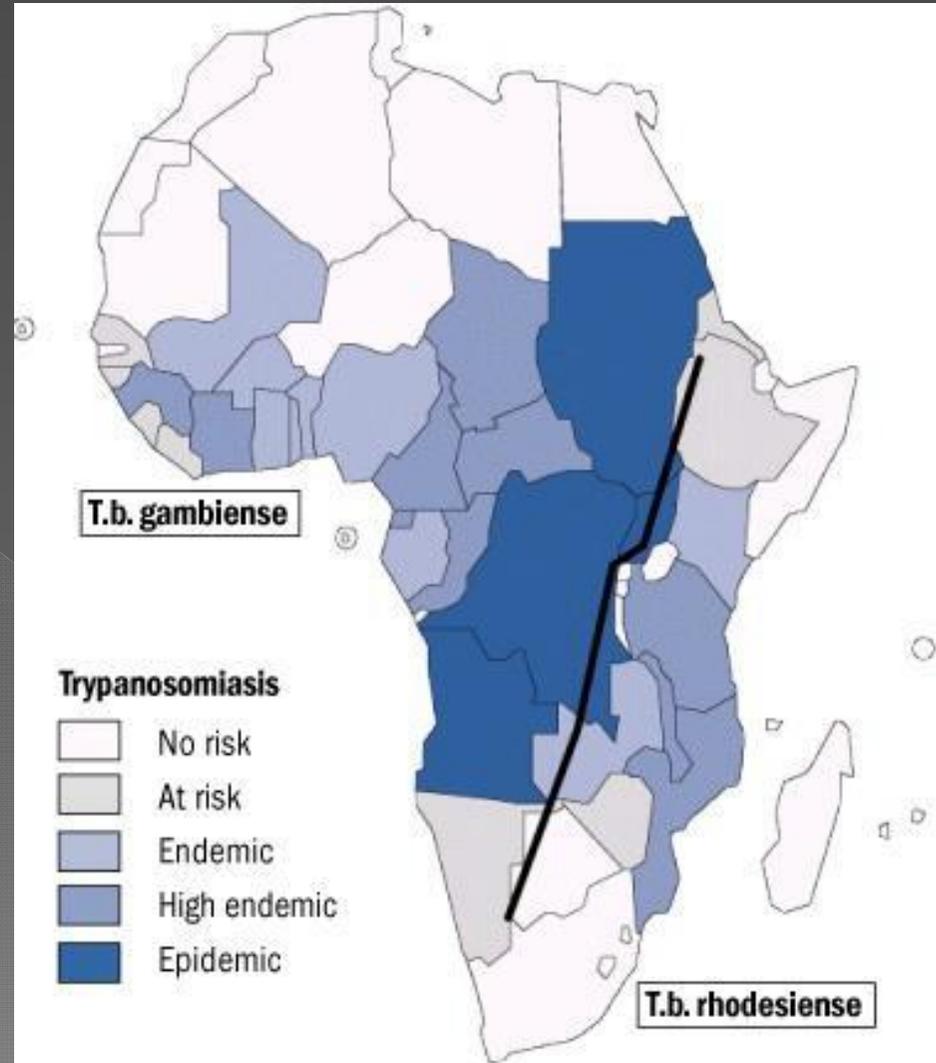
HAT is spread by the tsetse fly  
or through contaminated blood



# There are two Types of HAT

- *Trypanosoma brucei rhodesiense*
- *Trypanosoma brucei gambiense*
- Acute -- can cause death in weeks or months
- Chronic --lasts years

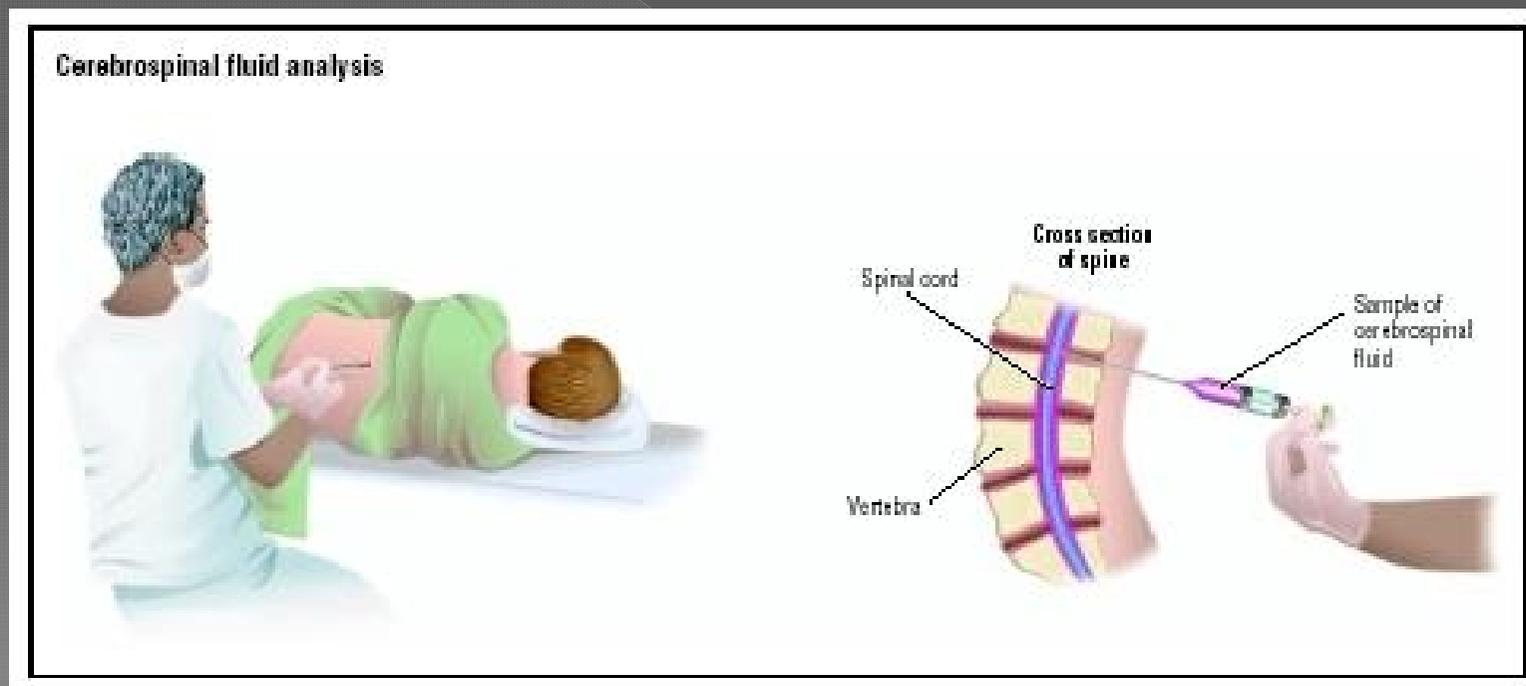
The two types of HAT affect different parts of Africa



100% **Fatal** if left untreated  
cardiac failure or from the infection itself

# Cerebrospinal Fluid Tests can also be used.

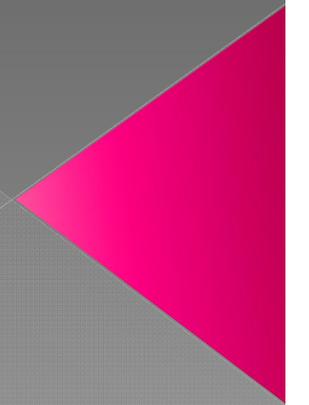
- Look for presence of trypanosomes
- High levels of CSP protein and WBCs

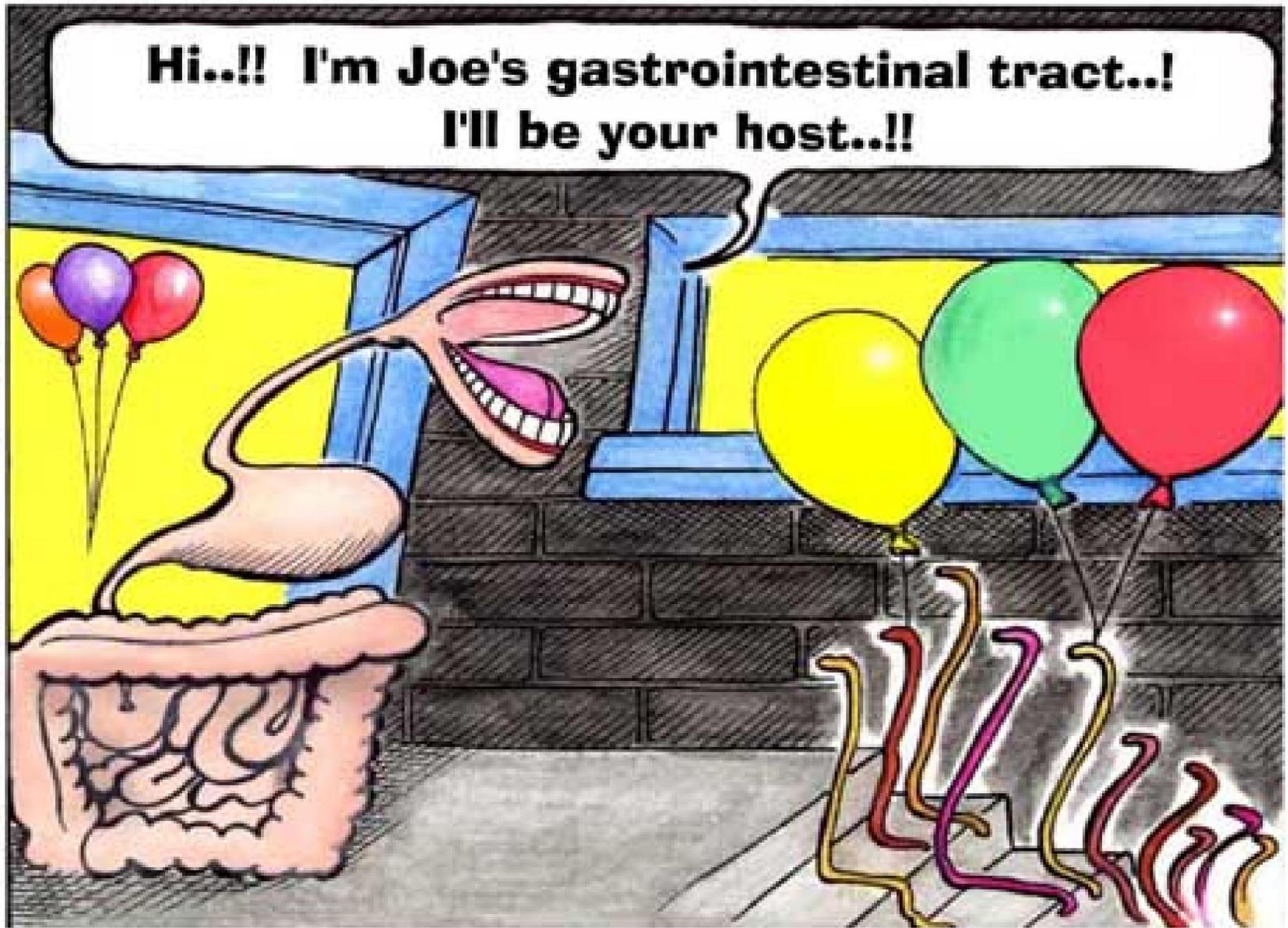


# Complete Blood Count (CBC) are another test used.

- Look for high levels of immunoglobulin protein M
- Anemia
- High levels of White blood cells

# Cestodes





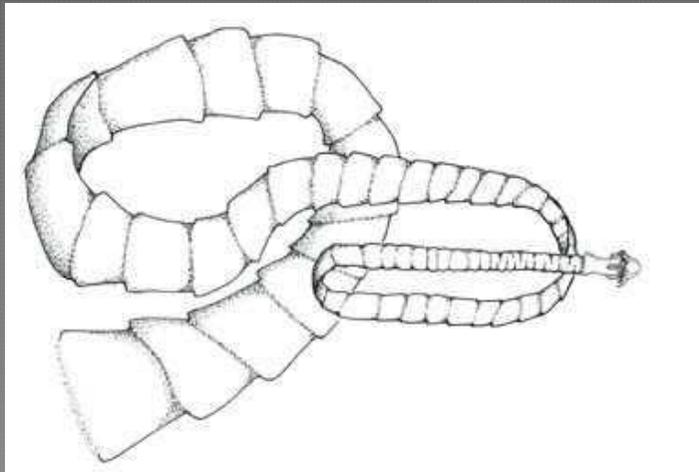
## Great Tapeworm Parties

# Cestodes (Tape Worms)

- *Taenia solium* (pork tapeworm) - Cysticercus
- *Taenia saginata* (beef tapeworm)
- *Diphyllobothrium latum* (fish tapeworm)
- *Echinococcus granulosus* (unilocular hydatid)
- *Echinococcus multilocularis* (alveolar hydatid)
- *Hymenolepis nana* (dwarf tapeworm)
- *Hymenolepis diminuta*
- *Dipylidium caninum*

# General Structure of Tapeworm

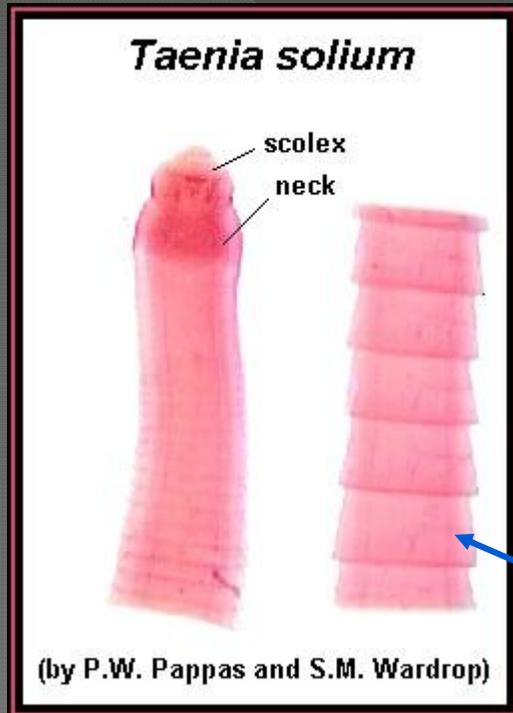
- Head region (scolex) : contains suckers and hooks used to attach to a host organism.
- *Proglottids* : square body segments used for reproduction.



# Tapeworm Structure

- Scolex - Attachment organ
- Zone of Proliferation - Undifferentiated area behind the scolex (neck region)
- Strobilia - Chain of **segments (proglottids)**
  - Immature proglottids - developing reproductive
  - Mature proglottids: mature reproductive organs.
  - Gravid proglottids: contain eggs in the uterus.

# Immature Segment



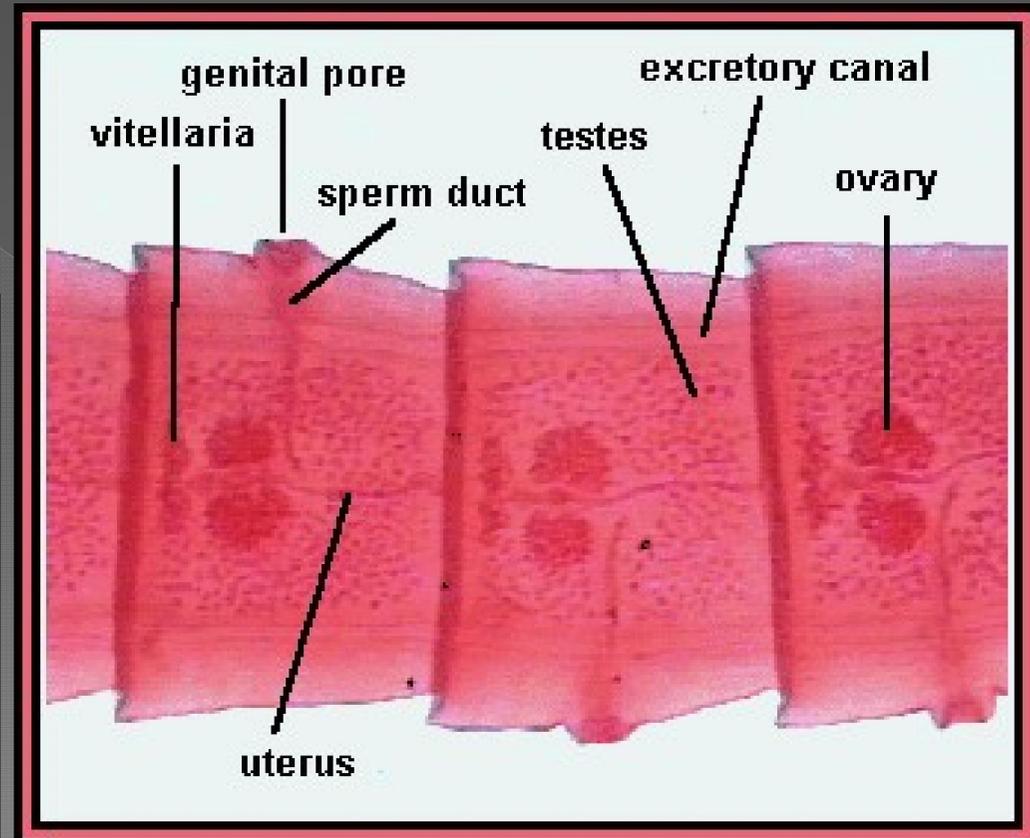
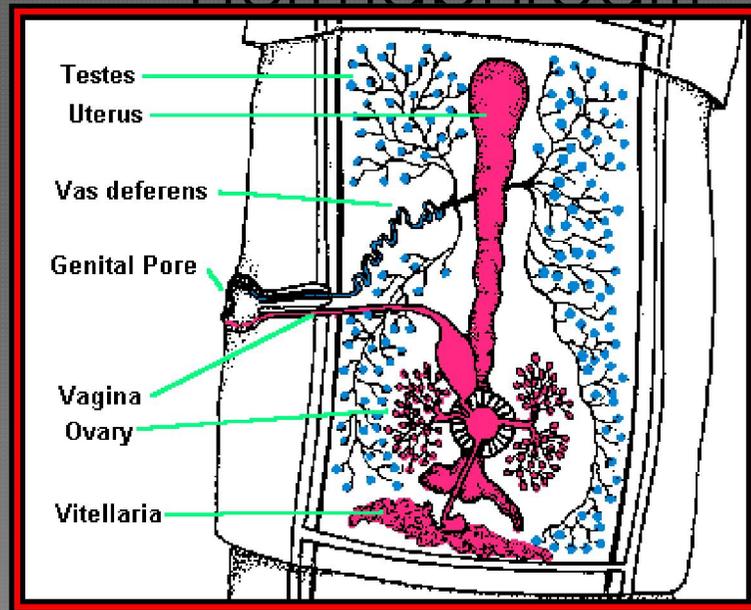
**note that the reproductive organs are just beginning to differentiate.**

○ (Carmines stained)

Developing reproductive organs

# Mature Segments (Proglottids)

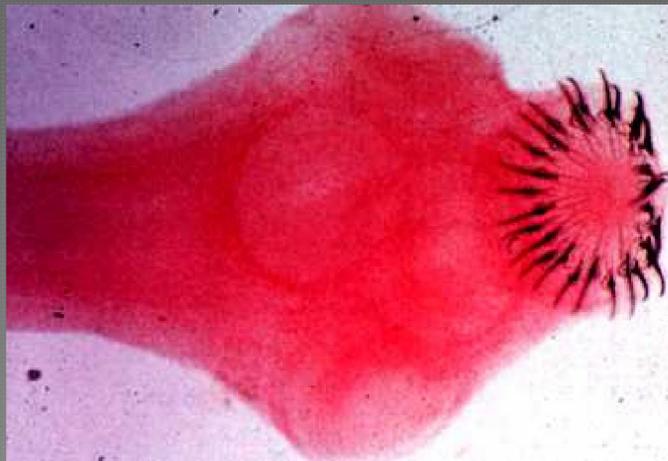
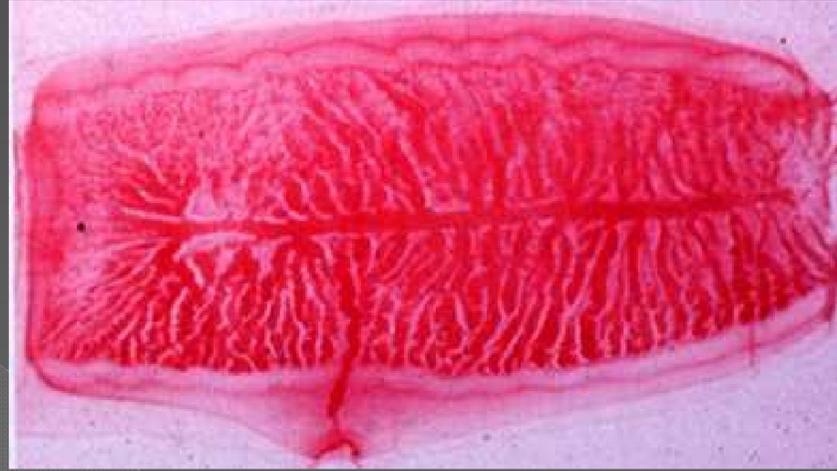
Tapeworms  
are  
Hermaphroditi



# Taeniasis: Geographic Distribution

- Worldwide, depending on dietary habits, and quality of cattle and pork farming.

# *Taenia saginata* and *T. solium*: Scolex And Proglottids



# *Taenia solium* (Pork Tapeworm) Morphology

Adult Worm:  
2-4 m long,  
700-1000  
segments:  
Scolex  
Neck  
Immature  
segment  
Mature  
segment  
Gravid  
segment



# Taenia eggs

**The eggs of *Taenia saginata* and *T. Solium* are morphologically indistinguishable.**

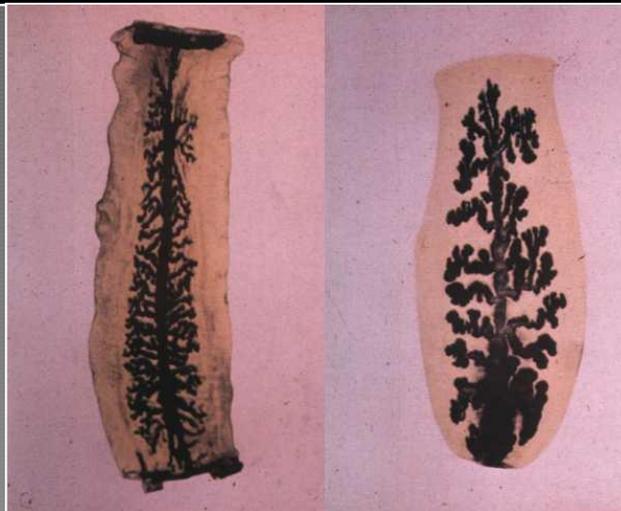


# Taeniasis: Diagnosis

## Symptoms

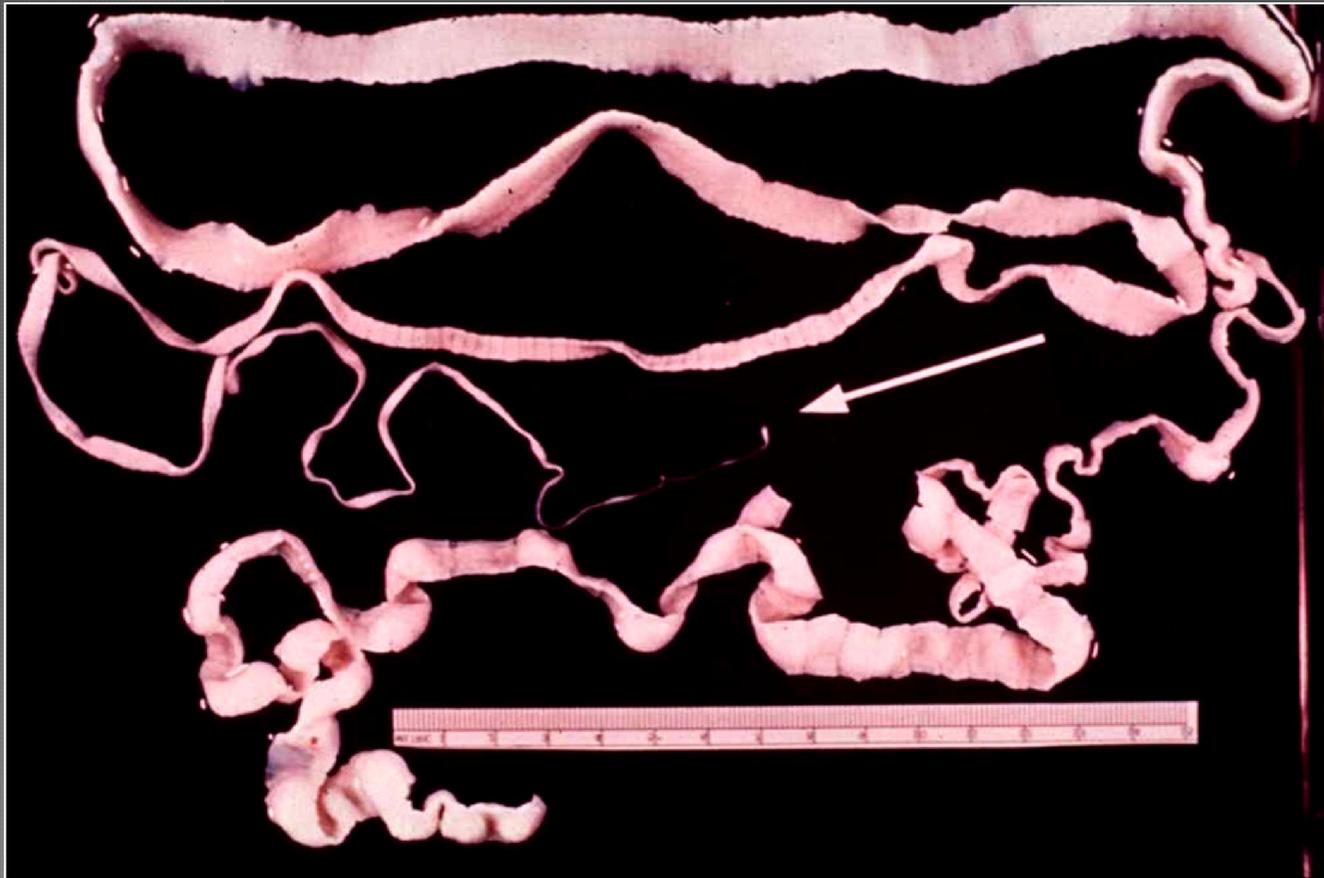
History of eating  
undercooked beef or  
pork

Recovery of proglottids  
and/or eggs in the stool



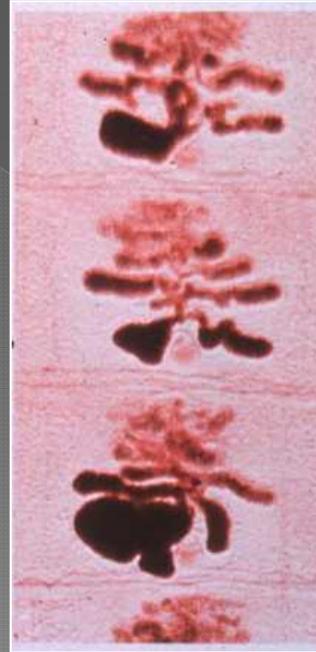
# Fish Tapeworm

## *Diphyllobothrium latum*



Distributed worldwide: freshwater (great lakes)

# *Diphyllobothrium latum*: Morphology



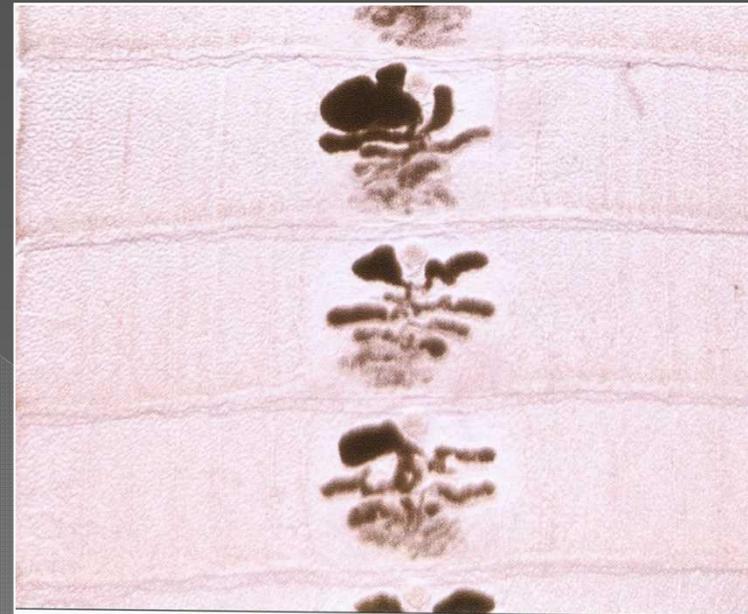
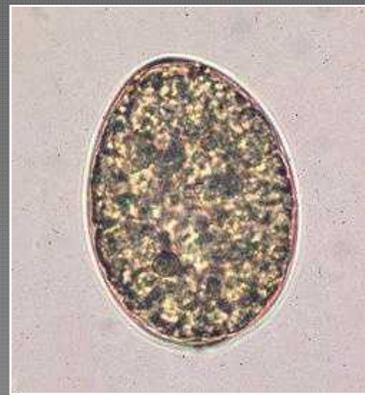
1 cm



0 25 50 75

# Diphyllobothriasis: Diagnosis

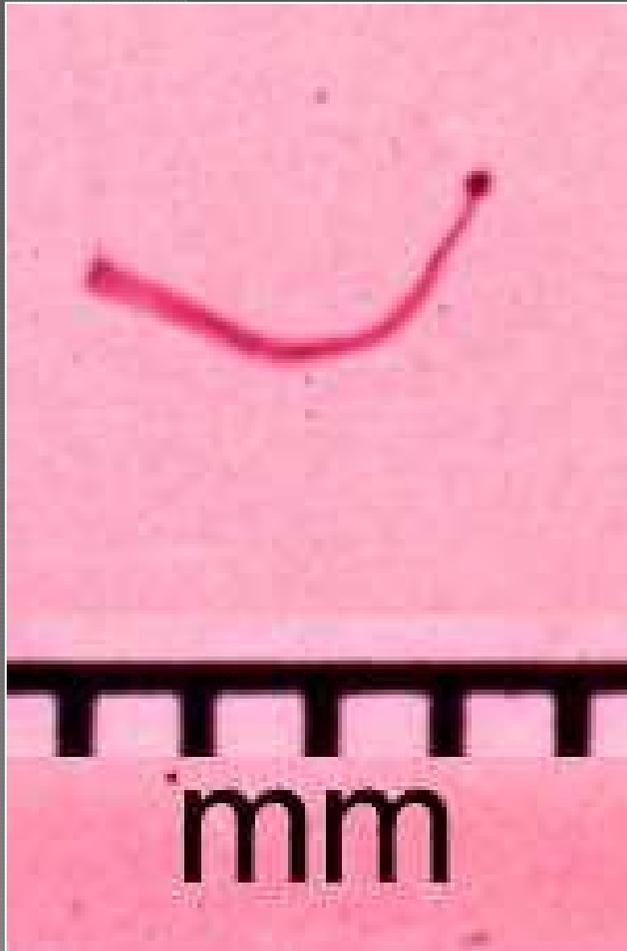
- symptoms
- history of eating raw fish
- recovery of proglottids and/or eggs in the stool



# Diphyllobothriasis: Treatment

-  Praziquantel is the drug of choice
-  Avoid uncooked fish from infested waters
-  Freezing for 24 hours and pickling kills the tape

# *Hymenolepis nana* (Dwarf Tape Worm) Morphology



*Hymenolepis nana* (Dwarf  
Worm)  
Symptoms

- Lighter infections: mild abdominal disturbance
- Heavier infections: enteritis

# *Hymenolepis nana* (Dwarf Worm) Diagnosis, Treatment And Control

Diagnosis  
rodent infestation  
ova in the feces

Treatment and  
Control  
Praziquantel is the  
drug of choice  
rodent population  
control



# Blood and Tissue Protozoa



# Leishmaniasis

- focal distribution throughout world, especially tropics and subtropics
  - new world: southern Texas to northern Argentina
  - old world: Asia, Africa, middle east, Mediterranean
- transmitted by sand flies
  - new world: *Lutzomyia*
  - old world: *Phlebotomus*
- parasite replicates within macrophages of vertebrate host
- a variety of disease manifestations

# Clinical Spectrum of Leishmaniasis

## Cutaneous Leishmaniasis (CL)

most common form, relatively benign self-healing skin lesions (aka, localized or simple CL)

## Mucocutaneous Leishmaniasis (MCL)

simple skin lesions that metastasize to mucosae (especially nose and mouth region)

## Visceral Leishmaniasis (VL)

generalized infection of the reticuloendothelial system, high mortality



# Diagnosis

- geographical presence of parasite
- demonstration of parasite in skin lesion or bone marrow
- delayed hypersensitivity skin test (cutaneous forms)
- serological tests (visceral disease)

# Treatment

- pentavalent antimonials
- amphotericin B (less toxic, expensive)
- miltefosine (phase IV, no hospitalization)

# MALARIA

- causative agent = *Plasmodium* species
  - 4 human *Plasmodium* species
- 40% of the world's population lives in endemic areas
  - primarily tropical and sub-tropical
- 3-500 million clinical cases per year
- 1.5-2.7 million deaths (90% Africa)
- increasing problem (re-emerging disease)
  - resurgence in some areas
  - drug resistance (↑ mortality)

*P. falciparum*  
*P. vivax*  
*P. ovale*  
*P. malariae*



1 mm long nematode

<http://www.ucmp.berkeley.edu/phyla/ecdysozoa/nematoda.html>

# Phylum Nematoda

- The nematodes are quite species diverse (about 15,000 species although this is probably a huge underestimate) and the many parasitic forms have a significant impact on humans.
- Most nematodes are under 5cm and many are microscopic. However, some parasitic forms can be over a meter in length.

# Phylum Nematoda

- Nematodes use their pseudocoelom as a hydrostatic skeleton.
- A pseudocoelom is a fluid-filled body cavity in which mesoderm lines only the outer edge of the developing blastocoel. No peritoneal lining develops.
- The body has a thick cuticle (made primarily of collagen) secreted by the underlying epidermis, which resists the high hydrostatic pressure exerted by the fluid in the pseudocoelom.



R. Gaugler, DEEZ, Rutgers U

Free-living nematode

<http://kentsimmons.uwinnipeg.ca/16cm05/16labman05/lb5pg8.htm>

# Free-living nematodes

- Most free-living nematodes are carnivorous.
- However, some feed on algae and fungi and some are detritivores. Others feed on plants, especially the roots.

# Free-living nematodes

- Many root feeding nematodes are major agricultural pests. These species pierce root cells and suck out their contents.
- Nematodes are estimated to destroy 12% of the world's cash crops annually.

# Parasitic nematodes

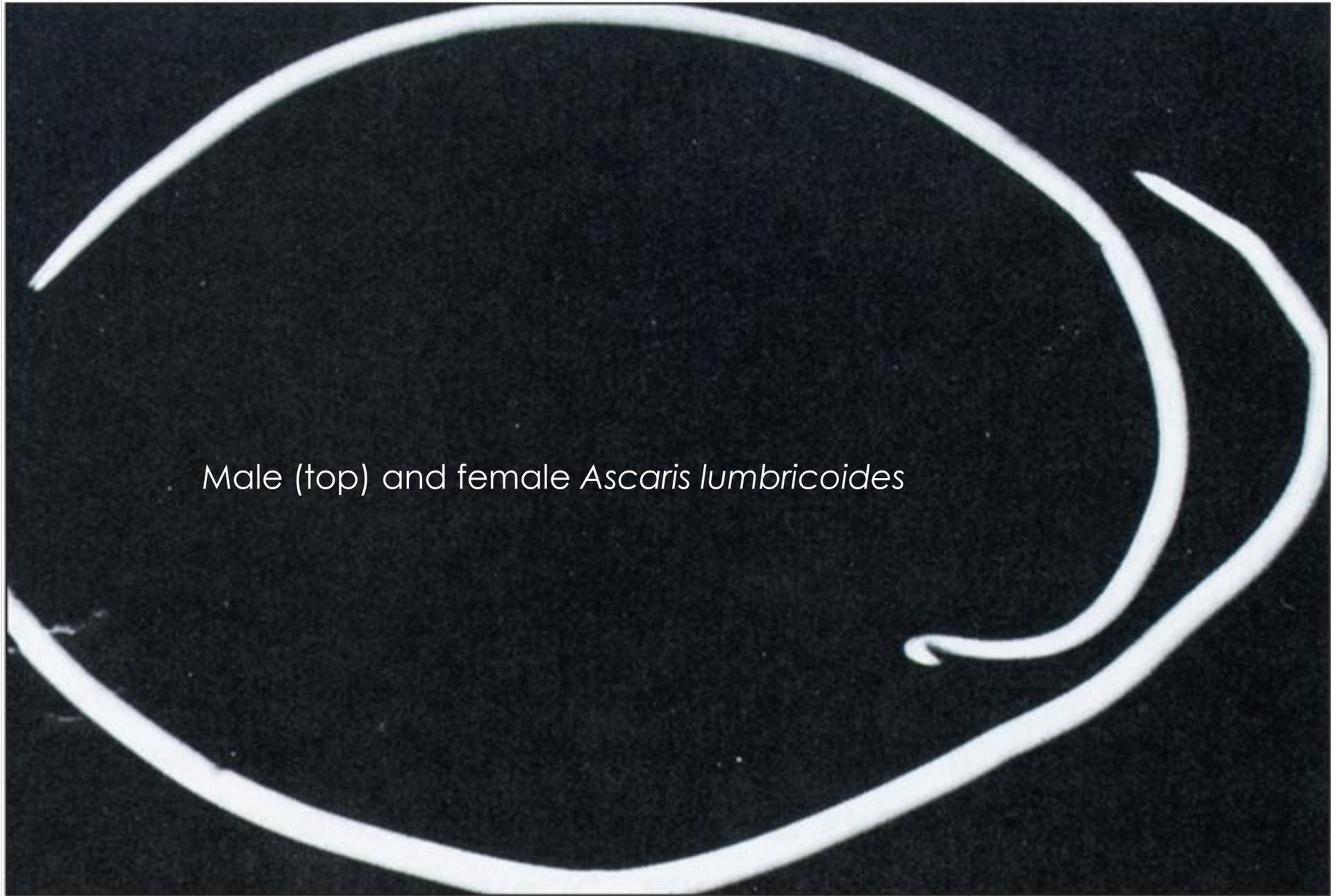
- There are a great many species of parasitic nematodes and they attack virtually all groups of animals and plants.

# Ascaris lumbricoides: large roundworm of humans

- It's estimated that worldwide as many as 1.4 billion people are infected with *Ascaris lumbricoides* which lives in the small intestine.
- Females may be a foot long and produce 200,000 eggs a day.
- Infection occurs when parasite eggs are eaten with uncooked food or when soiled fingers are put into the mouth.

# Ascaris lumbricoides: large roundworm of humans

- In the intestines the worms cause abdominal symptoms and allergic reactions and may produce an intestinal blockage.



Male (top) and female *Ascaris lumbricoides*

# Hookworms

- Hookworms are named for the dorsal curve in their anterior end.
- Hookworms are quite small, the commonest species *Necator americanus* is only 11mm long. However, because they feed on blood a heavy infection can produce severe anemia.



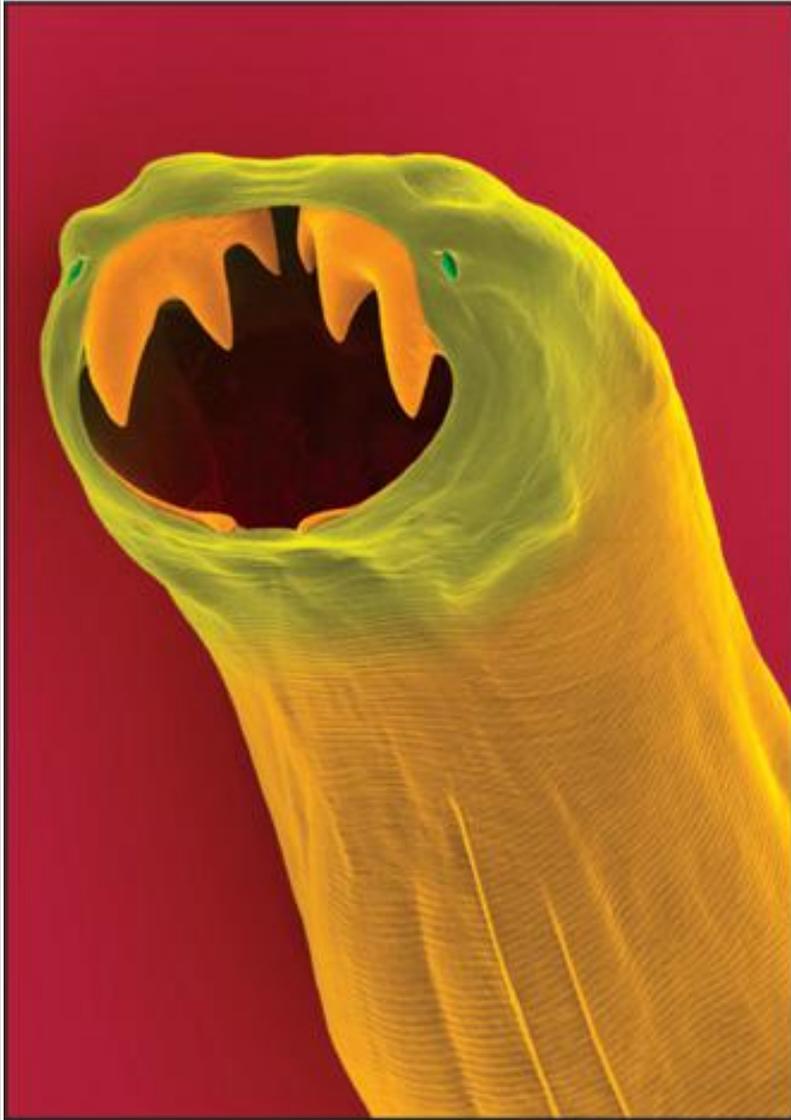
<http://www.virginmedia.com/images/hookworm.jpg>

# Hookworms

- Large plates in the hookworm's mouth are used to cut the intestinal lining of the host.
- The parasite then pumps blood through its gut, partially digesting it before excreting it.
- Because hookworms suck more blood than they use, they can cause debilitating anemia. In children a hookworm infection can stunt growth and cause a general lack of energy.

Figure 15.06

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**A**

Plates



**B** Section through hookworm attached to dog intestine

# Hookworms

- Hookworms do not permanently attach in one spot, but move around the gut and reattach when they are ready to feed.
- Hookworms have evolved sophisticated anti-clotting factors that keep platelets from clumping and forming a clot while the hookworm is feeding.

# Filarial worms

- Filarial worms are thread-like nematodes of which there are at least 8 species for which humans, especially in tropical regions, are the definitive host.
- Approximately 250 million people worldwide are infected with these worms which are spread by mosquitoes.
- Different species inhabit different locations in the body. Some live in the lymphatic system, others subcutaneously and others in the abdominal cavity.

# Filarial worms

- ◉ Females can be 10cm long and they release live young microfilariae into the blood and lymphatic system.
- ◉ The microfilariae are picked up by mosquitoes where they develop, become infective and can infect another person.

# Filarial worms

- In some people exposed to persistent infections with filarial parasites that live in the lymphatic system, **elephantiasis** may develop.
- This is caused by blockage of lymphatic ducts and inflammation. There may be excessive growth of connective tissue and enormous swelling of infected parts including legs, arms and scrotum.

Figure 15.11

Elephantiasis of leg  
caused by filarial worms



Figure 15.12

*Dirofilaria immitis*  
Dog heartworm



# River blindness

- River blindness is also caused by filarial worms that live subcutaneously.
- In this case the insect that transmits the disease is a blackfly.
- 18- 30 million people are infected worldwide (mainly central Africa and parts of South America) and more than 300,000 have been made blind.

# Trichina worms



[http://en.wikipedia.org/wiki/File:Trichinella\\_larv1\\_DPDx.JPG](http://en.wikipedia.org/wiki/File:Trichinella_larv1_DPDx.JPG)

- *Trichinella spiralis* is a tiny nematode that causes the potentially fatal disease trichinosis.
- Humans typically become infected by eating undercooked pork. *Trichinella* lives in cysts formed in individual muscle cells of the host.

# Trichina worms

- Trichinella when it hatches from an ingested cyst in its host's gut drills through the wall of the gut where females produce living young.
- These juveniles travels in the circulatory system to a muscle.
- The juvenile penetrates an individual muscle cell and breaks the cell down so it can be remade.

# Trichina worms

- Trichinella, just as a virus does, manipulates the host cell's DNA. It causes the cell to recruit a blood supply to supply food to the cell and also produce collagen to form a cyst around the cell.
- The Trichinella juvenile awaits ingestion by another host. When ingested it emerges from its cysts enters the mucosal lining of gut, develops into an adult and continues the life cycle.

# Trematodes

# Trematodes (Flukes)

- ◉ *Schistosoma*

- *S. mansoni*
- *S. hematobium*
- *S. japonicum*

- ◉ *Fasciolopsis buski*

- ◉ *Fasciola hepatica*

- ◉ *Opisthorchis*

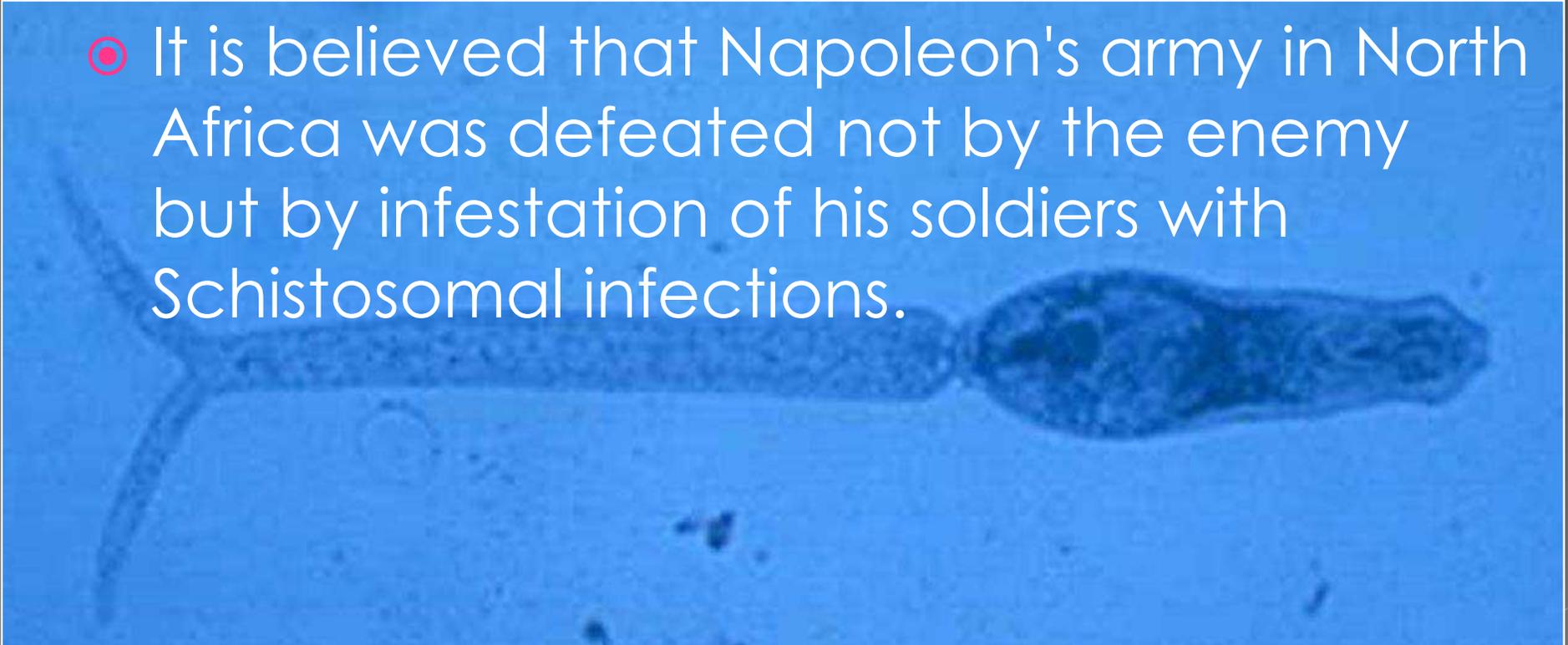
- *O. sinensis*
- *O. felineus*
- *O. viverrini*

- ◉ *Paragonimus*

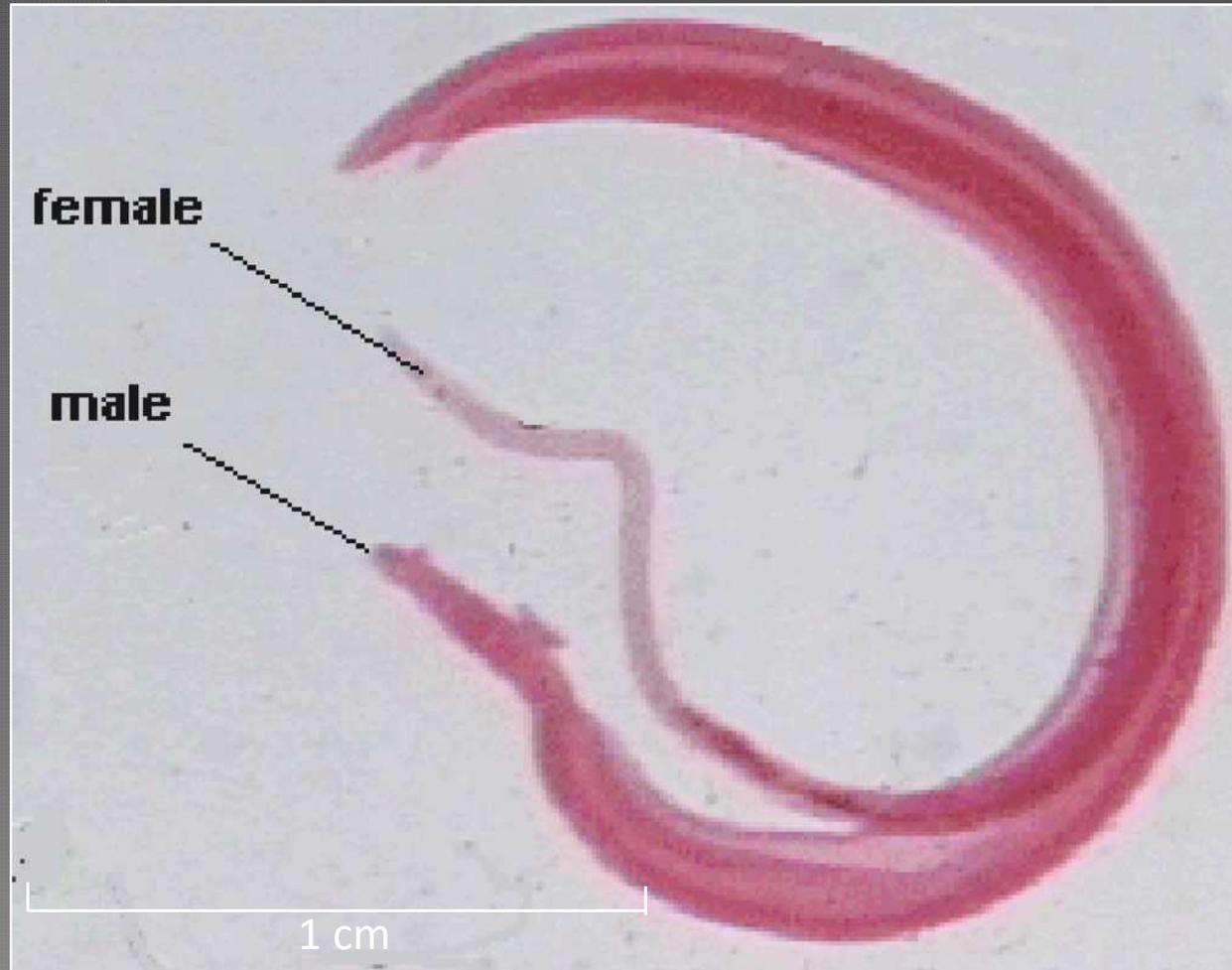
- *P. westermani*
- *P. kellicotti*

# Schistosomiasis

- It is believed that Napoleon's army in North Africa was defeated not by the enemy but by infestation of his soldiers with Schistosomal infections.



# The Schistosome



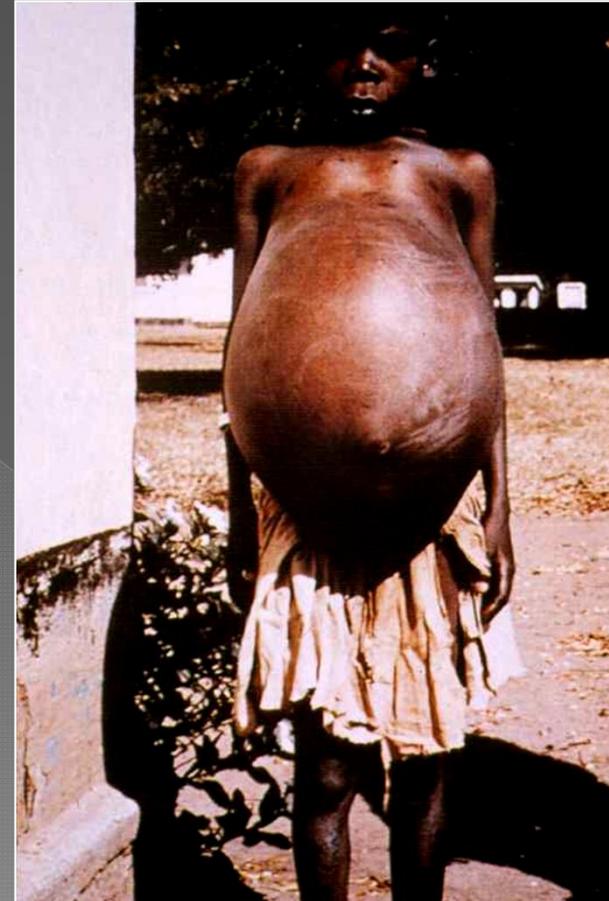
# Schistosomiasis: Symptoms

Site	Symptoms	Pathogenesis
Skin	Dermatitis (swimmers' itch)	parasitic toxic material, skin damage
GI	abdominal pain, ascites, diarrhea, bloody stool ( <i>mansoni</i> & <i>japonicum</i> )	inflammatory response to eggs (mucosal fibrosis)
Urogenital	chronic cystitis and urethritis	granulomatous fibrosis due to egg-deposits

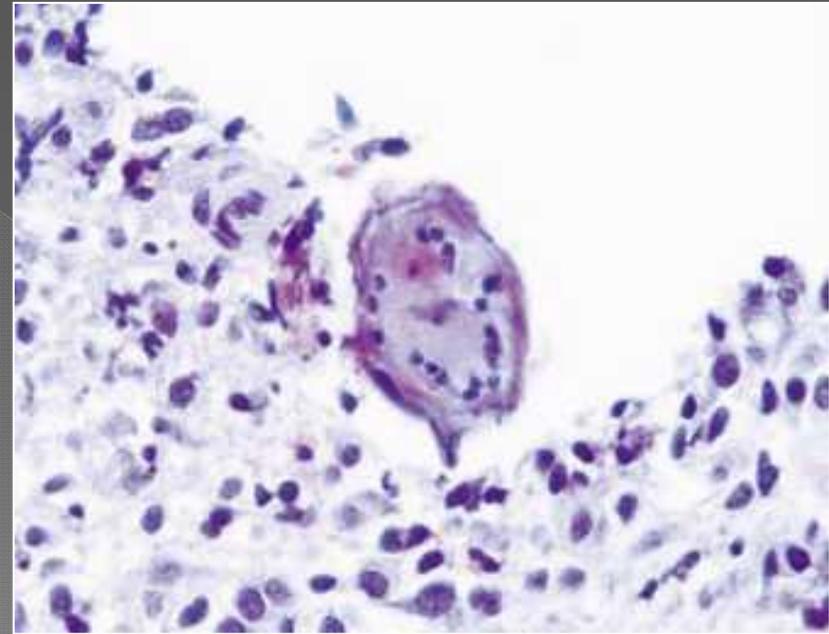
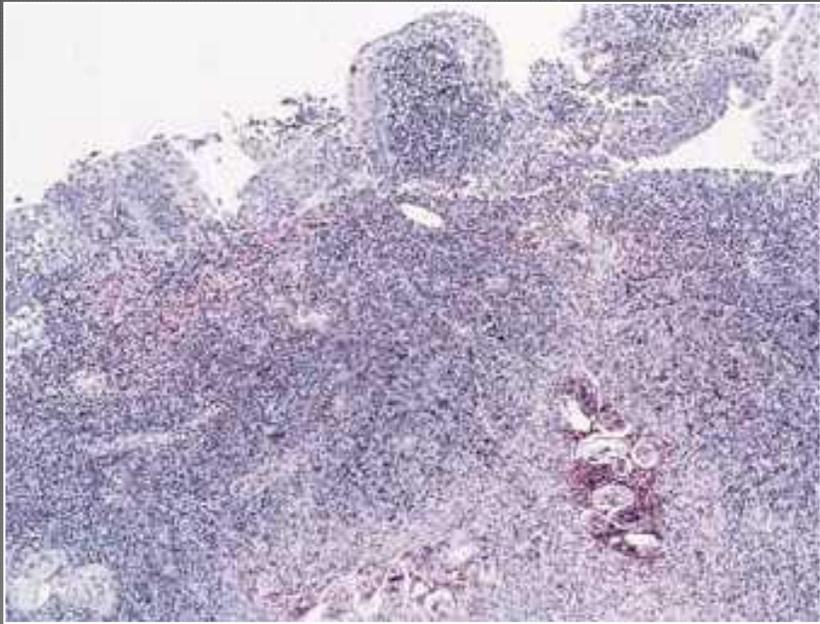
# Schistosomiasis: Symptoms



**Cercarial Dermatitis**



# Schistosomiasis: Histologic Appearance



# Schistosomiasis: Diagnosis

- History
- Symptoms
- Histology
- Eggs in the urine or stool

*S. Hematobium*  
Terminal Spine



*S. Mansoni*  
Lateral Spine



*S. Japonicum*  
Smaller egg  
Minute Spine



50  $\mu$ m

*Fasciolopsis buski*:  
Morphology



# *Fasciola hepatica* : Symptoms

- Upper quadrant tenderness and pain
- Chills and fever
- Eosinophilia
- Hepatitis
- Hyperplasia and blockage of bile duct

# *Fasciola hepatica* : Diagnosis

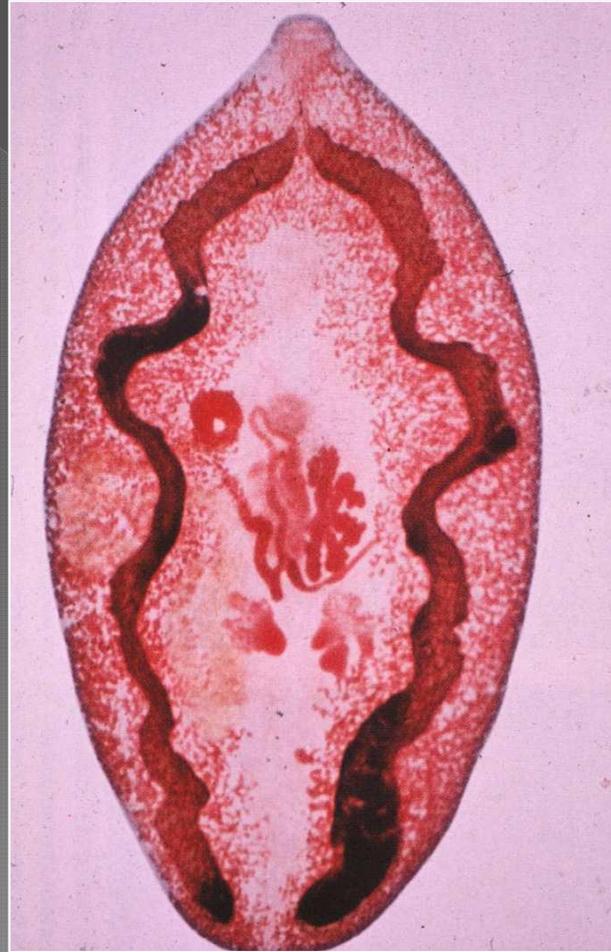
- Symptoms
- History of eating uncooked watercress from infested locale
- Eggs in stool



# *Fasciola hepatica*: Treatment and Control

- This species of fluke is **Praziquantel resistant**
- Triclabendazole is effective
- Avoid eating uncooked watercress in endemic areas
- Elimination of snails

# *Paragonimus westermani*: Morphology



5 mm

# *Paragonimus westermani:* Symptoms

- Dry cough, pleurisy
- Pulmonary pain
- Blood-stained rusty brown sputum
- Fluke may migrate to brain, produce eggs and cause epilepsy-like symptoms

# *Paragonimus westermani*: Diagnosis

- Symptoms
- History of eating improperly cooked crab-meat in endemic areas
- Eggs in the sputum

