# Helminths

- Phylum Nematoda (Roundworms) - "Nematodes"

- Phylum Platyhelminthes (Flatworms)
  - Class Cestoidea (segmented flatworms) - "Cestodes"
  - Class Trematoda (non-segmented flatworms) - "Trematodes"

# The tapeworms (Cestodes):

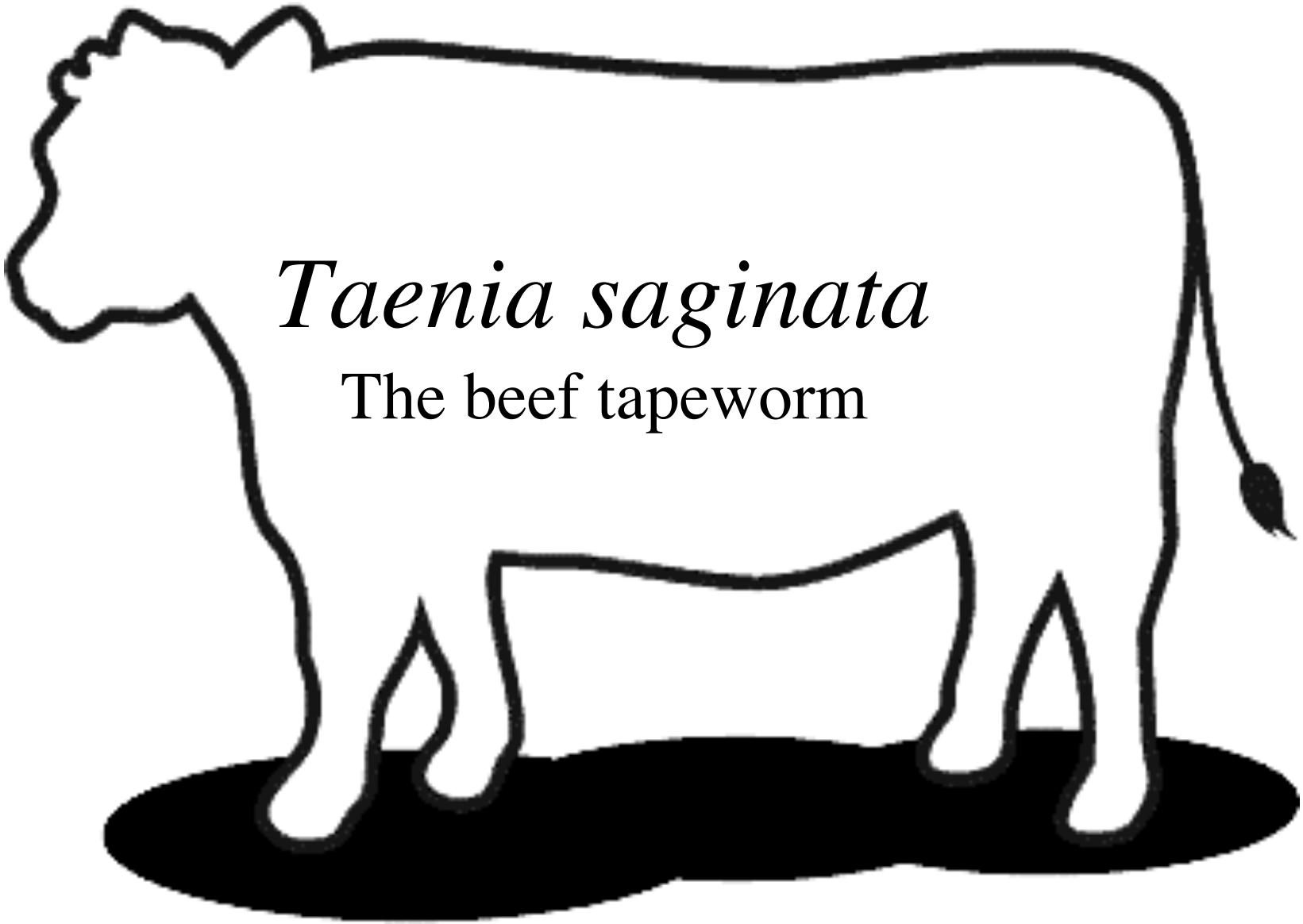
Taenia *saginata* (beef tapeworm)

Taenia *solium* (pork tapeworm)

---> Cysticercosis

Echinococcus *granulosus* (dog tapeworm)

---> Hydatid Disease


*Taenia saginata*
The beef tapeworm

# “Field o’ beeves”

D. Despommier,  master photographer and fly-fisherman

# “Plate o’ Beef”
# a la “Wellington

D. Despommier,  expert chef

# Cysticerci - heart of cow

Veterinary Pathology Laboratory, Univ. Penn

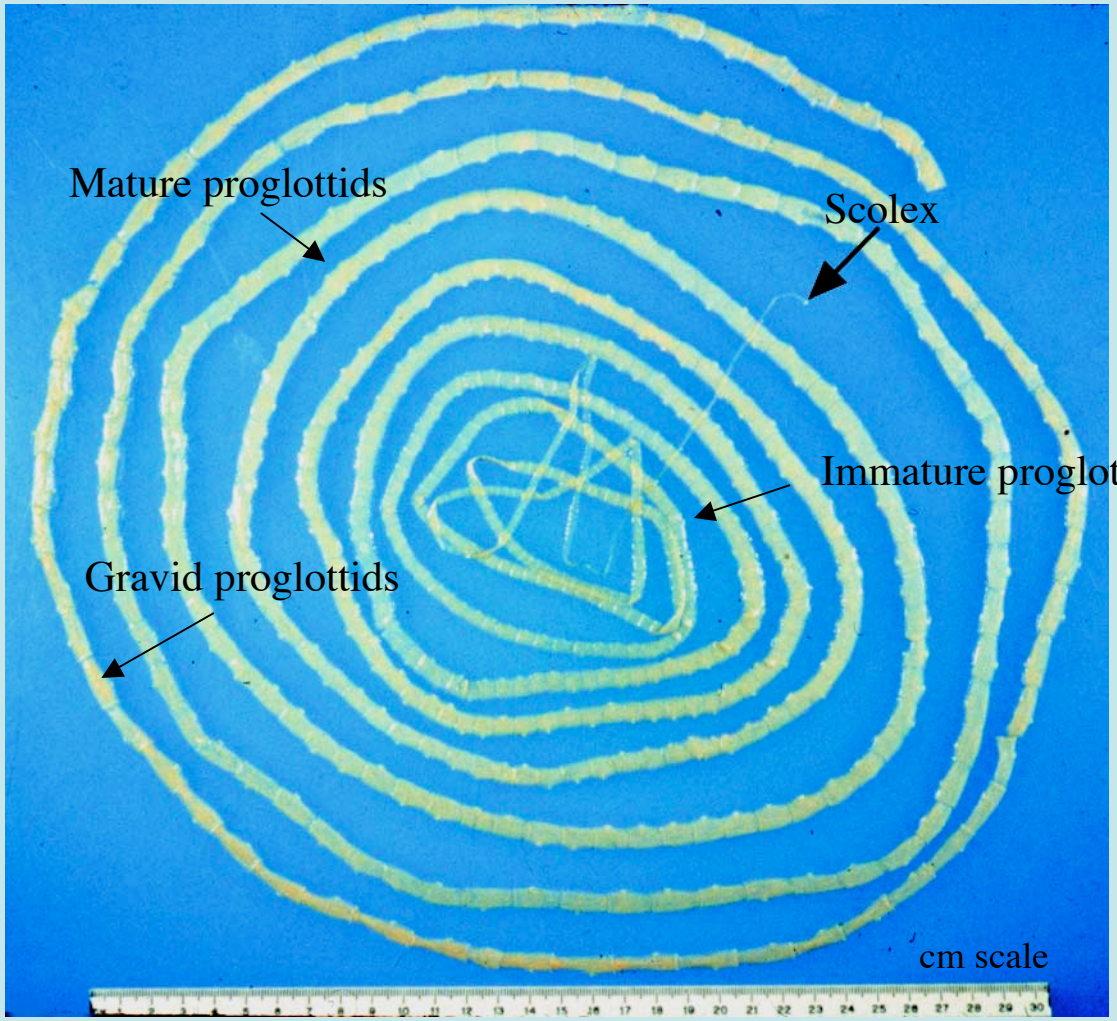
# Cestode hosts

***T. saginata***

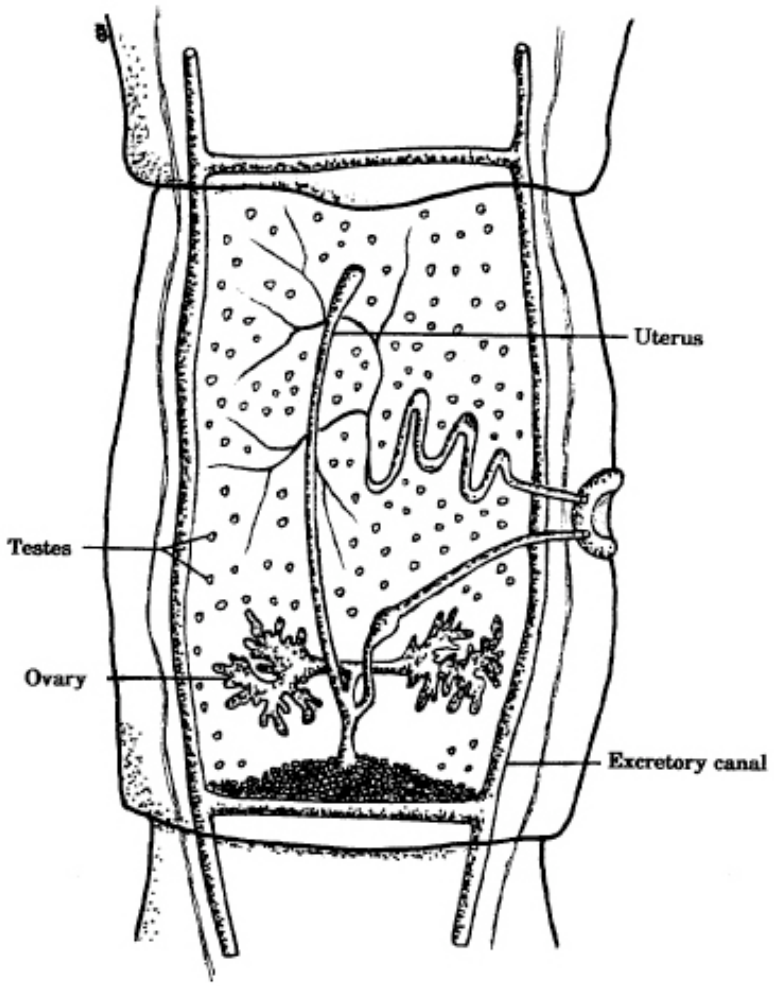
Definitive Host: Human

Intermediate Host: Cow

# Adult *Taenia saginata*



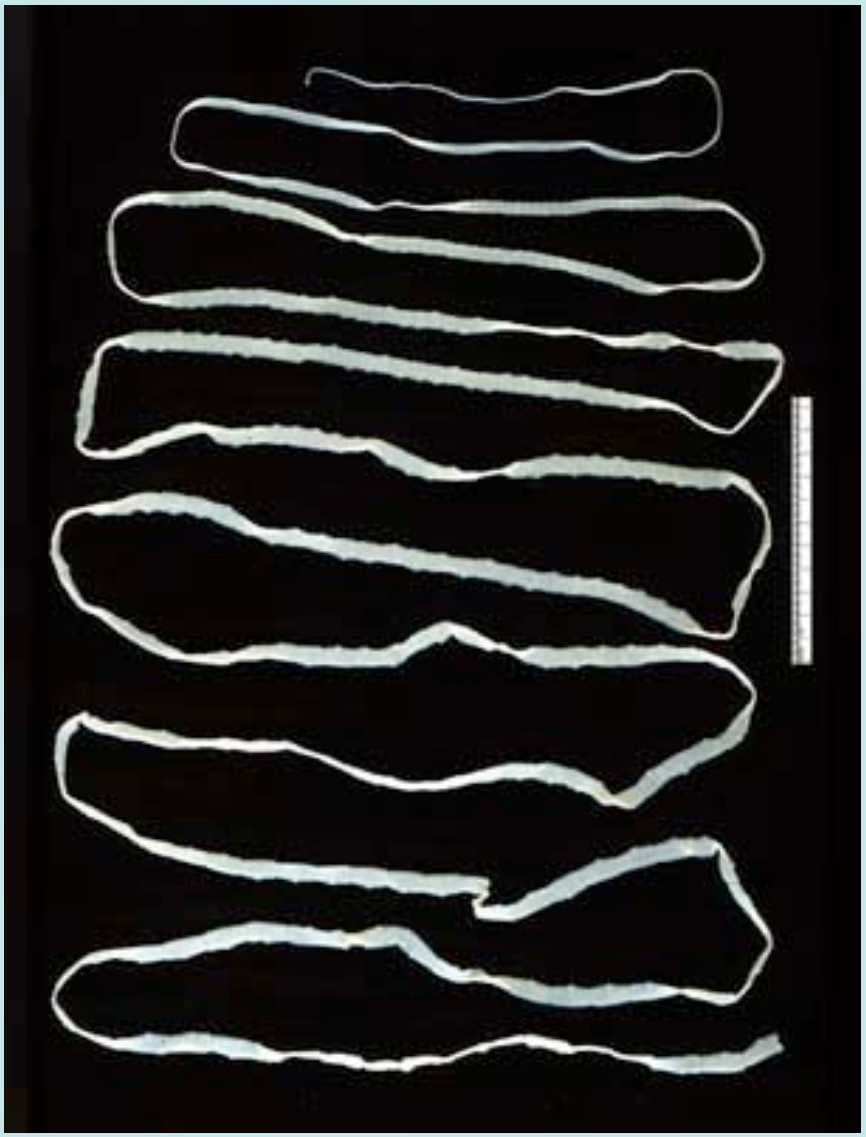
# *Taenia saginata scolex*




Tapeworm Proglottid

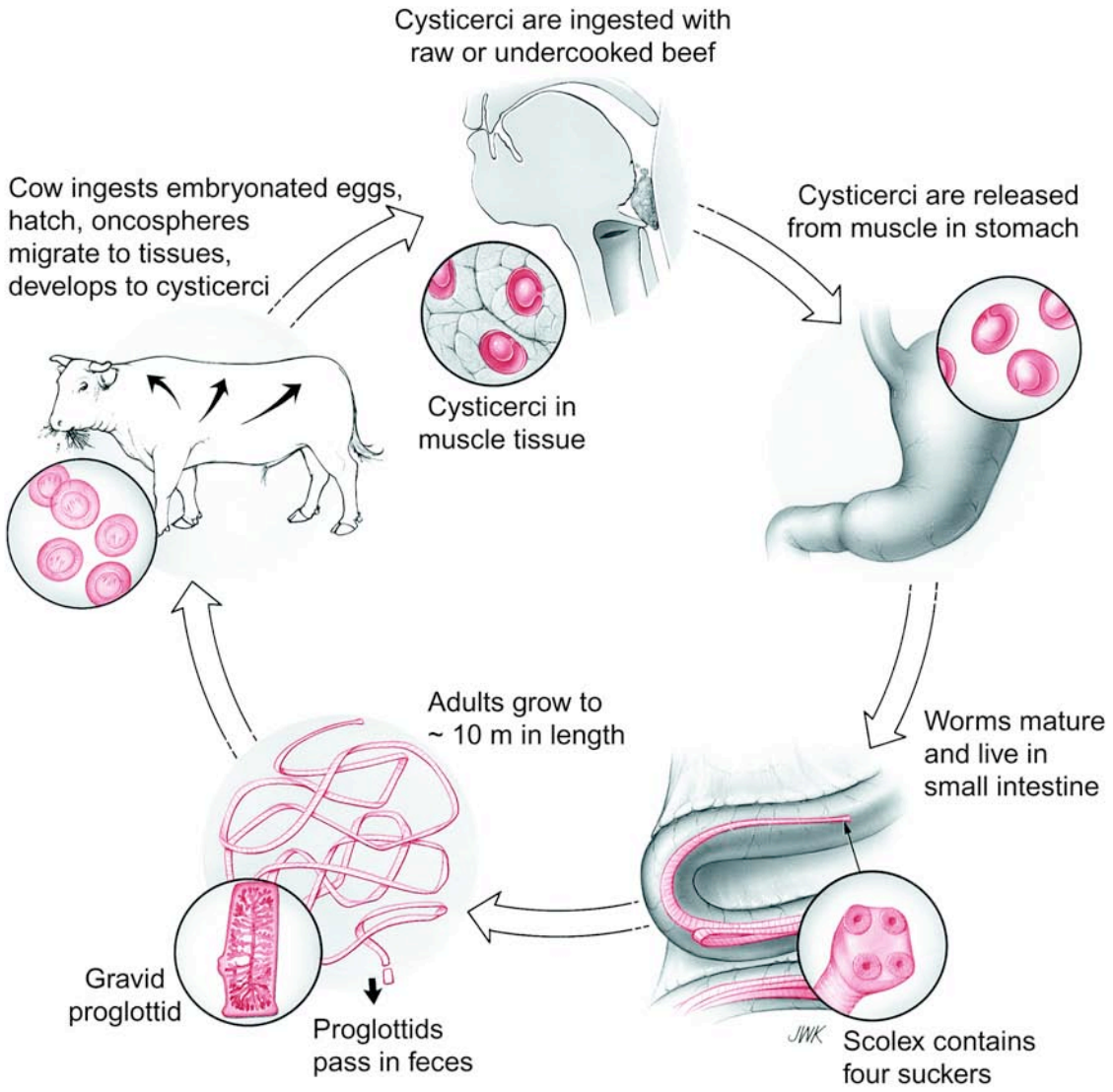
# Taenia *saginata* adult

"Bowl o' Worms"

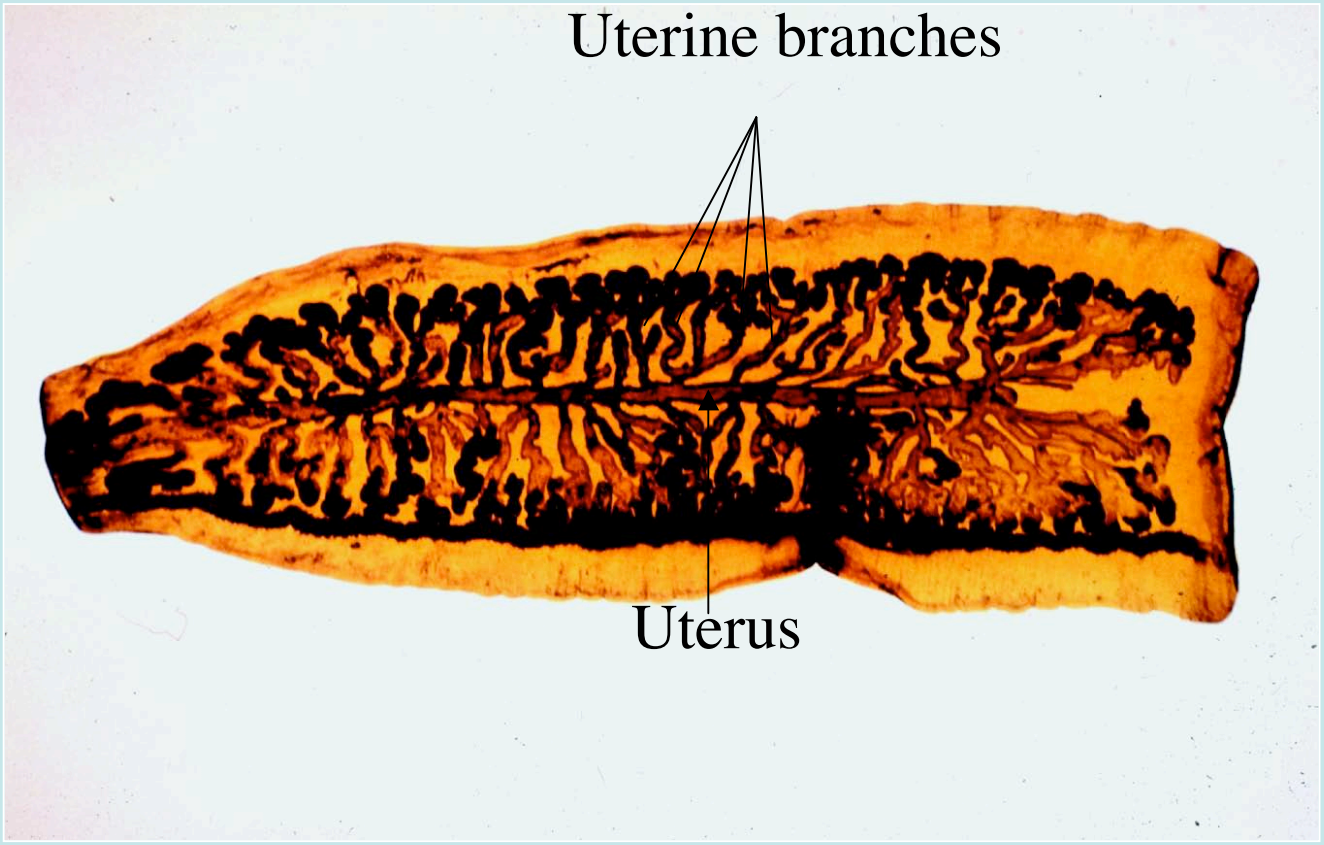


www.Healthinplainenglish.com/health/infectious_diseases/tapeworm

# *Taenia saginata*

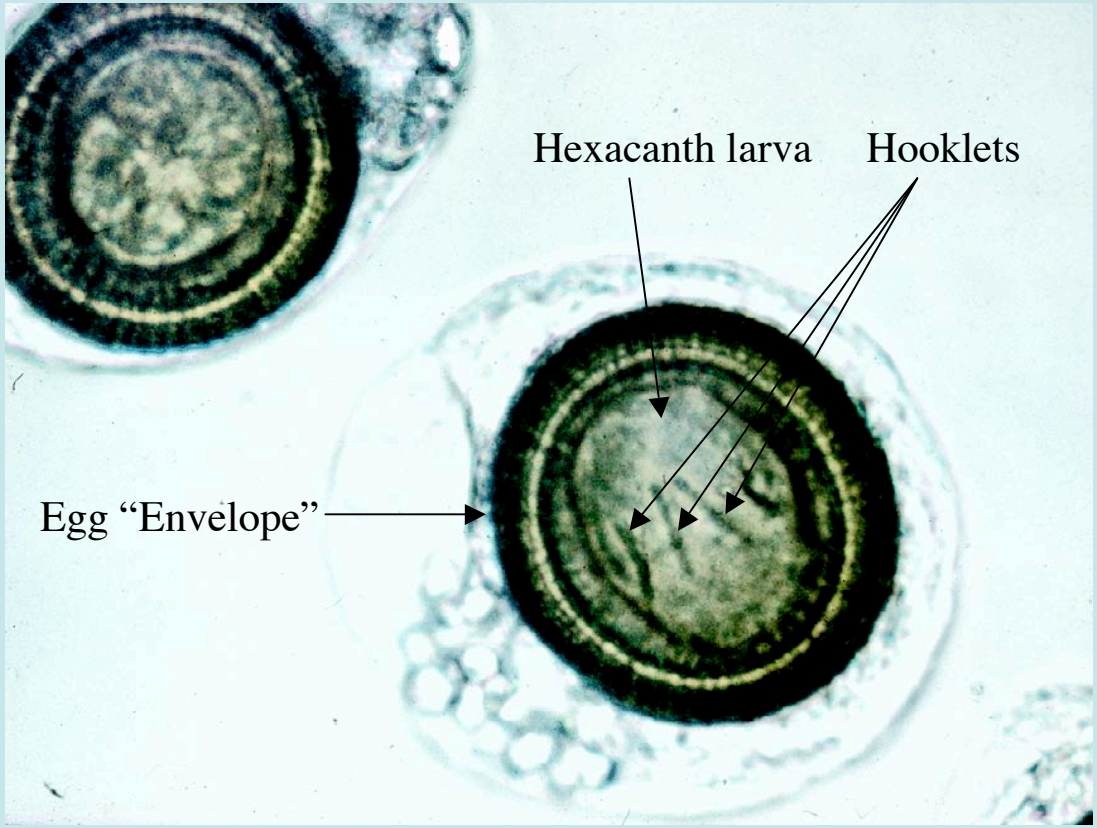


# Gravid Proglottid of *Taenia saginata*




*The central uterus of T. saginata has more than 12 branches on a side*

# Embryonated, infectious taeniid eggs




Cannot distinguish species of Taenia tapeworms based on morphology of eggs

# Pathogenesis:

None

# Clinical Disease:

None in humans

# Diagnosis:

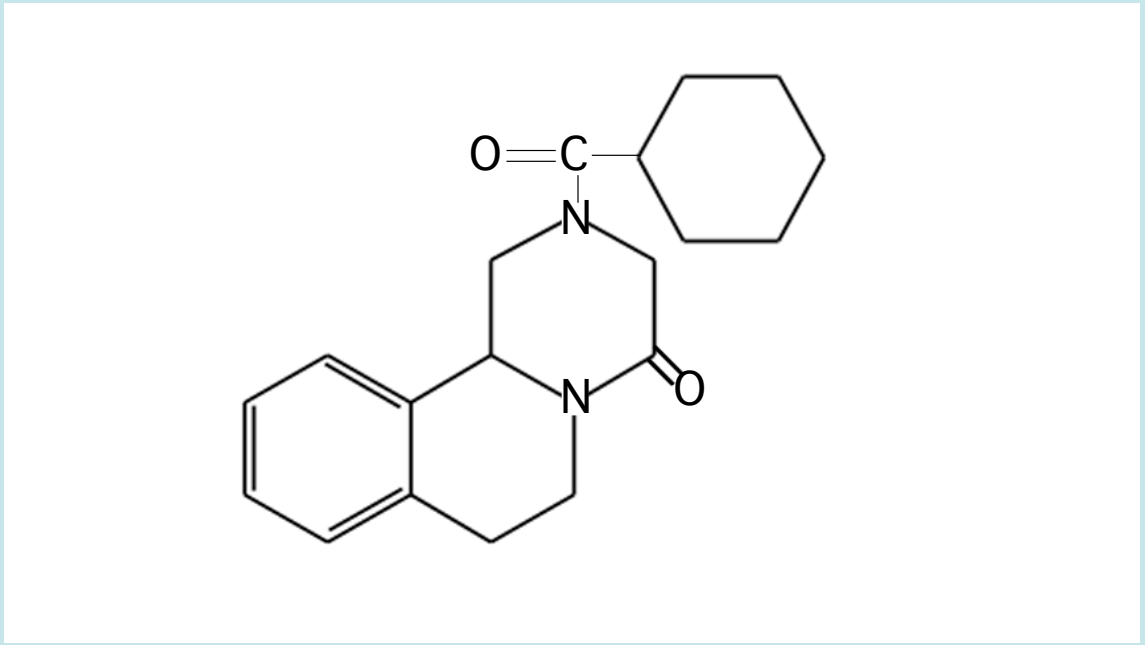
1. Find eggs or proglottids in stool

2. Identify species based on proglottid morphology, after formalin and India Ink

3. Identify scolex

# Drug of Choice

**Praziquantel**




Mode of Action:

Increases permeability of flatworm tegument to $Ca^{2+}$ ions, Causing muscle tetany and worm detachment.

# Prevention and Control:

## 1. Sanitary disposal of human feces

# Prevention and Control (cont'd):

2. Prevent cows from coming into contact with human feces, ie good sanitation and physical restraints.

3. Freeze and/or cook all beef until well-done
   Good luck, NYC restaurants!!
   (No more rare filet mignon or steak tartar)

4. Federal meat inspection programs (muscle exam or serum ELISA specific to larval stage).

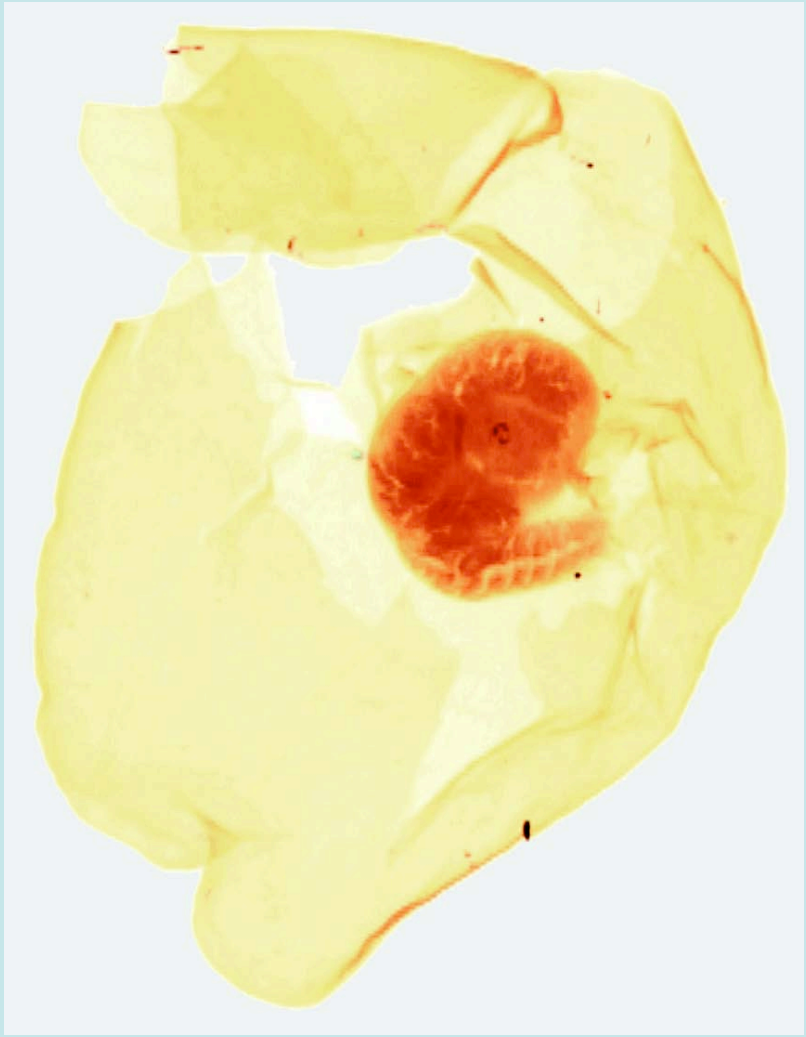
# *Taenia solium*

## The Pork Tapeworm

# *Still Life With Ham.  Or not?*

Oil on canvas, Paul Gauguin

# Whole cysticercus of *Taenia solium*



# Adult *Taenia solium*

# *Taenia solium* scolex

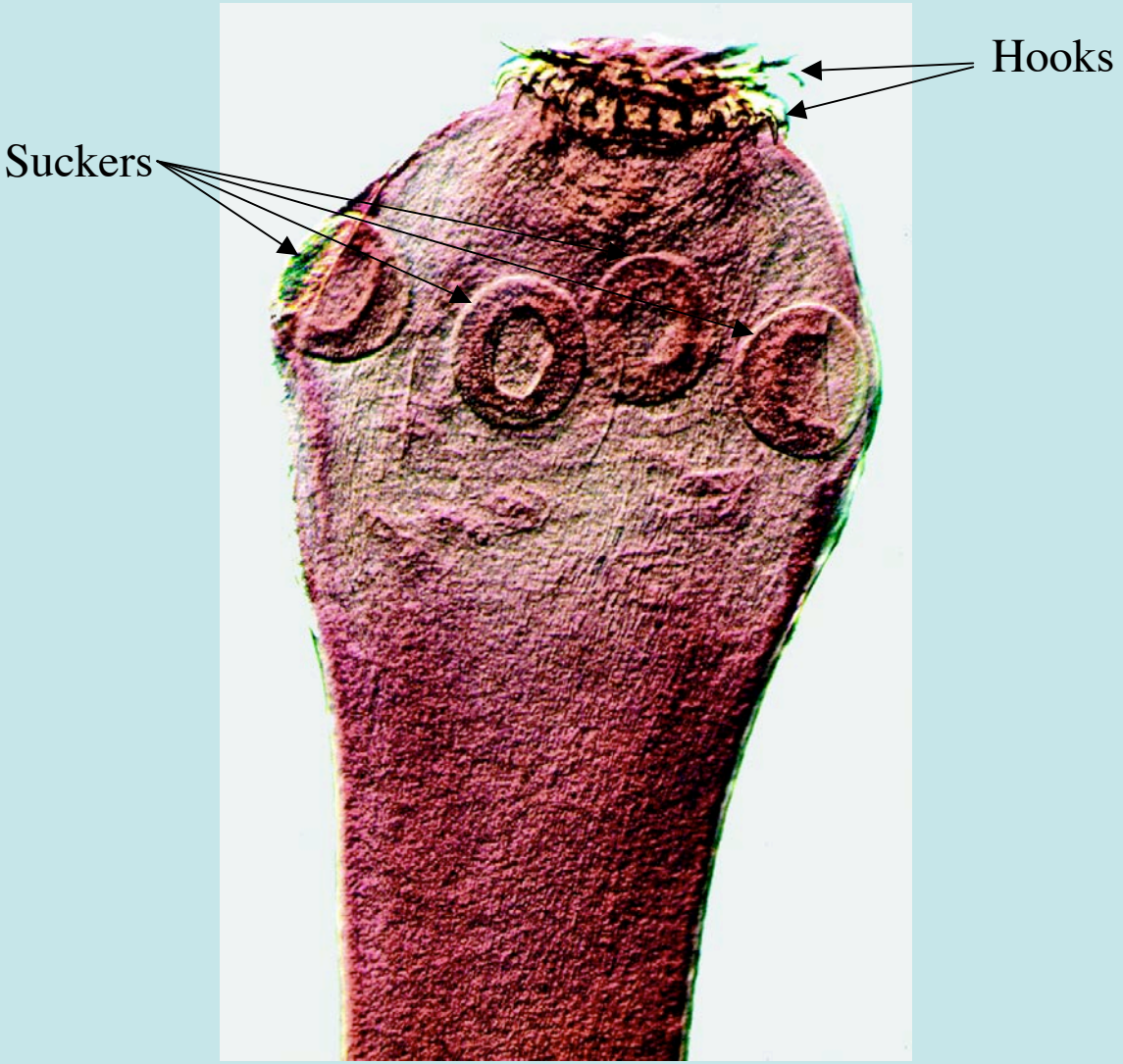
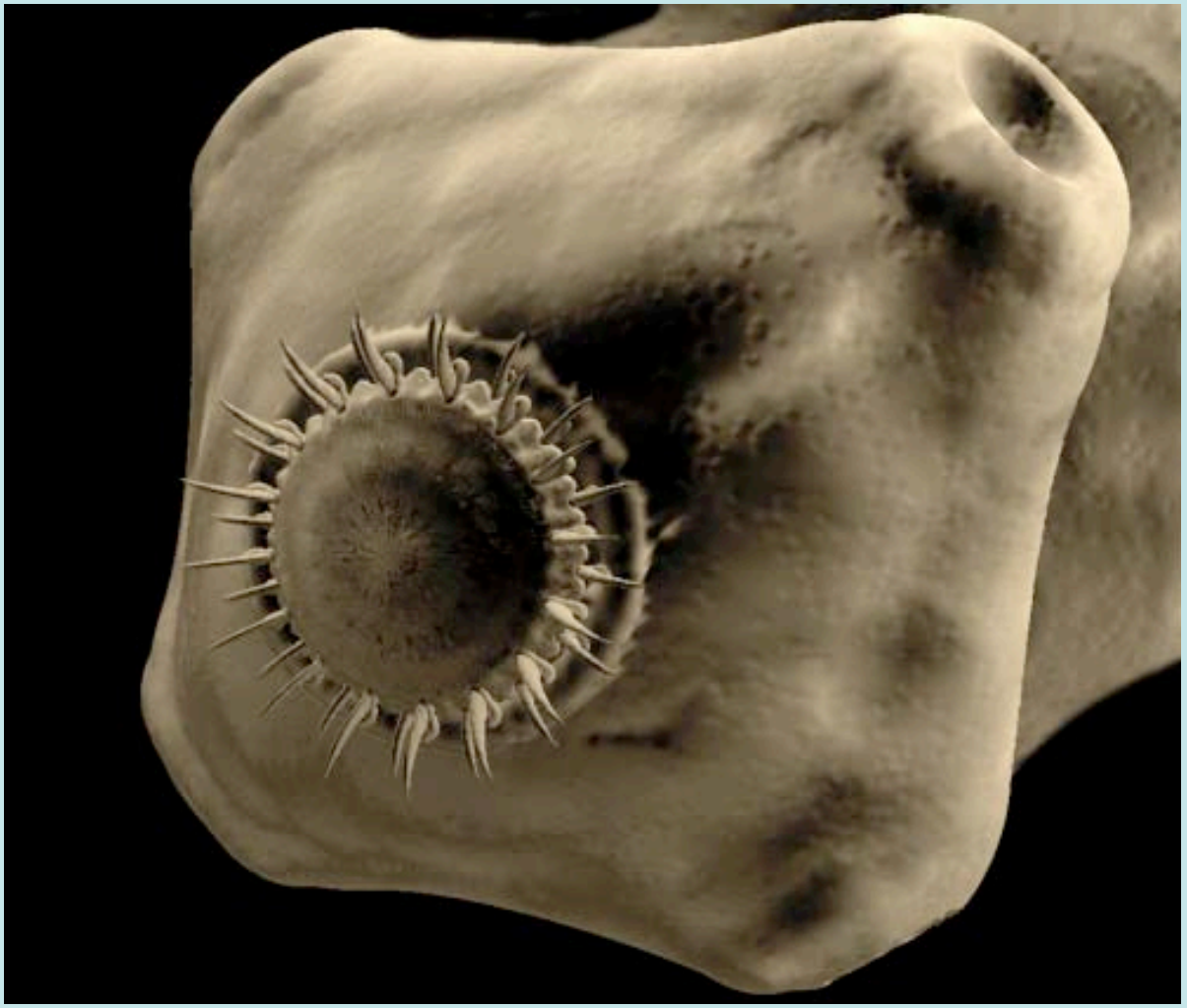
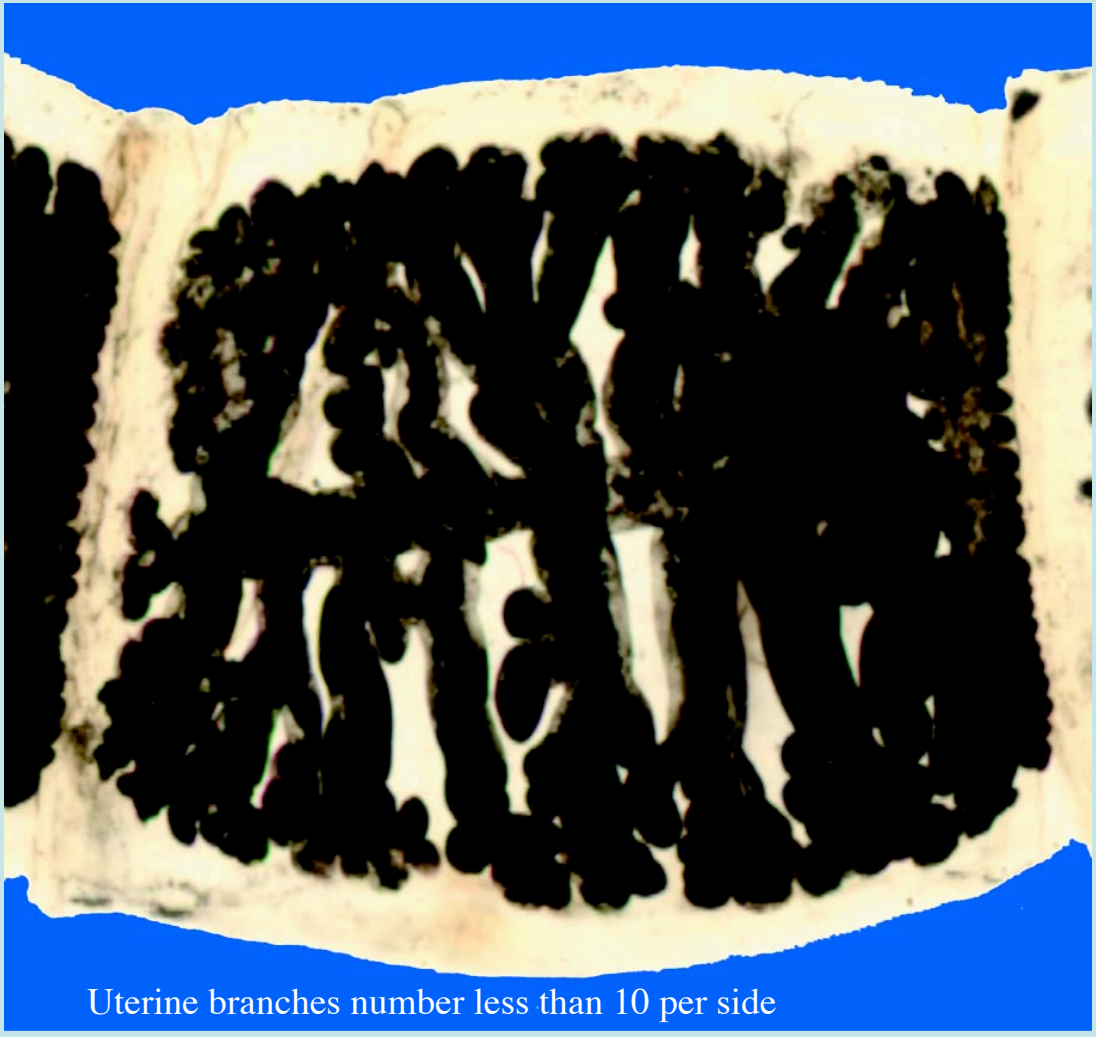



Photo: E. Grave

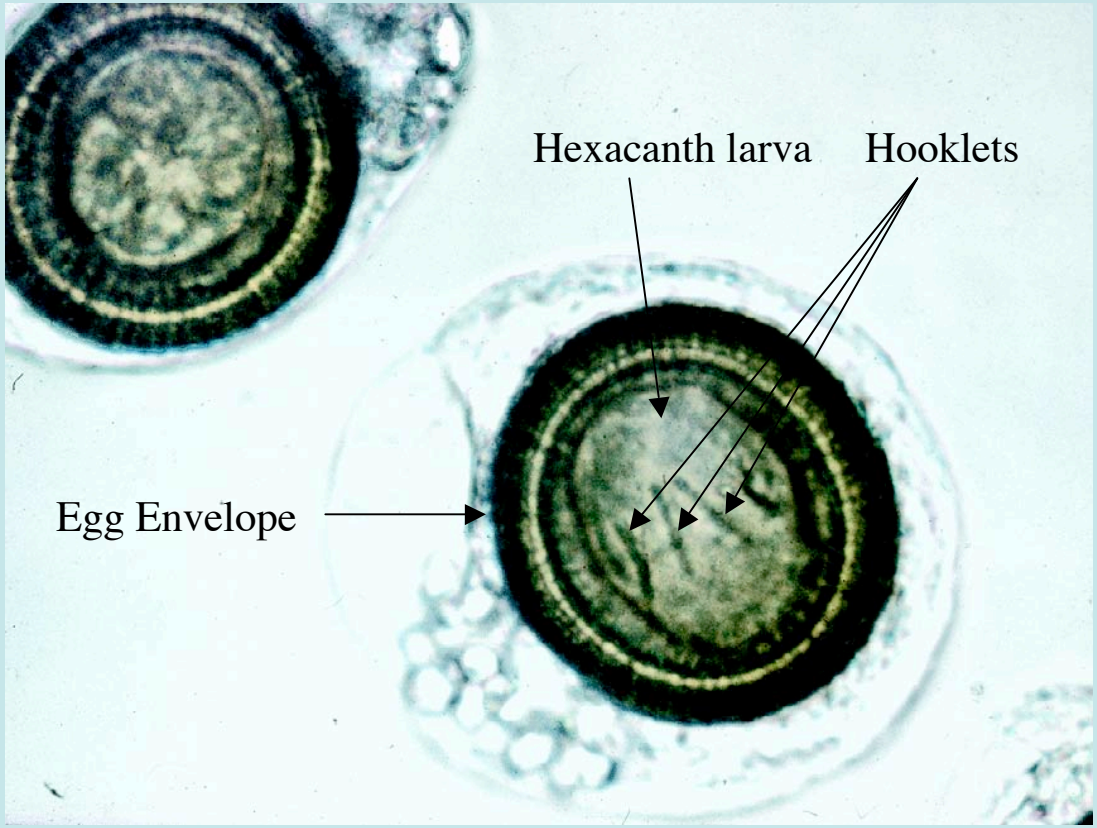
# T. Solium Scolex



# Gravid proglottid *Taenia solium*

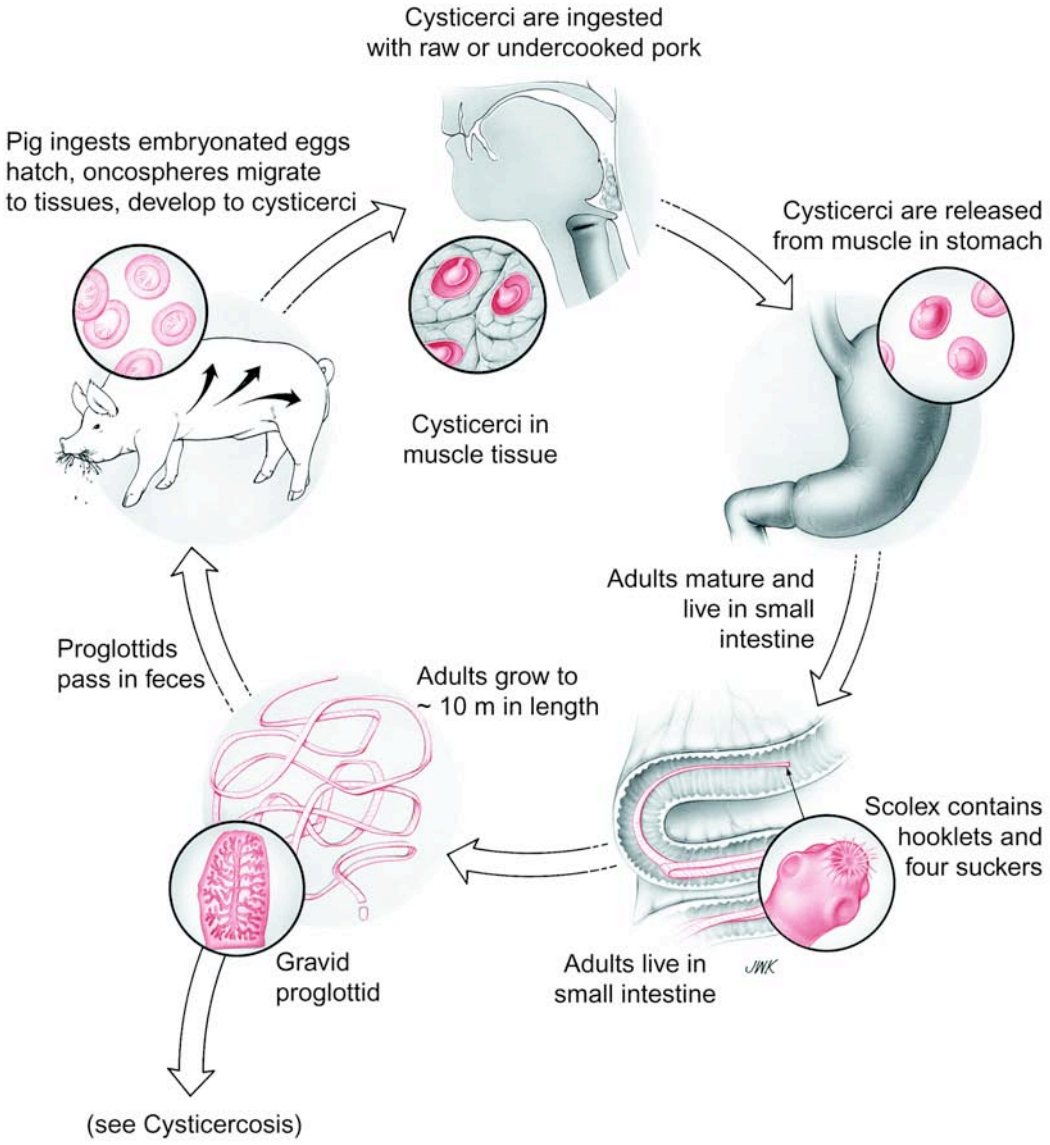


# Embryonated, infectious taeniid eggs




Cannot determine the species of Taenia based on egg morphology

# *Taenia solium*



# Pathogenesis:

None

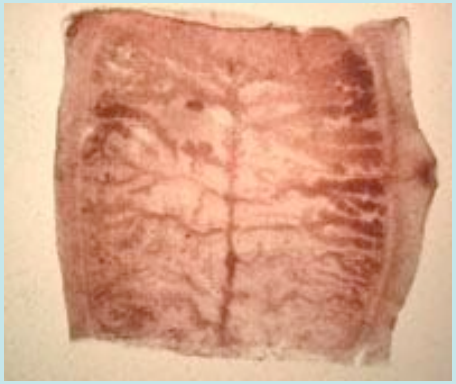
# Clinical Disease:

None

# Diagnosis:

1. Find eggs or proglottids in stool

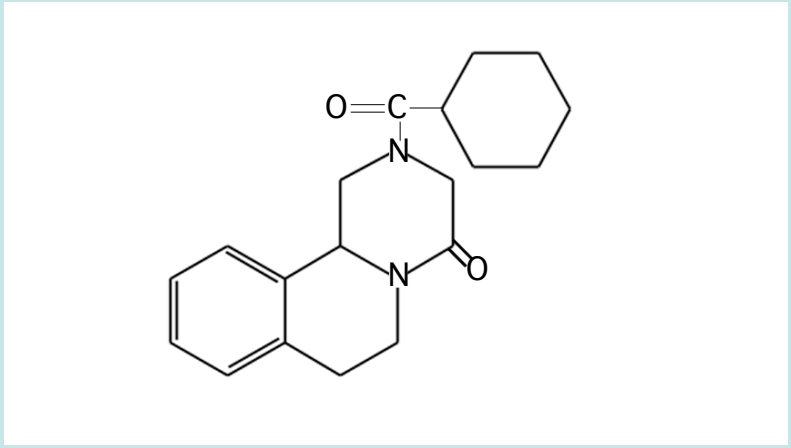
2. Identify species based on proglottid morphology



3. Identify scolex
4. Stool PCR or ELISA (yeah, right)

# Drug of Choice:

1. Praziquantel




2. Niclosamide
   - Not absorbed systemically
   - Uncouples cestode oxidative phophorylation, preventing ATP production.
   - Parasite is then digested by host enzymes.

# Prevention and Control:

1. Sanitary disposal of feces

# Prevention and Control (cont'd):

2. Good sanitary practices on pig farms.

3. Federal meat inspection programs.

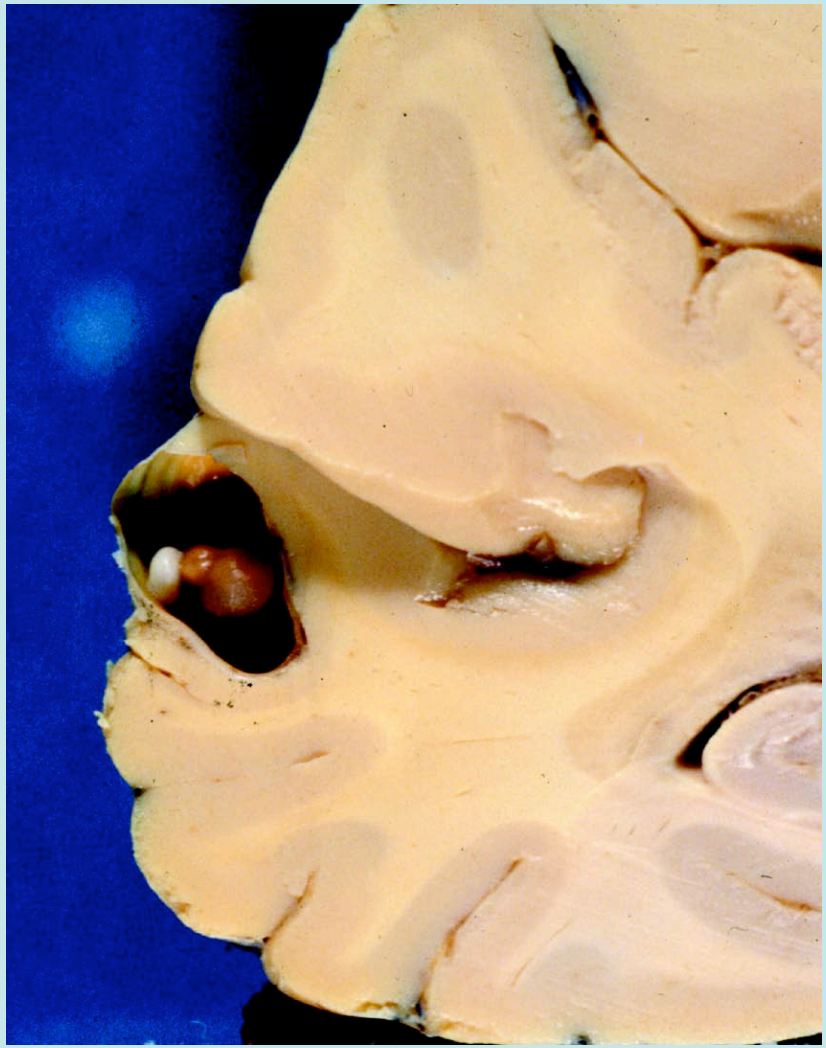
4. Cook and/or freeze pork products thoroughly.

5. Treat pigs or vaccinate pigs,
   using new oncosphere mRNA vaccine, in eradication programs. (WHO Assembly, 2003).

# Cestode hosts

| | *T. saginata* | *T. solium* |
|---|---|---|
| Definitive Host: | Human | Human |
| Intermediate Host: | Cow | Pig |
| | | Human |

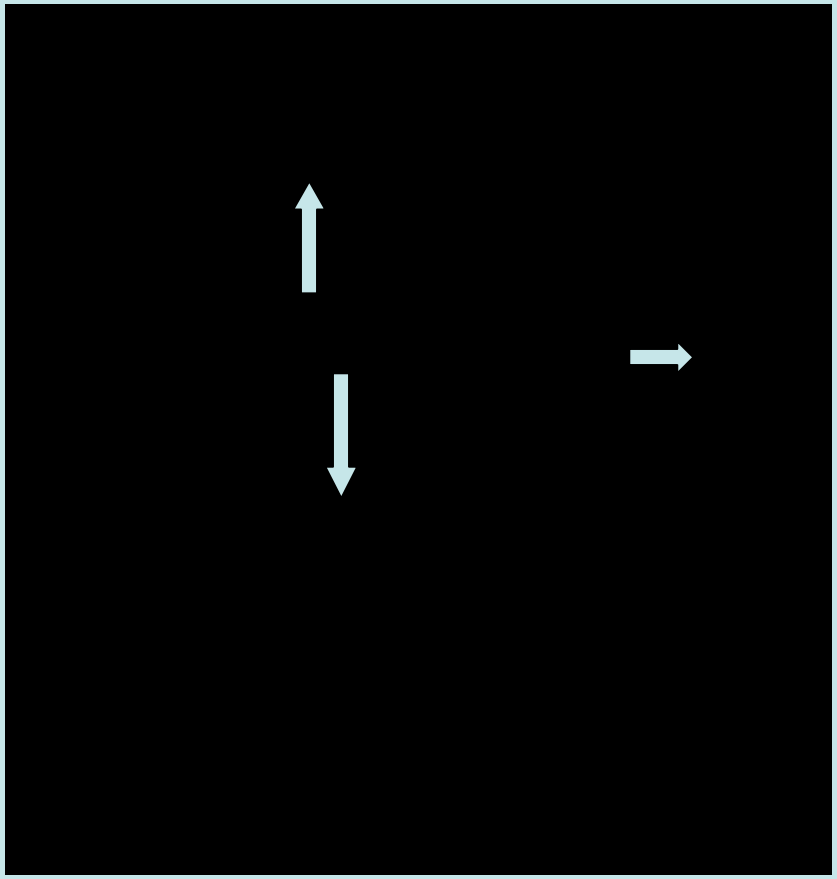
# Cysticercus in brain, on post-mortem pathology

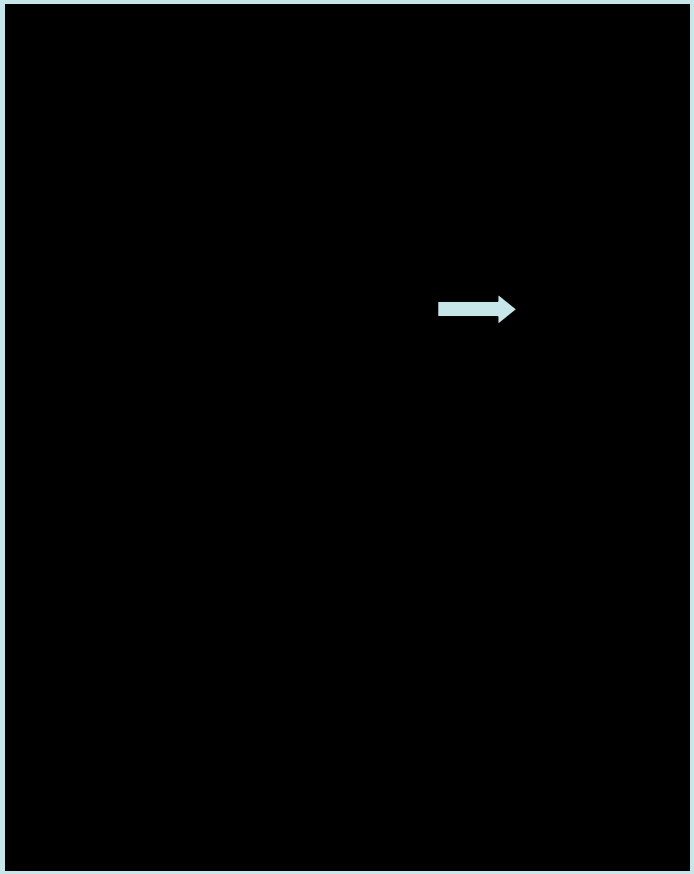


Asymptomatic cyst.  Actual cause of death, mesothelioma

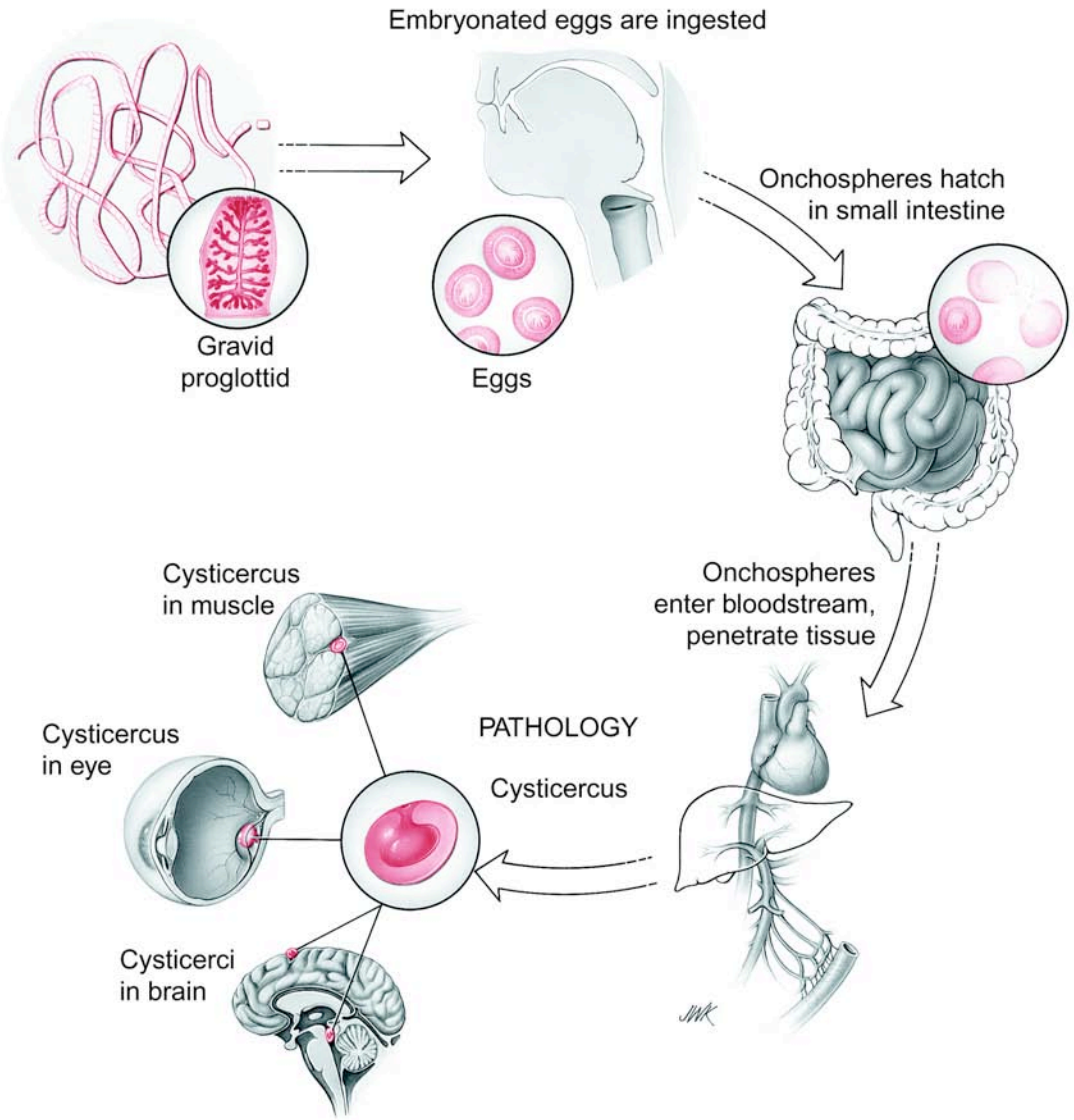
# Cysticercosis and Neurocysticercosis

Multiple Intracerebral Cysts

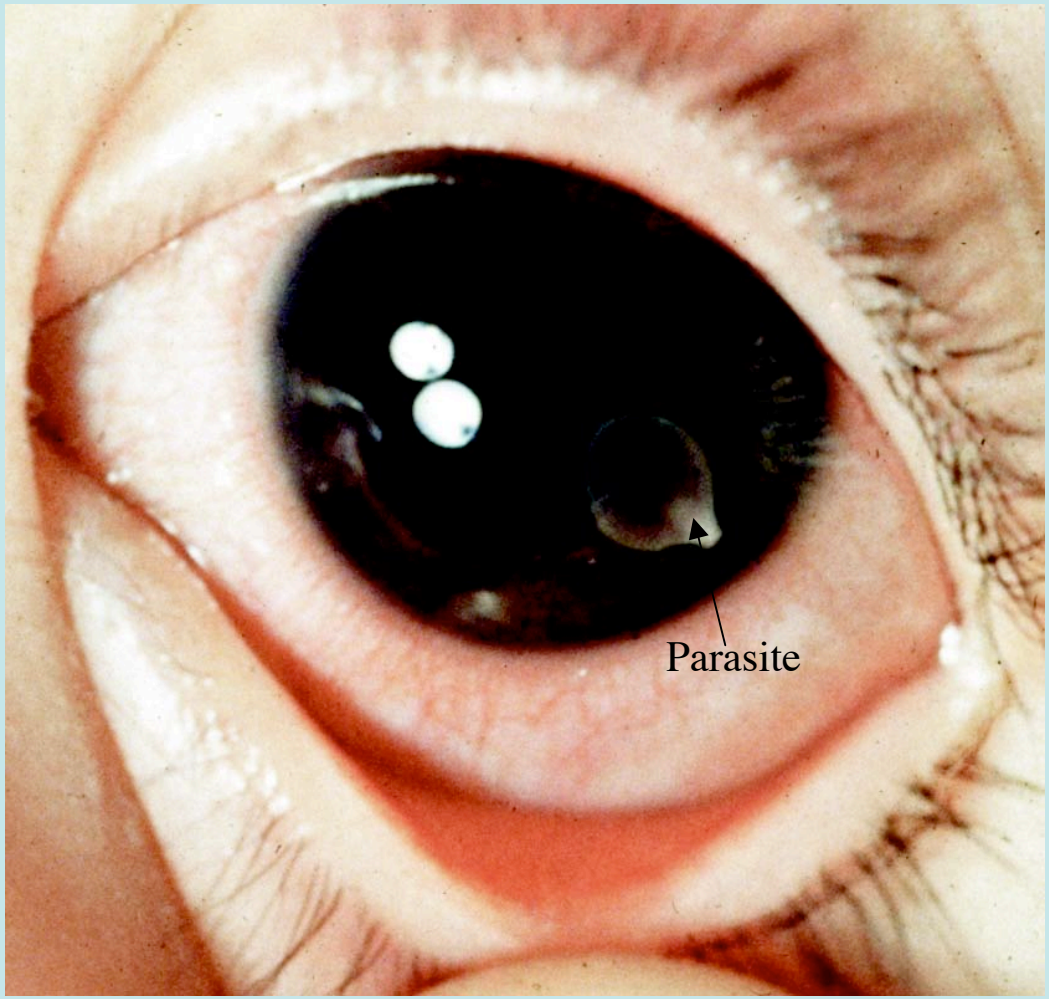




# *Cysticercosis*
## *(Taenia solium)*

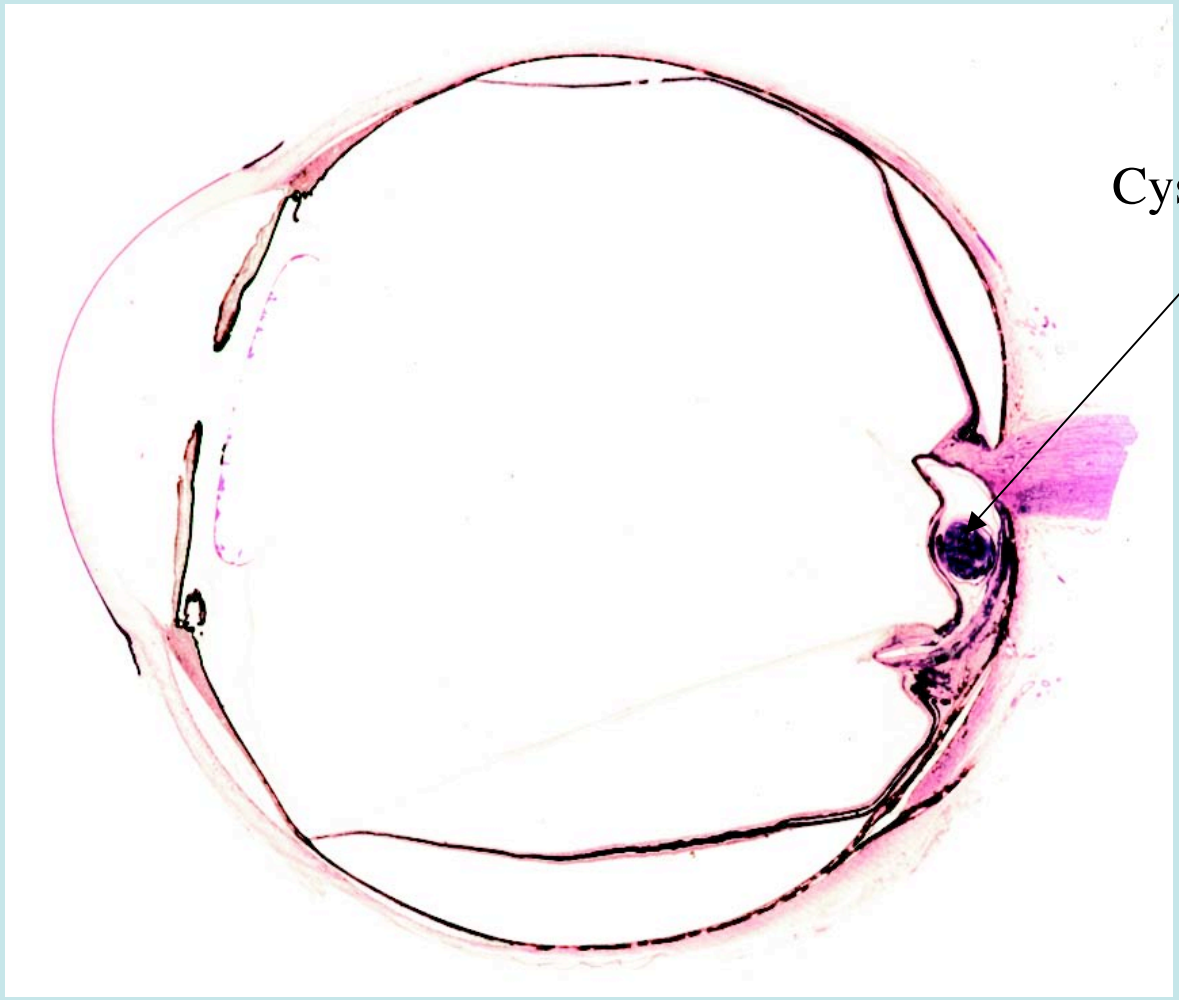


# Cysticercus floating freely in anterior chamber



# Cysticercosis of eye:

cysticercus near optic nerve, mis-diagnosed as retinoblastoma.

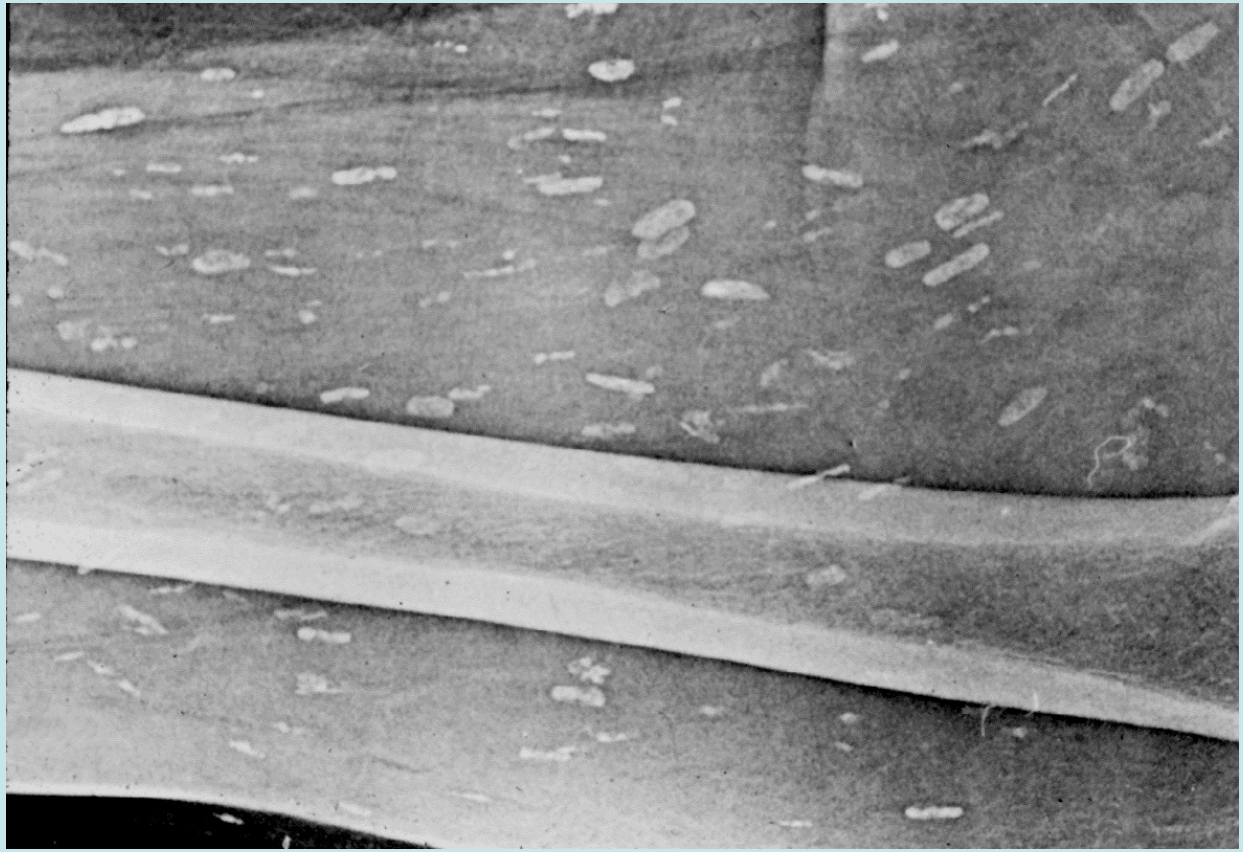


Enucleated globe in cross-section

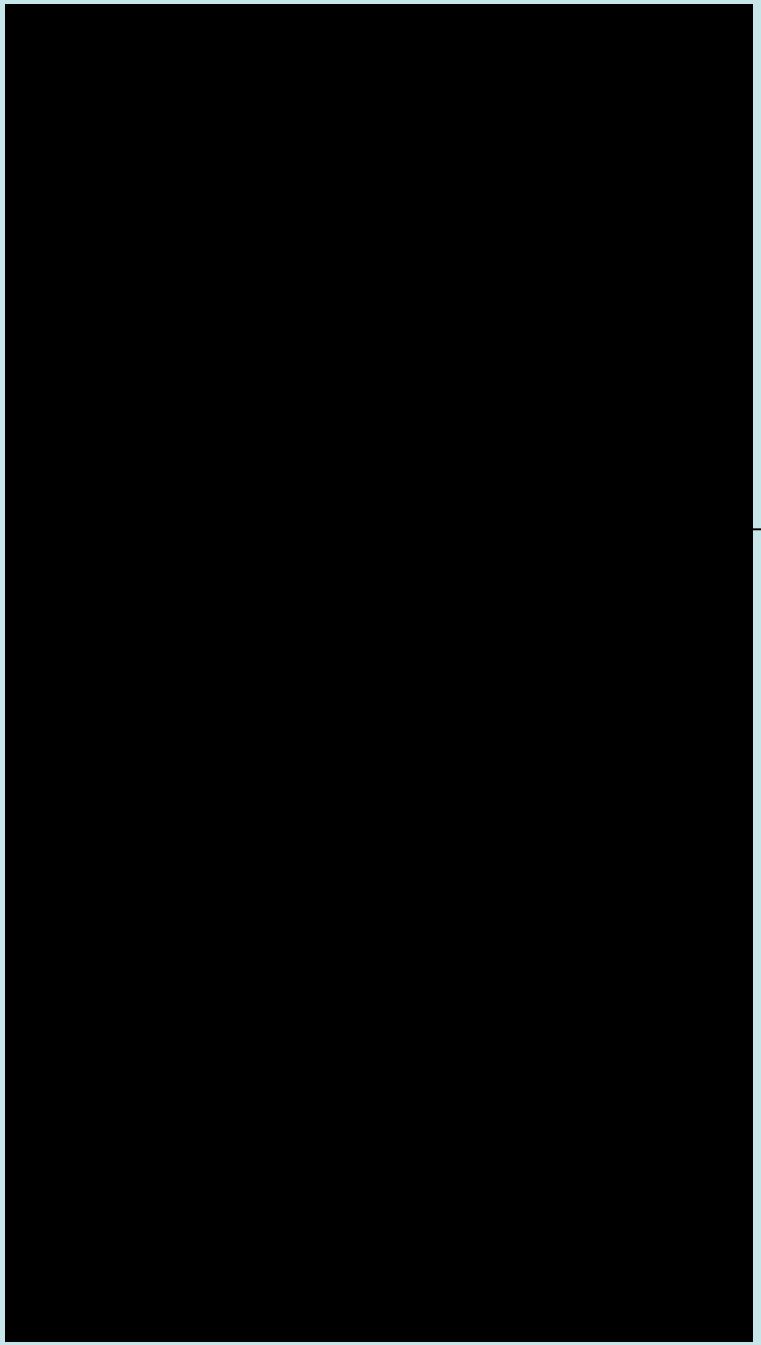
Cysticercus

"The Alien"

# Radiogram of lower leg with numerous calcified cystercerci of *T. solium*



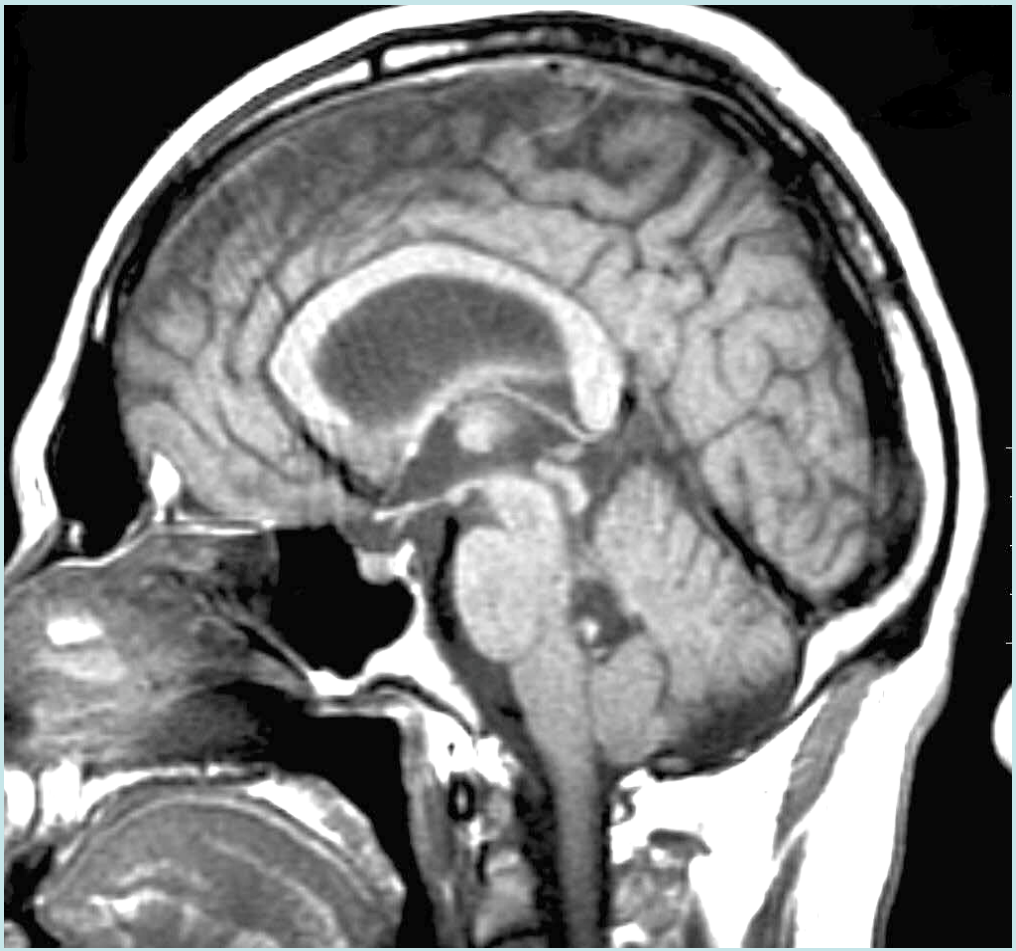
# Subcutaneous Cysts



Neurocysticercosis
of the spine

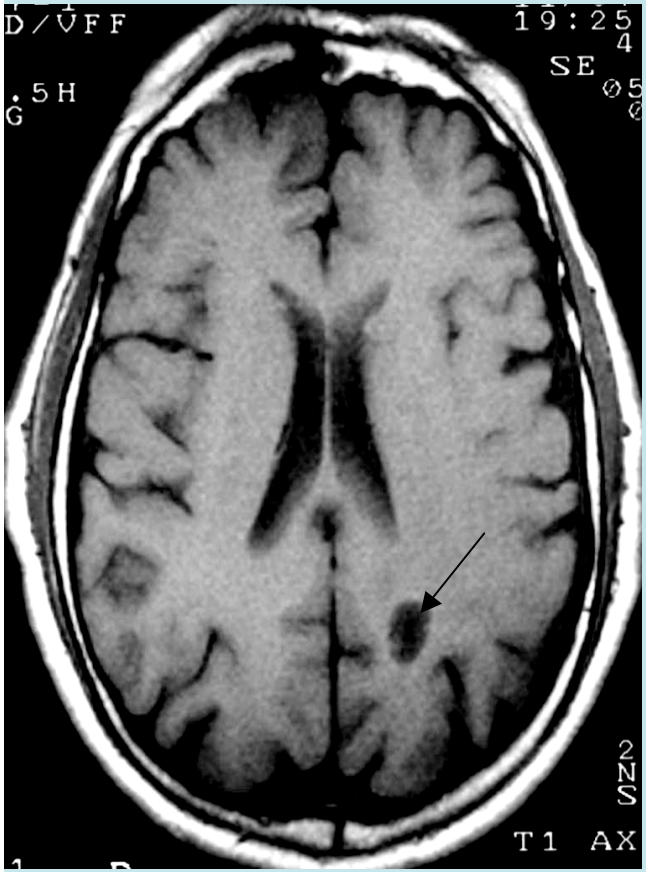
# Cerebello-pontine angle cysticercus

## This may cause hydrocephalus



MRI sagittal and axial views with flare

# Neurocysticercosis




T1 weighted

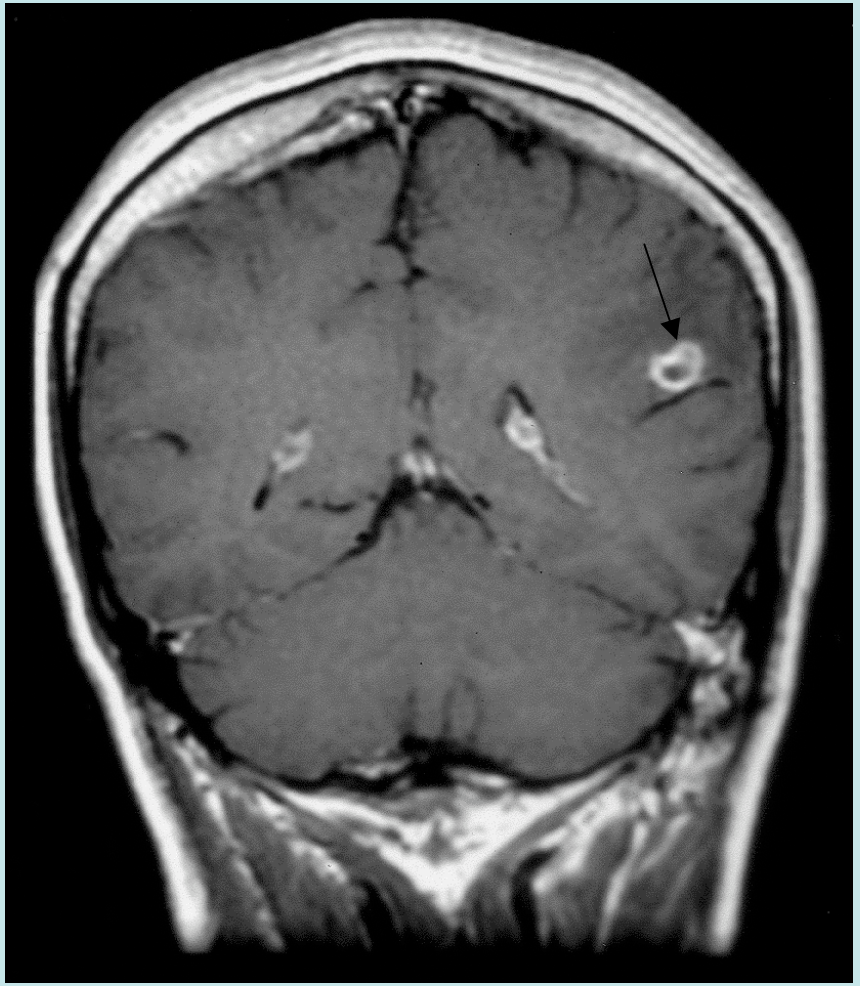

T1 with contrast

T2 weighted

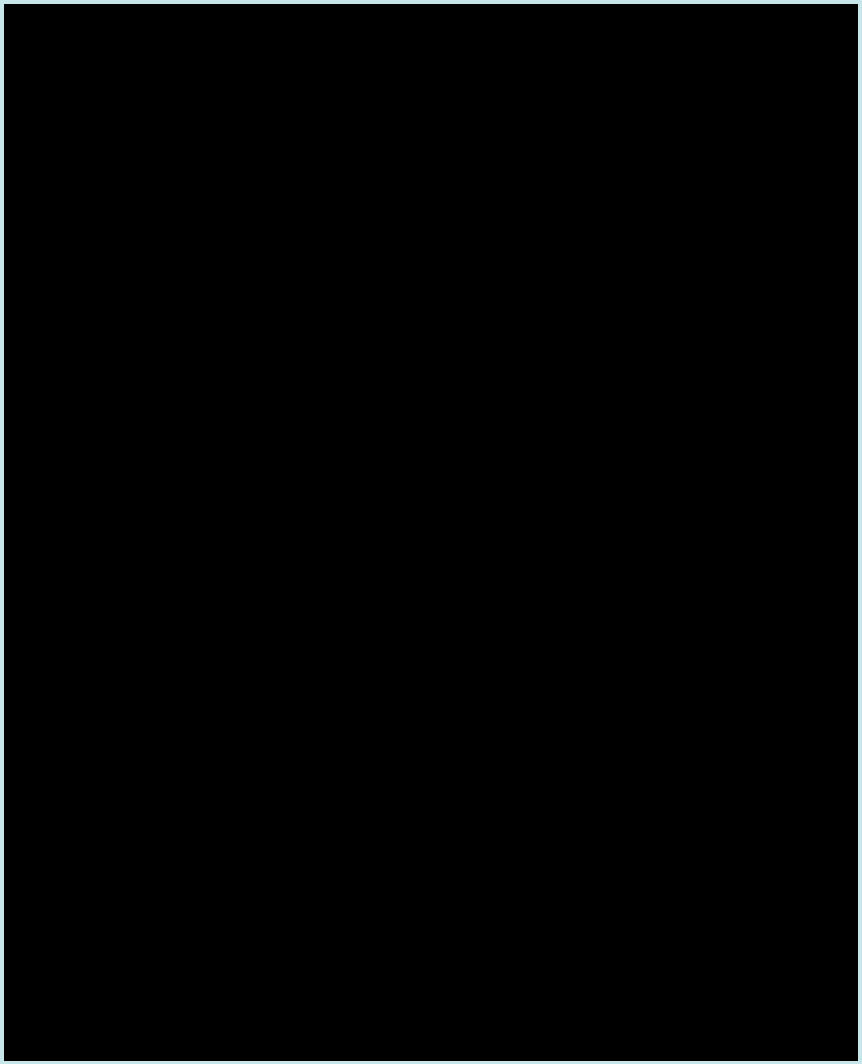
# Neurocysticercosis

CT Scan

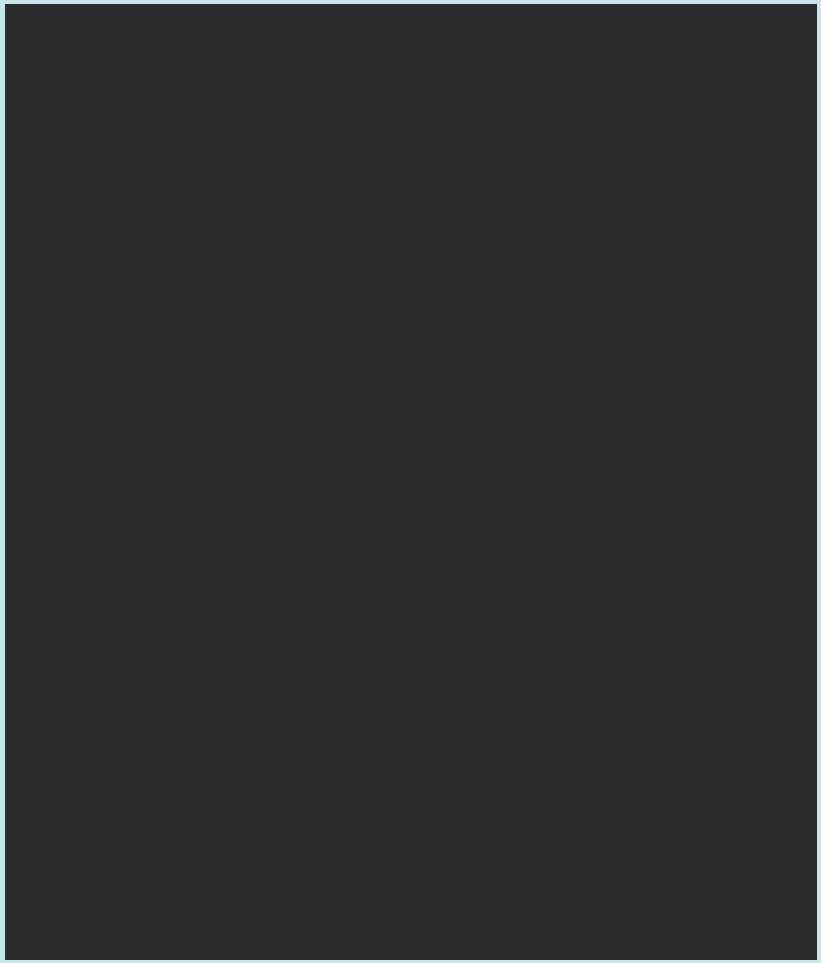
MRI

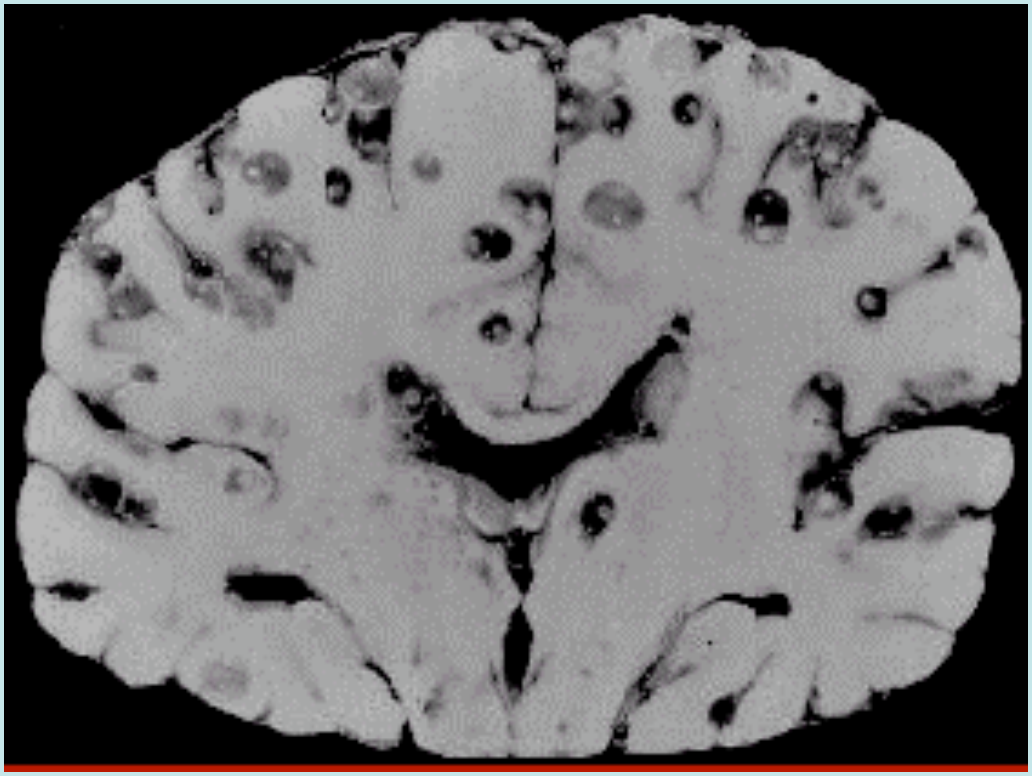


# Intracerebral Calcifications



# How bad can things get?

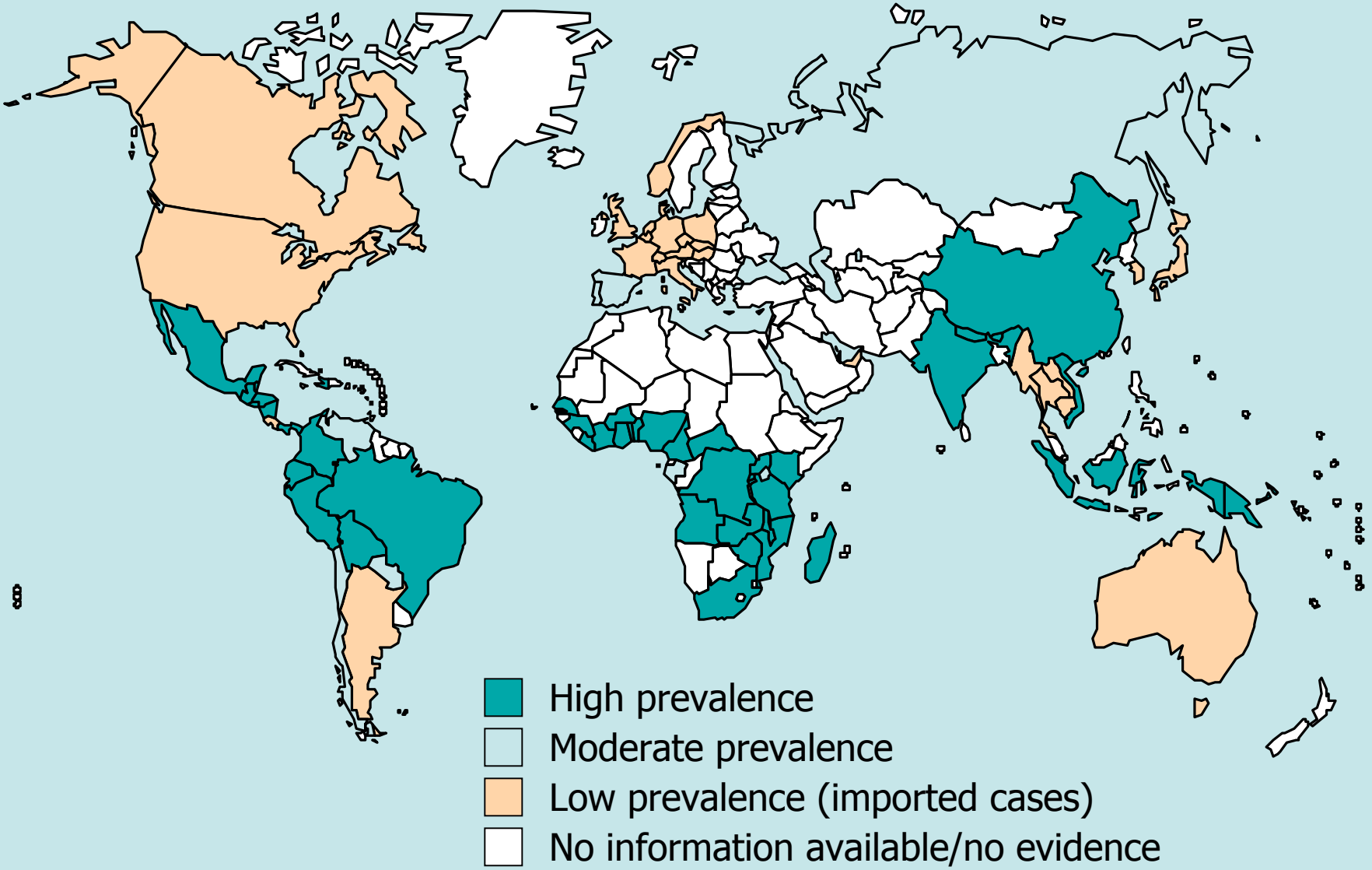




# Immunomodulation

- Taeniastatin: protease inhibitor
- Paromycin
  - Inhibits complement
- Other proteases:
  - Degrade Interleukin-12, immunoglobulins and interferon

# Global distribution of *Taenia solium* cysticercosis/taeniosis



# Clinical Epidemiology of Cysticercosis

- Est. 50 million people with Intestinal Taeniasis, world-wide
- 20% have cysticercosis; half will be symptomatic
- Leading cause of adult-onset seizures worldwide (~40%)
  - Other causes are trauma, TB, tumors, toxins, other.
- In US: Est. 1000 new cases per year (no mandatory report)
  - Immigrants account for ~ 95% annually
  - Travelers account for 3%-5%
  - Autochthonous transmission: rare

# Pathogenesis:

Space-Occupying lesion

Local Immunologic Reaction

# Clinical Disease:

1. Vision impairment / Blindness
2. Seizures / Death
3. Hydrocephalus / Coma / Death
4. Neurological or other deficits, dependent upon location

# Diagnosis:

Must differentiate between cysticercosis and other possible lesions (benign cysts, solid tumors, etc.)

1. Biopsy whenever possible

2. Physical (palpation) and radiological evidence

3. Enzyme-linked immunoblot serological test,
   can be as high as 98% sensitive, 100% specific.

4. MRI

# Treatments:

1. Surgical removal of cysticercus when appropriate

2. Steroids (e.g., dexamethazone) during time of neurological symptoms

3. Anticonvulsants (e.g. Dilantin)

4. Antiparasitic antibiotics: Praziquantel or albendazole + steroids + anticonvulsants
   if multiple symptomatic cysticerci or inoperable (still being studied)

# *Echinococcus granulosus*

## The Dog tapeworm

### Hydatid Disease in Humans

# Cestode hosts

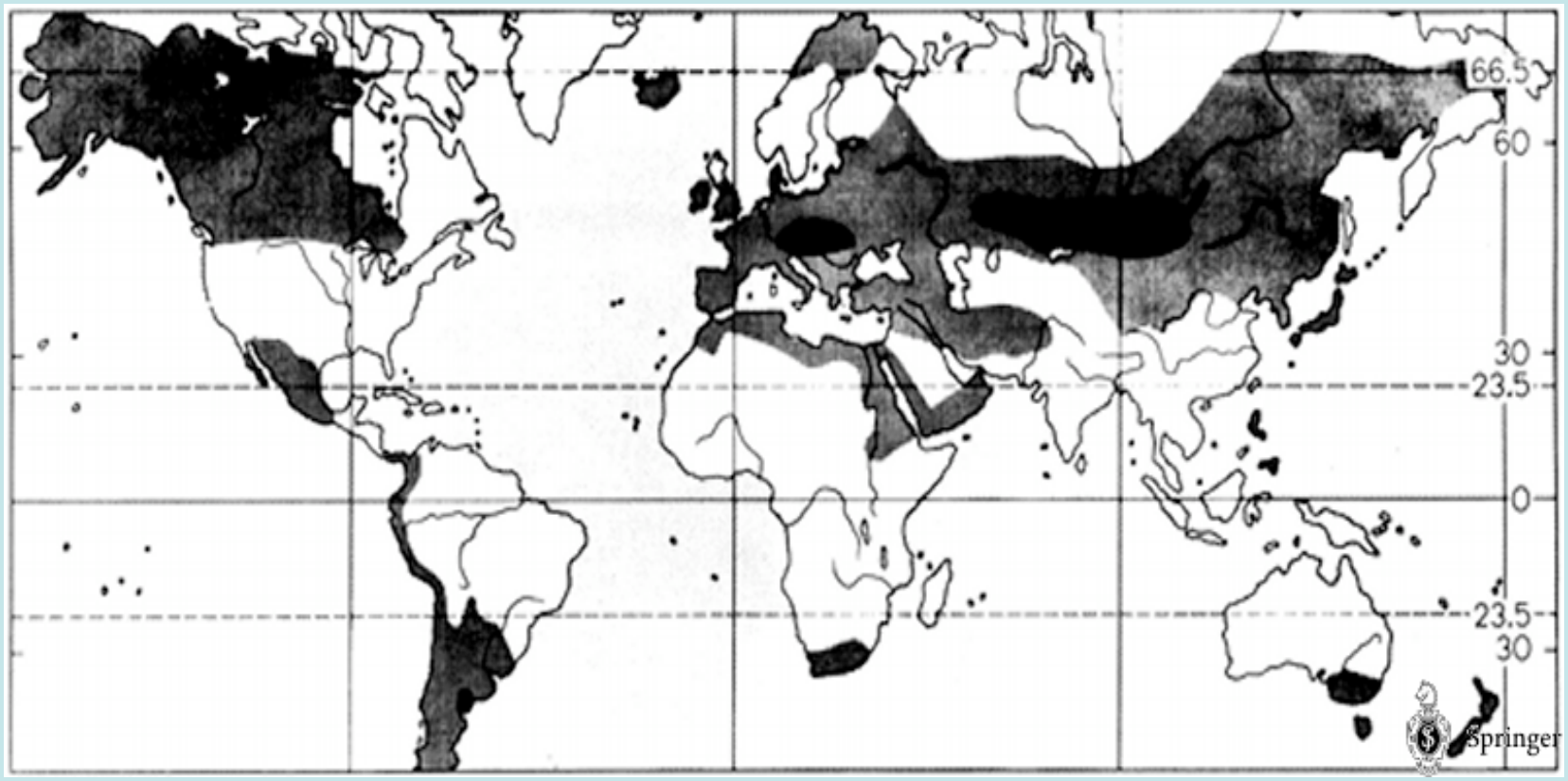
| | *T. saginata* | *T. solium* | *Echinococcus granulosus* |
|---|---|---|---|
| Definitive Host: | Human | Human | Dog |
| Intermediate Host: | Cow | Pig | Sheep |
| | | Human | Human |

Traditional sheep husbandry and farming practices help to maintain the cycle in animals and humans.

Navaho, Arizona

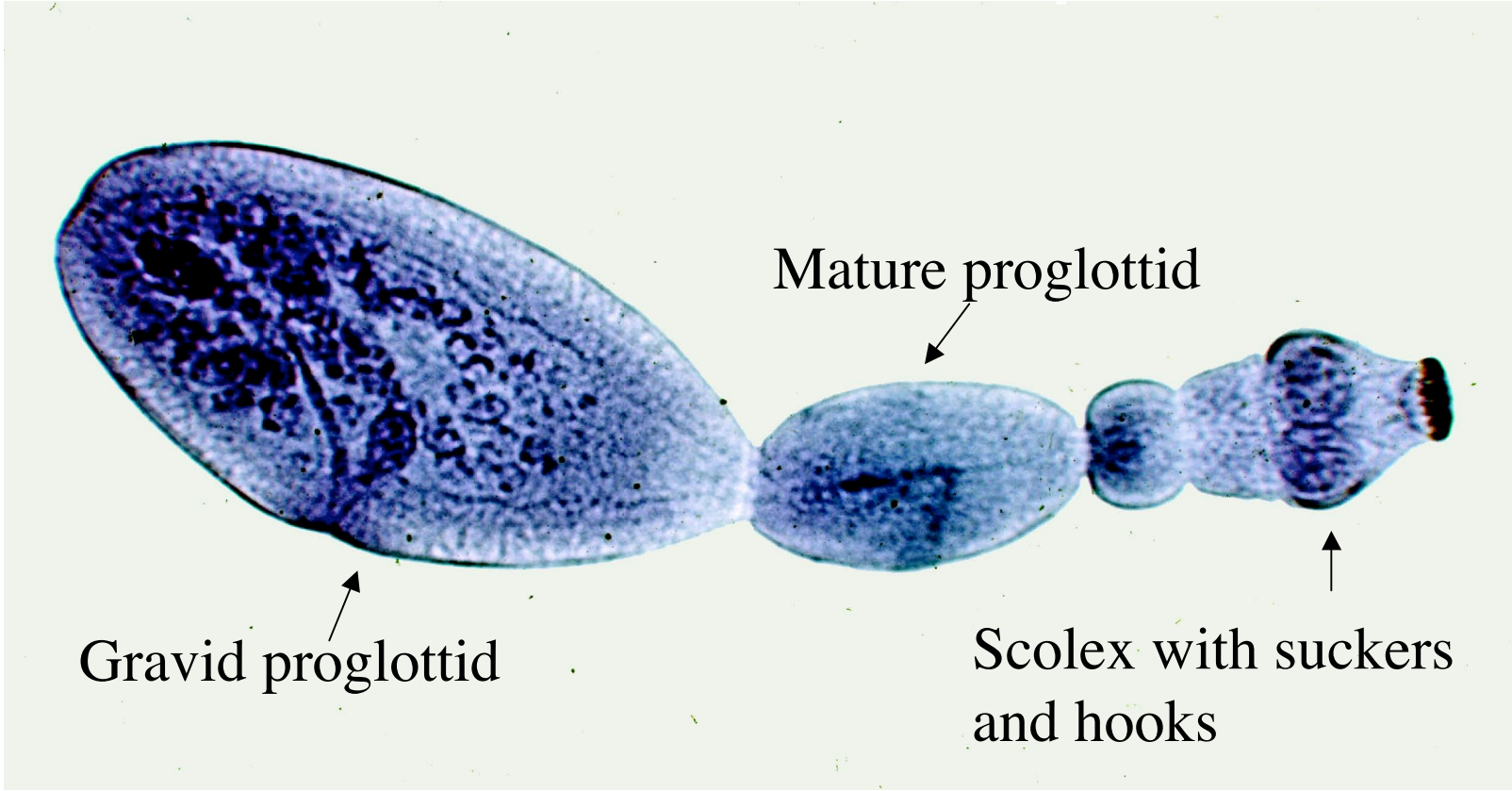
Tibetan Plateau

Abattoir, Ecuador



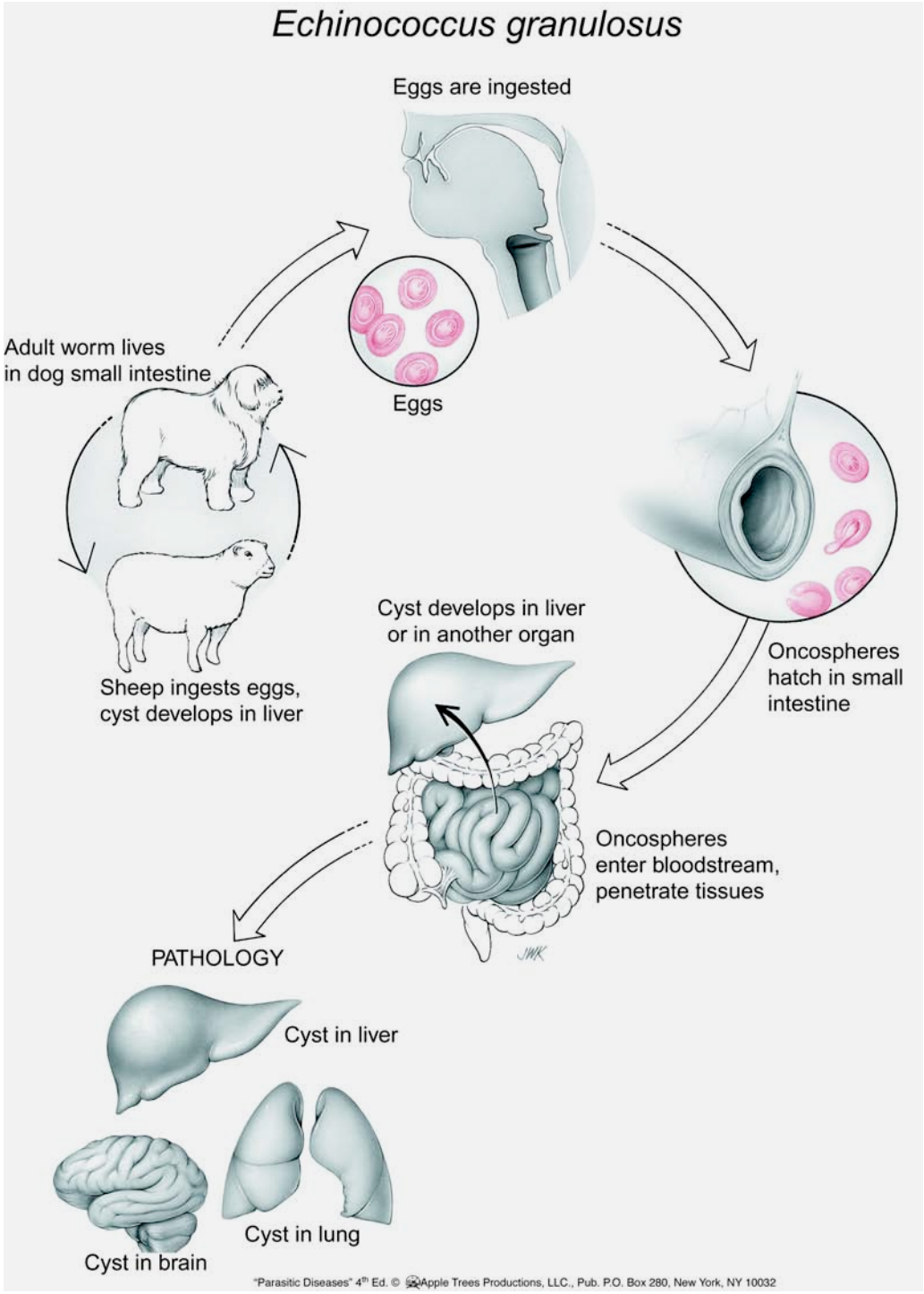

Distribution map of *Echinococcus granulosus* (grey) and *E. multilocularis* (black), which is now also found in Hokkaido (Japan), Alaska and also in the whole of Germany.

# Adult of *Echinococcus granulosus*

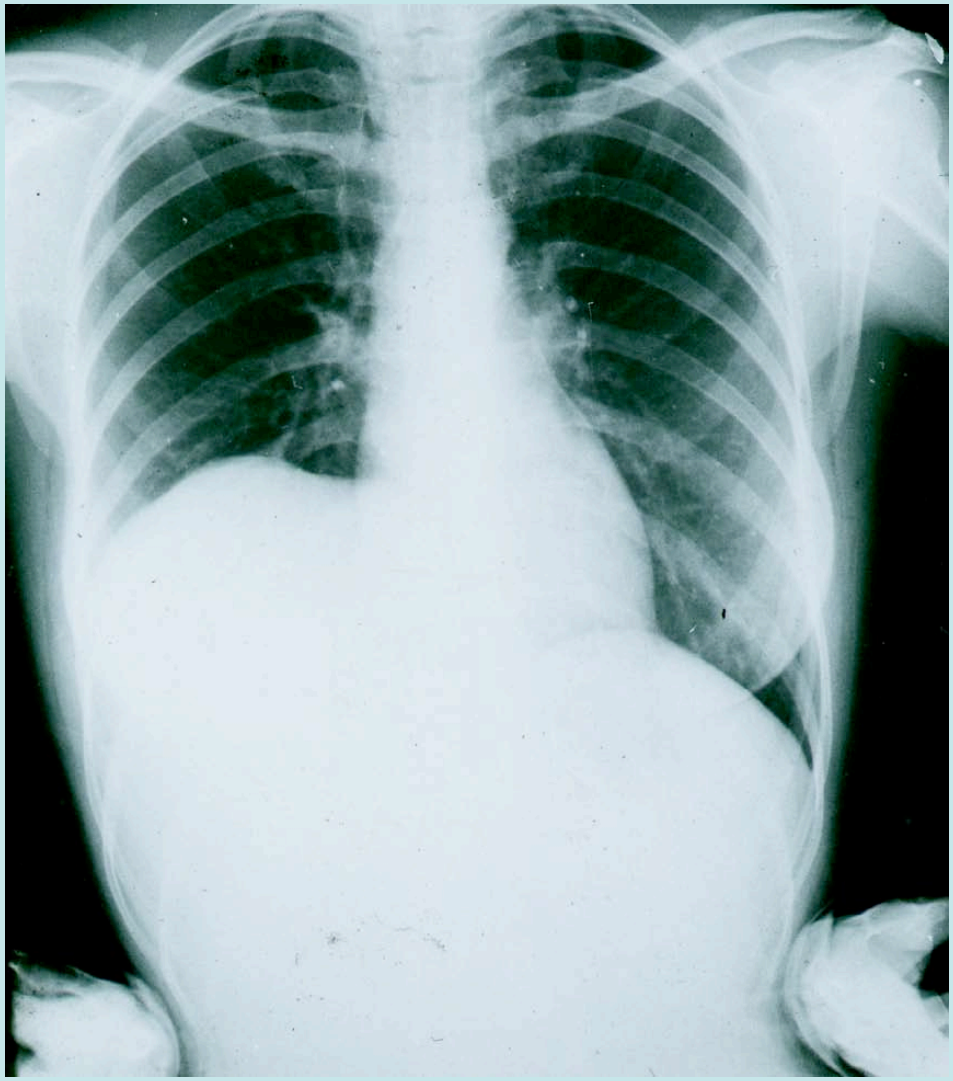


# Echinococcus Granulosus Adult

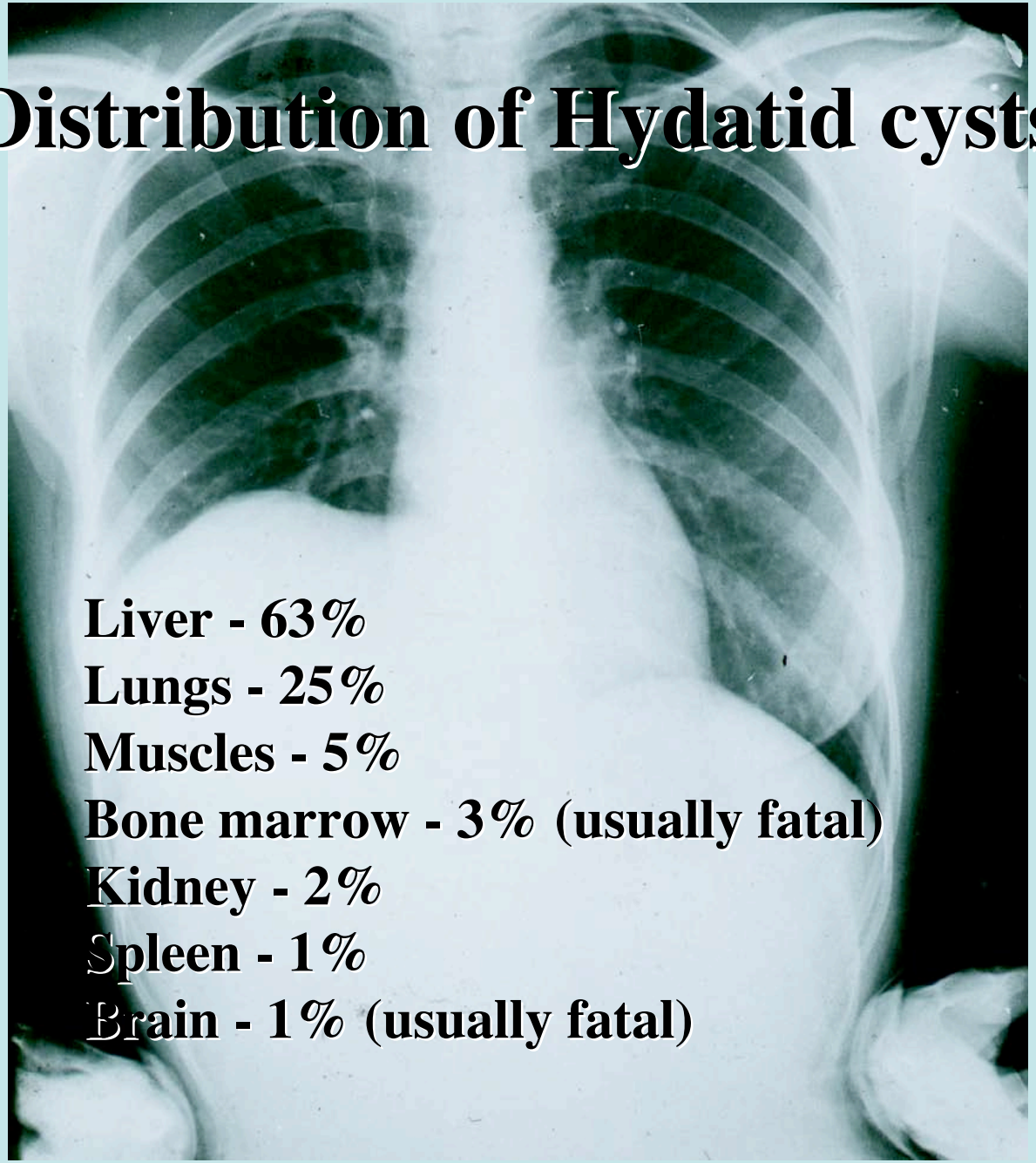
cute, n’est-ce pas?


Echinococcus granulosus
Eggs are ingested
Eggs
Adult worm lives
in dog small intestine
Sheep ingests eggs,
cyst develops in liver
Oncospheres
hatch in small
intestine
Cyst develops in liver
or in another organ
Oncospheres
enter bloodstream,
penetrate tissues
PATHOLOGY
Cyst in liver
Cyst in lung
Cyst in brain
"Parasitic Diseases" 4th Ed. © Apple Trees Productions, LLC., Pub. P.O. Box 280, New York, NY 10032

# Radiogram of upper body showing elevation in right lobe of liver due to large hydatid cyst



# Distribution of Hydatid cysts

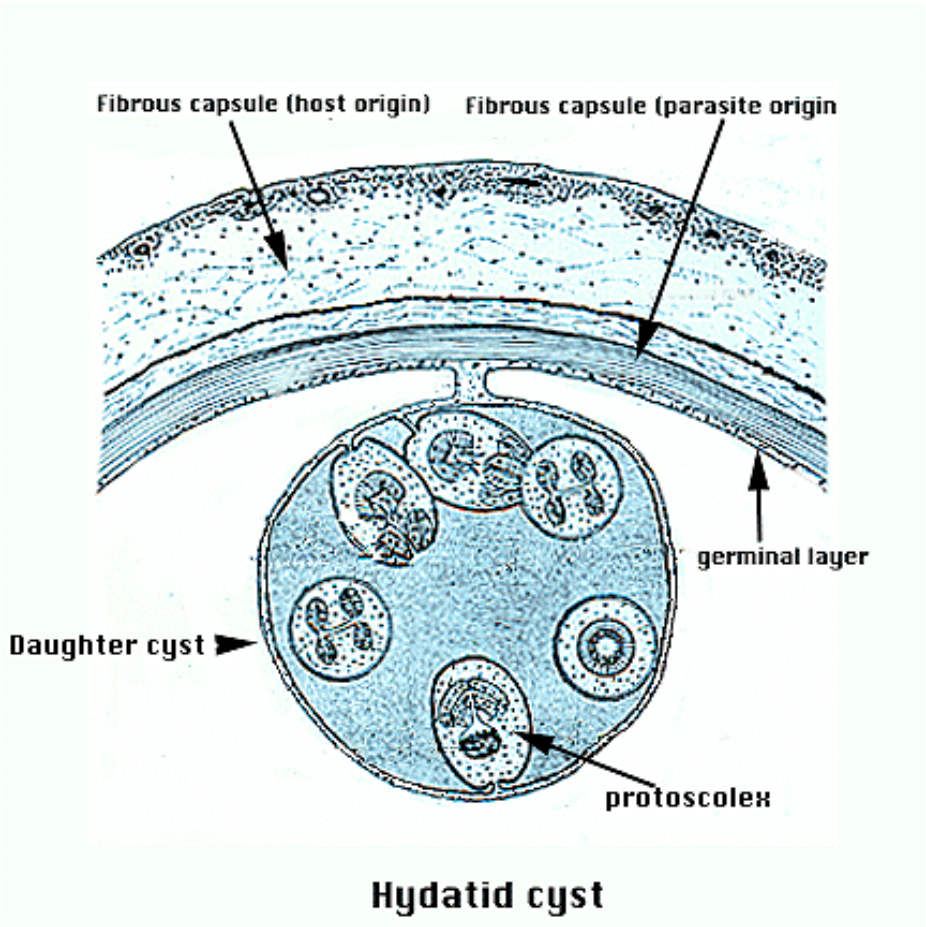


**Liver - 63%**
**Lungs - 25%**
**Muscles - 5%**
**Bone marrow - 3% (usually fatal)**
**Kidney - 2%**
**Spleen - 1%**
**Brain - 1% (usually fatal)**

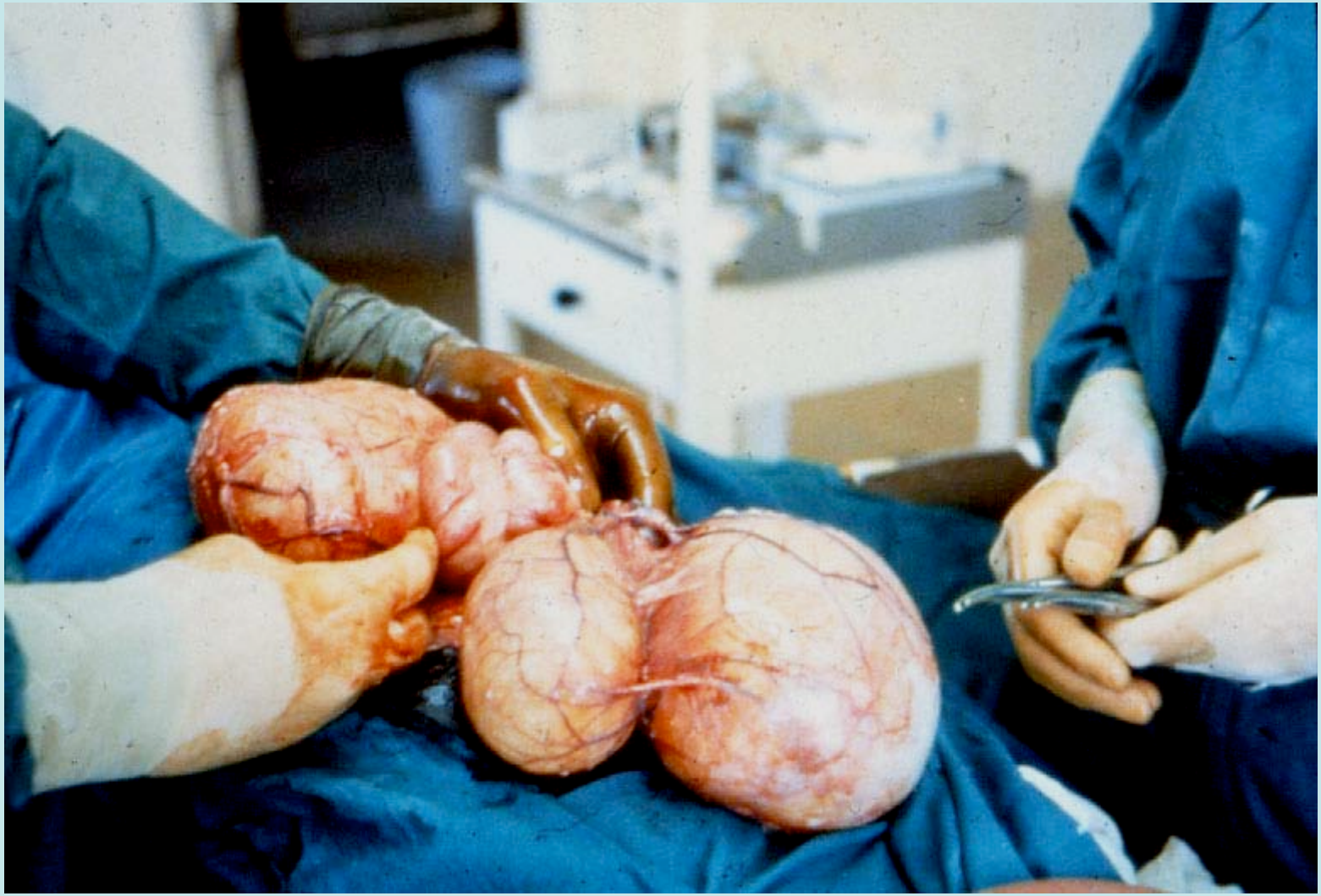
# Hydatid cyst of Liver


Visualize:  Hydatid cyst, daughter cysts, hydatid fluid

# Hydatid Cyst diagram



# Hydatid cysts
# removed from human liver



# Hydatid cyst of Parietal Lobe

# Pathogenesis and Clinical disease:

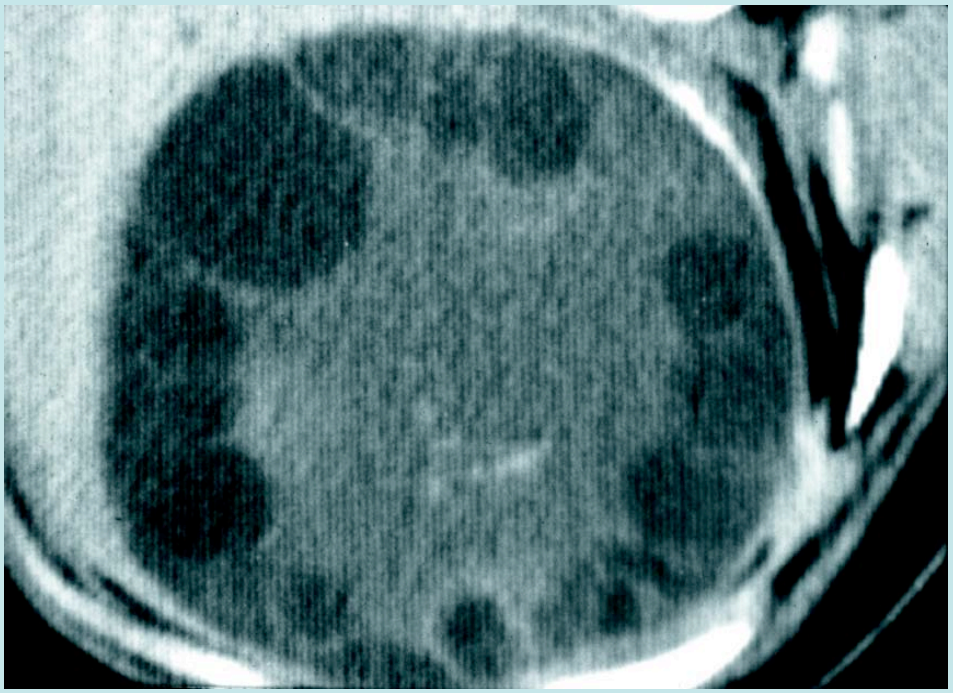
1. When intact, it may be immunologically and clinically silent, especially in the liver.

2. In other organs (e.g., brain, lung, bone marrow), hydatid cyst is a space-occupying lesion.

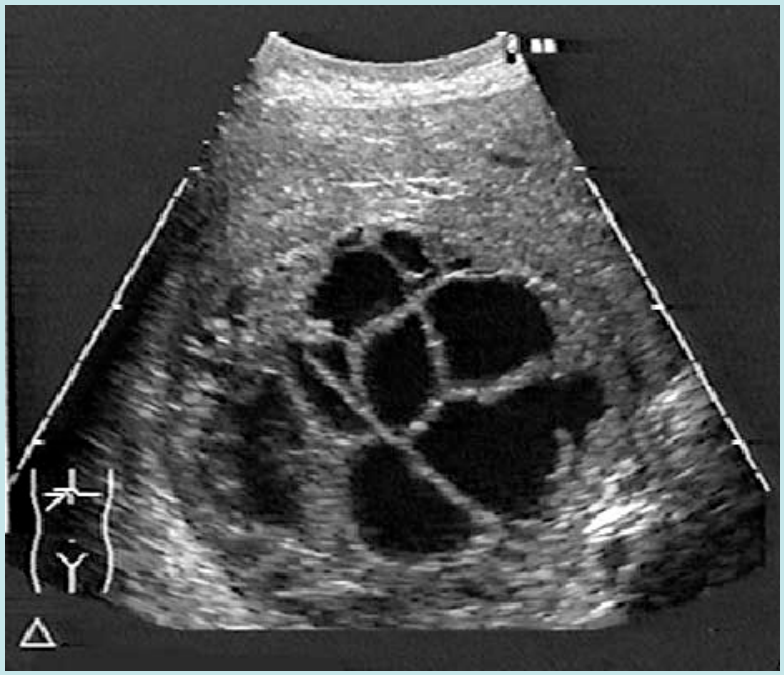
3. It may leak or rupture, seeding adjacent areas.

4. When it ruptures, allergic reactivity and anaphylaxis often ensue. This may be fatal.

Liver infected with **hydatid cyst** of *Echinococcus granulosus*



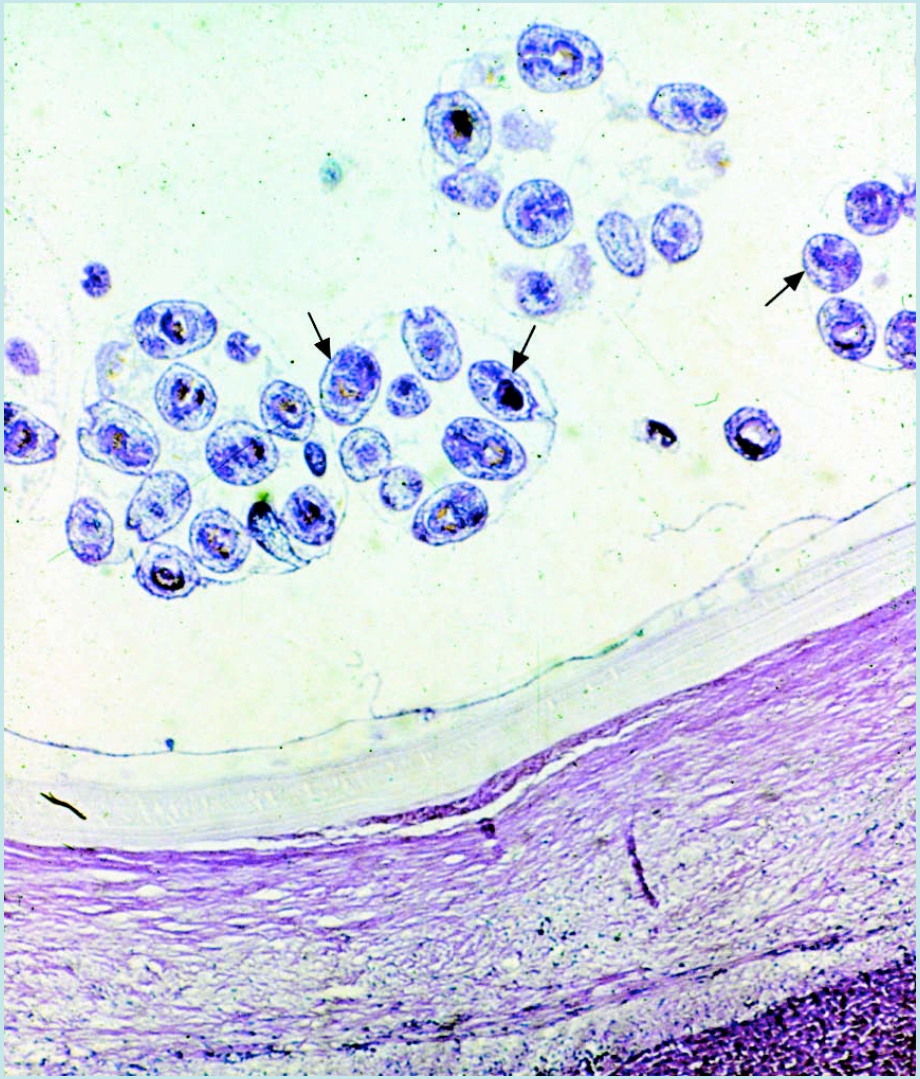
CT Scan



Ultrasound

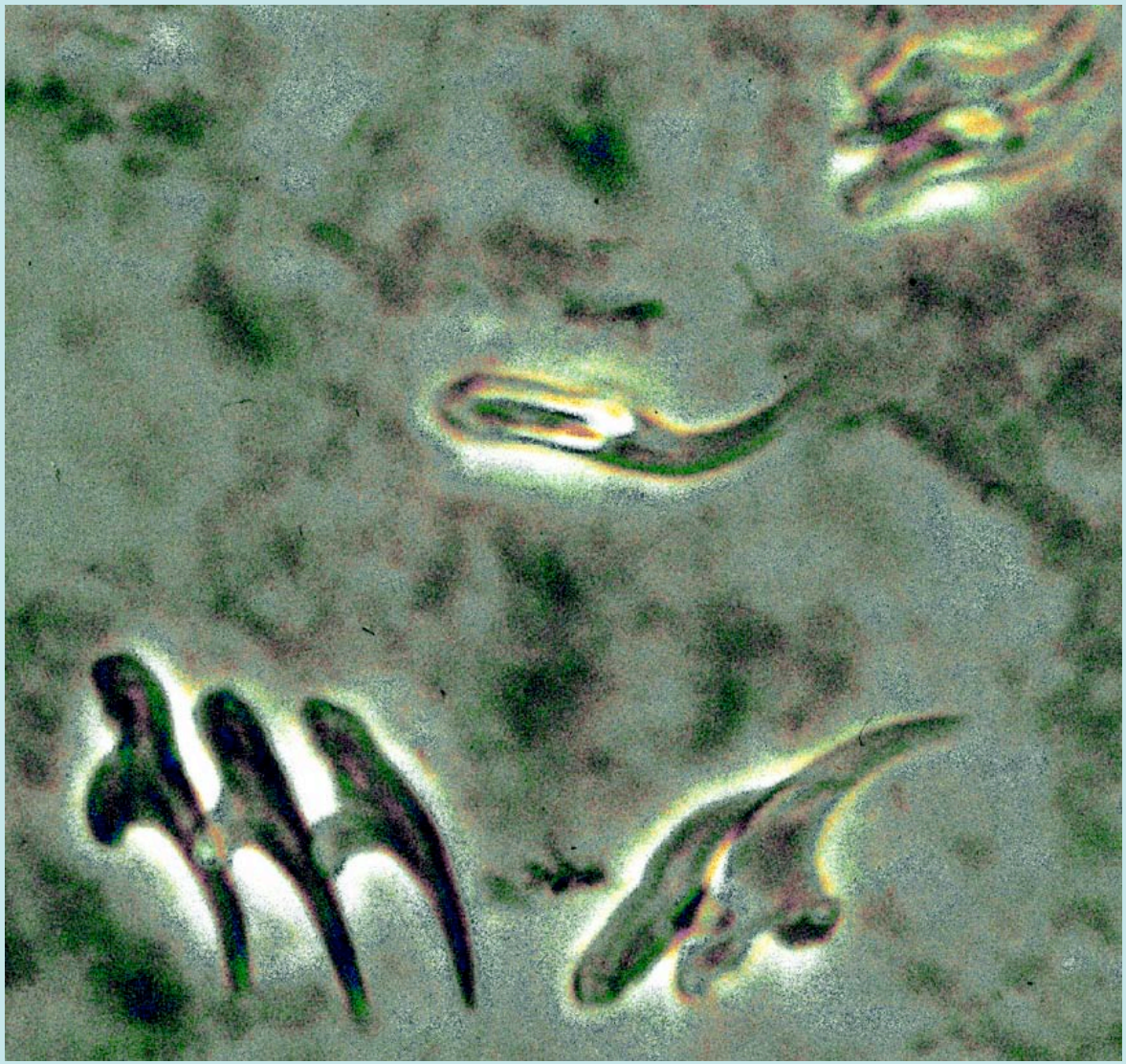
# Petri dish filled with daughter cysts of *Echinococcus granulosus*

# Histological section through brood capsules in hydatid cyst of *Echinococcus granulosus*



# Brood capsule with protoscolices of *Echinococcus granulosus*

# “Hydatid sand”



# Diagnosis:

A. Direct

1. NO BIOPSY!
2. Microscopic examination of fluid from hydatid cyst after surgical removal, see “hydatid sand”

B. Indirect

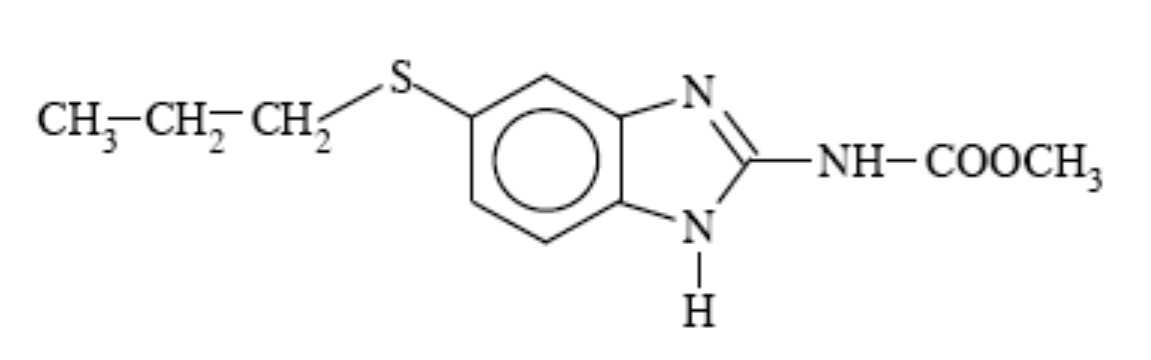
1. ELISA-based serology
2. MRI, CAT, x-ray
3. Accurate case history (ownership of dogs, living on a farm, etc.)

# Treatment:

- Surgical, whenever possible
- PAIR Technique for liver lesions
  - (puncture, aspirate, Inject, re-aspirate)
- Pharmacologic has less than 50% success

# Drug of Choice:

## Albendazole (for 1-6 months)




**Mode of Action:**
Prevents microtubule polymerization, blocking glucose absorption, starving worm

# Prevention and Control:

1. Regularly treat all dogs with niclosamide that have contact with sheep. This drug kills the adult parasites.

2. Avoid feeding hydatid cyst material (sheep offal) to dogs.

3. Public health education of sheep farmers.


Why are you still sitting in the dark?
See you in the lab…