

## Platyhelminthes

### Introduction :

Phylum Platyhelminthes belongs to kingdom Animalia. This phylum includes 13,000 species. The organisms are also known as flatworms. These are acoelomates and they include many free-living and parasitic life forms. Members of this phylum range in size from a single-celled organism to around 2-3 feet long.

The simplest animals that are bilaterally symmetrical and **triploblastic** (composed of three fundamental cell layers) are the Platyhelminthes, the flatworms. Flatworms have no body cavity other than the gut (and the smallest free-living forms may even lack that!) and lack an anus; the same pharyngeal opening both takes in food and expels waste. Because of the lack of any other body cavity, in larger flatworms the gut is often very highly branched in order to transport food to all parts of the body. The lack of a cavity also constrains flatworms to be flat; they must respire by **diffusion**, and no cell can be too far from the outside, making a flattened shape necessary.

Flatworms were once divided into three groups. The mostly free-living Turbellaria include the planarian, *Dugesia*, shown above; these are found in the oceans, in fresh water, and in moist terrestrial habitats, and a few are parasitic. The Trematoda, or flukes, are all parasitic, and have complex life cycles specialized for parasitism in animal tissues. Members of one major taxon of flukes, the Digenea -- which includes the human lung fluke depicted at right -- pass through a number of juvenile stages that are parasitic in one, two, or more **intermediate hosts** before reaching adulthood, at which time they parasitize a **definitive host**. The Cestoda, or tapeworms, are intestinal parasites in vertebrates, and they also show anatomical and life history modifications for parasitism.

Platyhelminths have practically no fossil record. A few trace fossils have been reported that were probably made by platyhelminths (Alessandrello et al., 1988), and fossil trematode eggs have been found in Egyptian mummies and in the dried dung of Pleistocene ground sloth. Trematode larvae that parasitize molluscs may leave pits or thin spots on the inside of the shell, and these pits may be recognized on fossil shells. If the mollusc is irritated by the presence of trematode larvae, it may be able to surround them with layers of shelly material - and thus do parasites become natural pearls.

### **Characteristics of Platyhelminthes**

Platyhelminthes have the following important characteristics:

1. They are triploblastic, acoelomate, and bilaterally symmetrical.
2. They may be free-living or parasites.
3. The body has a soft covering with or without cilia.
4. Their body is dorsoventrally flattened without any segments and appears like a leaf.
5. They are devoid of the anus and circulatory system but has a mouth.
6. They respire by simple diffusion through the body surface.
7. They have an organ level of organization.
8. They do not have a digestive tract.
9. The space between the body wall and organs is filled with connective tissue parenchyma which helps in transporting the food material.
10. They are hermaphrodites, i.e., both male and female organs are present in the same body.
11. They reproduce sexually by fusion of gametes and asexually by regeneration by fission and regeneration. Fertilization is internal.

12. The life cycle is complicated with one or more larval stages.
13. They possess the quality of regeneration.
14. The flame cells help in excretion and osmoregulation.
15. The nervous system comprises the brain and two longitudinal nerve cords arranged in a ladder-like fashion.

### **Unique Characteristics of Platyhelminthes**

Some of the characteristics that distinguish the organisms belonging to phylum Platyhelminthes from others are:

- Presence of flame cells.
- Ladder-like nervous system.
- Presence of parenchyma in the body cavity.
- Self-fertilization

### **Physiological Processes of Flatworms**

The free-living species of flatworms are predators or scavengers. Parasitic forms feed on the tissues of their hosts. Most flatworms, such as the planarian shown in Figure 1, have a gastrovascular cavity rather than a complete digestive system. In such animals, the “mouth” is also used to expel waste materials from the digestive system. Some species also have an anal opening. The gut may be a simple sac or highly branched. Digestion is extracellular, with digested materials taken in to the cells of the gut lining by phagocytosis. One group, the cestodes, lacks a digestive system. Flatworms have an excretory system with a network of tubules throughout the body with openings to the environment and nearby flame cells, whose cilia beat to direct waste fluids concentrated in the tubules out of the body. The system is responsible for the regulation of dissolved salts and the excretion of nitrogenous wastes. The nervous system consists of a pair of nerve cords running the length of the body with connections between them and a

large ganglion or concentration of nerves at the anterior end of the worm, where there may also be a concentration of photosensory and chemosensory cells.

There is neither a circulatory nor respiratory system, with gas and nutrient exchange dependent on diffusion and cell-cell junctions. This necessarily limits the thickness of the body in these organisms, constraining them to be “flat” worms. Most flatworm species are monoecious, and fertilization is typically internal. Asexual reproduction is common in some groups.

### **Diversity of Flatworms**

Platyhelminthes are traditionally divided into four classes: Turbellaria, Monogenea, Trematoda, and Cestoda (Figure 2). As discussed above, the relationships among members of these classes is being reassessed, with the turbellarians in particular now viewed as a paraphyletic group, a group that does not have a single common ancestor.

The class Turbellaria includes mainly free-living, marine species, although some species live in freshwater or moist terrestrial environments. The ventral epidermis of turbellarians is ciliated and facilitates their locomotion. Some turbellarians are capable of remarkable feats of regeneration in which they may regrow the body, even from a small fragment.

The monogeneans are ectoparasites, mostly of fish, with simple lifecycles that consist of a free-swimming larva that attaches to a fish to begin transformation to the parasitic adult form. The parasite has only one host and that host is usually only one species. The worms may produce enzymes that digest the host tissues or simply graze on surface mucus and skin particles. Most monogeneans are hermaphroditic, but the male gametes develop first and so cross-fertilization is quite common.

The trematodes, or flukes, are internal parasites of mollusks and many other groups, including humans. Trematodes have complex lifecycles

that involve a primary host in which sexual reproduction occurs, and one or more secondary hosts in which asexual reproduction occurs. The primary host is almost always a mollusk. Trematodes are responsible for serious human diseases including schistosomiasis, a blood fluke. The disease infects an estimated 200 million people in the tropics, leading to organ damage and chronic symptoms like fatigue. Infection occurs when the human enters the water and a larva, released from the primary snail host, locates and penetrates the skin. The parasite infects various organs in the body and feeds on red blood cells before reproducing. Many of the eggs are released in feces and find their way into a waterway, where they are able to reinfect the primary snail host.

The cestodes, or tapeworms, are also internal parasites, mainly of vertebrates (Figure 3). Tapeworms live in the intestinal tract of the primary host and remain fixed using a sucker on the anterior end, or scolex, of the tapeworm body. The remaining body of the tapeworm is made up of a long series of units called proglottids, each of which may contain an excretory system with flame cells, but contain reproductive structures, both male and female. Tapeworms do not possess a digestive system; instead, they absorb nutrients from the food matter passing them in the host's intestine. Proglottids are produced at the scolex and gradually migrate to the end of the tapeworm; at this point, they are "mature" and all structures except fertilized eggs have degenerated. Most reproduction occurs by cross-fertilization. The proglottid detaches from the body of the worm and is released into the feces of the organism. The eggs are eaten by an intermediate host. The juvenile worm infects the intermediate host and takes up residence, usually in muscle tissue. When the muscle tissue is eaten by the primary host, the cycle is completed. There are several tapeworm parasites of humans that are transmitted by eating uncooked or poorly cooked pork, beef, and fish.

### **Classification of Phylum Platyhelminthes:**

In the evolutionary process, the evolving of mesoderm, a third layer between ectoderm and endoderm has further resulted in structural complexities, coupled with increased in size. Animals built on this three layered foundation have been designated as triploblastic. Platyhelminthes is considered to be one of the primitive triploblastic groups.

Platyhelminthes or flatworms are a diverse group comprising of 25000 living species that show evolutionary achievements over the diplo-blasts in having a structural body plan that is based on bilateral symmetry and in having definite organs or system of organs.

They, however, lack coelom (the space between the various organs being filled with a special connective tissue called parenchyma), the body being compact (acoelomate) and the absence of blood vascular system.

According to the classification scheme followed of **Ruppert and Barnes, 1994 (6th edn.)** - the phylum Platyhelminthes is divided into four classes. Three are entirely parasitic and include Trematoda, Monogenea and Cestoidea (tapeworms). The fourth class, Turbellaria, is free-living and from this group arose the ancestors of the three parasitic classes.

### **Systematic Resume of Phylum Platyhelminthes:**

#### **Class Turbellaria:**

i. Turbellarians are mainly free-living and aquatic (majority marine, few fresh water), but there are some terrestrial species also confined to humid areas. Aquatic forms are benthic.

ii. Body size ranges from a few millimeters to 50 centimeters.

iii. An acoelomate grade of body construction present with a low level of cephalization.

iv. Most turbellarians move by cilia (lining the epidermis), which provide the propulsive force; larger forms (poly-clads) are markedly flattened and move by combine ciliary motion with muscular undulations.

v. Mucus produced from the gland cells, lubricates and protects the body surface, provides leverage for the cilia and is used in the capture of food by entangling the prey.

vi. The mouth, which is present on the ventral surface, is located at the end of an eversible pharynx and leads into a sac-like, lobed or much branched intestine.

vii. Digestion is initially extracellular and then intracellular. Most turbellarians are predators and scavengers while a few are herbivores, commensals or parasites.

viii. Excretion by protonephridia.

ix. Several pairs of longitudinal nerve cord are radially arranged and associated with peripheral nerve nets. Numerous pigment cup, ocelli and statocysts are the principal sensory organs.

x. Hermaphrodite, with internal fertilization. Cleavage is spiral and development is direct in most species. Many turbellarians also reproduce asexually by means of budding or transverse fission and show high power of regeneration.

**Examples:**

Ectocotyla (commensal on hermit crab), Planeria (fresh water flat worm), Anaperus (marine flat worm), Gyatrix (marine interstitial species), Stenostomum (fresh water species), Bipalium (land planarian), Bdelloura (horse-shoe crab, commensal), Dugesia (fresh water).

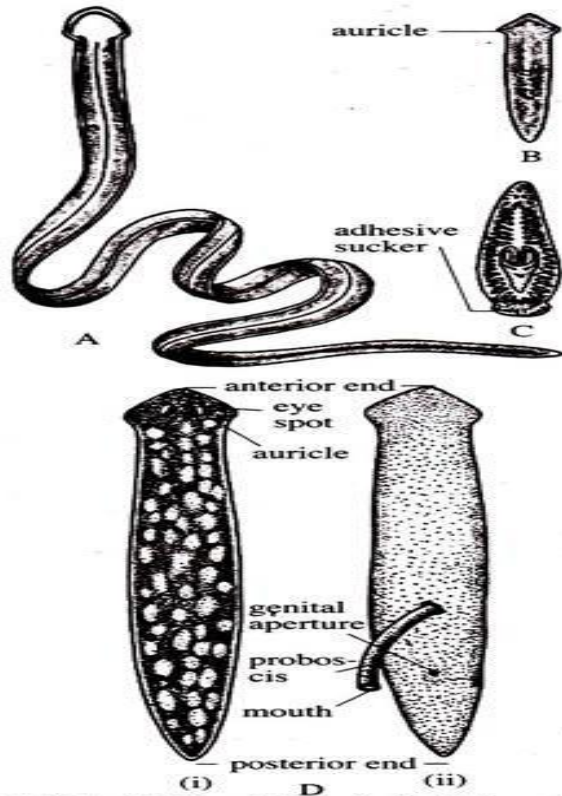


Fig. 1.45 : A. *Bipalium*, B. *Dugesia*, C. *Bdelloura*, D. External features of *Planaria* (i) Dorsal view, (ii) Ventral view. Note that pharynx is shown in everted condition as proboscis.

### Class Trematoda:

- i. All are parasites, occurring especially in vertebrates.
- ii. Body cylindrical or leaf shaped.
- iii. Rhabdites or cilia are absent.
- iv. Body is covered by cuticle, which provides protection against hosts enzyme- action and defense mechanism.
- v. Suckers and acetabulum present for attachment.
- vi. Mouth is anteriorly situated.
- vii. A well-developed gut is present.

viii. In most cases the testes are two but always one ovary is present. Reproduction is always sexual.

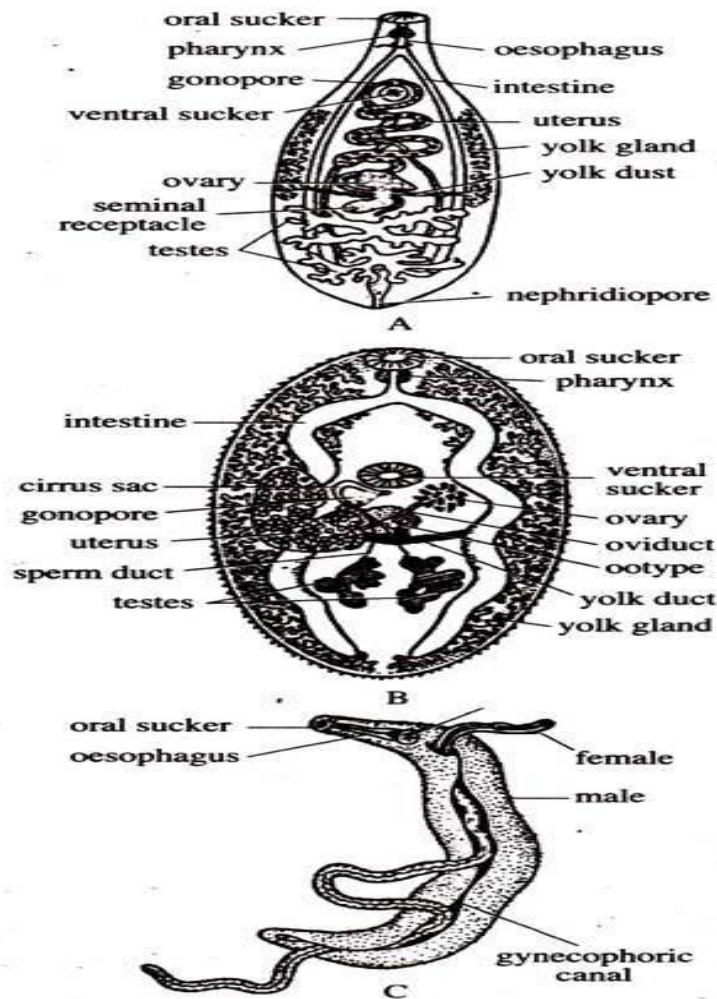


Fig. 1.46 : A. *Clonorchis*, B. *Paragonimus*, C. *Schistosoma*.

### Class Monogenea:

- i. Monogeneans are mostly ectoparasites of aquatic vertebrates, particularly fishes, but amphibians, reptiles and cephalopod molluscs are also hosts.
- ii. Body dorsoventrally flattened and have a large, posterior attachment organ, the haptor, which bears hooks and suckers.
- iii. Anterior end has also adhesive glands.

- iv. A gut is present -but mouth lacks a sucker. The pharynx secretes a protease that digests the host's skin.
- v. They respire aerobically, being ectoparasites.
- vi. Monogeneans have inconspicuous proto- nephridia for excretion.
- vii. All members are hermaphrodite.
- viii. Life cycle simple and having no intermediate host.
- ix. One egg by way of a ciliate larva (Oncomiracidium) gives rise to only one adult worm and hence the name monogenea meaning "one generation".

**Examples:**

Poly stoma (bladder of frogs), Polystomoidella (Urinary bladder of turtles), Dactylogyrus (gills of freshwater fishes).

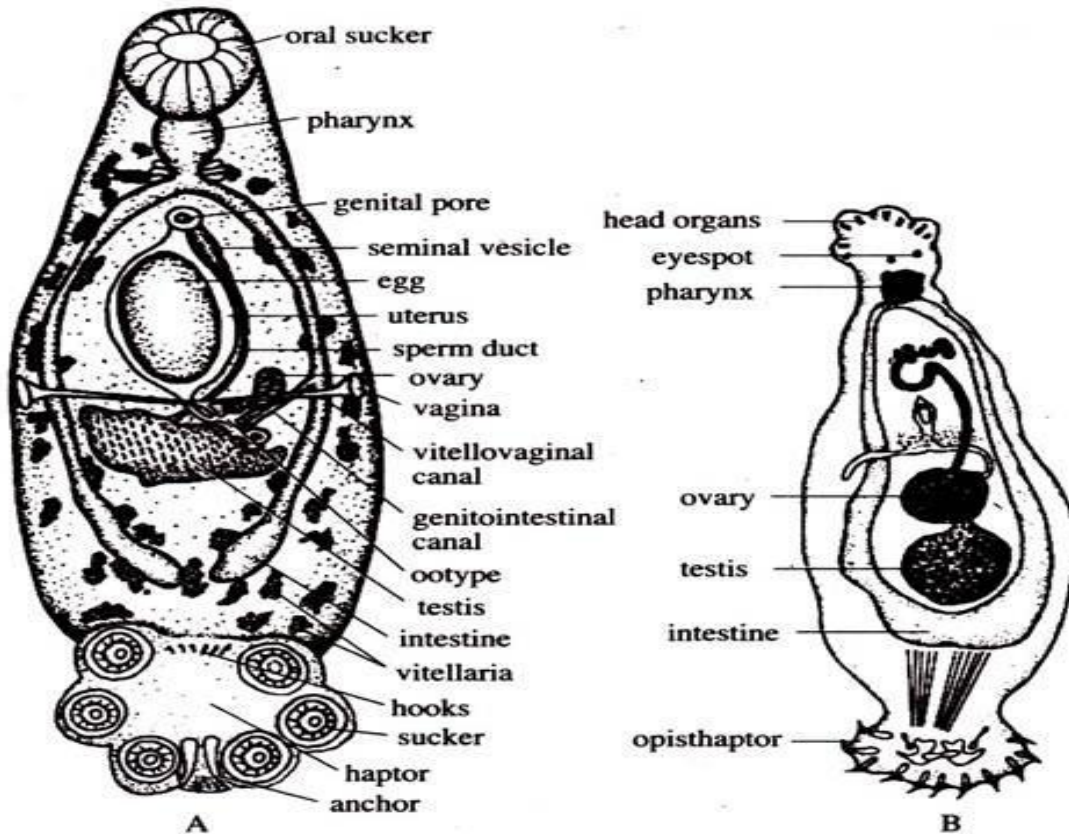


Fig. 1.48 : A. *Polystomoidella*, B. *Dactylogyrus vastator*.

### Class Cestoidea:

- i. Endoparasitic helminth, whose body is covered by a syncytial tegument.
- ii. Cestoideans have special tegumental modifications associated with nutrient uptake as they lack a mouth and digestive tract.
- iii. Organs of attachment in the form of hooks and suckers are present.
- iv. Absence of sense organs.
- v. Each segment excepting the head and neck is provided with one or two sets of complete sex organs.

vi. Hermaphrodite. Life cycle is complicated and involves a larval stage.

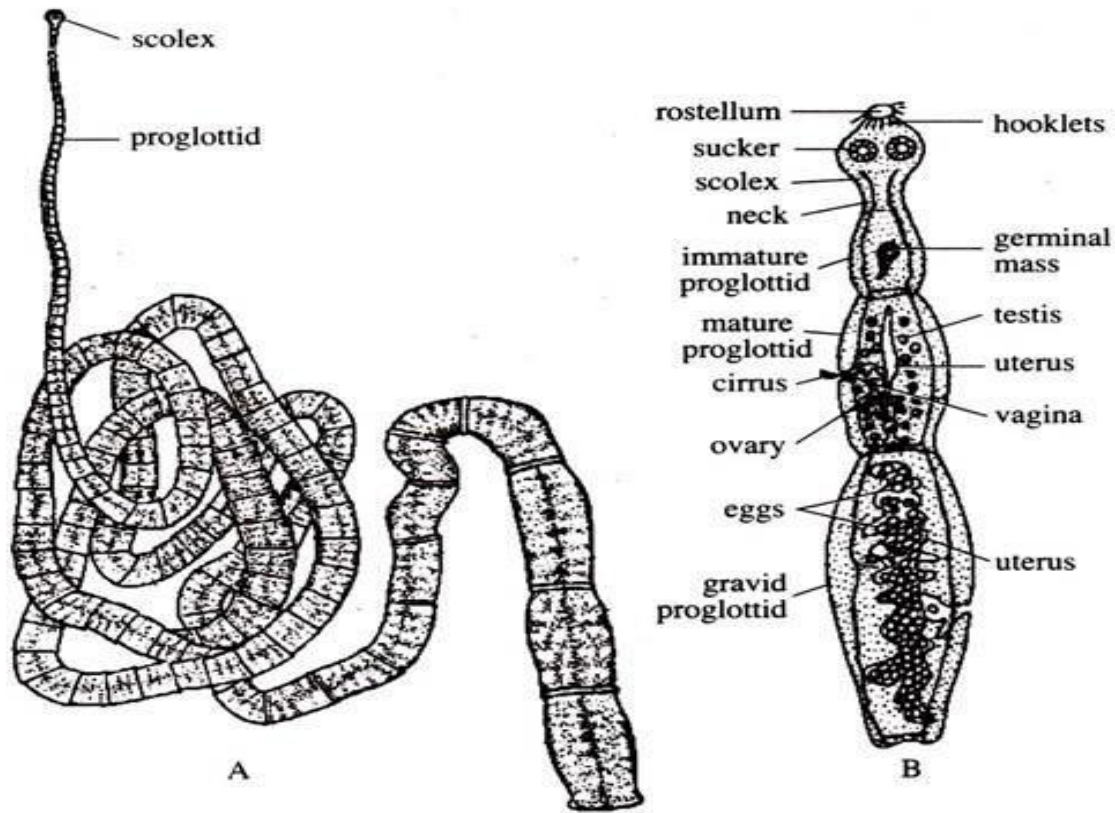


Fig. 1.49 : A. *Taenia solium* , B. *Echinococcus granulosus*.

### **Taenia solium :**

#### **Lifecycle :**

*Taenia solium* is one of the many species of cestodes (tapeworms) that can infect humans. It belongs to the phylum Platyhelminthes, class Cestoidea, order Cyclophyllidea, family Taeniidae. In general terms, tapeworms are complex organisms having complex life cycles that require at least two hosts for their completion. In the case of *Taenia solium*, humans are the most important definitive hosts, whereas both pigs and humans are the main intermediate hosts. The list of other

animals that may act as definitive or intermediate hosts of *Taenia solium* is large but clinically irrelevant.

Tapeworms are internal parasites that attack vertebrates like human beings, cats, dogs and fish. The disease caused by tapeworm is known as cestodiasis. Physically the tapeworm has an elongated body segment, head and suckers or hooks for attaching themselves to the host. Tapeworm bodies are covered with hard cuticle covering, through which they absorb food.

- The life cycle is completed in two hosts.
- Definitive host: Human
- Intermediate Hosts: Pig, occasionally human.
- Humans acquire infection by ingestion of inadequately or improperly cooked pork infected with cysticerci.
- Inside the alimentary canal of man the scolex on coming in contact with bile evaginates and anchor to the gut wall with its hooks and suckers.
- The larvae develops into an adult worm by gradual strobilisation.
- The worm grows to sexual maturity in 2-3 months and start producing eggs which are then passes in the faeces along with the gravid segments.
- The pig gets infection by ingestion of eggs or gravid proglottids passed in human faeces.
- In the intestine of pig, the oncospheres hatch out of eggs.
- They attach to the intestinal mucosa by hooks, penetrate the gut-wall and gain entrance into the portal vessels or mesenteric lymphatic, finally reaching the systematic circulation.
- Usually they travel via the portal vein and successively reach the liver, right side of heart, lungs, left side of heart, brain or other tissue with high blood flow.

- The naked onchospheres are filtered out from the circulating blood into the muscular tissue where they ultimately settle down and undergo further development.
- They lose their hooklets, enlarge, and develop into a fluid-filled cyst within a period of 9-10 weeks.
- They remain viable for up to 8 weeks in muscle of pig during which they remain infective for human.
- The new host gets infection by ingestion of the infected meat of pig and the cycle is repeated.
- Occasionally humans get infection by eating food or drinking water contaminated with eggs.
- On ingestion, the onchospheres are released from the eggs in the intestine. These larvae invade the intestinal mucosa and are then carried by the circulation to different tissue where they develop into cysts.
- In human most cysts are produced in the CNS, skeletal muscles, eye and subcutaneous tissue giving rise to a condition called **cysticercosis**.

### **Mode of transmission:**

- Ingestion of uncooked pork infected with tapeworm
- Ingestion of food and water contaminated by the eggs present in the infective faeces of a *Taenia* carrier.
- Endogenous auto infection: Anus-hand-mouth transfer of eggs by contaminated hands of person with poor personal hygiene.
- Autoinfection: Reverse peristalsis in which eggs produced by *T. solium* are thrown back to the duodenum, where they hatch and cause tissue infection

Majority of tapeworms are hermaphrodite. A hermaphrodite is an organism with both male and female reproductive organs. They produce gametes of both male and female sexes.

In the life cycle of *Taenia solium*, the adults (length 2 to 7 m; less than 1,000 proglottids; longevity up to 25 years) develop not only in humans but also some other animal species (monkeys, hamsters). Humans develop taeniasis when they ingest undercooked pork meat containing cysticerci. They may become infected by ingesting *T. solium* eggs, either by ingestion of fecally contaminated food, or by autoinfection. In the latter case, a human infected with adult *T. solium* ingests eggs produced by that tapeworm, either through fecal contamination or, more arguably, from proglottids carried into the stomach by reverse peristalsis. The cysticercus develops not only in striated muscle, but also in the brain, liver, and other tissues of pigs and other animals, including humans.

*Taenia solium*- pork tapeworm Humans are definitive host Pigs are the most common intermediate host Many animals including humans can harbor cysticercus usually in striated muscle, but often in other tissues/organs The eggs of *T. solium* are morphologically rounded or subspherical, diameter 31 - 43  $\mu\text{m}$ , with a thick radially striated brown shell. Inside each shell is an embryonated oncosphere with 6 hooks.

Adult tapeworms complete the sexual stages of life cycle in humans as definitive hosts. Pigs serve as an intermediate host where metacestodes (larva stage) survive in the muscles and other tissues as cysticerci. However, *T. solium* is unable to mature to adult stages in pigs to complete the reproductive cycle. While pigs acquire *T. solium* from ingesting *Taenia* eggs present in the human feces, humans acquire the infection directly from eating viable cysticerci present in uncooked pork or through ingestion of contaminated food or water containing eggs or proglottids.

# Taenia solium

