V. Subclass Digenea (Chapters 15-18, BLY 459 2009)

A. Background
   1. "Flukes"
   2. "Digenea" refers to having an alternation of hosts in the life cycle

B. Characteristics
   1. Cuplike suckers without hooks
      a.. ORAL SUCKER is around the mouth
      b. ACETABULUM = posterior sucker
   2. Ventral genital openings are between suckers
   3. Single posterior excretory opening

C. Organ systems
   1. Tegument
      a. Covered with mucopolysaccharides
      b. Functions
         (1). Probably some absorption of nutrients
         (2). Respiration
         (3). Protection
            (a). Host immune system
            (b). Host digestive system
   2. Reproduction
      a. Most are hermaphroditic
      b. Asexual reproduction occurs in first intermediate host
      c. VITELLARIA produce the yolk precursor protein, VITELLOGENIN

D. Life Cycle (Larval & Juvenile Development; pp. 228-234)
   1. At least 2, usually 3, sometimes 4 hosts
   2. Final hosts are vertebrates
      a. Usually fish and birds
      b. Humans can be hosts
   3. Adults
      a. Typically in digestive tract (= lumen) of host (There are important exceptions that infect humans.)
      b. Limited to mucosal and epithelial tissues
   4. Eggs
      a. Pass out in feces
      b. Can be eaten by first intermediate
      c. Can hatch into miracidia (plural)

Slide: Egg of *Schistosoma mansoni*

   5. MIRACIDIUM
      a. Free living larval stage
      b. Most are swimmers
      c. Find and penetrate tissues of the first intermediate host (always a mollusk)
      d Covered with cilia

Slide: Miracidium of *Fasciola hepatica*

   6. SPOROCYST

a. Sac in intermediate host snail
b. Depending on species, they undergo asexualreproduction to produce . . .
(1) Daughter sporocysts
(2) Rediae (plural)

7. REDIA
a. Characteristics
(1). Mouth
(2) Sucker
(3). Rudimentary gut
(4) Motile
b. Some have been observed to consume the larval stages of other trematodes in the snail host (= interspecific competition)
c. Reproduce by sequential polyembryony to produce (depending upon density) . . .
(1) Daughter rediae
(2) Cercariae (plural)

Slide: Redia of *Fasciola hepatica*

8. CERCARIA
a. Produced asexually by both daughter sporocysts and rediae
b. Characteristics
(1) Two suckers
(2). Tail
c. Free living stage that leaves snail to either . . .
(1). Penetrate skin of definitive host
(2). Encyst in a second intermediate host to become metacercariae (plural)

Slide: Cercaria of *Fasciola hepatica*
Slide: Cercaria of *Schistosoma mansoni*

9. METACERCARIA
a. Found in/on almost anything that is eaten by a vertebrate
(1). Fish
(2) Crabs
(3). Snails
(4). Hydromedusae
(5). Plants (Encyst upon, not in)
b. Second intermediate host eaten by vertebrate definitive host
c. Metacercariae excyst in digestive juices of definitive host

Slide: Metacercariae in grass shrimp & crab meat
Slide: Metacercarial cysts of the trematode, *Microphallus turgidus*, in the abdomen of a grass shrimp (*Palaemonetes pugio*)

E. Important trematodes
1. Family Schistosomatidae (pp 248-61)
a. Background about schistosomiasis

(1). Ranked 2nd in importance as a human eukaryotic disease (behind malaria)

(2) Ironically, it is the human immune system that does much of the damage to body tissues when it fights the disease (= immunopathological reaction).

(a). Schistosome eggs may end up in many body organs

(b). Immune system develops antibodies to eggs

(c). Immune response to eggs in human tissues damages tissues (= scarring)

Slide: Eggs of *S. japonicum* forming granulomas in host tissues (See Fig. 16-15)

(3). Damage to liver causes it to compensate by growing larger

Slide: Advanced Schistosomiasis Leyte, Philippines (Fig. 16-17)

(4). Characteristics

(a) Adult male worms have a deep groove called the GYNECOPHORAL CANAL (SCHISTO = split; SOMA = body)

(b) Female lies in groove

1) Female is longer than the male and sticks out of both ends

2) Male nourishes female

Slide: *Schistosoma mansoni* Male and Female *in copula* (See Fig. 16-5)

(5). Generalized life cycle

(a) Adults located within hepatic portal system of circulation

1) Characteristics of hepatic portal system

a) Carry blood from urinary bladder and digestive system to liver

b) Blood pressure is low as it has gone through the capillary system in the intestine

c) Rich in nutrients after host feeds

2) Eggs laid in venules of intestinal wall

a) Eggs have a hook and work their way through the intestinal wall in the lumen (damage host)

b) Some eggs carried by blood to other organs

(b) Eggs leave human in feces or urine

(c) Miracidium invades snail intermediate host

1) Sporocysts produced

2) Cercariae leave snail and burrow into

l egs of humans working in rice paddies

(d) Worms migrate throughout body in lymph and blood vessels

(e) Life span of adult worms is about 5-30 years

Slide: Life Cycle of *Schistosoma mansoni* (Fig. 16-7)

b. *Schistosoma japonicum*
(1) Southeast Asia and China
(2) Adult worms in the superior mesenteric vein (Drains the small intestine)
(3) Eggs in feces

Slide: *Schistosoma japonicum* Male and Female (See Fig. 16-5)

c *Schistosoma haematobium*
(1) Africa and parts of Mediterranean
(2) Live in mesentery vessels draining the urinary system
(3) Adults are covered with tubercles
(4) Eggs appear in urine
(5) Cancer of the urinary bladder is a common side effect

Slide: *Schistosoma haematobium* Male gynecophoral canal (See Figs. 16-5 & 16-6)
Slide: *Schistosoma haematobium* Eggs in Urinary Bladder (See Fig. 16-18)

d. *Schistosoma mansoni*
(1) Mainly in Central & South America
(2) Adults worms in the inferior mesenteric veins (Drain large intestine)
(a) Eggs work their way through lining of large intestine
(b) Eggs leave host in feces

Slide: *Schistosoma mansoni* Male and Female in Intestinal Vein
Slide: *Schistosoma mansoni* Egg Working through Intestinal Wall (See Fig. 16-15)

e. Schistosomal dermatitis (See Fig. 16-19)
(1) "Swimmers's itch"
(2) Cercariae of flukes whose definitive hosts are aquatic birds will burrow into skin of humans who are in the water.
(3) Cercariae in humans will not complete their life cycle, but may cause an immune reaction (= skin rash).
(4) Irritating, but harmless

2. Family Fasciolidae (pp 266-271)
a. *Fasciola hepatica*: Liver fluke of humans and mammalian herbivores
b World-wide distribution
c Characteristics
(1) Large size
(a) 100 mm in length
(b) Often used in biology lab demonstrations even though it is not a typical trematode
(2) Major organs are extremely branched

Slide: *Fasciola hepatica* Adult branching gut (See Fig. 17-4)

d. Life cycle (See Fig. 17-5)
(1) Adults
(a) Found in liver, gall bladder & bile passages
(b) Eggs enter small intestine from bile ducts
(2) Metacercariae encyst on vegetation

(3) Definitive host acquires infecton by . . .
(a) Eating uncooked, aquatic vegetation
(b) Drinking water with metacercariae

Slide: *Fasciola hepatica* Life Cycle (See Fig. 17-5)
Slide: *Fasciola hepatica* Cross Section through Liver Duct

3. Family Troglotrematidae (pp 279-283)
a. Infect birds and mammals
b *Paragonimus westermani*
(1) Human lung fluke
(2) Characteristics
(a) Oval
(b) About 10 mm long
(c) Red
(3) Found in Asia and South America
(4) Life cycle (Fig. 18-8)
(a) Adults occur in cysts in human lungs
(b) Eggs coughed up in phlegm
(c) Cercariae enter freshwater crabs and crayfish following ingestion by the crustacean

Slide *Paragonimus westermani* Adult (Fig. 18-7)
Slide: *Paragonimus westermani* Cross Section of Adult in Lung Tissue
Slide: *Paragonimus westermani* Egg in Phlegm
Slide: 2006 newspaper article about lung fluke infections resulting from eating raw crabs at a sushi bar in Southern California

4. Family Dicrocoeliidae (p 275-277)
a. *Dicrocoelium* and *Eurytrema*
b Adults in domestic animals and occasionally in humans
c Second intermediate hosts are ants and grasshoppers that eat cercarial balls produced by terrestrial snails
d QUACK ATTACK: Hulda Clark (*The Cure for All Diseases,* 1995) claims . . .
(1) *Eurytrema* causes diabetes
(2) By killing this parasite with her "Zapper" and removing wood alcohol from one's diet, the need for insulin can be cut in half in 3 weeks

5. Family Opisthorchiidae
a. Testis are located posterior to ovaries (OPISTHO = behind; ORCHIS = testicle)
b *Clonorchis sinensis* (pp. 285-89)
(1) Chinese liver fluke
(2) Found in Asia
(3) Life cycle
(a) Eggs eaten by snail
(b) Definitive host eats metacercariae in uncooked fish

(c) Metacercariae hatch in small intestine and move up the common bile duct to enter liver

Slide: *Clonorchis sinensis* Adult (See Fig. 18-18)

F. Trematode-Killifish-Bird Interaction (Lafferty & Morris, 1996)
1. Life-cycle
   a. Metacercariae in killifish, *Fundulus*
   b. Predatory wading birds get infected when they eat killifish
2. Parasitized killifish exhibited conspicuous behavior
   a. Parasitized fish spent more time at surface than did unparasitized fish
   b. Parasitized fish underwent behaviors such as "flashing" and " shimmying"
   c. The higher the intensity of parasites in a fish, the more conspicuous behaviors it exhibited (Fig. 1)
3. Differential predation experimental design
   a. Two large cages built
      (1) One covered to prevent bird access to fish
      (2) Other uncovered, birds could feed on fish
   b. Stocked each cage with equal numbers of parasitized and unparasitized fish
   c. Ran experiment for 20 days and then sampled fish to determine relative numbers of parasitized and unparasitized fish
4. Results (Fig 2)
   a. Enclosed pen (no bird predation, but natural mortality)
      (1) Unparasitized fish went from 53 to 50
      (2) Parasitized fish: 95 to 91
   b. Open pen (bird predation and natural mortality)
      (1) Unparasitized fish: 53 to 49
      (2) Parasitized fish: 95 to 44
5. Conclusion:
   a. Parasitized fish were 31 times more likely to be eaten than unparasitized fish in the same habitat.
   b. Heavily parasitized fish were more likely to be eaten than lightly parasitized fish (Fig. 3)
6. Implications
   a. Trematode parasites might benefit birds by acting as a delivery system that enables birds to eat fish that are otherwise difficult to capture
   b. Parasites might allow the persistence of a predator in areas where one could not previously exist.