Chapter 15 - Trematoda: Classification and Form and Function of Digeneans

Subclass Digenea

The great majority of digenetic trematodes are inhabitants of the vertebrate alimentary canal or its associated organs, especially the liver, bile duct, gall bladder, lungs, pancreatic duct, ureter and bladder
These are organs containing cavities rich in potential semi-solid food materials such as blood, bile, mucous and intestinal debris

Readily distinguished from the Monogenea by their relatively simple external structure, in particular the absence of complicated adhesive organs
In the digeneans only simple suckers are present
They also differ markedly in having complex heteroxenous life cycles involving at least one intermediate host

With 2 exceptions, in all life cycles the first intermediate host is a mollusc, usually a gastropod

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

Form and Function

Most species are 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

Monostome is used to describe worms with one sucker (oral)
Flukes with an oral sucker and an acetabulum at the posterior end of the body are called **amphistomes**
Distomes are flukes with an oral sucker and a ventral sucker, but the ventral sucker if somewhere other than posterior

Tegument

The tegument is a **syncytial epithelium** (distal cytoplasm is continuous, with no intervening cell membranes)
It comprises an outer, anucleate layer of cytoplasm connected by cytoplasmic strands to the nucleated portions of the cyctoplasm

In addition to its 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

The outer plasma membranes possess a coating called the glycocalyx
As an integral part of the tegument (i.e., not just an adherent extraneous layer) it probably plays a role in the protective, absorptive and immunological properties of the tegument

Muscular System

Longitudinal and circular muscle layers occur near the body surface
Some fibers occur with the suckers

Nervous System

Paired ganglia at the anterior end of the body serve as the brain
From this nerves extend anteriorly and posteriorly

Sensory receptors are, for the most part, lacking among the adults
They do have tangoreceptors,
Larval stages have many kinds of sensory receptors, including light receptors and chemoreceptors

Excretion and Osmoregulation

It is a protonephridial system consisting of flame cells
Ducts or tubules contain fingerlike projections that presumably aid re-absorption by increasing the internal surface area

Digestive System

The mouth leads to the pharynx, the esophagus, and the gut (cecum) which generally has 2 branches
There is usually no anus, although in a few species (echinostomes) an opening exists between the ceca and the excretory vesicle

Food of trematodes consists of blood, mucus and tissue
The mode of feeding is suctorial, associated with the attachment process of the oral sucker and muscular pharynx
Digestion in most species is extracellular in the ceca

Reproductive Systems

Most trematodes are hermaphroditic (a notable exception are the schistosomes) and some of these can self-fertilize
Most engage in cross-fertilization

Males

Protandry is the general rule among the Digenea
Usually 2 **testes** are present, but some flukes can have more than 100
Also present are vasa efferentia, a **vas deferens**, **seminal vesicle** (storage), **ejaculatory duct** and a **cirrus** (analogous to a penis) enclosed is a **cirrus sac**

Females

Females have a single **ovary** with an **oviduct**, a **seminal receptacle**, 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)
In addition, they possess a canal called **Laurer's canal**, which leads from the oviduct to the dorsal surface of the body
Most trematodes possess an **ovicapt,** an enlarged portion of the oviduct where it joins the ovary
It probably controls the release of ova and spaces out their descent down the uterus

Life Cycle Overview

Eggs leave the host and are either eaten by a snail in which they hatch, or they hatch in the water and become a ciliated free-swimming larva called the **miracidium**
If it is a free-swimming miracidium it must penetrate the snail host
Soon after penetration, the larva discards its ciliated epithelium and metamorphoses into a simple sac-like **sporocyst**

Germinal cells within the sporocyst develop into **rediae** (singular **redia)**
These mature and emerge from a birth pore or are liberated by rupture of the sporocyst

Each germ cell in the redia develops into a **cercaria**
These also mature and emerge from a birth pore or are liberated by rupture of the redia

Cercariae leave the snail host and are propelled through the environment by a tail-like structure
Cercariae usually develop into encysted **metacercariae** in a second intermediate host

The fully developed, encysted metacercaria is infective to the definitive host and develops there into the adult trematode

Life Cycle Stages: Detail

Egg (shelled embryo)

The egg of trematodes is not an ovum, but the developing embryo enclosed by a shell (capsule)
In some cases, the egg contains a fully developed miracidium

Most embryos develop when outside the body of the host (in the environment)
In order for the embryo to develop there must be water or considerable moisture

The egg capsule has an opening **(operculum)** at one end through which the miracidium larva can eventually escape
The hatching of eggs containing miracidia is controlled by a number of factors, the most important being light, temperature, and osmostic pressure

Note:
Some eggs hatch only be ingestion by the snail intermediate host

Miracidia

A typical miracidium is essentially a swimming sac-like larva
Each carries a number of germinal cells from which will arise subsequent generations of organisms (e.g. sporocysts, etc.)

Miracidia contain a number of glands
Chief among these is a large **apical gland** - it empties rapidly during penetration and is thought to release proteolytic enzymes which could aid in the process

After penetration, the miracidium normally sheds its ciliated covering and elongates to become a sporocyst

A pair of **penetration** or **adhesive glands** secrete a mucoid material which appears to assist in the attachment to snail host tissue

There is some evidence that miracidia are attracted to its molluscan host via chemotaxis
And various substances present in snail conditioned water have been thought to serve as attractants

Sporocysts and Rediae

Sporocysts are essentially 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 develops into the final generation of organisms called cercariae

If sporocysts give rise to daughter sporocysts, the latter give rise directly to cercariae and rediae are not formed
If sporocysts give rise to rediae before producing cercariae, these may produce a second or even third generation of rediae before producing cercariae

Parasitic Castaration

The presence of large numbers of sporocysts and rediae in host snails can have a pronounced affect on their biology
A well-known condition is called **parasitic castration,** some larval parasites secrete chemicals that inhibit the development of the snail reproductive system

Cercariae

They are essentially young flukes which develop parthenogenetically in rediae and sporocysts
During their development, propagatory cells, derived from the original germ cell, give rise to the anlagen of the reproductive system of the adult fluke

Most cercariae have a mouth and it is usually surrounded by an oral sucker
A pharynx followed by a forked intestine are also usually present
Most are furnished with 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

Once the cercariae have emerged from a molluscan host they begin to seek the second intermediate host
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 during which time they are known as metacercariae

Note:
The term mesocercariae is also used to describe prolonged cercarial stages which occur unencysted (rarely) in some genera (e.g. *Alaria*)

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 definitve host and develop to adults without passing through the metacercariae stage
- they penetrate the intermidiate host and behave in one of the following ways:

    - they undergo some growth without encystment
    - they encyst at the beginning of a growth phase
    - they encyst at the end of a growth phase
    - they encyst without a growth phase

Development in a Definitive Host

Develop in the definitive host can occur once the cercariae have penerated the host
Or, for those trematodes that have metacercariae, once the metacercariae excyst in the definitive host's gut after being ingested
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