

# **Medical parasitology:**

## **Helminthes**

# Helminths

## Phylum Platyhelminths

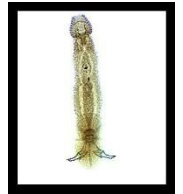
Turbellarians

Free-living  
worms



Monogenea

Monogenetic  
flukes



Trematodes

Digenetic  
flukes



Cestodes

Tapeworms



## Phylum Nematoda

# Pretty planaria, not all flatworms are ugly parasites

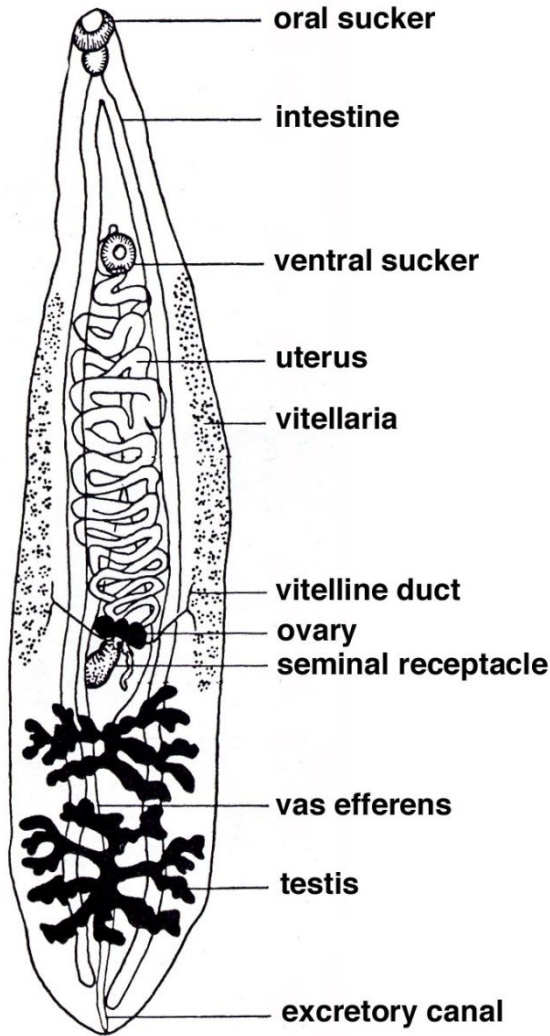


# trematodes or flukes - when they say 'flat' worms they mean it



- All digenea are parasitic
- Small dorso-ventrally flattened worms with simple anatomy and without segmentation
- No coelom (secondary body cavity lined by mesoderm), but animals are filled with mesodermal parenchyma
- No blood vessels, simple ladder nervous system

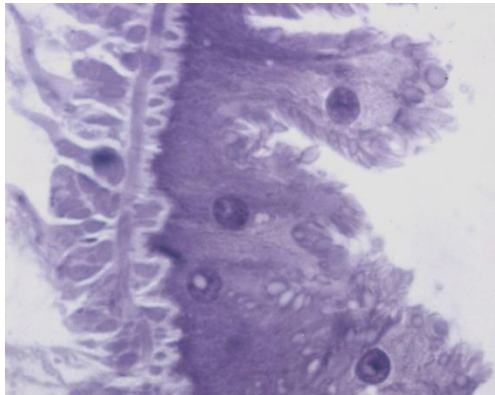
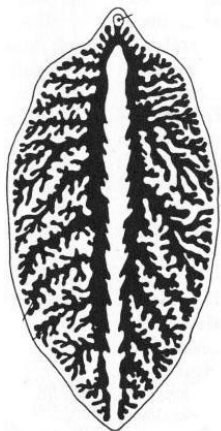
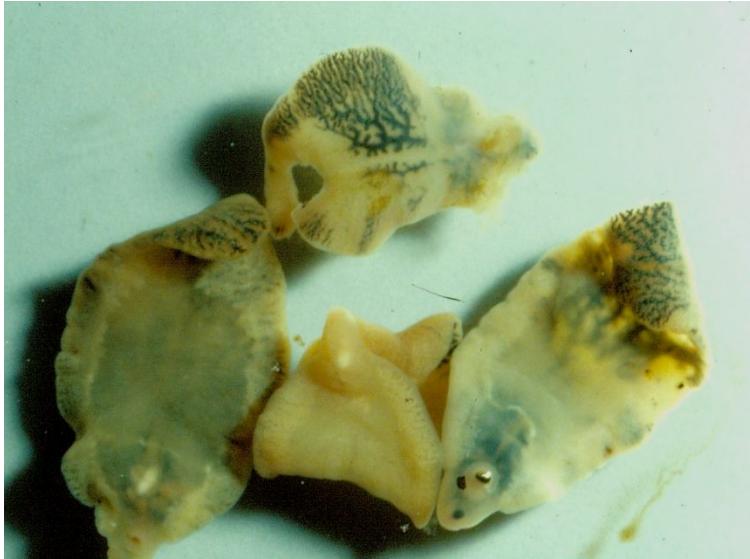
# trematodes or flukes - know your worm



- Digenea possess two suckers (oral and ventral acetabulum) which they use to attach within the host
- Oral sucker contains the mouth
- Muscular pharynx permits the worm to pump food into the blind ending gut
- Most trematodes are hermaphrodites (they are male and female, and cross as well as self-fertilization occurs)

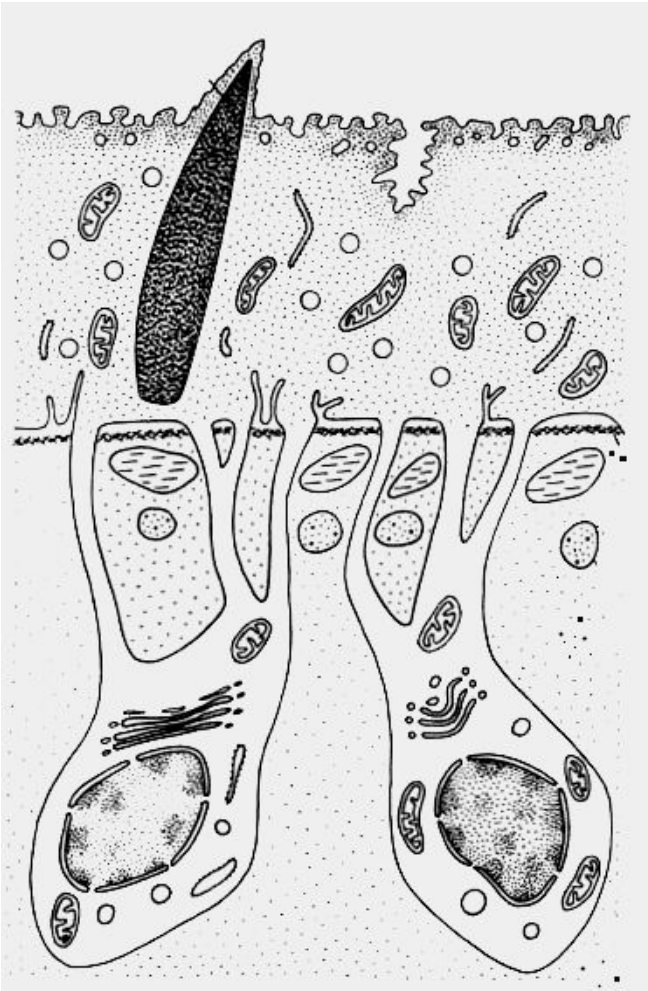


# trematodes or flukes - know your worm



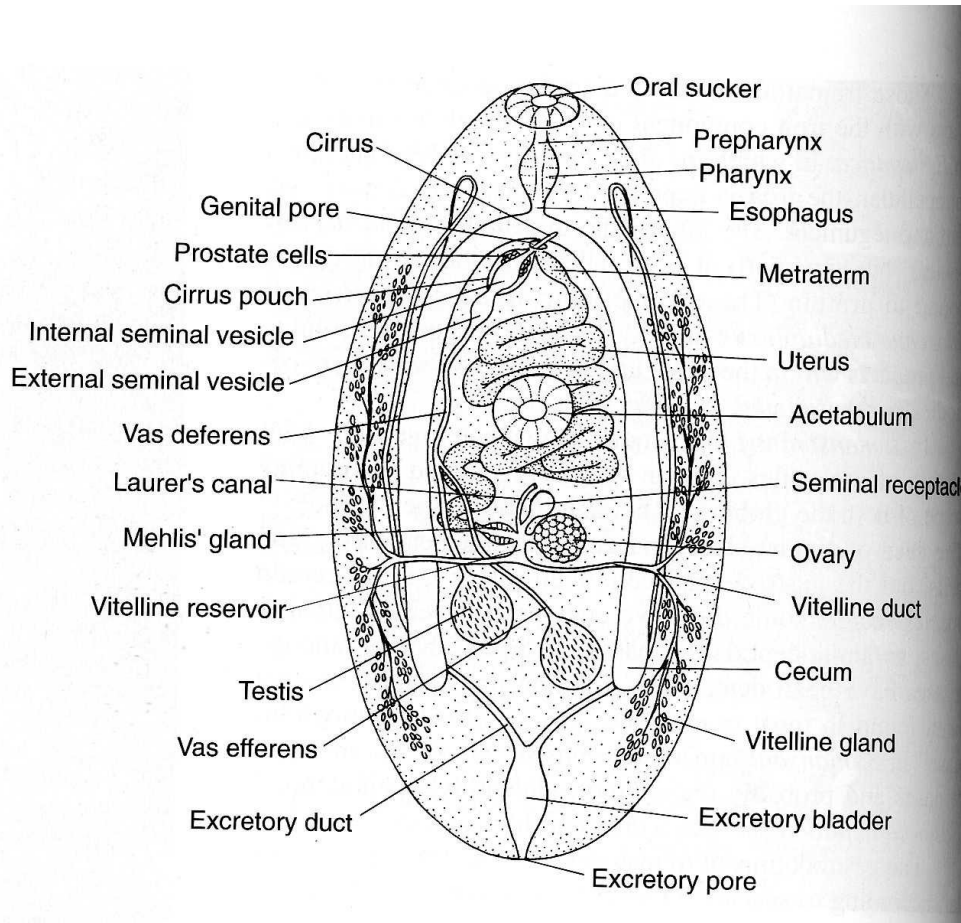
- The gut of trematodes is blind ending but can be quite extensive and highly branched (here shown in living *Fasciola* (liver) flukes, the dark staining is due to bile)
- Smooth muscle fibers (longitudinal and cross) run under the tegument and around all the organs (the gut is shown in this picture)

# trematodes or flukes - know your worm



- The gut is not the only organ these worms use for food uptake
- The tegument (“skin”) is highly active in nutrient uptake
- The epidermis is essentially a single cell (a syncytium formed by fusion of multiple cells)
- The tegument’s cell bodies and nuclei underlie the two muscle layers
- Actin spines are found in many species and help the worms to anchor themselves

# trematodes are massively fertile – but their love life is complex

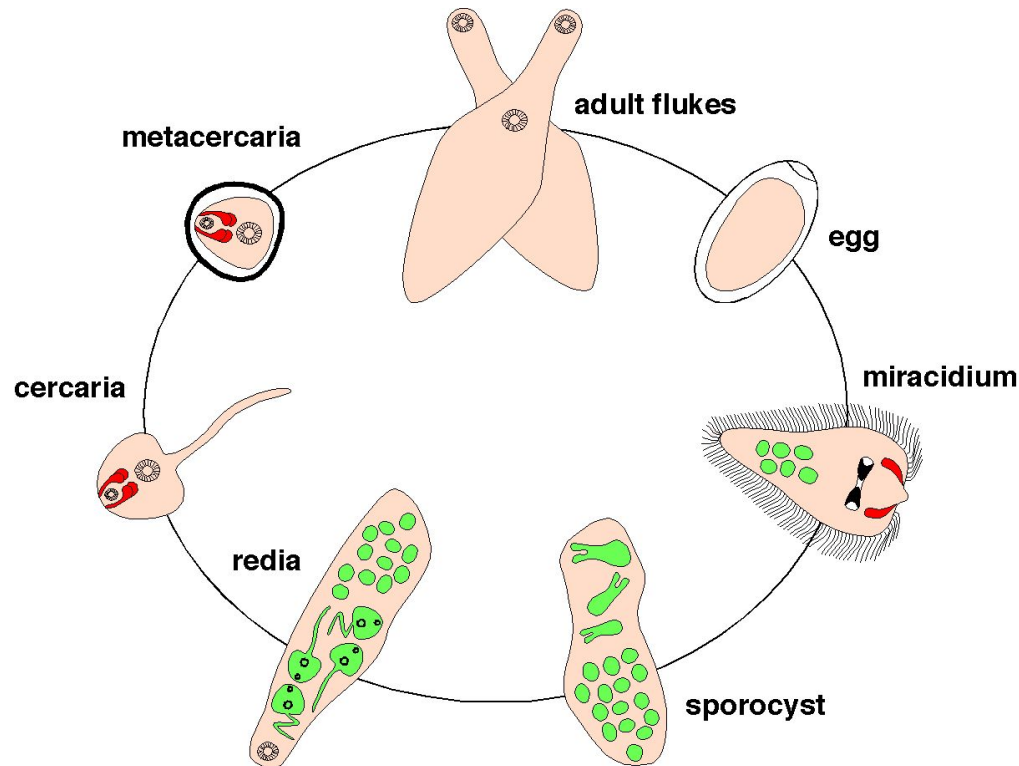


- To enhance the chances to complete the complex life cycle trematodes produce massive number of offspring
- The adults are hermaphrodites
- The reproductive systems takes up a large portion of the body of the animal
- In particular the female system is complex and different physiological functions are distributed onto different organs



# Trematode life cycles

## Definitive host



## Intermediate host

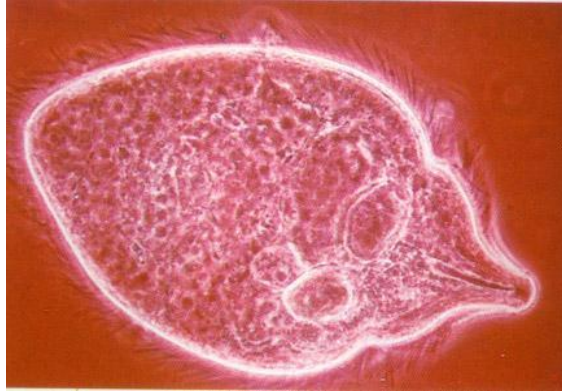
- Trematodes produce an enormous number of offspring by combining sexual and asexual reproduction cycles
- Asexual reproduction occurs in germinal balls. These areas are home to omnipotent (stem cell-like) progenitor cells that can initiate the development of embryos without fertilization
- All have at least two hosts of which one is a snail
- Not all stages are found in the life cycle of all species
- Miracidia and cercariae are infective (invasive) stages

# Trematode life cycles -- the egg

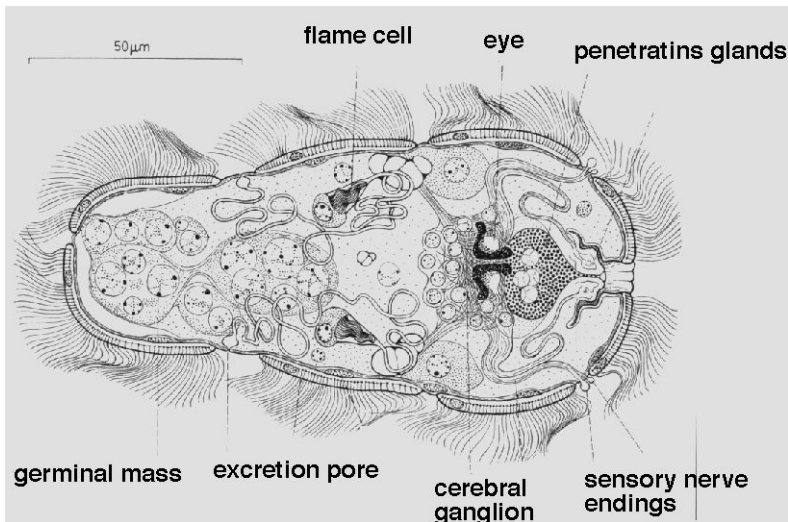


- The egg contains an embryo rather than an oocyte
- Eggs are shed at different degrees of maturity by different flukes
- Eggs have to leave the body of the final host to continue development
- The mature miracidium within the egg uses light, osmolarity and temperature as clues to when hatching is appropriate
- Hatching proceeds in most species through a preformed “door” the operculum

# Trematode life cycles -- the miracidium



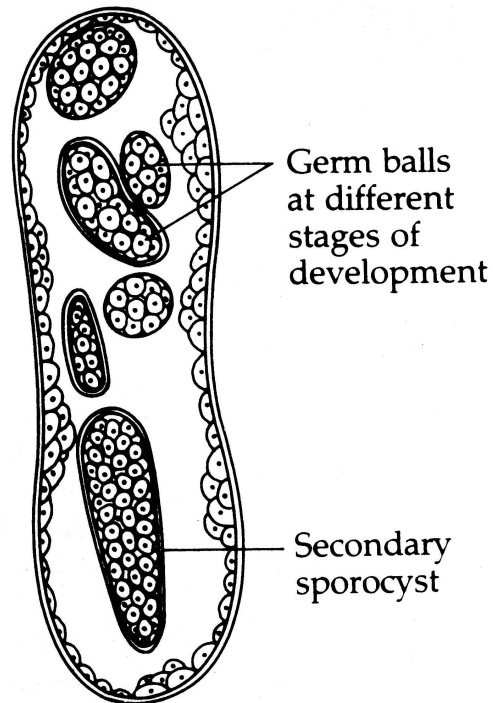
- The miracidium is highly motile due to the cilia on its surface
- Miracidia have simple eyes (they avoid light) and several chemical and mechanical receptors which they use to find the intermediate snail host
- Penetration glands secrete proteases and other lytic enzymes on contact with appropriate host
- Miracidia of flukes with land snails as intermediate host will hatch upon ingestion by the snail and penetrate the gut epithelium



# Trematode life cycles -- the miracidium



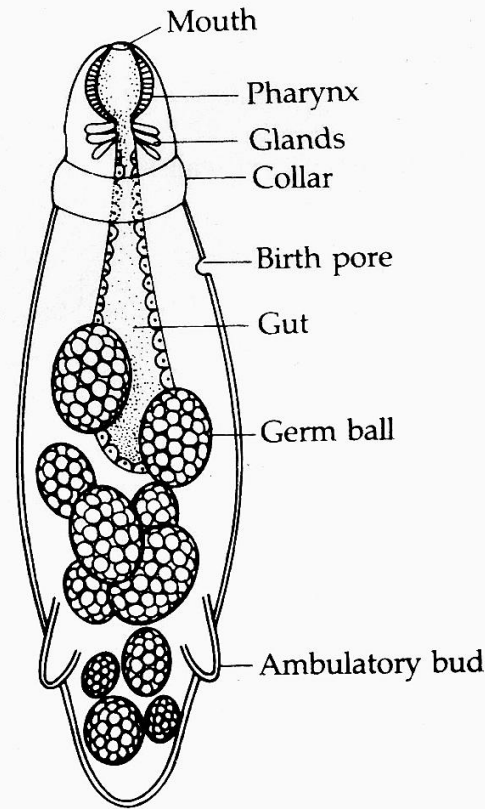
# Trematode life cycles -- the sporocyst



- After penetration the miracidium undergoes metamorphosis into the sporocysts
- This stage has most organ systems reduced to the bare minimum and acts as a germinal sac
- The sporocyst takes up nutrients only over its tegument and the germinal mass expands and develops into daughter sporocysts, redia or cercaria



# Trematode life cycles -- the redia



- Sporocyst can produce cercaria or a next amplification generation the redia
- Redia have features of the adult fluke like oral and ventral sucker, a gut and “birth pore” to release cercaria
- Redia are mobile in the snail and can prey on sporocysts and redia of the same or other species (competition)

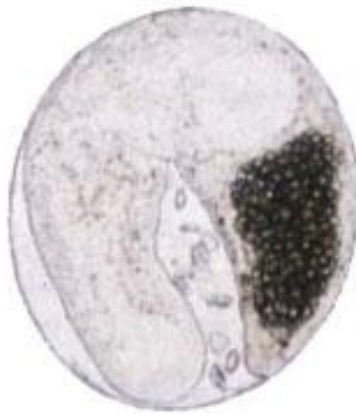
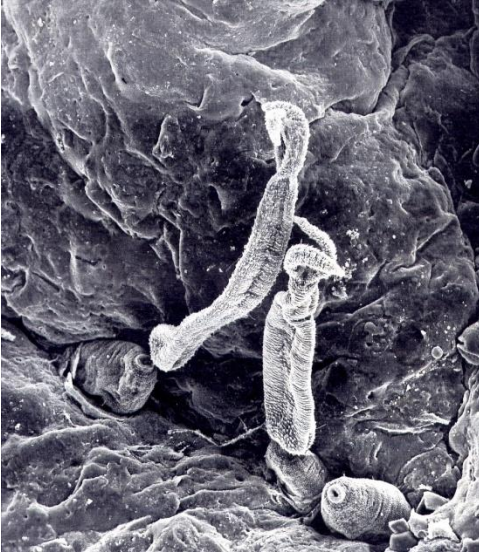
# Trematode life cycles -- the cercaria



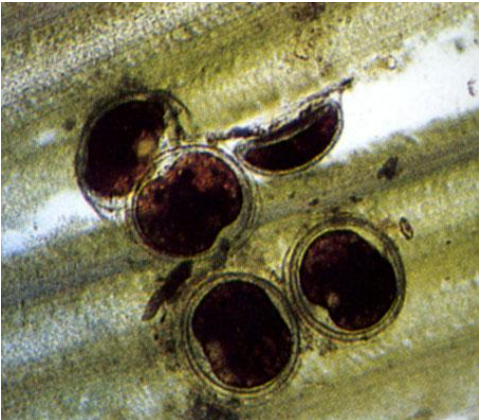
- Cercaria are the stages that leave the intermediate host and infect the final host
- There can be many consecutive waves of “shedding” from the snail
- Cercaria already show many anatomical features of the adult fluke



# Trematode life cycles -- the cercaria

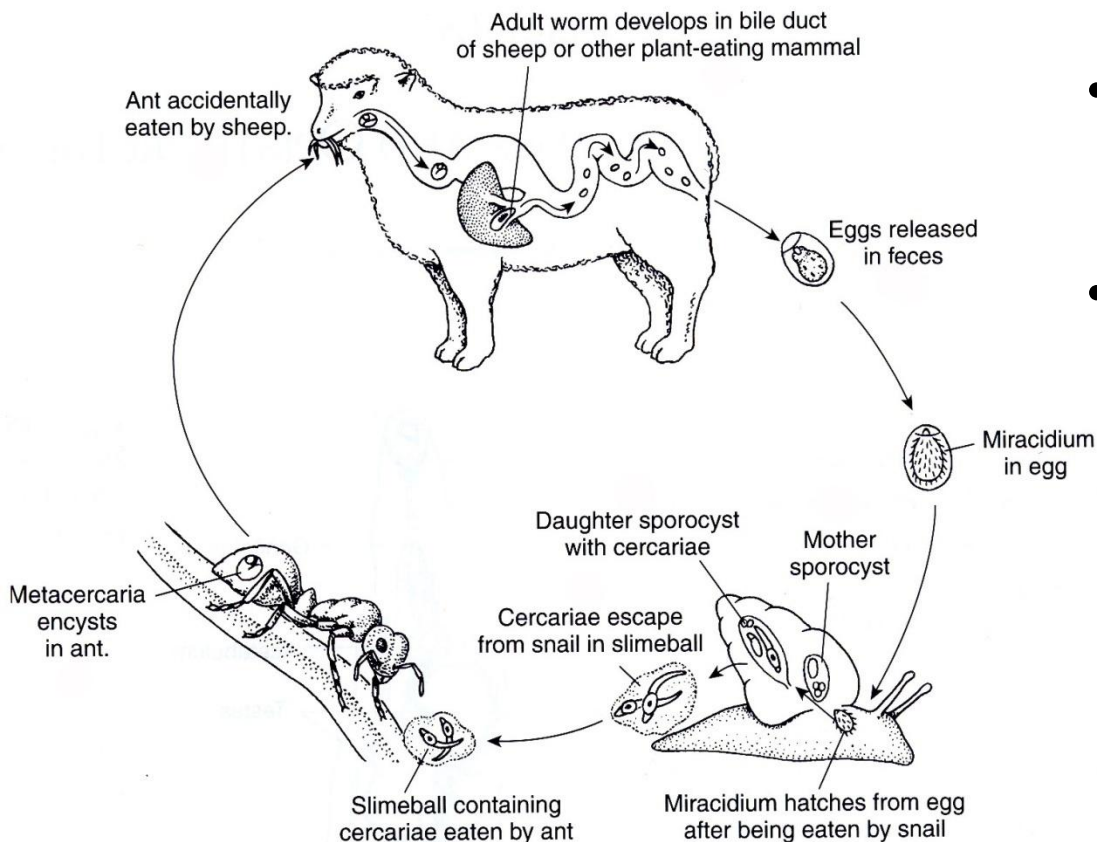


- Reflecting the ecology of their hosts cercaria have developed an array of adaptations to achieve successful infection
- Direct penetration of host skin upon water contact (*Schistosoma*),
- Encystation within the muscle of intermediate hosts (e.g. metacercaria in fish *Clonorchis*)
- Encystation on plants (*Fasciola*)



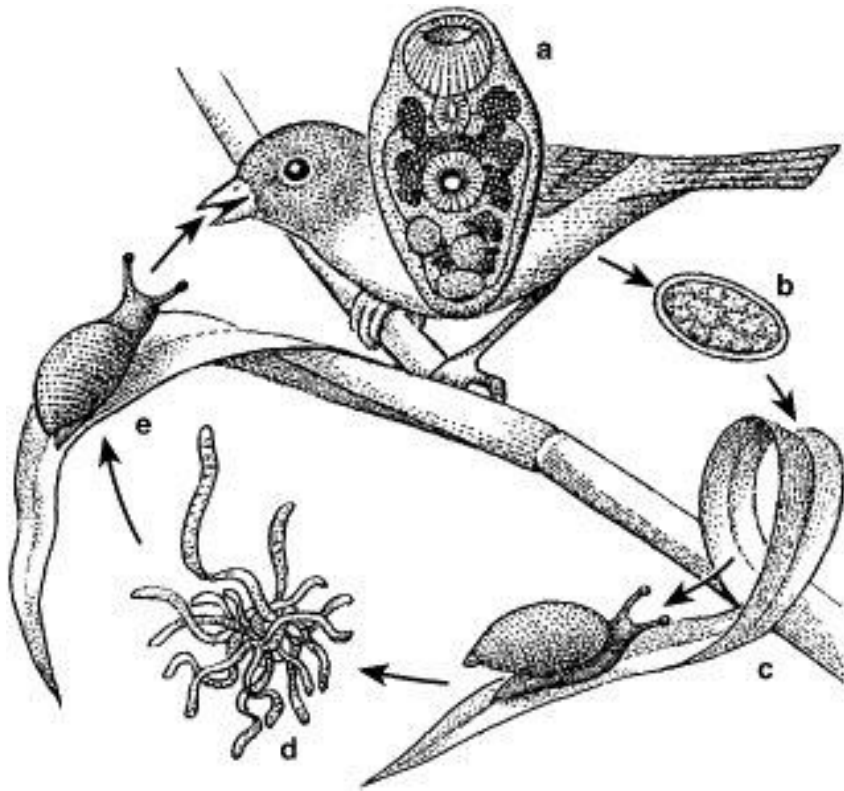
# Trematode life cycles -- enhance transmission

- *Dicrocoelium dendriticum* the lancet fluke
- One metacercaria becomes the 'brain worm' and lodges into the central ganglia of the ant
- The brain worm manipulates the behavior of the ant. In the evening when the temperature drops they experience spasms of their mandibles





# Trematode life cycles -- enhance transmission



- *Leucochloridium* sp. is a tiny digenic trematode living in the gut of small song birds
- Worm eggs are passed with the feces and are taken up by amber snails.
- Miracidia hatch, penetrate the gut epithelium and develop into sporocysts within the hepatopankreas.
- Within the sporocyst cercaria develop which infect birds that eat infected snails.



# Trematode life cycles -- enhance transmission



**Amber snails (uninfected, upper panel and infected, lower panel) and *Leucochloridium* sp. sporocyst dissected from a snail (lower right)**



# Trematode life cycles -- enhance transmission

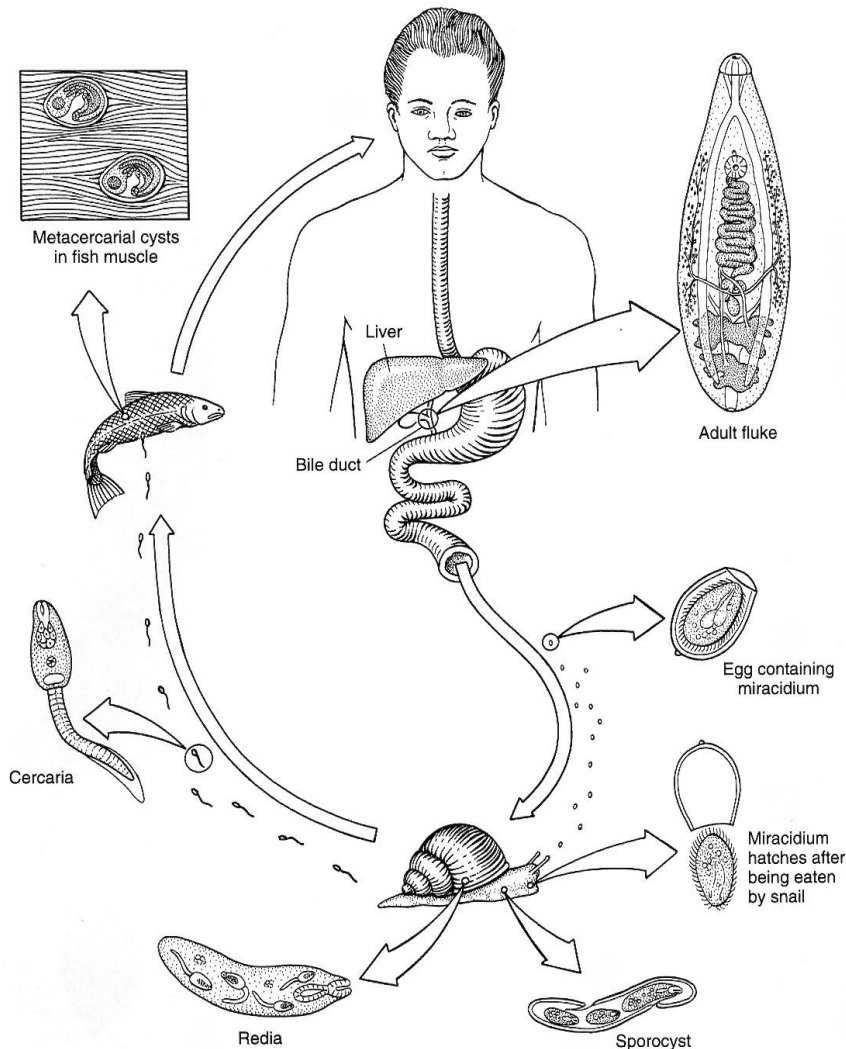


# Trematodes of medical importance

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

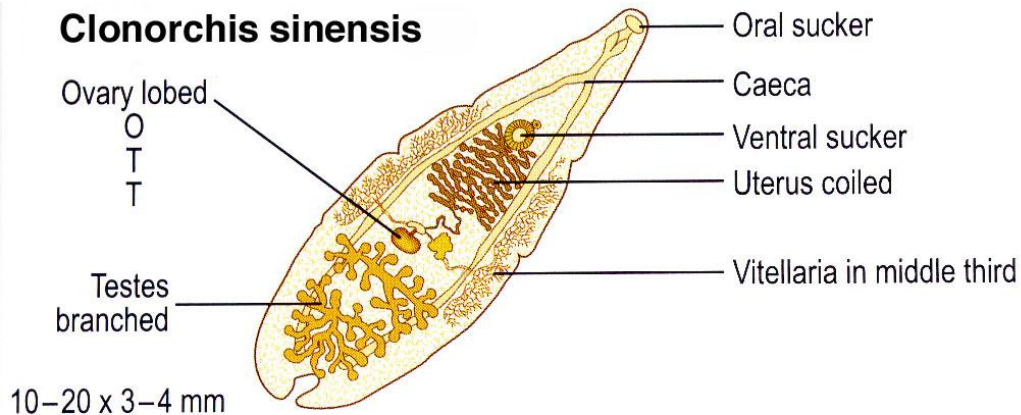
# Human liver fluke disease

- Caused by *Clonorchis sinensis* and *Opisthorchis felinus* and *O. viverrini*
- All locally common in East Asia and Eurasia
- ~20 million people infected



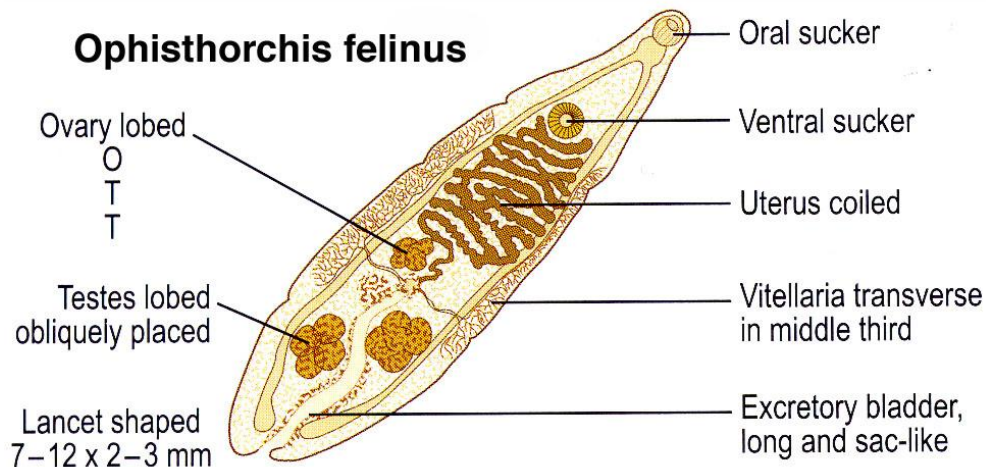
# Human liver fluke disease

## **Clonorchis sinensis**



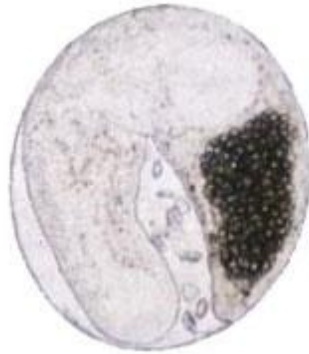
- **Clonorchis and Opisthorchis are quite similar causing similar disease**

## **Opisthorchis felinus**



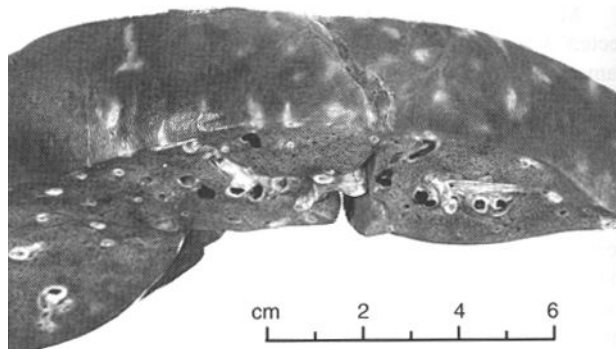


# Human liver fluke disease



- **Metacercariae are found in many fish especially various carp related species**
- **Raw or undercooked fish dishes are a source of human infection**
- **Fertilization of ponds with untreated night soil boost infection in fish**
- **Cats, dogs and other carnivores can be additional hosts and reservoirs**

# Human liver fluke disease



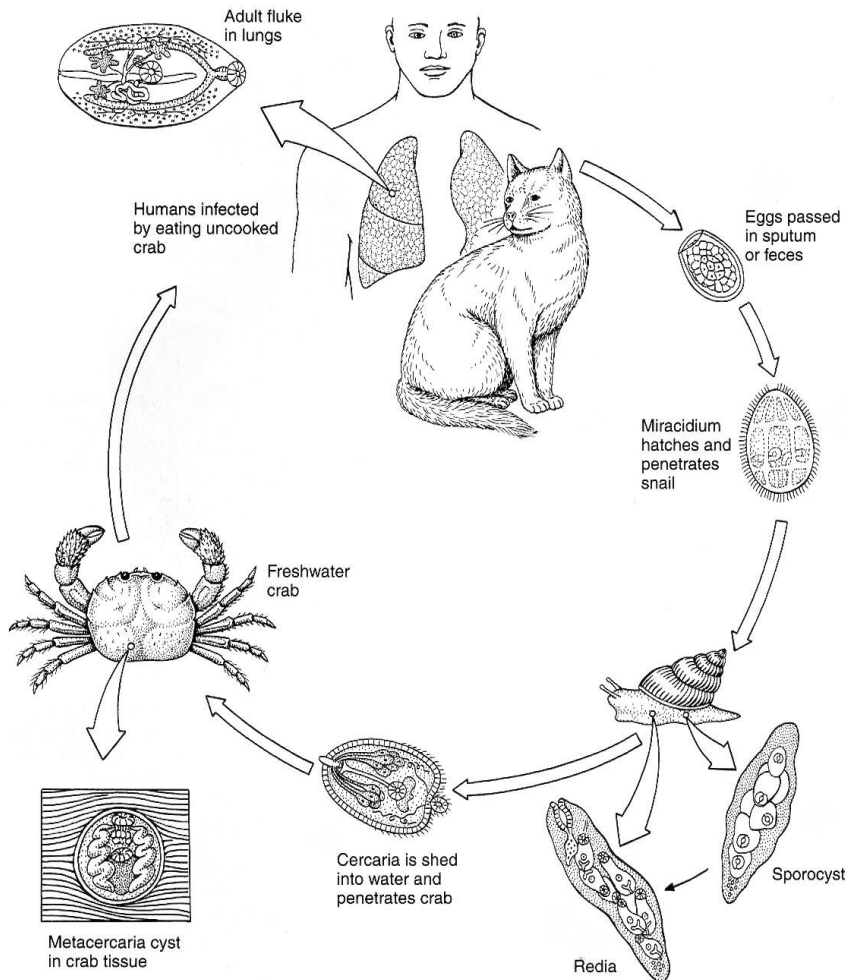
- Pathology depends on worm burden, generally infections are light and free of major symptoms
- Heavy infections Flukes residing in the biliary ducts can chronically irritate the epithelium resulting in hyperplasia of the epithelium and fibrosis around the ducts (pipe stem fibrosis)
- Blockage of bile ducts and impairment of liver function, liver swelling

# Human liver fluke disease



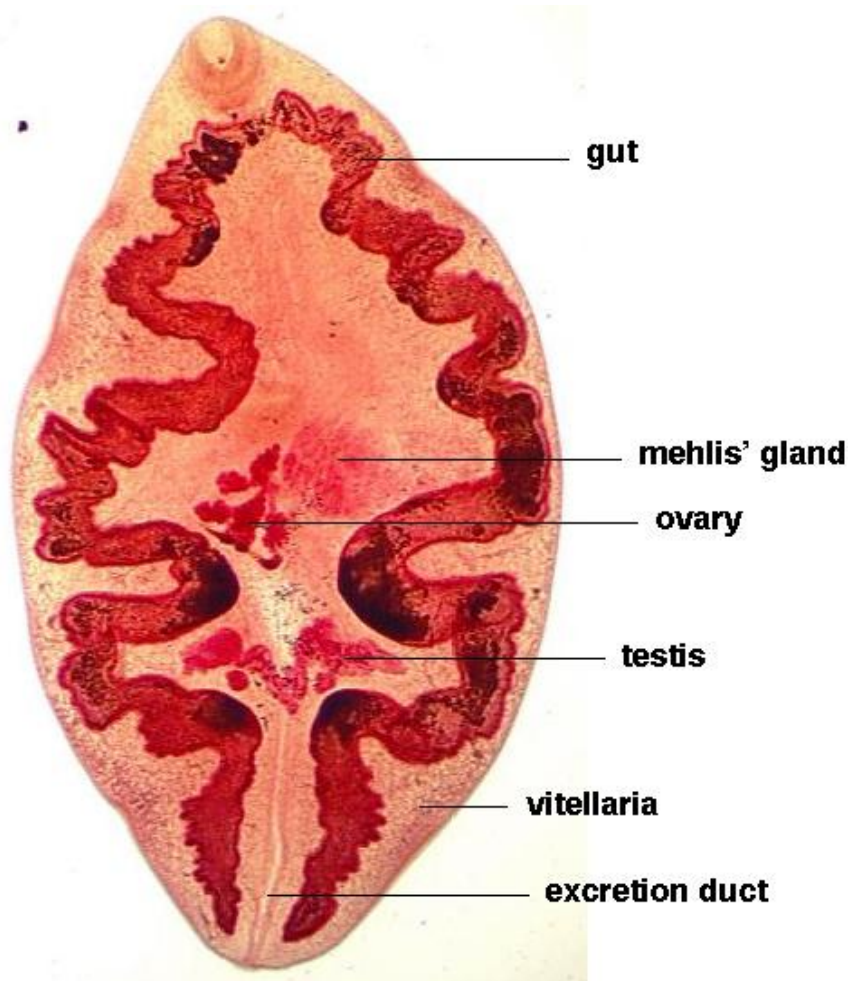
- Diagnosis occurs by microscopic demonstrations of fluke eggs in the feces (~30x15  $\mu\text{m}$ )
- Prepatency is a month
- Readily treated with Praziquantel

# Human lung fluke disease



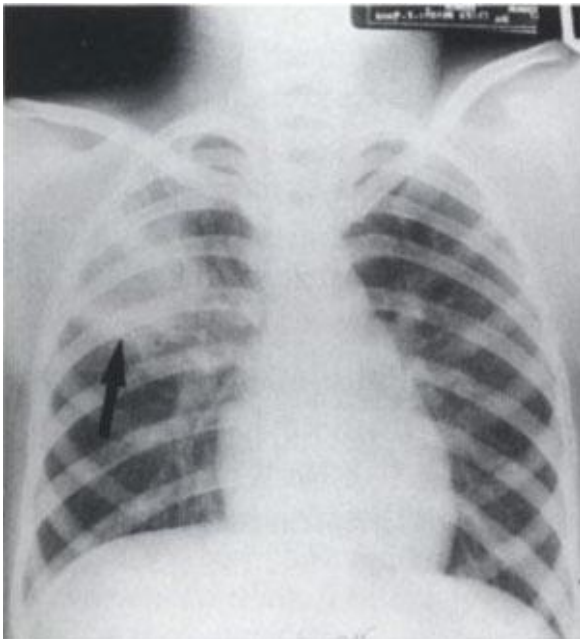
- *Paragonimus westermanii* is best known but a number of other species infect humans around the world
- Several carnivores serve as reservoir
- Upon eating crabs by the final host metacercariae excyst in the duodenum and penetrate the gut, penetrate the diaphragm and pleura and enter the bronchioles, mature in 12 weeks
- May end up in ectopic locations like brain, skin and mesentery

# Human lung fluke disease



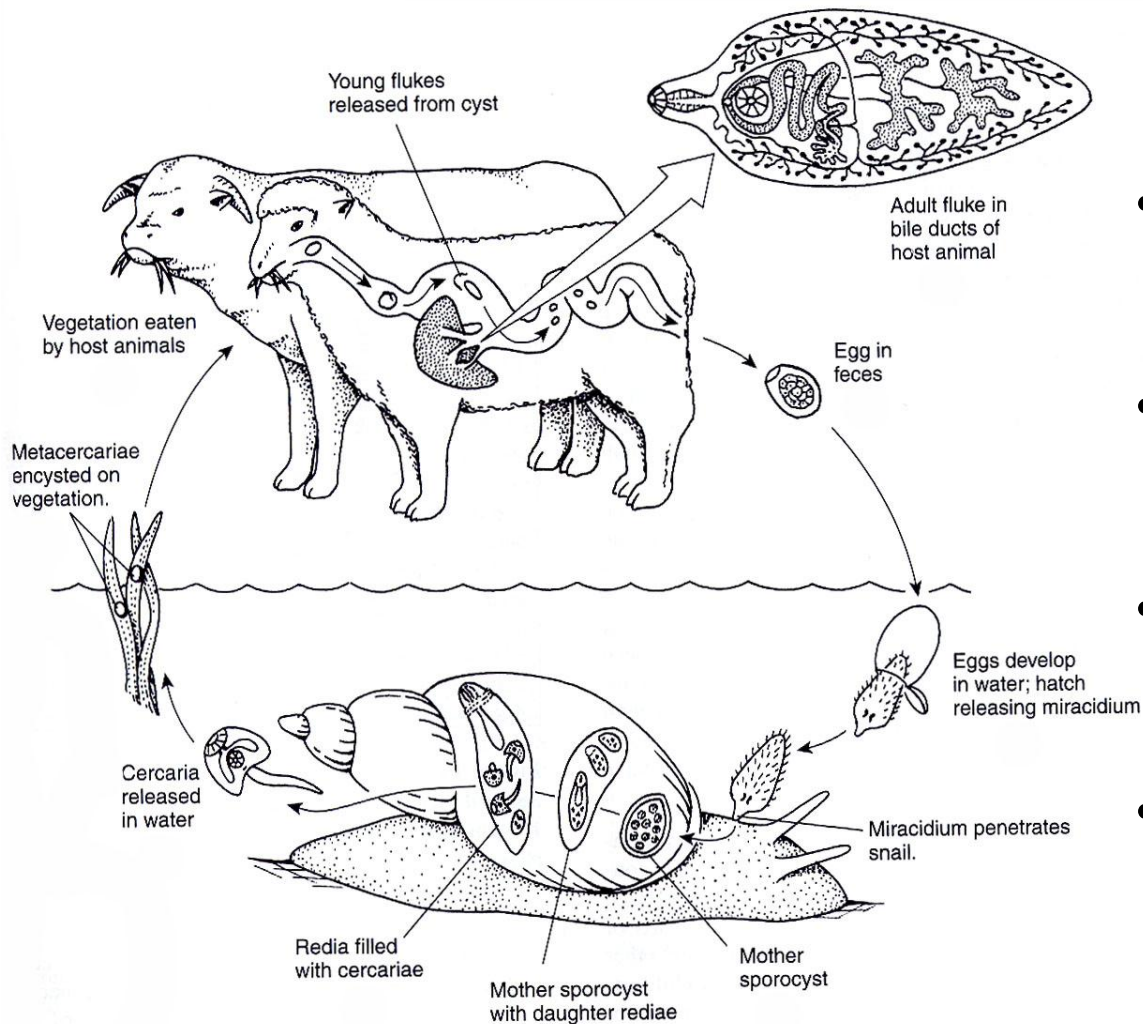


# Human lung fluke disease



- Adults are encapsulated in a granuloma (often two at a time)
- Cyst rupture can result in cough and increase sputum, and chest pain
- Chronic high worm burden can result in chronic bronchitis and dyspnea and increasing fibrosis -- symptoms can be very similar to pulmonary tuberculosis
- Cerebral paragonimiasis produces headaches, fever, nausea, visual disturbances and convulsive seizures

# Fasciola & Fasciolopsis



- Important parasite of livestock, occasionally infects humans
- Symptoms similar to Clonorchis but Fasciola is much bigger
- Fasciolopsis buski the human intestinal fluke has similar ecology
- Usually asymptomatic if not heavy burden

# Schistosomiasis

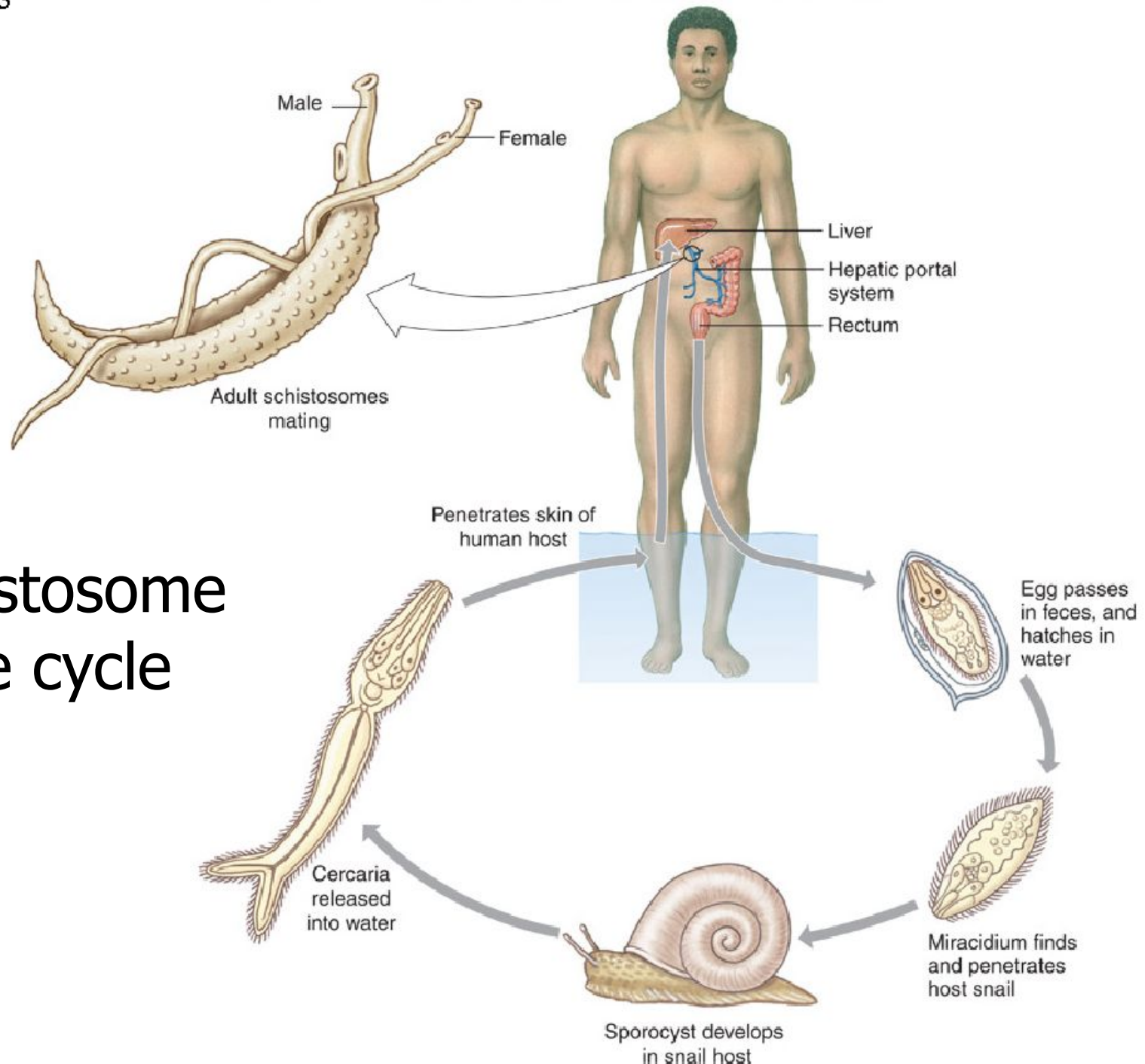
- Schistosomiasis (also known as bilharzia) is an infection with blood flukes and is a major infectious diseases.
- More than 200 million people are infected worldwide with these flukes, which they acquire swimming or walking in water in which the intermediate snail host lives

# Schistosomiasis

- Schistosome eggs enter the water when infected people urinate or defecate in or near water.
- Eggs hatch and the miracidium seeks out a snail. Inside the snail the parasite develops into a sporocyst and asexual reproduction takes place. Cercaria eventually are released into the water.

Figure 14.13

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



# Schistosome life cycle



# Schistosomiasis

- When a schistosome cercaria swims it takes care to avoid UV light which can damage it, but is very sensitive to the scent of humans.
- When it senses molecules from human skin it swims rapidly and jerks around looking for the person. When it makes contact it releases chemicals that soften the skin and it burrows and shedding its tail at the same time.

# Schistosomiasis

- The fluke searches until it finds a capillary and enters it.
- The capillary is only barely wide enough for the fluke and it moves along using its pair of suckers. Eventually, it reaches a larger blood vessel in which it can float until it reaches the lungs and enters an artery and eventually makes its way to the liver.

# Schistosomiasis

- Once in the liver, the fluke feeds on blood and begins to mature and develops ovaries or testes depending on its sex.
- The fluke grows dozens of times larger in the course of a few weeks and then begins to search for a mate.

# Schistosomiasis

- The fluke produces chemicals to attract members of the opposite sex.
- Females are slender and delicate, whereas males are much bigger and have a spiny trough or groove into which the female fits and locks in.

# Schistosomiasis

- Once paired up, the pair mature sexually and travel from the liver to a permanent home that is species-specific.
- In *Schistosoma mansoni* it is near the large intestine, in *S. haematobium* it is the bladder, and in *S. nasale*, a blood fluke of cows, it is the nose.



# Schistosomiasis

- Schistosomiasis has a low mortality rate, but it is a chronic illness that debilitates the infected person.
- Symptoms can include anemia, diarrhea, fever, fatigue and can result in organ damage. In children infection can result in reduced growth and mental development.