Class Trematoda (fluke worm)

- This class consisting of 3 subclass:
  - Subclass monognea (fish)
  - Subclass aspidogasteria (fish - snail)
  - Subclass digenea (animals & human)

Subclass Digenea

- Inhabitants of the vertebrate alimentary canal or its associated organs, especially the liver, bile duct, gall bladder, lungs, pancreatic duct, ureter and bladder; environments rich in potential semi-solid food materials such as blood, bile, mucous and intestinal debris
- The digenetic trematodes are distinguished from the Monogenea by their relatively simple external structure, in particular the absence of complicated adhesive organs; only simple suckers are present
- Also, digeneans have complex life cycles involving at least one intermediate host
- The first intermediate host is a mollusc, usually a gastropod; in exceptional cases, the first intermediate host is an annelid
- The larval phases are unusual in undergoing polyembryony (development of a single zygote into more than one offspring) so that enormous numbers of larvae may result from small initial infections
- Flukes are hermaphrodite (monoecious) exception of schistosome are (diecious).
- Reproductive system is highly developed ended by common genital pore
- Digestive system: begin in oral cavity lead to esophagus then intestine which consist of 2 elementary canals blind ended called (ceca), no anus
- Adult worm
  - Most species are elongate and dorso-ventrally flattened; but some have thick fleshy bodies and some are round in section
  - There are typically 2 suckers, an anterior oral sucker surrounding the mouth, and a ventral sucker sometimes termed the acetabulum, on the ventral surface
  - Body wall: musculo-tegumental sac
  - Parenchyma (structure between body wall and internal organs): connective tissue fibers, cells and space between them

Tegument

- The tegument or cuticle ,which may be partially or completely covered with spine
- In addition to its obvious protective role, the tegument has numerous other functions:
  - absorption of nutrients; although they have a well developed gut, materials can be brought in via the tegument
  - synthesis and secretion of various nutrients
  - excretion and osmoregulation
  - sensory role (due to the presence of various sensory organs)

The outer plasma membranes possess a coating called the glycocalyx
Muscular System

- The bodies and parts of bodies of flatworms are often seen to expand, contract, and twist, and this movement indicates the presence of muscles.
- These muscles lie in groups or layers primarily near the body surface as longitudinal or circular fibers.
- Some fibers do occur with the suckers.

Nervous System

Paired ganglia at the anterior end of the body serve as the brain; from here, nerves extend anteriorly and posteriorly.

Most sensory receptors are lacking among the adults; they do have tangoreceptors, receptors sensitive to touch.

Larval stages have many kinds of sensory receptors, important for locating hosts in the environment. Many have light receptors and chemoreceptors.

Excretion and Osmoregulation

- The flame cells are connected by tubules unifying to form larger ducts that open either independently to the outside or join to form a urinary bladder that opens to the outside near the posterior end (=excretory pore).
- Flame cells and their ducts function not only in excretion, but also for water regulation, and possibly to keep body fluids in motion.
- Ducts or tubules contain fingerlike projections that presumably aid re-absorption by increasing the internal surface area.

Male Reproductive System

- Usually 2 testes are present, but some flukes can have more than 100.
- Also present are a vas deferens, seminal vesicle (storage), ejaculatory duct, and a cirrus (analogous to a penis) enclosed in a cirrus sac.

Female Reproductive System

- Single ovary with an oviduct, a seminal receptacle (sperm storage), a pair of vitelline glands (yolk and egg-shell production) with ducts, the ootype (a chamber where eggs are formed), a complex collection of glands cells called Mehlis’ gland (lubricates uterus for egg passage).
Life Cycle Overview

**Egg (shelled embryo)**
- Contain a developing embryo or a fully developed miracidium
- Most embryos develop when outside the body of the host, but require water or considerable moisture
- The egg capsule has an opening (*operculum*) at one end through which the miracidium larva can eventually escape; hatching of eggs containing miracidia is controlled by a number of factors, the most important being light, temperature, and osmotic pressure
- Some eggs hatch only when ingestion by the snail intermediate host; the process may be stimulated by the action of host enzymes

**Miracidia**
- A swimming sac-like larva, carrying a number of germinal cells from which will arise subsequent generations of organisms (e.g. sporocysts, etc.)
- Possess an *apical gland* - empties rapidly during penetration and is thought to release proteolytic enzymes
- After penetration, the miracidium normally sheds its ciliated covering and elongates to become a sporocyst
- A pair of glands called *penetration* or *adhesive glands* secrete a mucoid material which appears to assist in the attachment to snail host tissue

**Sporocysts and Rediae**
- Sporocysts are germinal sacs containing germinal cells which have descended from the original ovum from which the miracidium developed
- Within the sporocyst, the germinal cells multiply and form new germinal masses, these may either:
  - a) produce daughter sporocysts like the parent sporocyst or
  - b) produce rediae
- Both of these generations produce embryos which develop into the final generation of organisms called cercariae
• **Cercaria**
  - Young flukes which develop parthenogenetically in rediae and sporocysts
  - During their development, propagatory cells, derived from the original germ cell, give rise to the reproductive system of the adult fluke
  - Mouth is usually surrounded by an oral sucker
  - Mouth lead to the pharynx followed, by a forked intestine
  - Many cercaria a forked tail and various kinds of glands (=penetration glands) that aid in penetration of the second intermediate host
  - Also present are **escape glands** that assist in the escape of the cercariae from the snail
  - The excretory system of cercariae is well developed
  - Most have any of a number of different kinds of adaptations to facilitate this host seeking process

**Metacercariae**
- Before becoming infective, most cercariae (except the blood flukes) must undergo a further developmental phase - metacercariae
- Overall, released cercariae behave in one of the following ways:
  - they become ingested directly by the definitive host
  - they encyst directly on vegetation
  - they penetrate the skin of the definitive host and develop to adults without passing through the metacercariae stage
  - they penetrate the intermediate host

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**Development in a Definitive Host**
- Develop in the definitive host can occur once the cercariae have penetrated the host
- For those trematodes that have metacercariae, it occurs once the metacercariae excyst in the definitive host’s gut following ingestion
- A variety of mechanisms can lead to excystation, including host enzymes, temperature, etc.
- Once excystation has occurred, the worms migrate to their appropriate location in the definitive host
The Blood Flukes

General features of *Schistosoma* spp.:

1. Separate male and female worms exist in this group of flukes.
2. The female is long and slender, the male is shorter, cylindrical and characteristically in-curved to form a gynecophoral groove in which the female reposes.
3. Eggs are non operculate, and spines present on the eggs.
4. The release of enzymes along with necrosis of tissue results in release of eggs into the intestine or bladder.
5. No redia formation
6. Forked tail cercariae
7. Infection by penetration of unbroken skin

Species of Schistosomes:

*Schistosoma haematobium*: Africa, Portugal, isolated focus in India, recently Jordan: Vesicles assoc. with bladder, characteristic haematuria

*Schistosoma mansoni*: Africa, Brazil, Venezuela, parts of the Carribean, mesenteric veins of colon, no imp reservoirs

*Schistosoma japonicum*: Far East, parts of China, Japan, Philippines, Indonesia: mesenteric veins of small intestine, many imp. reservoirs. Produces more eggs

subclass Digenea (Trematoda) – include:

- **Blood:**
  - *Schistosoma haematobium*
  - *Schistosoma mansoni*
  - *Schistosoma japonicum*

- **lung:**
  - *Paragonimus westermani*

- **liver:**
  - *Fasciola hepatica*
  - *Clonorchis sinensis*

- **intestinal:**
  - *Fasciolopsis buski*
  - *Heterophyes heterophyes*
Differential Features of Schistosoma spp.
### MALE

<table>
<thead>
<tr>
<th></th>
<th><strong>S. haematobium</strong></th>
<th><strong>S. mansoni</strong></th>
<th><strong>S. japonicum</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>size</td>
<td>10-18 by 1 mm (medium)</td>
<td>10-12 by 1mm (small)</td>
</tr>
<tr>
<td>2.</td>
<td>Tuberculation on cuticle</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>3.</td>
<td>Re-union of intestinal ceaca in the body</td>
<td>in the middle</td>
<td>In the anterior third of the body</td>
</tr>
<tr>
<td>4.</td>
<td>No. of testes</td>
<td>4-5</td>
<td>6-9</td>
</tr>
</tbody>
</table>

### FEMALE

<table>
<thead>
<tr>
<th></th>
<th><strong>S. haematobium</strong></th>
<th><strong>S. mansoni</strong></th>
<th><strong>S. japonicum</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>size</td>
<td>16-20 by 0.25 mm</td>
<td>10-20 by 0.16 mm</td>
</tr>
<tr>
<td>6.</td>
<td>Position of the ovary</td>
<td>Posterior half</td>
<td>Anterior half</td>
</tr>
<tr>
<td>7.</td>
<td>Length of the uterus</td>
<td>Long</td>
<td>short</td>
</tr>
<tr>
<td>8.</td>
<td>No. of ova in the uterus</td>
<td>10-50</td>
<td>1-4</td>
</tr>
</tbody>
</table>

### OVA

<table>
<thead>
<tr>
<th></th>
<th><strong>S. haematobium</strong></th>
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<th><strong>S. japonicum</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.</td>
<td>shape</td>
<td>Oval with Terminal spine</td>
<td>Oval with Lateral spine</td>
</tr>
<tr>
<td>10.</td>
<td>Size</td>
<td>150 by 62 mm</td>
<td>140 by 61 mm</td>
</tr>
<tr>
<td>11.</td>
<td>Found in</td>
<td>urine</td>
<td>feces</td>
</tr>
<tr>
<td>12.</td>
<td>Main Habitat</td>
<td>Vesical plexuses</td>
<td>Veins (large intestines) inferior mesenteric veins.</td>
</tr>
</tbody>
</table>

### Life cycle

<table>
<thead>
<tr>
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<th><strong>S. japonicum</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>13.</td>
<td>Definitive host</td>
<td>human</td>
<td>Human and rodents</td>
</tr>
<tr>
<td>14.</td>
<td>Intermediate host.</td>
<td><em>Bulinus</em></td>
<td><em>Biomphalaria</em></td>
</tr>
</tbody>
</table>
Schistosomiasis is caused by digenetic blood trematodes. The three main species infecting humans are *Schistosoma haematobium*, *S. japonicum*, and *S. mansoni*. Two other species, more localized geographically, are *S. mekongi* and *S. intercalatum*. In addition, other species of schistosomes, which parasitize birds and mammals, can cause cercarial dermatitis in humans.

Eggs are eliminated with feces or urine. Under optimal conditions the eggs hatch and release miracidia, which swim and penetrate specific snail intermediate hosts. The stages in the snail include 2 generations of sporocysts and the production of cercariae. Upon release from the snail, the infective cercariae swim, penetrate the skin of the human host, and shed their forked tail, becoming schistosomulae. The schistosomulae migrate through several tissues and stages to their residence in the veins. Adult worms in humans reside in the mesenteric venules in various locations, which at times seem to be specific for each species. For instance, *S. japonicum* is more frequently found in the superior mesenteric veins draining the small intestine, and *S. mansoni* occurs more often in the superior mesenteric veins draining the large intestine. However, both species can occupy either location, *S. haematobium* most often occurs in the venous plexus of bladder, but it can also be found in the rectal venules. The females deposit eggs in the small venules of the portal and perivesical systems. The eggs are moved progressively toward the lumen of the intestine and of the bladder and ureters (*S. haematobium*), and are eliminated with feces or urine, respectively. Human contact with water is thus necessary for infection by schistosomes.

Various animals, such as dogs, cats, rodents, pigs, hourse and goats, serve as reservoirs for *S. japonicum*, and dogs for *S. mekongi*.
**Laboratory diagnosis:**

1. Detection of fluke eggs in faecal or urine samples, often after concentration by sedimentation/flotation or filtration techniques. The eggs are sufficiently characteristic to facilitate specific diagnosis. On occasion, microscopy of rectal biopsies has been used to diagnose *S. haematobium* infections.

2. Detection of proteinuria and hematuria

3. Immunoserological tests have been developed to detect host antibodies against infection but they have experienced cross-reactivity problems and cannot discriminate between previous and active infection.

4. More recently, molecular techniques have been used to detect parasite antigens or DNA in host samples; some tests showing good correlations with parasite burdens.