Introduction to Cestodes

Taenia saginata and Taenia solium

Helminths

Nematodes

Cestodes

Trematodes

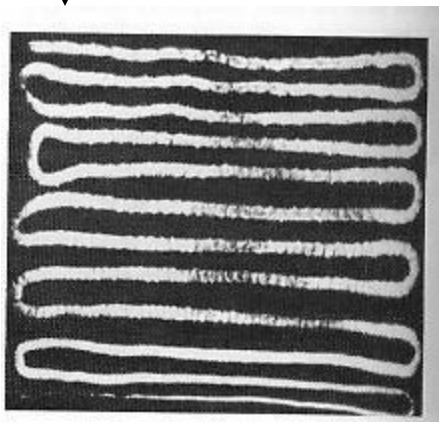
Taenia

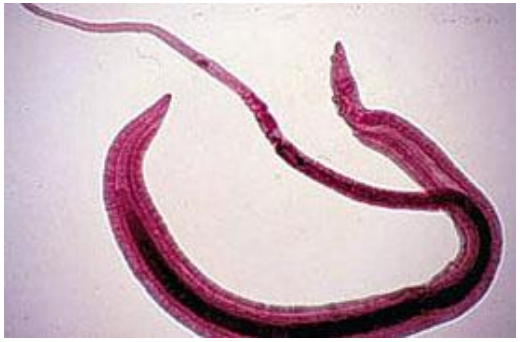
Echinococcus

T. solium

T. saginata

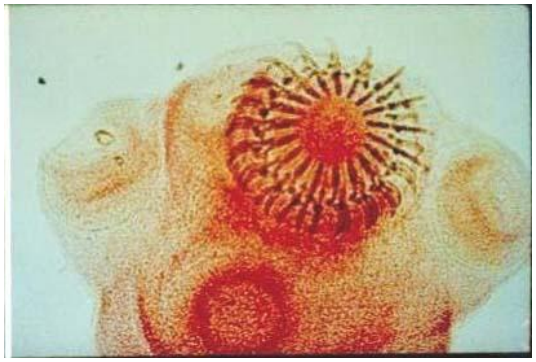
Ascaris

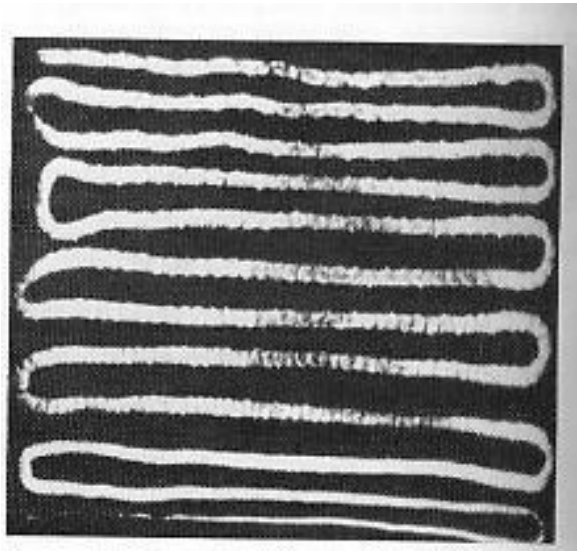


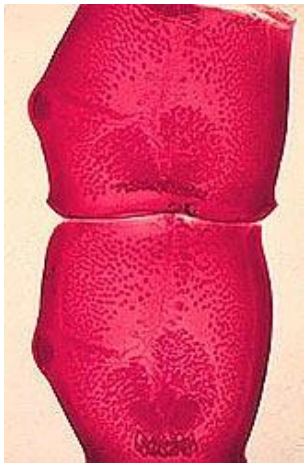


Characteristics of adult cestodes

- Head (scolex):
  - 4 suckers
  - Rostellum with hooks
- Segmented body (Proglottids)
  - Flat (ribon)
- Hermaphrodite
  - Mature proglotids with 30-50,000 eggs each







NematCharacteristics of adult cestodes

- Together, all proglottids are referred to as the strobila.
- Tapeworms do not have a functional gut.
- Rather, the segments are enclosed in a specialized tegument, whose structure and function are directly related to nutrient acquisition.
- Evenly-spaced microvilli cover the entire surface of the tegument.
- Like and an inside-out-intestine.
- High levels of ATPase in the tegument are related to active transport and help the worm resist digestion by the mammalian host.

NematCharacteristics of adult cestodes

- Each proglottid has 2 layers of muscle.
- Segments are anatomically independent, but they are connected by a common nervous system.
- Mature proglottids possess both male and female sex organs.
- Gravid proglottids develop after mating, containing hundreds of thousands of eggs.
- Proglottids detach from the parent organism and exit via the host's feces.
- Eggs contain a larvae called the oncosphere.

NematCharacteristics of adult cestodes

- Eggs remain viable in the external environment for weeks to months after being deposited in soil.
- Hatching occurs typically in the small intestine of the intermediate host.
- The oncosphere then penetrates the gut tract and lodges within the tissues, developing into a metacestode.
- This stage is ingested by the definitive host.

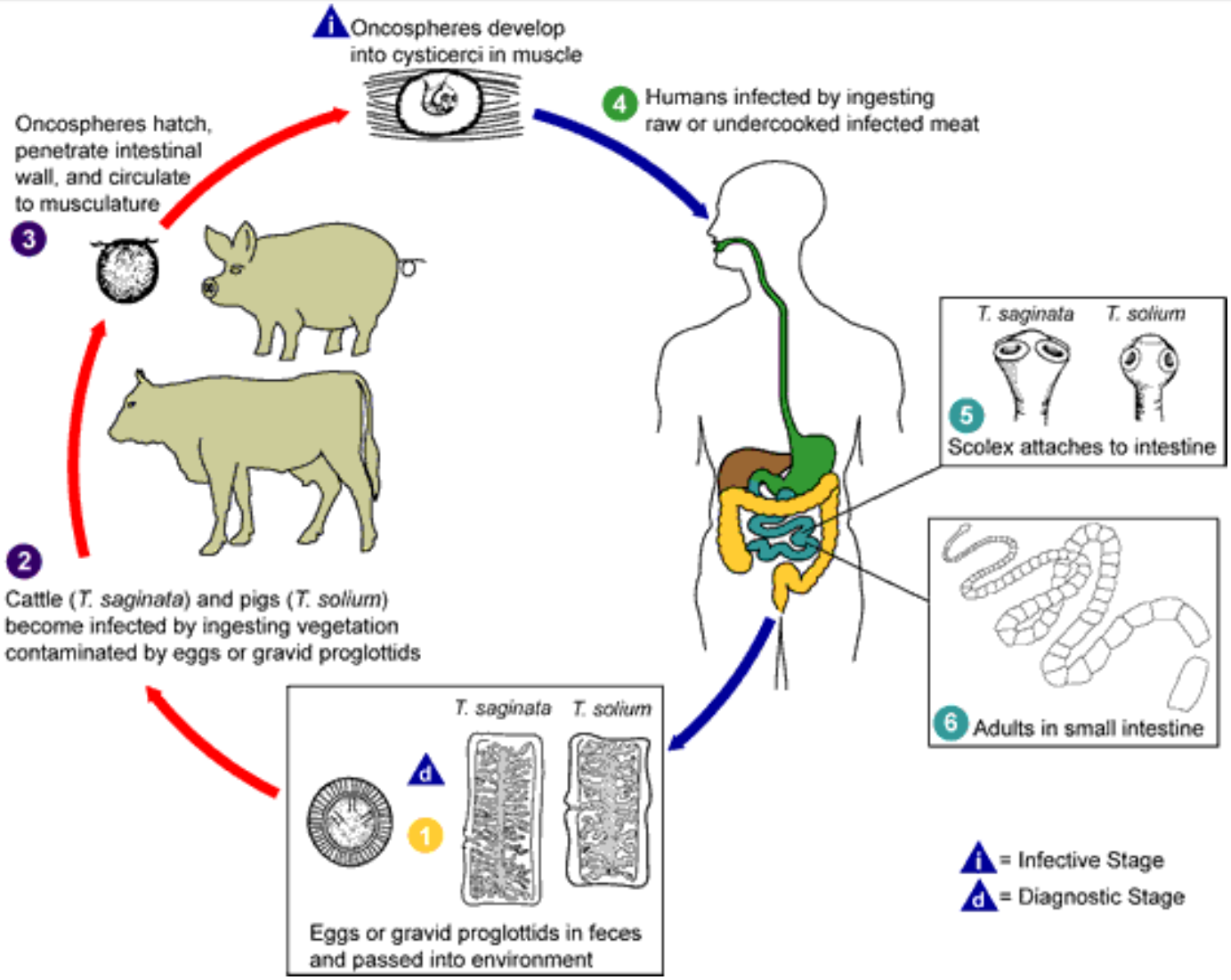
Taenia saginata-beef tapeworm

- One of the largest parasites infecting humans.
- Can reach 8-10 meters in length.
- Lives in the lumen of the upper half of the small intestine.
- No reservoir hosts.
- Occurs where cattle husbandry is prevalent and where human excreta are not disposed of properly.

Taenia saginata-Distribution

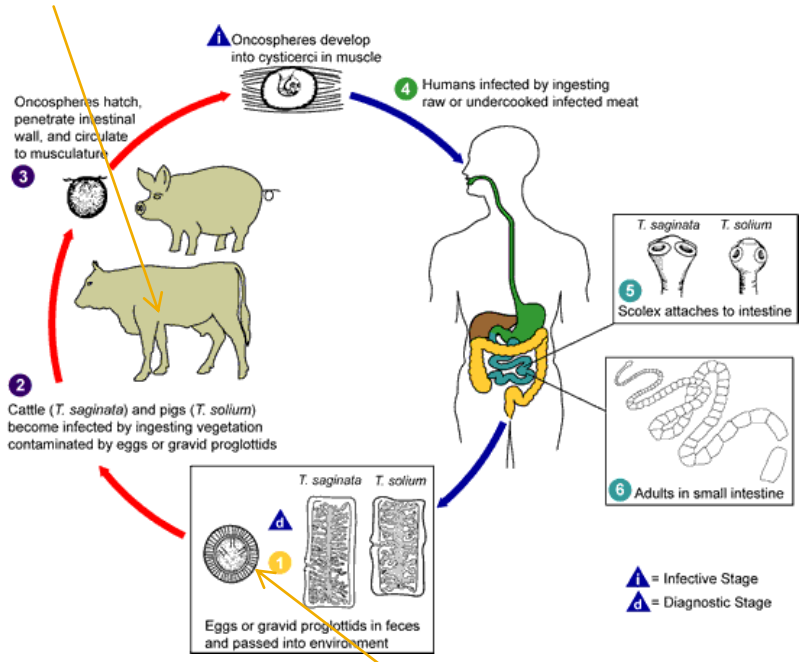
- Vast regions of sub-Saharan grasslands.
- Mexico
- Argentina
- Middle Europe
- Sometimes in the United States.

T. saginata-Lifecycle



T. saginata-Lifecycle

Metacestode



- Cysticercus is ingested along with raw or undercooked beef.
- The cyst is digested away, freeing the worm inside.
- Parasite everts its scolex and attaches to the intestinal wall.

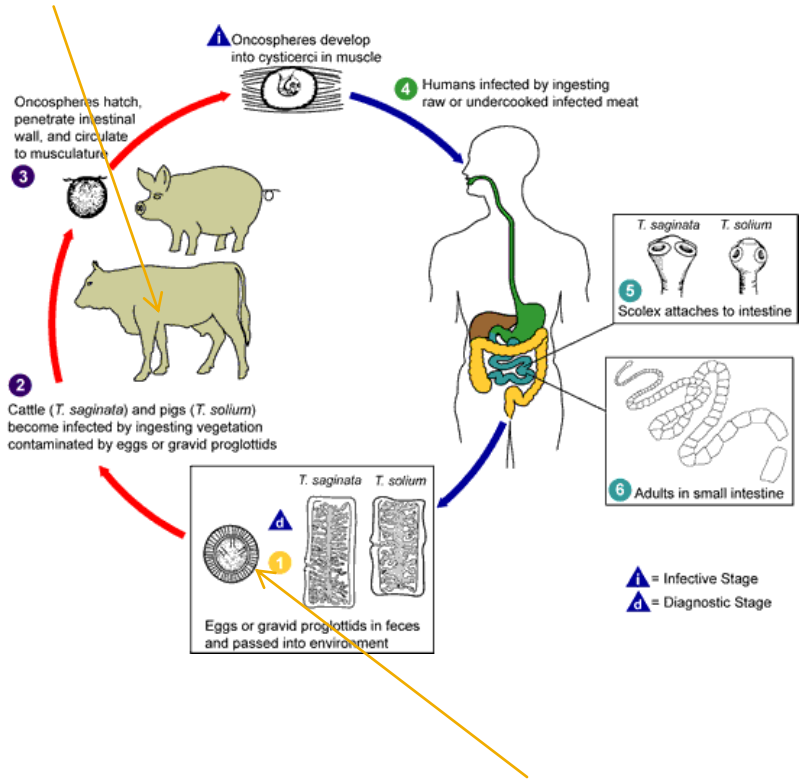
Oncosphere (hexacanth or six-hooked larva)

T. saginata-Oncosphere

New York State Department of Health

T. saginata-Lifecycle

Metacestode



- **Cattle can experience disease due to the space-filling lesions created by cysticerci.**
- **Usually, however, they do not show signs of infection.**

Oncosphere (hexacanth or six-hooked larva)

T. saginata-Cellular and Molecular Pathogenesis

- Bowel obstruction does not occur because *T. saginata* is thin and flexible and relatively fragile.
- Antibodies produced in humans.
- In cattle, IgA responses to the onchospheres is protective.
  - Colostrum from immune mothers protects sheep from invasion by oncospheres in experimental infections.

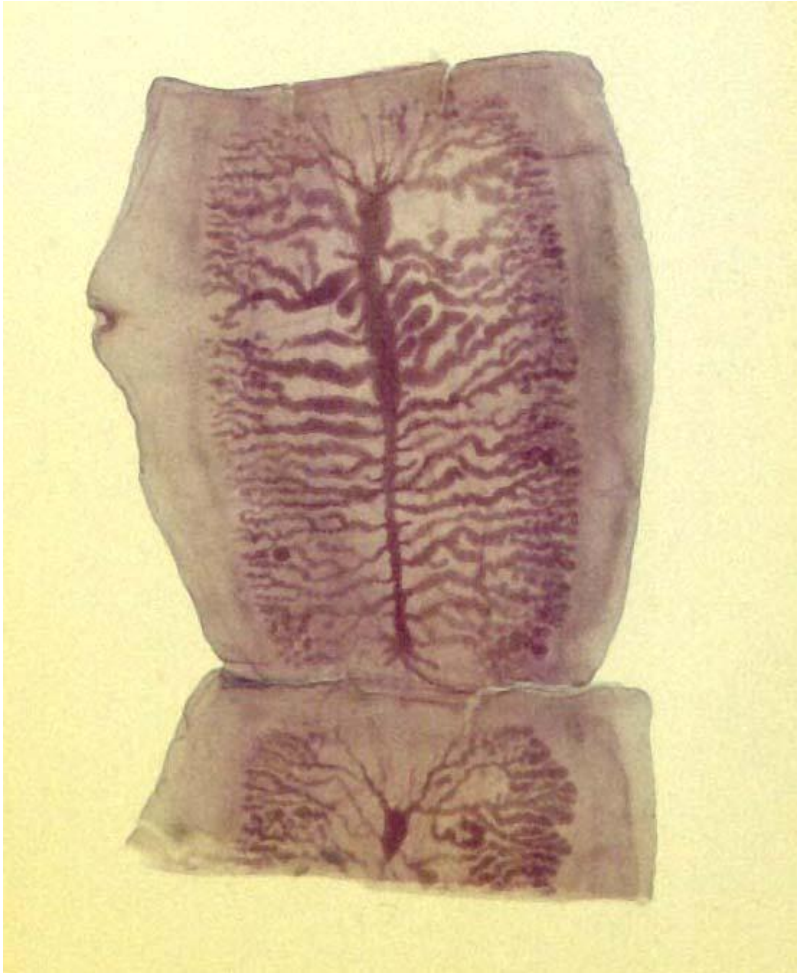
T. saginata-Clinical Disease

- Most infections induce no symptoms.
  - Nausea
  - Vomiting
  - Diverticulitis

T. saginata-Diagnosis

- Definitive diagnosis is by identification/inspection of proglottids.
- Gravid proglottids should be fixed in 10% formaldehyde solution, and the uterus injected with India ink.
- *T. saginata* proglottids typically have 15 or more side branches on either side of the uterus.

T. saginata-Proglottids



T. saginata-Diagnosis

- *T. saginata* eggs are occasionally found in stool.
- However, the species cannot be determined based on morphology since all members of the family Taeniidea produce identically-shaped ova.

T. saginata-Treatment

- **Praziquantel**
  - **Allows for the recovery of the scolex, thereby confirming cure of the patient and identification of the type of tapeworm.**
- **Niclosamide**
  - **Blocks the parasite's ATPase, thus preventing it from interfering with host digestive enzymes.**
  - **The consequence of treatment is dissolution of the adult worm, hence, a search for the scolex is futile.**

T. saginata-Scolex

T. saginata-Prevention and Control

- Proper disposal of human feces.
  - In many parts of the world it is used as fertilizer.
- Thoroughly cooking beef.
- Thoroughly freezing it (meat) prior to cooking.
- Vaccine against the oncosphere of *T. saginata* for use in cattle.
  - Cost of use is a problem.

Taenia solium

"...as worm to a toad, a toad to a snake, a snake to a pig, a pig to a man, and man to a worm."

--Ambrose Bierce (1842-1914)

Taenia solium-pork tapeworm

- Can reach 6 meters in length.
- Lives in the lumen of the upper half of the small intestine.
- No reservoir hosts.
- In contrast to *T. saginata*, infection with the metacestode form, referred to as cysticercosis, can be a serious, even fatal disease.
- Each proglottid can produce 50, 000 eggs.

Taenia solium-Distribution

- Endemic in most of South America (particularly in the Andean region and Brazil).
- Central America
- Mexico
- China
- Indian subcontinent
- Southeast Asia
- Sub-Saharan Africa
- Eastern Europe

- In endemic regions, up to 6% of the population may harbor *T. solium* tapeworms.
- In the U.S. the highest prevalence of infection occurs among Hispanic populations in Southern CA, NM, and TX.

Taenia solium-Historical Information

- Goez, in 1792, described the adult parasite.
- Cysticercosis in pigs was described by Hartmann in 1688.
- Kuchenmeister, in 1855, transmitted the infection to a condemned murderer who was about to be executed; he secretly contaminated the man's food with cysticerci.
  - At autopsy, 5 days after the prisoner had dined on contaminated meat, Kuchenmeister recovered immature adults of *T. solium* in the man's small intestine.

Taenia solium-Cellular and Molecular Pathogenesis

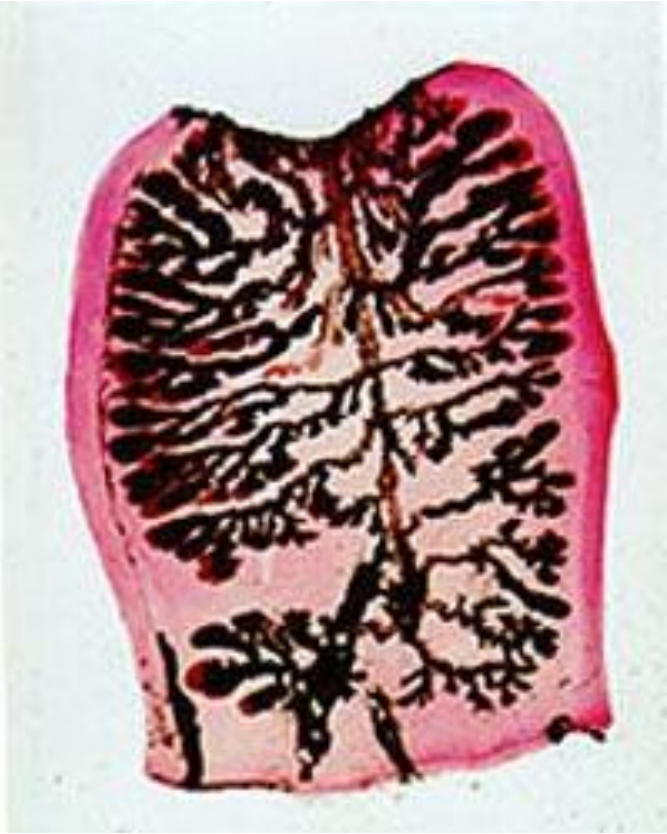
- Adult parasites do not usually cause a significant inflammatory response, but does elicit antibody formation.
- Infected pigs do not become reinfected when they ingest more eggs (similar to what is observed with reinfections with *T. saginata* and cattle).

Taenia solium-Clinical Disease

- Patients usually asymptomatic and do not become aware of infection until they discover the proglottids in stool.
- Some patients report abdominal pain, distension, diarrhea, and nausea but there are no controlled studies linking symptoms to infection.

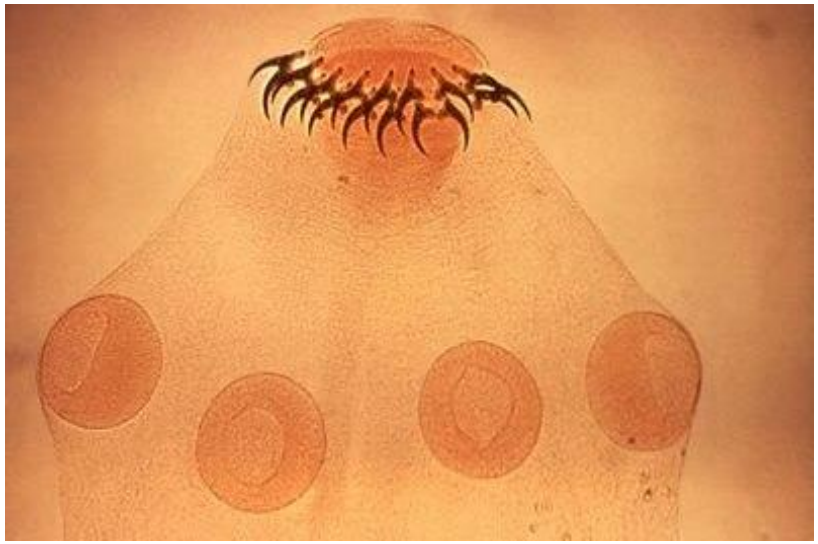
Taenia solium-Diagnosis

- Analysis of the gravid proglottids.
  - *T. solium* proglottids have less than 14 uterine branches per side.
  - Care must be when when handling unfixed proglottids.



Taenia solium-Diagnosis

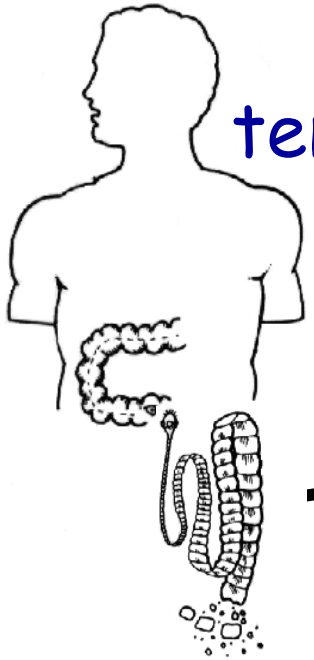
- Recovery of the scolex.
- Polyethylene glycol salt purges to improve bowel cleaning significantly improves the likelihood of scolex recovery.
- ELISA that detects fecal antigen is 95% sensitive and 99% specific.
- MRI, CT



Taenia solium-Treatment

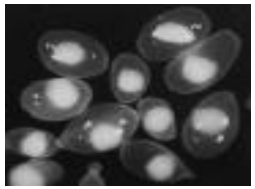
- Niclosamide is the drug of choice.
  - Not absorbed from the intestinal lumen.
- Praziquantel is also effective but its use must be tempered by the possibility that this treatment will also destroy cysticerci in the brain.
- Purgatives should not be used because they increases the chance of regurgitating eggs into the stomach and thus initiating the infection leading to cysticercosis.

Taenia solium-Treatment



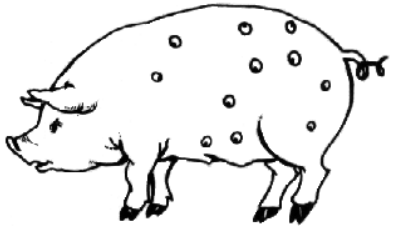
teniosis

Neurocysticercosis



cysticerci

T. solium eggs



cysticercosis

Epileptic seizures

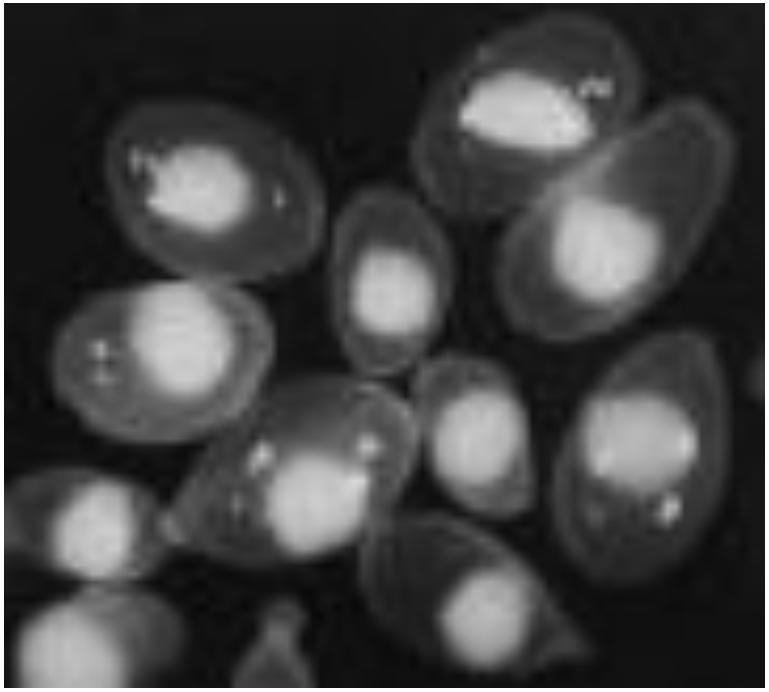
Hydrocephalus

meningitis

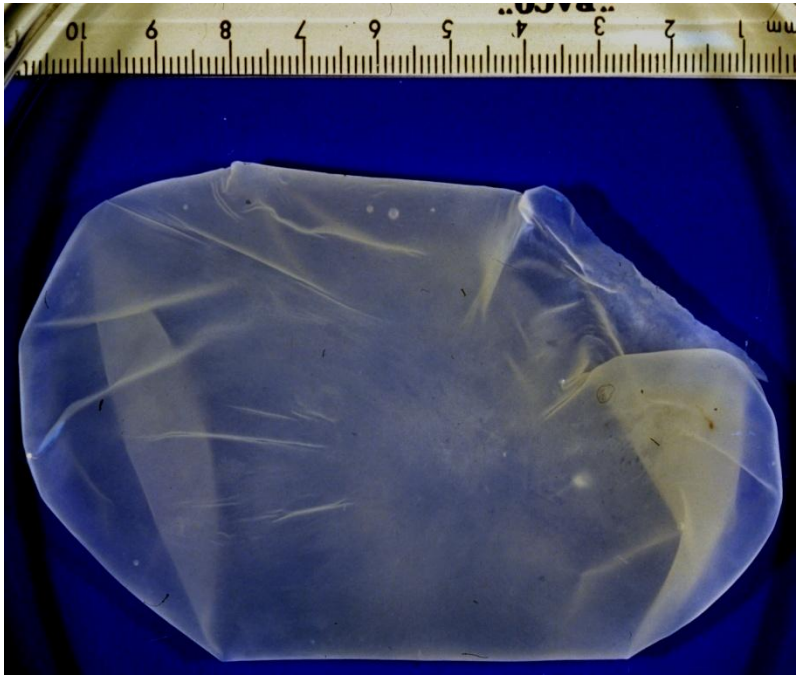
Mental disorders

Taenia solium metacestodes or cysticerci

CELLULOSE (1 CM)



RACEMOS (9 CM)



Epidemiology of NCC

- One of the most common parasitic infections of the human CNS
  - 20 million infected
  - WHO- 50,000 deaths per year
  - many of the surviving patients are left permanently disabled
    - recurrent seizures
    - neurologic damage

Epidemiology of NCC

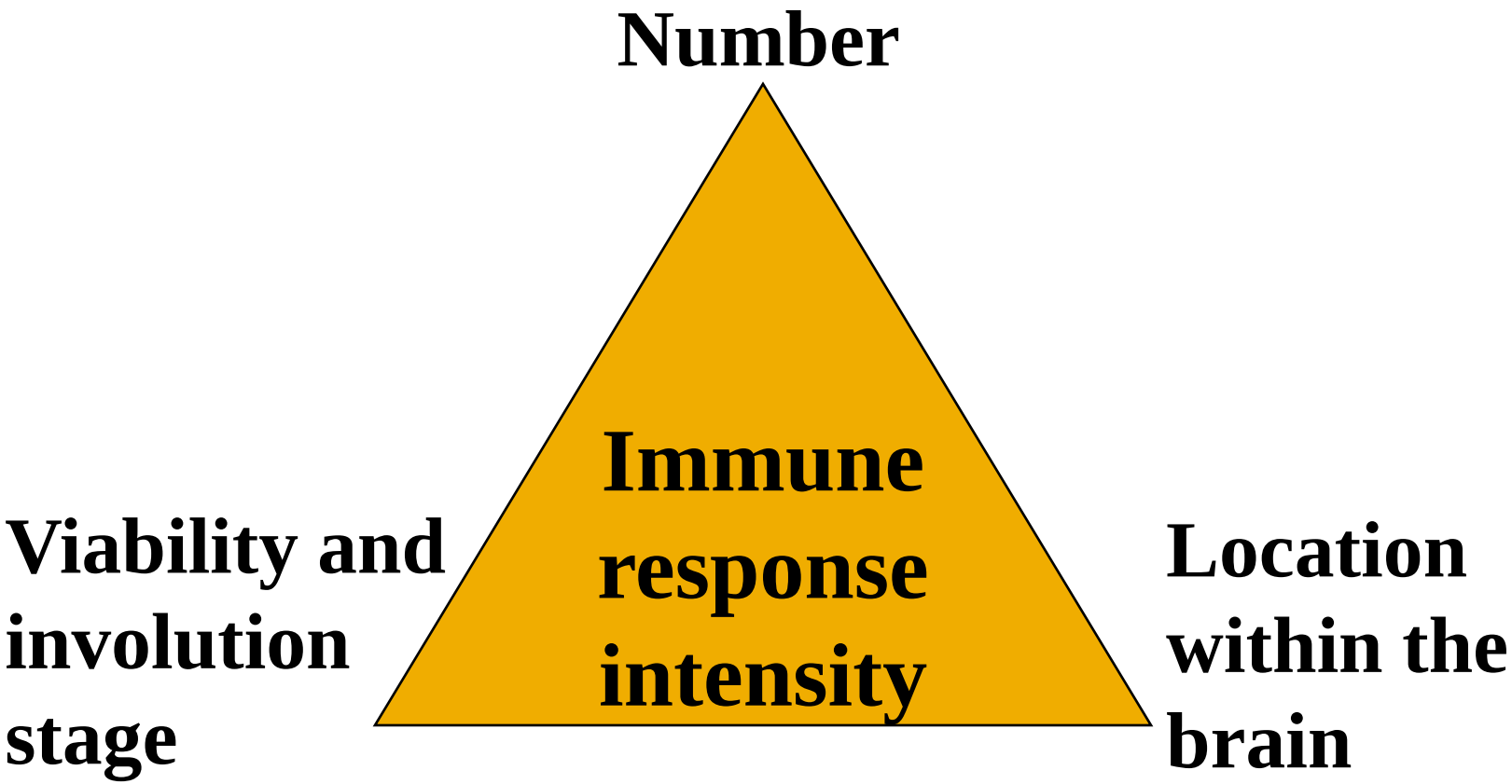
- Endemic in developing countries of Latin America, Asia and Africa
- In the U.S.A. it has been recognized as a medical problem
  - 90% Hispanic immigrants
  - 10% locally acquired

Clinical manifestations

Presentation	%
Seizures	60
Headache, vomiting, papilledema	25
Altered mental status (dementia, confusion, stupor)	15
Focal neurological findings (hemiparesis, aphasia, paraparesis, visual loss)	10
Chronic meningitis	25
Asymptomatic and accidental discovered	10

Davis & Kornfeld, 1991

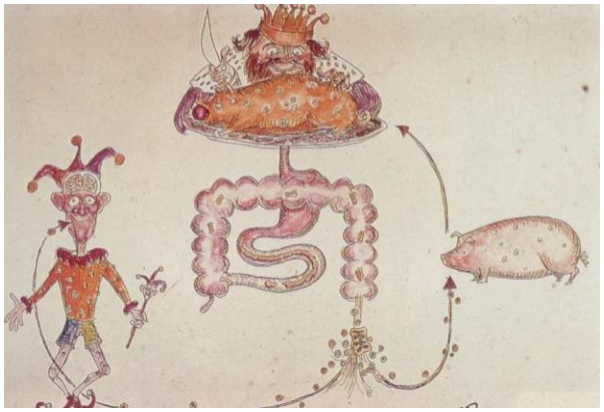
Parasite factors associated with immune stimulation

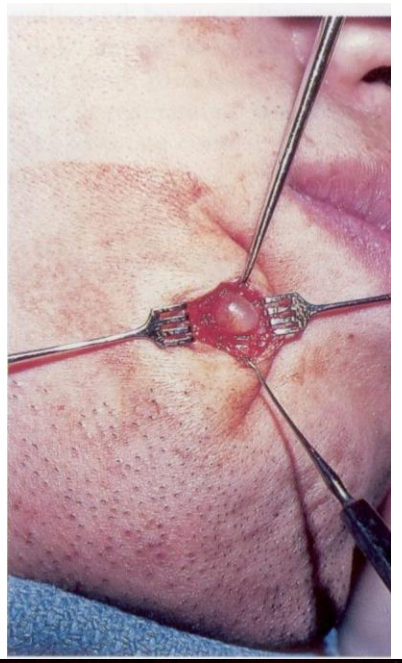


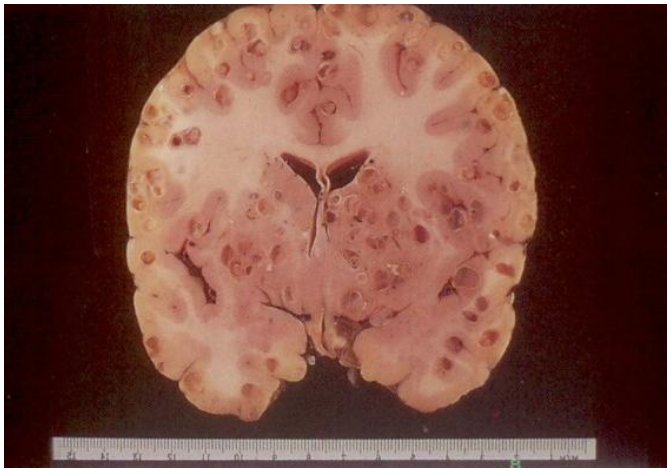
How does the parasite affect the CNS?

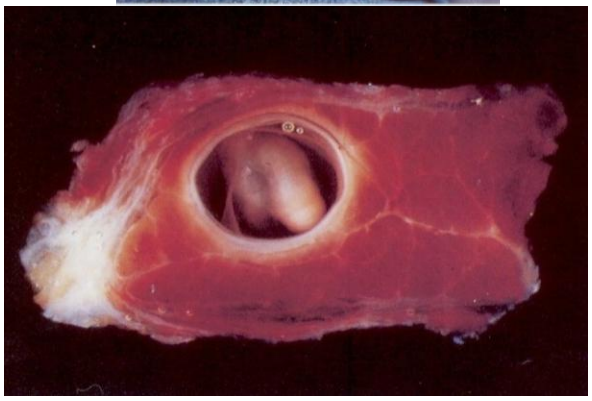
- Directly
  - obstruct CSF circulation
  - pressure on the nervous tissue
- Indirectly
  - inducing an immune response
    - edema and alteration of the microenvironment

Cysticerci can affect multiple tissues



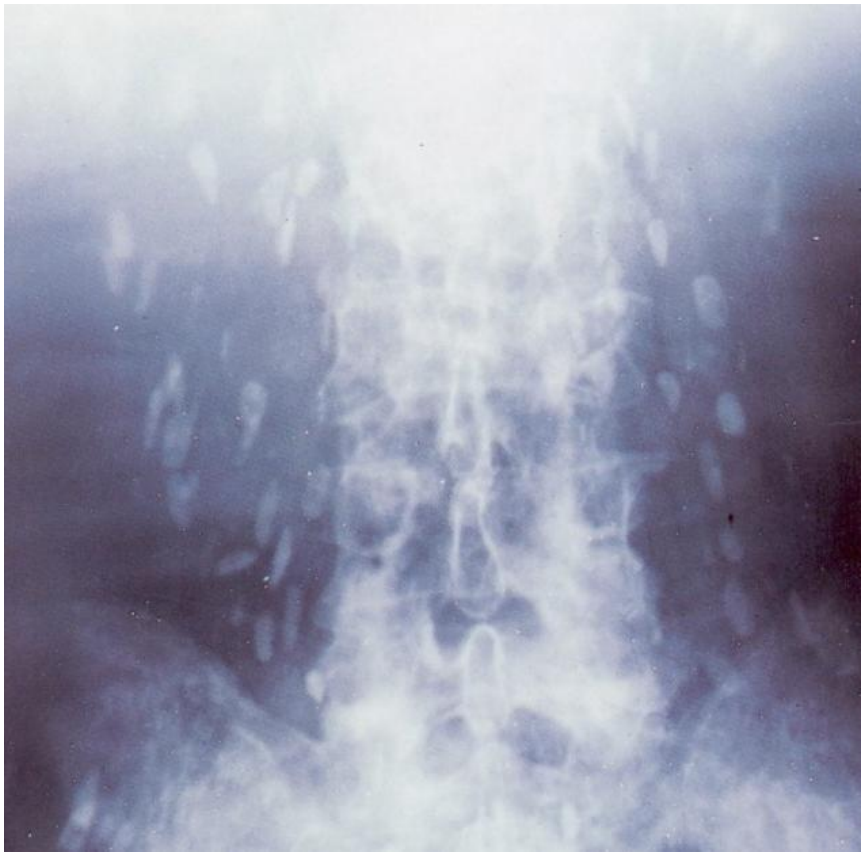






Cysticerci can affect multiple tissues

- An adult male African took a "medicinal" potion containing a ground up proglottid of *T. solium*.
- The eggs became cysticerci and eventually calcified, giving much o f his body the appearance of a snow storm.



ANIMAL MODELS TO STUDY NCC

- **Porcine**
  - **Parasite: *T. solium* oncospheres**
  - **Inoculation: Oral (natural infection)**
- **Murine**
  - **Parasites:**
    - ***Mesocestoides corti***
    - ***Taenia crassiceps***
  - **Inoculation route: i.c. and i.p**

Taenia solium-Prevention and Control

- ***T. solium*** **is a significant public health problem, even outside the endemic areas, due to the association of cysticercosis with the adult infections.**
  - ***e.g.*****, an outbreak of cysticercosis was reported among an orthodox Jewish community in New York City resulting from the ingestion of *T. solium* eggs passed from domestic employees who were recent emigrants from Latin America.**

Taenia solium-Prevention and Control

- Protecting pig's feed from contamination.
- Sanitation
- Education
- Thoroughly cooking pork or by freezing it at -10°C for a minimum of 5 days.
  - Cysticerci can survive at 4°C for 30 days.
- Inoculation of pigs with recombinant antigens cloned from parasite onchoshere mRNA appears to be an effective vaccine.
  - Treating pigs with oxfendazole eliminated 100% of viable cysticerci in one study.

Recombinant expression of *Taenia solium* TS14 antigen and its utilization for immunodiagnosis of neurocysticercosi

ACTA Tropica, 2006

Marcia Ramos Monteiro da Silva[a, b, ,], Antônio Augusto Mendes Maia[b], Noeli Maria Espíndola[c], Luís dos Ramos Machado[d], Adelaide José Vaz[c] and Flávio Henrique-Silva[a]
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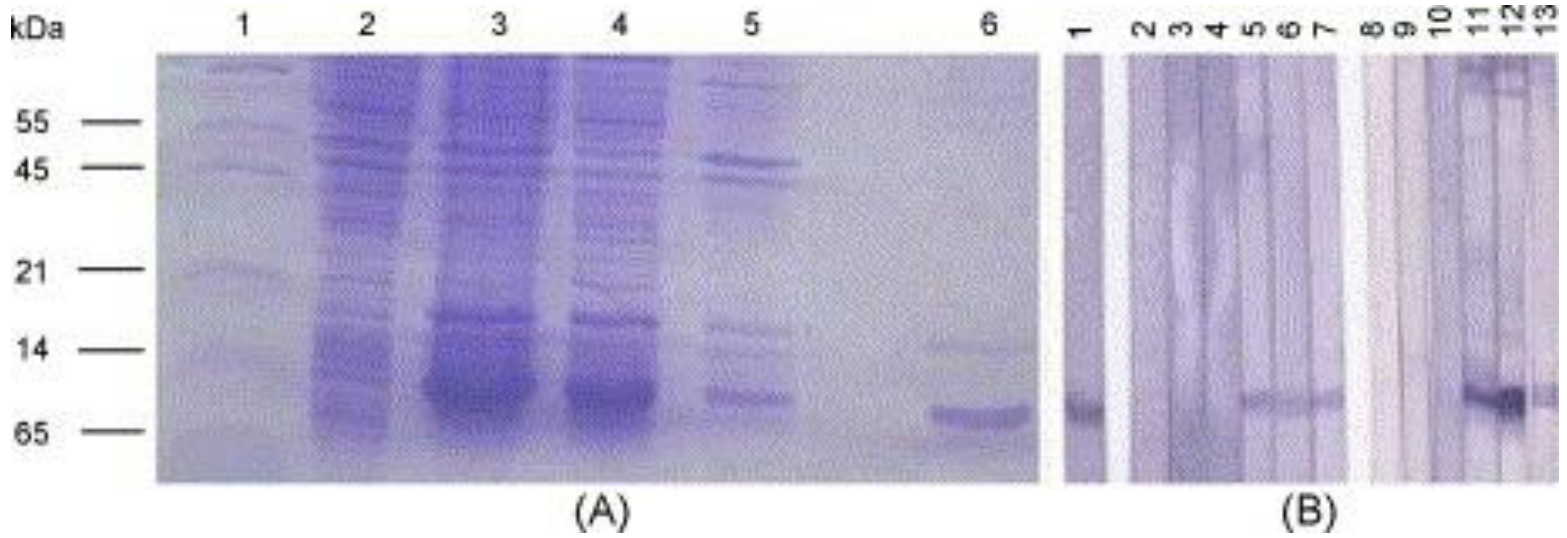
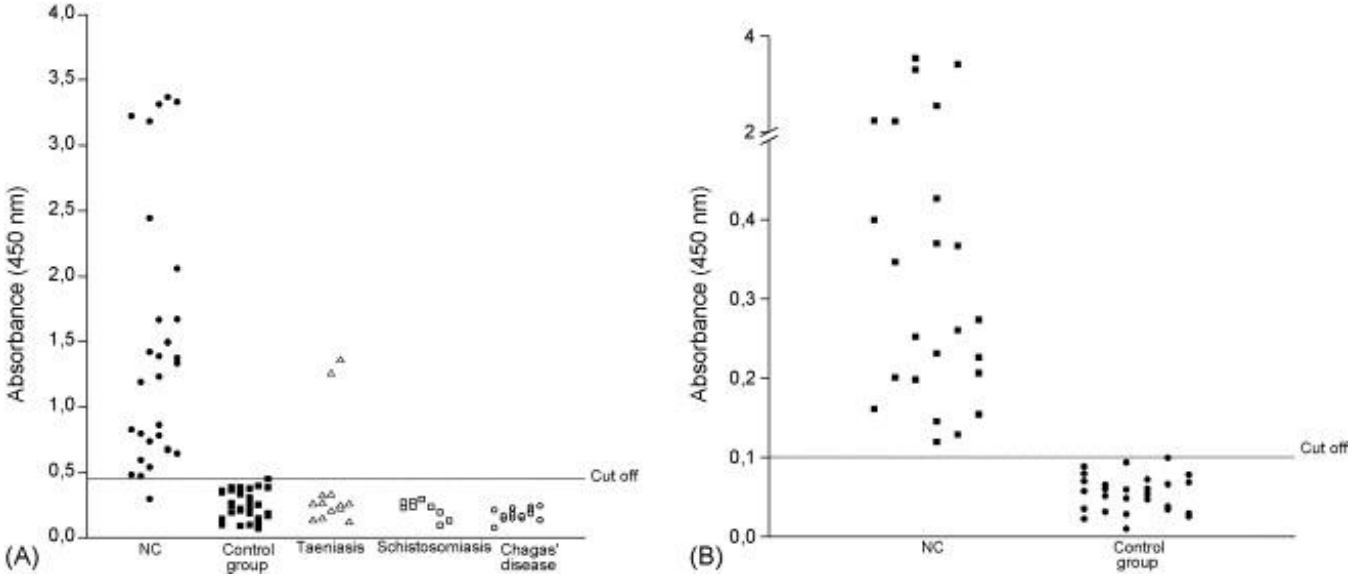
Trycine-PAGE analysis of $_{HIS}$TS14 purification

- Lane 1, molecular-weight markers; lane 2, total *Escherichia coli* proteins from uninduced cultures containing the recombinant plasmid; lane 3, post-induction cell proteins of bacteria containing the recombinant plasmid; lane 4, supernatant after solubilization in 0.25% sodium-*N*-lauroylsarcosine; lane 5, proteins unbound to Ni-NTA column; lane 6, elution fraction with 100 mM imidazole. (B) Immunoblot analysis of TS14 antigen probed with: (1) MoAb against $_{HIS}$TS14; (2–4) serum sample from control group; (5–7) serum sample from NC patients; (8–10) CSF sample from control group; (11–13) CSF sample from NC patients.



Results of ELISA using *HIS*TS14 antigen

- In (A) serum samples of NC patients, control group, taeniosis, schistosomiasis and Chagas' disease; in (B) CSF samples of NC patients and control group.



The role of sex steroids in the complex physiology of the host-parasite relationship: the case of the larval cestode of *Taenia crassiceps* (J. Morales, *Parasitology*, 2005)

- The role of host sexual differences first appeared in a Mexican national serological survey showing that women were more frequently seropositive.
- Female mice also carried larger parasite loads (1.3-10x more).
- Greater number of cysticerci in naturally infected female rodents.

The role of sex steroids in the complex physiology of the host-parasite relationship: the case of the larval cestode of *Taenia crassiceps* (J. Morales, *Parasitology*, 2005)

- Experimental approaches *e.g.*, neonatal gonadectomy and thymectomy, and/or whole body irradiation suggested that both the endocrine and immune systems are involved in the host's sexual differences of parasite loads.
  - Orchidectomy greatly increases parasite loads.
  - Ovariectomy reduces them.
    - Oestradiol and testosterone supplementation of gonadectomized mice restores their parasite loads to normal levels.

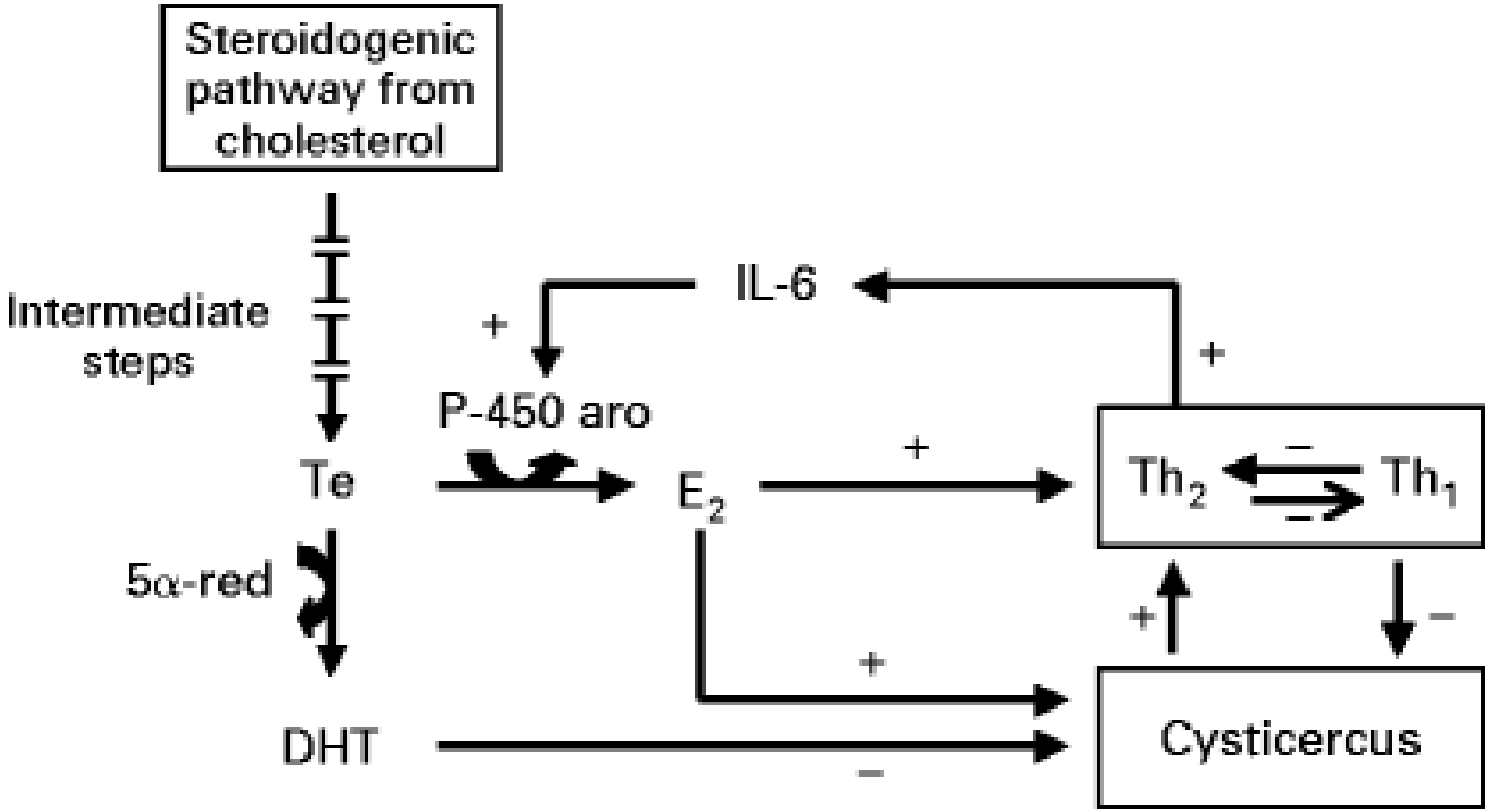
Molecular Feminization

(J. Morales, *Parasitology*, 2005)

- **"The startling finding of 'parasite-induced feminization of the host' is almost alone in the literature of parasitic infections (Phillips and Cannon, 1978), especially in mammals (Lin et al. 1990; Isseroff et al. 1989) and has, inexplicably, attracted little attention."**

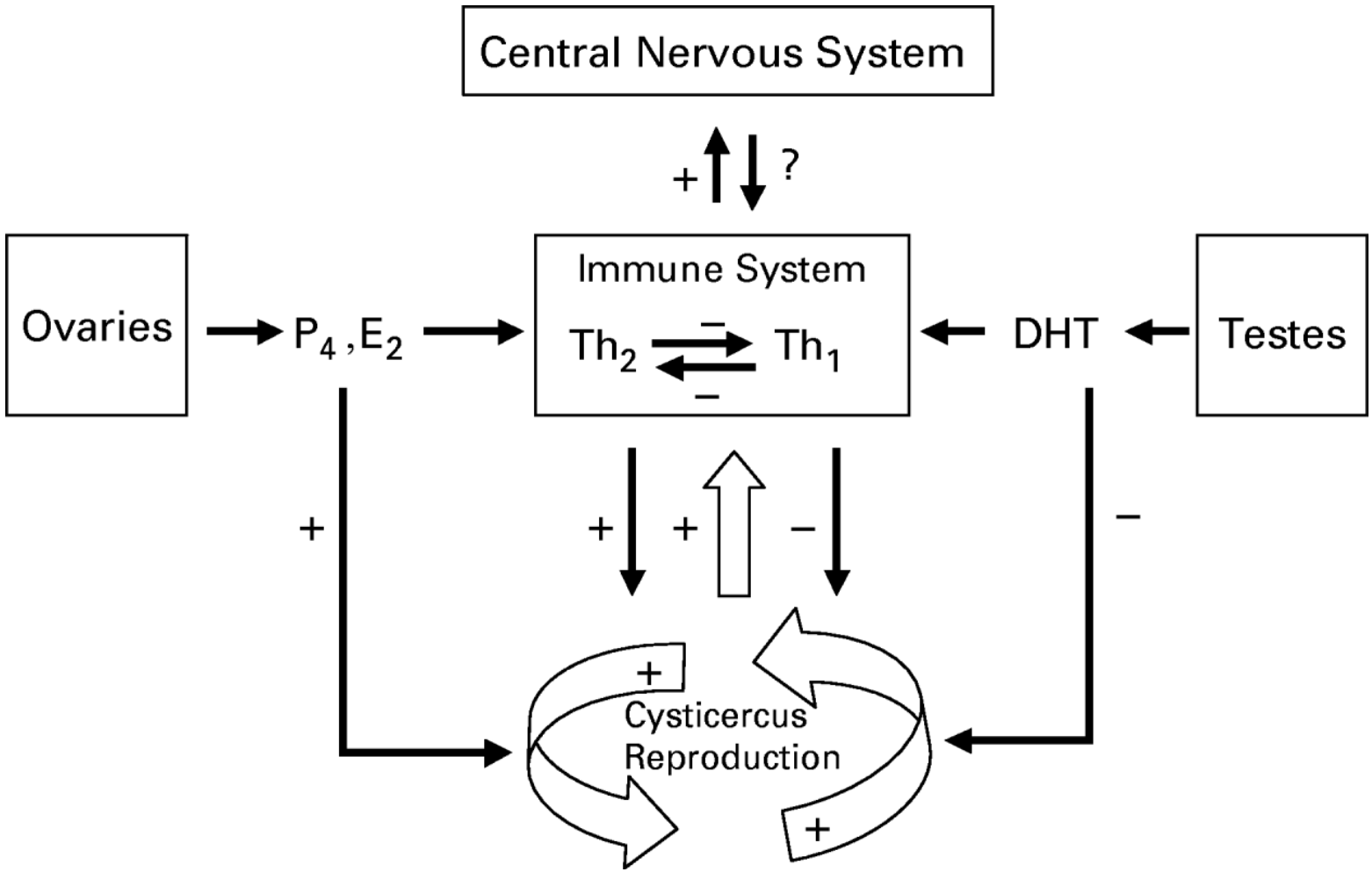
Molecular Feminization

(J. Morales, *Parasitology*, 2005)



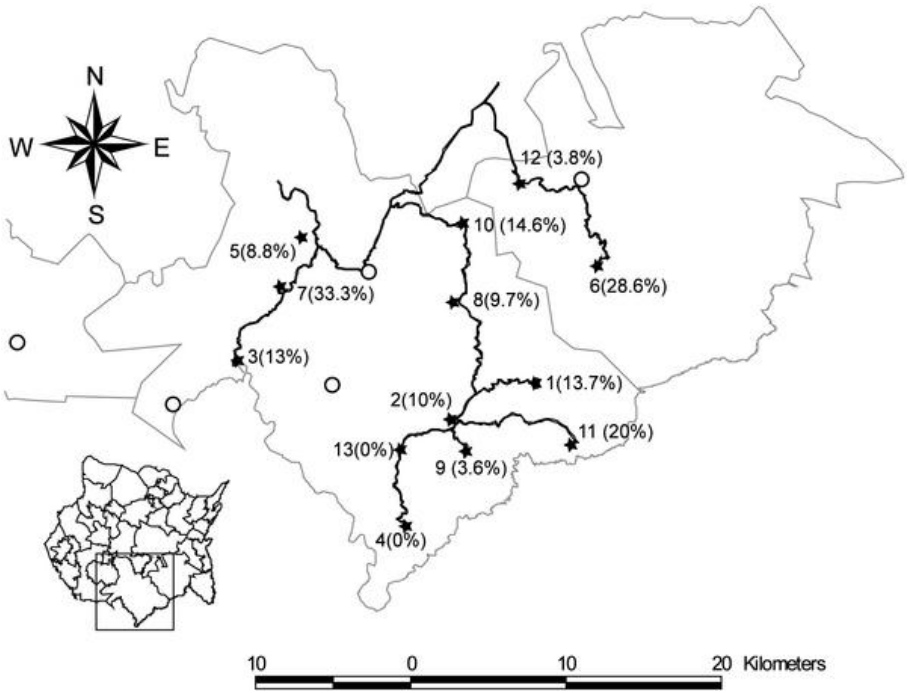
Direct Effect of Human Sex Hormones on Parasite Growth

(J. Morales, *Parasitology*, 2005)

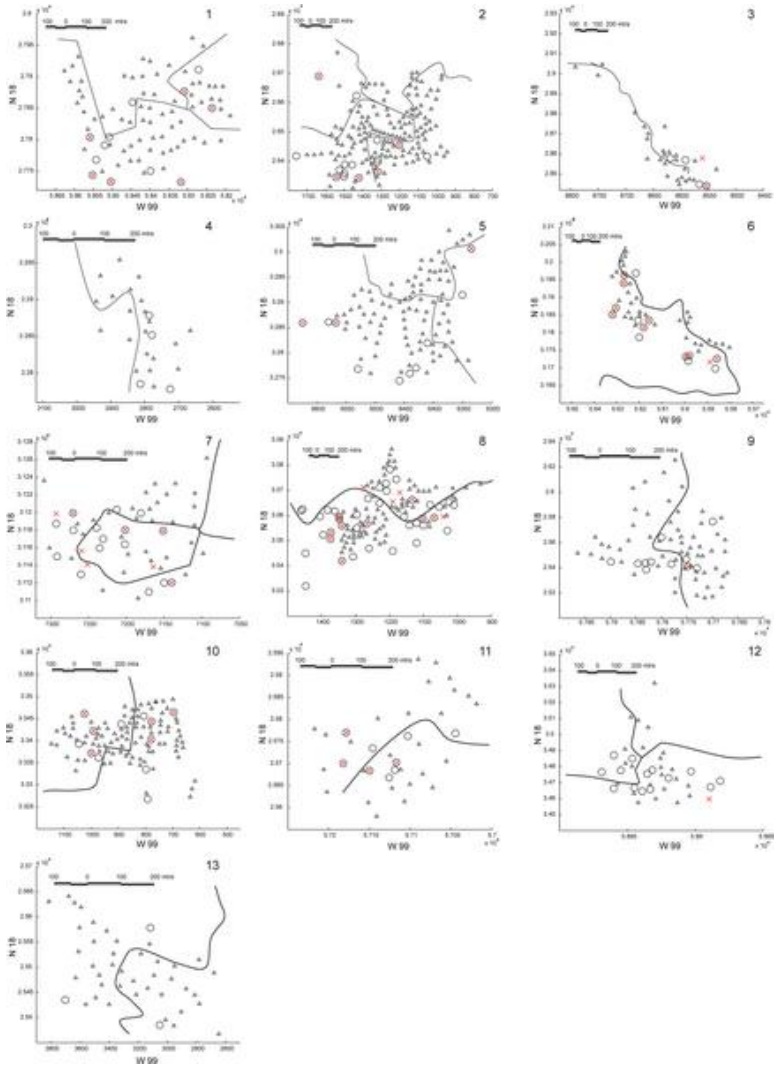


Spatial Distribution of *Taenia solium* Porcine Cysticercosis within a Rural Area of Mexico

(J. Morales, *PLOS*, 2008)

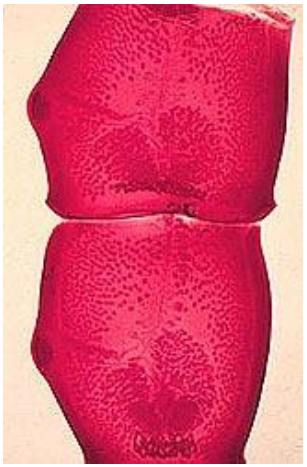


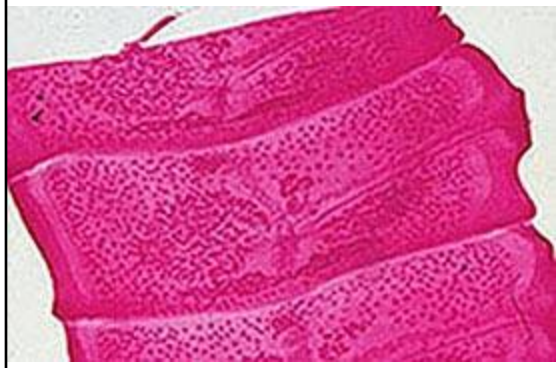
Morelos, Sierra de Huautla



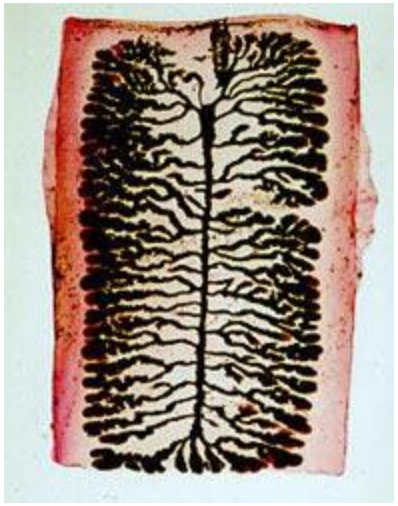
Features of adult *Taenia*

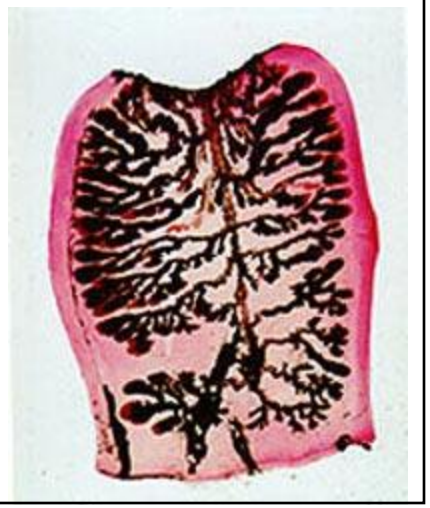
Proglotids





Uterine ramifications





Head (scolex): rostellum