# Wastewater Biology

## Parasites

By: Dr. Mel Zimmerman

Biology Department
Lycoming College

# Definitions

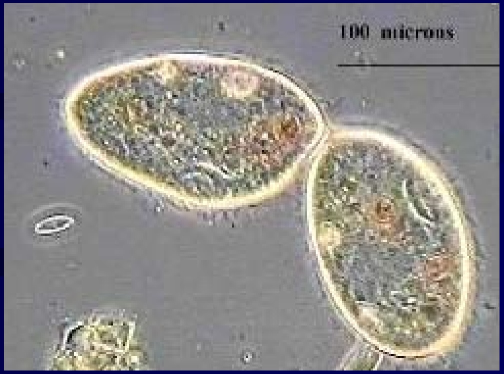
- A parasite lives on ectoparasite or in endoparasite another organism of a different species from which it derives its nourishment. This organism is the parasite host.
- The host in which the parasite reaches sexual maturity and reproduction is usually termed the definitive host.
- An intermediate host is one in which some developmental or larval stage of the parasite occurs.
- A reservoir host is another animal (besides man) in which the parasite can use to complete its life cycle

# Reasons for Increased Attention to Transmission of Protozoa and Helminths in Wastewater

- Recognition of increased parasitic infestations in U.S.
- Return of military personnel and travelers from abroad
- Increased level of immigration in U.S.
- Food imported from countries with high parasitic disease prevalence
- Existence of resistant stages of parasites
  - Helminth eggs
  - Protozoan cysts

# Parasites of concern

- Protozoa




- Helminths (worms)
  - Flatworms (flukes and tapeworms)
  - Roundworms

  (nematode worms

# Risk of Infection is Real!

- Variety of parasites live domestic wastewater and they can present an occupational health hazard.
- WEF survey incidence for disabling parasitic illness is < 1 - 2 %

# Survey of 75 Municipal Plants

(Locations: Alabama, Florida, Louisiana, Minnesota, Mississippi, New York, Ohio, Texas and Washington)

- Resistant stages of 23 types of parasites were found in samples, which may represent over 30 different human and animal parasites
  - Densities may vary, parasites are distributed throughout all of the continental US
  - 4 most common parasite were the nematodes, *Ascaris spp., Trichuris, and Toxocara spp*.
  - Total number of parasite ova recovered varied according to the source of sludge and season of the year and averaged 14,000 eggs/kg (dry weight) of sludge

# Survey Continued

- Percentage of total parasite ova in the slude sample that were viable (infection causing capability) ranged from 0 – 100%, but was generally greater than 45% for primary sludge and 69% for treated sludges
- Primary and secondary undigested sludge samples were found to contain in order of decreasing average densities 9,700 *Ascaris spp*. ova, 1,200 *Toxocara spp*. ova, 800 *T. trichiura* ova, and 600 *T. vulpis* ova/dry kg of sample
- Average number of these parasites in stabilized sludge samples were 9,600 *Ascaris spp*. ova, 2,600 *T. trichiura* ova, 700 *Toxocara spp*. ova, and 700 *T. vulpis* ova/dry kg of sludge sample

# Major Transmission Areas for Parasitic Protozoa

- Wastewaters
- Sludges
- Sludge-amended soils
- Sludge disposal sites

# Minor Transmission Areas for Parasitic Protozoa and Helminths

- Aerosols
- Groundwater
- Why? Because size and weight of protozoan cysts and helminth eggs
  - Hinder their conveyance on aerosols
  - Hinder their movement through soil in groundwater

# Parasites

**Figure 166**. Cyst of *Giardia* sp. (arrow) ≈10 µm in length, from primary sludge, Alabama. These are parasitic flagellates that live in the small intestine of vertebrates. Resistant cysts, which serve to infect the next host, are passed out with feces.

**Figure 167.** Same as **Figure 166** except dead.

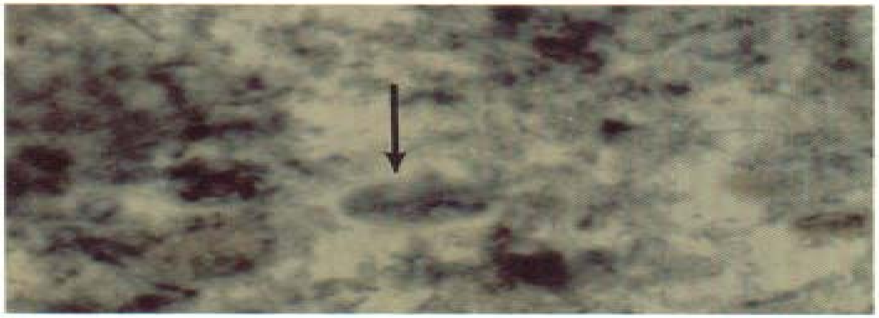


**Figure 168.** Cyst (arrow) of *Giardia intestinalis* (=*lamblia*), ≈12 µm in length, stained with hematoxylin. This species infects humans. The active flagellates in the intestine have two nuclei and eight flagella. After encystment, the nuclei divide, so that four nuclei are present in cysts. Several are in the plane of focus here. The other darkly staining structures in the cyst are microtubular bands and fragments of the sucking disc with which it attaches to the intestinal wall.

**Figure 169.** *Entamoeba coli* cysts, ≈10 µm in diameter, from sludge, Washington. These amoebae live as commensals in the intestine and eat bacteria without doing harm to their host. There are several rounds of nuclear division after encystment, so that mature cysts contain eight nuclei. They can be distinguished from *E. histolytica*, the causative agent of amoebic dysentery in humans, by the number of nuclei in cysts. *E. histolytica* cysts contain four nuclei.

**Figure 170.** *E. coli*-like cyst, ≈12 µm in diameter, from primary sludge, New York.

**Figure 171.** Coccidian oocyst, ≈12 µm long, from sludge drying bed, Alabama. When an oocyst is swallowed by an appropriate host, sporozoites inside will emerge in the intestine and begin multiplying in the cells of the intestinal epithelium. Many species of coccidia exist. Identification of this species is not possible from this photograph.

*NOTE: All photographs of parasites except for Figures 168 and 172 were contributed by Dr. M. Dale Little of Tulane University.*

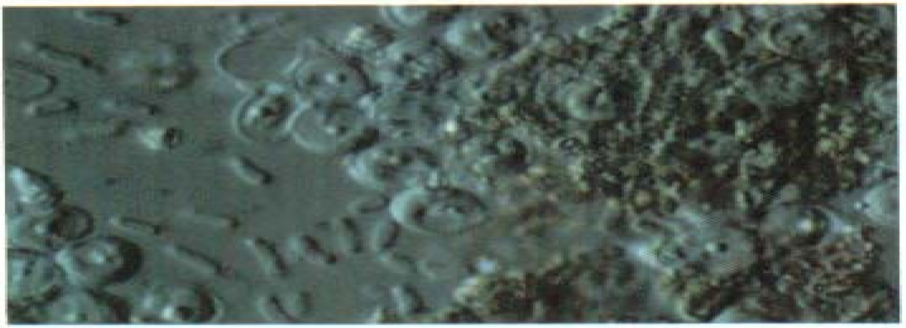


**Figure 172**

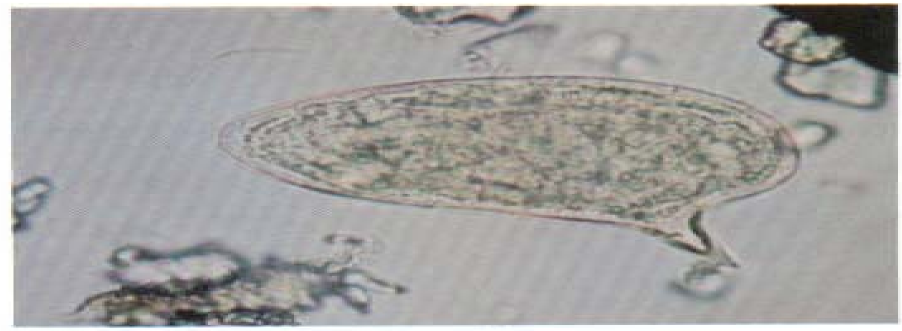


**Figure 173**

**Figure 172.** *Cryptosporidium parvum* oocysts (round structures) and sporozoites (smaller cylindrical structures with rounded ends) from cattle feces. Oocysts ≈5 µm in diameter; sporozoites ≈3 to 5 µm long. Differential interference contrast. This species is a coccidian parasite that can infect humans causing a self-limiting diarrhea. It can be more serious for immunocompromised individuals. Sporozoites would not survive outside the oocyst in wastewater. The oocysts of this photograph were placed in an excystation medium, so that sporozoites would be released.

**Figure 173.** Egg of the trematode *Schistosoma mansoni*, 125 µm long, from primary sludge, New York. The adult worms parasitize humans, living in the blood vessels surrounding the large intestine. Their eggs migrate through tissue to reach the lumen of the intestine, after which they are passed out in the feces. The larvae hatch from the egg in water and must find an aquatic snail of the genus *Biomphalaria* for the life cycle to continue. It bores into the snail tissues and begins growing. It produces large numbers of cercariae (a motile swimming stage that leaves the snail) that penetrate the skin of humans wading in the water and then migrate to the blood vessels around the large intestine, where they reach maturity. It is common in Africa and the New World tropics. Although different sanitation standards and the absence of the appropriate snail host prevent transmission from occurring in the continental U.S., it is still found here, as it is brought in by travelers and immigrants.

---

**Figures 174, 175, 176.** Egg of the tapeworm *Diphyllobothrium latum*, 60 µm long. **Figure 174** from primary sludge, Minnesota; **Figure 175** from human feces, preserved; **Figure 176** from primary sludge, New York. The egg has an operculum on one end and a barely developed knob at the other, features that are most apparent in **Figure 175.** The swimming larva that emerges from the egg survives only if eaten by a copepod. It bores through the intestinal wall and takes up residence in the hemocoel. If the copepod is then eaten by a fish, the tapeworm larva migrates to the muscle and grows further. They can be seen as white blobs in the meat of freshly caught fish. The life cycle is completed when a predator consumes the fish; the tapeworm reaches maturity in the intestine of the predator. *D. latum* is a common human parasite throughout the world. In the U.S., it is most common in the Great Lakes area.

**Figure 174**

**Figure 175**

**Figure 176**

**Figure 177.** Egg of the tapeworm *Hymenolepis diminuta*, ≈90 µm long, from primary sludge, Washington. It will hatch after being ingested by a grain beetle, and the larvae will bore through the intestinal wall using the six hooks visible in the photograph. It will settle in the hemocoel and wait for a rat or human to ingest the beetle. After ingestion by a rat or human, the tapeworm will grow to maturity in the intestine.

---

**Figures 178-184.** Development of an *Ascaris* egg. The nematode *Ascaris lumbricoides* is a common human parasite that lives as an adult in the intestine. The eggs, about 60 µm long, are characteristically bumpy and brown. People become infected by ingesting eggs containing a young worm (**Figure 184**). Rather than remaining in the intestine, the worms migrate to the lungs. After crawling up to the throat from the lungs or being coughed up, the worms are reswallowed, and this time they stay in the intestine where they grow into adult worms. **Figure 178** from anaerobic digester, New York. **Figure 179** from sludge, source unknown. **Figure 180** from sludge drying bed, Alabama. **Figure 181** from primary sludge, New York. **Figure 182** from primary sludge, New York. **Figure 183** from activated sludge, Washington. **Figure 184** from sludge drying bed, Florida.

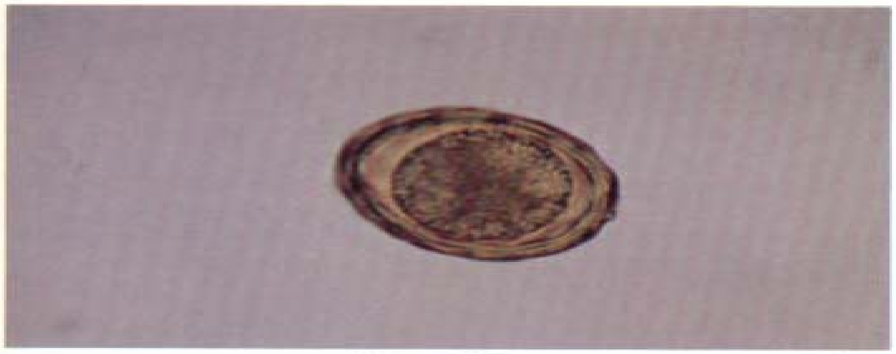


**Figure 178**

**Figure 179**

**Figure 180**

**Figure 181**

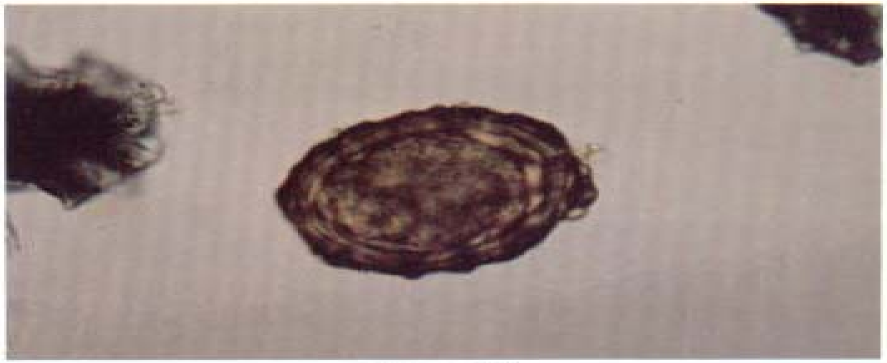


Figure 182

Figure 183

Figure 184

**Figure 185.** Egg of *Parascaris equorum* from anaerobic digester, Washington. This is an ascarid parasite of horses and has the same life cycle as *A. lumbricoides*.

**Figure 186.** Nematode egg (*Ascaridia* sp. or *Heterakis* sp.) from poultry waste, Alabama.

**Figures 187–192.** Development of a *Toxocara canis* egg. This ascarid parasite of dogs has the same life cycle as that of *A. lumbricoides* when it infects puppies. In adult dogs, the larvae cannot complete migration to the lungs. They survive in the tissues for a while before dying. **Figure 187**, *T. canis* surface, from primary sludge, Minnesota. **Figure 188**, two-cell stage, from anaerobic digester, Washington. **Figure 189**, four-cell stage, from raw sludge, New York. **Figure 190**, eight or more cells, from sludge drying bed, Alabama. **Figure 191**, early larval stage, from primary sludge, New York. **Figure 192**, infective stage, source unknown.

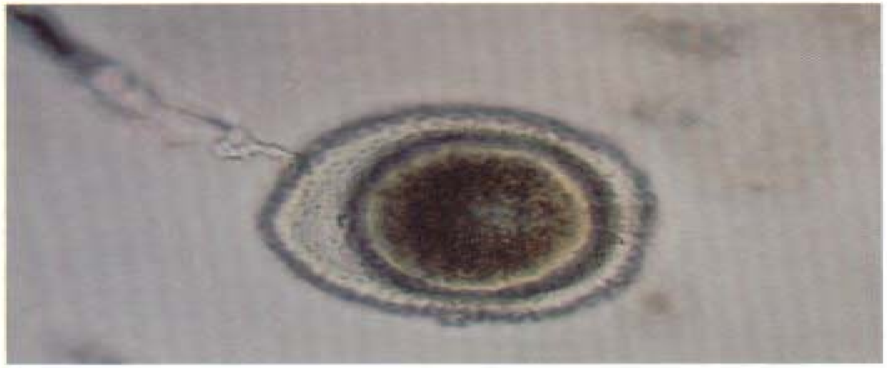


**Figure 187**

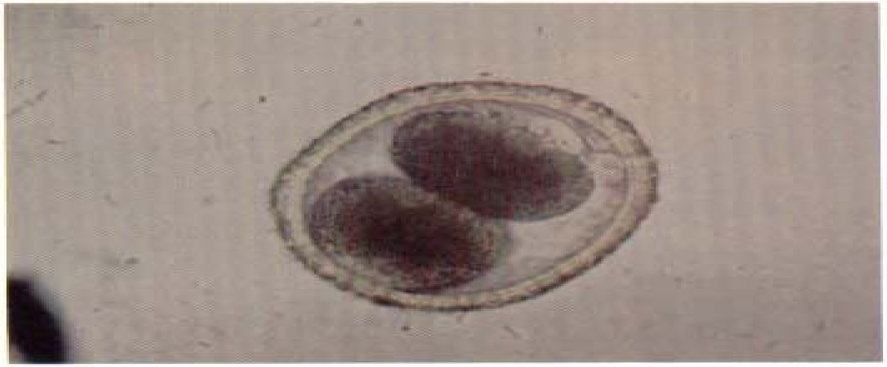


**Figure 188**

**Figure 189**

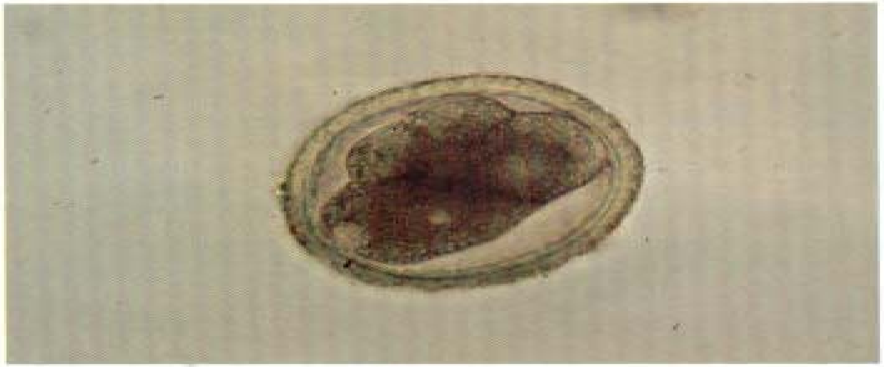


**Figure 190**

**Figure 191**

**Figure 192**

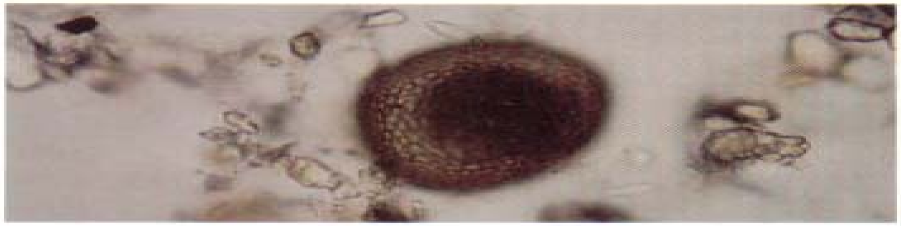


**Figure 193**

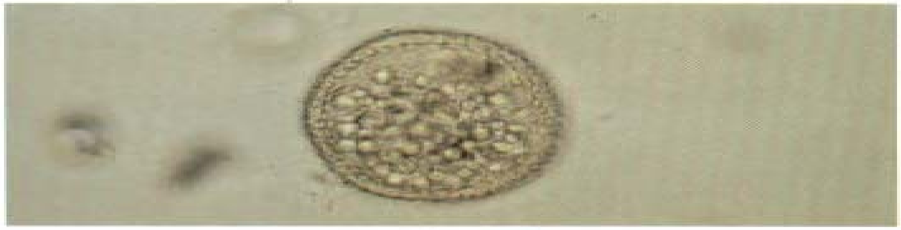


**Figure 194**

**Figures 193, 194.** Dead *T. canis* eggs. **Figure 193** from activated sludge, New York. **Figure 194** from drying bed, Alabama.

**Figure 195.** Egg of *Toxocara cati*, which infects cats, from Imhoff tanks, New York. Egg is in the two-cell stage. *T. cati* eggs are 80 to 90 µm in diameter.

---

**Figures 196–199.** Development of *Trichiuris trichiura* egg. This nematode parasite of humans is sometimes called a whip worm, because it has a long thin anterior end and a short fatter posterior end—the whip handle. Adults live in the intestine, and eggs are passed in feces. Humans become infected by ingesting eggs. **Figure 196**, two-cell stage, from aerobic sludge, Alabama. **Figure 197**, eight-cell stage, from anaerobic digester, New York. **Figure 198**, *T. trichiura* viable egg from primary sludge, New York. **Figure 199**, infective egg, source unknown.

**Figure 196**

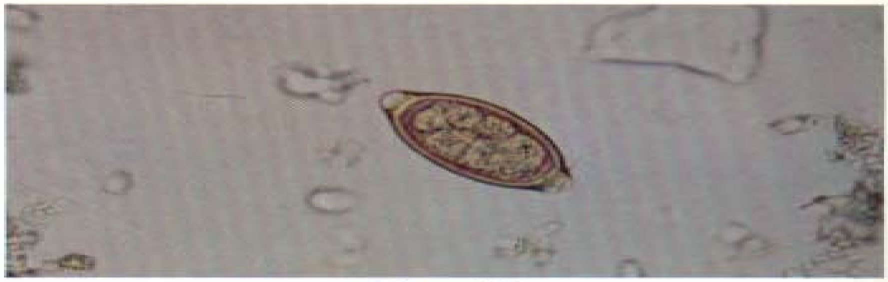


**Figure 197**

**Figure 198**

**Figure 199**

**Figures 200–203.** Eggs of *T. vulpis*, the dog whipworm. **Figure 200** from drying bed, Mississippi. **Figure 201**, two-cell stage, from anaerobic digester, New York. **Figure 202**, viable egg in the eight-cell stage, from primary sludge, New York. **Figure 203**, infectious stage, from drying bed, Florida.

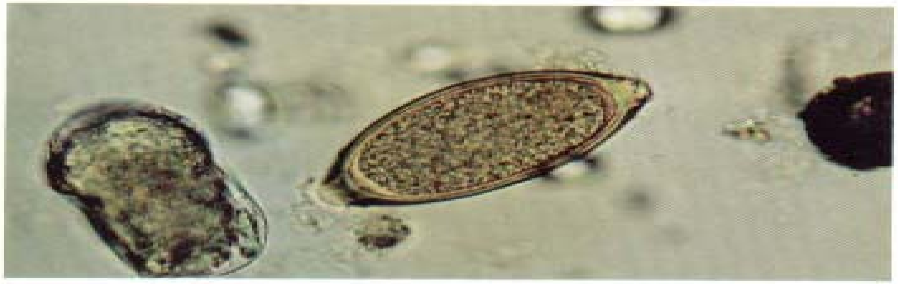


**Figure 200**

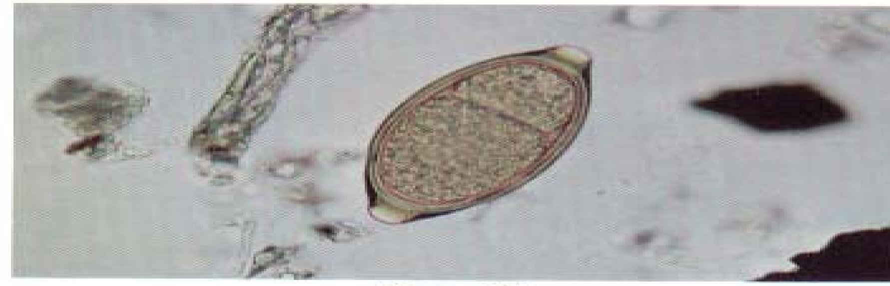


**Figure 201**

**Figure 202**

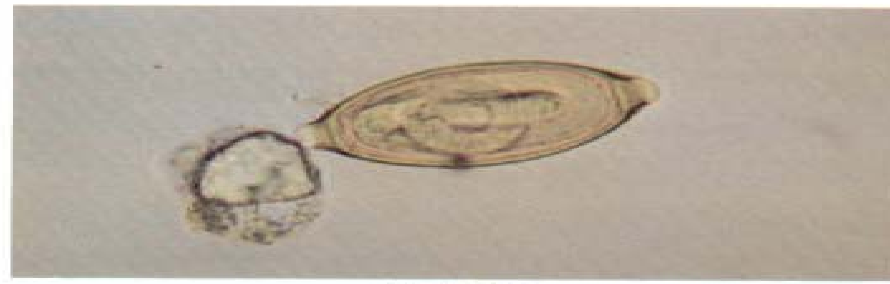


**Figure 203**

**Figure 204.** Egg of the rat nematode *Trichosomoides* from anaerobic digester, Washington.

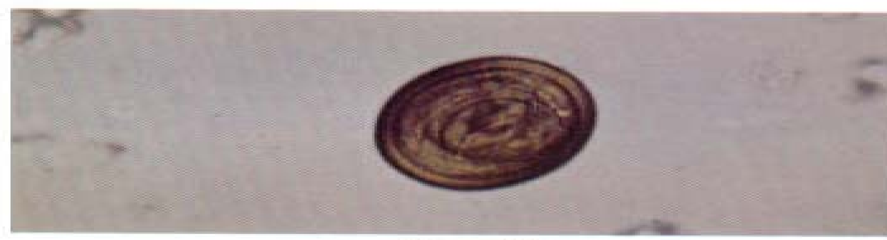


**Figure 205**

**Figure 206**

**Figures 205, 206.** Unidentified nematode eggs from raw sludge, New York.

# Frequently Asked Questions & Answers about Wastewater and Biosolids Worker Health & Safety

**Do wastewater and biosolids workers have a higher rate of potential exposure to pathogens than the general public?**

A common characteristic of untreated wastewater is its high concentration of microorganisms. Biological secondary treatment followed by disinfection is an important way to treat wastewater because it significantly reduces microorganisms. The disinfection process that follows then kills many pathogens before the cleaned water is discharged to the receiving streams. Because of their daily exposure and contact with biological materials, wastewater personnel may have a higher incidence of potential exposure to pathogens than the general public. For most workers, however, the risk of developing an occupational illness is significantly reduced or eliminated when standard safety and personal hygiene procedures are followed.

**What are some of the common wastewater facility hazards?**

As in many occupational settings ranging from hospitals, restaurants, food processing, agriculture, and health-care professions, wastewater personnel can also be potentially exposed to biological hazards. Even routine procedures such as changing a baby's soiled diaper and preparing meat dishes can expose an individual to contamination if proper personal hygiene is not followed. Some of the potential hazards for individuals who work around any collection system or wastewater facility may include: infectious disease, physical injury, confined spaces, oxygen-deficient spaces, toxic or harmful chemicals and gases, explosive gas mixtures, fires, electrical shock, noise, and dust and fumes. It is important, therefore, that workers follow standard safe work procedures to minimize or eliminate the potential for injury and illness.

What are some of the health and safety concerns with biosolids composting?

The major wastewater worker health and safety concerns involve the potential effects of primary pathogens, bioaerosols, heavy metals, and other microorganisms at facilities processing wastewater and biosolids. Worker exposure could occur through inhalation, ingestion, and dermal contact. Adherence to good personal hygiene and use of personal protective equipment are recommended for workers in these occupational environments.

Have there been any studies relating to the incidence of illness to wastewater workers?

Studies have been conducted over the past 25 years relating to wastewater worker occupational illnesses. Although most studies cited in the scientific literature indicate that infections from specific agents are not common, workers in contact with wastewater or biosolids, especially during their first few years of employment, have been known to experience some increased symptoms associated with gastrointestinal or upper respiratory illnesses. However, other studies also point out that wastewater workers build immunity over time against these types of illnesses and are generally healthier than the general population.

What can wastewater workers do to minimize potential exposures to pathogens?

Proper personal hygiene and use of personal protective equipment are critical because infections from contact and exposure to microorganisms may occur without symptoms and antibodies to bacteria and viruses may develop without illness symptoms being readily apparent.

**What are the most common bacterial pathogens found in wastewater?**

The most common bacterial pathogens found in untreated wastewater are *Salmonella* and *Shigella*. Other bacterial microorganisms include *Vibrio, Clostridium, Yersinia, Campylobacter, and Leptospira. Escherichia coli (E.coli),* which can cause gastroenteritis, is generally not considered a pathogen because it is a microorganism that naturally inhabits the gastrointestinal tract of man.

**What is the difference between a virus and bacteria?**

A virus is any group of ultramicroscopic agents that reproduce only in living cells. Unlike viruses, bacteria do not require a living host cell to reproduce. Pathogenic bacteria are microscopic in size and common in wastewater. Because bacteria can reproduce outside the body, microorganisms can be present in large quantities in the wastewater collection system and treatment process.

**What types of viruses are found in wastewater?**

Viruses multiply in the living cells of the intestinal tract and end up in human feces. The common human viruses in wastewater include Norwalk, Rotavirus, Adenovirus, Coxsackie A and B, Echovirus, Hepatitis A, Poliovirus, and Reovirus. These viruses have the potential to cause gastrointestinal and upper respiratory illness when proper safety procedures are not followed in the workplace.

**Can parasites be found in wastewater?**

Waterborne parasites found in wastewater consist of various types of protozoa and worms. Many of these organisms often do not survive the journey through the wastewater collection system and treatment facilities. The cysts and eggs, in which the protozoa and worms reproduce, are often resistant to adverse conditions and may show up in wastewater or biosolids samples. Because hand-to-mouth contact is the principal cause of infection, it is important that workers wash their hands frequently.

Are wastewater workers at risk to contracting AIDS or Hepatitis B in the workplace?

AIDS and hepatitis B are both blood-borne viruses and cannot reproduce outside the human body. For disease transmission, AIDS and hepatitis B must enter the bloodstream directly. The Centers for Disease Control (CDC) has stated that there is no scientific evidence that AIDS or hepatitis B can be contracted through occupational exposure associated with wastewater treatment.

What is the most common route of wastewater worker infection?

The most common cause of infection is due to poor personal hygiene. The three basic routes that may lead to infection in the wastewater environment include ingestion through splashes, contaminated food, or cigarettes; inhalation of infectious agents or aerosols; and infection due to an unprotected cut or abrasion. Ingestion is generally the major route of wastewater worker infection. The common practice of touching the mouth with the hand will contribute to the possibility of infection. Workers who eat or smoke without washing their hands have a much higher risk of infection. Personal hygiene practices including frequent washing of the hands will minimize these potential opportunities for exposure.

**What are the risks of infection to biosolids operators?**

In addition to the general risks to wastewater workers, biosolids workers that are at locations where wastewater or biosolids are sprayed should avoid prolonged exposures where contact with such aerosols are likely. In instances where prolonged exposure to aerosols is anticipated, the use of surgical masks and goggles will significantly minimize contact and risk of infection.

**What can wastewater workers do to prevent infections?**

The most important consideration is the use of good common sense and following appropriate personal hygiene and using personal protective equipment where appropriate. Some of the standard workplace precautions and personal hygiene steps that should be followed include:

- Wash hands frequently with soap and water after contacting wastewater; after visiting rest rooms; before eating, drinking, or smoking; and at the end of the work shift.
- Promptly treat cuts and abrasions using appropriate first aid measures.
- Wear heavy-duty gloves (double gloving) and boots that are waterproof and puncture resistant.
- Wear surgical-type masks and goggles or face shields for prolonged exposure to wastewater aerosols.

- Change soiled uniforms or protective clothing as soon as the job is completed.
- Shower before changing into clean street clothes and shoes.
- Wherever possible, use dual lockers to separate work and street clothes
- Launder work clothes at work and not at home.
- Handle sharp items with extra care to prevent accidental injuries.
- Clean contaminated tools after use.
- Follow good common sense and exercise extra caution whenever there is contact with contaminated water or sludge.
- Promptly clean body parts that contact wastewater or biosolids.

Do the Centers for Disease Controls recommend any special immunizations for wastewater or biosolids workers?

No additional immunizations above those recommended by CDC for the adult general population are advised for workers in contact with wastewater or biosolids. Wastewater and biosolids workers and all other adults in the general population should be adequately vaccinated against diphtheria and tetanus. The preventive effect of the vaccine immune serum globulin for hepatitis A is short lived (about 3 weeks), and is not routinely recommended for wastewater or biosolids workers. This vaccine is only recommended where there has been direct exposure to wastewater splashed into an open wound or the mouth or a severe outbreak has occurred in the community. The vaccine for hepatitis B is not routinely recommended for wastewater or biosolids workers because the risk of transmission of the virus by wastewater is extremely remote.

# REFERENCES

"Biological Hazards at Wastewater Treatment Facilities," A Special Publication. Water Environment Federation (1991).

"Safety and Health in Wastewater Systems," Manual of Practice SM-1. Water Environment Federation (1994).

Clark, C.S. "Potential and actual biological related health risks of wastewater industry employment." J. Water Poll. Control Fed. 59 (12): 999-1008 (1987).

# Parasitic Protozoa Life Cycle

- Protozoa exists as a trophozoite in intestinal tract of infested individuals
- Trophozoite is fragile and dies quickly outside the intestinal tract
- Protozoa survives outside intestinal tract (in feces) as a cyst
  - Contains a thick hyaline wall (provides environmental resistance)

# Factors Affecting Types and Levels of Protozoan Cysts

- Prevalence of disease in contributing human population
- Degree of animal contribution to conveyance system

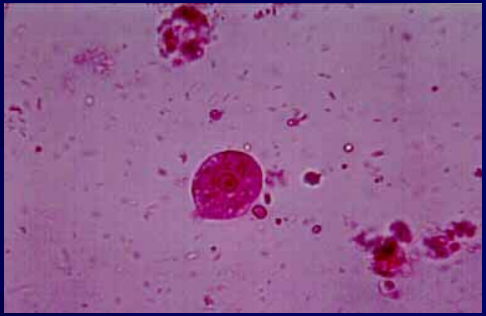
# Parasitic Protozoan That May Be Found in Wastewater

- *Balantidium coli*
- *Dietamoeba fragilis*
- *Entamoeba histolytica*
- *Giardia lamblia*
- *Isospora belli*
- *Isospora hominis*
- *Toxoplasma gondii*
- Others

# Major Parasitic Protozoa

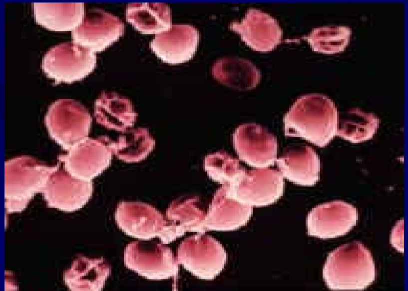
- *Balantidium coli*

- *Entamoeba histolytica*



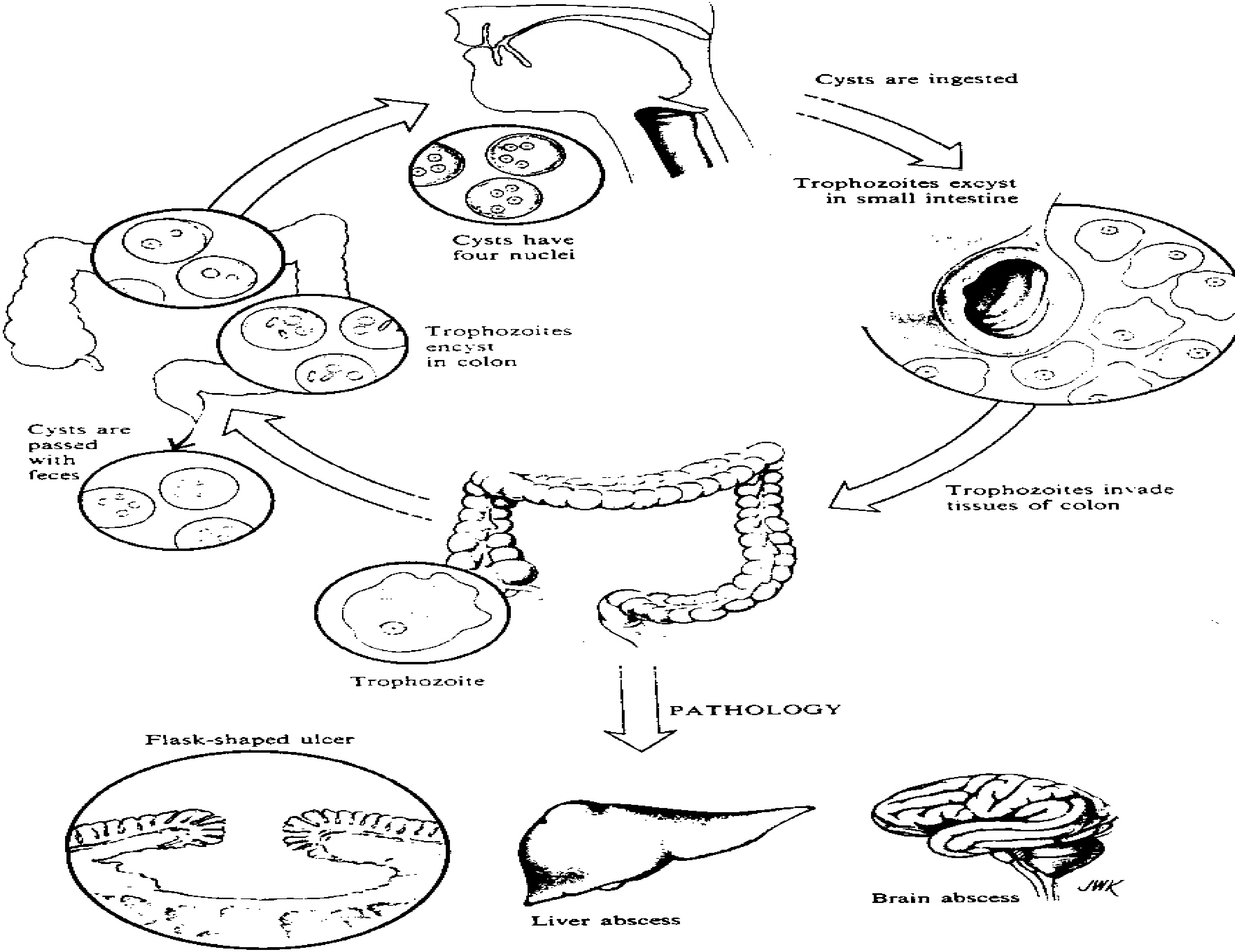
- *Giardia lamblia*

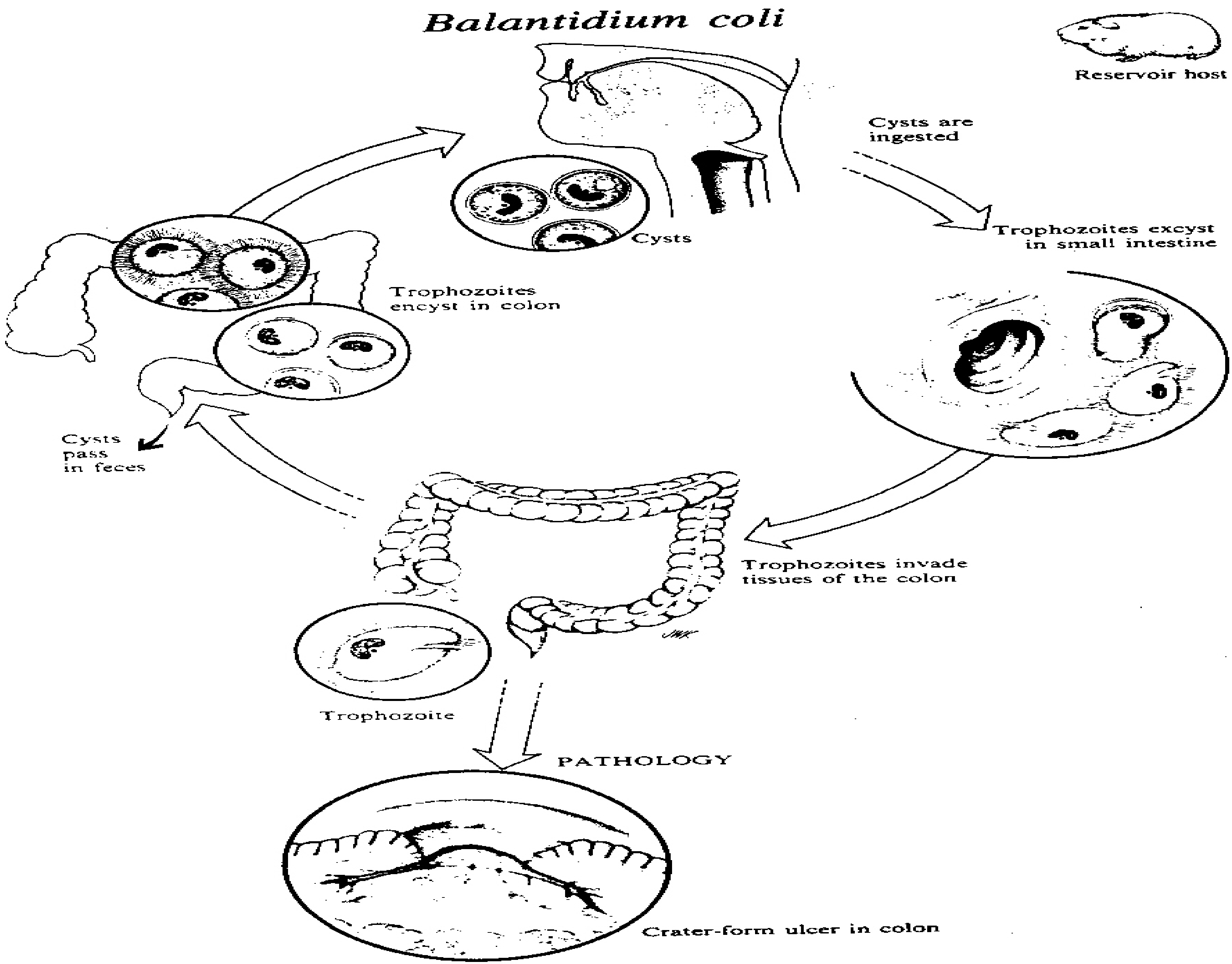
- *Cryptosporidium parvum*



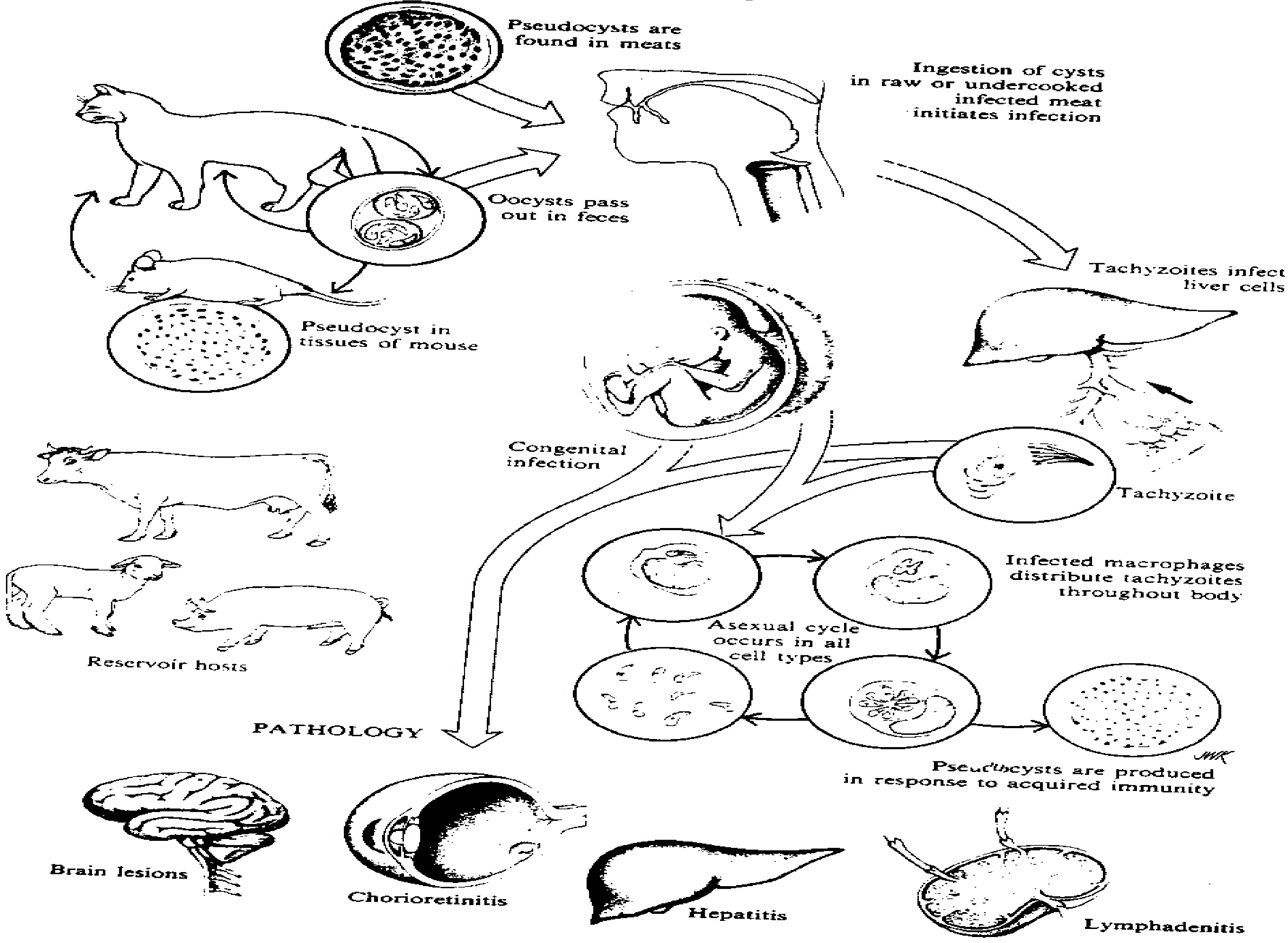
| Species | Types of Wastewater | Concentration (cysts/L) |
| --- | --- | --- |
| 1. *E. histolytica* | Untreated<br>Effluent<br>Untreated 50% Prevalence | 4.0<br>2.2<br>5000 |
| 2. *G. lamblia* | Untreated<br>Untreated 50% prevalence | 80,000<br>4,000,000 |

# *Entamoeba histolytica*



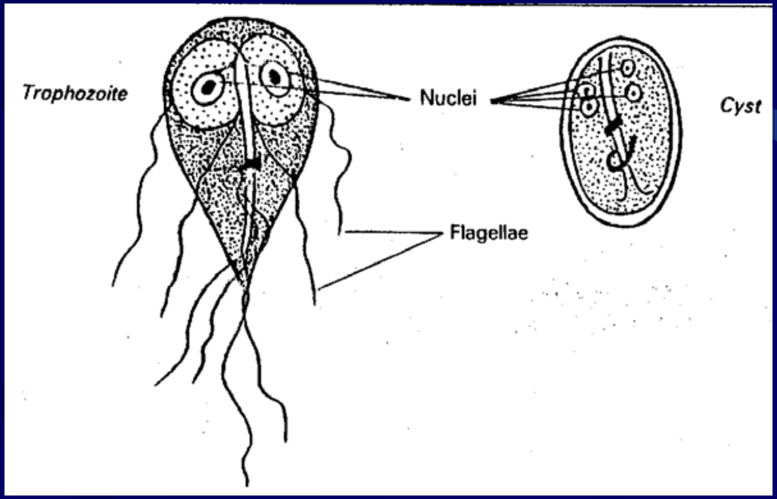

Balantidium coli
Reservoir host
Cysts are ingested
Trophozoites excyst in small intestine
Cysts
Trophozoites encyst in colon
Cysts pass in feces
Trophozoites invade tissues of the colon
Trophozoite
PATHOLOGY
Crater-form ulcer in colon

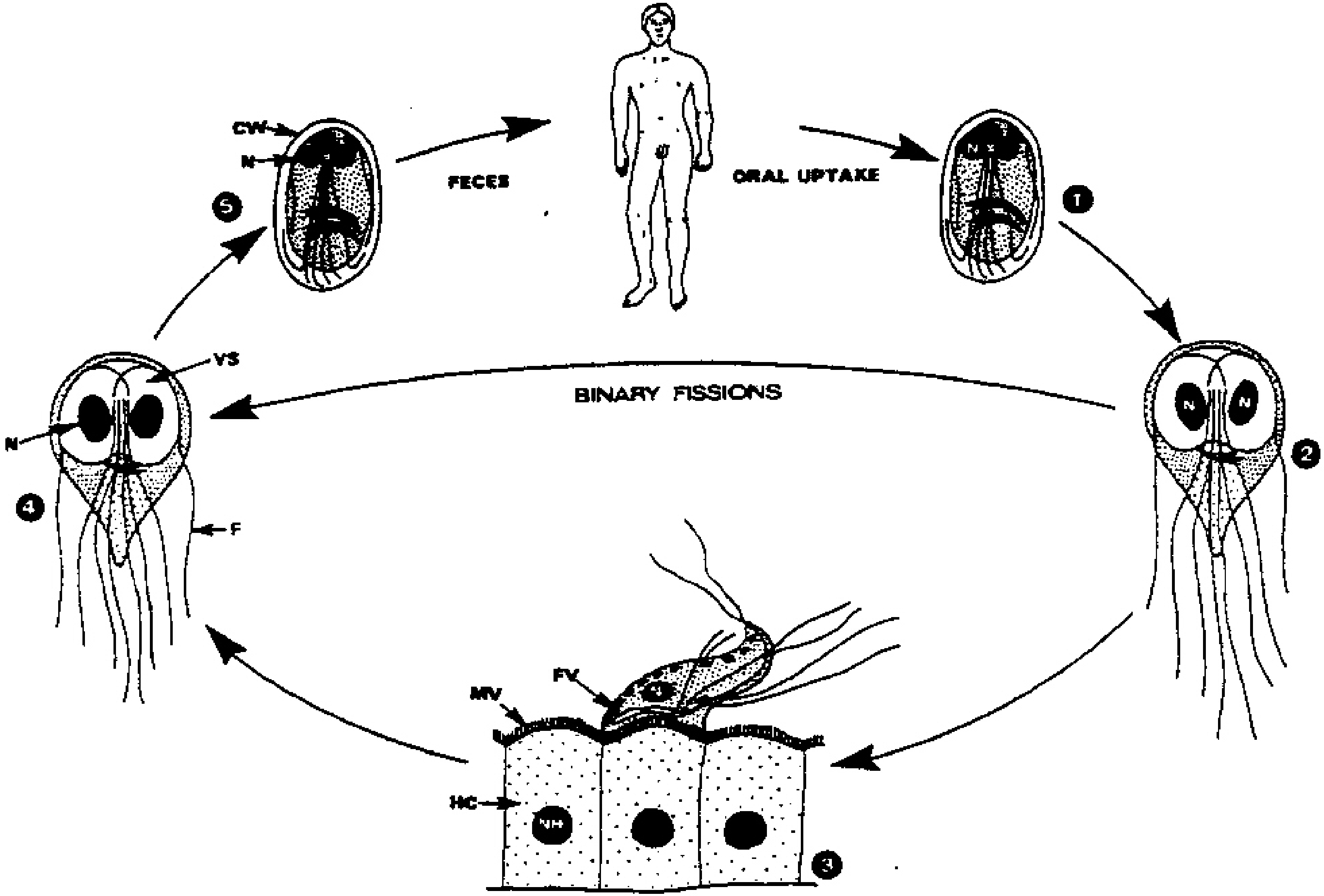
# Toxoplasma gondii



# *Giardia lamblia* Distribution

- Worldwide or cosmopolitan
- United States occurrences
  - Endemic forms (restricted)
  - Epidemic forms (widespread)
- Highest prevalence in the U.S.
  - Communities using surface water supplies
  - Potable water treatment consists primarily of disinfection only
  - Locations
    - New England States
    - Mid-Atlantic States
    - Pacific Northwest States
    - Rocky Mountain States





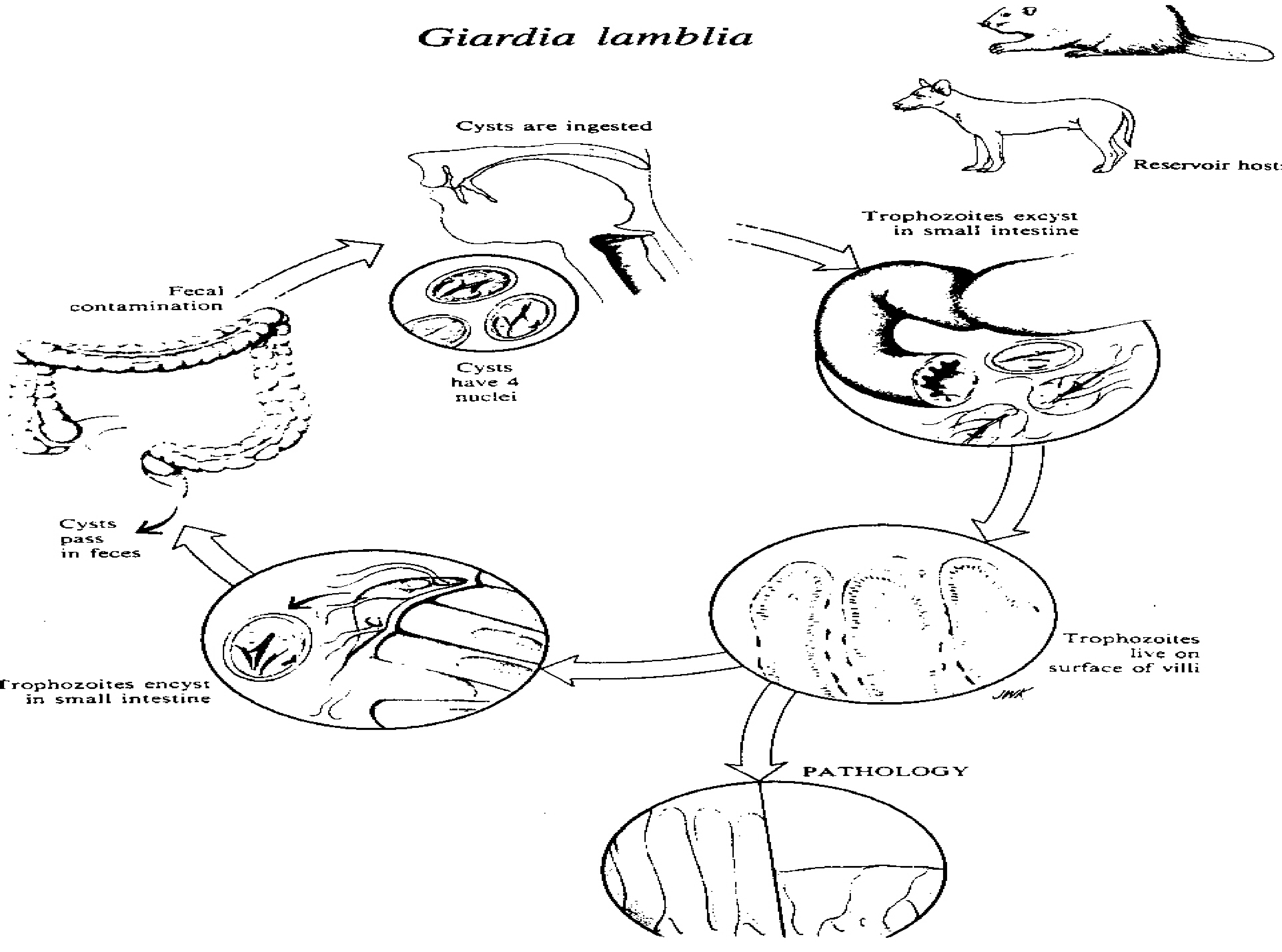

Life Cycle for *Giardia lamblia*

# *Giardia lamblia*

- Flagellated protozoa
- Causative agent for giardiasis or lambliasis
- Giardiasis: infects the small intestine
  - Severse diarrhea
  - Wight loss
- Prevalence in the United States
  - 1.5 to 20%
  - Most cases asymptomatic
- Most frequently identified intestinal parasite in the United States

# *Giardia lamblia* Continued

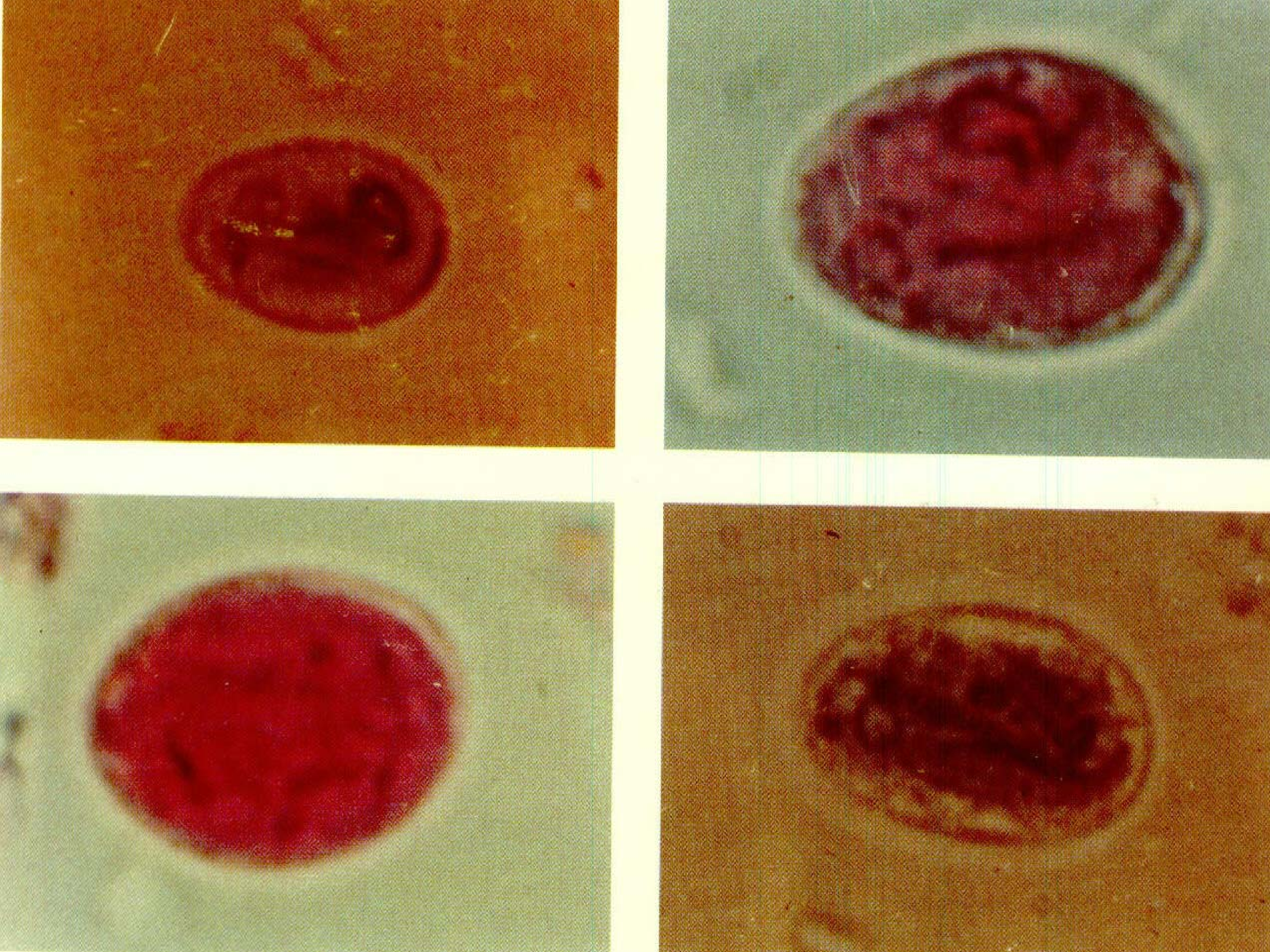
- Transmission
  - Municipal water supplies
  - Human-to-human contact
  - Contaminated food
  - Remote mountain streams
  - Wastewater contaminated with infected feces
- Reservoir hosts
  - Beaver
  - Muskrat
  - Vole



Giardia lamblia
Reservoir hosts
Cysts are ingested
Trophozoites excyst in small intestine
Fecal contamination
Cysts have 4 nuclei
Cysts pass in feces
Trophozoites live on surface of villi
Trophozoites encyst in small intestine
PATHOLOGY
JWK

# Life Cycle of *Giardia lamblia*

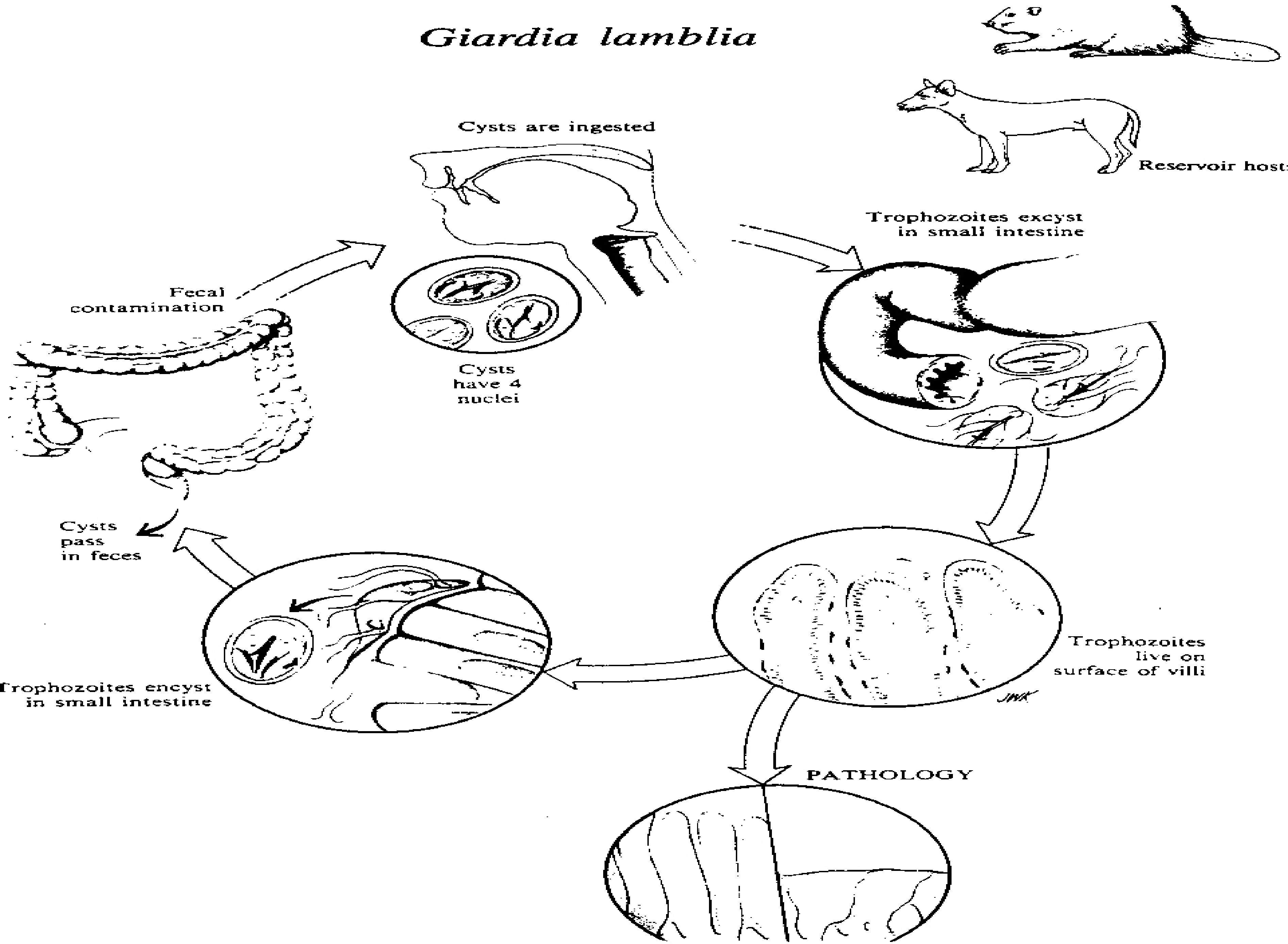
- Dormant cysts are swallowed
  - Oval
  - ~ 8 to 14 um long and ~ 7 to 10 um wide
  - Four nuclei
  - Thick hyaline wall
  - Can survive
    - In most environments for ~ 2 weeks
    - In mixture of urine, feces, and water for ~ 1 week
- Cysts undergo excystation in upper portion of small intestine
  - Hyaline wall breaks down
  - Newly formed trophozoites emerge



# Life Cycle Continued

- Trophozoites attach to epithelial cells of intestinal wall of small intestinal tract
  - Sucking disks used for attachment
  - Disks resist peristalisis
  - Trophozoite structure
    - Pear-shaped
    - ~ 9 to 22um long and ~ 5 to 15 um wide
    - Displays bilateral symmetry
    - Has two anterior nuclei
    - Has four pair of nuclei
    - Reproduces by simple fusion

# *Giardia lamblia*



# Life Cycle Continued

- Several thousand trophozoites can fit on end of pin
- Trophozoites pass through intestinal tract and encystaton occurs, i.e. cysts develop
- Cysts released to environment through feces

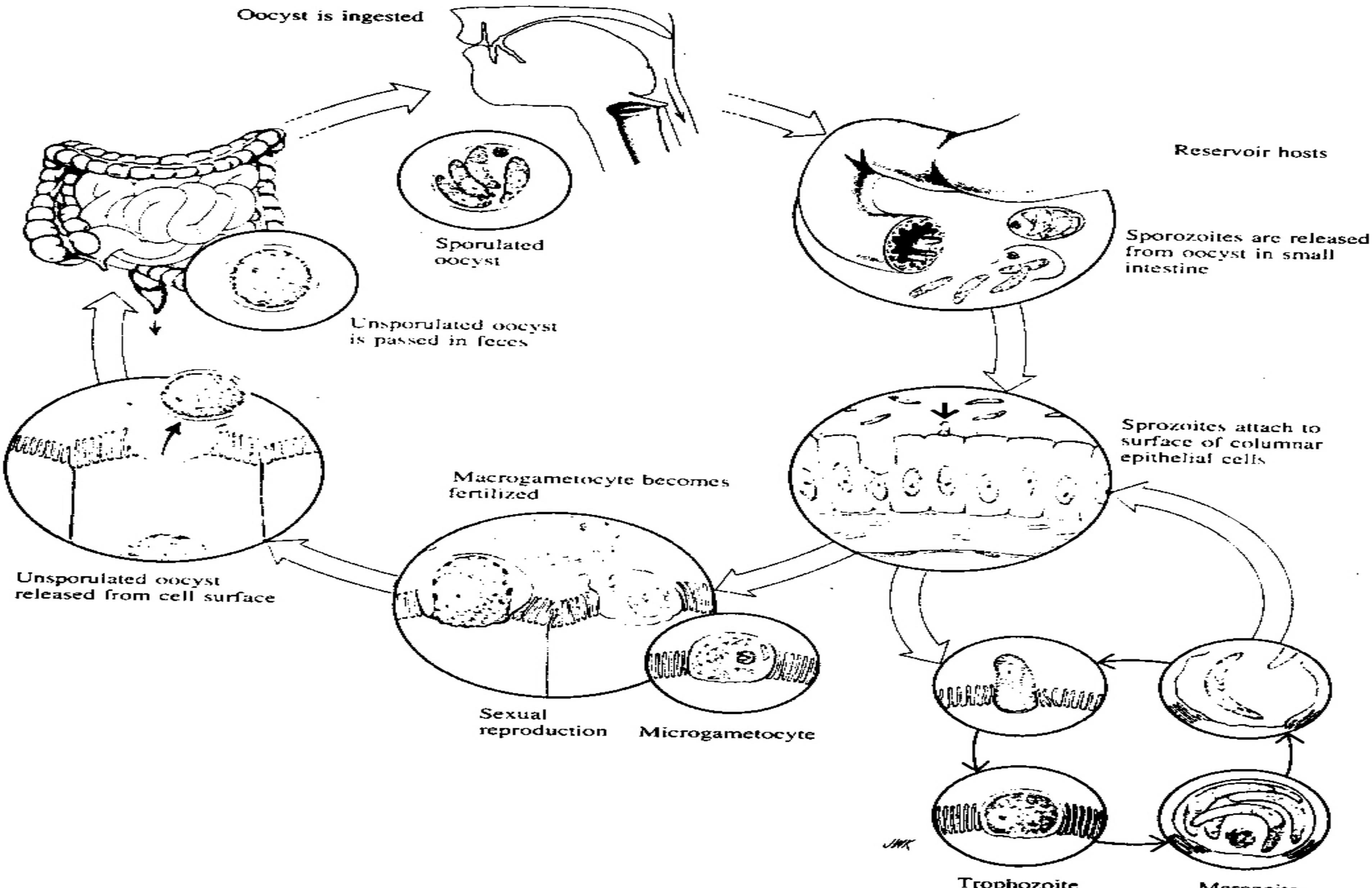
# Symptoms of Giardiasis

| Acute Condition | Chronic Condition |
| --- | --- |
| • Abnormal crams<br>• Bleaching<br>• Epigastric tenderness<br>• Flatulence<br>• Mild diarrhea | • Abdominal cramps<br>• Bloating<br>• Lethargy<br>• Loss of appetite<br>• Severe diarrhea<br>• Loss of weight<br>• Shock<br>• Ulceration of intestine<br>• Vitamin deficiencies |

# Sampling for Giardia lamblia cysts

- Water supplies
  - Routine coliform counts inadequate for evaluation of presence and number of *Giardia lamblia* cysts, because cysts are extremely resistant to chlorination at generally accepted chlorine residual values
  - Filtration technique for high-volume sampling (HVS) can be employed (current edition of Standard Methods)
- Wastewater supplies
  - Examine sludges where cysts are most concentrated
  - Used floatation technique
    - Current edition of Standard Methods
    - Parasitology laboratory manual

# *Cryptosporidium*



# Parasitic Helminths

- Parasitic helminths’ complex life cycle
  - Difficult to determine degree of “risk”
  - Difficult to incriminate “occupational risk”
  - Life cycle often has stages tolerating harsh environmnetal conditions
- Helminths
  - Roundworms (*Ascaris lumbricoides*)
  - Flatworms (*Taenia solium*) - tapeworms and flukes
- Factors affecting genera and levels of parasitic helminth eggs in wastewater
  - Levels of disease in contributing human populations
  - Levels of disease in contributing animal populations

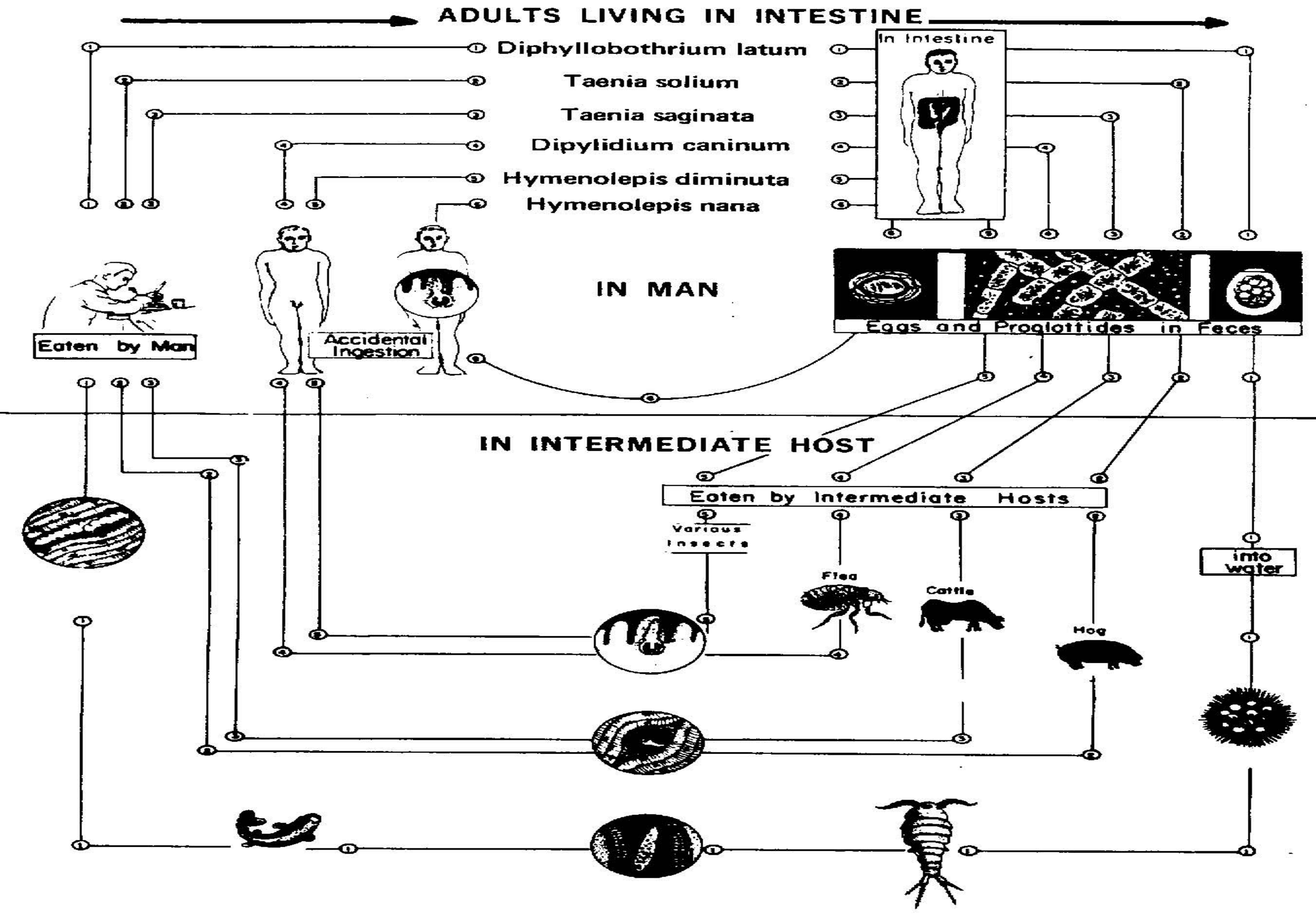
# Helminths of Concern

- *Ancylostoma brazilienze* – cat hookworm
- *Ancylostoma caninum* – dog hookworm
- *Ancylostoma duodenale* – hookworm
- *Ascaris lumbricoides* – roundworm
- *Ascaris suum* – roundworm
- *Enterobius vermicularis* – pinworm
- *Necator americanus* – hookworm
- *Stronglyoides stercoralis* – dog roundworm
- Toxocara canis – dog roundworm
- *Toxocara cati* – cat roundworm
- *Trichuria trichuria* - whipworm

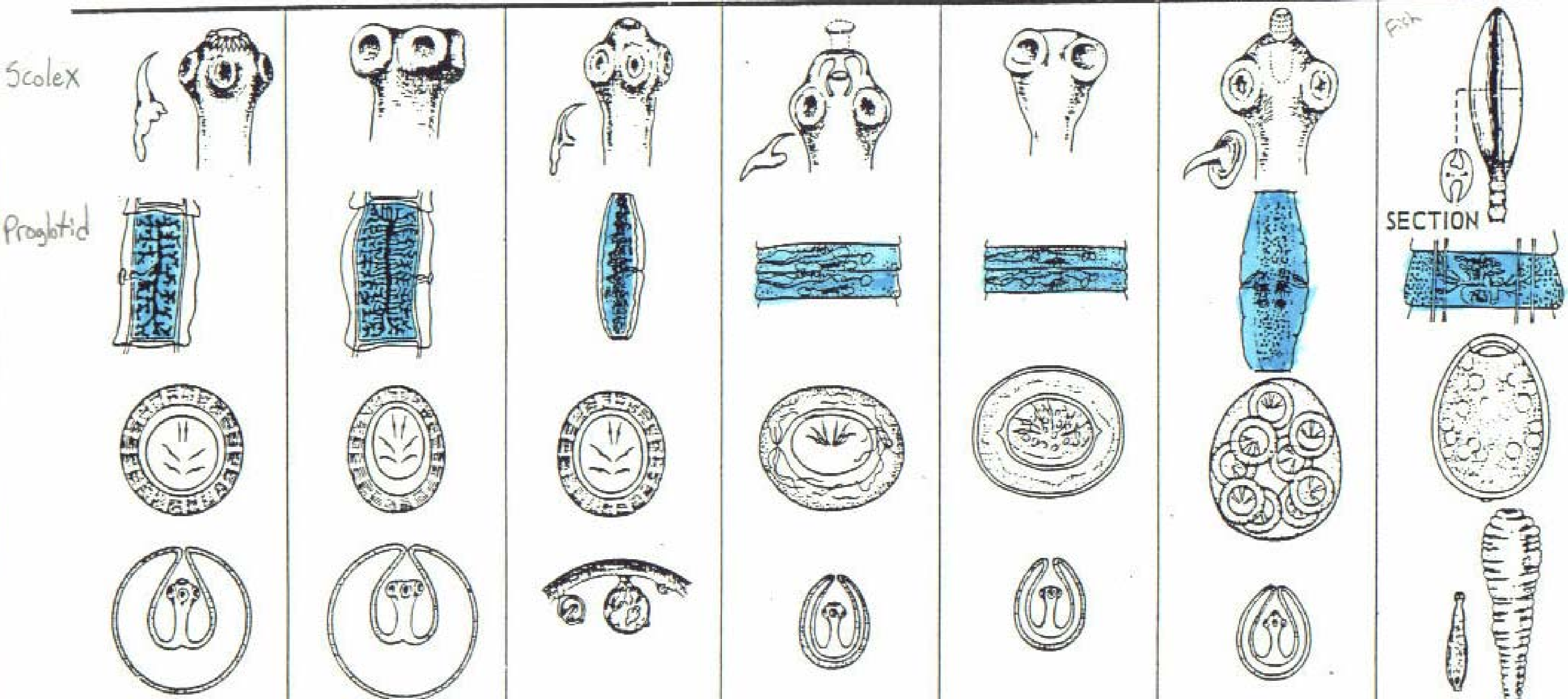
# Cestodes (Tapeworms)

- *Echinococcus granulosus* - dog tapeworm
- *Hymenolepis nana* – dwarf tapeworm
- *Taenia saginata* – beef tapeworm
- *Taenia solium* – pork tapeworm

# LIFE CYCLES IMPORTANT HUMAN TAPEWORMS

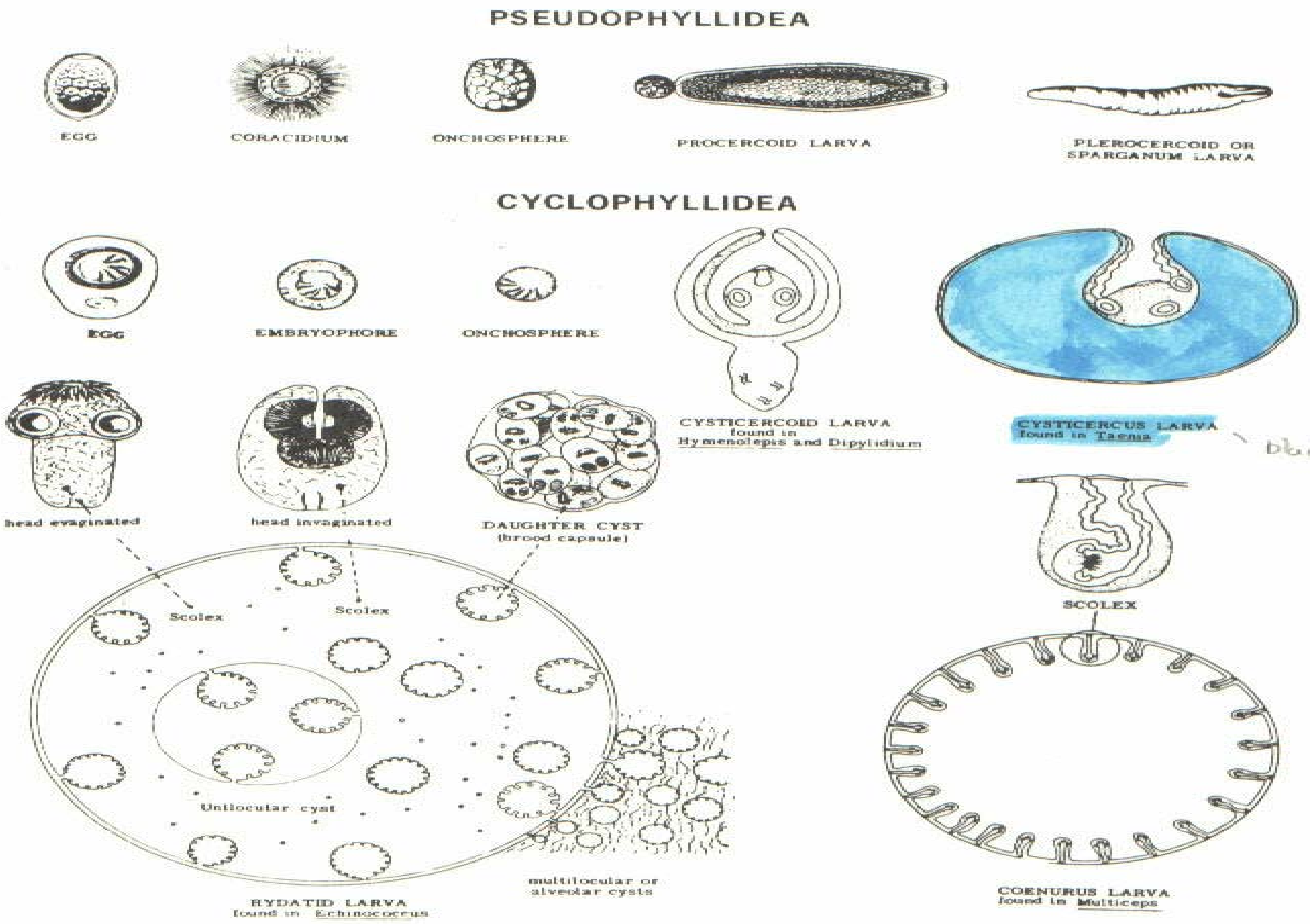


| PHYLAM | CLASS | ORDER |
|---|---|---|
| FAMILY | | |
| GENUS | | |
| SP | | |




| | | | | | | |
|---|---|---|---|---|---|---|
| Taenia Solium | Taenia Saginata | E. Granulosus | | Hymenolepsis Diminata | Dipylidium Caninum<br>Dog | D. Latam |
| | | | | | | |

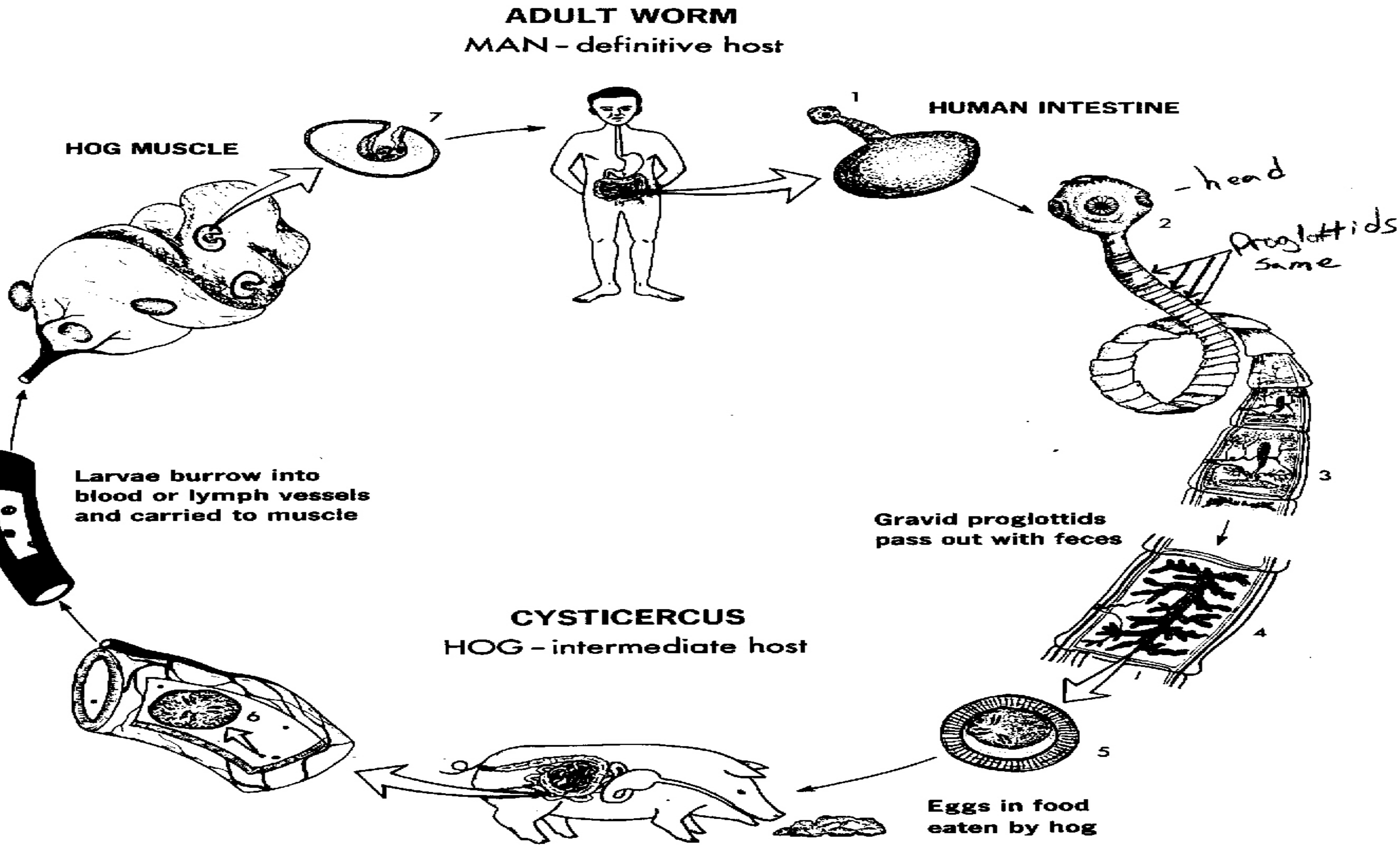
# IMMATURE STAGES OF HUMAN TAPEWORMS



# *Taenia solium* Life Notes

- Average life span for adults ~ 25 years
- Eggs released/day/worm > 10,000

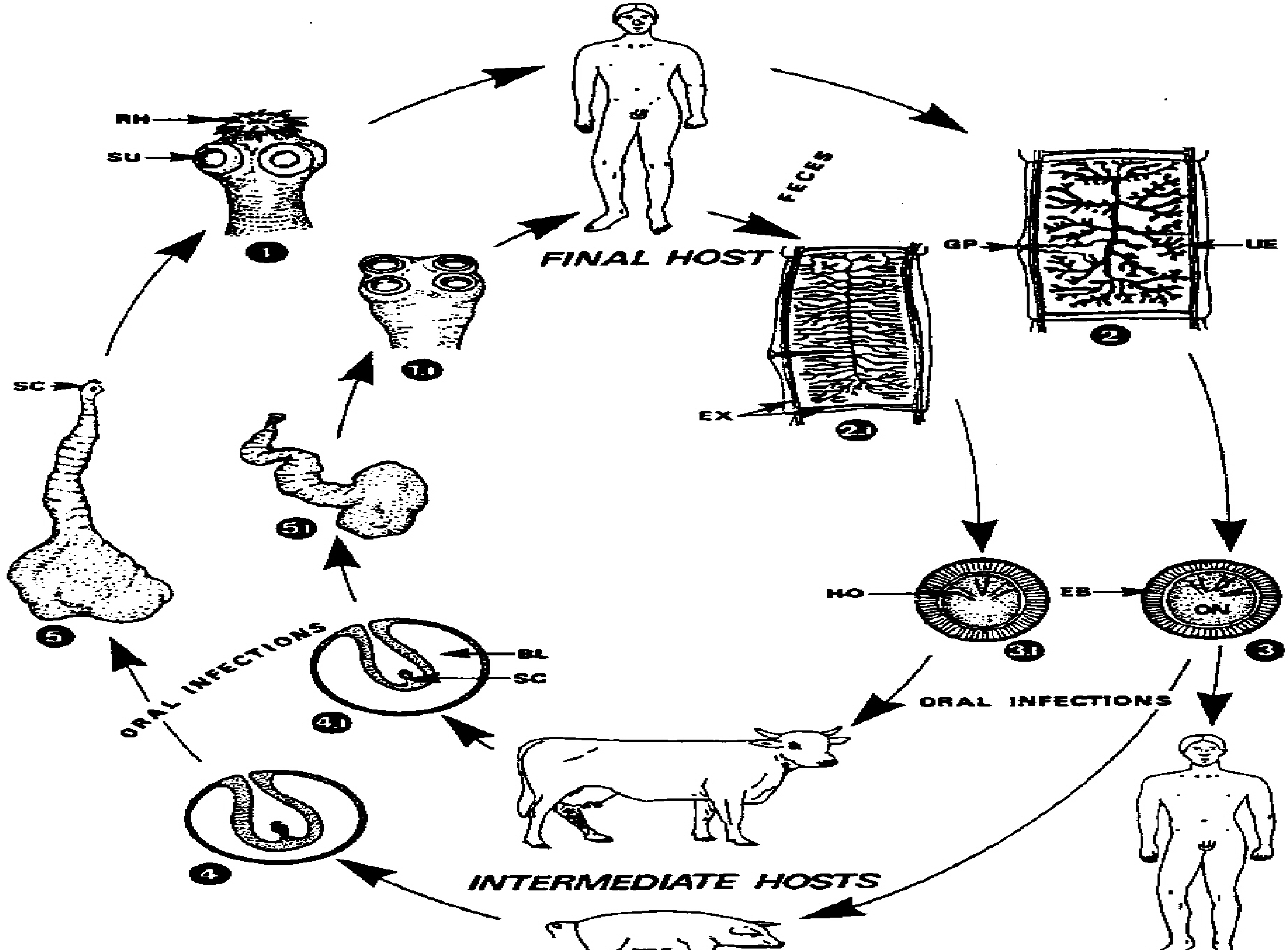
# TAPEWORM LIFE CYCLE
*Taenia solium*




1. Cysticercus (everted scolex)
2. Adult tapeworm
3. Mature proglottid
4. Gravid proglottid
5. Egg
6. Oncosphere (6 hooked embryo)
7. Cysticercus (bladder worm)

# *Taenia solium* (tapeworm) Life Cycle

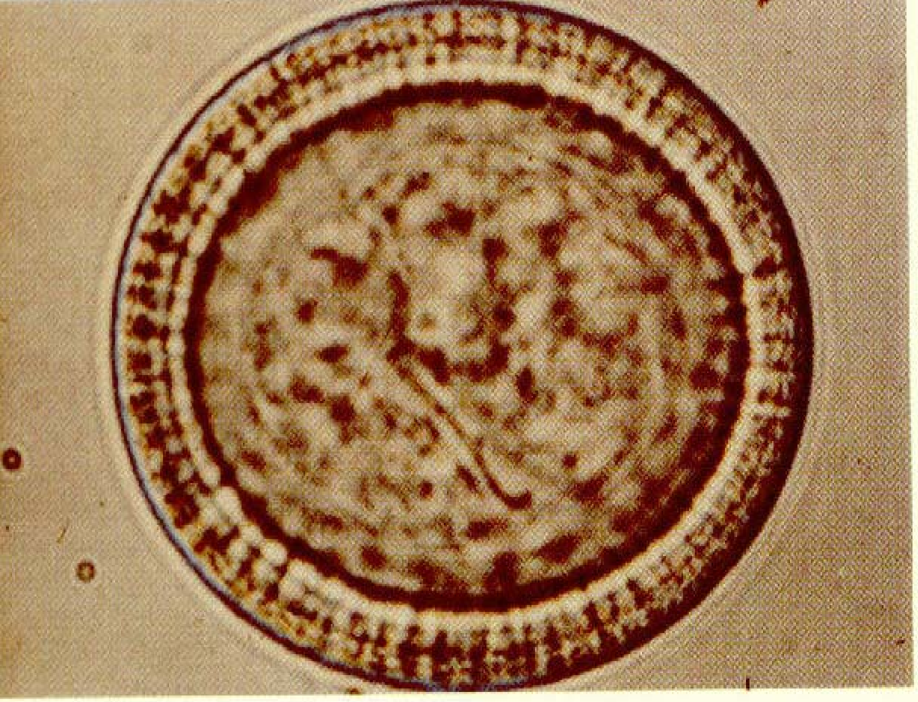
- Infestation initiated when rare pork containing cysticerci ingested
  - Wastewater and sludges not significant vessels for cysticerci
  - Wastewater and sludges significant vessels for tapeworm eggs
- Adult tapeworm develops and matures in intestinal tract
  - Attaches with sucking discs in scolex
  - Attaches with hooks on scolex

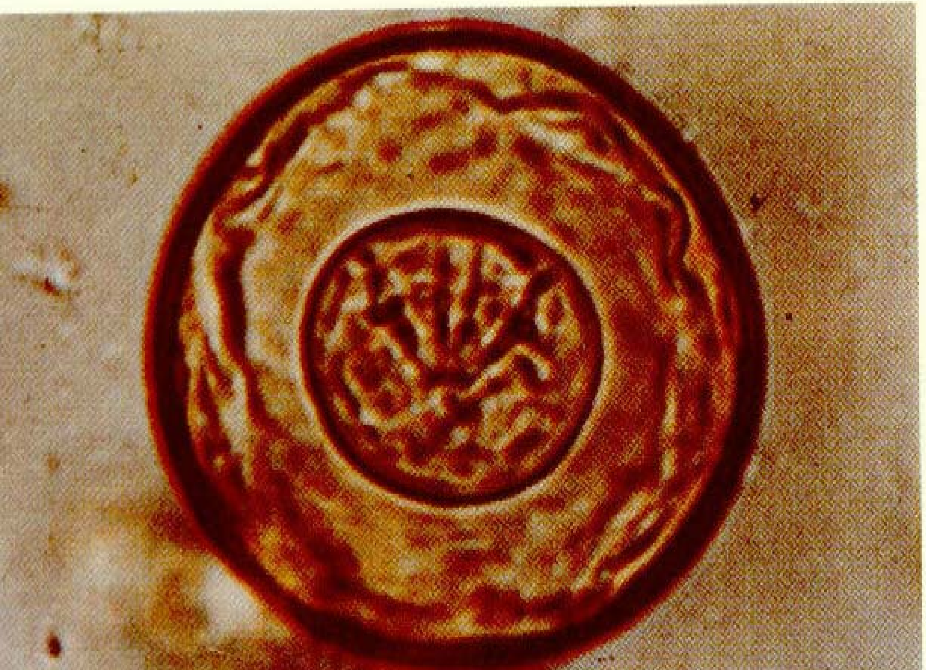
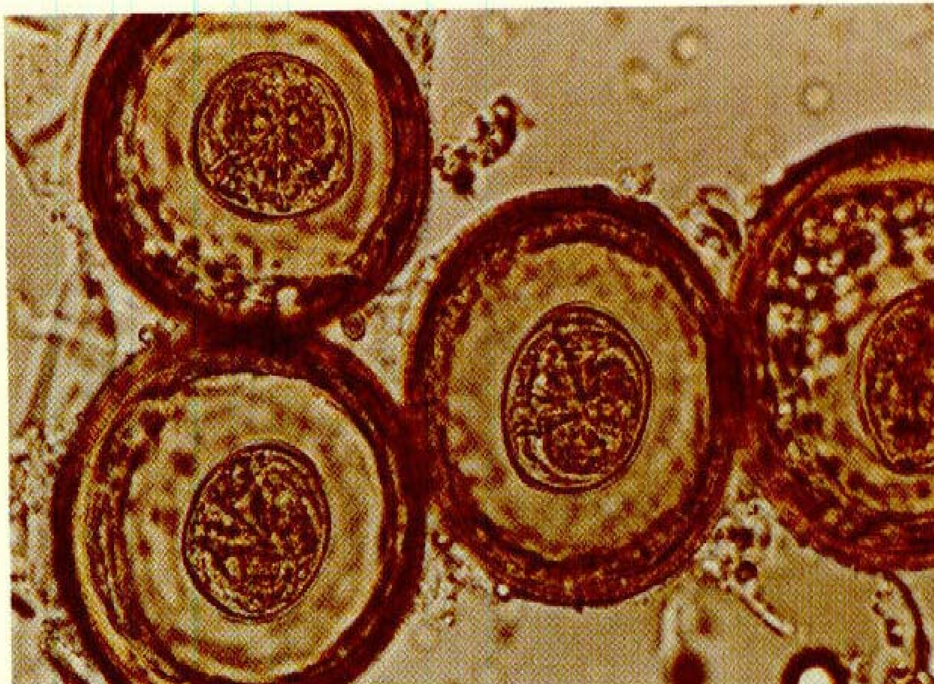



Life Cycle for *Taenia solium*

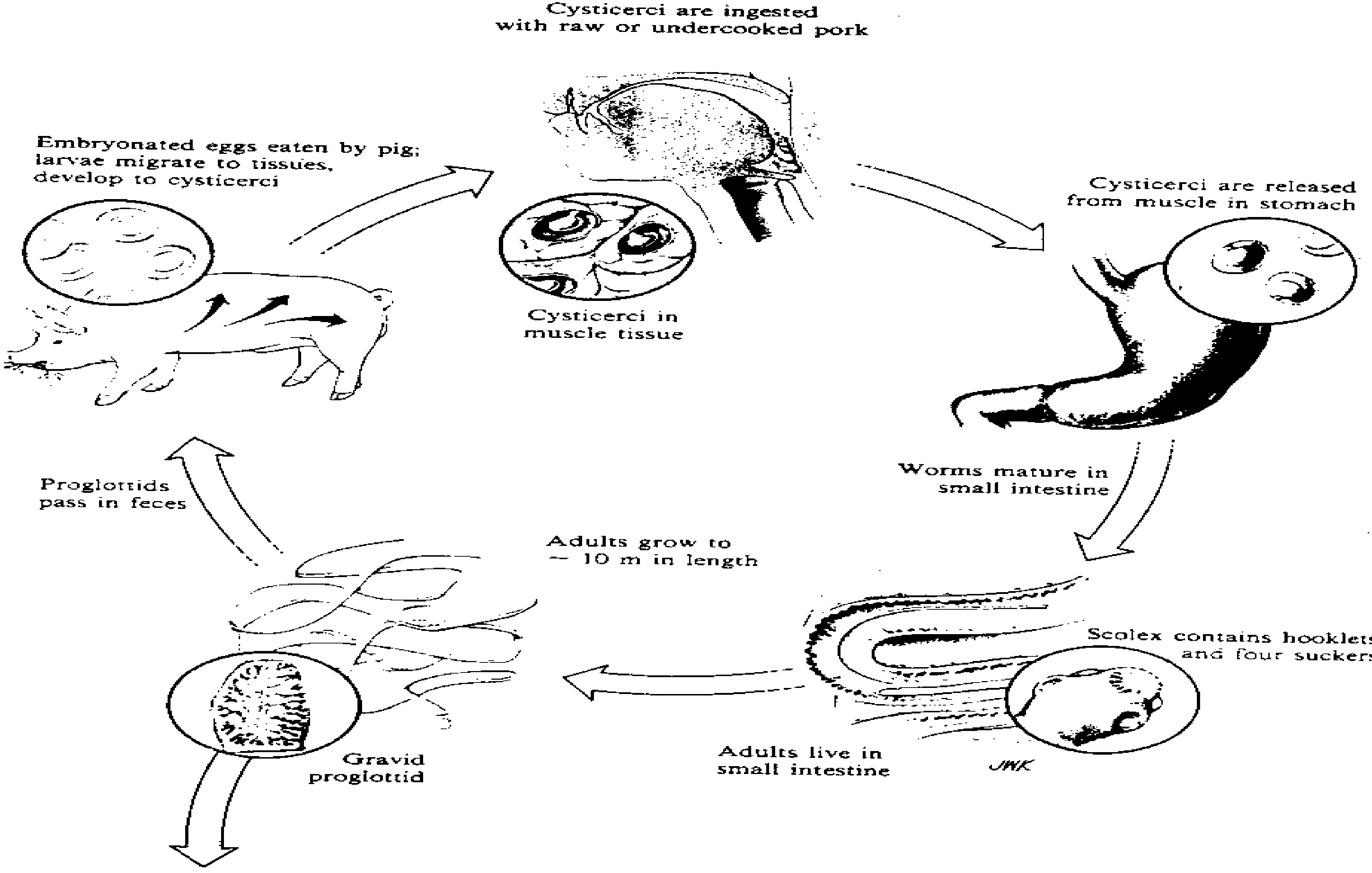
# *Taenia solium* (tapeworm) Life Cycle Continued

- Adult tapeworm possesses female and male gonads
  - Eggs develop within proglottids
  - Eggs released with feces
- Egg-contaminated waste fed to pigs
- Oncosphere: embryo from egg
  - Penetrates intestines of pig
  - Enters circulatory or lymphatic system
- Cysticercus develops in pig muscle
- Cysticerci consumed by man

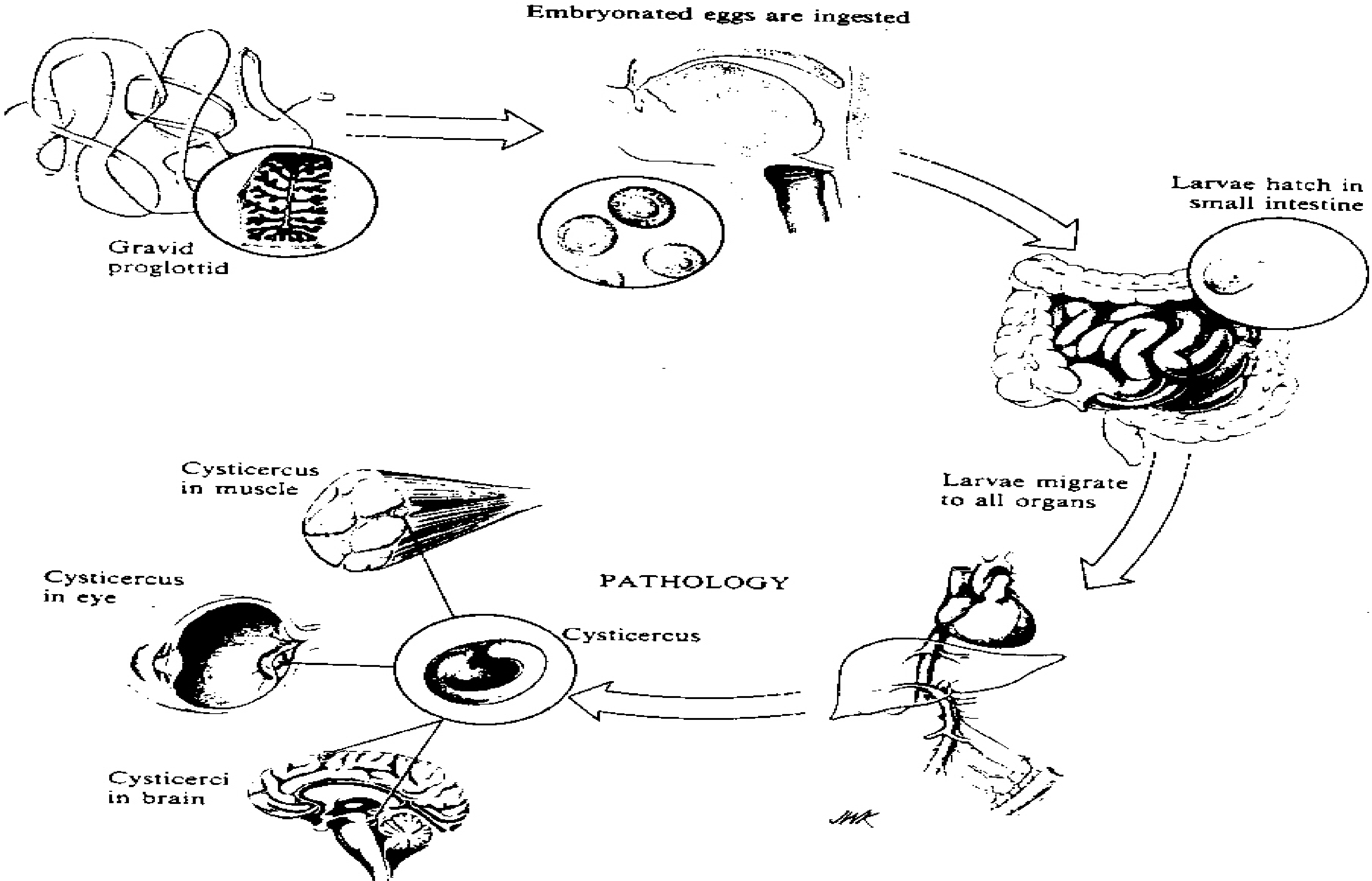


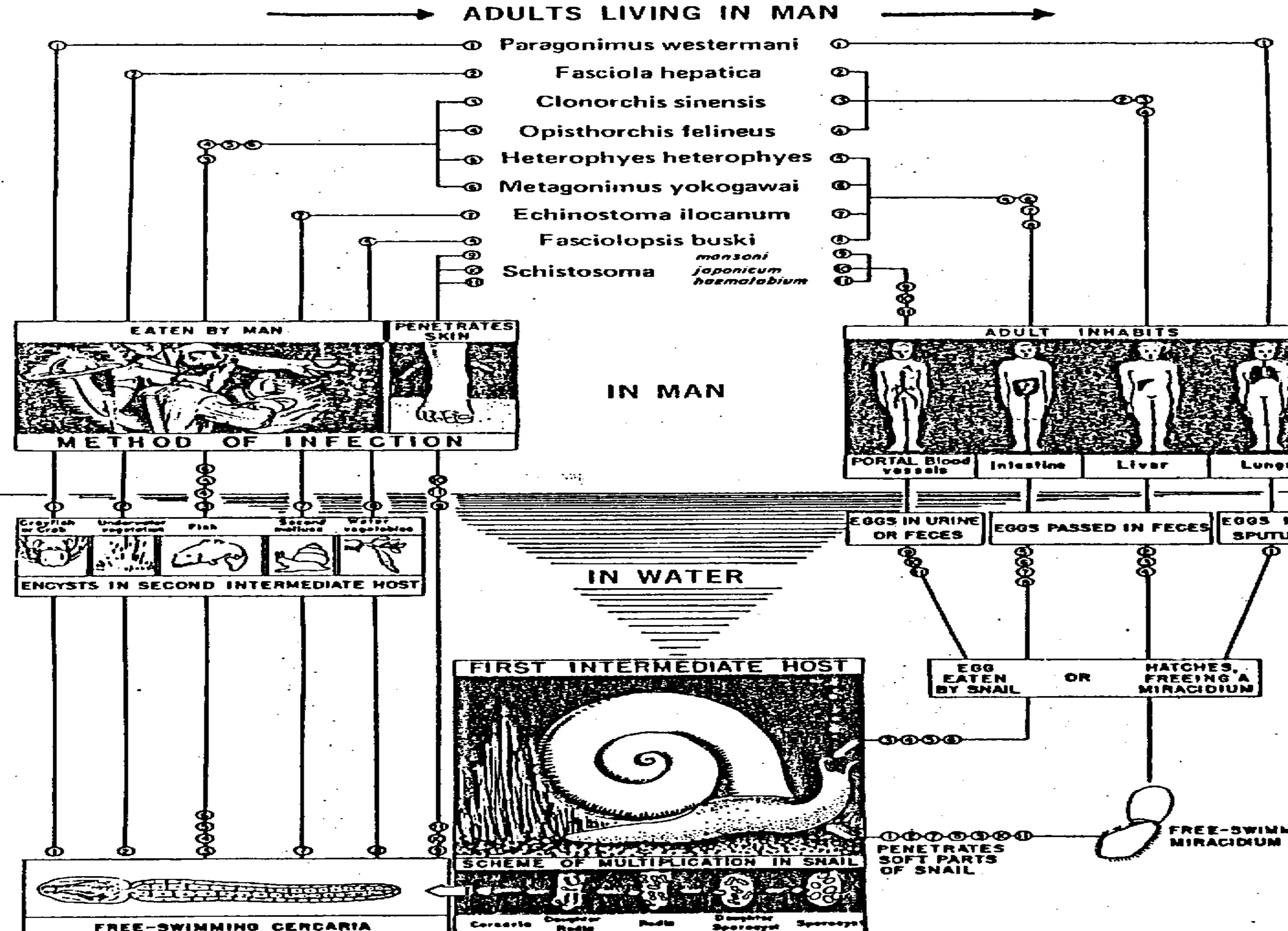
# *Taenia solium*



# Cysticercosis

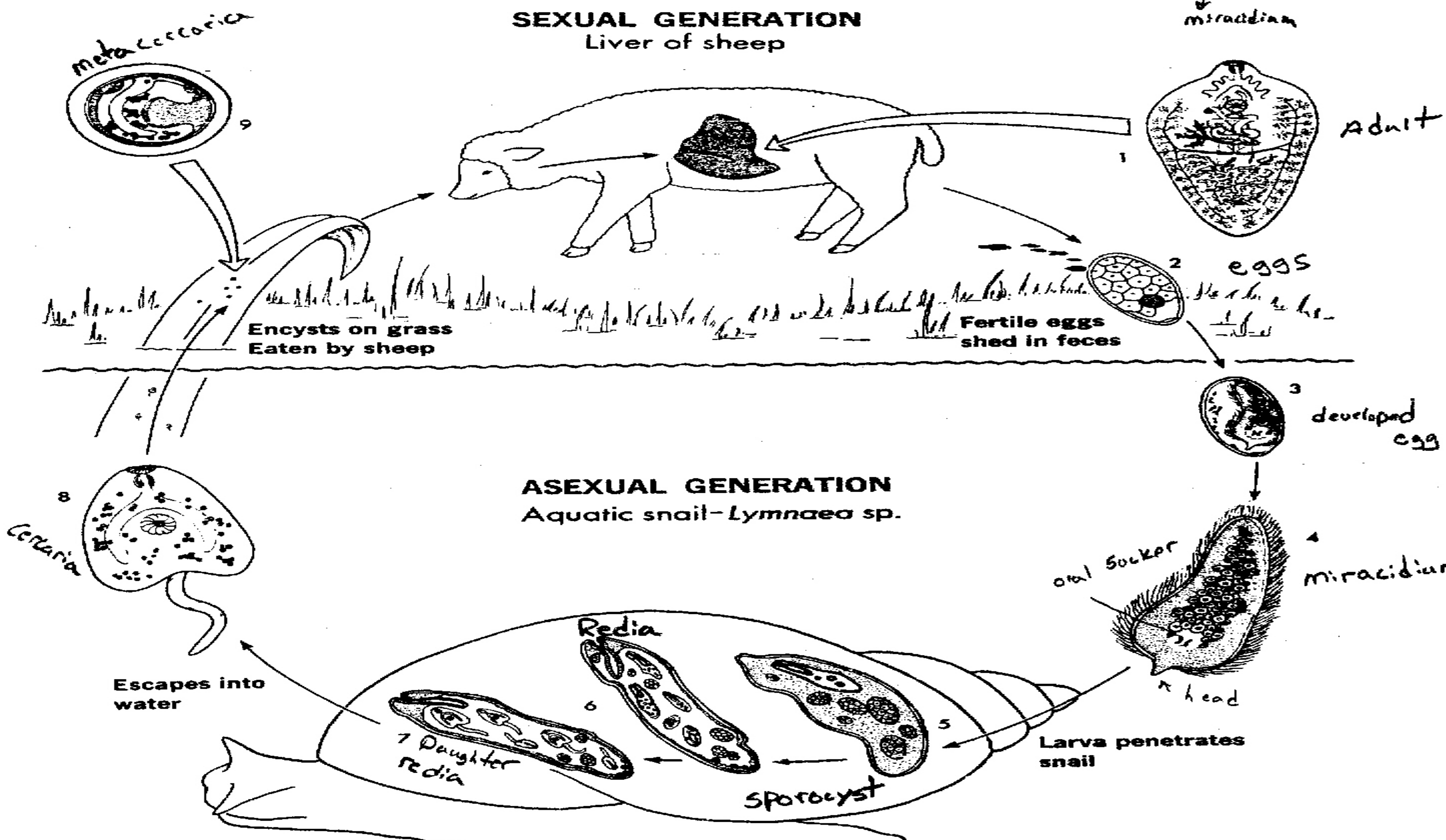


# LIFE CYCLES OF IMPORTANT HUMAN FLUKES



# FLUKE LIFE CYCLE

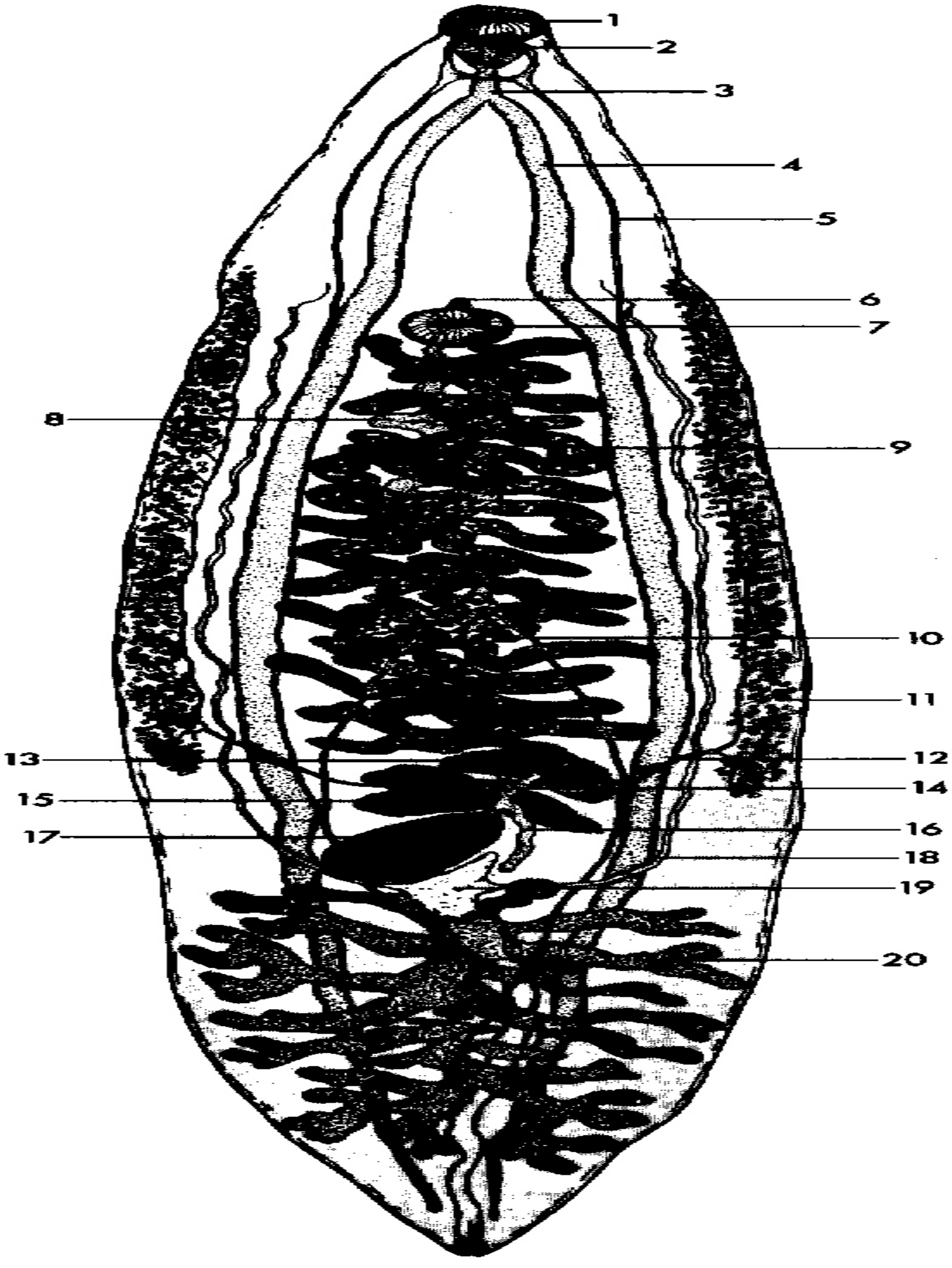
*Fasciola hepatica*




1. Adult fluke
2. Egg
3. Fully developed egg
4. Miracidium
5. Sporocyst ✓
6. Redia ✓
7. Daughter redia ✓
8. Cercaria ✓
9. Metacercaria in cyst

✓-may or not be
Present may ha
two of them a
None of one

# FLUKE ANATOMY
## *Clonorchis*

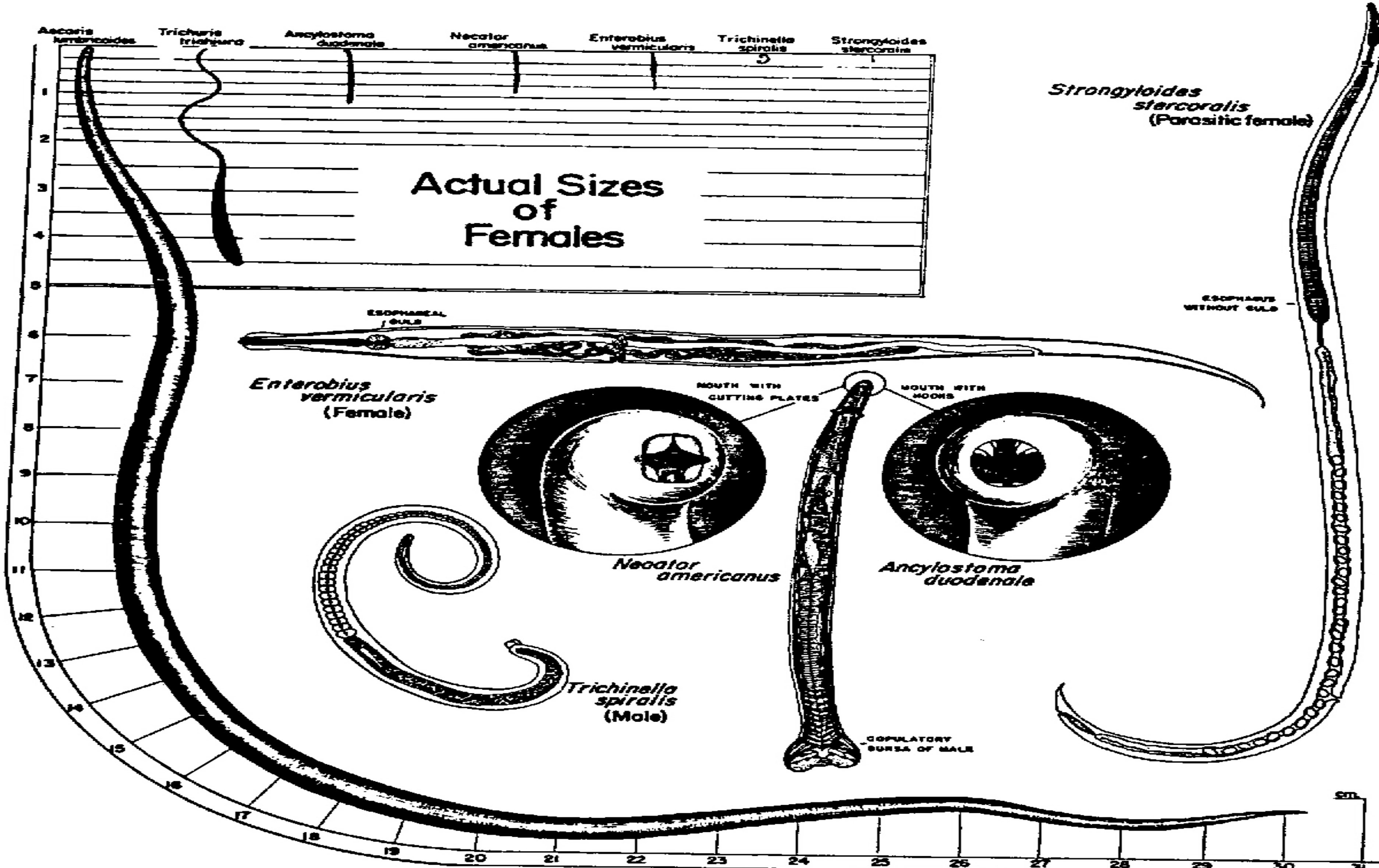



1. Oral sucker
2. Pharynx
3. Esophagus
4. Intestine
5. Nerve cord
6. Genital opening
7. Ventral sucker
8. Vas deferens
9. Uterus
10. Vas efferens
11. Vitelline gland
12. Vitelline duct
13. Shell gland
14. Oviduct
15. Ovary
16. Laurer's canal
17. Seminal receptacle
18. Excretory duct
19. Excretory vesicle
20. Testis

Differential Characteristics of

# IMPORTANT HUMAN ROUNDWORMS

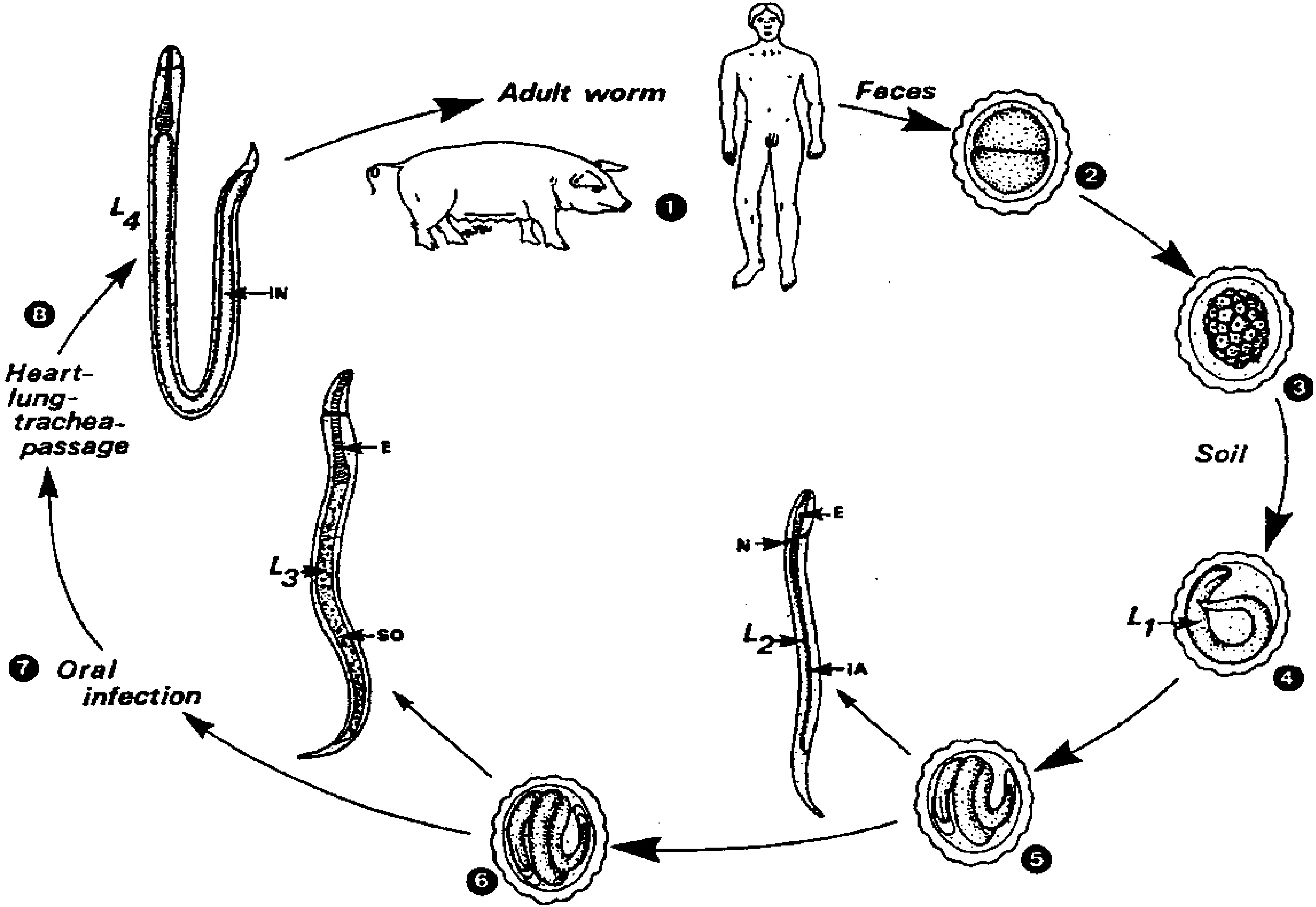
## Adults Living in Intestine




NAVAL MEDICAL SCHOOL

# *Ascaris lumbricoides* Life Notes

- Average life span for adults ~ 3 years
- Eggs released /day/female > 200,000
- Eggs embryonate in soil in 2 to 3 weeks



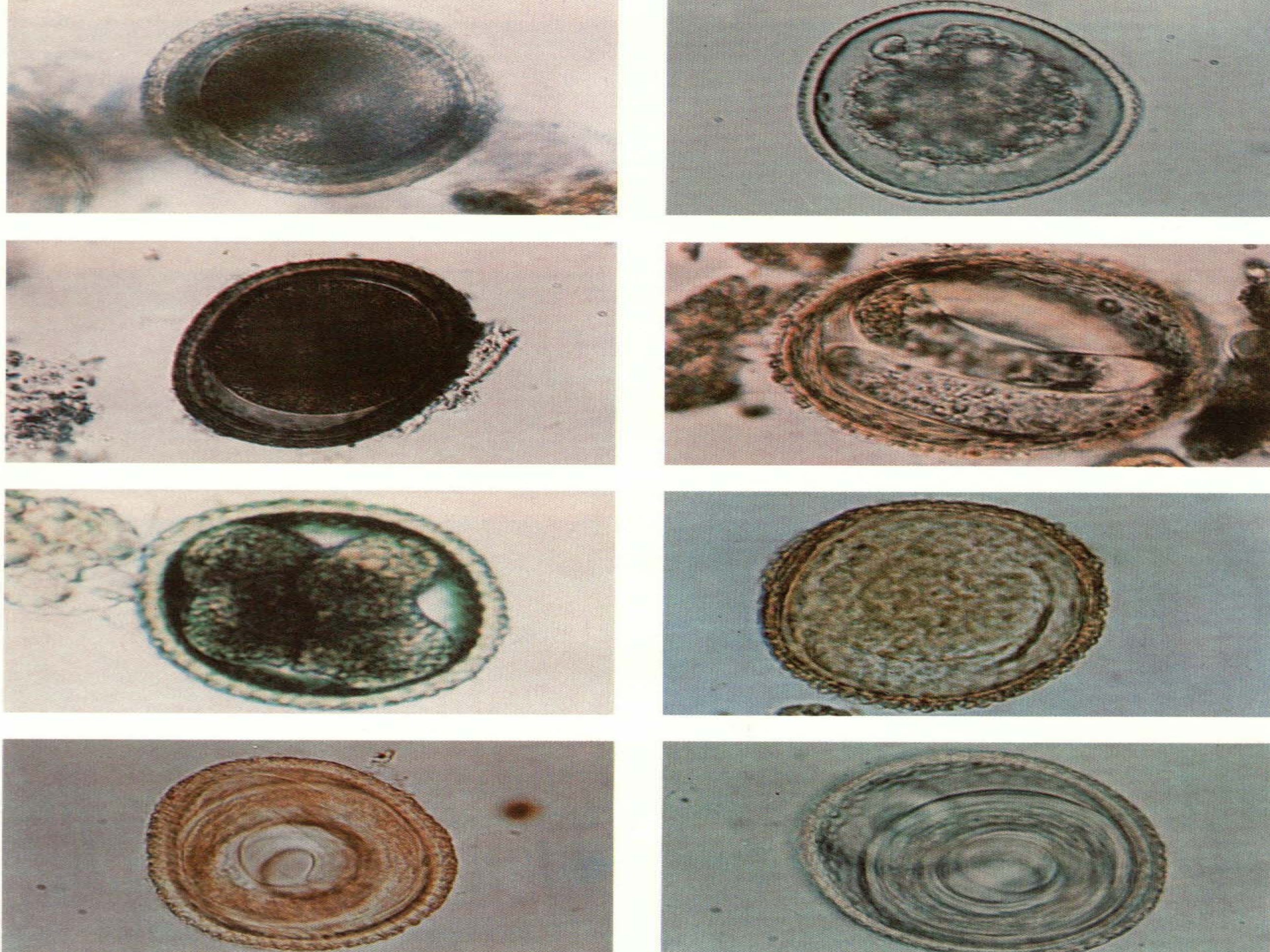

Life Cycle for *Ascaris lumbricoides*

# *Ascaris lumbricoides* Life Cycle

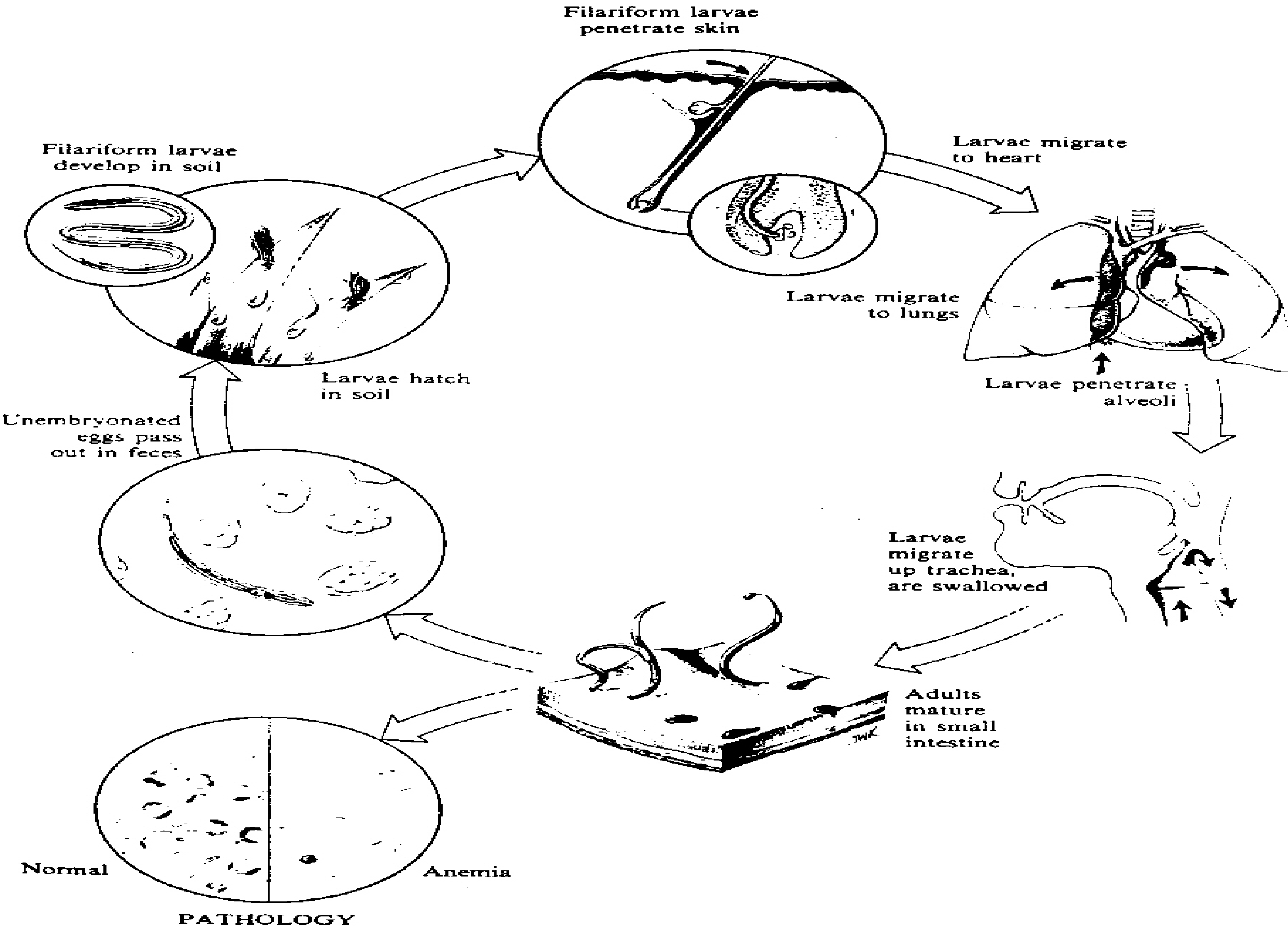
- Infestation initiated when embryonated egg with SECOND stage larva swallowed
- Eggs hatch in small intestine
- Larvae penetrate intestinal wall
- Larvae enter the circulatory system
  - Larvae migrate to the heart
  - Larva moult – THIRD STAGE
- Larvae pumped via pulmonary artery to alveolar space of lungs
- Larvae migrate up respiratory tract to pharynx

# *Ascaris lumbricoides* Life Cycle Continued

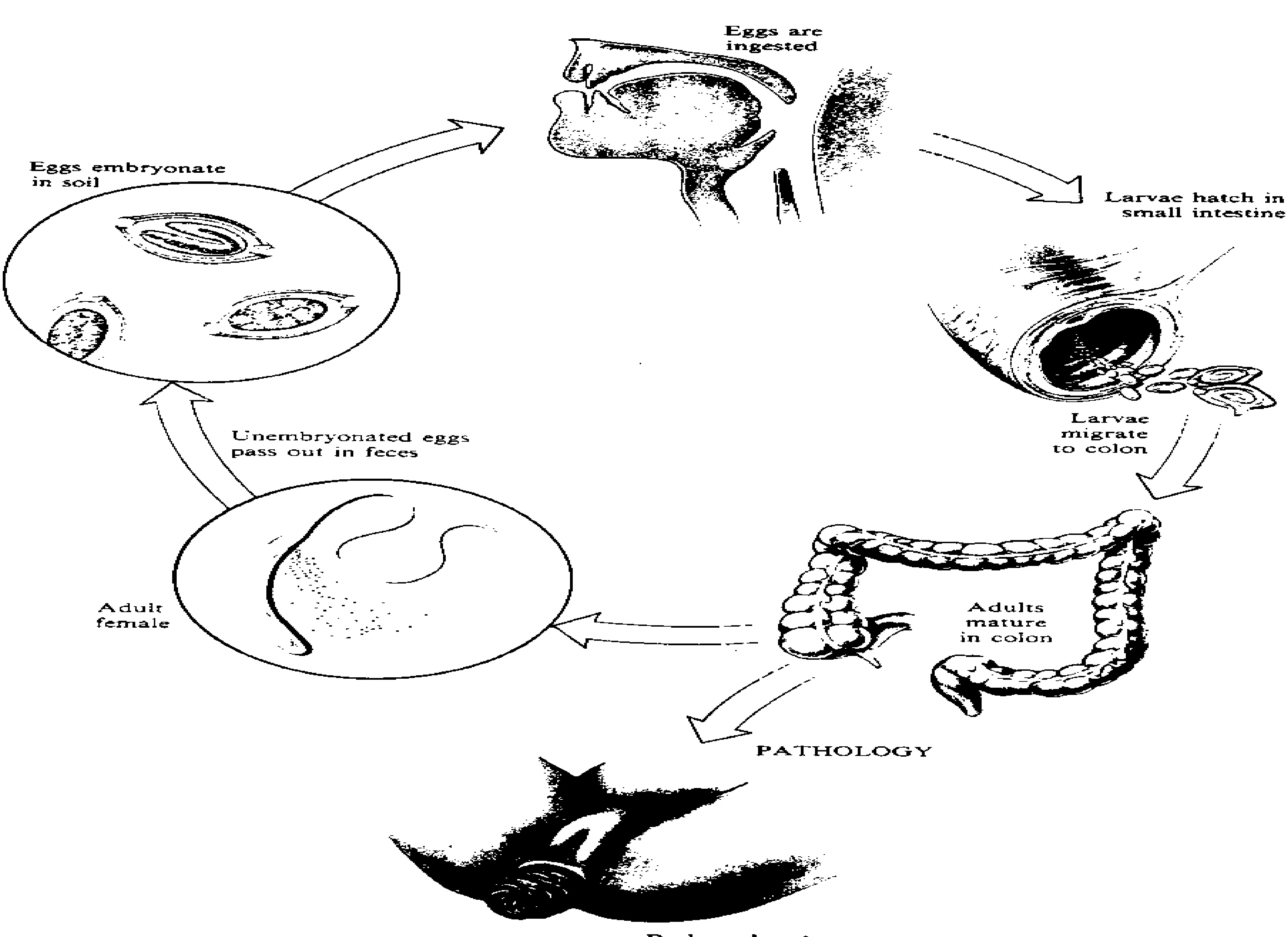
- Larvae swallowed and enter small intestine
  - Larvae moult – FOURTH STAGE
  - Larvae moult – MATURE ADULTS
- Adults attached to intestinal wall
  - Separate sexes
  - Mate
  - FEMALE RELEASES EGGS

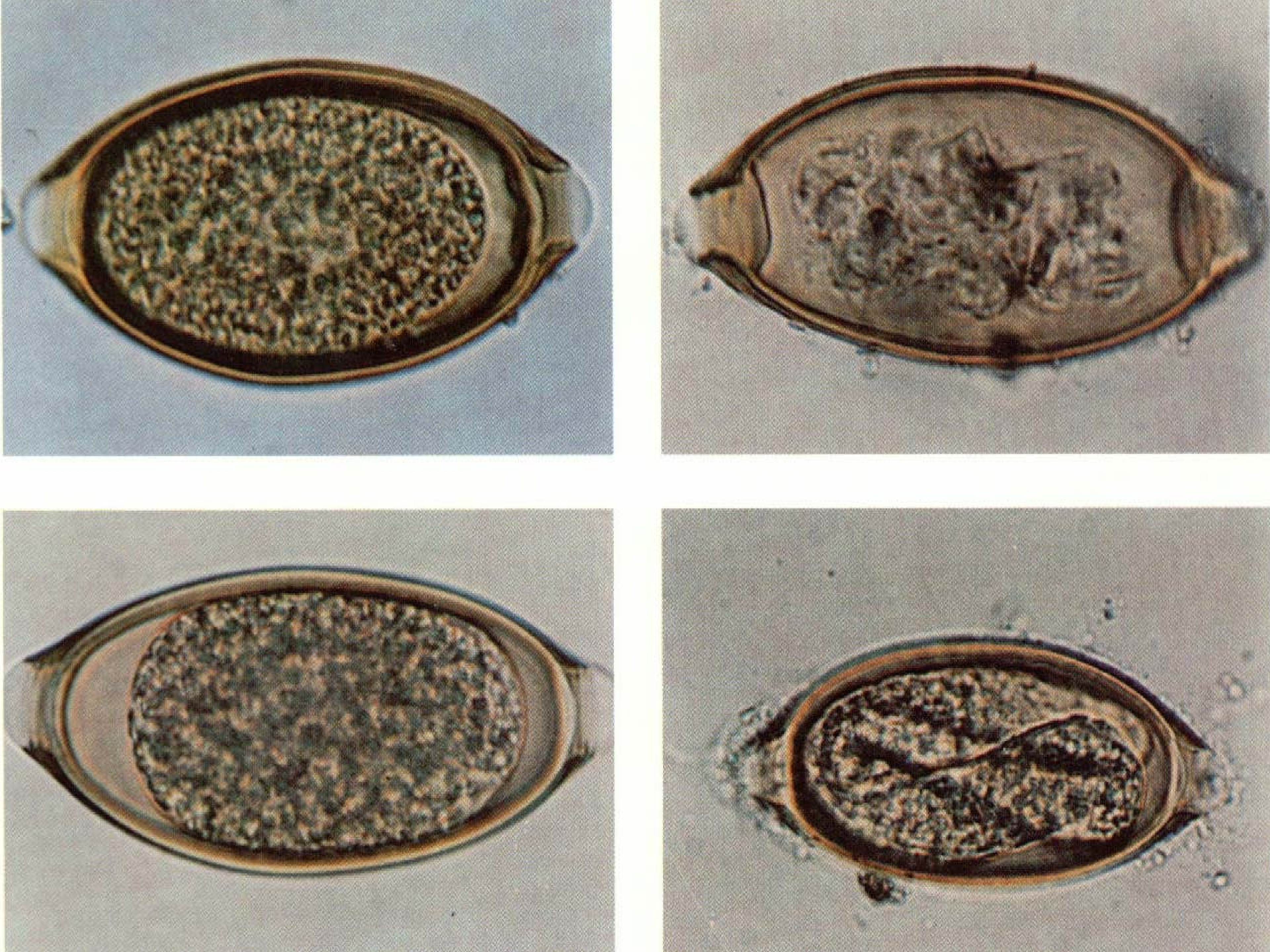


# *Necator americanus*

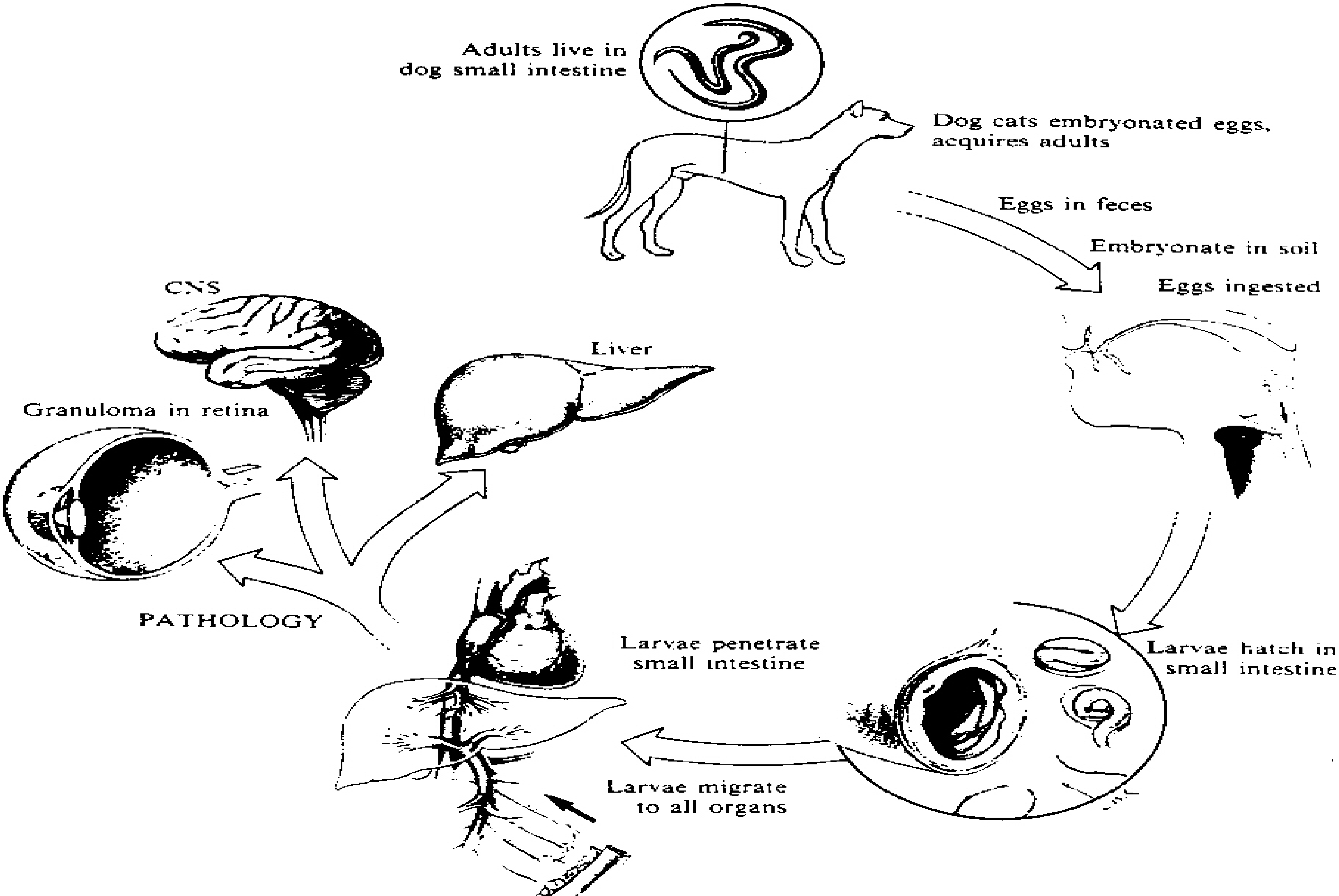


# *Trichuris trichiura*





# *Toxocara canis*



# Resistance to Treatment

- During sludge digestion, destruction of resistant parasite ova is primarily due to temperature and nt to a specific digestion process. Aerobic and anaerobic digestion inactivated parasite ova at temperatures great than 131$^{o}$F (55$^{o}$C) in 2 hours and at 113$^{o}$F (45$^{o}$C) within days but only retarded ova development at temperatures less than 113$^{o}$F (45$^{o}$C). *Ascaris* and *Toxocara* ova were the most resistant.

# Resistance to Treatment Continued

- Lime treatment of sludges did not produce consistent inactivation of *Ascaris*.
- The results of ammonification treatment were inconclusive, especially with *Ascaris*.
- Ultrasonication was effective in destroying *Toxocara* ova at 49 kHz during a 6 minute exposure, but was not effective in destroying *Ascaris* eggs.