

## Helminths (Parasitic worms)

- Multicellular - tissues & organs
- Degenerate digestive system
- Reduced nervous system
- Complex reproductive system - main physiology
- Complex life cycles

Kingdom Animalia

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graph TD
    A[Kingdom Animalia] --> B[Phylum Platyhelminths]
    A --> C[Phylum Nematoda]
    B --> D[Flatworms]
    C --> E[Roundworms]
    
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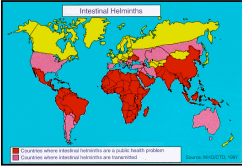

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## Helminths - Important Features

- Significant variation in size
  - Millimeters to Meters in length
- Nearly world-wide distribution
- Long persistence of helminth parasites in host
- PUBLIC HEALTH
  - Indistinct clinical syndromes
  - Protective immunity is acquired only after many years (decades)
  - Poly-parasitism
  - Greatest burden is in children
  - Malnutrition, growth/development retardation, decreased work
  - Morbidity proportional to worm load

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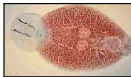


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## Helminths (Parasitic worms)

Kingdom Animalia

```

graph TD
    A[Kingdom Animalia] --> B[Phylum Platyhelminths]
    A --> C[Phylum Nematoda]
    B --> D[Tubellarians]
    B --> E[Monogenea]
    B --> F[Trematodes]
    B --> G[Cestodes]
    D --> H[Free-living worms]
    E --> I[Monogenetic Flukes]
    F --> J[Digenetic Flukes]
    G --> K[Tapeworms]
    
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## Phylum Platyhelminths

General Properties (some variations)

- Bilateral symmetry
- Generally dorsoventrally flattened
- Body having 3 layers of tissues with organs and organelles
- Body contains no internal cavity (acoelomate)
- Possesses a blind gut (i.e. it has a mouth but no anus)
- Protonephridial excretory organs instead of an anus
- Nervous system of longitudinal fibers rather than a net
- Reproduction mostly sexual as hermaphrodites
- Some species occur in all major habitats, including many as parasites of other animals.

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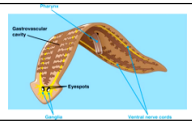
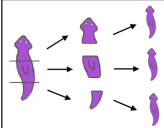
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## Planaria - Newest model system?

- Planaria - common name
- Free-living flatworm
- Simple organ system
- RNAi - yes!
  - Large scale RNAi screen
- Amazing power to regenerate
  - Neoblasts - stem cell-like
  - Stem cell regulation
  - Nervous system regeneration

Only neoblasts proliferate

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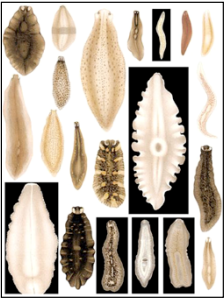


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## Planaria Diversity


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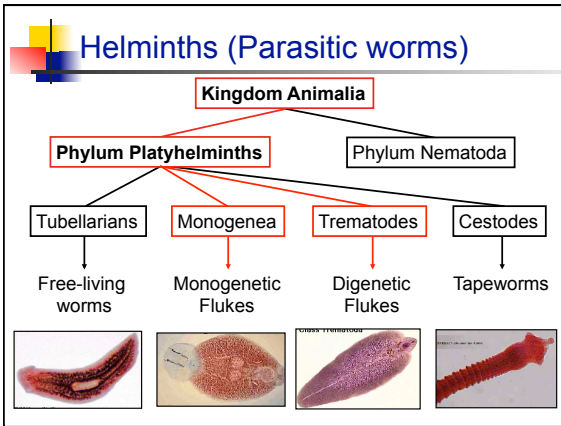
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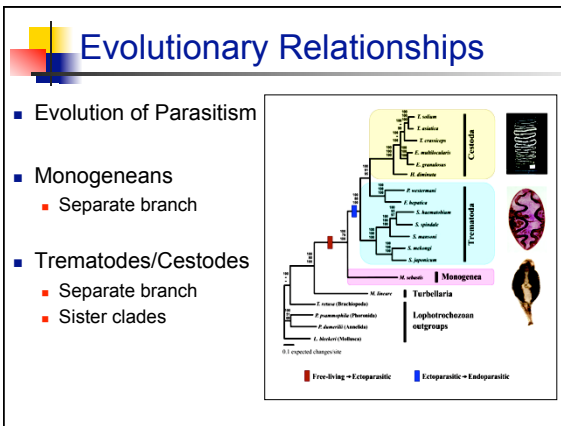
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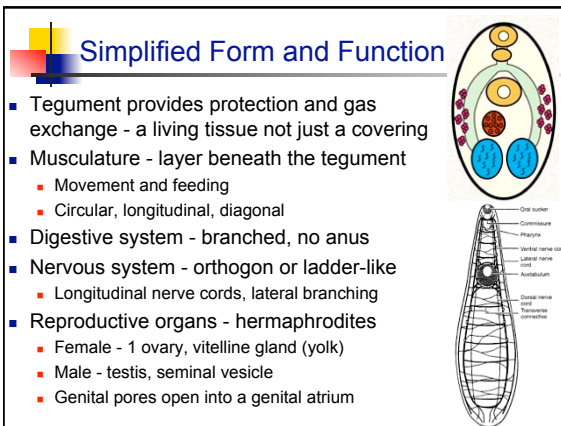
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## Monogeneans

- Taxonomy still controversial
- Look similar to Digenetic flukes
- Ectoparasites - 0.3 mm - 20 mm
  - Gills or body of fish - a few occur on amphibians & reptiles
- Large holdfast organ at posterior end
  - **Haptor** - may have hooks
- May also have holdfast organ at anterior end
  - **Prohaptor**


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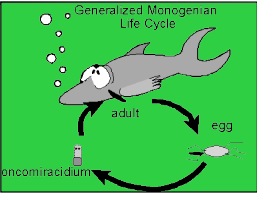
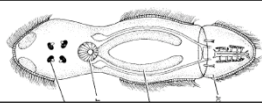
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## Monogenean Life Cycle

- Not well understood
- Direct development
- Monogenean = 1 generation
  - 1 egg = 1 adult
- Single host
  - Niche specificity as well
- Eggs contain long filaments
- Eggs hatch in the water
- Hatching releases an oncomiracidium that is ciliated
  - Egg laying usually coincides with breeding season of host

**Oncomiracidium**  
Short-lived form - free swimming

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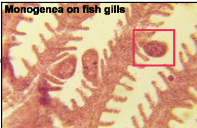


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## Monogeneans

- Generally non-pathogenic infections
  - Crowded conditions will promote higher parasite #'s
- Some economically important
  - Fish hatcheries - large die-offs
  - Attachment to gill filaments - loss of blood, epidermis, increase in bacterial infections
- Hermaphroditic
  - Cross fertilization vs. self
  - Diplozoon juveniles will fuse and this promotes maturation of reproductive tissues (Cross)


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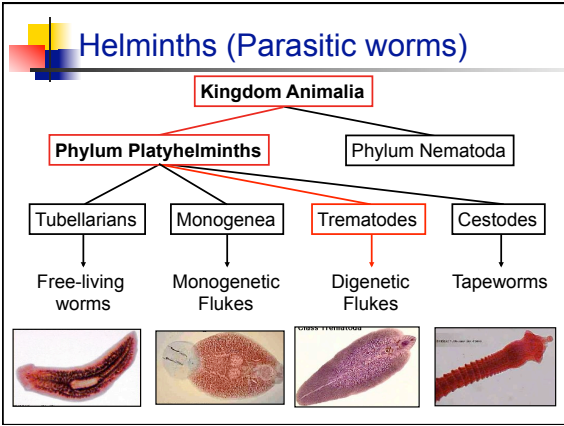
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### Trematodes - Flukes

- Digenean (di = two) (genea = beginnings)
- Flat, leaf-like structure
- Ventral and oral sucker
- Obtain food by absorption through cuticle (tegument)
- Hermaphroditic and separate sexes

<ul style="list-style-type: none"> <li>■ Tissue Flukes           <ul style="list-style-type: none"> <li>■ <i>Clonorchis sinensis</i></li> <li>■ <i>Fasciola hepatica</i></li> <li>■ <i>Paragonimus westermani</i></li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>■ Blood Flukes           <ul style="list-style-type: none"> <li>■ <i>Schistosoma mansoni</i></li> <li>■ <i>Schistosoma haematobium</i></li> <li>■ <i>Schistosoma japonicum</i></li> </ul> </li> </ul>
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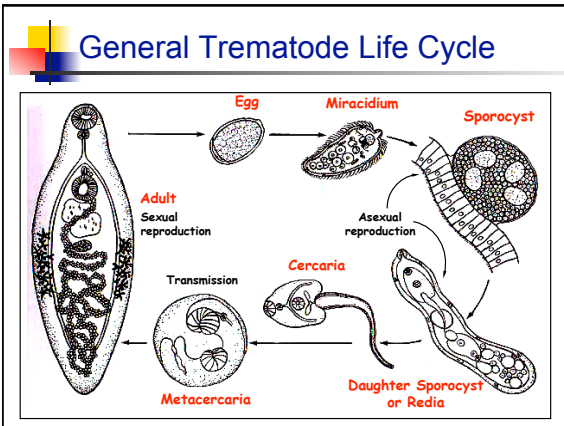
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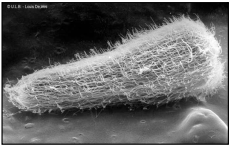
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### Life Cycle Terminology

- Egg = shelled **embryo**
  - Operculum cap - lid-like specialization
  - May need to embryonate
    - Water - avoid desiccation
    - Temperature is important
    - Eggs are killed by freezing
- Eggs hatch - release miracidium
  - Most just require water
  - Others hatch only when eaten by suitable host
- Miracidium - ciliated larval stage
  - Very active free-swimming form
  - Seek out intermediate host (molluscs)
  - Penetrates tissue with auger like motion - about 30 sec to penetrate!


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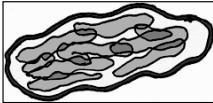
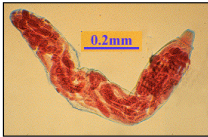
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### Life Cycle Terminology

- Sporocyst
  - Develops in Molluscan host
  - Hollow fluid filled sac of embryos
    - Contains a birth pore at anterior end
    - No mouth or digestive system - absorbs nutrients
    - Differences here depending on species
      - Daughter sporocyst
      - Redia
      - Cercaria
- Redia - 2nd larval form in Mollusc
  - Burst out of the sporocyst
  - More active form, posses a simple gut
  - Mouth, and birth pore @ anterior end
  - Develop into cercaria


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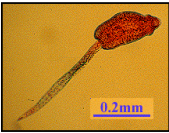

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### Life Cycle Terminology

- Cercaria - very small
  - Leaves the snail to find the next host
  - Looks like a miniature adult with a tail
  - Utilizes tail for swimming, and will lose it as it penetrates the next host
- Metacercaria
  - Infective stage for the definitive host
  - "Resting stage" in the life cycle
  - Miniature adult curled up inside a tissue cyst
  - Waiting for intermediate host to be eaten by definitive host.


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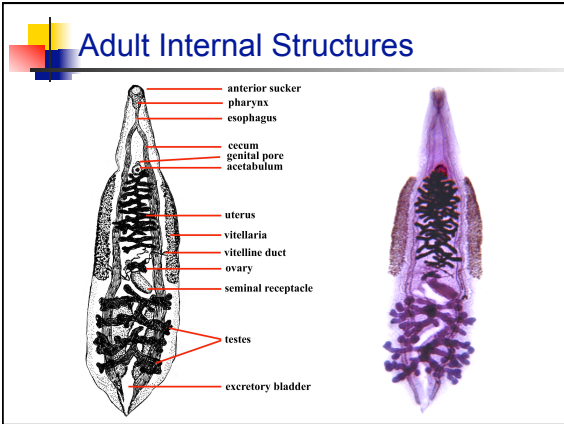
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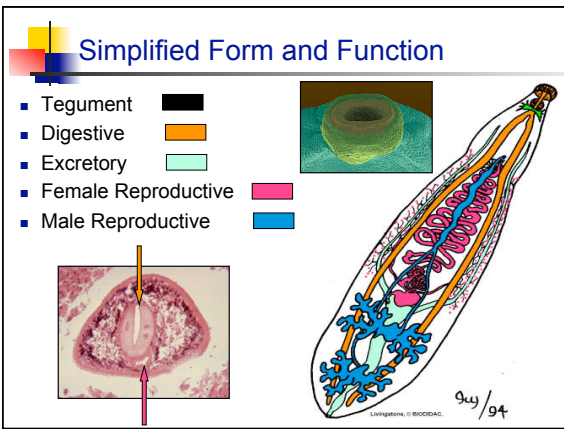
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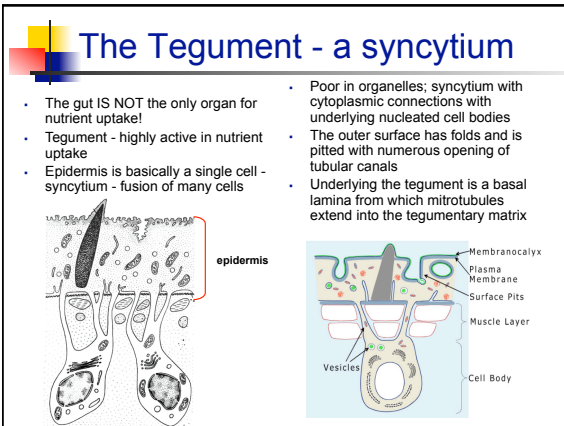
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## Trematodes of Medical Importance

- Schistosoma, blood flukes
- Clonorchis & Opistorchis, liver flukes with metacercaria in fish
- Paragonimus, lung flukes with metacercaria in crabs
- Fasciolopsis, Fasciola, Dicrocoelium, intestinal and liver flukes with metacercaria on plants

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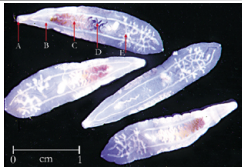
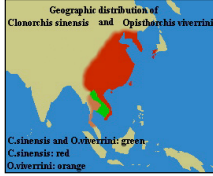
## Clonorchis sinensis Chinese Liver Fluke

**Definitive Host** - Humans, pigs, dogs, cats, rats, camels

**First intermediate Host** - freshwater snails

**Second intermediate Host** - freshwater fish (mainly carp and crayfish)

- Geographic Distribution
  - Japan, Korea, China, Taiwan, and Vietnam.
  - Also found around "China Towns" in the U.S.
  - Approximately 7.1 million infected worldwide

Geographic distribution of Clonorchis sinensis and Opisthorchis viverrini  
C. sinensis and O. viverrini: green  
C. sinensis: red  
O. viverrini: orange

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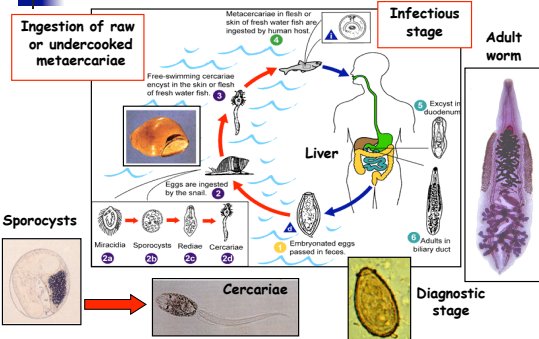
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## Clonorchis sinensis Life Cycle



**Ingestion of raw or undercooked metacercariae**

**Infectious stage**

**Adult worm**

**Sporocysts**

**Cercariae**

**Diagnostic stage**

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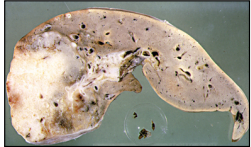


## Clonorchis sinensis Pathology

- Light Infection
  - Common, asymptomatic, mild indigestion, upper right abdominal pain
- Heavy Infection (>200 worms)
  - Abdominal pain, diarrhea, anorexia, hepatomegaly, abdominal tenderness, jaundice
- Chronic Infection
  - Liver cancer
- Treatment
  - Praziquantel
  - Albendazole



Flukes in bile duct - thickening of wall



Liver cancer from heavy infestation

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## Family Fasciolidae

- Mainly parasites of herbivores
- *Fasciola hepatica* - liver
- *Fasciola gigantica* - liver
- *Fasciolopsis buski* - intestinal
  - One of the largest trematodes found in humans!



7.5 cm

Cone-nosed



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## Fasciolopsis buski - intestinal fluke

- **Definitive Hosts:** Humans and Pigs
- **First Intermediate Hosts:** Aquatic snails, particularly *Segmentina* and *Hippeutis*.
- **Second Intermediate Host:** Aquatic (freshwater) vegetation, including water chestnuts, water caltrop, lotus, and bamboo.
- **Geographic Distribution:** Mainly Orient.
  - About 10 million people are infected.
- **Transmission to D.H.:** Ingestion of metacercaria on vegetation.
- **Location in D.H.:** Small Intestines. Each worm can produce 25,000 egg/day!





Geographic distribution of Fasciolopsis buski infection

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## Pathology

- **Pathology:** Generally very little. Attachment sites can ulcerate, and worms may obstruct small intestines and interfere with food absorption. Absorption of worm waste results in verminous intoxication similar to tapeworms.
- **Symptoms:** Depends on the number of worms (worm burden). Can include nausea and chronic diarrhea.

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## Fasciola hepatica - liver fluke

**Definitive Host:** Herbivorous mammals, occasionally humans

**First intermediate Host:** aquatic snails

**Second intermediate Host:** Metacercariae form on aquatic plants

- **Geographic Distribution:** Cosmopolitan.
  - Very common in western U.S. livestock.
  - About 2.4 million humans worldwide are infected.
- **Transmission to D.H.:** Ingestion of metacercariae. Human infections usually come from ingestion in water or on water cress.
- **Location in Definitive Host:** Liver, particularly bile duct.

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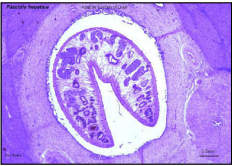
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## Disease Pathology

- **Disease:** first described as "liver rot"
  - Human infection is common in Europe, Africa, S. America
- **Pathology:** Migration through liver can cause necrosis. Feed on the cells of liver and blood. Adults cause edema and inflammation in bile duct.
- **Symptoms:** Anemia, cirrhosis, jaundice, similar to other liver diseases.
- **Diagnosis:** Eggs in feces, liver blockages plus history of eating water cress in U.S. ELISA test.
- **Treatment:** Triclabendazole is drug of choice for livestock and humans (Rafoxanide).
- Praziquantel IS NOT as effective

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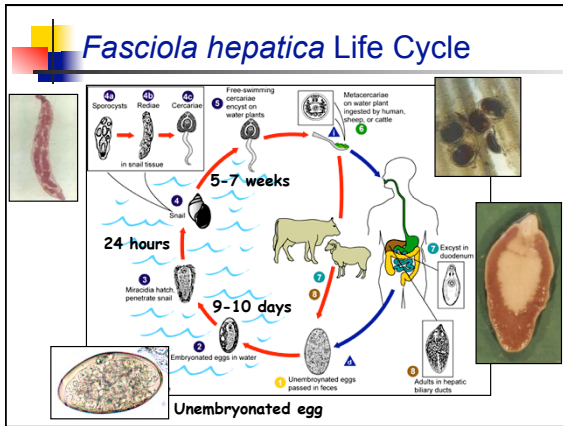
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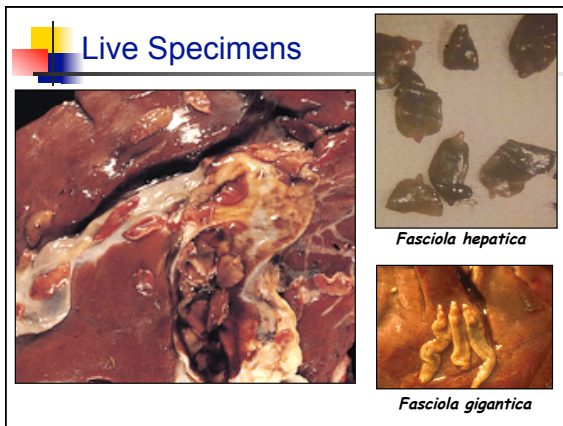
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### Fasciola Notes

- *F. hepatica* and *F. gigantica* are closely related species
- Parasites are relatively common in the US.
- Up to 17% of Montana cattle are infected, but human disease in the US is rare.
- Pasture rotation is an important control mechanism to reduce livestock infection

Approximate Geographic Distribution of *Fasciola hepatica* in the U.S.

Ecology of fasciolosis, ponds and creeks in direct vicinity of pasture

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### Paragonimus westermani - Lung Fluke

- Definitive Host:** Humans and other fish-eating mammals
  - Large reservoir in canids, felids, mustelids, and viverrids (civets).
- First Intermediate Hosts:** Aquatic snails
- Second Intermediate Hosts:** Freshwater crabs and crayfish
- Geographic Distribution:** Asia and Oceania
  - particularly Japan, Korea, and the Philippines
  - Approximately 20.8 million people.
- Transmission to D.H.:** Ingestion of undercooked crustaceans. Pickling does not kill metacercaria
- Location in definitive host:** Lungs, sometimes other organs.


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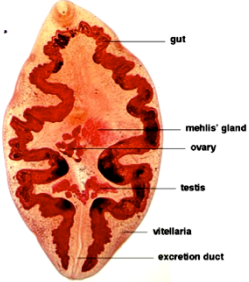

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### Paragonimus westermani - Lung Fluke


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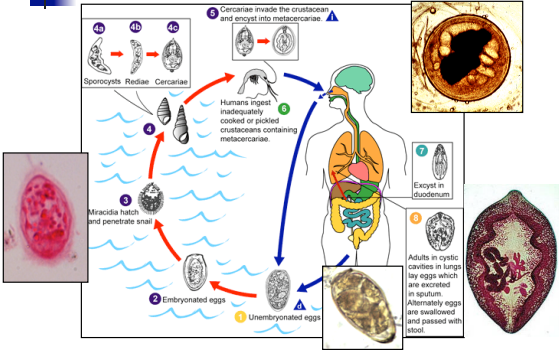
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### Paragonimus sp. Life Cycle



The diagram illustrates the life cycle of Paragonimus sp. in a circular flow:

- Unembryonated eggs are passed in sputum or stool.
- Embryonated eggs are ingested by a snail.
3 Miracidia hatch and penetrate the snail.
- Inside the snail, the parasite develops through Sporocysts, Rediae, and Cercariae.
- Cercariae invade the crustacean (crab/crayfish) and encyst into metacercariae.
- Humans ingest metacercariae from undercooked/pickled crustaceans.
- Metacercariae excyst in the duodenum.
- Adults in cystic cavities lay eggs, which are excreted in sputum.
- Alternately, eggs are swallowed and passed with stool.

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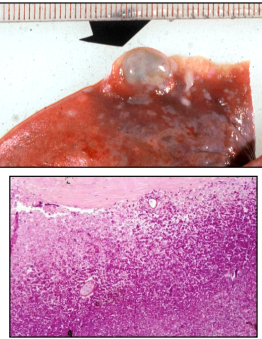
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## Pathology

- **Pathology:**
  - Adults in lungs stimulate inflammatory response resulting in granulomas - fibrotic capsule formation.
  - Movement of worms to heart or brain causes death.
- **Symptoms:** Disease called Paragonimiasis.
  - Chronic cough, , bronchitis, difficulties breathing, sputum with blood or brownish streaks.
  - When moves to brain, can cause blindness, paralysis, disequilibrium, sudden onset of epilepsy.




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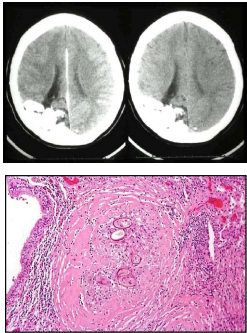
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## Paragonimus migration

- Juvenile worms can migrate to other sites
- Case: migration to the brain
  - Large lesion
  - Worms and eggs cause the pathology
  - Inflammatory response




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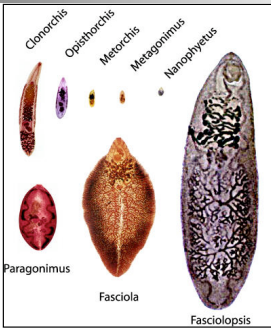
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## Size Comparison - Flukes

- *Fasciolopsis buski* is the largest - up to 7.5 cm
- *Fasciola hepatica* - up to 3.0 cm
- *Paragonimus sp.* - up to 1.5 cm
- *Clonorchis* - up to 2 cm




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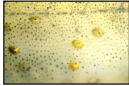


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## Summary of Tissue Flukes

- Clonorchis & Opisthorchis***
  - Liver Flukes
  - Metacercaria in fish
- Paragonimus***
  - Lung Flukes
  - Metacercaria in crabs
- Fasciola & Fasciolopsis***
  - Intestinal and Liver Flukes
  - Metacercaria on plants


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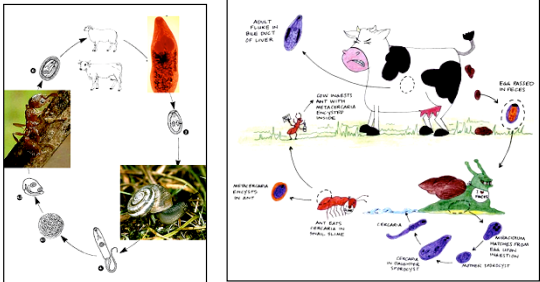
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## Trematodes - enhance transmission

*Dicrocoelium dendriticum* modulates ant behavior!




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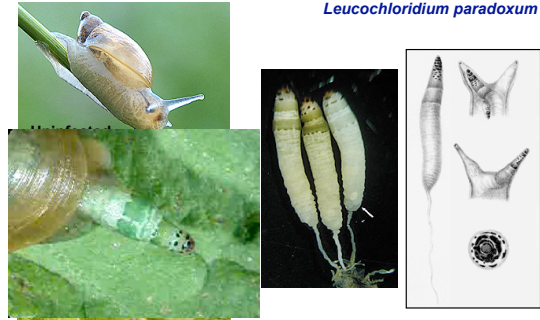
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## Trematodes- enhance transmission

*Leucochloridium paradoxum*




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## Assignment

**What other trematodes enhance transmission?**

**Find other examples of trematode that enhance transmission.**

**Email the trematode and the associated life cycle (link)**

**Email a primary Journal article (PDF - not a link)  
related to the enhanced transmission**

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