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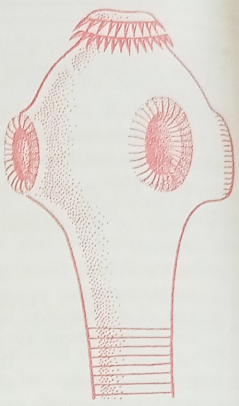
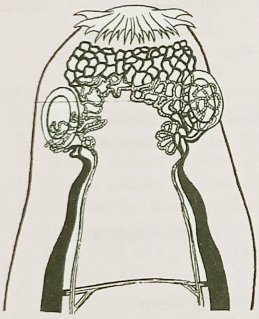


Taenia solium : The Pork Tapeworm

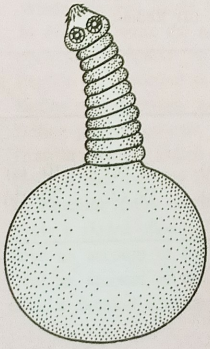


Cestodes belong to the class cestoda of phylum Platyhelminthes and are exclusively endoparasites. They differ from turbellarians and trematodes in the total absence of a digestive tract. They are commonly known as tapeworms for their long, flat and ribbon-like form. Genus *Taenia* includes several species parasitizing man and domestic animals. Common examples are *T. solium* (the pork tapeworm) and *T. saginata* (the beef tapeworm).

The present text mostly relates to *T. solium*, the pork tapeworm of man.

Taenia solium

SYSTEMATIC POSITION



Phylum	Platyhelminthes
Class	Cestoda
Subclass	Eucestoda
Order	Taenioidea (= Cyclophyllidea)
Family	Taenidae
Genus	*Taenia*
Species	*solium*

History of Discovery

In history tapeworm infections have been recorded from 1500 B.C. and it has been recognized as one of the earliest human parasite. Life cycle of the parasite has been identified by the 1850s. Two species *T.solium* and *T.saginata* are very small. *T.solium* (extra intestinal infection) is far more serious and dangerous.

HABITS AND HABITAT

Taenia solium, like *Fasciola hepatica*, completes its life cycle in two hosts. The adult dwells as internal parasite in the small intestine of man (primary or final host) where it is anchored to the intestinal mucosa by its scolex. It has no mouth or digestive cavity but absorbs the host's digested food through its body wall. The larval stage occurs in the tissues of a secondary or intermediate host which is usually pig and sometimes dog and sheep. A number of other animals such as goat, cattle, horse, bear and monkeys have also been mentioned as intermediate hosts.

Taenia solium is found in all those parts of the globe, where pig is domesticated and consumed as food. Its distribution, thus, is cosmopolitan.

EXTERNAL MORPHOLOGY

[I] Shape, Size and Colouration

Taenia solium is usually opaque white in colour but creamish, yellowish or greyish colouration is also common. Body is 1 to 5 meters long, and flattened like a ribbon or tape. The two flat surfaces represent the dorsal and ventral surfaces respectively, but from external examination it is

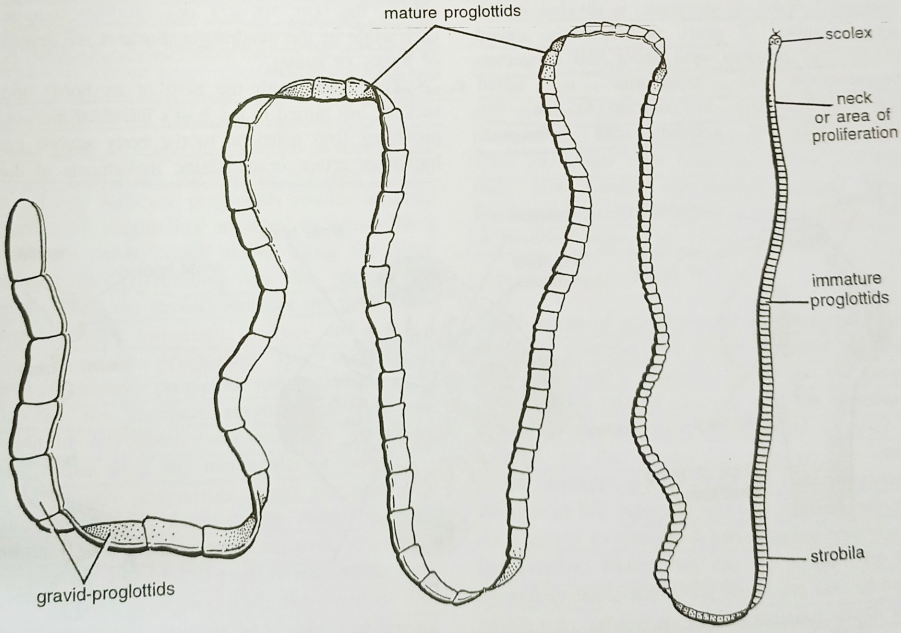


Fig. 1. *Taenia solium.* Entire animal.

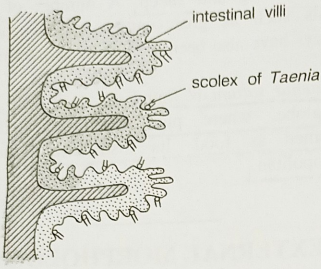


Fig. 2. Scolex of *Taenia* attached to the host's intestinal wall.

not possible to identify them. Internal view reveals that surface closer to testes is dorsal and nearer the female reproductive organs, the ventral surface. Elongated body is extremely narrow anteriorly and gradually broadens towards the posterior end.

[II] Segmentation

Elongated body of tapeworm is divided into a great number of parts or segments, called **proglottids**, possibly upto about 850 altogether. Segmentation of tapeworms is called **pseudometamerism** in contrast to the **true metamerism** of annelids and arthropods (chapter 15). Therefore, the term 'segment' in tapeworm is being used solely for convenience and in no way implies a true metameric segment. Entire body is divisible into three distinct parts : (i) an anterior **scolex** or head, (ii) a short unsegmented **neck**, and (iii) a segmented **strobila**.

[III] Scolex

It represents the anterior end of body. It is knob-like, biradially symmetrical and 0.6 to 1 mm wide. In en-face view it appears roughly quadrangular. At the apex is a prominent rounded mobile cone, the **rostellum**. It is armed with 22 to 32 curved chitinous **hooks**, arranged in two rows or circles around its base. Hooks of anterior circle are larger, each measuring 0.14 to 0.18 mm and those of posterior circle are smaller each measuring 0.11 to 0.14 mm. Each hook consists of a **base** by which it is fixed, a blunt projection or **handle** directed towards the apex, and a conical outwardly directed **blade**. The broadest part of scolex bears four hemispherical highly muscular suctorial organs, the **true suckers** or **acetabula**, one at each angle of the quadrangle. Suckers are devoid of hooks or spines.

The scolex with the help of its hooks and suckers, lies buried in the host's intestinal mucosa, providing firm adhesion to the body against the loosening action of peristaltic movements of the

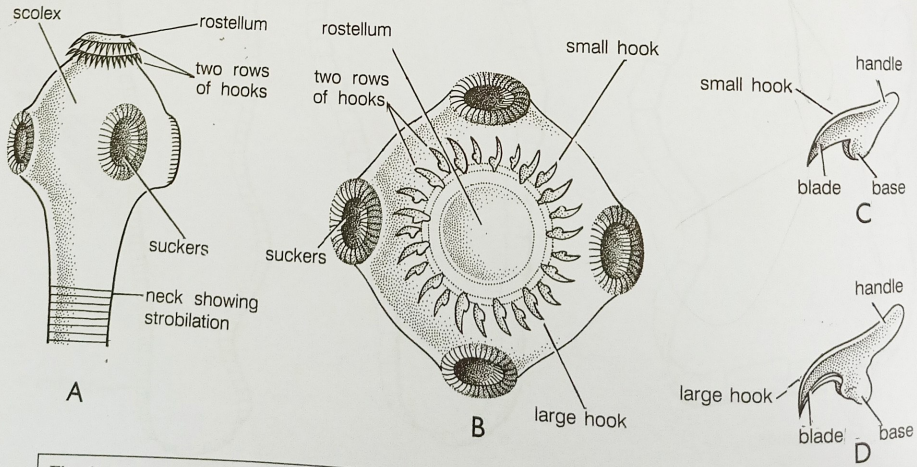


Fig. 3. *Taenia solium.* **A.** Scolex and neck in side view. **B.** Scolex in en-face view. **C.** Small hook. **D.** Large hook.

host's intestine. It is thus an organ of attachment or **holdfast**. It plays no role in perceiving or catching food. The term 'head' frequently used for the scolex is, thus, inappropriate.

[IV] Neck

It is a well-defined, short, narrow and unsegmented region behind scolex. Unlike scolex, it is dorsoventrally flattened. It has been variously termed the **budding zone**, **growth zone**, **area of proliferation** and **area of segmentation**, because it is this region where the segments or proglottids, constituting **strobila**, are budded off and pushed backwards.

[V] Strobila

It forms the main bulk of body. It consists of 800 to 1,000 segments or **proglottids** arranged in a linear series in a **chain-like** fashion. (The species *solium*, according to **Leuckart**, has got its name from **schuschel**, a **Syrian** word referring to a **chain**). A proglottid is a unit part of the body enclosing a complete set of genitalia. Linear repetition of proglottids, and hence of genital organs, is termed **proglottisation**. Proglottids are budded off in the neck region and pushed backwards due to addition of more proglottids in front. Thus, in a strobila, anterior proglottids are the youngest, while those at the posterior end are the oldest. Adjacent proglottids remain attached together by longitudinal muscles, excretory ducts and nerve cords, which extend along the entire body length. According to the degree of development, the strobila includes the three kinds of proglottids : **immature**, **mature** and **gravid**.

1. Immature proglottids. These comprise of about 200 anterior proglottids just behind the neck. They are the youngest, sexually immature and devoid of reproductive organs. They are short, broader than long and rectangular in outline.

2. Mature proglottids. There are about 450 mature proglottids forming the middle part of strobila. These are large and squarish in outline. The anterior 100 to 150 proglottids contain only male reproductive organs, while the posterior 250 mature proglottids develop both male and female reproductive organs making them hermaphrodite.

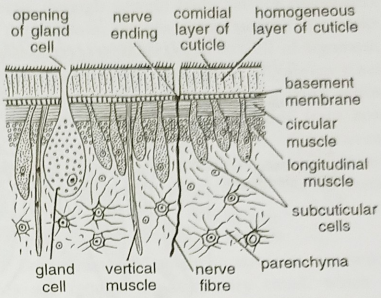


Fig. 4. *T. solium.* V.S. body wall under light microscope.

Each mature proglottid, on one side bears a tiny protuberance, the **genital papilla**, at the tip of which is situated the **common genital pore**. These pores, in the successive proglottids, are situated alternately on the right and left sides. A mature proglottid is a complete reproductive unit and produces eggs which are fertilized by its own sperms (**self fertilization**) or by those of other mature proglottids (**cross fertilization**).

3. Ripe or gravid proglottids. The oldest and the last 150 to 350 proglottids, upto the posterior emd of body, are termed **gravid** or **ripe**. They are longer than broad in outline. All the male and female reproductive organs have degenerated except the highly branched **uterus** full of fertilized eggs (Fig. 12).

[VI] Apolysis

Small groups of gravid proglottids regularly detach from the posterior end of strobila and pass out with the host's faeces. Shedding of gravid proglottids is termed **apolysis** and the tapeworm exhibiting this phenomenon is called **apolytic** in contrast to the **anapolytic tapeworms** (most pseudophyllids), which retain all their proglottids throughout life. Apolysis serves a twofold purpose, (i) It serves to transfer the developing embryos to the exterior, where they can be ingested by the secondary host, and (ii) it limits the size of body which may otherwise attain enormous length due to continued proliferation in the neck region.

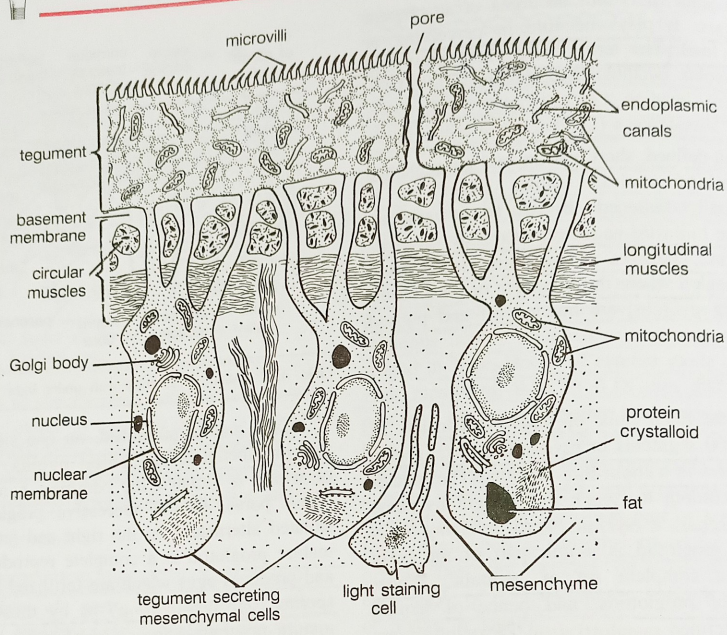


Fig. 5. *T. solium.* V.L.S. body wall based on electron microscope.

BODY WALL

Like flukes, tapeworms also lack a cellular or ciliated epidermis. Layers of body wall from surface are : (i) **tegument**, (ii) **basement membrane**, (iii) **integumentary muscles**, and (iv) **parenchyma**.

[I] Tegument

It is a thick resistant layer clothing the body in the absence of a cellular epidermis. It is composed of protein impregnated with calcium carbonate and is perforated by numerous fine canals. Under light microscope, three layers can be distinguished in this layer : (i) outermost hair-like or fringe-like **comidial layer**, (ii) middle thick **homogeneous layer**, and (iii) innermost **basement membrane**.

As no living structures are visible, this layer used to be regarded as non-living **cuticle**. Studies under electron microscope by **Threadgold** and others have shown that outermost cuticle is in fact a thick, living and syncytial layer called **tegument**, continuous with **tegument secreting cells**, of mesenchyme. Tegument contains mitochondria and lysosomes and gives out **microvilli-like** processes, called **microtriches**, on its outer surface. The Microvilli serve two purposes : (i) they facilitate absorption of host's food by increasing the surface area of body, and (ii) they partially act as holdfast organs (**A. H. Rothman**, 1963) by interlocking with microvilli of cells lining the host's intestine. Tegument is also perforated by numerous fine **pore canals** through which substances (in solution) are absorbed from the host's intestine.

Tegument is constantly renewed by the underlying **tegument secreting cells** with which it is continuous.

[II] Basement Membrane

With a light microscope, region beneath tegument (then cuticle) appears as a thin, well-defined acidophilic **basement membrane**. However, with electron microscope, its outer edge is identified, while its inner edge merges imperceptively with the underlying mesenchyma.

[III] Integumentary Musculature

Beneath the basement membrane musculature consists of well-developed outer **circular** and inner **longitudinal** fibres. Lying in the mesenchyme also is the **mesenchymal musculature** consisting of **longitudinal**, **transverse** or **circular**, and **vertical** or **dorsoventral muscle** fibres.

[IV] Mesenchyme or Parenchyma

It consists of loosely-packed cells with fluid-filled interspaces, forming a **packing** around various internal organs. In young proglottids and in neck region, however, mesenchyme is more compact. Numerous round or oval calcareous bodies, composed of concentric layers of calcium carbonate, are present in mesenchyme. These are secreted by special mesenchymal **lime cells**, which later atrophy, setting the bodies free in mesenchyme. Besides, it also contains a large number of **tegument secreting cells**. Circular muscle fibres of the mesenchymal musculature, except at the margins, divide the mesenchyme into an outer **cortex** or **cortical zone** and inner **medulla** or **medullary zone**.

In addition to its skeletal function mesenchyme acts as an important transport medium in the absence of a blood vascular system.

NUTRITION

As already mentioned, tapeworm completely lacks alimentation in all stages of life-history. The predigested food in host's small intestine (especially ileum) is the chief source of nourishment for tapeworm. Soluble nutrients, like glucose, amino acids, glycerol, etc., diffuse in directly through general body surface (tegument). As noted above, the absorptive surface of parasite is greatly increased by the microvilli of tegument. The swift efficiency with which absorption takes place has been compared with the soaking action of blotting paper. Some tissue fluids from host are probably absorbed by scolex of tapeworm insinuated deeply into intestinal mucosa. Stored food consists mainly of glycogen and of some lipoid substances. Glycogen content of *T. solium*, by net weight, is 2.17%.

For its mode of obtaining nutrients, tapeworm does not require an alimentary canal, which is thus totally absent in all stages of its life history. Moreover, presence of an alimentary canal would not have suited the mode of life of tapeworm as it would have rendered impossible the process of apolysis is indispensable for it. The alternative mode of nutrition described above is thus a parasitic adaptation of tapeworms, unique in the animal kingdom.

RESPIRATION

Respiration of the tapeworm is mainly **anaerobic** or **anoxybiotic**. Glycogen, the principal reserve food and the chief source of energy, undergoes glycolysis, producing carbon dioxide and fatty acids. Steps involved are same as in liver fluke. In addition to fatty acids, other organic acids, like lactic acid, are also produced.

Free oxygen, whenever available, is also consumed by tapeworms. Rate of consumption is maximum in the anterior proglottids and declines gradually towards the posterior end.

EXCRETORY AND OSMO-REGULATORY SYSTEM

It consists of : (i) lateral longitudinal canals, (ii) secondary canals, (iii) capillaries, and (iv) flame cells.

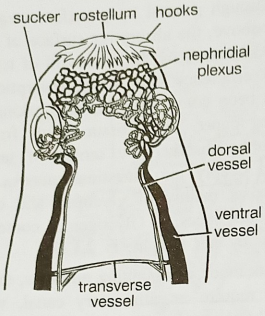


Fig. 6. *Taenia solium.* Excretory system at the anterior end.

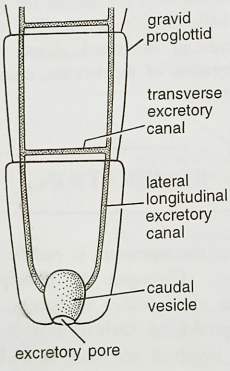


Fig. 7. *Taenia solium.* Caudal vesicle in last proglottid.

[I] Excretory Canals

There are, on each side, two **lateral longitudinal excretory canals** or the **collecting tubules** of which one is dorsal and the other ventral. In scolex they get connected with one another by a network of tubules or **nephridial plexus**. The canals run through proglottids, just inner to the mesenchymal musculature. **Dorsal canals** are produced and confined to the anterior part of strobila. **Ventral canals** are large and extend along its entire length. Two ventral canals are connected by a **transverse canal** at the posterior part of each proglottid (except the last). In the last

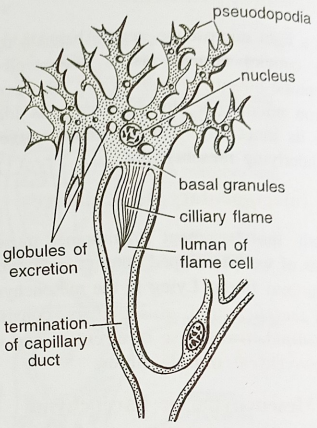


Fig. 8. *Taenia solium.* A flame cell.

proglottid, they join to form a pulsatile **caudal vesicle**, opening to the exterior by a single **excretory pore**. When the last proglottid is shed off (apolysis), the terminals of the two ventral canals behave as independent excretory pores.

Each longitudinal excretory canal receives numerous **secondary canals** all along its length.

[II] Flame Cells

A secondary canal is formed by the union of several fine **capillaries**, each connected to a **flame cell**. These are scattered throughout parenchyma from which they remove metabolic wastes. A flame cell is of irregular shape, with granular cytoplasm and a nucleus. Bundle of cilia, or flame, arises from basal granules near nucleus. Cilia are enclosed into a funnel-shaped lumen formed by the terminal blind end of a capillary.

[III] Physiology

Longitudinal canals are lined internally by cuticle, while secondary canals and capillaries have a ciliated lining. Cilia set up a hydrostatic pressure which drives out the excretory products through excretory canals and out of excretory pores. Exact nature of excretory products is, however, not known. Fluid contents of body are also regulated

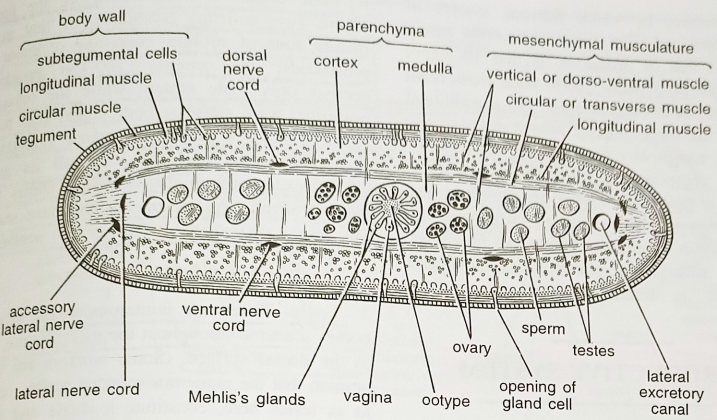


Fig. 9. *Taenia solium.* T.S. mature proglottid through ootype showing positions of 10 longitudinal nerves.

by this system, which is, therefore, also **osmoregulatory**.

NERVOUS SYSTEM

Nervous system of *Taenia solium* has not been thoroughly examined so far. Among the taenoid tapeworms, *Moniezia* (**Tower**, 1900) and *Anoplocephala* (**Becker**, 1921) have been best studied for this system. Their findings in these tapeworms are probably true for other taenoid tapeworms also. Nervous system of *Moniezia* is, however, described below.

In the scolex lies a pair of stout **cerebral ganglia** connected by (i) a ring consisting of a **dorsal** and a **ventral commissure**, and (ii) a thick, ganglionated **cross commissure** or the **transverse commissure**. From the **brain complex** so formed, 8 nerves are given out anteriorly (4 from ring commissure and 4 from transverse commissure). These terminate into another smaller ganglionated **rostellar nerve ring**. Fibres from ganglia in scolex supply the suckers and rostellum. From brain complex, 3 pairs of longitudinal nerve cords arise and extend posteriorly into strobila. These are : (i) **lateral nerve cords** arising from cerebral ganglia and extending through medullary region of mesenchyme, outer to the excretory canals, (ii) **dorsal nerve cords** arising from dorsal commissure, and (iii) **ventral nerve cords** arising from ventral commissure. In each proglottid, all the 6 nerve cords are connected by a **ring commissure** or **transverse connective** behind the transverse excretory canal.

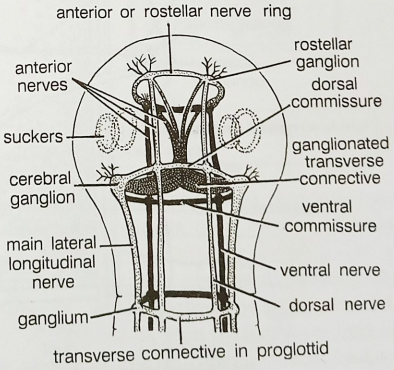


Fig. 10. *Moniezia.* Nervous system in scolex.

One feature, in which nervous system of *Taenia solium* and most other tapeworms surely differs from that of *Moniezia*, is that 10 **nerve cords** instead of 6 (three pairs) arise from brain complex and run through strobila. The 4 additional nerve cords are the **accessory lateral nerve cords**, 2 of which accompany each lateral nerve cord.

Special receptors, as found in turbellarians, are lacking in tapeworm. However, numerous free sensory nerve-endings are present throughout the body specially in the scolex. A detached proglottid, passing out with faeces, shows some movement and sensitivity to stimuli.

REPRODUCTIVE SYSTEM

All tapeworms, except *Dioecocestus* (a genus allied to *Taenia*), are **hermaphrodite**. Each proglottid, at maturity, contains a complete set of male and female reproductive organs. These organs develop from mesenchyme and lie embedded in it. Male organs differentiate before the female organs (**protandrous** condition), so that in the mature zone of strobila, consisting of about 450 proglottids, the anterior 100-150 proglottids possess only male system while the remaining posterior ones possess both male and female systems. After a period of intense reproductive activity, mature proglottid loses all its genital organs except the highly-branched uterus filled with fertilized eggs. Segments that have reached this stage, are called **ripe** or **gravid** segments.

[I] Male Reproductive System

1. Testes. Testes are numerous small, spherical bodies scattered throughout the mesenchyme, close to the dorsal surface. (Some workers are of the opinion that the numerous rounded bodies, referred to as testes here, constitute a single and highly subdivided testis).

2. Vasa efferentia. From each testis arises a fine ductule, the **vas efferens**, which frequently gets interconnected with similar ductules from the surrounding testes. All the vasa efferentia finally

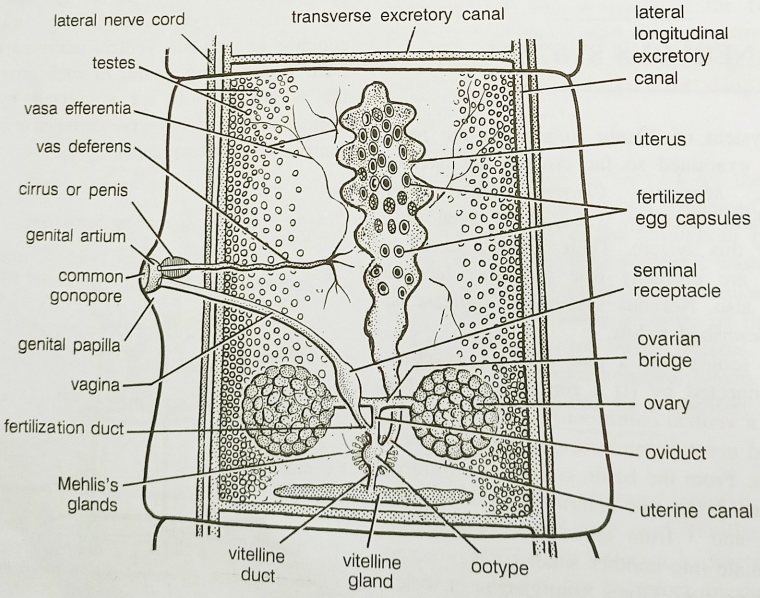


Fig. 11. *Taenia solium.* Reproductive system in a mature proglottid.

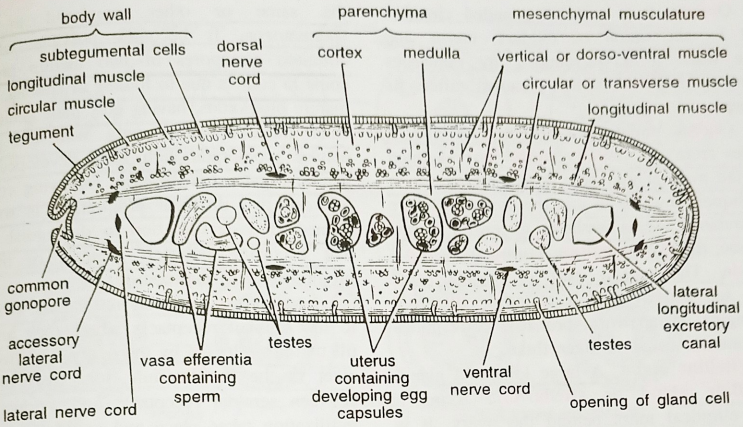


Fig. 12. *Taenia solium.* T.S. mature proglottid through uterus and genital atrium.

unite, approximately in the middle of proglottid, to form a common **sperm duct** or **vas deferens**.

3. **Vas deferens.** It is a thick and convoluted tube, extending upto the lateral margin of proglottid, at right angles to it.

4. **Cirrus.** Outer end of **vas deferens** forms the lumen of a thick, muscular, eversible, copulatory organ, the **cirrus**, enclosed in a firm **cirrus sheath**. There is no seminal vesicle.

5. **Genital atrium.** Cirrus opens into a cup-shaped **genital atrium** through the **male genital pore**. Genital atrium, in turn, opens to the exterior through the **common gonopore** situated at the peak of a tiny protuberance, the **genital papilla**, in the middle of the lateral margin of proglottid. Gonopore is provided with a sphincter muscle. Common gonopores of successive proglottids lie alternately on both the sides.

[II] Female Reproductive System

It resembles with the corresponding system of liver flukes.

1. **Ovary.** A single bilobed **ovary** or **germarium** lies ventrally in the posterior part of proglottid. Each lobe of the ovary (regarded by some as one complete ovary) is dorso-ventrally flattened and consists of a number of radially-arranged **germinal cords** or **follicles**. The right and left lobes are connected medially by a transverse, tubular bridge, the **ovarium isthmus**.

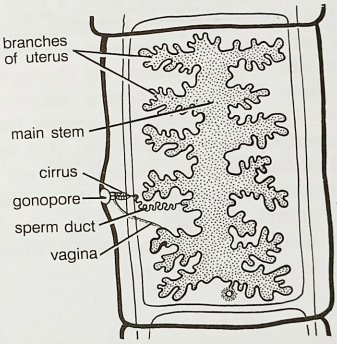


Fig. 13. *Taenia solium.* A gravid proglottid showing branched uterus.

2. **Oviduct.** A short oviduct arises from about the middle of ovarian isthmus. It runs backwards, joins another slender tube, the **vagina** and then forms a swollen chamber, the **ootype**.

3. Ootype. It is a small rounded chamber formed by the union of oviduct, uterus and vitelline duct. It is surrounded by numerous unicellular **Mehlis's glands**, known after its discoverer.

4. Vagina. Vagina is a bent narrow tube. It originates from the **female genital pore** located behind the male genital pore in genital atrium. It runs obliquely inwards to join the oviduct. Before joining oviduct, vagina swells up to form a sperm-storing sac, the **receptaculum seminis** or **seminal receptacle**. The narrow part of vaginal duct between sac and oviduct is called **fertilization duct**. Vagina of tapeworm probably corresponds to the Laurer's canal of liver fluke.

5. Vitelline gland. A large lobulated gland, the **vitelline gland** or **vitellarium**, forms a compact elliptical mass behind the ovary. It is connected with the ootype by a short median **vitelline duct**. Vitelline gland consists of numerous follicles secreting yolk cells.

6. Uterus. From ootype arises a blind and cylindrical tube, the **uterus**, extending upto the anterior part of proglottid. It consists of a proximal short and narrow tubular portion, the **uterine duct**, and a distal broad part forming the **uterine expansion**. Uterus is the most characteristic feature of reproductive system of tapeworms. It is meant to accommodate thousands of fertilized eggs and in the process of accomplishing this, it forms 7 to 13 lateral branches on each side. The branched uterus is the only genital structure presisting in a gravid proglottid.

LIFE HISTORY AND DEVELOPMENT

[I] Copulation and Fertilization

Life cycle of *T. solium* is **digenetic**, involving two hosts as in case of a fluke. But life cycle of tapeworm is much simpler and without a free larval stage. Presence of a single tapeworm in a host diminishes possibility of cross-fertilization. Fertilization is preceded by **copulation** which is accomplished by insertion of cirrus into vagina of the same or other proglottid to release spermatozoa. It becomes possible when the common gonopores of two mature proglottids come in contact due to folding of strobila. Anterior mature proglottids, having only male genitalia, can enter into copulation only with the posterior mature proglottids with fully developed female genital organs. Fertilization, following copulation between two different proglottids, is sometimes termed **cross-fertilization** to distinguish it from that occurring between gametes of the same proglottid (**self-fertilization**).

Spermatozoa injected into vagina, swim down to the seminal receptacle where they are stored till **ova** are released by the ovary. The two finally meet in the **fertilization duct** (part of vagina between seminal receptacle and oviduct) where fertilization takes place and **zygotes** are formed. Thus, fertilization is **internal**.

[II] Capsule Formation

Zygotes or **egg cells** pass into the ootype, where each becomes associated with a large **yolk cell** or **vitelline cell** provided by the vitelline gland. The two become enclosed in a thin **shell** or **chorionic membrane**, formed by material exuded by the yolk cell. The **capsule** so formed passes into uterus, where further development takes place. Passage of capsules into uterus is lubricated by the secretion from Mehlis glands. As more and more capsules pass into uterus, it develops lateral branches to accommodate them.

[III] Onchosphere Formation

1. Cleavage. Zygote or egg cell undergoes **cleavage** when the capsule is in uterus. Cleavage is holoblastic and unequal. First **unequal** division results in a larger **megamere** and a smaller **embryonic cell**.

2. Morula. Megamere divides further and forms several similar **megameres**, while embryonic cell divides repeatedly producing two types of embryonic cells, larger **mesomeres** and smaller **micromeres**. Thus, three types of cells result from the zygote; small micromeres, medium mesomeres and large megameres. Micromeres form a rounded mass, the **morula**, surrounded by an inner envelope of mesomeres and an outer envelope of

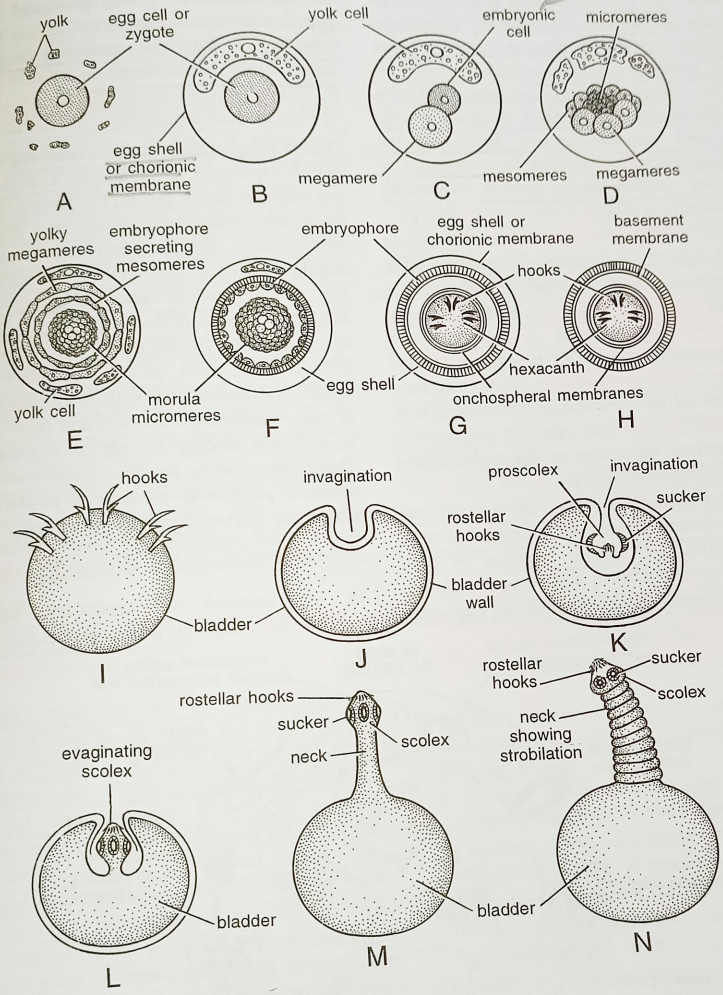


Fig. 14. *Taenia solium.* Stages in development. **A.** Zygote. **B.** Zygote in egg shell. **C.** Two-cell stage. **D.** Early morula **E.** Late morula. **F.** Formation of embryophore. **G.** Young onchosphere. **H.** Onchosphere without egg shell. **I.** Free hexacanth. **J.** Bladderworm with invagination of scolex. **K.** Bladderworm with proscolex. **L.** Evagination. **M.** Young cysticercus. **N.** Neck budding off proglottids.

megameres. The yolk or vitelline cell transfers its yolk to the megameres and gradually disappears. Large yolky megameres fuse to form an outer syncytial nutritive envelope or **outer embryonic membrane**, which nourishes the embryonic cells and finally disappears. Medium mesomeres form a thick, hard, cuticularized and radially striated shell, known as **embryophore** or **inner embryonic membrane**, surrounding morula. Beneath embryophore is a thin **basement membrane**.

3. Hexacanth and Onchosphere. Morula, at its morphologically posterior end, develops three pairs of chitinous **hooks** secreted by differentiated cells, called **onchoblasts**. This six-hooked embryo, called **hexacanth**, possesses a pair of large penetration glands (Reid, 1947). It is surrounded by two **hexacanth membranes**. The hexacanth, together with all the membranes surrounding it, is known as **Onchosphere**. It loses the original thin shell or chorionic membrane so that embryophore forms its outermost covering.

By the time onchospheres are formed, the proglottid becomes gravid and increases in size. Its uterus forms 7-13 lateral branches on each side and contains 30,000 to 40,000 onchospheres. In *Taenia saginata*, another intestinal tapeworm of man, uterus of gravid proglottid has 16-20 lateral branches on each side. Leaving the highly-branched uterus, the remaining structures of reproductive system degenerate.

[IV] Infection to Secondary Host (Pig)

Gravid proglottids at the posterior end of strobila detach (apolysis) in groups of 4 or 5 and pass out with the host's faeces. On ground, proglottids eventually disintegrate, setting free thousands of onchospheres. The secondary or intermediate host acquires infection by ingesting the onchospheres. Pig, which regularly feeds on human excreta is the usual secondary host, but dog, monkey and sheep are also known to get the infection. Man himself may serve as the secondary host by ingesting onchospheres with inadequately cooked or raw vegetables. Auto-infection may take place in a person already serving as a primary host. This happens when due to **reverse peristalsis** the detached proglottids are carried to the stomach, where the onchospheres are liberated.

[V] Migration within Secondary Host

In the stomach of secondary host (pig) **Onchosphere** loses its embryophore and basement

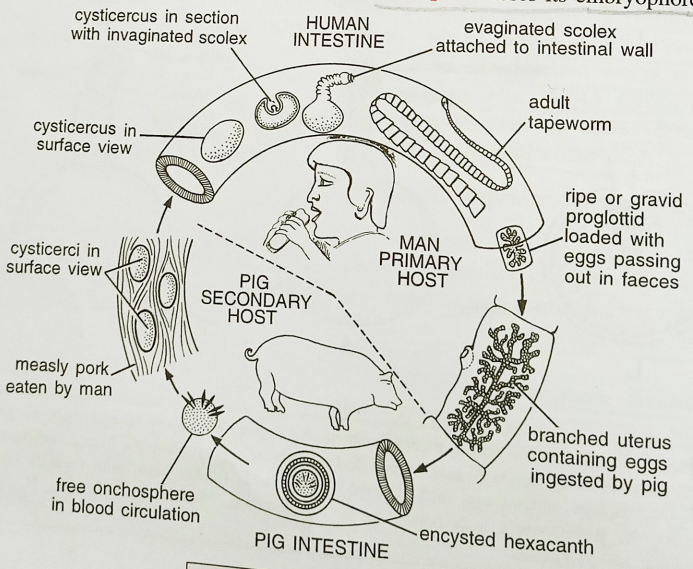


Fig. 15. *Taenia solium.* Life cycle.

membrane by the action of acidic juices (acid pepsin). The free hexacanth embryo then passes into the small intestine, where the two persisting hexacanth membranes are also lost by the action of alkaline juices. Hexacanth, now activated by the presence of bile salts, bores its way through the intestinal epithelium to reach a submucosal blood or lymph vessel. This is accomplished, perhaps jointly by the six hooks and penetration glands. Hooks merely anchor the hexacanth to the intestinal wall, while secretion of penetration glands dissolves the intestinal tissues. Entire process takes about 10 minutes, after which the hooks, are of no further use, and are shed off. Submucosal blood vessel carries hexacanth to liver via hepatic portal vein. From liver it reaches heart and enters the arterial circulation. It finally reaches the striped (voluntary) muscles usually of the tongue, shoulder, neck, thigh, heart, etc., where it settles to develop into a **bladder-worm** or **cysticercus**. However, these may also develop in other organs such as lungs, liver, kidney or brain. Non-muscular vital organs like eyes, brain or liver may frequently become the sites of cysticercus formation.

[VI] Cysticercus or Bladderworm Formation

Hexacanth, now devoid of hooks, absorbs nourishment from host's tissue and grows in size attaining a diameter of about 18 mm. A central cavity appears as cells in that region break down. It enlarges and becomes filled with a fluid consisting mainly of blood plasma of the host. The fluid-filled vesicle or **bladder**, as it is now called, has a thin wall consisting of an outer layer of thick syncytial protoplasmic mass (the so-called cuticle) and an inner mesenchymal or germinal layer. At a point, morphologically the anterior end (*i.e.*, opposite the side where hooks were present), the wall thickens and invaginates. The invagination, which looks like a hollow knob, differentiates into an **inverted scolex** possessing suckers, hooks and rostellum. It is called **proscolex**, the embryo at this stage is called a **bladderworm**. In *T. solium*, bladderworm is of **cysticercus** type which is characterised by a large vesicle and one scolex. That is why the bladderworm is also referred to as **cysticercus**. It appears to have a wall of cellulose and for this reason, sometimes called **cysticercus cellulosae**. Formation of cysticerci is completed in about 10 weeks in the pig.

Cysticercus develops in adult tapeworm only when ingested by the human host. In pig's body it leads quite an inactive life and remains viable for several years, after which it dies and becomes calcified. Pork (pig's flesh) containing viable cysticerci is called **measly pork** for its spotted appearance. One kg gm of measly pork may contain 500 or more cysticerci.

[VII] Infection to Primary Host (Man)

Man gets infection by eating undercooked measly pork. Cysticercus becomes active on reaching the small intestine. Proscolex everts or evaginates and anchors to the intestinal wall. Neck begins to proliferate proglottids and the bladder, sooner or later, gets detached and digested. In 10 to 12 weeks the parasite attains adulthood and possesses gravid proglottids ready for apolysis.

PARASITIC ADAPTATIONS OF *TAENIA*

Tapeworm shows several adjustments to its internal parasitic life, in comparison with a free-living animal.

(1) External body covering or **tegument**, is freely permeable to water and nutrients, but protects against digestion by host's alkaline digestive juices.

(2) Internal osmotic pressure is higher than that of the surrounding host's fluid or tissue, and pH tolerance is high, 4 to 11.

(3) Adult as well as larva lack cilia and other organs of locomotion, which are not needed.

(4) Scolex, with suckers and spines, serves for attachment with the epithelial lining of the host's intestine, so that parasite may not be ejected from intestine due to its peristaltic contractions.

(5) Alimentary canal is totally absent as the parasite absorbs readily available digested

(Contd. on page 414)