

The Worms of Humans: Intestinal Nematodes

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Lecture Overview

1. General Facts about Intestinal Nematodes
2. 4 major intestinal nematodes: *Ascaris*, *Trichuris*, hookworm and *Strongyloides*
 - Public Health Implications
 - Lifecycle
 - Clinical presentation
 - Treatment
3. Trends in Intestinal Parasitism among Refugees



Introduction: Context & Environment

- Natural disasters introduce new infectious risks & re-introduce old ones.





Haiti's worst natural disaster



- January 12, 2010 is a day that will always be remembered.
- Conditions remain hazardous, with extensive damage to buildings, roads, sanitation systems, and other infrastructure.



Purpose

- To provide guidance for health care providers:
 - Understand how natural disasters affect the types of infections present –
 - Here specifically the type of intestinal worm infections encountered
 - Learn to recognize, diagnose, and treat these infections
 - Understand how to reduce their incidence
 - Improve morbidity & mortality





Parasitic Helminths

- Trematodes (flukes)
 - Venous system: *Schistosoma*
 - Biliary tract: *Clonorchis*, *Fasciola*
 - Lung: *Paragonimus*
- Cestodes (tapeworms)
 - *Taenia saginata*, *Taenia solium*, *H. nana*
- Nematodes (roundworm)
 - Intestinal
 - Blood, lymphatic, subcutaneous



Nematode subtypes in humans:

- *Ascaris lumbricoides* (roundworm),
- *Ancylostoma duodenale* (hookworm),
- *Necator americanus* (hookworm), and
- *Trichuris trichiura* (whipworm)
- *Enterobius vermicularis* (pinworm) and
- parasites of the genus *Schistosoma*



Then

- Pre and Post Environmental Disaster – changes in nematode types

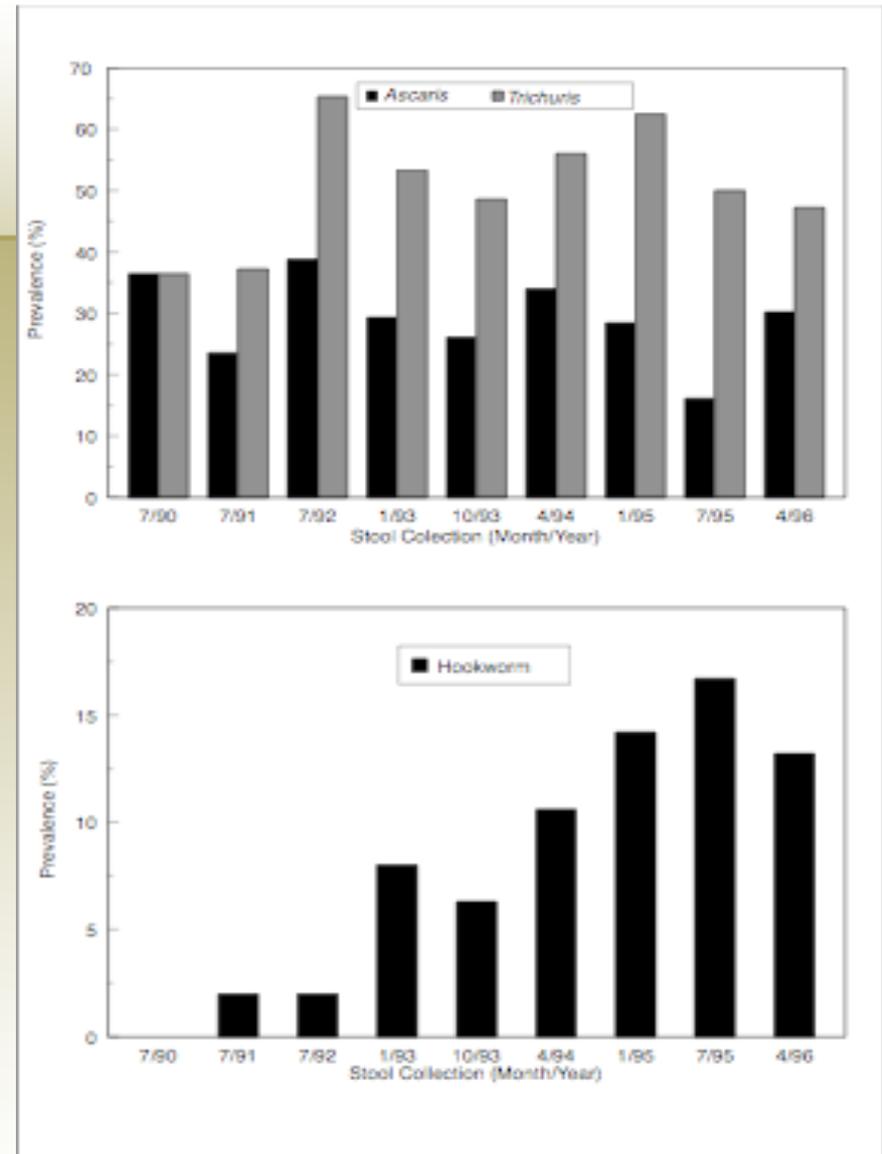


Figure. Upper panel: The prevalence of *Ascaris* (solid bars) and *Trichuris* (hatched bars) for each of the indicated stool collection periods. Lower panel: The prevalence of hookworm infection for the same collection periods. A total of 881 stools were examined after Formalin-ethyl acetate concentration (mean 98 per collection period, range 33-174).



And Now

- Still highly linked to poor sanitation & living conditions





Water & Sewage





Challenges to attaining & maintaining potable water -





Given the impressive challenge pictured....





Let's 1st Learn Some General Facts about Intestinal Nematodes

- Frequently nonspecific symptoms
 - Often asymptomatic until worm burden becomes large
 - Weight loss, GI discomfort
 - Diarrhea or fever from nematodes is uncommon
- Polyparasitism
- Burden is greatest in children



General Facts about Intestinal Nematodes

- Tropical and subtropical predominance
- Don't multiply in host
 - 2 exceptions
- Infection limited to life span of worm unless reinfection occurs
 - Lifespan: 2 months – 5 years
 - Rare Exceptions:
 - *Strongyloides*, *C. philippinensis*: autoinfection
 - Pinworm: self-reinfection



Soil Transmitted Helminths (STH) = Geohelminths

- Part of development occurs in the soil
- Average 3 – 4 weeks in soil until infective
- Infection via eggs in contaminated soil (*Ascaris*, *Trichuris*) or skin penetration (hookworm)





Soil Transmitted Helminths (STH)

- Infection rates and burden of disease greatest among conditions of poverty, poor sanitation





Epidemiology

- Helminths are widespread
- Prevalence highest in tropical, developing countries.
- In 2002, an estimated 1.5 billion, 1.3 billion, and 1.1 billion people were infected with *Ascaris*, hookworm, and *Trichuris*, respectively.
- Risk in travelers is low.
- Sporadic exposure less likely to produce symptomatic disease.
- Because eggs must pass through a developmental phase in soil before becoming infective or releasing infective larvae, soil-transmitted helminth infections are not transmitted person to person.



General: Hookworm Transmission

- Adult female worms in the intestine of infected people:
 - Produce eggs → eggs then excreted in the stool → defecation on the ground and use of stool to fertilize crops → eggs reach soil
 - Infection with *Ascaris* and *Trichuris* occurs when eggs in soil have become infective and are ingested





Hookworm Transmission Continued

- Hookworm eggs are not infective
 - release larvae in soil that can penetrate skin
- Infection primarily from skin contact with contaminated soil - walking barefoot
 - can also occur through ingestion of larvae
- Ascaris larvae, after they have hatched from eggs in the small intestine, & hookworm larvae, after they have penetrated the skin → lungs → become adult worms in the intestine





Clinical Presentation

- Most infections asymptomatic, especially if few worms present.
- Heavy infections & complications very rare in travelers.
- But very common in locals.





Case

- 2 young Haitian boys present to a clinic in Thomonde, Haiti.
- Report a 2-month history of progressive anorexia, fatigue, shortness of breath on exertion.
- No diarrhea.
- Each appears fatigued, but non-toxic.
- Vitals within normal limits except tachycardia.
- Weight not available.
- Lungs clear.
- Abdomen distended but not tender.
- No rashes.



What do you think is going on?





What do you think is the causative organism?





How would you diagnose it?



How would you treat them?





Concepts to Consider

- In Haiti, moderate to heavy *Ascaris* infections can impair the nutritional status of children.
- The most serious complication is intestinal obstruction, usually of the small intestine.
- Pulmonary symptoms - in small % of patients when *Ascaris* larvae pass through lungs.
 - Symptoms include cough, fever, & chest discomfort.
- Hookworm infection can lead to anemia & protein deficiency due to blood loss.
- *Trichuris* infection can cause blood loss from dysentery & rectal prolapse.



General Diagnosis

- Identify eggs on microscopic examination of a stool specimen.
- Adult *Ascaris* worms may occasionally be coughed up or found in stool or vomit.



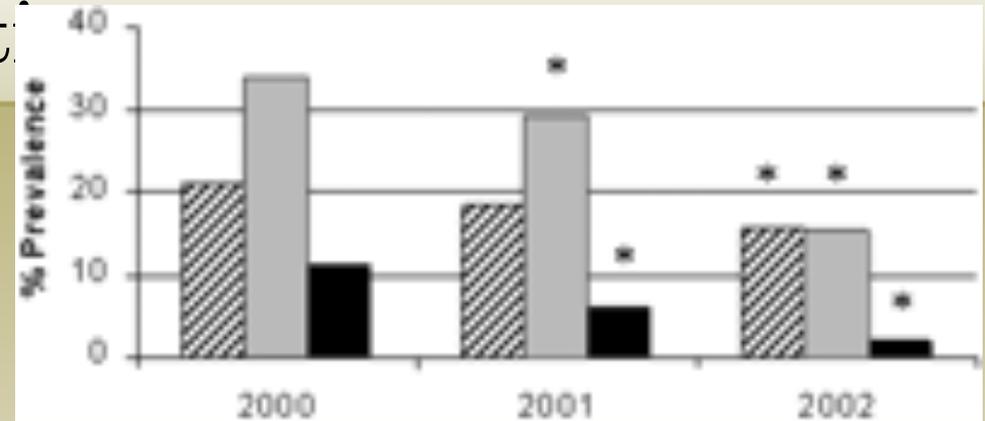
Treatment

- Soil - transmitted helminth infections are usually treated with albendazole or mebendazole (more on this in a few slides)
- Both effective and well tolerated



Back to the impact the earthquake had on worms in Haiti

- Several reports since the late 1990's have found an increase in the prevalence of hookworm infections - specifically in areas of Haiti where intestinal parasites are common, but not hookworm previously.
- Changing environmental conditions, specifically deforestation & subsequent silting of river, cause periodic flooding with deposition of a layer of sandy loam topsoil and increased soil moisture → increased transmission of hookworms.





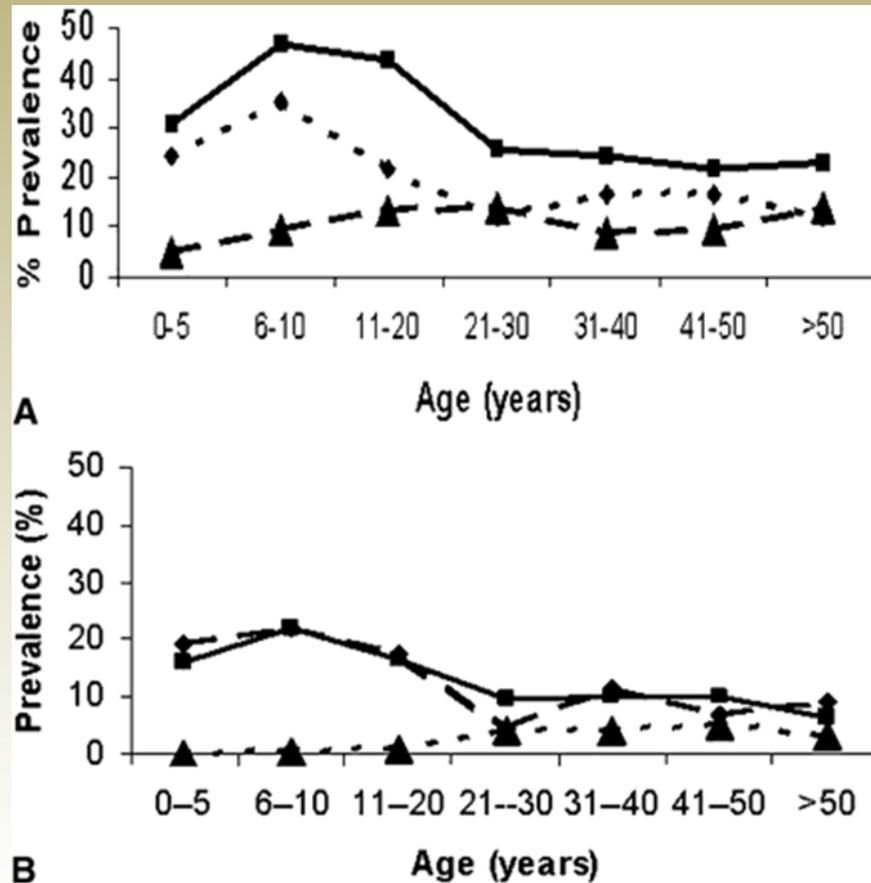
How can prior studies guide our approach now? What do we know about the effectiveness of mass treatment programs?

- Study in Leogane
- Annual mass drug administration (MDA) with: DEC (6 mg/kg) and Albendazole (400 mg in a single dose)
 - 1st conducted in October 2000
 - DEC for the program was provided by the World Health Organization (WHO)
 - Albendazole was donated by GlaxoSmithKline (Middlesex, UK)





Results

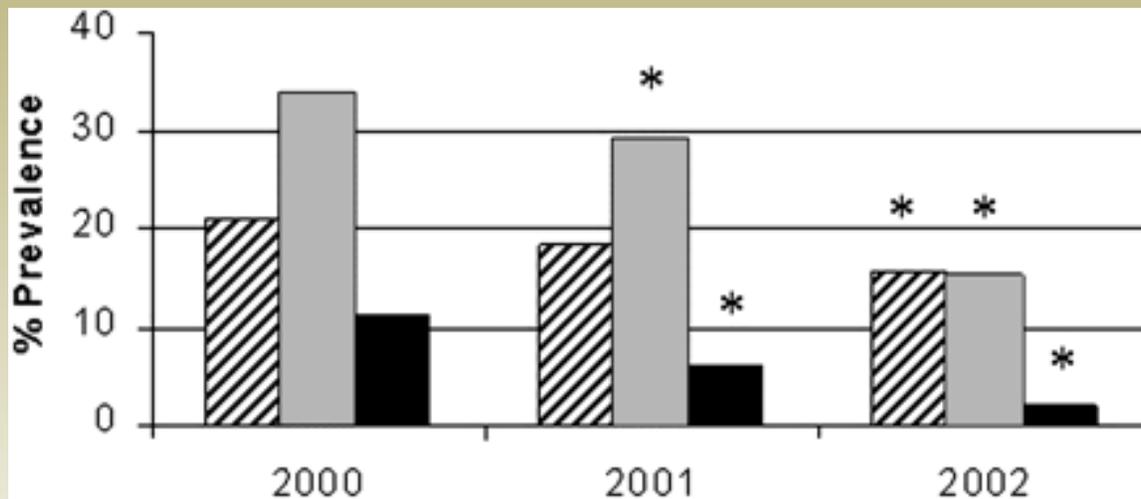


- Age-specific prevalence of intestinal helminth before (A) and after (B) two rounds of mass treatment.

- The prevalence of infection (%) is plotted for the indicated age groups. Ascaris is plotted with a dotted line with diamonds, Trichuris with a solid line with squares, and hookworm with a dashed line and triangles.



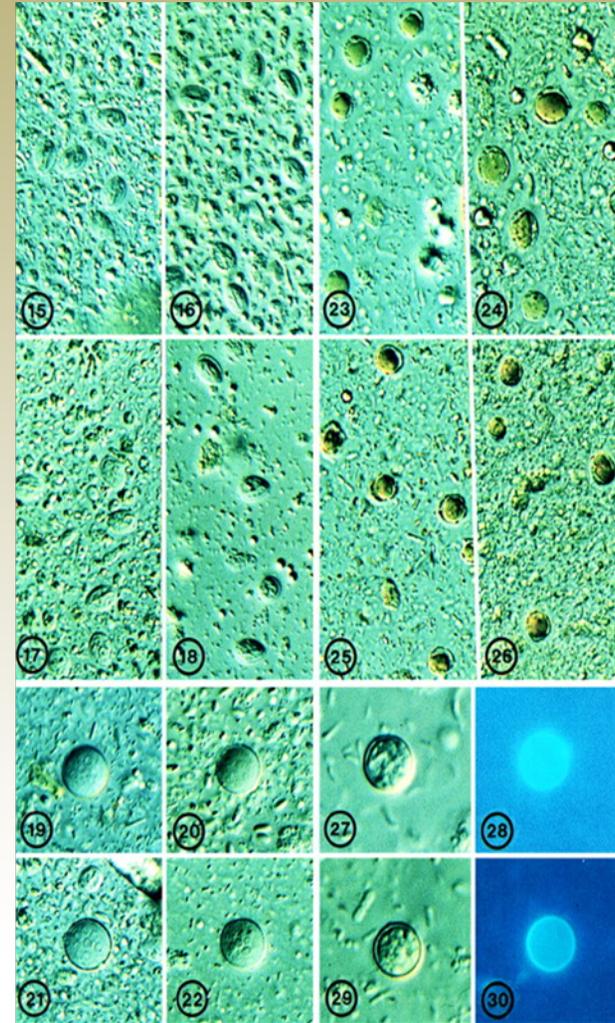
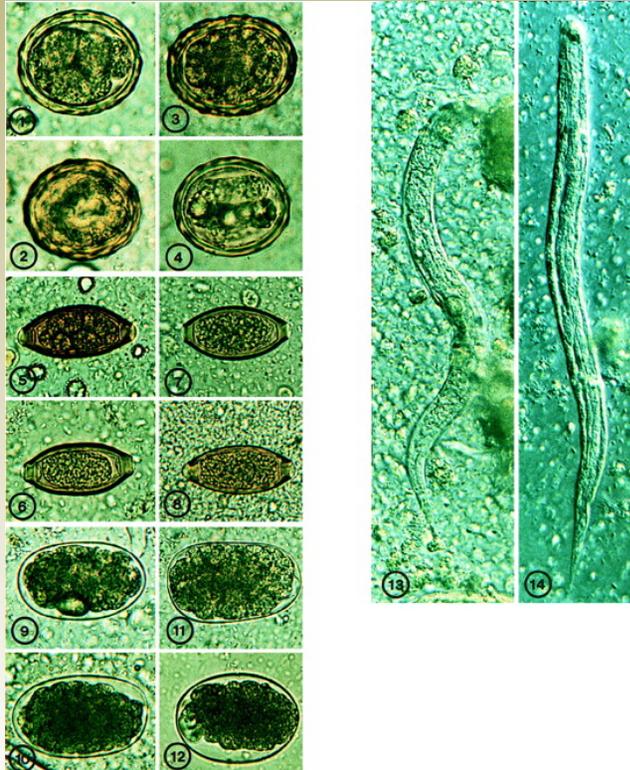
Results continued



- Intestinal helminth prevalence before & after mass treatment with diethylcarbamazine and albendazole.



Various Helminth Eggs



Haitian Children With Soil-Transmitted Helminth Infections

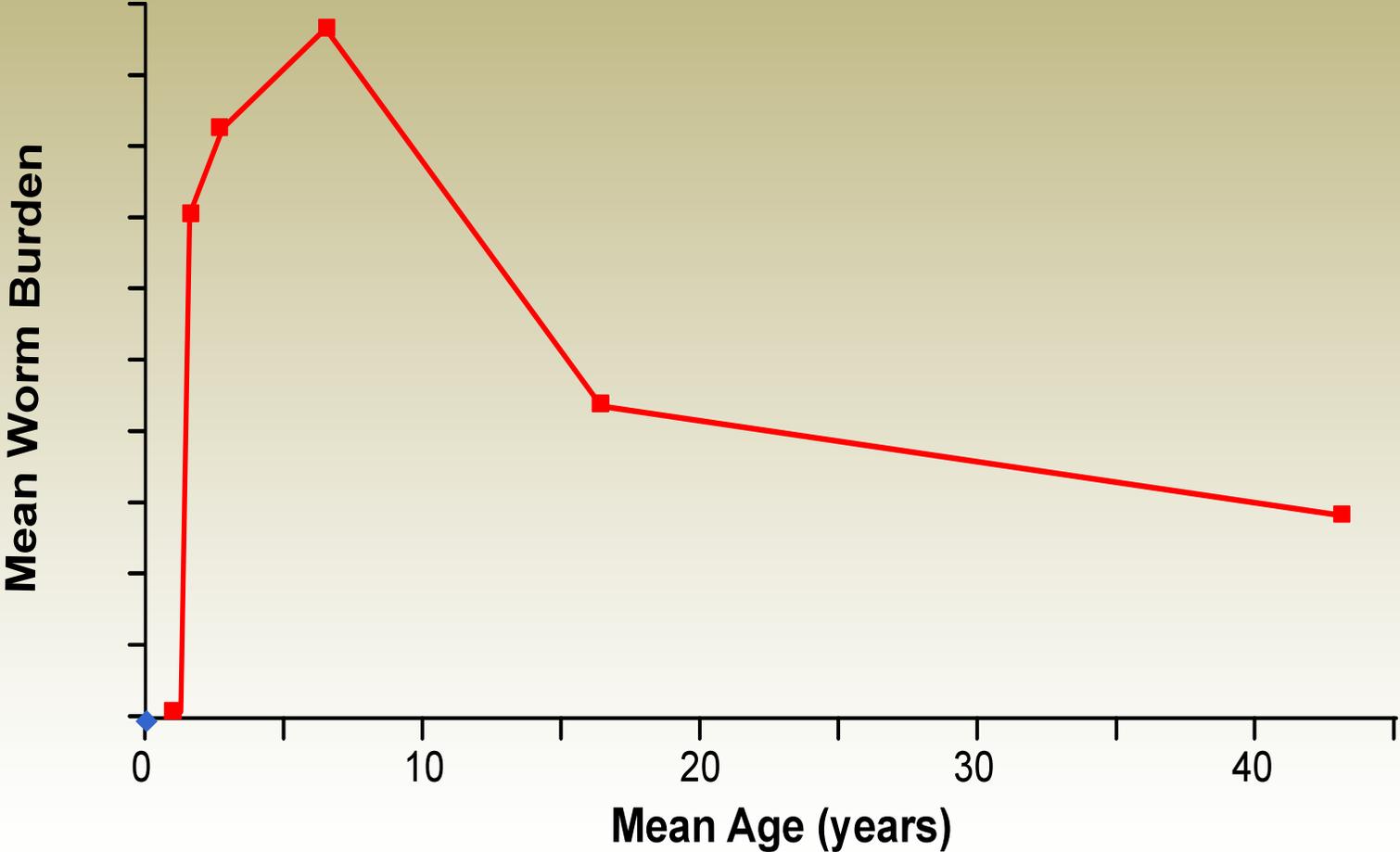


- Stunting, anemia, loss of IQ, diminished school performance
- Many years of lost primary schooling attributable to STH





Highest Worm Burdens in School-aged Children





Growth Curve of Child With Soil-transmitted Infection





Ascaris lumbricoides

- 1/8th the world's population infected
- Largest of nematodes infecting humans
- Adult habitat: small intestine (jejunum)
- Obligatory extra-intestinal migration (eosinophilia)
- Lifespan: 1 – 2 years
- Intensity of infection greatest in children, ages 5 – 10 years

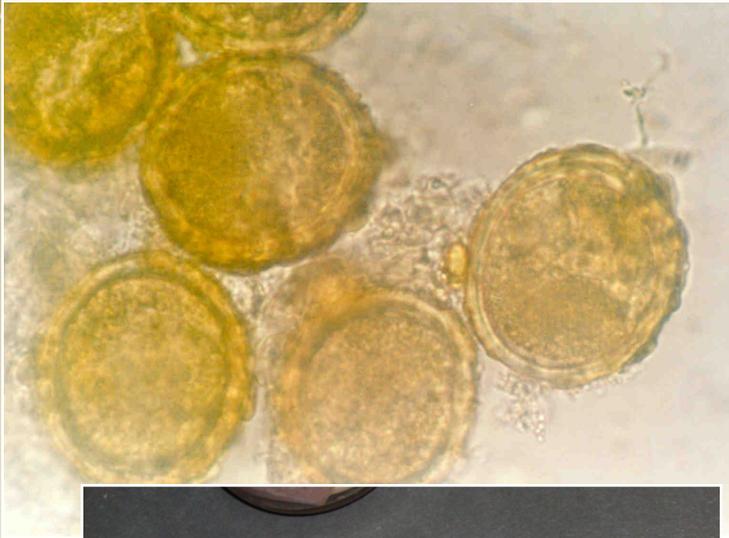




Ascaris infection in Haiti and Paraguay



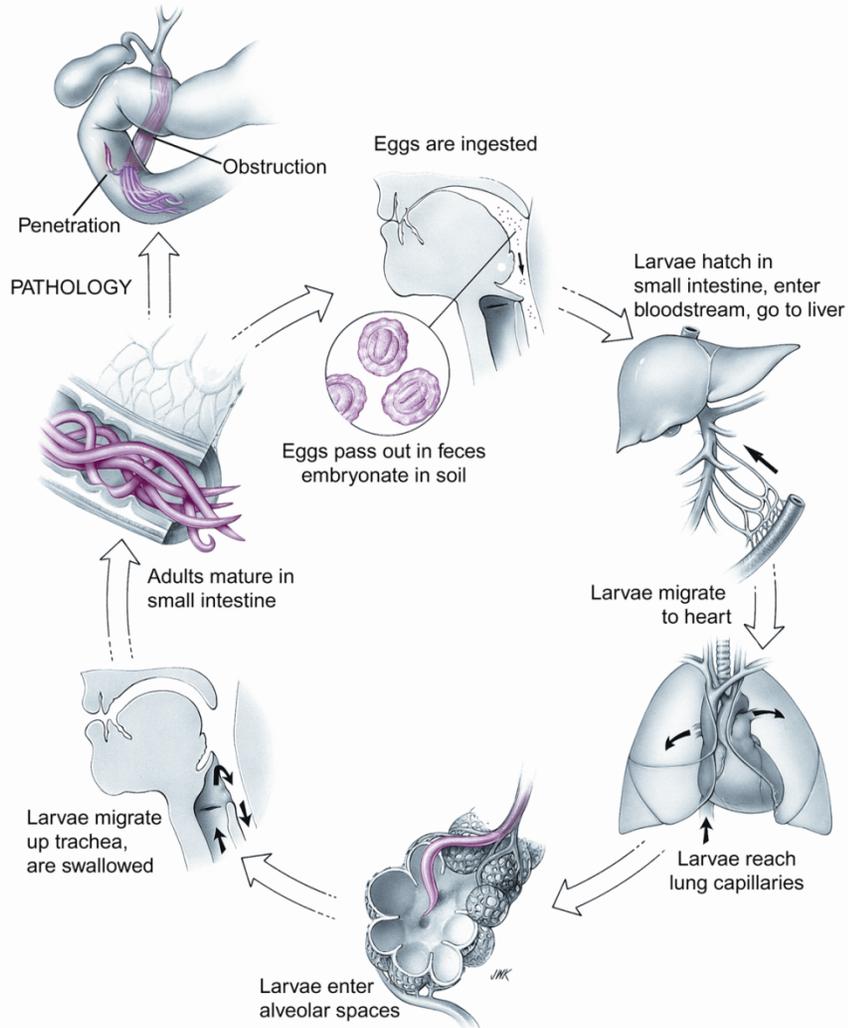
Ascaris



Geographic prevalence
highest in warm, wet
climates

1 adult female = 200,000
eggs/day

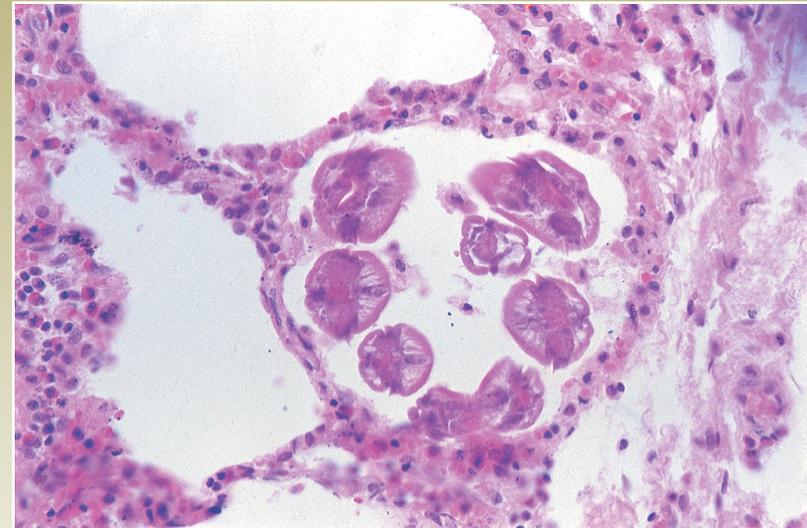
Ascaris lumbricoides



Pre-patency:
2 months

Pneumonitis:
4 – 16 days after
infection,
short duration
(~3 wks)

Löffler Syndrome (Pneumonitis)



Transverse sections of
Ascaris larvae in
pulmonary alveoli



Ascaris lumbricoides

- Larval phase: eosinophilia, pneumonitis
- Adult phase:
 - Malnutrition, Impaired Physical Growth
 - Mild abdominal discomfort → → Small bowel obstruction (in children, few as 60 worms)
 - Wandering ascaris: biliary tract obstruction, cholangitis, pancreatitis, liver abscess
- Treatment: Albendazole x 1 dose



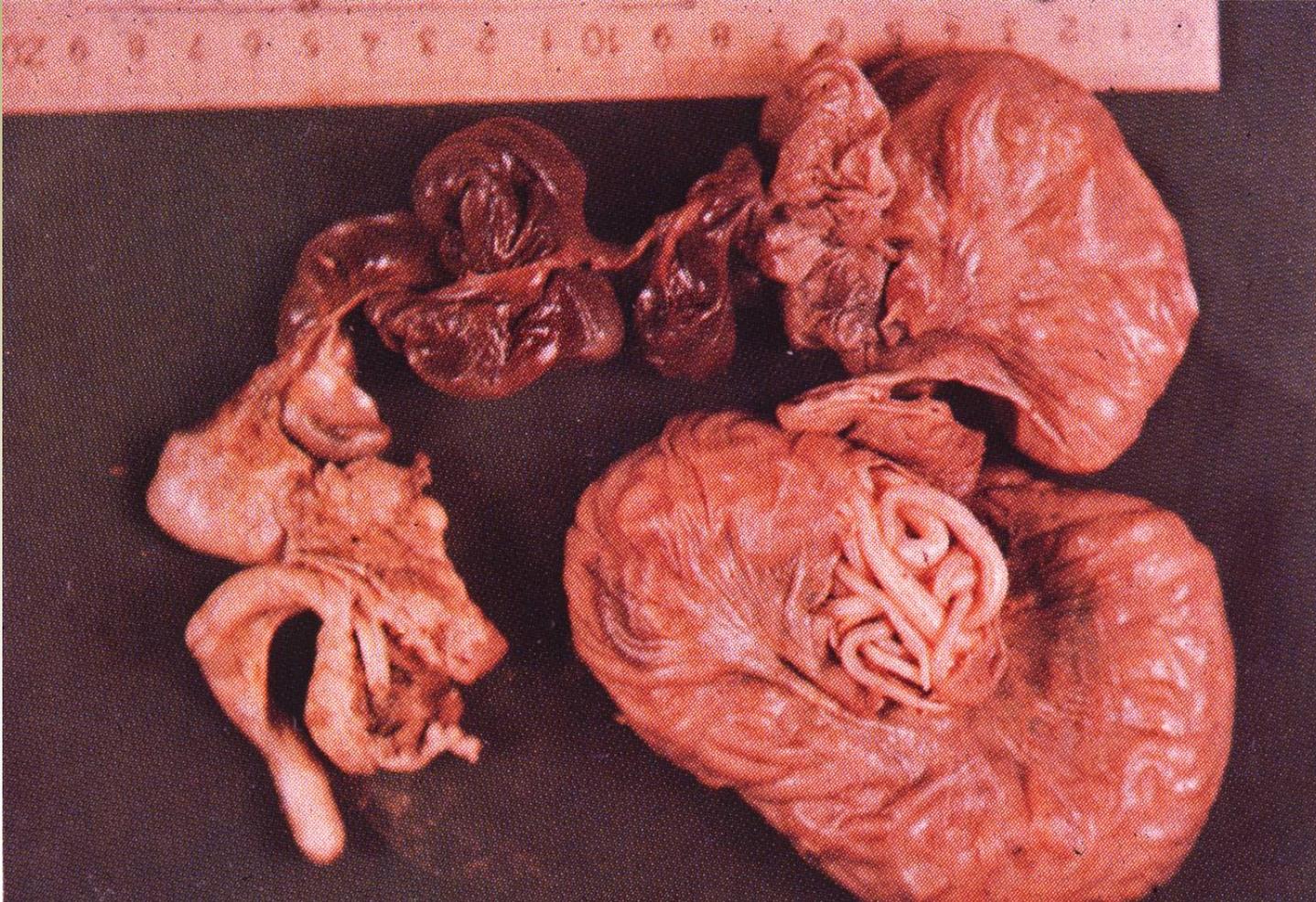
Adult *Ascaris*
worms migrating in
liver



Ascaris causing
intestinal
obstruction.



Acute G.I. Obstruction from Ascaris





Ascaris
(roundworm):

The only
nematode ever
coughed or
vomited up





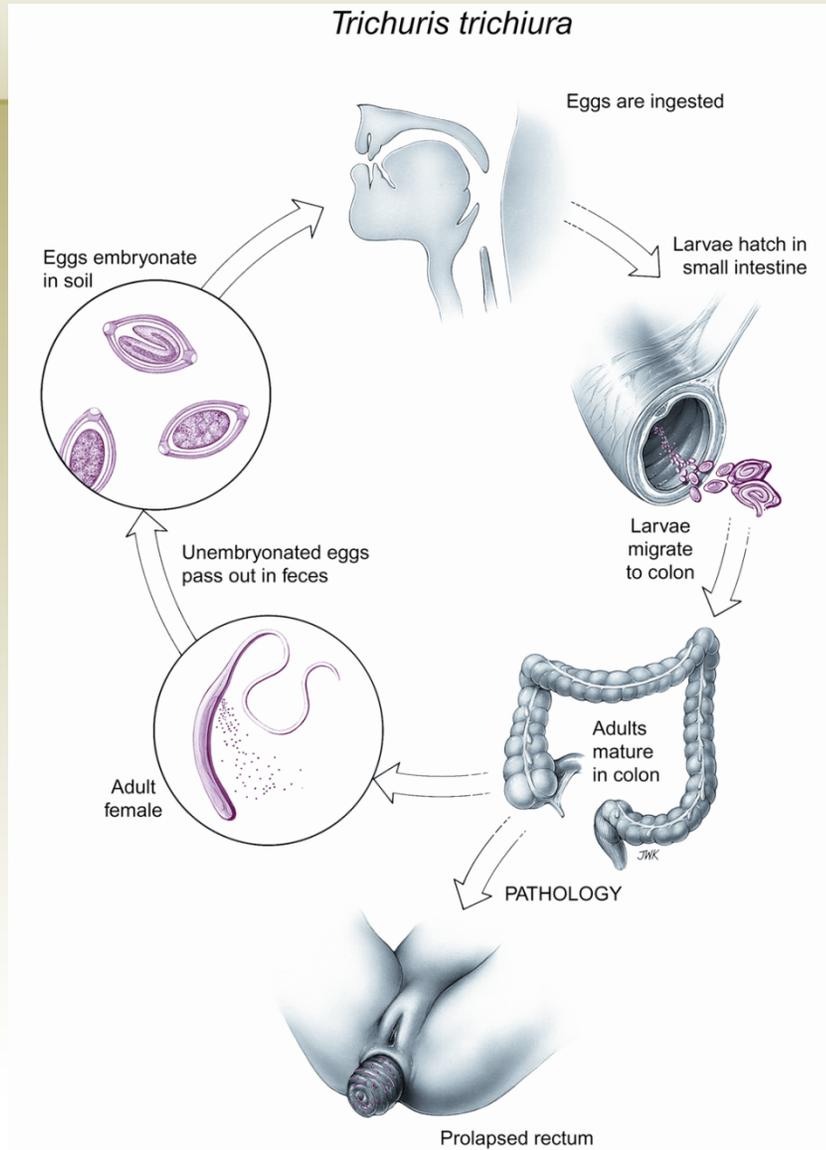
Result of chronic malnutrition from lack of food and from worm or parasitic GI infections: Protein Malnutrition





Whipworm:
Trichuris trichiuria

- Adult habitat: caecum, colorectum
- No extra-intestinal phase
- Lifespan: 1 - 3 years
- 90% infections are asymptomatic
- Symptoms with heavy infections
 - Intensity of infection peaks by age 10



Pre-patency:
2 months



Whipworm:
Trichuris trichiuria

- Clinical Features:
 - Asymptomatic
 - Physical Weakness, Anemia
 - Stunted Growth, Cognitive Deficits
 - Stool frequency (12+/day), nocturnal stooling
 - *Trichuris dysentery syndrome*
 - *Trichuris colitis*
 - *Rectal prolapse*
- Treatment: Albendazole x 3 days.

Whipworm: Trichuriasis Colitis



Rectal Prolapse from Trichiuriasis





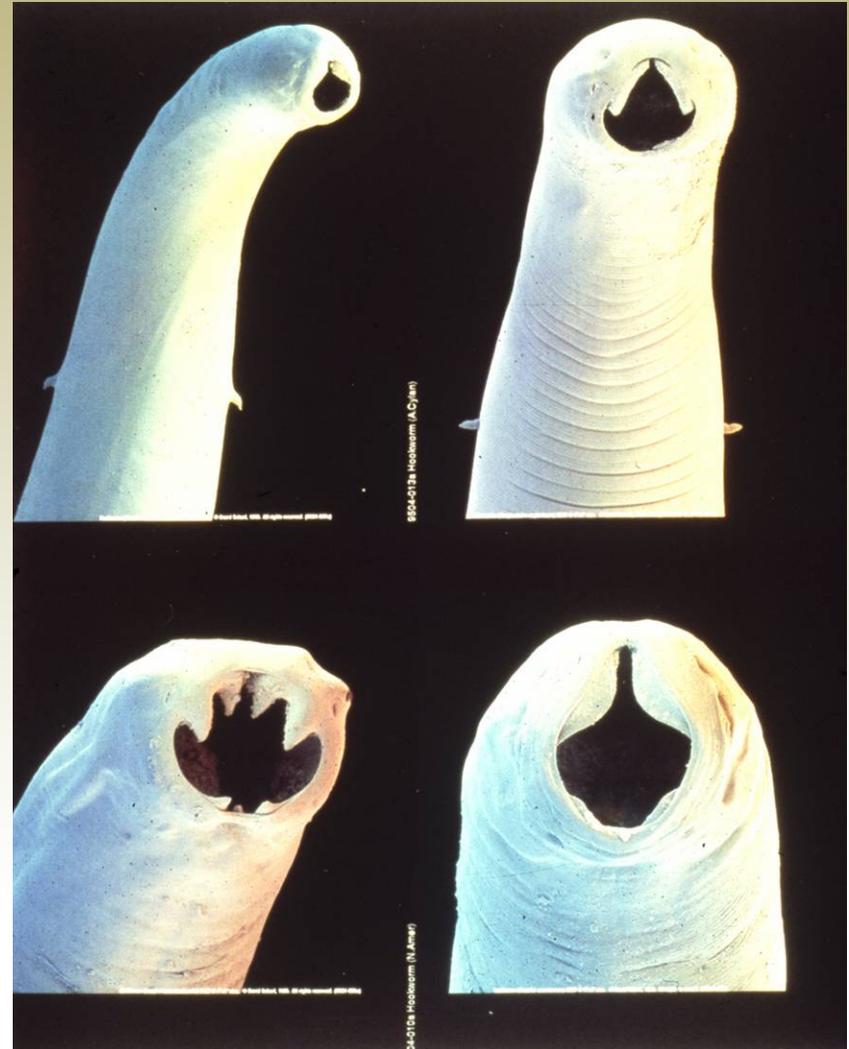
Whipworm Egg: 2 polar plugs





The Human Hookworms

Necator americanus
Ancylostoma duodenale





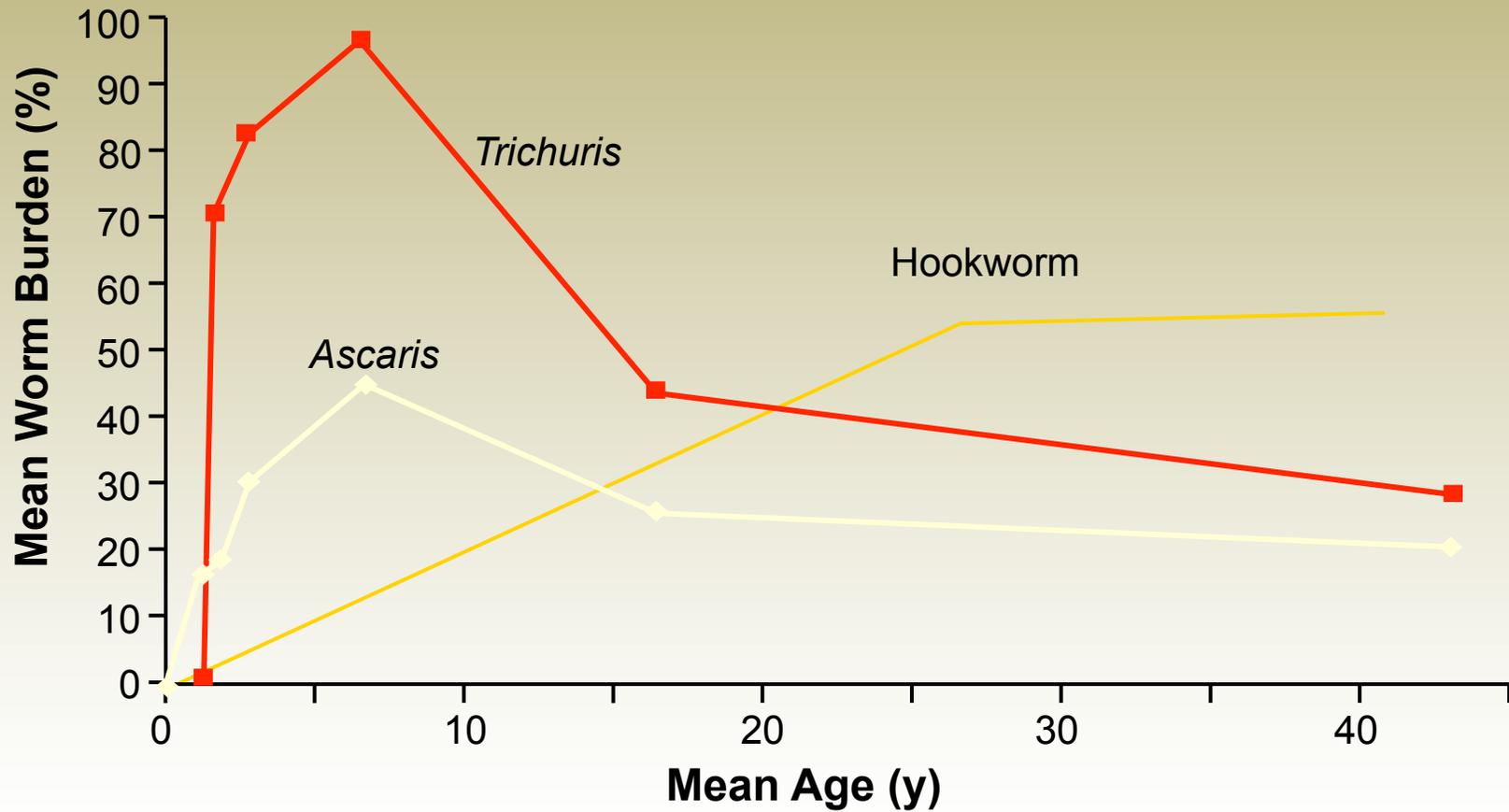
Hookworm:

Necator americanus & *Ancylostoma duodenale*

- One – tenth the world's population infected
 - Significant cause of anemia & protein malnutrition
- Adult habitat: small intestine
- Lifespan:
 - ~ 1 year (*A. duodenale*)
 - ~ 3 - 5 years (*N. americanus*)
- Worm burdens do not decline in adult years



Typical Age and Intensity of Infection Relationship





Human Hookworm Infection

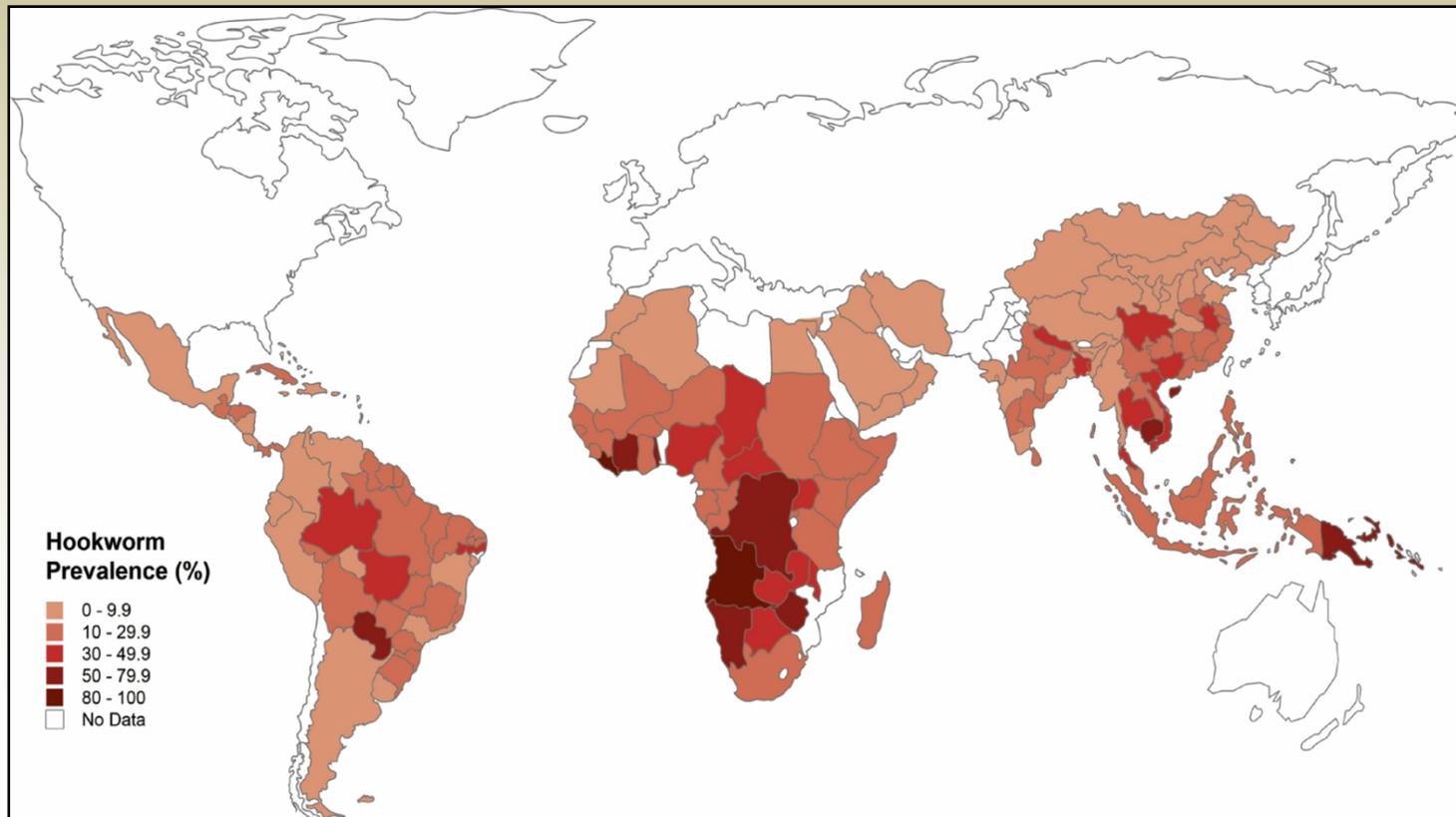
~600 million cases worldwide

(rural poverty >>> urban slums)

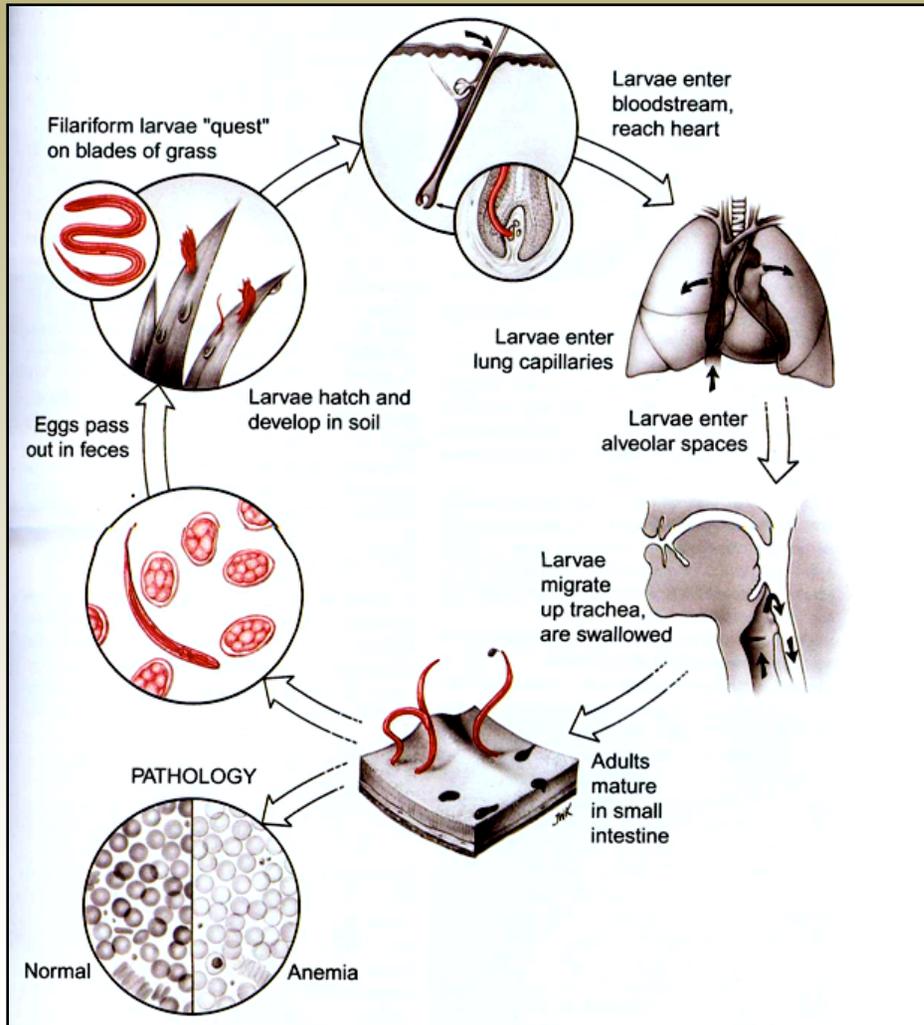
44 million pregnant women infected

Iron-deficiency anemia: Physical & Intellectual Retardation

Necator americanus is the predominant hookworm species



Life Cycle of Hookworm

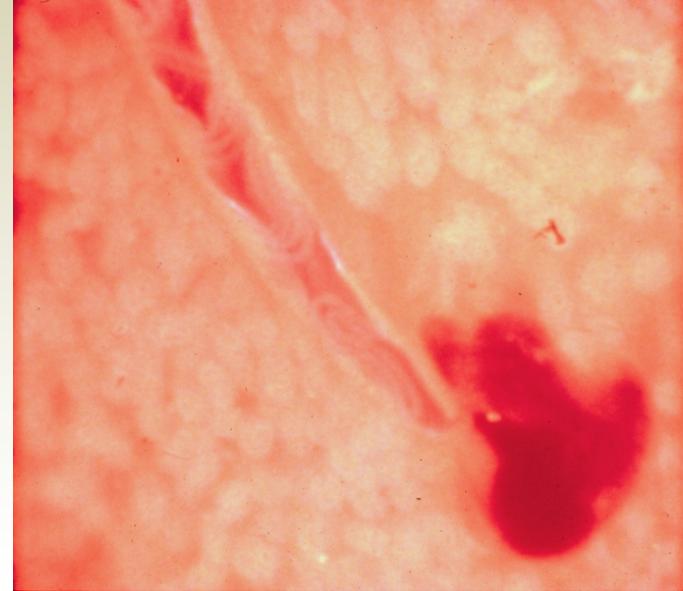


Pre-patency:
months - year

Hookworm-Blood Loss

Adult worms injure their host by causing intestinal blood loss:

- Anticoagulants, Hemolysins, and Hemoglobinases
- 30 to 200 μL blood per day per hookworm
- Intestinal blood loss and Iron Deficiency Anemia



Adult Hookworms in Situ (1 cm)

Adult size: 0.5
— 1 cm

Daily eggs per
worm:
5 – 20,000





Hookworm:

- Clinical Features:
 - Ground-itch → Dry cough, wheezing (1-2 wks later) in primary infection
 - Abdominal discomfort
 - Progressive iron-deficiency anemia
 - 40 – 160 worms associated with Hgb < 11 g/dL
 - Failure to thrive, extreme fatigue
 - IQ loss
- Treatment: Albendazole x 1 dose



Hookworm Disease



**Pallor and
Facial Edema**



Anasarca



At-Risk Populations for Hookworm Disease

- Women and Children: Low Iron Stores
- Children:
 - Physical growth stunting
 - Cognitive deficits and intellectual retardation
- Women of Child-bearing age
 - Puberty
 - Menstruation
 - Pregnancy
 - Increased Maternal Mortality (anemia)
 - Low Birthweight
 - Infant Mortality





School Based Deworming

- In 2001, (WHO) adopted a resolution aimed at the “deworming” of 75 percent of all at-risk school-age children by 2010,
 - Improvements in iron, Hgb status
 - Improved Cognition, Educational Achievement
 - Reduction in school absenteeism
 - Reduction in community helminth transmission of ascariasis & trichuriasis





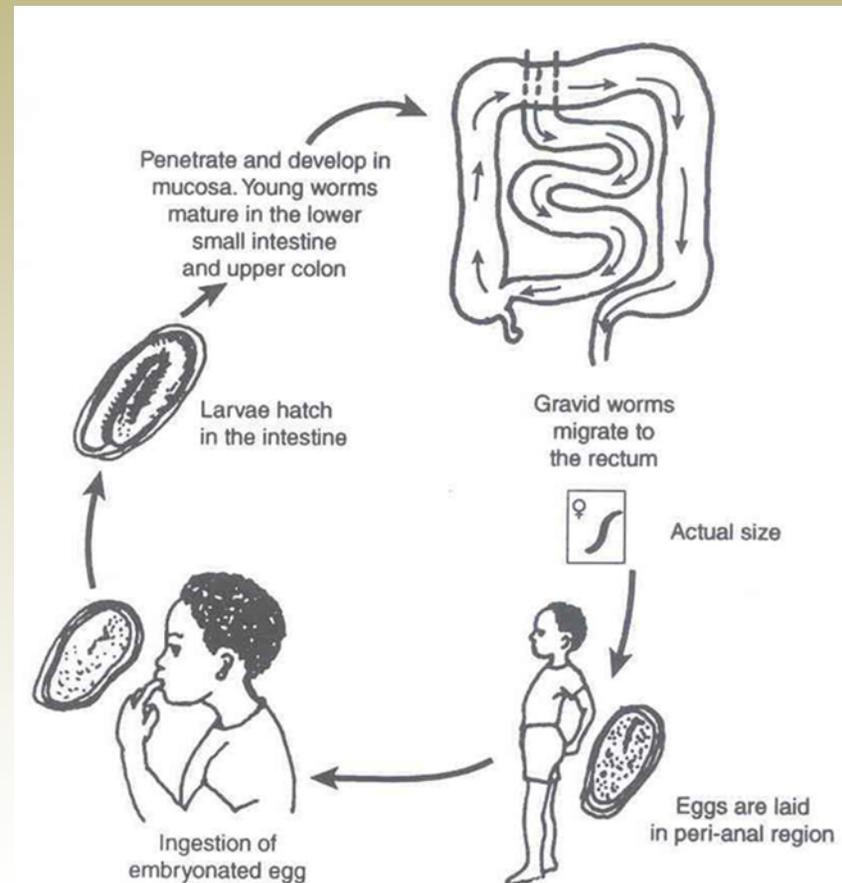
Control

- Anti-helminthic drugs:
 - 50 million tablets of mebendazole donated per year by Johnson & Johnson
 - Albendazole available from GlaxoSmithKline for 2¢ per pill
- Currently no vaccine exists for ascariasis or trichuriasis
- Human Hookworm Vaccine Initiative (HHVI): Phase I trials



Pinworms (Enterobiasis, Oxyuriasis, Threadworm): Overview & Transmission

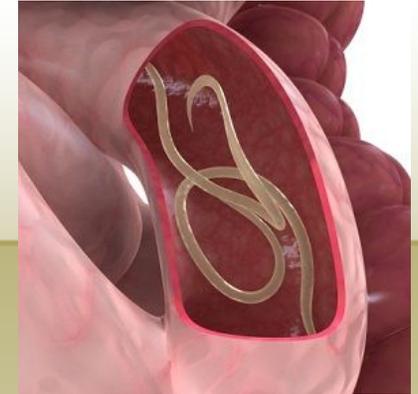
- Fecal-oral ingestion of egg
- Direct person-to-person contact
- Indirect contact via contaminated hands, dust, food, or objects (bedding, clothing, toys, bathwater, toilet seats)
- Incubation period from when the egg is ingested to when the adult worm migrates to the anus:
 - 1–2 months
 - Eggs can remain infective indoors for 2–3 weeks
- Humans are only known natural host
- Animal pinworms do not infect humans





Transmission Risks

- Poor hygiene (hand washing and poor toilet hygiene)
- Unsanitary or inadequate toilet facilities
- Crowded living conditions or living in same household as infected person
- Close day-to-day contact (living and working) with people, particularly institutionalized people or preschool- and school-age children

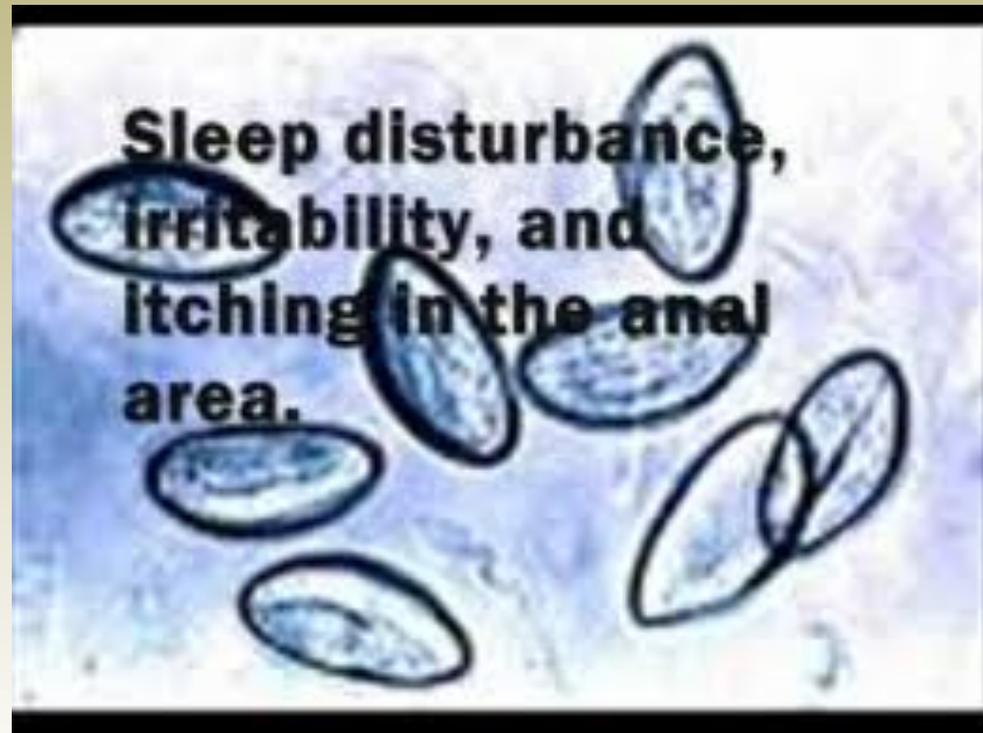




Clinical Presentation

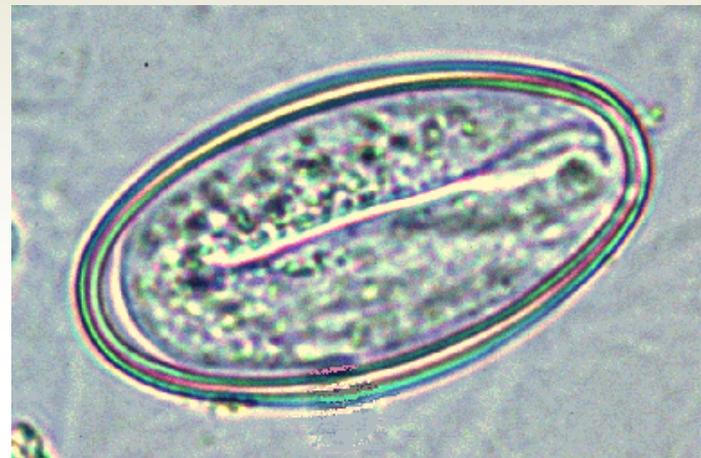


- Asymptomatic, or
- Common symptoms include nocturnal perianal and perineal pruritus and restless sleep.
- Urethritis, vaginitis, salpingitis, hepatitis, or peritonitis may occur if adult worms migrate from the perineum to other sites.



Diagnosis

- Direct visualization: female worms
- Microscopic identification: worm eggs
- “scotch tape test”
- Eosinophilia is unusual (because of absence of tissue invasion)
- serologic testing is not useful or widely available.
- Eggs and worms are rarely found in routine stool samples.



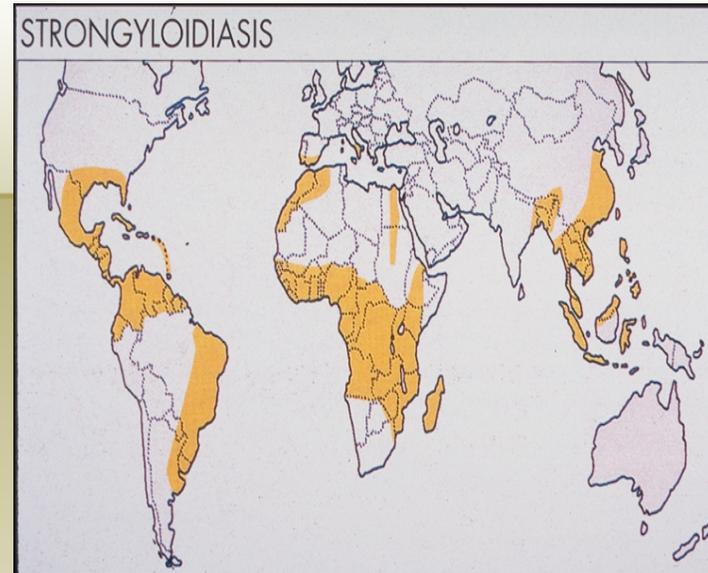
Treatment

- Anthelmintic x 1 dose; repeat in 2 weeks.
- Drugs of choice:
 - mebendazole, albendazole, or pyrantel pamoate.
- Treat all household contacts & caretakers at the same time
- Daily morning bathing removes a large proportion of eggs
- Change underclothing & bedding frequently & launder in hot water.
- Reinfection occurs easily
- Instruction about prevention is mandatory to eliminate continued infection and spread.





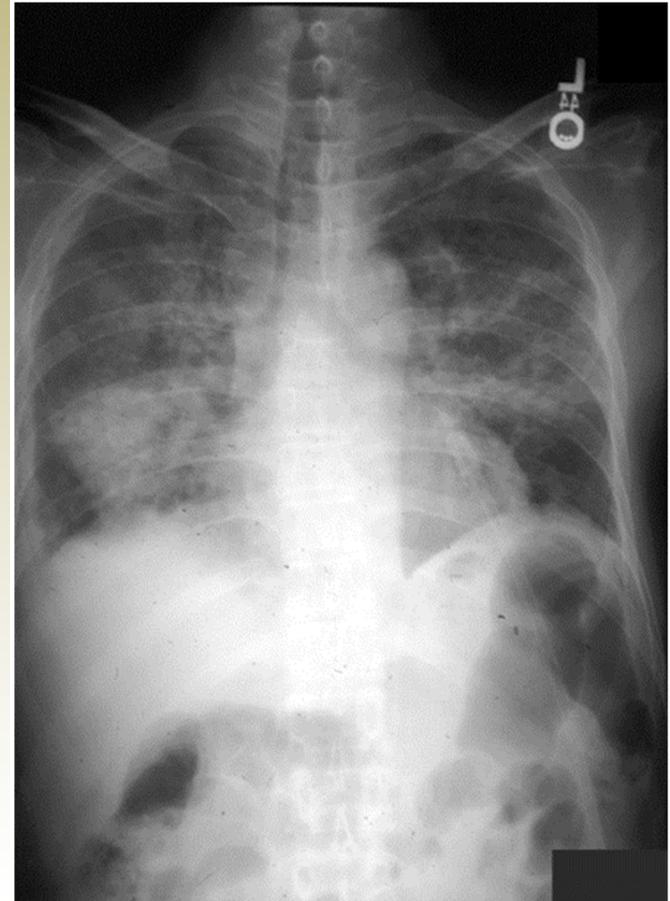
Strongyloidiasis: *Strongyloides stercoralis*



- Worldwide prevalence: ~100 million
- Adult habitat: duodenum, jejunum
- Lifespan: unknown. Ongoing autoinfection.

Strongyloidiasis - Clinical Presentation

- Asymptomatic eosinophilia
- Abdominal pain
- Dermatitis - larva currens
- Pulmonary infiltrates with eosinophilia
- Dissemination with sepsis





Documented length of infections in years

Strongyloides	> 60
Schistosomiasis	32
Burkholderia pseudomallei (Meliodosis)	26
Echinococcus (hydatid disease)	>20
Trichinella larvae in muscle	18
Cysticercosis (Taenia solium)	>15
Onchocerciasis (adult worms)	10-15

Adapted from Hospital for Tropical Disease

London, 1997

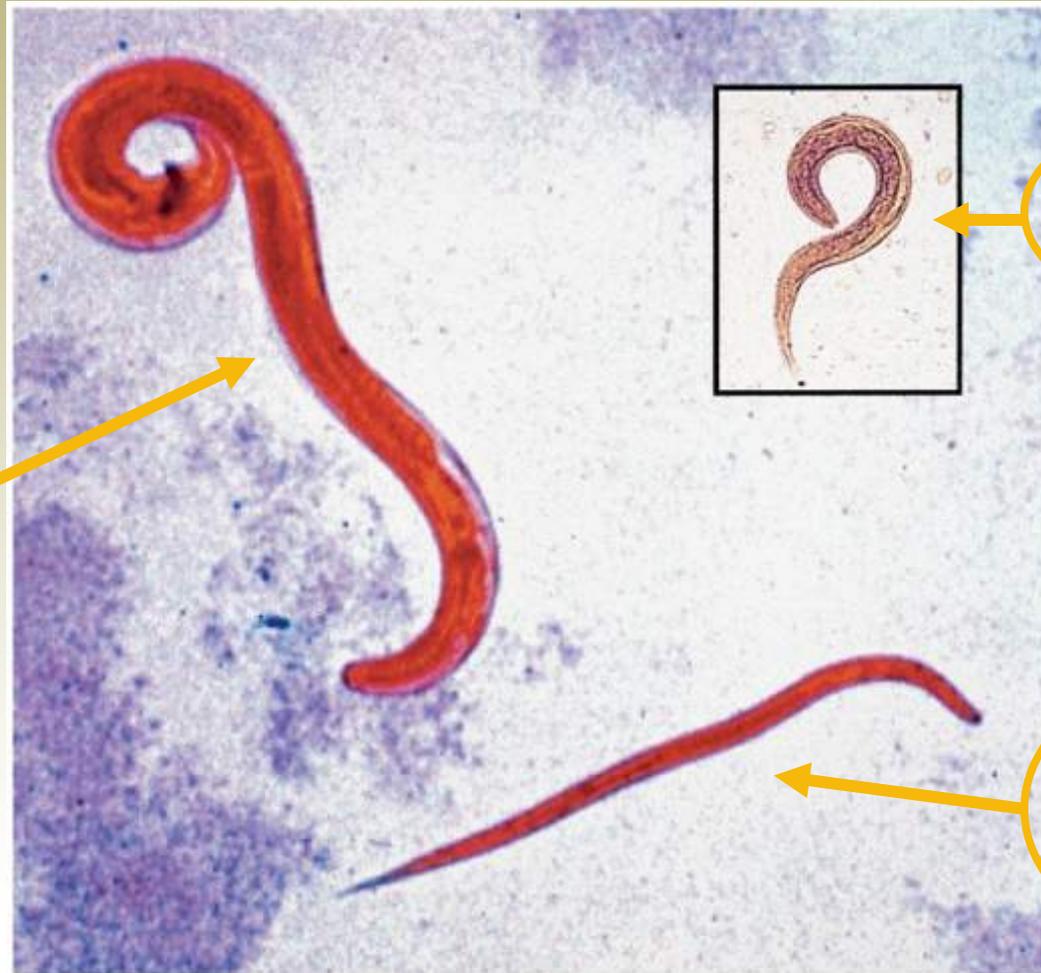
Pruritic Larva Currens from *Strongyloides*



Larva currens = autoinfection with
Strongyloides filariform larvae



Strongyloides Rhabditiform Larvae
may transform to Filariform Larvae...
penetrating perianal skin and bowel mucosa



Adult

**Rhabditiform
Larvae**

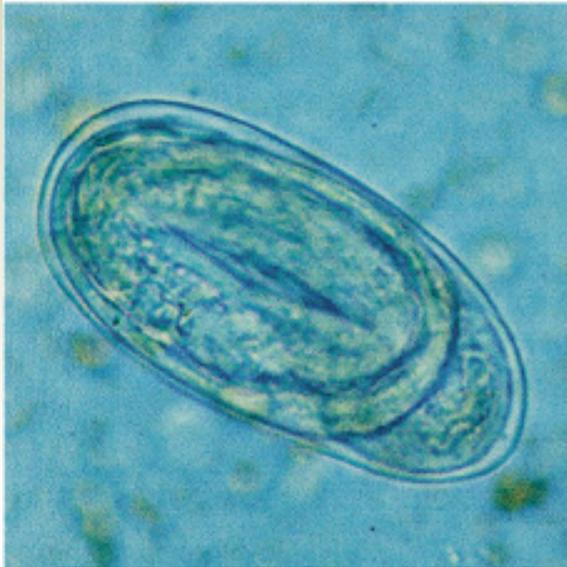
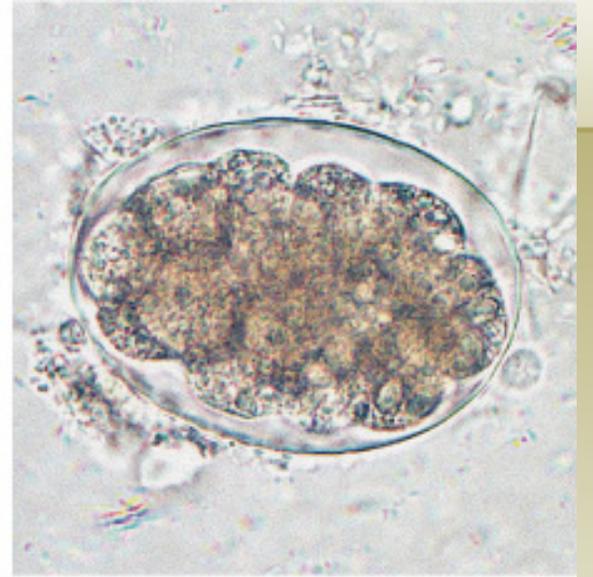
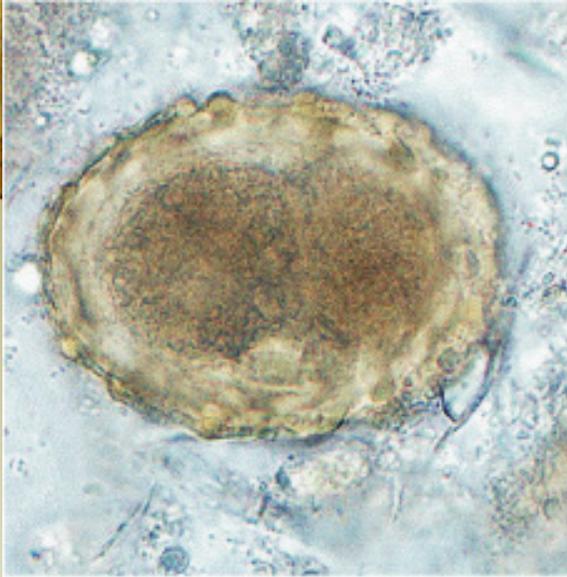
**Filariform
Larvae
(penetrating)**



Strongyloidiasis Hyperinfection:

Strongyloides stercoralis

- Hyper-Infection:
 - intestinal perforation
 - hemorrhagic pneumonia
 - shock, sepsis, gram-negative meningitis
 - eosinophilia may be limited



Received with stool sample
5-2-76

Dear Who Ever You Are -

I can't believe what
I just had to do and

I damn sure can't
believe what you

have to do - I thought

I was dedicated to my
job but this is something

else - I really feel

for you —



Good news: Pre-departure treatment for intestinal parasites in US bound refugees

Since 1999, CDC has implemented empiric treatment with single dose albendazole for all refugees departing from sub Saharan Africa





To Review... General Truths about Nematodes

- Polyparasitism
- Burden greatest in children
 - except hookworm, ?*Strongyloides*
- Don't Multiply in Host (2 exceptions)
- Eosinophilia = tissue invasion
 - Larval stages or *Strongyloides*

What is the most likely worm to be coughed or vomited up?

- *Trichuris*
- Hookworm
- *Strongyloides*
- Tapeworm
- *Ascaris*

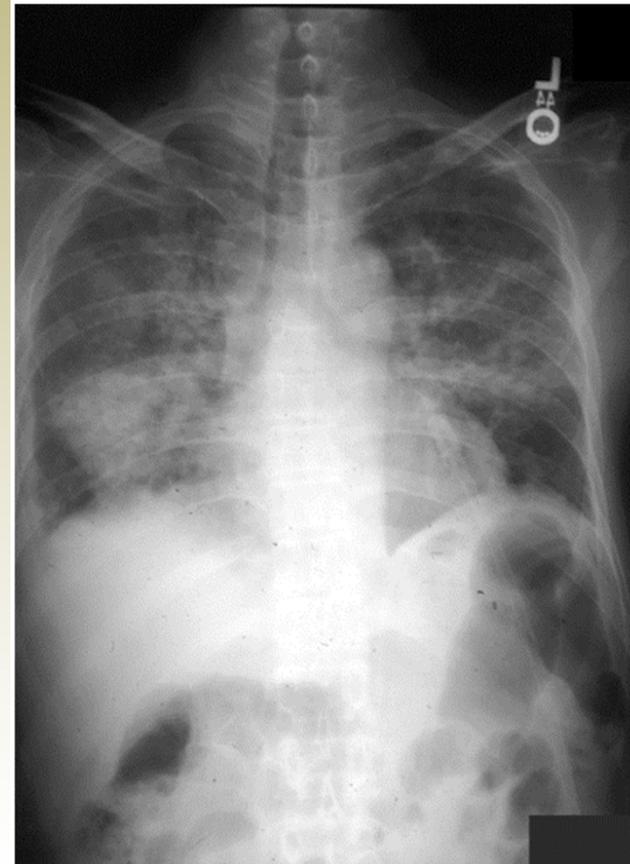




Which worm infection do you ALWAYS want to treat?

- *Ascaris*
- *Trichuris*
- *Strongyloides*
- Pinworm
- Hookworm

Haitian male, in US for 8 years, developed fever, rash and pneumonia after being placed on steroids for uveitis.





Which worm's burden of illness increases through your late childhood and early adulthood years?

- *Strongyloides*
- Hookworm
- *Ascaris*
- *Trichuris*
- Pinworm





Which worm infection is most likely to mimic colitis?

- *Trichuris*
- *Ascaris*
- *Strongyloides*
- Pinworm
- Hookworm





Which Nematode is the most likely to be the cause of eosinophilia in an immigrant/refugee from Africa who has been in America x 9 months?

- *Trichuris*
- *Strongyloides*
- Pinworm
- Hookworm
- *Ascaris*





When is the ideal time to check Stool O & P in Returning Traveler?

- IMMEDIATELY upon landing
- Within 1 week
- 1 month
- 2 month
- 6 months
- 1 year





Recommended References

TROPICAL INFECTIOUS DISEASES
Principles, Pathogens, & Practice,
Second Edition, 2006
Guerrant, Walker, Weller
Churchill Livingstone

MANSON'S TROPICAL DISEASES
Twenty-first Edition, 2003
Cook & Zumla
W.B. Saunders

**ATLAS OF TROPICAL MEDICINE &
PARASITOLOGY**
Sixth Edition, 2007
Peters & Pasvol
Mosby Elsevier

RED BOOK
2006 Report of the Committee on Infectious
Diseases
Table 4.10. Drugs for Parasitic Infections

**COMMUNITY-WIDE REDUCTION IN
PREVALENCE AND INTENSITY OF
INTESTINAL HELMINTHS AS A
COLLATERAL BENEFIT OF LYMPHATIC
FILARIASIS ELIMINATION PROGRAMS**

MADSEN BEAU DE ROCHARS et al

