Class: M.Sc.
Semester :IV (Parasitology)
Course : XV A Physiology & Biochemistry of Parasites
Unit : 2a
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Nutrition

Every living organism has two basic goals-

1. To feed and survive
2. To continue the progeny i.e., reproduce

Parasites are not exception to this. One the very famous ecologist Charles Elton once remarked about parasites that- parasites live off their capital and predator live off their interest. This suggests that parasite use to live at the expense of their host. But in reality it is not truth, in general they do not eat themselves out of home. They use to consume only those many morsels which is capable of sustaining their life, they never want their host to die. The truth is this that parasite also die with the death of their host.

Nutritional physiology of parasites is very complex subject for several reasons-

a. They use to inhabit wide variety of hosts.
b. They use to harbour variety of tissues and organs
c. During course of transmission they use to live in more than one host mostly.
d. During transmission a few stages are free living and even non feeding

Due to all this it is very difficult to give a broad brush view of parasite physiology. What so ever information is available is based on the studies performed on gut dwelling parasites and blood dwelling parasites that too for a very limited number of parasites.

One of the most important aspect of nutritional physiology of helminth is HOST PARASITE INTERFACE. This is in fact the region of contact between the parasite and the host from where transfer of nutritive materials use to take place. These are- alimentary canal and the tegument (outer body surface. In parasites wher alimentary canal is absent (Cestodes & acanthocephalan), 100% nutrition demands are full filled from the tegument. Where as helminths where alimentary canal is present (monogenea,digenea,nematode) 70% of the nutritional requirements comes from tegument and remaining 30% from the alimentary canal.

PROTOZA HAS ALREADY BEEN STUDIED BY YOU AT MANY OCCASSIONS SO STUDY YOURSELF

MONOGENEA: FOOD,FEEDING AND DIGESTION

The alimentary canal in monogenea confirms the basic pattern. It starts from mouth, pharynx, oesophagus and intestine. The intestine exhibit wide variation in different monogeneans. Anus is altogether wanting.

Mouth is terminal or sub terminal in position on ventral surface. However in Polyopisthocotyleans, it is very often located at the margins eg. *Microcotyle, Polystoma* etc.

Mouth is in the form of rounded opening but some times found surrounded by slightly muscular labia. Mouth leads to buccal cavity, which is not a regular feature. Buccal cavity (if present) is provided with buccal gland. Some times between buccal cavity and pharynx the is a small conducting tube known as pre- pharynx.

Pharynx: Buccal cavity leads into a muscular pharynx which is a powerful suctorial organ. The musculature of pharynx is well developed and comprises of longitudinal, oblique and circular muscles (exterior to interior). In some cases pharyngeal glands are found associated with pharynx.

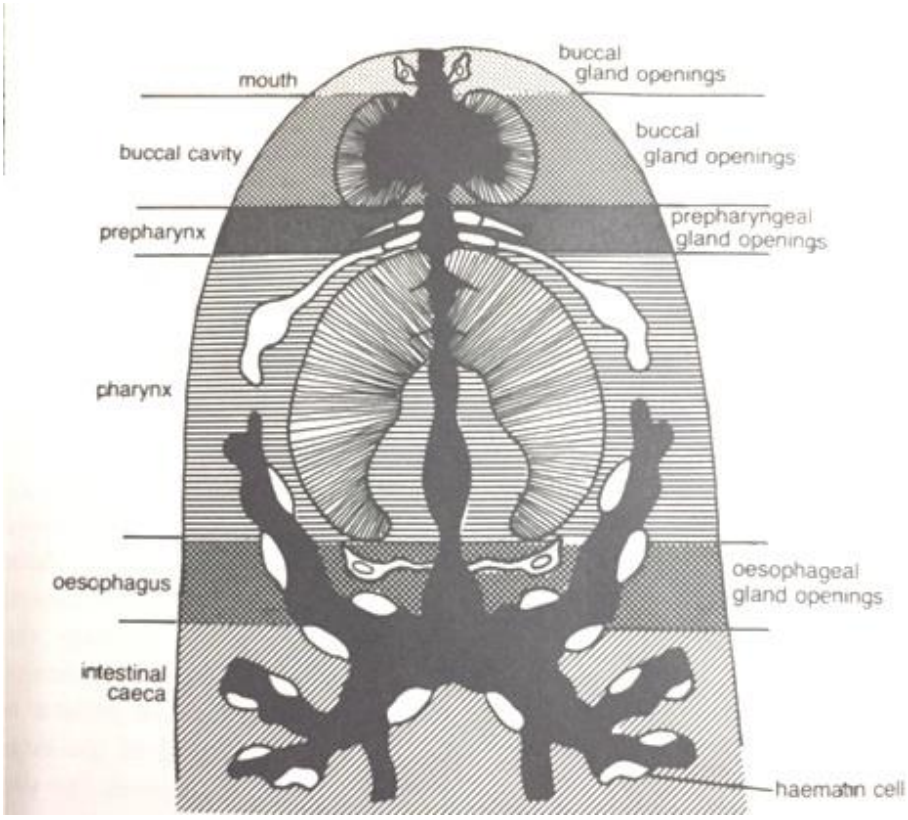
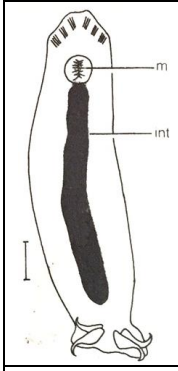
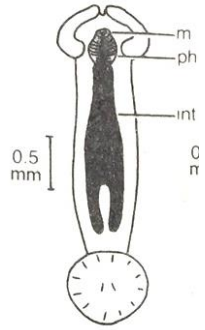
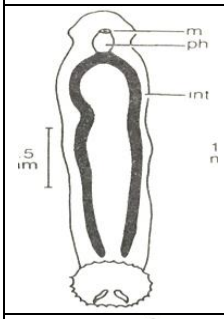
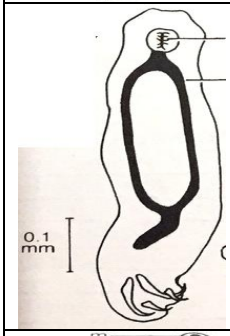
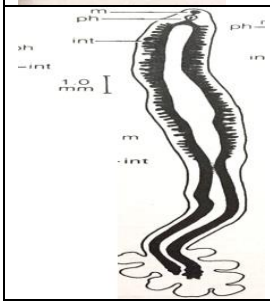
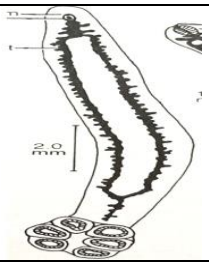
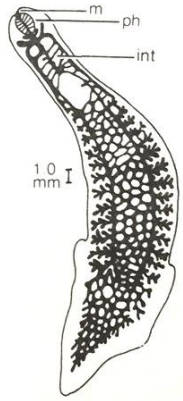


Fig. Typical structure of upper part of monogenean alimentary canal (Halton et al.,1976)

Oesophagus : Pharynx leads into a short oesophagus. Which in some groups is provided with openings of glands.

Intestine: is most variable components of monogenean digestive system. The variations which are observed are-

	It is in the form of of simple tube eg. Tetraonchus
	It is some times forked in posterior part, and crura use t terminate blindly Eg., *Ananchohaptor*
	I majority of cases intestinal crura use to terminate blindly in posterior par of body eg.,*Silonditrema , Murreytrema* etc
	In a few cases intestinal crura rather than terminating blindly unite with each other and intestine is said to be cyclocoeled Eg.*Ancylodescoides, Parancylodescoides* etc
	Some times specially in Polyopisthocotyleans intestinal caeca are found to be diverticulated externally in proximal part/distal part/ throu out thre caeca eg. *Chimericola, Pricea, Paramazocrease* etc

	Some times intestine is diverticulated and united posteriroly eg., *Paradiclobothrium*
	In majority of Polyopisthocotyleans eg. *Microcotyle*,, intestine is highly anastmosed

Workers Bychowasky(1966) are of opinion that there is good relationship between diet and morphology of alimentary canal.

Monopisthocotyleans which are tissue feeders, feed on mucous, dead and damaged cells intestinevtends to be simple

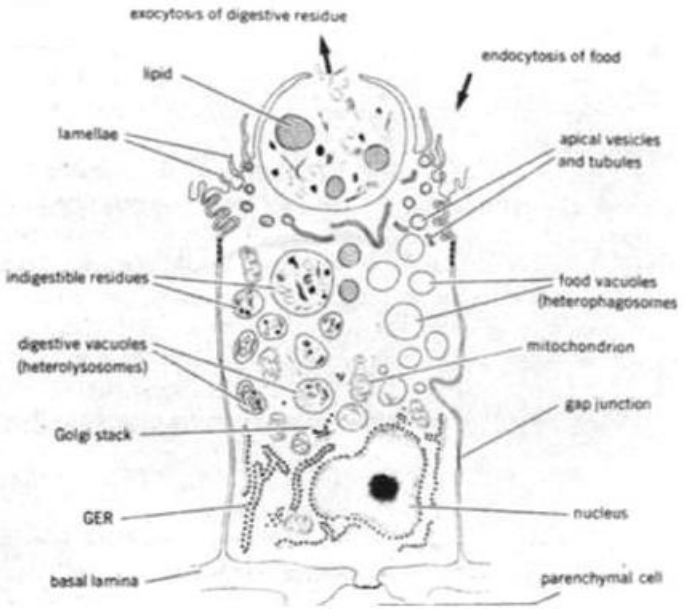
Polyosthocotyleans which are blood feeders intestine is complex, branched.

This difference is not limited to food there are major difference in histology of intestine too. Internal cellular lining of alimentary canal are homologous to gastric mucosa (gastrodermis) of invertebrataes.

Gastrodermis in monopisthocotyleans is found to be continuous and made up of specialised cells known as caecal cells. Where as in polyopisthocotyleans the gastrodermal lining is discontinuous or deciduos. The cells are called haematin cells.

1. **Caecal cells**

   Ceacal cells are modified columnar epithelial cells. It is characterized by having basla nucleus, cytoplasm containing mitochondria, Rough Endoplasmic reticulum, golgi stacks and large number of vacuoles.Lysosomes and food vacuoles are also visible in cytoplasm.



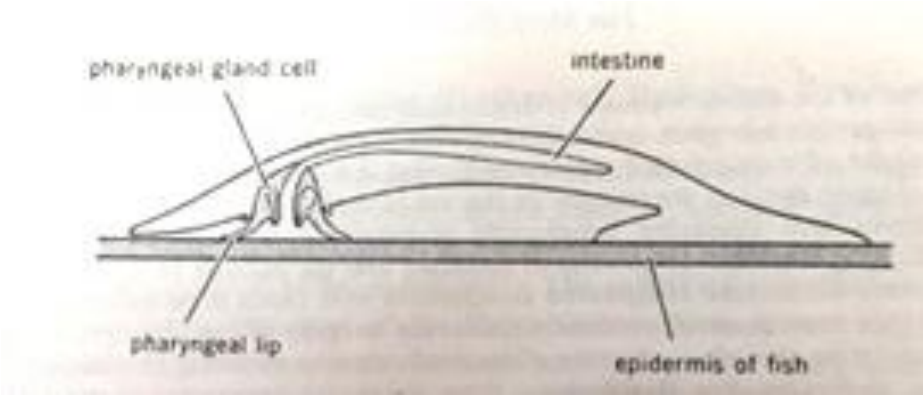
At the distal free boarder of the cell, there exists a collar of microvilli/ lamellae which performs duel purpose- absorption of digested food from the intestinal lumen and capturing the undigested food and importing it inside the cell in the form of food vacuole. Internalized food is digested and undigested waste materials are exocytosed back into the intestinal lumen.

2. **Haematin cells**

These are characteristic feature of sanguivorous mongogenean. The Cells are modified cuboidal epithelial cells having characterstic free border lodged with microvilli through out the length. They are specialised in digesting blood meal.

Feeding

Account of feeding and its details are poorly known. Mostv detailed studies of the feeding was performed by Kearn (1999) in monogenean, *Entobdella soleae*.Pharynx is eveted at the time of feeding after enclosing a small selected skin of the piscine host,it is firmly fixed using lips in the form of inverted bell. Buccal and pharyngeal glands use to pour hydrolytic enzymes which hydrolysis fish skin wich in this cup which is in turn sucked by muscular pharynx like suction pump. In Polyopisthocotyleans there is addition provisions for adding anticoagulant to prevent blood cloating from some of the fore gut glands.



Digestive Glands

Following different digestive glands have so far been identified-

1. Pre-Pharyngea glands (= buccal glands)
2. Pharyngeal glands
3. Oesophageal glands
4. Scattered glands

Glands 1-3 are visible in the first figure. Most of these are basophilic glands and use to open in the lumen of intestine through separate openings.

The scattered glands are present throughout the body their ducts use to pen at the surface abd the main body of the glands are found lodged in the tegument. The exact function of these glands are still obscure but it is believed that they are protective in nature and use to protect the worm from defence chemicals and cells of the host. However some workers believe that pheromone like substances are discharged.

Digestive Enzymes*

Mostly hydrolytic enzymes have been identified which use to work either at acidic or neutral pH. These enzymes are-

a. Proteases
b. Thiamene Phosphatases
c. Phosphatase
d. Carboxylic Esterase

*Explain your self

Digestive Physiology

Digestive process of monogenea is divided into two parts-

A. Extracorporeal Digestion

It takes place out side the alimentary canal with the help of hydrolytic enzymes of buccal and pre-pharyngeal glands. Semi digested food is sucked in the gut

B. **Intracorporeal Digestion**

Intra corporeal digestion takes place in the gut lumen and is further divided into two phases-

(i) Extracellular digestion or luminal digestion which takes place in the intestinal lumen. Hydrolytic enzymes from buccal gland, Pharyngeal glands, oesophageal glands mixed with with food keep getting digested in the lumen and use full materials are absorbed and assimilated in paranchymetous tissue.

(ii) Intra cellular digestion takes place inside Caecal or haematin cells with the help of hydrolytic enzymes of the lysosomes.

The is no anus, undigested waste product is discharged out from the body through mouth it self by antiparastalisis.

Digenea

Like monogeneans, digeneans are also classified into several grouped which differ from eather not morphologically but physiologically as well. Although digenean classification is still uncertain but on the basis of suckers they are classified into following main types-

1.Gastrostome: Intestine simple, mouth away from the terminal eg. Bucephalopsis

2. Monostome: Generally one sucker is absent, usually it is ventral but may be oral. However some times both the suckers are absent eg., *Notocotylus*

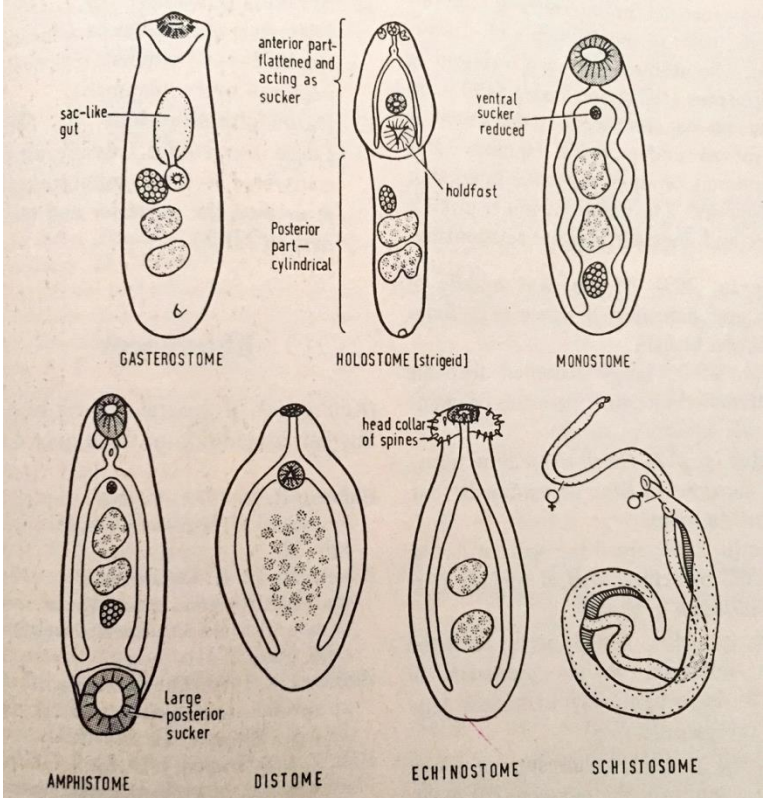
3. Amphistome: Body thick flashy with well developed posterior sucker eg Paramphistomum

4.Distome: Mouth surrounded by oral sucker. The other sucker may be any where in body eg. *Fasciola*

5. Echinostome: Oral sucker is encircled by characteristic ring of collar spines eg. *Echinostome*

6. Holostome: Body divided into anterior and posterior parts. Anterior part is provided with additional adhesive organ called hold fast eg. *Diplostomum*

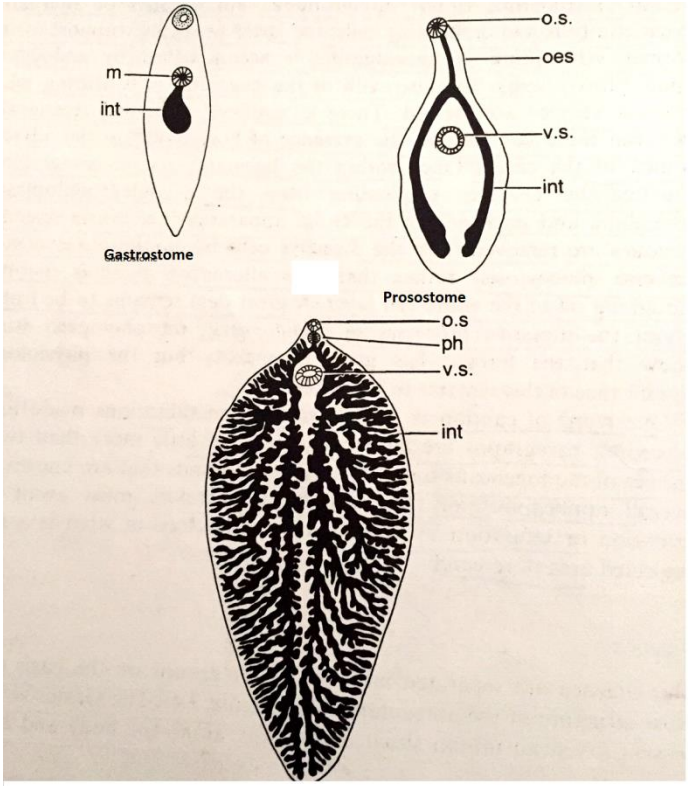
7. Schistosome: Elongate dioecious worm like Eg. *Schistosome*



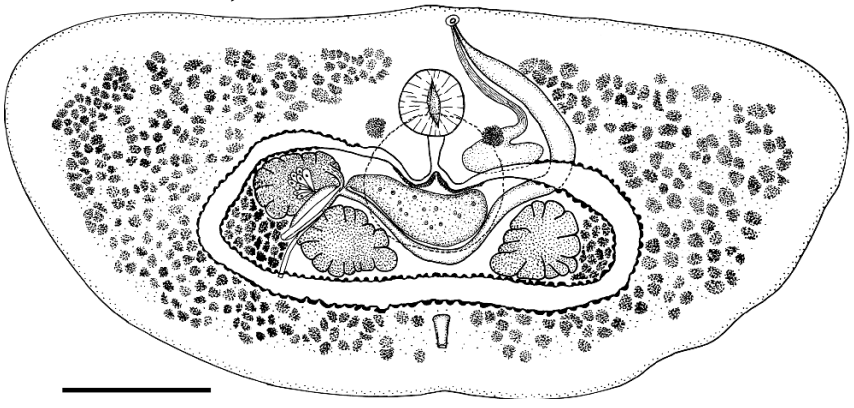
Alimentary Canal

Normally digeaneans are grouped into two major groups on the basis of gross structure of alimentary canal. Gastrostomes in which mouth is ventral situated part away along the body and have simple sac like intestine. On the other hand, Prosostomes closely resemble with sister monogeneans having basic mouth, buccal cavity, pre-pharynx, pharynx oesophagus and intestine.

Unlike monogeneans, mouth is the principle feeding devise and is surrounded by powerful oral sucker and further assisted by pharynx.



Variation in the intestine is seen like monogeneans. Caeca in most of digeneans is in the form of blind ending tubes. But some times crura use to unite with other and is said to be cyclocoeles as in case of ectoparasitic trematode, *Transversotrema*.



Anus is generally missing however, in certain echinostomes intestinal caeca opens into excretory canals which in turn open to exterior through excretory pore. Some piscine digeneans have well defined anus Eg., *Acanthostomum,Schistorchis* etc. But since waste material are normally voided through mouth thus practical significance of anus is still not known.

Food

On the basis of food preference digeans are classified into 3 categories-

- Blood feeders eg.,*Haematolechus, Azygea* etc
- Tissue feeders eg., *Pleurogenes, Ganeo,tremiorchis* etc.
- Both Tissue and blood feeders eg.,*Fasciola, Diplodiscus* etc

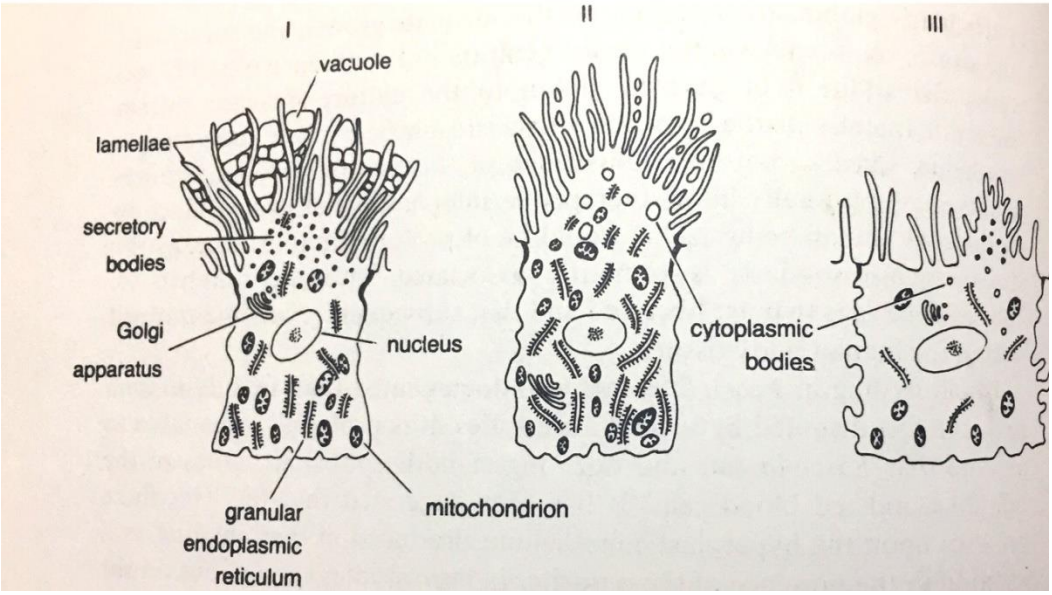
Feeding

Trematodes are predominantly suctorial feeders and exhibit very little variation in the mechanism of their feeding (Halton,1967,smyth and halton,1983). Most trematodes suck food through the efficient action of the oral sucker and pharynx.. Both these structures are highly muscularized (all three different types of muscle fibres: circular, longitudinal and oblique are found). In some apharyngeate genera like *Diplodiscus, Gorgoderina etc* proximal part of oesophagus is muscularized and simulates the pharynx.

In few trematodes like *Haplometra* secretions from ventral sucker also plays significant role. Hydrolytic enzymes from the embedded glands of ventral sucker hydrolyse the host tissue for feeding. However these glands also secrete mucous and other substances that serves to protect them from digestive juices of the host as n case of *Opisthoglyphae* as reported by Chappel,2009.

Digestion

Digestion in case of digenetic trematode is more or less similar to those of monogeneans. Major part of digestion takes place in the intestinal lumen.The internal lining of intestine, the gastrodermis is highly irregular in appearance. It was Robinson and Threadgold (1995) who studied gastrodermal cells in detail and identified three different types of cells-



Goroup I Cells

These are most abundant type of cells found in clusters of 4-7 cells. These are modified columner epithelial cells 25-40 micro meter tall. Apices of these cells are given out in the form of numerous lamellae. These lamellae are packed with large number of vacuoles which does not permit them to collapse. Cytoplasm is provided with large number of rough endoplasmic reticulum and filled with large number of secretory bodies. These cells are secretory in function

and discharge hydrolytic enzymes in the intestinal lumen for the hydrolysis of ingested food. These cells are largely located in the upper part of intestine.

Group II Cells

These are also columner epithelial cells, located in lover part of intestine. These are 20- 35 micro meter tall. Lamillae are present at the apices of these cells. Endoplasmic reticulum is less developed and secretory bodies are also absent. They are provided with cytoplasmic bodies which are filled with coiled membranous materials, to increase the absorptive surface area. These are absorptive cells.

Group III Cells

These are cuboidal epithelial cells measuring 10-20 x 10 – 20 micro meter. Lamillae at apices are very short, provided with numerous mitochondria and secretory bodies. Workers believe that these are absorptive cells and distributed through out the intestinal lumen. But a few workers are of opinion that these are toti-potent cells and can develop into either.

Digestive Enzymes

Large number of digestive enzymes have been identified viz., Proteases, Aminopeptidase, Lipase, Esterase, Alkaline phosphatise, Acid Phosphatase, ATPase, Glucose 6 phosphatase etc. The activities of these enzymes vary from each other. Optimum activity of Proteases are noted at pH 3.9 - 4.5 besides this it was also found that it is nearly 5 times more active in female as compared to male.

Placental Digestion

One additional factor operates in trematodes digestion is called as Placental digestion. It is found that certain additional organs of attachment (strigeids) hold fast organs besides attachment also help in extracorporeal digestion. This phenomenon has been studied in detail in *Apatemon, Alaria, Holostephanus, Diplostomum* etc.

These hold fast organs discharge hydrolytic enzymes which use to partially hydrolyse the host tissue before ingestion

Nematoda

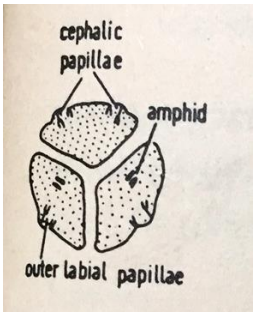
Alimentary Canal

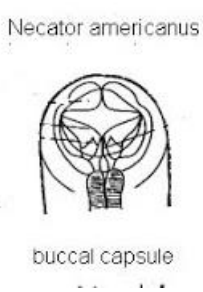
The digestive system of nematodes includes the stoma, oesophagus, intestine and posterior gut. The inner body tube is divided into 3 main regions.

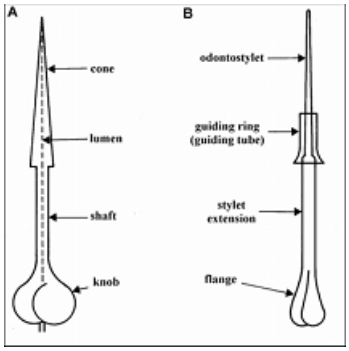
1. Stomodeum : which constitute the stoma (mouth), buccal cavity,pharynx, oesophagus and cardia
2. Mesenteron : which constitute the intestine
3. Proctodeum : which is the posterior –most region comprising rectum and anal opening.

It was reported by several workers that internal linings of stomodium and proctodium is of cuticle and exhibit annual moulting.

Mouth is surrounded by 3-6 pairs of lips each bearing papilla. These papillae may be arranged in two rows.

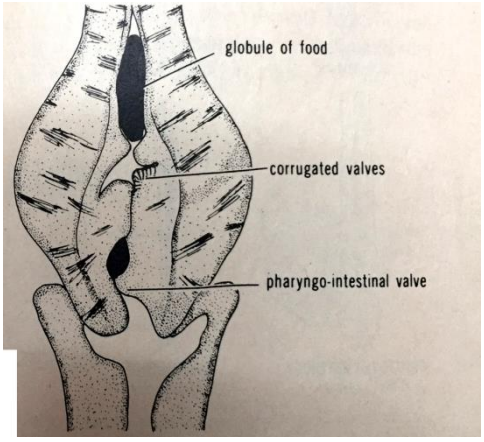


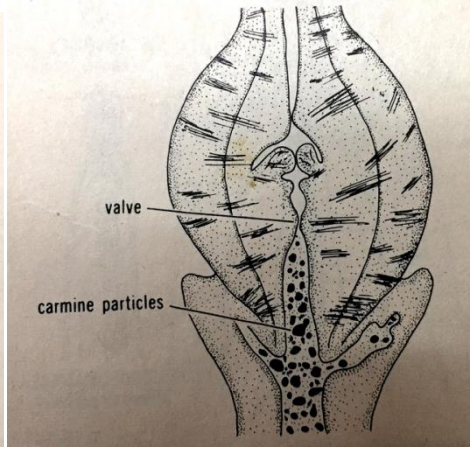




Buccal cavity is variable in shape, size and degree of differentiation.In most of the cases it is simple, internally lined by cuticle. In some case as in case of hook worms it is provided with cuticular denticles eg., *Ancylostoma, Necator*. In plant parasitic nematodes it is equipped with piercing and sucking devices.

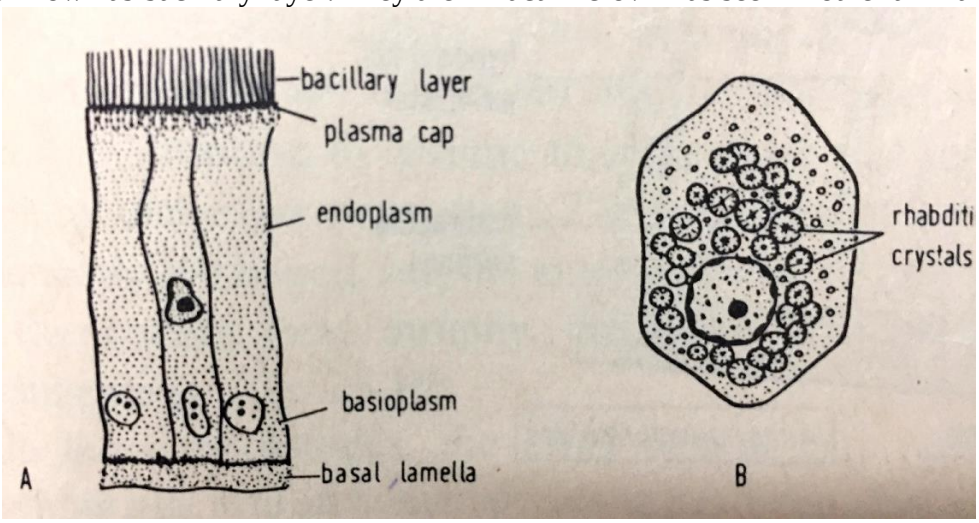
Pharunx or Oesophagus forms an important and variable part of alimentary cana and is most characteristic feature of nematode morphology. The parynx was originally thought to be made up of syncytial tissue. But with development of electron microscope its cellular nature was established' It is now very well known that it is made up of muscle, supporting cells, nerve cells and gland cells. Proximal part of pharynx is internally lined by cuticle and posterior par is often muscular and provided with one or two bulbs. Pharynx exhibit considerable variation in structure



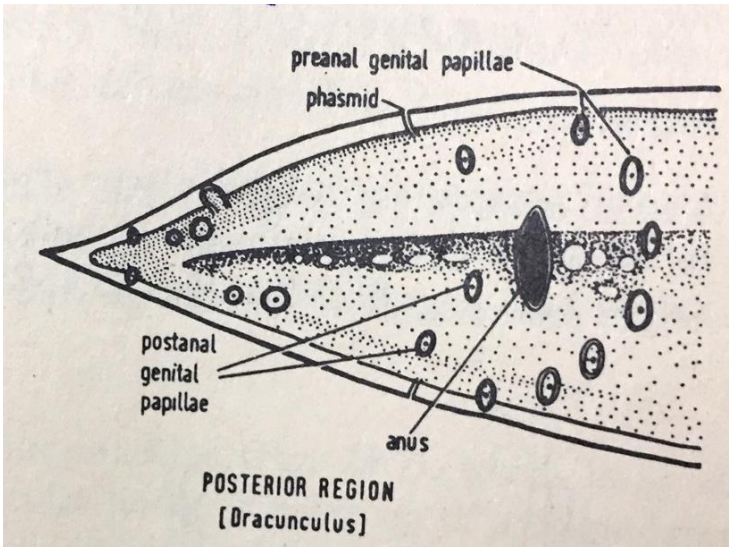


and function which is normally related to its food and feeding habits.

Intestine does not exhibit any specific variation; it is in the form of straight tube and made up of single layer of epithelial cells. The border of these cells facing intestinal lumen bear hir like projections known as bacillary layer. They are in fact microvilli as seen in other animals.



The hind gut is also lined by cuticle. In females it forms rectum but in males the male gonopore open into it thus it forms the true cloaca. Large number of rectal glands use to open into rectum and finely it opens to exterior through anus. Around the anus varying number of papillae are found.



Food

On the basis of food animal parasitic nematodes are divided into four major groups-

1. Feeders on gut contents of the host like *Ascaris*
2. Epithelium feeder eg *Ancylostoma*
3. Tissue feeders eg *Trichuris*
4. Fluid feeder eg *Wuchereria*

Feeding

Based on type of food feeding stretigies are variable. But in general cuticular teecth of buccal cavity, lips, muscularized suctorial pharynx are the feeding tools in gearal

Digestion

1. The majority of nematodes have a complete digestive system, consisting of the buccal cavity and oesophagus, intestine and rectum. At the anterior end of the animal there are sensitive structures which are usually involved in the localization of food. This is sucked up by the oesophagus (circular, muscular and triradiate) and propelled up to and through the intestine by rapid contractions.
2. The intestine is occluded by the pressure exerted on it by the hydrostatic skeleton of the pseudocele since it does not have associated musculature. When the muscles of the oesophagus are relaxed it occludes, thus preventing the food from returning towards the mouth.
3. Among the oesophageal muscles there are several glands, usually three, one between each interradial zone (the dorsal being larger than the two ventrolateral), and which open into the oesophageal lumen.
4. These glands generally secrete digestive substances such as proteolytic enzymes and amylases. In Necator spp. and Ancylostoma spp. the glandular secretions contain peptidases and hyaluronidases which degrade the tissue and capillaries engulfed by the parasite when it anchors itself with the buccal capsule to the intestine wall of the host, as well as anticoagulant proteins.
5. The oesophagus can take several forms, depending on the order and species, and is thus an important taxonomic feature. In fact, some authors, have related the level of development of the oesophageal glands of some nematodes to their feeding habits.
6. It has also been observed in this species that proteolytic enzymes accumulate in granules within the oesophageal glands. It is thought that, due to the disposition of the glands, the secretions of the dorsal gland are involved in extracorporeal activities while those of the subventral glands are involved in intestinal digestion.
7. The oesophagus leads to the intestine, a simple tubular structure with an epithelium formed by a single layer of cells over the basal lamina, composed of collagens, with a brush border with numerous long folds supported by actin filaments increasing the surface area of the lumen by between 75 and 90 times.
8. The front part of the intestine of Ascaris sp. is mainly for secretion and the rear part for absorption, with both apocrine and merocrine type secretions being described.
9. Waste products are expelled when the anus dilates, as there is a muscular sphincter, and hydrostatic pressure forces them out.
10. The digestive enzymes of nematodes comprise endopeptidases (of which the cysteine peptidases have been especially well studied in many organisms), exopeptidases, glycosidases, lipases, phospholipases and esterases. These may be secreted and released both externally and internally or are membrane proteins found on the luminal surface of the digestive tube. Van den Bossche and Borgers (2014).
11. In certain nematodes it is reported that *A. suum* exhibited a low level of endocytosis in the intestinal epithelium suggesting that the acid hydrolases present in the intestinal microvilli might perform extracellular digestion of macromolecules in order to absorb the nutrients later.

External surface and Nutrition in Parasites