Lecture 03 - Morphology and Anatomy of Nematodes

Even though nematodes occupy nearly every habitat on earth, they are remarkably similar in morphology and life stages. Despite their structural complexity, certain basic principles are common to all nematodes. Nematodes are triploblastic, bilaterally symmetrical, unsegmented, Pseudocoelomate, vermiform and colourless animals. The plant parasitic nematodes are slender elongate, spindle shaped or fusiform, tapering towards both ends and circular in cross section. The length of the nematode may vary from 0.2 mm (*Paratylenchus*) to about 11.0mm (*Paralongidorus maximus*). Their body width vary from 0.01 to 0.05 mm. In few genera, the females on maturity assume pear shape (Meloidogyne), globular shape (Globodera), reniform (*Rotylenchulus reniformis*) or saccate (*Tylenchulus semipenetrans*). The swelling increases the reproductive potential of the organism. Radially symmetric traits (triradiate, tetraradiate and hexaradiate) exist in the anterior region. The regions of intestine, excretory and reproductive systems show tendencies towards asymmetry. The nematodes have one or two tubular gonads which open separately in the female and into the rectum in the male which also have the copulatory spicules.

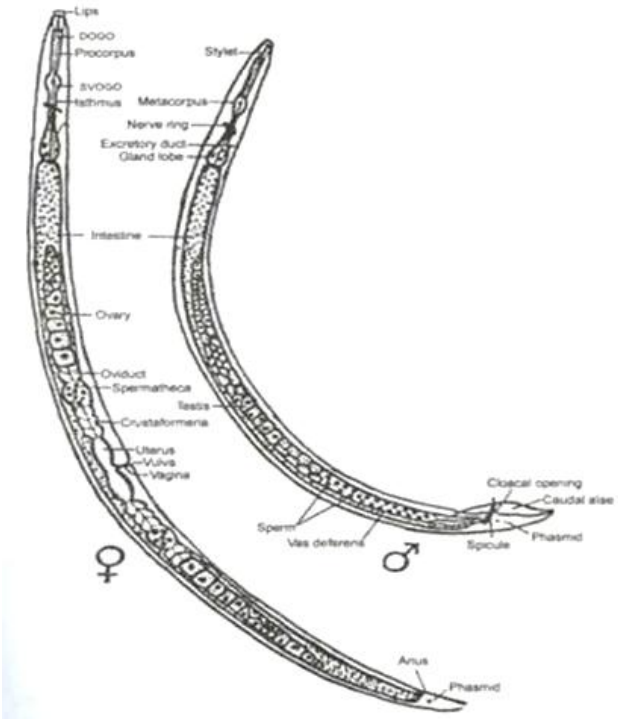


Fig. 1- Body morphology of a typical vermiform plant parasitic nematode DOGO - dorsal oesophageal gland orifice, SVOGO - subventral oesophageal gland orifice

The free living saprophytic nematodes are generally larger in size. The animal and human parasitic helminthes may have length of few centimeters to even a meteer or more. The helminth parasitising whale fish is about 27 feet long. The study on these animal and human parasites are known as Helminthology.

The following are some examples of Helminths

1. Filarial worm - *Wucheria bacrofti*
2. Guinea worm - *Dracunculus medinesis*
3. Round worm - *Ascaris lumricoides*
4. Tape worm - *Taenia solium*

The nematode body is not divided into definite parts, but certain sub – divisions are given for convenience. The anterior end starts with the head, which consists of mouth and pharynx bearing the cephalic papillae or setae. The portion between the head and the oesophagus is known as the neck. Beginning at the anus and extending to the posterior terminus is the tail.

Longitudinally the body is divided into four regions as dorsal, right lateral, left and ventral. All the natural openings like vulva, excretory pore and anus are located in the ventral region. The nematode body is made up of several distinct body systems. They are the body wall, nervous system, secretory – excretory system, and digestive system and reproductive system. Nematodes do not posses a specialized circulatory or respiratory system. The exchange of gases is thought to occur through the cuticle and circulation proceeds through the movement of fluids within the pseudocolelom and by simple diffusion across membranes.

T**he following are the characteristics of members of the phylum Nemata.**

1. Inhabit marine, freshwater and terrestrial environments as free – livers and parasites.
2. Bilateraly symmetrical, triploblastic, unsegmented and pseudocoelomates.
3. Vermiform, round in cross – section, covered with a three – layered cuticle.
4. Growth accompanied by molting of juvenile stages, usually four juvenile stages.
5. Oral opening surrounded by 6 lips and 16 sensory structures.
6. Possess unique cephalic sense organs called amphids.
7. Body wall contains only longitudinal muscles connected to longitudinal nerve chords by processes extending from each muscle.
8. Unique excretory system containing gland cells or a set of collecting tubes.
9. Longitudinal nerve cords housed within the thickening of the hypodermis.

Genera of the most common plant parasitic nematodes

1. Cyst nematode *Globodera spp*. and *Heterodera spp*.
2. Dagger nematode *Xiphinema* spp.

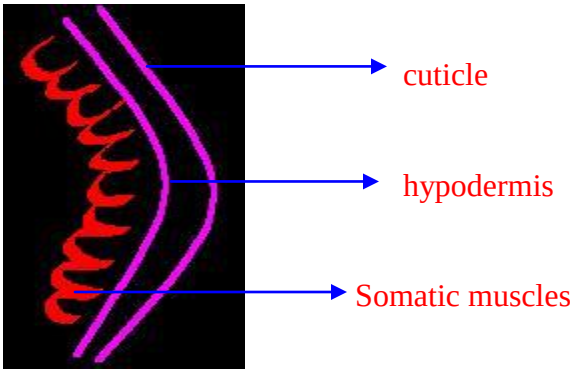
3. Foliar nematode — *Aphelechoides* spp.
4. Lance nematode — *Hoplolaimus* spp.
5. Lesion nematode — *Pratylenchus* spp.
6. Needle nematode — *Longidorus* spp.
7. Pin nematode — *Paratylenchus* spp.
8. Reniform nematode — *Rotylenchulus* spp.
9. Ring nematode — *Criconemella* spp.
10. Root – knot nematode — *Meloidogyne* spp.
11. Sheath nematode — *Hemicycliophora* spp.
12. Spiral nematode — *Helicotylenchus* spp.
13. Sting nematode — *Belonolaimus*
14. Stubby – root nematode — *Paratrichodorus* spp and *Trichodorus* spp.
15. Stunt nematode — *Tylenchorhynchus* spp.

The nematode body is divided into three regions. They are the outer body tube or body wall, inner body tube and body cavity or pseudocoelome.

The outer body tube

The outer body tube or body wall includes the cuticle, hypodermis, and somatic muscles. The body wall protects the nematode from the harsh external environment, serves as the exoskeleton and provides the mechanism for movement of the organism through the soil and plant tissue. The body wall also contains much of the nervous and secretory – excretory systems, and it plays a role in the exchange of gases.

Outer body tube



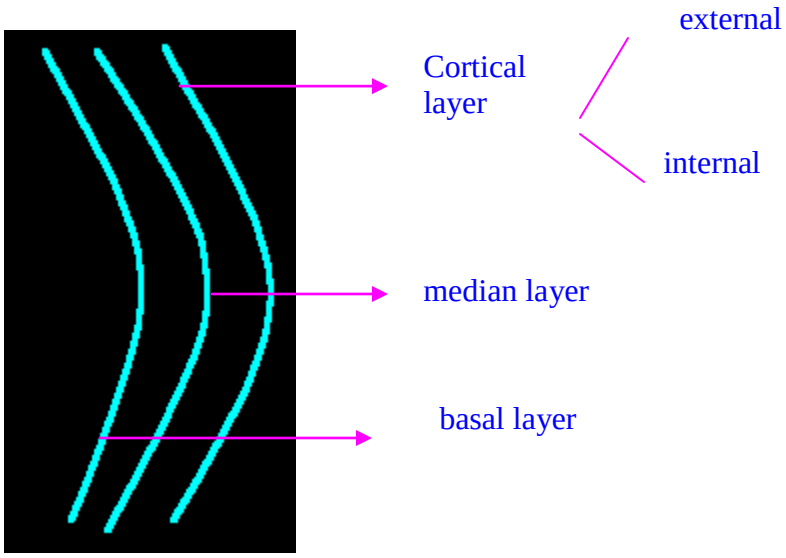
The cuticle or exoskeleton

The cuticle is a non living, non cellular, triple – layers covering that is secreted by the underlying hypodermis. The cuticle is flexible. It covers the entire body and lines the oesophagus, vulva, anus, cloaca, excretory pore and sensory organs. The feeding stylet and copulatory spicules are formed from cuticle.

The composition and from of the cuticle is highly variable. In general, the cuticle is composed of three primary zones viz., the cortical layer, median layer and basal layer.

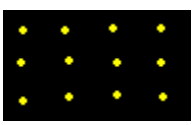
The cuticle of may nematodes have markings on the surface. They are varied and complex and have been often used by taxonomists to assist in the identification of various species. The cuticular markings are categorized into different types. I. Punctuation ii. Transverse marking or striations and iii Longitudinal markings.

Cuticle



i. Punctuations

These are minute, round dots arranged in a pattern. They act as structures for strengthening the cuticle rather than as pore canals through which cuticular proteins may be transported. In the perineal pattern of *Meloidogyne hapla* these punctuations can be seen.

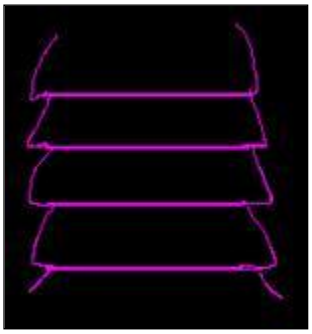


Punctuations **Cut RKN** **Perineal pattern**

ii. Transverse marking or Striations

There are transverse lines present on the surface of the cuticle. These markings exhibit distinct variations among the plant parasitic nematodes and often used by the taxonomists for identification. The transverse markings cause a pattern of ridges and furrows right from head to tail and these markings gives the false appearance as if the nematode is segmented. These markings are well pronounced in some families such as *Criconematidae, Tylenchidae* and *Heteroderidae*. In *Criconematids*, the annulations are clearly visible and known as scales and spines. The perineal pattern in the posterior body region of *Meloidogyne* females, as well as rugse wall pattern of *Heterodera* cysts, are considered to be the modifications of transverse markings.

Transverse marking



Criconematids- Annulations

iii. Longitudinal markings

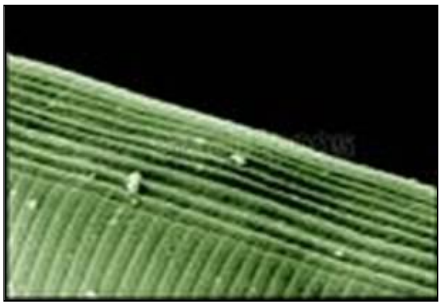
These markings are the lines on the cuticle, which runs longitudinally throughout the length of the nematode body. These markings are divided into **a) lateral lines or incisures and b) longitudinal ridges.**

a) Lateral lines or Incisures

These are lines running longitudinal to the body axis of nematode but they are confined to the lateral field in area just on top of lateral hypodermal chords on either side of the nematode body running throughout the length. The number of lateral lines or incisures is an important taxonomic character as it shows stability within the genus.

b) Longitudinal ridges

Longitudinal ridges are raised lines present on cuticle running longitudinal to nematode body axis but are confined in the area other than lateral field. The number of these ridges is used by taxonomists for species identification.



Longitudinal ridges

Apart from this, alae also present. They are thickening or projections of the cuticle which occur in the lateral or sublateral region. There are 3 types of alae. I. Caudal alae ii. Cervical alae and iii. Longitudinal alae.

i. Caudal alae

These are found in the posterior region and restricted to males as copulatory bursa.

Eg. *Hoplolaimus*

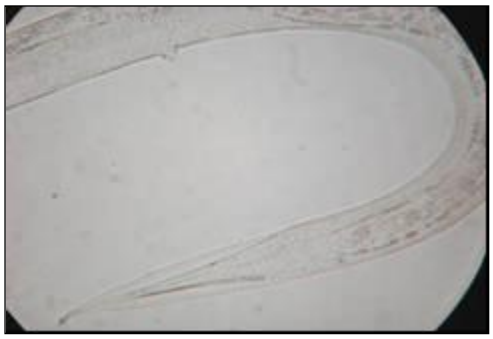
ii. Cervical alae

These are confined to the anterior part of the nematode body. Cervical alae are found in some species of marine nematodes.

Eg. *Toxcara*

iii. Longitudinal alae

The longitudinal alae delimit the later fields and are known as lateral alae. Their form varies in different species. They are transversed by striations or furrows varying in number from 1 to 12. Functionally, they probably assist in locomotion and may permit slight changes in the width of nematodes.



Eg. *Tripyla*

The functions of cuticle

Cuticle gives definite shape and size to the body, acts as an exoskeleton, helps in movement, being semipermeable, it regulates permeability and provides important taxonomic characters for identification of nematodes.

Somatic musculature

Platymyrian

A flat type of cell with contractile elements limited in places to the base lying close to the epidermis.

Coleomyarian

'U' shaped cells in which muscle fibre are adjacent and perpendicular to the hypodermis and extend along the sides of the muscle cell of varying distances.

Circomyarian

This type of muscle cells are almost round and the muscle fibres completely surround the cytoplasm

The platymyarian muscle cell is considered primitive which might have modified into coelomyarian type of narrowing and upward elongation of the fibrillar zone. Muscle cells are connected to each other by means of cytoplasmic bridges and have nerve connections.