Udai Pratap (Autonomous) College, Varanasi

E-learning Material

Module/Lecture	02
Subject	Zoology
Year/Semester	B.Sc. 5th Semester
Unit	II
Topic	Applied Zoology
Sub-topic	*Taenia solium*
Key-Words	Life Cycle, Pathogenecity and Control
Name	Dr Sanjay Kumar Srivastava
Department	Department of Zoology
Faculty	Assistant Professor
College	Udai Pratap (Autonomous) College, Varanasi
Mobile No.	9415390652
E-mail	drsanjay70@gmail.com

Taenia solimum :

Phylum	Platyhelminthes
Class	Cestoda
Subclass	Eucestoda
Order	Taenioidea
Genus	*Taenia*
Species	*Solium*

Habit and Habitat:

Taenia solium, also known as **pork tapeworm**, or the **Armed tapeworm** is found worldwide. Thus, its distribution is **cosmopolitan**

about 50 million people are infected worldwide. It is a flat-ribbon like tape worms that causes intestinal **Taeniasis**. Its adults dwell in man's small intestine **(upper jejunum)** as an internal parasite, i.e., endoparasitic, where it adheres to the intestinal mucosa by its Head (scolex). Its life cycle is completed in two hosts, i.e., **Digenetic**, man as the **primary host**, and pig as **a secondary host**. Other animals like goats, cattle, monkeys, and horses also serve as intermediate hosts. It is especially reported from the European countries where pork is eaten, either raw or improperly cooked. *T. solium* infections are endemic in central and South America, non- Islamic countries of South East Asia, South Africa especially among the Bantu communities. Eastern Europe and China areas of highest prevalence include Latin America and Africa. **It absorbs the host's digestive food through its body wall**.

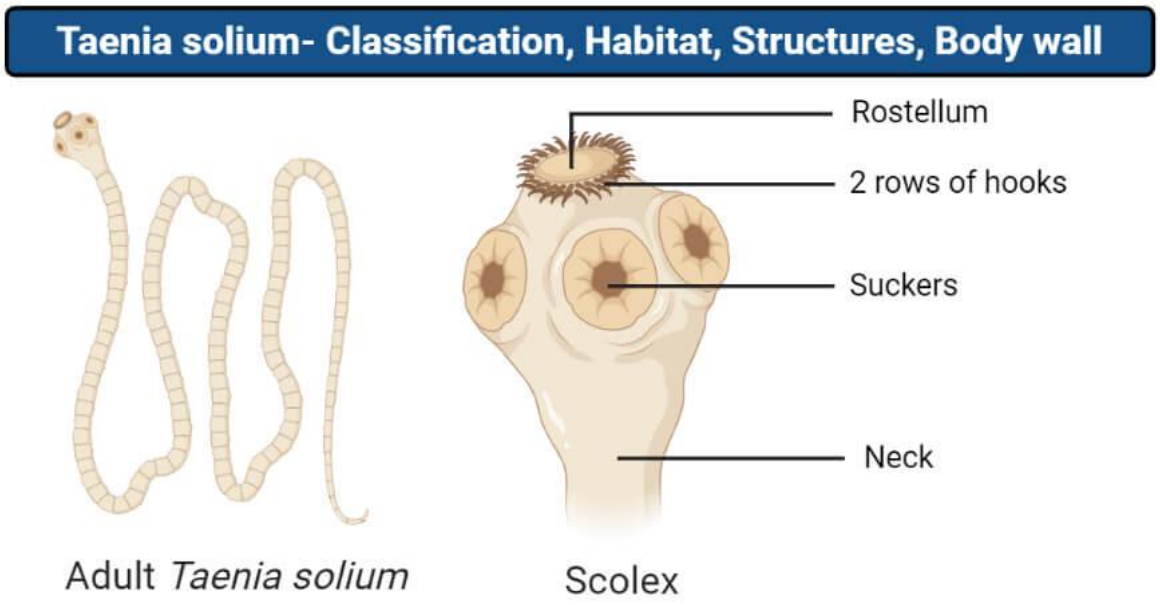
Adult worms are rarely pathogenic but the encysted larval stage (**Cysticercus cellulosae**) of the worm caused a serious disease in human called **Cysticercosis.**

Shape, size, and coloration

- Taenia solium is usually opaque white, but creamish, yellowish, or greyish coloration is also common.
- Its body is long (1-5 meters), dorsoventrally flattened, narrow, ribbon-like.
- The two flat surfaces represent the dorsal and ventral surfaces, respectively.

- The internal view reveals that the surface closer to the testes is dorsal, and nearer to the female reproductive organs is the ventral surface.
- Its body narrows anteriorly and gradually broadens posteriorly.

Structure of *Taenia solium* :



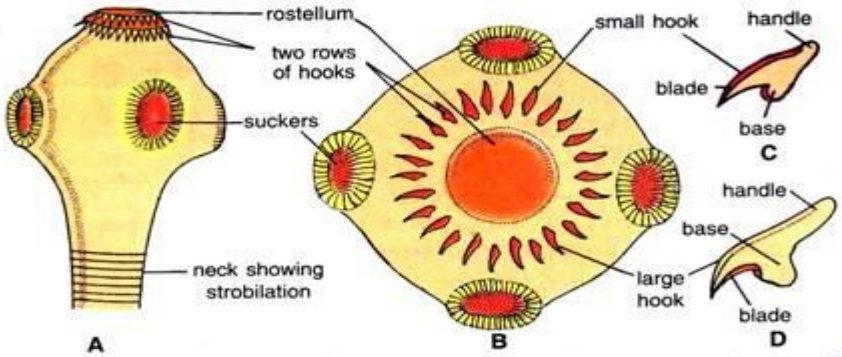


Fig. 42.2. *Taenia solium*. Scolex. A—Scolex magnified; B—Frontal view of scolex; C—Small hook; D—Large hook.

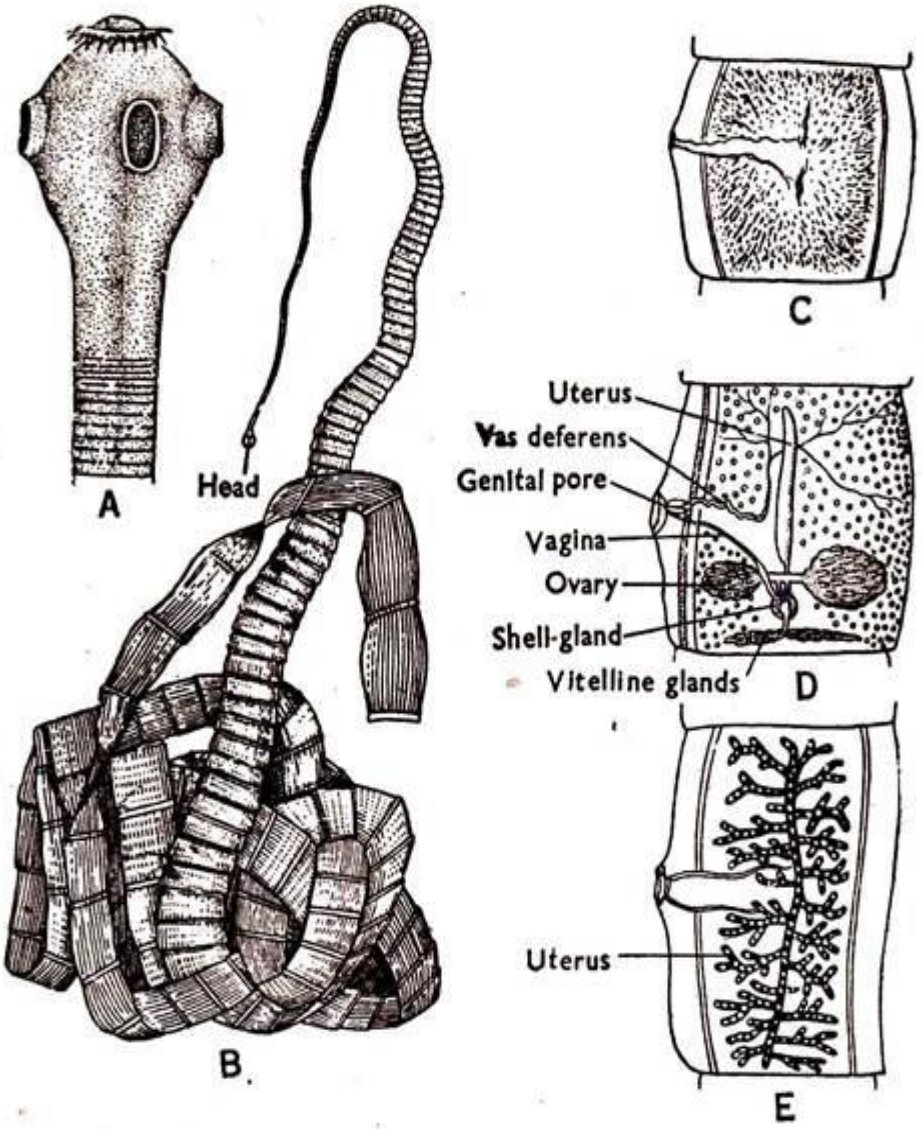


Fig.22. *Taenia solium*

A. Anterior end with scolex, neck and a small portion of strobila. B. An adult worm. C. An immature proglottis. D. Mature and. E. Gravid proglottis

Adult *Taenia solium* is a flattened ribbon like tapeworm that is white in colour. The adult worm measures about 1-5 meters in length. The body of the tapeworm is elongated divided into many segments or parts with about 850 to 1000 called proglottids. Segmentation of tapeworms is called pseudometamerism.The body of parasite can be divided into 3 parts:- Head (Scolex), Neck and Body (strobila).

Head (Scolex) :

It is present at the anterior end of the body. It is knob-like, biradially symmetrical, and 0.6 mm to 1 mm wide. It appears roughly quadrangular in the en-face view. It is smaller than the head of a Alpin, about 1mm in diameter. It consists of four cup-like muscular suckers having radial muscles. At its tip is a prominent rounded mobile cone, the rostellum. . The head is provided with a rostellum armed with a double row of alternating large and small hooklets (130-180 mm long).

The presence of hooklets gave its name **Armed tape worm**. Rostellum is armed with 22 to 32 curved and chitinous hooks in 2 circles, the inner circle with larger hooks and the outer ring with smaller ones. Large hooks each measures 14 to 0.18 mm, and those small each measures 0.11 mm to 0.14 mm. Each hook consists of a base by which it fixes, a handle directed towards the apex, and a conical blade directed outwardly. Four hemispherical highly muscular suctorial organs, **true suckers or acetabula**, are present on the scolex's broadest part. It is the organ of attachment to the intestinal mucosa with its suckers and hooks. Thus, it is an organ of adhesion or the holdfast.

Neck :

Behind, the scolex, well-defined, short, narrow, and

unsegmented region present, the neck. The neck is short measuring 5-10 mm in length. It has been variously termed the **budding zone, growth zone, area of proliferation, and segmentation area** because it grows continuously and **proliferates proglottids** by transverse fission or asexual budding.

Body (Strobila) :

The proglottids of strobila widen gradually along their length from the anterior to the posterior one. The neck is followed by the flattened, ribbon-like body, the strobila. It forms the main bulk of the body. It consists of 800 to 1,000 segments or proglottids arranged in a linear series in a chain-like fashion.

The strobila of mature tapeworm measures about 3 meters in length. A proglottid is a unit parts of the body enclosing a complete set of genitalia and surrounding tissue. The linear arrangement or repetition of these units is called proglottisation. The proglottids, internally, remain connected together by muscles, excretory vessels, and nerve cords. **Proglottids are independent, self-contained units, each with a complete set of male and female reproductive organs and a part of the excretory and nervous system.**

Proglottids are budded off from the neck region and pushed back due to more proglottids in front. Anterior proglottids are youngest in strobila, and posterior ones are oldest. The proglottids are differentiated into three kinds according to the degree of

development. The proglottids bear genital papilla and pore, alternating once to the right and then to the left.

Immature proglottids :

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

Mature proglottids :

They form the middle part of the strobila. They are about 450 in number.These are large and squarish in outline. **The anterior 100 to 150 proglottids contain male reproductive organs only.** The posterior 250 proglottids develop both male and female reproductive organs. Thus, mature proglottids are hermaphrodite.

Gravid proglottids :

These are the oldest and towards the posterior end of the body. They include 150 to 350 proglottids. The gravid segment measures 12 X 6 mm in diameter and looks grayish-black and transparent when fully developed. They are longer than broad in outline. They have no reproductive organs. **They contain only branched uterus packed with fertilized eggs.** The gravid consists of a median longitudinal stem of uterus having 7-13 branches on each side of the segment. Uterus is completely filled with eggs and each gravid consist nearly

30,000-50,000 eggs. The gravid segment are expelled passively, in chains of 5 to 6 at a time and not singly.

Apolysis :

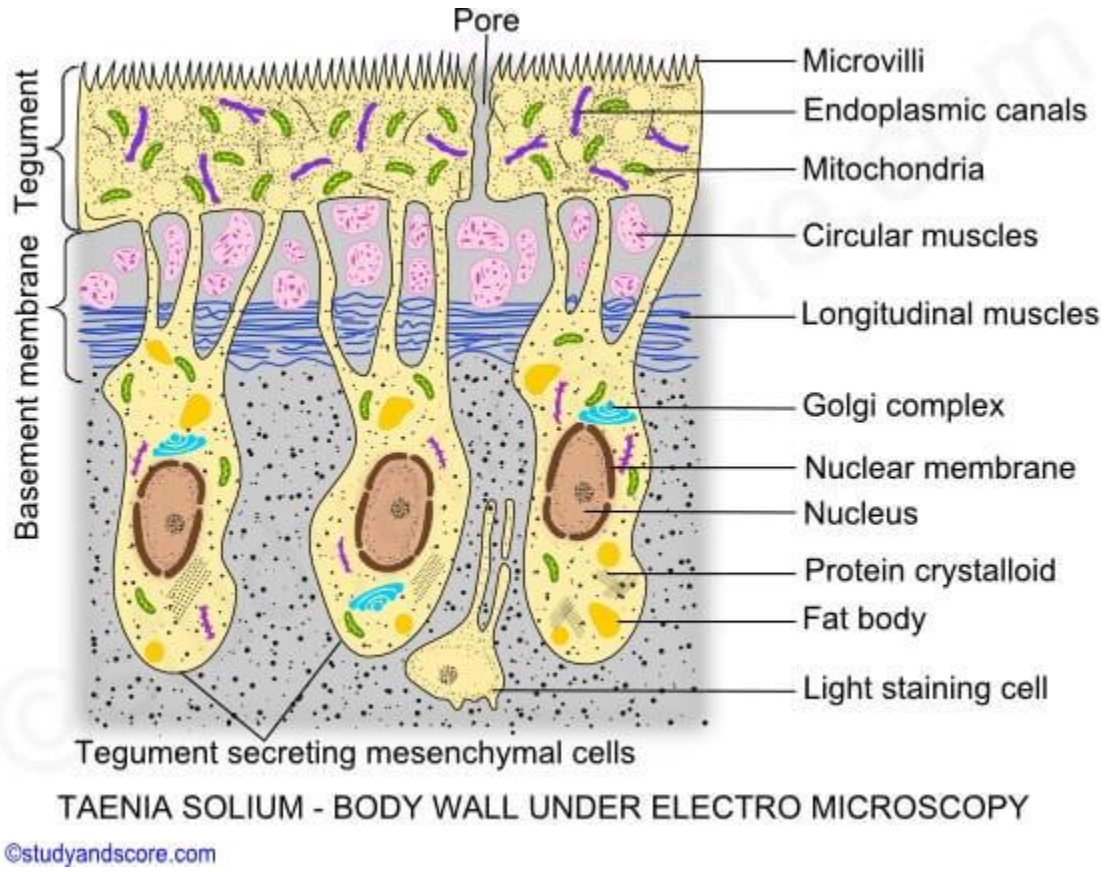
Small groups of gravid proglottids are regularly cut off from the posterior end of strobila and pass out with the host's feces, called apolysis. Apolysis serves to transfer the developing embryos to the exterior, where the secondary hosts can ingest them. It also keeps the body's size, which may otherwise attain enormous length due to the continued proliferation of new proglottids from the neck region.

Eggs:

Eggs are similar to those of *Taenia saginata.* Each egg is round, brown in colour, measures 40-50 µm in diameter. Each egg consists of two shells. The outer shell is thin, transparent and represents the remnant of yolk mass. The inner shell, also known as embryophore and is brown, thick walled and radially striated. It encloses the embryo. The embryo measures 14-20 µm in diameter with hooklets.Eggs do not float in saturated solution of common salt (NaCl).Eggs are infective to pigs as well as to humans.

Body wall of *Taenia solium* :

The tapeworm lacks a cellular or ciliated epidermis. The body wall of *Taenia solium* consists of an Outer tegument and inner basement membrane. The basement membrane includes both the musculature and the packing material called parenchyma.



Teguments :

It is the outermost, thick, waxy, and enzyme resistant layer clothing the body in the absence of a cellular epidermis. It is derived from the tegumentary secretory cells. It is composed of protein impregnated with calcium carbonate and is perforated by numerous fine canals. It consists of three layers outermost hair-like of finger-like comidial layer, the middle thick homogenous layer, and the innermost basement membrane. The studies done by **Threadgold and others** have shown that the outermost cuticle is an intact thick, living, and syncytial layer called tegument. The tegument is derived from the tegumentary secretory cells.

The tegument is connected to the tegumentary secreting cells with strands of cytoplasm called trabeculae. It contains mitochondria and lysosomes and gives out microvilli-like processes called microtriches, on its outer surface. The microvilli help in increasing the surface area of absorption of a nutritive substance from the host and also acts as holdfast organs.The tegument is helpful in protecting the inner parts of the body.The tegument is perforated by minute pores t through which substances are absorbed from the host's intestine.

Integumentary musculature :

It is situated just below the basement membrane. It consists of an outer circular and inner longitudianl fibers. The mesenchymal musculature consists of longitudinal, transverse, or circular, and vertical or dorsoventral muscle fibers.

Mesenchyme or parenchyma :

The tegument is followed by mesenchyme. It is a syncytial network formed by branched mesenchymal cells.It consists of loosely-packed cells with fluid-filled interspaces, forming packing substances around the internal organs.It does not contain a body cavity.The parenchyma in young proglottids and neck region is thicker and some free cells which later differentiate to form the reproductive organs.The turgidity of fluids helps to maintain the form of the body and it also acts as a hydraulic skeleton.

It contains numerous round or oval calcareous bodies composed of concentric layers of calcium carbonate which is secreted by the special mesenchymal lime cells.The secretion from the lime cells helps to neutralize the acid of the digestive juice of the host. circular muscle fibers at the margins, divide the mesenchyme into an outer cortex or cortical zone and inner medulla or medullary zone. Parenchyma also helps in the transport of substances to tissue in absence of a blood vascular system.

Life cycle of *Taenia solium* :

The life cycle is completed in two hosts. Definitive host is Human (Man) and Intermediate Hosts is Pig, occasionally the human (Man). Humans acquire infection by ingestion of inadequately or improperly cooked pork infected with cysticerci. Inside the alimentary canal of man the scolex on coming incontact with bile exvaginates 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.

Reproductive Organs of *Taenia Solium*:

The reproductive organs of Taenia Solium first appear at about 200th segment; the male part of the reproductive system appears first, becomes mature at about 400th segment, and the posterior segments

are filled up with greatly increased uterus, heavily loaded with developing embryos.

The male organs of ***Taenia solium*** consist of a much lobed testis with **efferent ducts, vas deferens and cirrus**, opening in the genital atrium by the male genital aperture. The female organs of ***Taenia solium*** consist of a **paired ovary** with their **ducts, uterus, yolk glands with ducts, shell glands with ducts, ootype, receptaculum seminis and the vagina** opening in the genital atrium through the female genital aperture.

With the development of the uterus, the other reproductive organs are degenerated and the gravid uterus looks like a longitudinal stem with 5-10 lateral branches.

Copulation and fertilization :

- Fertilization is preceded by copulation, inserting cirrus into the vagina of the same or another proglottid to release spermatozoa.
- Both self-fertilization and cross-fertilization occur in tape worm.
- The cross-fertilization between different proglottids of the same tapeworm is very common.
- ***T. solium*** **is protandrous**, i.e., **the testes mature first**. Hence spermatozoa injected in the vagina are stored in the seminal receptacle till the ovary releases ova.

- When ova are released, then fertilization takes place, and zygotes are formed.

Capsule formation :

- The zygotes or egg cells connect with yolk cells or vitelline cells in the ootype received from the vitelline glands.
- The zygote and the yolk then become enclosed in a thin shell or chorionic membrane, formed by material exuded by the yolk cell.
- The structures formed, capsule then passes into the uterus for further development.
- The passage of capsules into the uterus is lubricated by the secretion from the Mehlis glands.

As more and more capsules pass into the uterus, it develops lateral branched to accommodate them.

Onchosphere formation :

Cleavage

When the capsule is in the uterus, the zygote undergoes cleavage. Cleavage is holoblastic and unequal. The zygote divides unequally resulting in a larger megamere and a smaller embryonic cell.

Morula

The megamere divides further to form several similar megameres, while embryonic cells divide repeatedly producing 2

types of embryonic cells, larger mesomeres, and smaller micromeres. The smaller micromeres form a rounded mass, the morula surrounded by an inner envelope of mesomeres and an outer envelope of megameres.

The yolk or vitelline cell transfers its yolk to the megameres and gradually disappears. The large yolky megameres fuse to form the outer embryonic membrane which finally disappears.The medium mesomeres form the inner embryonic membrane or embryophore which is a hard, thick, cuticularized, and radially striated shell surrounding the morula. A thin basement membrane lies beneath the embryophore.

Formation of hexacanth larva:

The zygote becomes surrounded by yolk and a chitinoid egg shell, and passes to the uterus.The ripe proglottides loaded with developing embryos get detached in chains of 5 or 6, and pass to the exterior with the faeces of the host. The proglottides are eaten up by pig; muscles of the segments get digested and six-hooked or hexacanth embryos are liberated. **Hexacanth embryo or onchosphere.**

(a) The body of ***Taenia Solium*** is rounded and enclosed in two membranes.

(b) Six curved chitinoid hooks are present at one end.

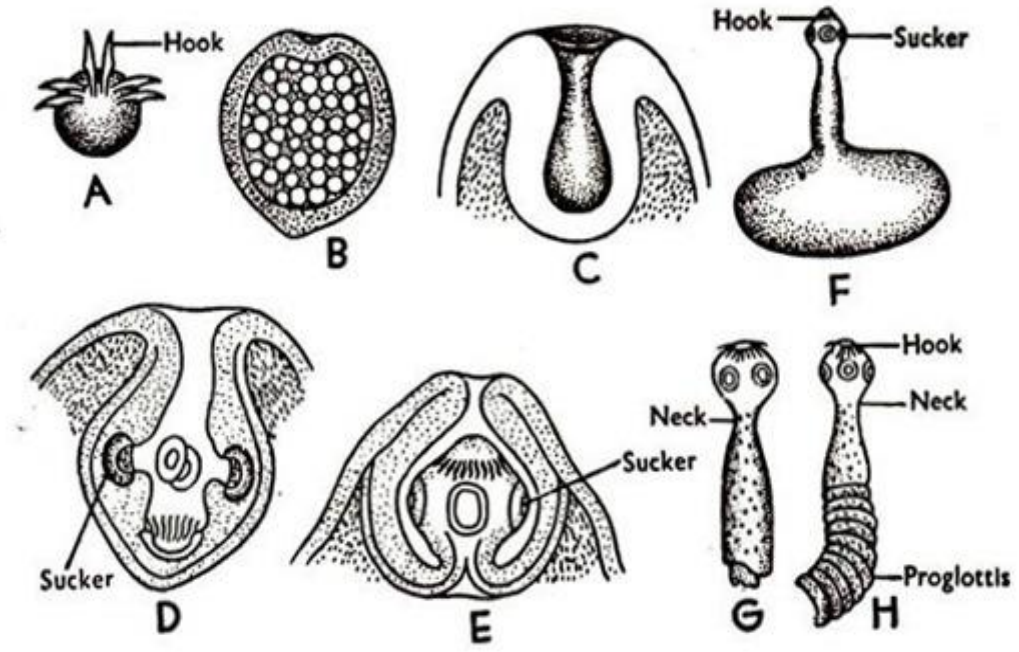


Fig. 23. *Taenia solium*. Life cycle
A. An onchosphere. B. Bladder-like stage. C. Early invagination. D. Appearance of hooks and suckers. E. A cysticercus. F. A cysticercus with evaginated scolex. G. Scolex with remains of bladder. H. Anterior end of a young *Taenia*

The embryos bore the wall of the gut of the host with the hooks and reach the voluntary muscles where the hooks are lost. The embryo then enters the general circulation, usually through the portal vein and reaches the following organs in succession → liver → right side of the heart → lungs → left side of the heart → the systemic circulation. The embryo is filtered out and finally enters the muscular tissue.

Here the embryo increases greatly in size, having a large cavity filled up with watery fluid and assumes a bladder-like structure. A hollow invagination or ingrowth takes place at one point of the bladder and on the inner surface of this invagination develop 28 hooks and 4 suckers, characteristic of the head of adult Taenia.

The hollow ingrowth becomes everted and the suckers and hooks come close to the surface. The embryo now looks like a bladder with a head and neck of Taenia lying within it. This is known as bladder worm or cysticercus stage. It is rich in salt and albuminous material and when the pig's flesh is infected with the cysticercus cellulose, it is known as measly pork.

If a portion of measly pork is eaten by man, the bladder is dissolved in the gastric juice. The gastric juice causes the albuminous material to swell up and forces the fluid into the cavity, thereby the head comes out through the pore. The scolex attaches itself to the wall of the intestine by hooks and suckers and develops the series of proglottides to reach the adult stage.

The worm gains sexual maturity by 2-3 months-time, and survive for 25 years or more.

Cysticercus cellulosae larvae :

- Larvae is ***cysticercus cellulosae*** and is the Infective form of parasite.

- It is also known as Taenia cyst.
- The larval form develops in the muscle of pigs as well as various organs of the human.
- A mature cyst is an opalescent ellipsoidal body and measures 8-10 mm width by 15mm in length. It has a fluid filled milky white bladder like structure.
- The long axis of cyst lies parallel with the muscle fiber. The cyst is separated from the host tissue by a thin collagenous capsule. There is a dense milk white spot at the side, where the scolex with its hooks and suckers remain invaginated.
- The cavity of cyst is fill with a clear fluid rich in albumin and salts.
- The larvae can live for about 8 months in muscles of pig and can only develop into adults when ingested by man.

Mode of transmission :

- Ingestion of uncooked pork infected with tape worm
- 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

Pathogenesis of *Taenia solium* :

- Both adult worm and cyst are pathogenic. The adult worms are less pathogenic. They occasionally cause mild irritation or inflammation of the intestinal mucosa by their armed scolex.
- The cyst**, (Cysticercus cellulosae)** are more pathogenic. They cause a serious disease cysticercosis in human, mostly cyst are produced in the skin, skeletal muscles, eye and CNS.
- The cyst can remain viable for few years.
- In the brain the cyst survives by overcoming the host defenses. It secretes the prostaglandins and other substances that inhibit activation of the complement and production of cytokines. This result in minimal host inflammation around the live cysticercus. The live cyst is surrounded by a local minimal cellular reaction that consists of few eosinophiles and macrophages.
- The dead cyst is surrounded by a dense infiltration that consists entire spectrum of inflammatory cells, including leucocytes and multinucleated giant macrophages, inflammatory cells and less frequently foreign body giant cells. Outside this area a zone of fibrosis and chronic inflammatory infiltration are present.

Clinical diseases caused by *Taenia solium* infection

1. Intestinal Taeniasis:

- Mostly the infection is asymptomatic.

- In symptomatic cases, the clinical symptoms are nonspecific and mild and includes- nausea, abdominal discomfort, hunger pain, loss of weight, chronic indigestion etc.
- Less frequently nausea, vomiting, headache and diarrhea are present in few cases.

2. Cysticercosis:

- Cysticercosis is the infection with the larval stage of the parasite.
- Human beings acquire infection through faccal oral contamination with T. solium eggs from tapeworm carriers or by auto infection.
- Clinical manifestation depend on the affected organ; neurocysticercosis and ophthalmic cysticercosis are associated with substantial morbidity.

i. Extraneural cysticercosis:

- Subcutaneous cysticercosis present as small, movable, painless modules that are commonly noticed in the arms or chest.
- After a few months or even years, the modules become swollen, tender and inflamed and then they gradually disappears.
- Muscular cysticercosis is a causal finding, appearing as dot shaped or ellipsoidal calcifications.
- In rare cases, very massive parasite burdens enlarge the patient's limbs (muscular pseudohypertrophy).

- The heart is another occasional location, infected in about 5% of patient's cardiac cysticercosis is asymptomatic.

ii. Ophthalmic cysticercosis:

- This condition is present in 20% of cases.
- Most cysts are found in the vitreous, subretinal space and conjunctiva.
- The condition may present as iritis, ureitis and palpebral conjunctivitis.
- The cyst in subconjunctival or subretinal sites may present as slowly growing nodules confusing with tumors.
- Occasionally, subretinal eye cyst may lead to blindness due to detachment of retina.

iii. Neurocysticercosis:

- The parasite commonly infects the CNS, causing neurocysticercosis as a clinical disorder.
- After entering the CNS, cysticerci are visible and elicit few inflammatory changes in the surrounding tissue.
- Cysticerci cause symptoms because of mass effect or by blocking the circulation of cerebrospinal fluid, most symptoms are the direct result of the inflammatory process that accompanies cyst degeneration.
- Symptoms and signs are varied and nonspecific.

- **Epileptic seizures** are the commonest presentation and generally represent the primary or sole manifestation of the disease.
- Seizures occur in 50-80% of cases with parenchymal brain cysts or calcifications.
- The disease also present with intracranial hypertension, hydrocephalus or both in 20-30% of cases.
- The syndrome is related to the location of parasites in the cerebral ventricles or basal cisterns blocking circulation of CSF and is caused by several different mechanisms- the presence of the parasite itself, ependymal inflammation or residual fibrosis.
- Occasionally a cyst grows larger than the usual and acts in the same way as a tumor mass (giant cyst).
- These giant cysts compress adjacent cerebral structures, causing localized deficits and intracranial hypertension. Motor deficits can also arise because of oedema secondary to cyst degeneration or as a result of stroke complicating the infection.
- In children and teenagers, an acute encephalitic presentation can happen, more likely in female than male. Massive non encephalitic forms also occur.
- Compromise of the spine occurs in adult 1% cases, presenting with compressive manifestation.

Laboratory Diagnosis of *Taenia solium:*

Specimen:

- Faeces, muscle tissue, blood, csf

1. Macroscopic examination:

- A naked examination of the specimen can be made for segment or proglottids.
- The whitish segment can easily be recognized against the dark yellow mass of the faeces.

2. Stool Microscopy:

- Demonstration of eggs and less frequently proglottids and scolex in faeces is used as tool for diagnosis.
- **Eggs:**
- Eggs are demonstrated by a thick faecal smear examination.
- The eggs shed irregularly, so 2-3 stool sample should be collected.
- Eggs can be seen in perianal area and can be detected by cellophane swab.
- Since eggs of T. soluim and T. saginata are similar, species diagnosis can be made by Acid-fast staining. Eggs of T. soluim are non-acid fast whereas T. saginata is acid fast.

Proglottids:

- The gravid proglottids are found in faeces or recovered from the under clothings.

- They are washed in clean water and placed between two sides.
- The sides are held by adhesive tape at each end and are examined by hand less for lateral branches.
- Demonstration can be facilitated by staining them with india ink, injected through the genital pores.

- **Observation:**
  - Taenia soluim: 7-12 lateral branches on each side of utetine stem
  - T. saginata: 10-20 lateral branches on each side of utenine stem.
- **Scolex:**
  - T. soluim – bears a row of hooks
  - T. saginata- lacks hooks.
  - The scolex is not always recovered following the treatment and the method is hazardous.

3. **Antigen detection:**

- This is a very useful for screening the cases of intestinal taeniasis.
- Antigens capture ELISA polyclonal antisera raised against Taenia is employed to detect antigen in faeces.

4. **Serodiagnosis:**

- Serological tests are employed to detect anti-cysticercus antibodies in serum or CSF.

- ELISA (sensitivity 75%, specificity 85%). Antigen can be detected by ELISA using specific monoclonal antibodies.
- Enzyme-linked immunoelectro transfer blot (EIIB). Sensitivity 90 % specificity 50-70%.
- Detection of antigens in serum or CSF indicates recent or viable infection.

Histopathological diagnosis

- Diagnosis of Neurocycticercosis (NCC) is made by demonstrating cysticerci in the biopsy tissue obtained from brain during post mortem.
- Skeletal cysticercosis can be diagnosed by histological examination of biopsy.

***6.* Imaging method:**

- X-ray of the soft tissue in arm and thigh, chest and neck may show dead, calcified or elongated cysts.
- X-ray of the skull may reveal cerebral calcification and intracranial lesions in the neurocysticercosis.
- CT scan is best method for detecting dead, calcified and multiple cysts is pathognomonic of neurocysticercosis.
- MRI shows a mural nodule within the cyst which is pathognomonic for NCC.

7. Other test:

- CSF protein level are elevated in neurocycticercosis.

- CSF may show lymphocytosis- Mononuclear pleocytosis is frequent
- Glucose levels may be mildly to moderate low.
- Cell counts rarely exceed 300/mm3
- Eosinophils in the CSF are common but nonspecific binding

Treatment of tape worm infection:

i. Praziquantel– drug of choice.

- Dose- oral.
- 50 mg/kg body weight
- 3 divided doses for 15 days.

ii. **Niclosamide:**

ii. Albendazole:

- A dose of 400 mg twice daily for 30 days.

iv. Surgery:

- For cysticercosis of ocular, ventricular and spinal cord.

Prevention and control of taeniasis:

- Avoidance of eating raw or insufficiently cooked pork
- Inspection of pork for cysticerci.
- Proper sanitation facilities.

- Treatment of infected persons.
- Avoidance of food contaminated with eggs of *T. solium*

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