Egg Shell Formation in Helminths

Introduction

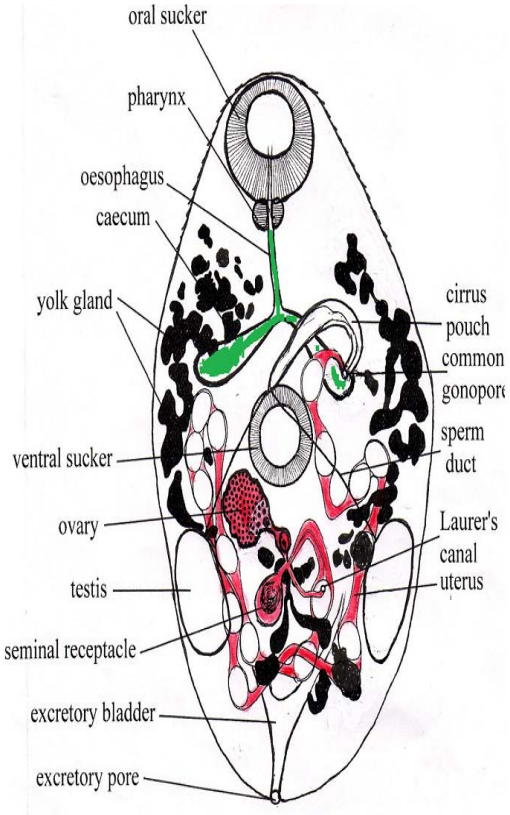
Platyhelminths are blessed with one of the most fascinating, interesting and protecting characteristic attribute is their embryo which are provided with shell (although incorrectly but called eggs).Presence of egg shell around embryo could be regarded as an insurance against various hazards which embryo faces during the course of development before hatching like desiccation, biological hazards, chemical hazards etc. Formation of egg shell takes place in the female reproductive system and it involves co ordinate sequence of events and chemical reactions.

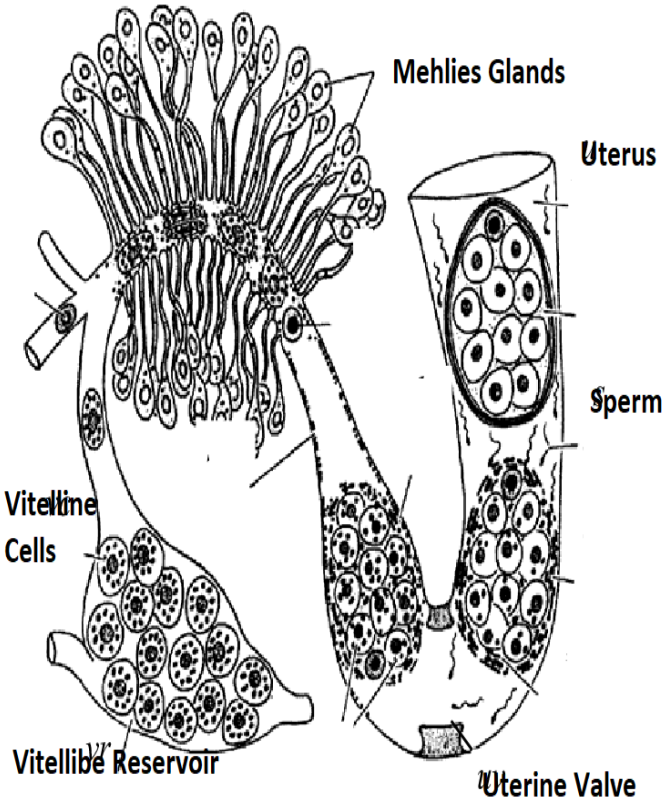
Considerable amount of work has been carried out by large number workers related to mechanism of egg shell formation. Chemical composition of egg shell, roles of Mehlis glands, ootype complex and vitelline glands. Most of these able workers concluded that-

1. Egg shell consists of resistant tanned protein which is subsequently covered by thin envelop of lipoprotein.
2. Precursors of shell formation are largely contributed by vitelline glands.
3. Mehlis' glands also play important role in egg shell formation.

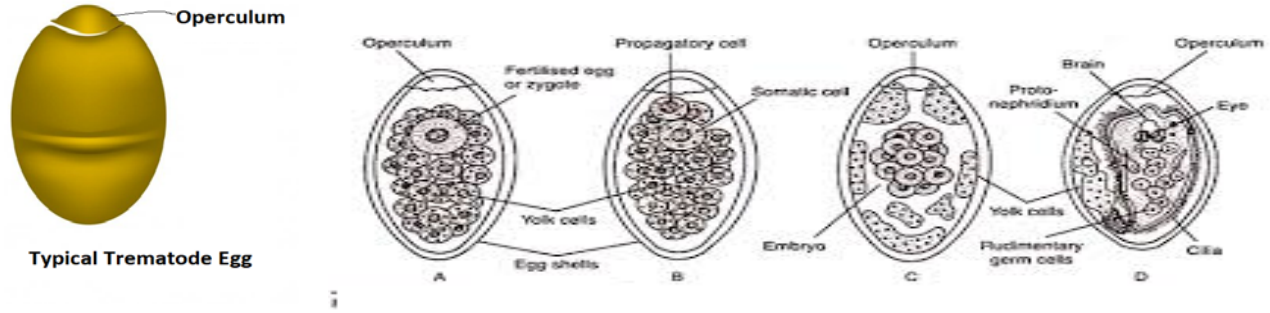
Egg Shell Formation in Trematodes (including monogenea)

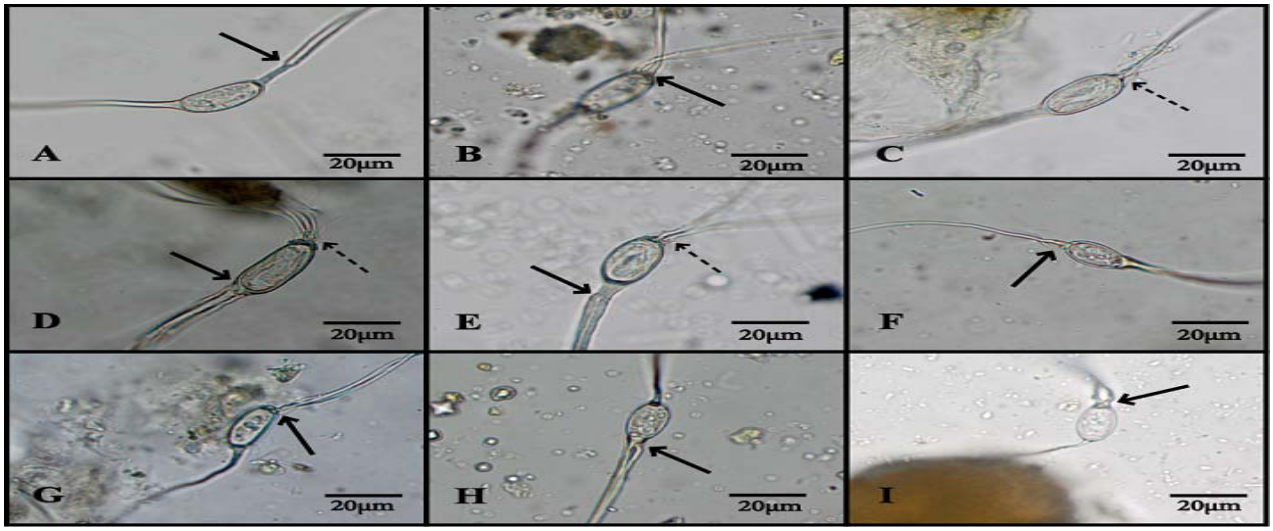
In order to understand the real mechanism of formation of egg shell formation we have to clearly understand the mechanism of egg shell formation we have to have an idea of female reproductive system of trematodes. Fortunately structure and function of reproductive system of monogenean and digentic trematodes is same. This system has already been dealt in detail while study of reproductive system. However, a brief out line is being given-





Structure of Egg





Mechanism

The formation of egg shell actually takes place in the Ootype complex. It is a complicated process and involves series of co-ordinated sequences.

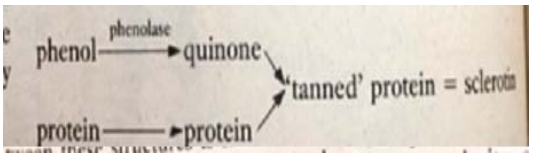
- At the outset mature ova is expelled from the ovary into oviduct by contraction of ovarian walls.
- The muscular sphincter, oocapt is relaxed periodically to let out the mature ova into ootype complex periodically.
- With in the ootype complex, a single sperm penetrates the mature ova and fertilize it.
- Due to which conformational changes takes place in the plasma membrane of fertilized ova which on one hand stops penetration of other sperm on the other hand stimulate mehlis' gland.
- Stimulated MG pour off lipoproteinous secretions into the lumen of ootype complex.
- This lipoproteinacious material forms an outer membrane around the whole of this mass called the egg.
- Vitelline cells at this stage secrete globules of precursors of shell materials.
- These precursor molecules now coalesce to form a semi liquid shell inside the lipoprotein layer.

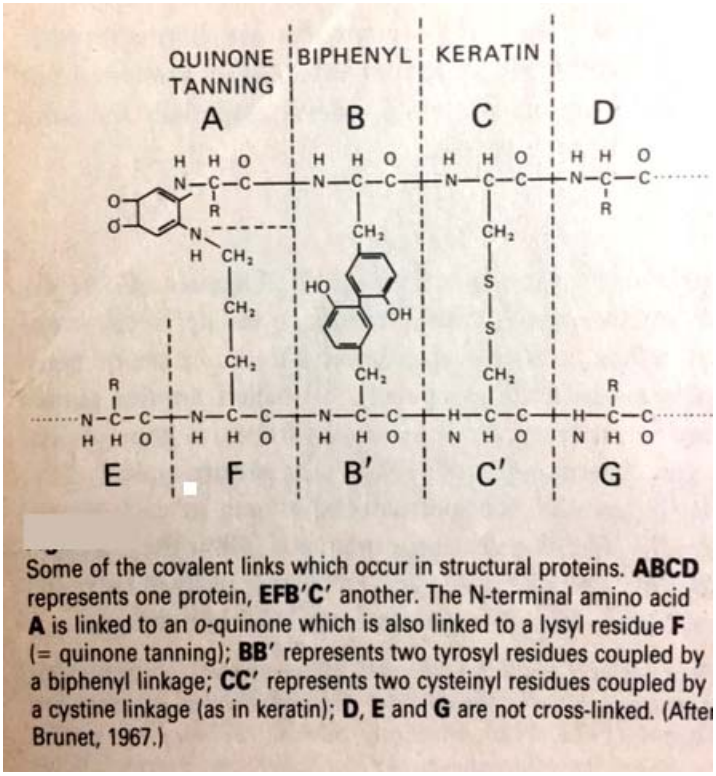
- This semi liquid layer undergoes Tanning process, as a result of which it becomes tough and resistant.
- The precursors for this shell materials also come from vitelline cells.

Chemistry

Chemically egg shell is made of highly resistant protein, sclerotin in almost all trematodes except amphistomes. Among amphistomes egg shell is made of keratin (Madhavi,1966-98).

Sclerotin is a tanned protein. Studies performed on the egg shell formation of monogeneans and digeneans prove that it is quinine tanning.





Some of the covalent links which occur in structural proteins. **ABCD** represents one protein, **EFB'C'** another. The N-terminal amino acid **A** is linked to an *o*-quinone which is also linked to a lysyl residue **F** (= quinone tanning); **BB'** represents two tyrosyl residues coupled by a biphenyl linkage; **CC'** represents two cysteinyl residues coupled by a cystine linkage (as in keratin); **D**, **E** and **G** are not cross-linked. (After Brunet, 1967.)

Erasmus (1972) reported that precursors of the quinine tanning(Phenols,Phenolase and proteins) can be histochemically localized in the globules of vitelline cells. This was later confirmed by several Indian workers like Ramalingam (1984) and Sharma (1989).

Tanning or Sclerotization includes alteration of –OH and _NH2 redicals in tyrosine rich proteins. The tryrosine moieties are first oxidised enzymatically into DOPA and then into quinine. The quinine now reacts with free -NH2 groups in adjacent protein chain and establishes strong covalent bond. In this way it forms cross linked highly strong and stable protein.

Madhvi (1966-68) reported that egg shell of paramphistomes is different due to difference in constituent basic protein. She reported that it is keratin and sher further pointed out that there is no trace of Phenol,Phnolase etc in the vitelline cells thus, it uses some other process for stabilization.

Role of Mehlis' glands in egg shell formation

Recent ultrastructural studies of the reproductive system reveals that Mehlis gland complex is made of 3 different cell types. Out of which two are secretory in nature and each produces secretions which chemically differe from each other.

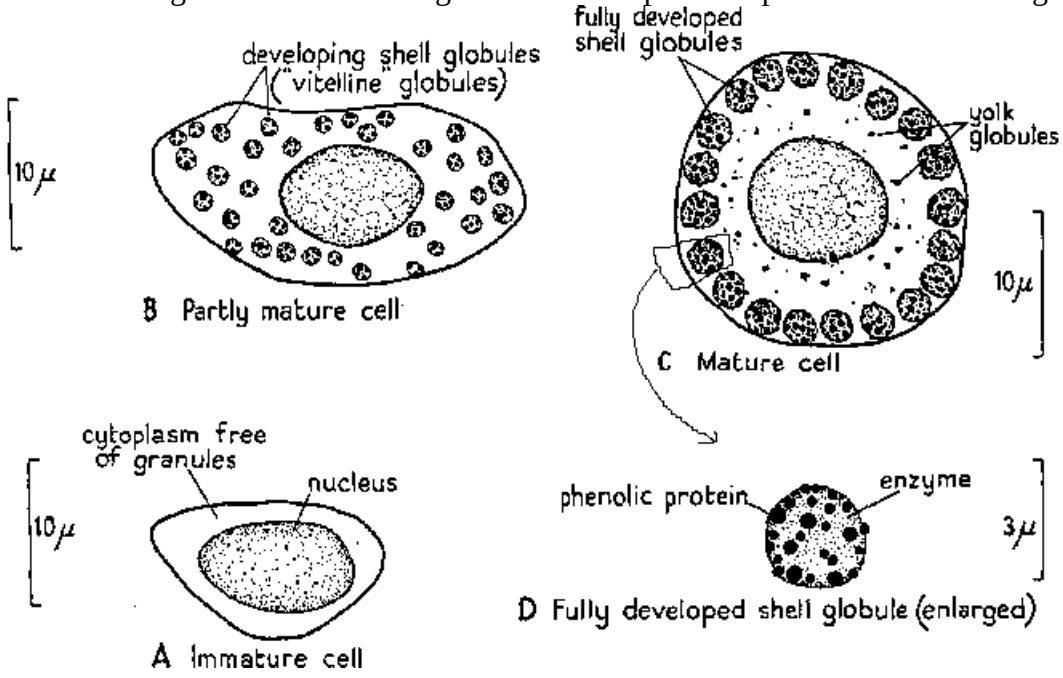
As for as functional aspects of these secretions are concerned-

1. Formation of memberanous envelop that encloses oocyte and vitelline cells.
2. Lubrication of internal linings of ootype and utrus
3. Stimulation of sperns
4. Stimulation of vitelline cells to discharge shell globules
5. Controlling and regulating quinone tanning.

Role of Vitelline glands

Role of vitelline cells has been evalauvated by some workers and it was found that vitelline cell exists in different stages of their development.

1. Immature cells which are irregular in outline and most of the cytoplasmic space is occupied by nucleus.
2. Partly Mature cells still irregular in shape . Cytoplasm contains developing shell globules (formed from golgi bodies),glycogen and lipid droplets (provided from surrounding nurse cells).
3. Fully mature cells circular in shape, very well formed shell globules arranged immediately beneath the plasma membrane. Golgibodies started degenerating. Each globules contains large molecules af phenolic proteins and oxidizing enzymes,

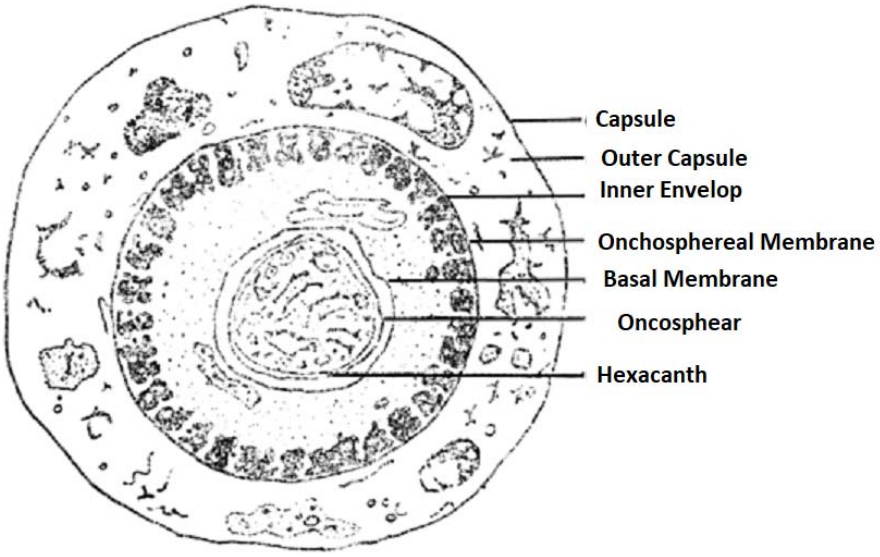


Egg Shell Formation in Cestodes

Structure

Like trematodes,fully formed egg of cestodes is usually provided with four primary membranes or embryonic envelops.

1. Capsule: Form a stiff water protecting envelop in members of the order Trypanorhyncha, Tetraphyllideaand Pseudophyllidea. But this is very poorly developed orabsent in the members of the order Cyclophyllidea.
2. Outer Capsule: In certain genera it is hard covering like trematodes but in cyclophyllidea it is divided to engender a coat and an outer envelop.
3. Inner Envelop: This is thin memberanous structures arises after the formation of Capsule and outer capsule. It is believed that a part of this layer leads to the formation of embryophore.
4. Oncospheral Membrane: Is relatively thin but of immense physiological significance. It encompasses the oncosphere.



In case of cestodes four main types of eggs are found together with their formation set up. They are broadly divided into 2 categories-

Types of Egg Shell

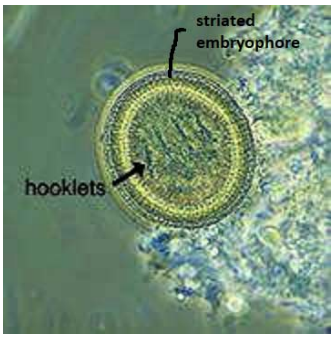
1. **Pseudophyllidea type**
   This type of egg (Fig . A) have thick sclerotin capsule and found in almost all species belonging to orders- Trypanorhyncha, Tetraphyllideaand Pseudophyllidea. Cestodes of these groups are generally provided with very well developed vitelline glands. In most of cases they generally use free living aquatic stage and aquatic intermediate hosts like trematodes. The physiology and mechanism of egg shell formation in this cestode group is more or less common as seen in case of trematodes.
2. **Remaining Type**
   Eggs which don't need a free living aquatic stage in their life cycle. They are embryonated when laid are placed in this category. They generally use terrestrial intermediate host. The eggs not only differ in size and morphology but also in density. On the basis of which they are differentiated into-

a) Dipylidium type

Such eggs (Fig.B)posses a thin capsule and embryophore, and are embryonated when laid eg. *Hymenolepis,Moniezia, Dipylidium* etc.The shell in this group are formed from the globules released from single yolk cell. Quinone tanning takes place in this egg.

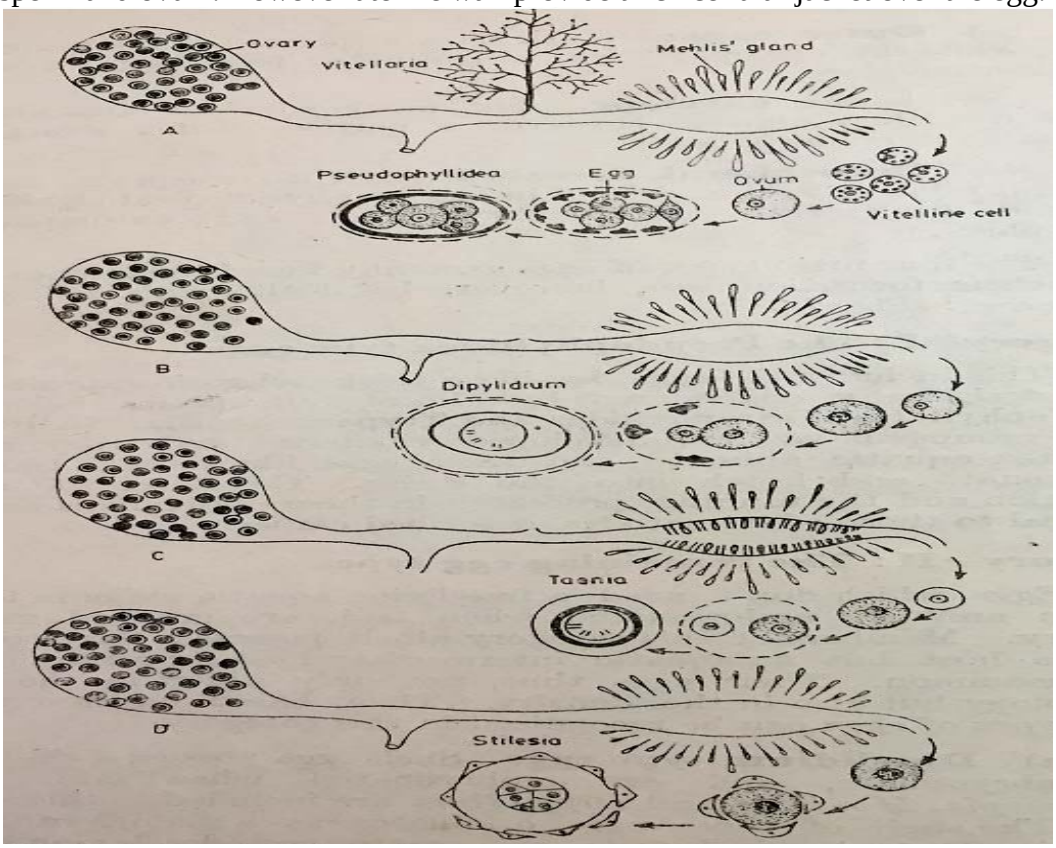
b) Taenia type

This type of egg (Fig.C) are normally surrounded by thin delicate membranous capsule and have thick embryophore eg., *Taenia, Echonococcus, Hydetigera* etc. In this case also just one vitelline cell is accociated but it does not contribute shell materials etc. The Embryophore is very thich and made up of blocks of keratin this gives striated appearance.



c) Stilasia type

Cestodes belonging to this group are not provided with vitelline glands and Mehlies glands (Fig. D)Eg. *Stilesis, Avitellina* etc. The eggs are made from sperm and ovum. However uterine wall provide thick cellular jacket over the egg.

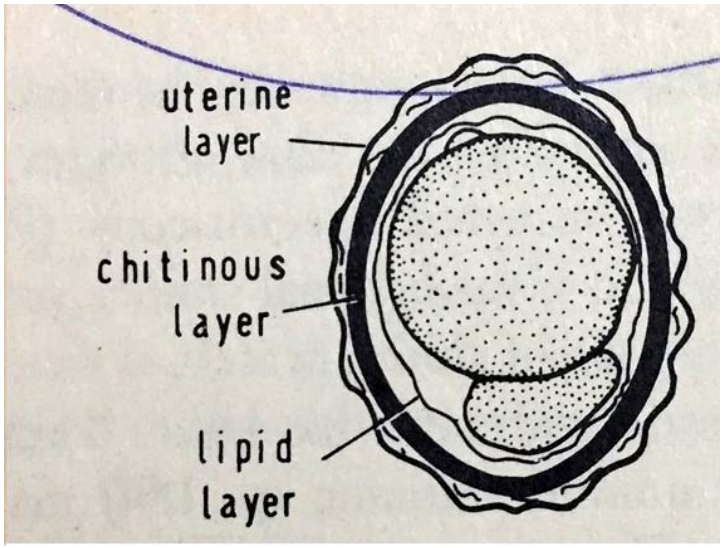


Egg Shell Formation in Nematodes

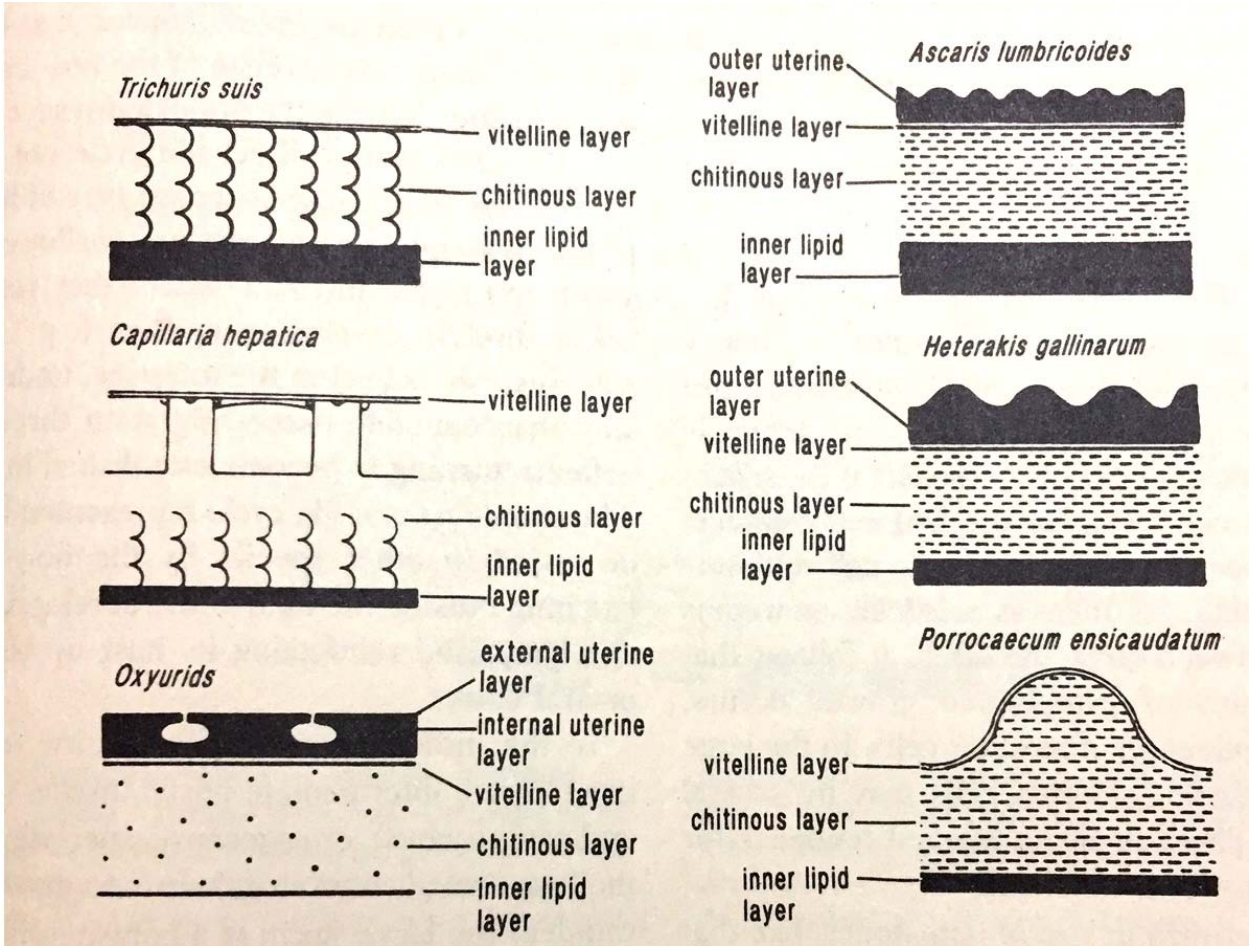
The egg shell is particularly well developed in most of the parasitic nematodes and is the most protective stage in the life cycle of nematodes. Since nematodes use to inhabit variety of biotopes the egg shell also exhibit significant variations, depending on the habitat.

Structure

Wharton (1980) gave a comprehensive review of structure and biology of different nematode eggs, described by various workers time to time. Nematode egg shell might consists of 1 to 5 layers. But the typical nematode egg has three basic layers -



1. Outer vitelline layer: This layer is made up of lipoprotein derived from the vitelline layer of the fertilized oocyte.
2. Chitinous layer: This is found to be the thickest layer of the egg shell and it use to provide structure strength to the egg. This layer is made up of chitin and protein. There is some evidence that quinine tanning is found in this layer.
3. Lipid layer: This layer is made up protein and lipid and is responsible for the impermiablity and protect the contained embryo from variety of hazards.In case of Acaris it was found that there is 25% protein and 75% lipid. The lipid fraction contains alpha-glycosides called ascaroside.
4. Uterine and rectal secretions: Forms the sticky coat around the egg.The internal uterine linings use to contribute this layer made of protein or mammalated layer


Trichuris suis
vitelline layer
chitinous layer
inner lipid layer
Ascaris lumbricoides
outer uterine layer
vitelline layer
chitinous layer
inner lipid layer
Capillaria hepatica
vitelline layer
chitinous layer
inner lipid layer
Heterakis gallinarum
outer uterine layer
vitelline layer
chitinous layer
inner lipid layer
Oxyurids
external uterine layer
internal uterine layer
vitelline layer
chitinous layer
inner lipid layer
Porrocaecum ensicaudatum
vitelline layer
chitinous layer
inner lipid layer

Mechanism