TDC FIRST SEM MAJOR: PAPER :1

UNIT 6: NEMATHELMINTHES
GENERAL CHARACTERISTIC AND CLASSIFICATIONUP TO CLASSES
LIFE CYCLE, PATHOGENICITY OF ASCARIS LUMBRICOIDES AND WUCHHERIA BANCROFTI
PARASITIC ADAPTATION IN HELMINTHES

BY: DR. LUNA PHUKAN

Nemathelminthes/Aschelminthes
general characteristic and classificationup to classes

- The phylum 'Nemathelminthes' (Gr; nematos = thread ; helminths = worm) or Nematoda comprises the roundworms.
- Triploblastic, bilaterally symmetrical, vermiform, unsegmented cylindrical true worms with pseudocoel (i.e pseudocoelomate or blastocoelomate)
- Pseudocoelom / False coelom derived from embryonic blastocoel.
- Tube within a tube body plan, organ-system grade of body organization.
- Body round in cross section and covered with transparent cuticle composed of scleroprotein.

- A syncytial epidermis generally without cilia.
- Body wall has only longitudinal muscles.
- No distinct head, digestive tract complete usually surrounded by lips bearing sense organs.
- Alimentary canal of roundworms have both mouth and anus.
- Both respiratory and circulatory system are absent.
- Excretory system comprised of one or two renette cells or protonephridia.
- Nervous system consists of circumpharyngeal nerve ring and six longitudinal nerve cords.

- Presence of sensory papillae. (Amphids : in mouth, Phasmids : in anus)
- All are dioecious ; i.e. sexes are separate with sexual dimorphism. [1st unisexual phylum]
- Eggs with chitinous shell, cleavage determinate and spiral.
- Larval forms are : Rhabditiform, Filariform, Microfilariae etc.
- Classification : 5 classes [Rotifera, Gastrotricha, Kinorhyncha, Nematomorpha and Nematoda]
- Examples:
- Ascaris lumbricoides (Round worm)
- Wuchheria bancrofti (Filarial worm)

Introduction

Phylum Nemathelminthes comprise of animals commonly called nematodes or roundworms. These are widely distributed animals found throughout the world. The word ‘Nematoda’ is derived from Greek words; Nema (νῆμα) meaning thread and -ode (-ώδη) which means like Nematodes are one of the most common phyla of animals, with over 20,000 different described species, out of which 15,000 are parasitic in nature.

Habit and Habitat

Nematodes have successfully adapted to different kinds of environments and are ubiquitous. Free-living nematodes are found in freshwater, marine, as well as terrestrial environments.

In fact, they are so numerous that they generally more in number than other animals.

Nematodes are generally found in large numbers in the upper soil, often near the roots of the plants and detritus region. Their number however decreases with the increasing depth of the soil. Yet, one square meter of the bottom mud off Dutch coast has been reported tocontain 4,420,000 nematodes. Free-living nematodes can also be observed in areas with extreme environment conditions, such as hot springs, Polar Regions, Antarctica and oceanic terenches.

Value Addition: Amazing Fact
Heading Text: Nematodes – So Numerous!!!
Body Text: Nematodes can occur in dense numbers in the soil and rotting vegetation. For example, • As many as 90,000 roundworms have been found in a single rotting apple. • Millions of nematodes occur in the top 3cm (1 inch) of one m^2 of good quality soil.
Source: http://nematode2011.wikispaces.com/

Most of the species of nematodes live a parasitic life. They parasitize almost all groups of plants and animals. Many of these worms are pathogenic to man, other animals and plants. In case of animals, almost all nematodes live inside the body of host and live as endoparasites.

Body Organization

Nematodes are triploblastic, bilaterally symmetrical animals with organs system level of body organization. These are slender thread-like worms with a cylindrical body and thus are commonly called roundworms.

Value Addition: Interesting to Know!!

Heading Text: Famous Quote by a 20th Century Nematologist

Body Text: N. A. Cobb (1914) has said..."If all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable, and if, as disembodied spirits, we could then investigate it, we should find its mountains, hills, vales, rivers, lakes and oceans represented by a thin film of nematodes. The location of towns would be decipherable, since for every massing of human beings there would be a corresponding massing of certain nematodes. Trees would still stand in ghostly rows representing our streets and highways. The location of the various plants and animals would still be decipherable, and, had we sufficient knowledge, in many cases even their species could be determined by an examination of their erstwhile nematode parasites."

Fig.1: Nathan Augustus Cobb (1859-1932)

Source: http://en.wikibooks.org/wiki/Horticulture/Nematodes#cite_note-hickman-2

Most of the nematodes are less than 2.5 mm (0.098 in) in length. Many of the nematodes are microscopic. However, free-living soil nematodes can reach up to a length of 7 mm while a few marine species can be 5 cm (2.0 in) long. Some parasitic species can even reach up to a length of one meter.

Body Wall: (A) Thick Cuticle

The cuticle of nematodes is quite thick, tough and non-cellular in nature as compared to that present in other helminthes. It is covered by a thin, lipoid and tanned epicuticle. The cuticle is made up of three layers:

Value Addition: Did You Know??
Heading Text: Largest and Smallest Nematode
Body Text: Largest nematode in the world is *Placentonema gigantissima*. It lives in the placenta of sperm whales and can reach up to a length of approximately 27.6 feet (8.4 meters). **Smallest nematode** species known today is *Micronema,* which lives between individual grains of sediment. It can reach only a length of 0.012 inches (0.3 mm).
Source: http://www.storyofsize.com/nematoda/

a) Outer Cortical Layer: It is often ringed and divided into segments called annuli. It is a dense layer which contains hard keratin.

b) Middle Cortical Layer: This layer exhibits variation depending on the species. It is spongy and may have granules, fibrils or skeletal rods.

c) Basal Layer: the innermost layer is highly fibrous consisting of collagen fibres and is often striated in appearance.

As the cuticle is very hard and thick, growth in young ones is accompanied by the shedding of the old cuticle, called moulting, which is followed by the formation of a new cuticle.

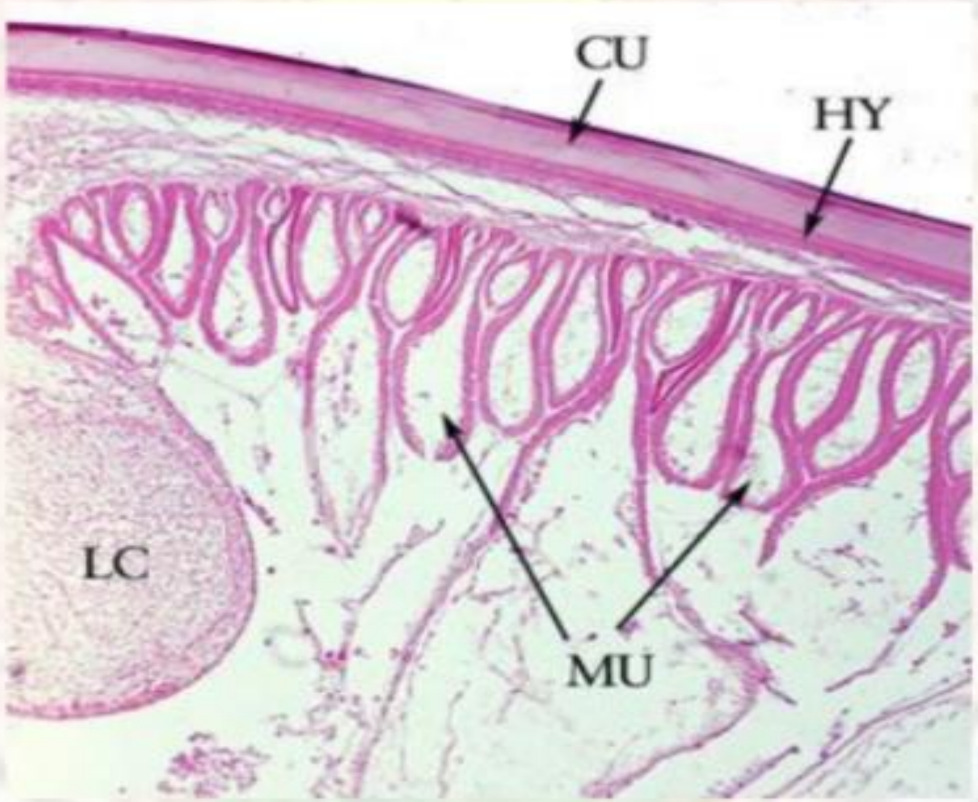

Fig. 2: Cross-section of an adult *Ascaris lumbricoides* showing different layers of the body wall

CU - cuticle, HY - hypodermis immediately below the cuticle, MU - prominent muscle cells and LC - one of the lateral chords

Source: http://www.dpd.cdc.gov/dpdx/HTML/ImageLibrary/a-f/ascariasis/body_Ascariasis_il5.htm

Thick cuticle provides many advantages to the nematodes.
a) It protects them from the diverse nature and osmotic stress of external environmentb) It is resistant to the digestive juices and thus provides an adaptation for the gut parasites.

(B) Syncytial Epidermis

The epidermis, also called hypodermis, of nematodes is partly or completely syncytial in nature. The word 'Syncytium' has been derived from two Greek words; syn (σύν), which means together, and kytos (κύτος), which means a box (cell). A syncytium is a multinucleated cell which is formed from typical cellular epithelium by break down of membranes between two cells. The syncytial epidermis has thus continuous cytoplasm and looks like single multinucleated cell.

Syncytial epidermis is less permeable than the cellular epithelium. It helps nematodes to live in the diverse habitats as it protects them from osmotic stress of the external environment. The hypodermis of nematodes is invaginated and expands at four places forming ridges. These are

- one mid-dorsal
- one mid-ventral
- two mid-laterals

These ridges, called longitudinal cords divide the body into four quadrants and extend along the length of the body.

(C) Thick Musculature – Only Longitudinal Muscles

The muscle layer present below the epidermis is very thick and made up of only longitudinal muscles. The circular muscles are completely absent in the body wall of nematodes. These are present between the four longitudinal cords. Each muscle fibre has a muscle tail which extends towards either the dorsal or ventral longitudinal cord.

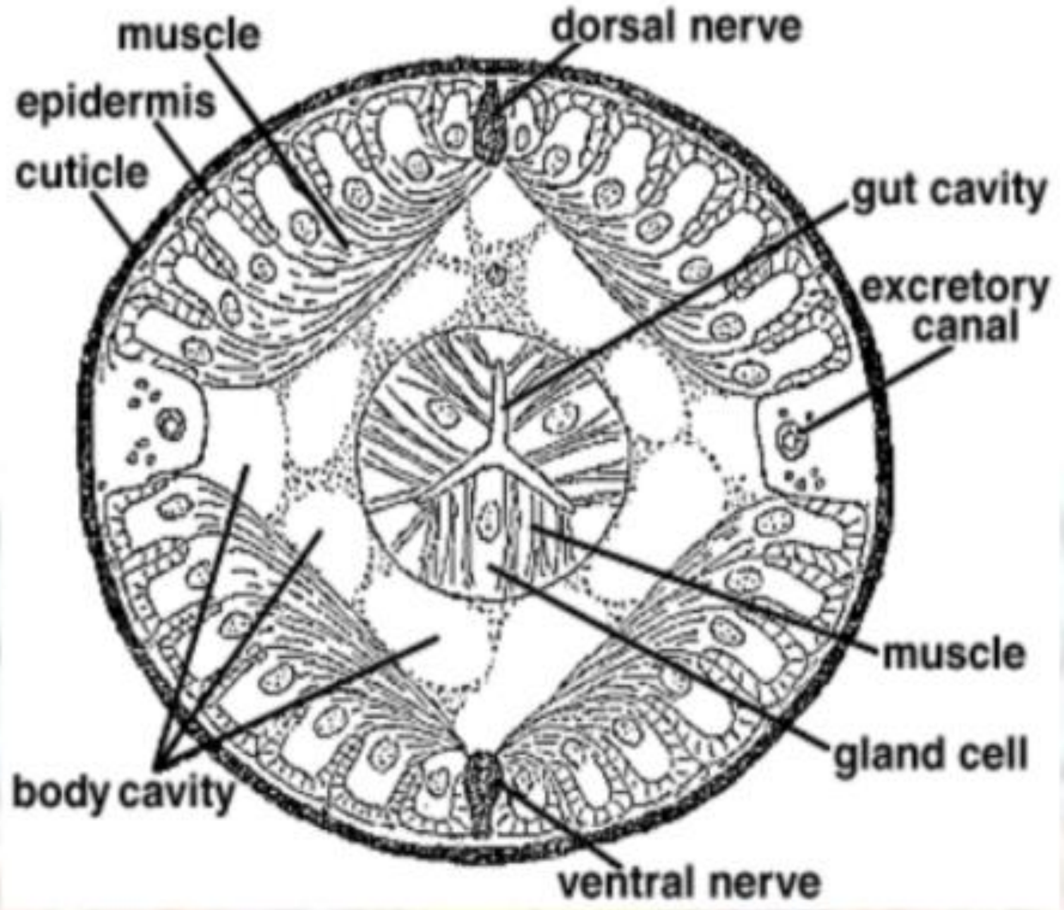

Fig. 3: Transverse section of *Ascaris lumbricoides* showing thick longitudinal muscles in four quadrants of body wall

Source: http://sharon-taxonomy2009-p2.wikispaces.com/Nematoda

Presence of Pseudocoleom

The body cavity of nematodes is a persistent blastocoel, called pseudocoel as it is not lined by coelomic epithelium. It is bound on the outer side by muscles while by cuticle on the inner side. Pseudocoel contains a fluid rich in proteins, and organic metabolites. It also contains a few phagocytic cells which help in defense of the body. The pseudocoelomic fluid is under pressure and serves as a hydrostatic fluid.

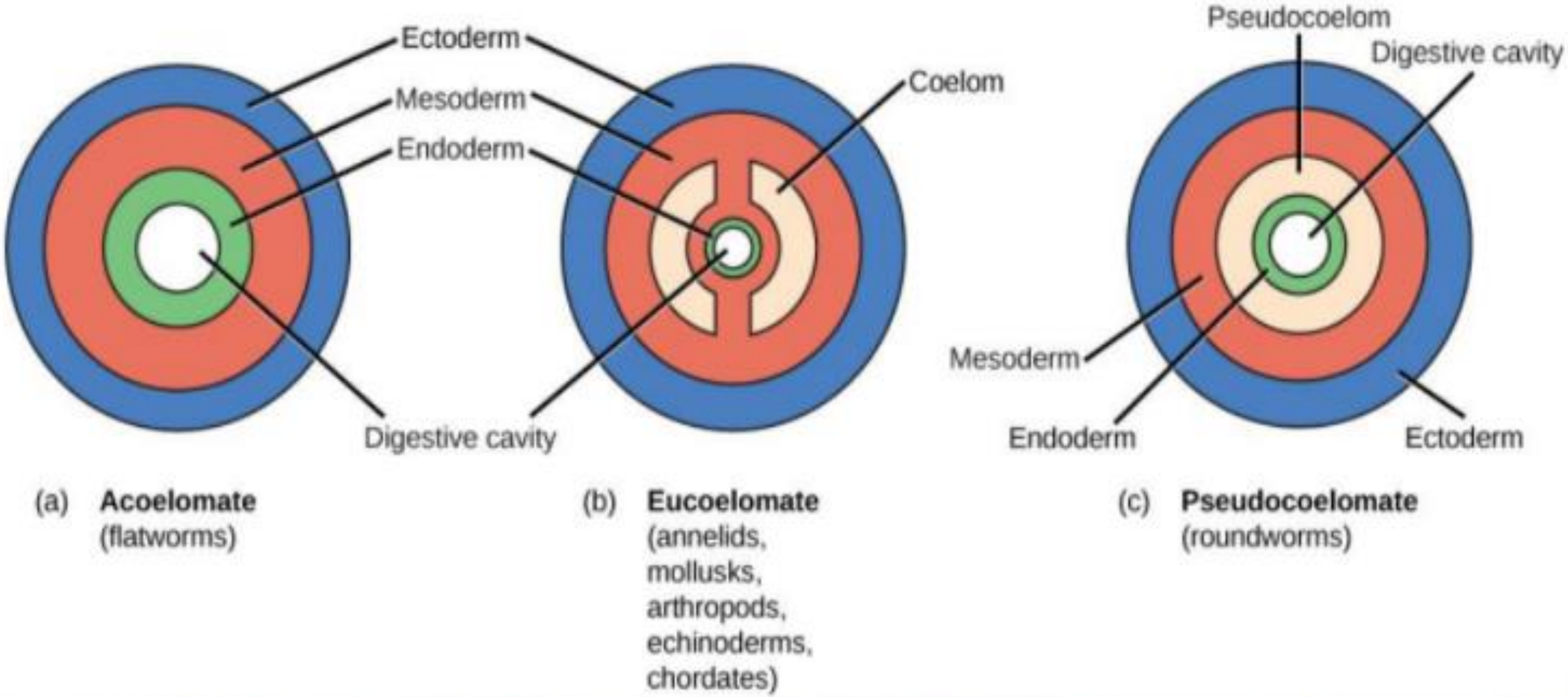

Fig. 4: Comparison of coelom in (a) Platyhelminthes, (b) Annelida and (c) Nematodes

Source: http://cnx.org/content/m47416/latest/

Locomotion

Most of the nematodes exhibit undulating movement in dorso-ventral plane.

The movement is produced by alternate contraction and expansion of the longitudinal muscles, as circular muscles are absent in the nematodes.

The other kinds of movement shown by different species of nematodes are swimming, crawling and springing.

Many nematodes move from one place to other using other organisms, such as dung beetles and birds.

Digestive System and Nutrition

- Nematodes are the first major group of animals to have a complete and straight digestive tract with two separate openings, mouth and anus.
- The mouth of the nematodes is guarded by lips which have sensory organs, amphids, and characteristic of nematodes. Amphids are chemoreceptors which detect the chemical nature of food.
- Mouth leads to oral cavity lined with cuticle and strengthened with ridges or teeth.
- The oral cavity opens into a muscular and sucking pharynx. It has pharyngeal glands which secrete digestive enzymes.
- Pharynx leads directly to intestine which further produces digestive enzymes and also absorbs digested food.
- The last portion of the intestine is called rectum which expels waste through the anus.
- The intestine has valves or sphincters at each end which prevents food from being forced out of intestine because of pressure of pseudocoelomic fluid and thus, controls the movement of food through the body.

Nematodes have different kinds of nutrition based on their habitat. Many free-living nematodes are carnivorous while others are phytophagous. Nematodes are known to feed upon algae, diatoms, fungi and bacteria too. Some nematodes live on dead or decaying organic matter and a few feed on soil particles. Intestinal parasitic nematodes, however ingest pre-digested food from the body of host.

Excretion and Osmoregulation

Nematodes do not have special flame cells, like Platyhelminthes. Aquatic nematodes excrete nitrogenous waste in the form of ammonia that diffuses through the body wall. However, osmoregulation in nematodes requires special complex excretory structures. Many marinenematodes have one or two renette cells which extend into pseudocoel and excrete salt through a pore close to the pharynx.

Most of the terrestrial nematodes excrete urea as the major excretory product. They have an H-shaped excretory system consisting of two parallel ducts connected by a single transverse duct. A common canal arises from this transverse duct which opens through the excretory pore and throws away the excreta.

Nervous System

The nervous system of nematodes comprises of a dense, circum-pharyngeal nerve ring surrounding the pharynx which serves as the brain and four peripheral longitudinal nerves -

1 dorsal, 1 ventral and 2 lateral. Smaller nerves run forward from the ring to supply the sensory organs of the head.

The different sense organs present in the nematodes are:

Sensory bristles: Bristles are present throughout the body of nematodes. These are tactile receptors and sensitive to touch.

Papillae: The lips of the nematodes contain a number of papillae. Like bristles, they are also tactile receptors.

Amphids: These are pouch-like invaginations of the cuticle and are present on each side of the head or on the lips. These are well supplied with nerve cells, and are probably chemoreceptive in function.

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Amphids: These are pouch-like invaginations of the cuticle and are present on each side of the head or on the lips. These are well supplied with nerve cells, and are probably chemoreceptive in function.

Ocelli: A few aquatic nematodes possess ocelli-like structures but their function is not yet certain.

Phasmids: In some nematodes, especially parasitic nematodes, a pair of unicellular glands is present on the either side of the tail.

Reproductive System

Unlike flatworms, most of the roundworms are dioecious. The males and females are separate with well developed gonads and exhibit sexual dimorphism. Male nematodes are usually smaller than females and have a characteristically curved tail which helps in copulation.

Gonads are unpaired or paired and are tubular or coiled. In males, the reproductive system opens at cloaca while in females, it open at vulva.

The cloaca of males has a pouch containing one or more copulatory spicules.

Reproduction is usually sexual. During copulation the spicules protrude out from the cloaca and inserted into the vulva of females releasing sperms.

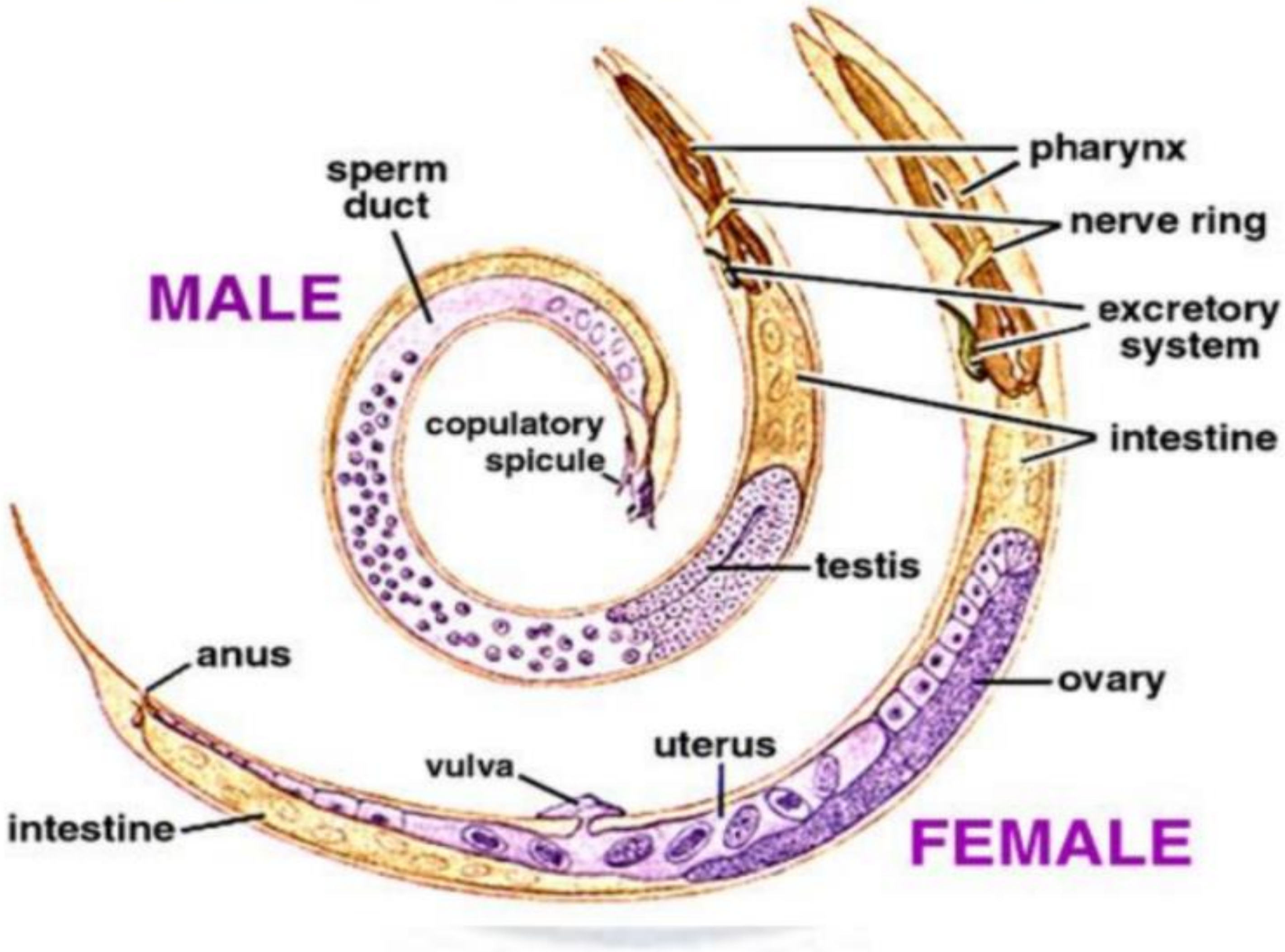


Fig. 5: Anatomical features of male and female nematode showing different body systems

Fertilized eggs released by females are protected by an outer shell and undergo determinate cleavage.

The eggs hatch into larvae which generally undergo four moults to reach sexual maturity.

The life cycle is much more complicated in parasitic nematodes which is completed with or without intermediate hosts.

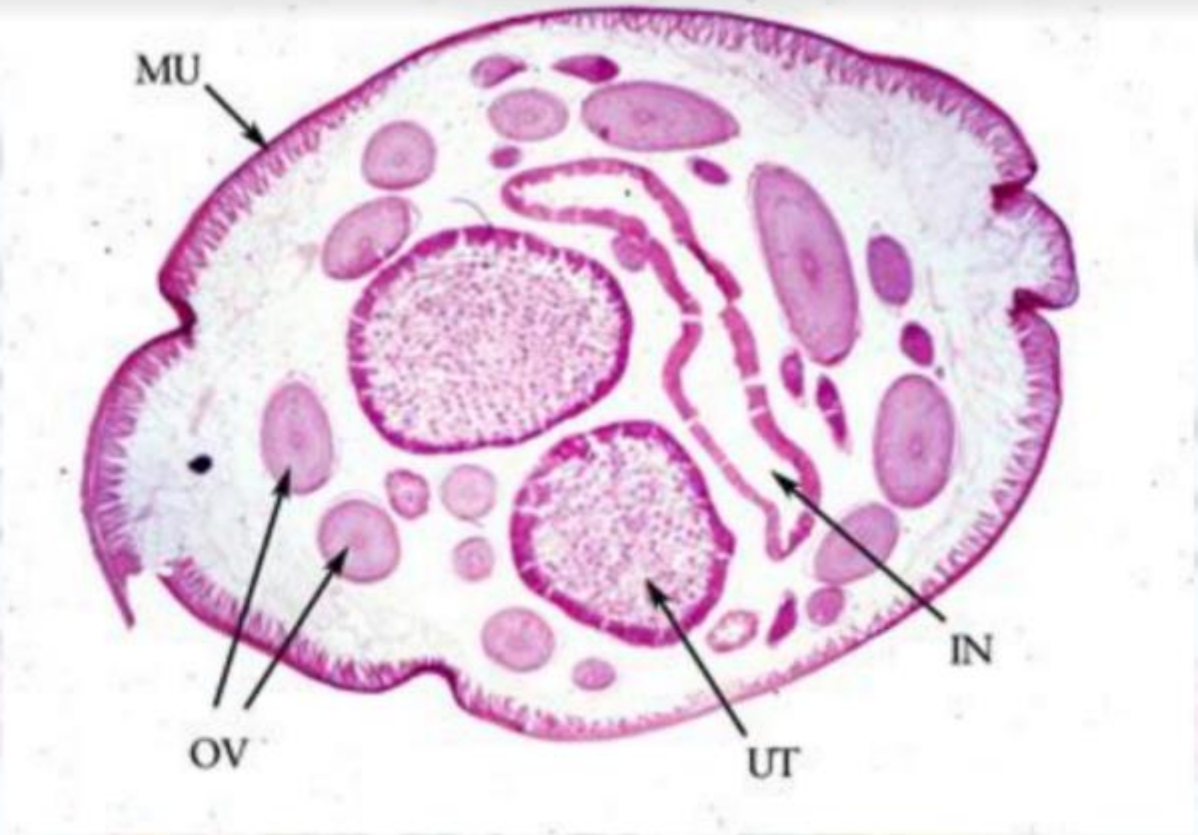


Fig. 6: Cross-section of an adult female *Ascaris lumbricoides* showing the presence of the prominent muscle cells (MU), gravid uterus (UT), intestine (IN) and coiled ovary (OV).

Value Addition: Do You Know??
Heading Text: Androdioecy in Nematodes
Body Text: The nematode model species *Caenorhabditis elegans* and *C. briggsae* exhibit a special feature, **androdioecy**, which is very rare among animals. The species of these animals are composed of a male population and a distinct hermaphrodite population. In some species (such as *Caenorhabditis elegans*) the hermaphrodite can mate with each other as well as with males, while in others (such as *Eulimnadia texana*) they can only self-fertilize or mate with the male population.
Source: http://en.wikipedia.org/wiki/Nematodes; http://en.wikipedia.org/wiki/Androdioecy

Classification of Phylum Nemathelminthes

Phylum Nemathelminthes is divided into two classes based on the presence or absence of phasmids.

a) Adenophorea or Aphasmidia

- are XiphinePhasmids, the sensory organs in the caudal end, are absent.
- Amphids are variably-shaped and are present behind the lips.
- Excretory canals are absent
- Most species are free living and some are parasitic.
- Free living species include almost all marine forms; and some terrestrial and
- freshwater forms
- A few examples ma, Mermis and Enoplus.

b) Secerenentea or Phasmidia

- Phasmids are present which open through minute pore on each side near tip of
- tail.
- Amphids are pore-like and are present in the lateral lips.
- Excretory canals are present.
- Most of the species are parasitic in nature.
- Free living species are soil inhabitants.
- A few examples are Ascaris, Wuchereria, Oxyuris, Ancylostoma and Dracunculus

A Few Common Nematodes

Table 1: A few free-living nematodes

Genus	Habitat
Rhabditis	Soil, organic matter, faeces of animals
Caenorhabditis elegans	Soil
Mermis nigrescens	Vegetation
Thoracostoma	Sea water

Table 2: A few nematodes parasitic on human beings

Nematode	Habitat of adult	Digenetic/ monogenetic	Primary Host	Secondary Host
Ascaris lumbricoides **(Common roundworm)**	Small intestine	Monogenetic	Human beings	-
Wuchereria bancrofti **(Filarial worm)**	Lymphatic sytem	Digenetic	Human beings	Different species of mosquitoes. In India: *Culex fatigans pipiens*
Ancylostoma duodenale **(Hook worm)**	Small intestine	Monogenetic	Human beings	-
Enterobius vermicularis **(Pin worm)**	Upper part of colon	Monogenetic	Human beings	-
Dracunculus medinensis **(Guinea worm)**	Deeper layers of skin, esp. arms, legs and shoulders	Digenetic	Human beings	Cyclops
Trichuris trichiura **(Whip worm)**	Large intestine, mainly the caecum of vermiform appendix	Monogenetic	Human beings	-

Summary

- Phylum Nemathelminthes comprises of animals commonly called nematodes or roundworms.
- Nematodes are ubiquitous and are found in freshwater, marine, as well as terrestrial environments.
- Most of the species of nematodes live a parasitic life, though a number of free-living forms are also present.
- These are triploblastic, bilaterally symmetrical animals with organs system level of body organization.
- Body is elongated, cylindrical, unsegmented and vermiform.
- Size of the nematodes varies considerably in different species.
- Body is covered by a resistant, inelastic and thick cuticle which is covered by a thin and lipoid epicuticle.
- Epidermis is syncytial in nature and is invaginated into four longitudinal cords.

- Epidermis is syncytial in nature and is invaginated into four longitudinal cords.
- Body wall has thick muscle layer composed of only longitudinal muscles which are present between four cords.
- The body cavity is a pseudocoel and is not lined by coelomic epithelium. It contains pseudocoelomic fliuid rich in proteins, and organic metabolites.
- Nematodes exhibit undulating movement in dorso-ventral plane produced by alternate contraction and expansion of the longitudinal muscles.
- Circulatory and respiratory system are absent.

- Digestive tract is straight and complete with two openings, mouth and anus.
- Flame cells are absent and excretory system consists of a few renette cells or a canal system.
- Nervous system comprises of a circum-pharyngeal nerve ring surrounding the pharynx and four peripheral longitudinal nerves.
- Sense organs are poorly developed and include amphids, phasmids, papillae, bristles and ocelli.
- Sexes are separate with distinct sexual dimorphism.

- Nervous system comprises of a circum-pharyngeal nerve ring surrounding the pharynx and four peripheral longitudinal nerves.
- Sense organs are poorly developed and include amphids, phasmids, papillae, bristlesand ocelli.
- Sexes are separate with distinct sexual dimorphism.
- Gonads are unpaired or paired and are tubular or coiled.
- Sexual reproduction is the common form of reproduction.
- Fertilized eggs are surrounded by a tough capsule.
- Cleavage is determinate and development includes usually four larval stages.
- Development of embryo takes place with or without intermediate hosts.
- Phylum Nemathelminthes is divided into two classes, Aphasmidia and Phasmidia,based on the absence or presence of phasmids.

Differentiate between
a) Amphids and Phasmids
b) Pseudocoelom and Eucoelom
c) Aphasmidia and Phasmidia
Q2. Name the following
a) Excretory cells of nematodes
b) Multinucleated epidermis of nematodes
c) Chemoreceptors present on the lips of Ascaris
d) A digenetic nematode
e) A soil nematode
f) Excretory product of aquatic nematodes
g) A hermaphrodite nematode
h) Process of shedding old cuticle in larval forms

Answer the following questions in short.

(a) Why do nematodes exhibit enormous diversity in nature?

(b) What is the significance of sphincters present at both the ends of intestine in a nematode?

(c) Write the advantages of presence of thick cuticle in the body wall of a nematode.

(d) List the sensory organs present in the nematodes with their functions and location.

(e) How do male nematodes differ from the female nematodes?

Q4. Answer the following questions in detail.

(a) Classify Phylum Nemathelminthes till class and write the characteristic features of
each class. Support your answer with suitable examples.

(b) List the features which make nematodes more advanced animals than
Platyhelminthes.

(c) Describe the structure of body wall of a nematode.

(d) Give a few examples of parasitic nematodes and their hosts.

(e) Write the distinguishing features of Phylum Nemathelminthes.

Classification of phylum Aschelminthes/Nemathelminthes

Aschelminthes is classified into five classes

Class 1 Nematoda

(Nema: thread)

They are endoparasites

Body is Bilaterally symmetrical and vermiform.

Body covered in a complex cuticle.

Sexes are separate

Examples: Ascaris (round worm), Ancyclostoma (hook worm), Enterobius (pinworm)

Class 2 Rotifera

They are minute microscopic aquatic
Sexes are separate
Excretion: two protonephridia tubes
Examples: Brachionus, Colotheca, Philodina

Class 3 Gastrotricha

They are minute aquatic free living
Sexes are separated or united
Excretory organ: present or absent
Examples: Urodasys, macrodasys, Chaetonot

Class 4 Kinorhyncha

Minute microscopic marine

Body is internally segmented

Sexes are separates

Development: indirect (with larval form)

Examples: Echinoderes, Centroderes

Class 5 Nematomorpha

They are long slender un-segmented worm

Known as hair worm

Sexes are separate

Examples: Nectonema, Gordiu

Glossary

Amphids: Sensory organs, chemoreceptive in function, present on or behind the lips of nematodes

Bilateral synmmetry: The symmetry in which an animal can be divided into two equal halves only along one plane; saggital plane

Definitive host: Host in which the parasite passes its sexual adult life; also called primary or final host

Digenetic parasite: Parasite that requires two hosts; definitive and intermediate; to complete its life cycle

Endoparasite: Parasite that lives within the body of host for its nutrition

Moulting: Shedding of old cuticle in larval forms to enable them to grow in size.

Nematoda:Thread-like animals

Phasmids: Sensory organs present on the caudal part of nematodes

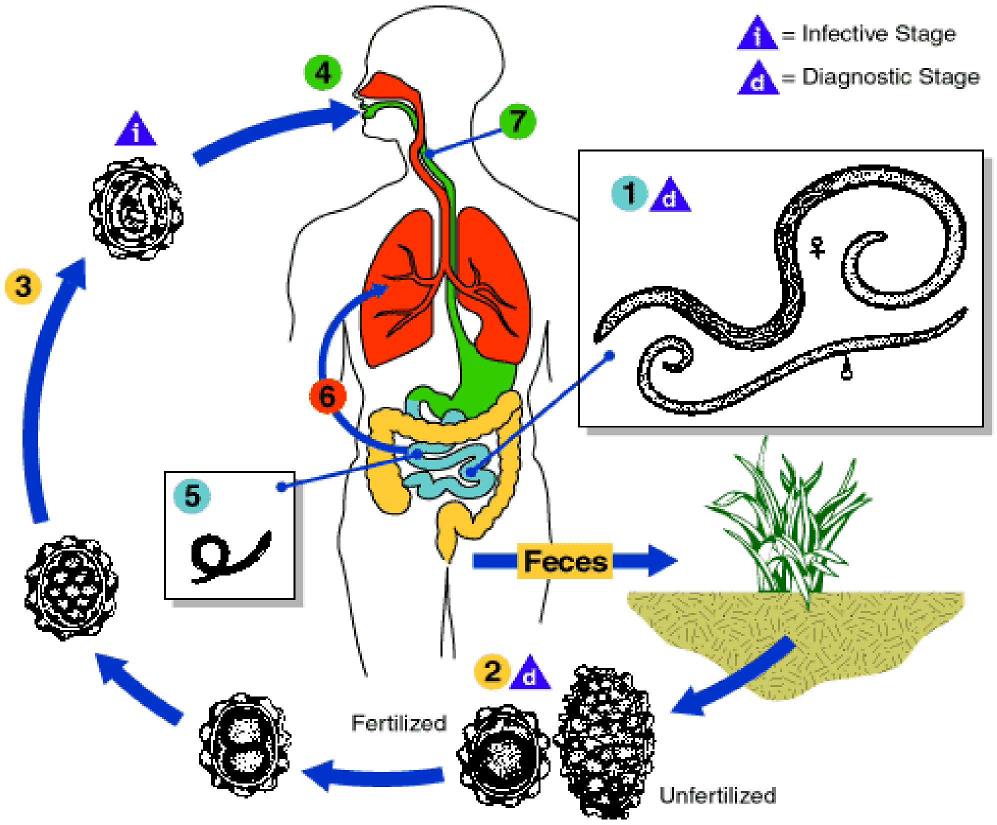
Pseudocoel: Persistent blastocoel not lined by coelomic epithelium

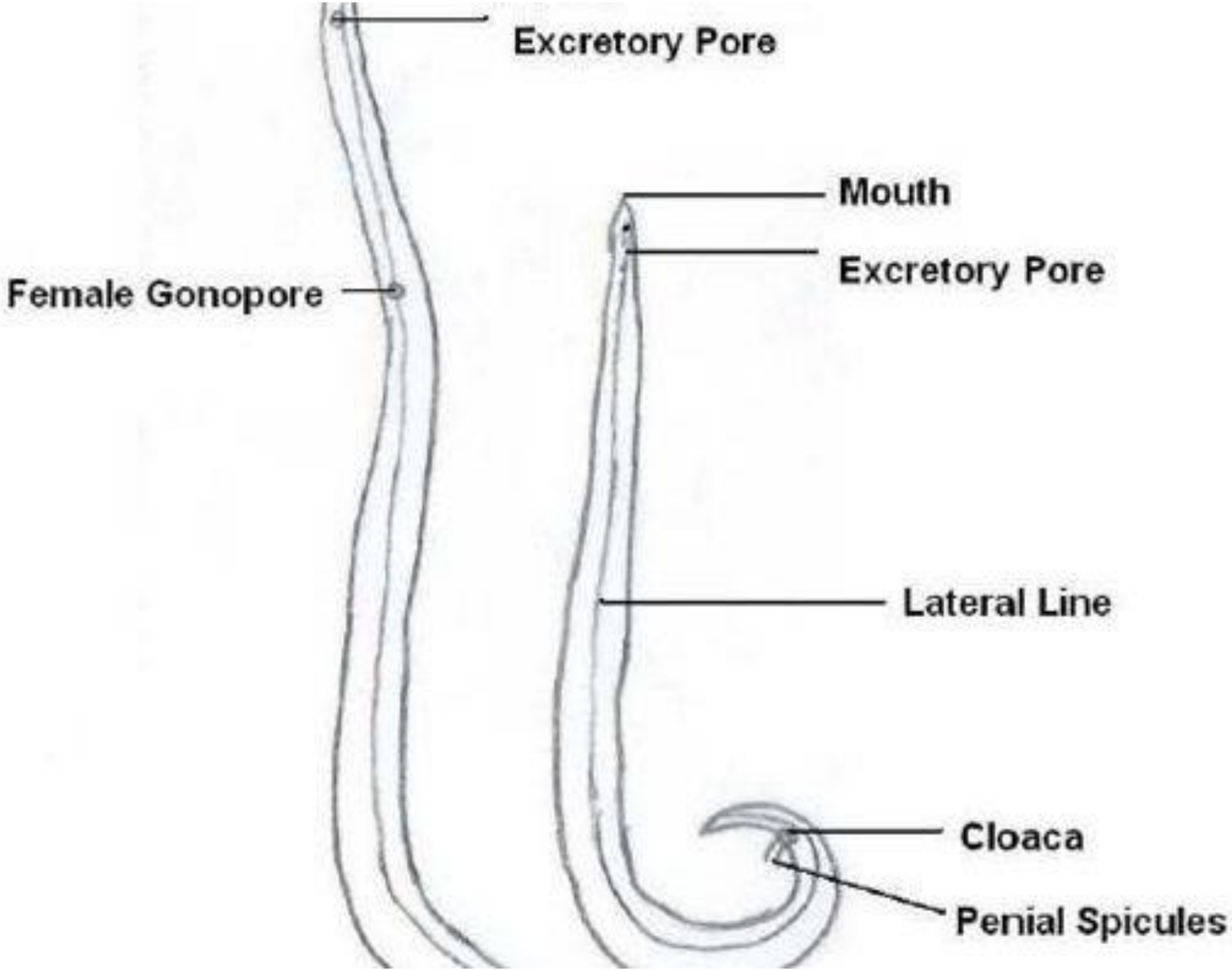
Renette cells: Excretory cells present in marine nematodes

Syncytial epidermis: Acellular and multinucleated epidermis

Sexual dimorphism: Conspicuous morphological differences between male and female

Llife cycle, pathogenicity of ascaris lumbricoides




Excretory Pore
Female Gonopore
Mouth
Excretory Pore
Lateral Line
Cloaca
Penial Spicules

Ascaris lumbricoides is an intestinal round worm. It is the largest intestinal nematode to infect Human.

The adult worm lives in small intestine and grow to a length of more than 30 cm. Human is only the natural host and reservoir of infection.

The round worm infection occurs worldwide. The number of infected persons is estimated to be more than 2 billion.

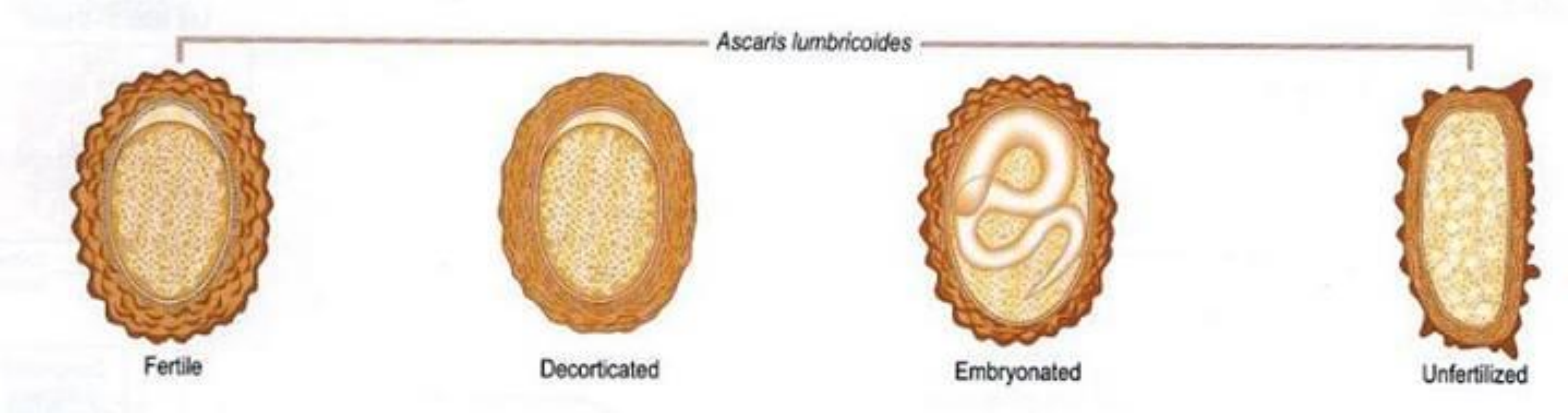
The main epidemic region with prevalence rate of approx. 10-90% includes countries on South east Asia, Africa and latin America.

The worm is sexually diamorphic.

Adult male: 15-30 cm in length, 3-4 mm in diameter, tail curved
Adult female; 20-40 cm length, 2-6mm diameter, tail straight
Egg:

Ascaris egg is round or oval, 60*40 µm size, thick brown shell and have rough surface. It is the infective form of parasite.

i) Un fertilized egg; large, more elongated (38-55*78-105) µm
ii) fertilized egg; ovoid (35-50*50-70)µm, golden brown color



Adult worm lives in small intestine

Stages in life cycle:

Stage I: Eggs in faeces

Sexually mature female produces as many as 200,000 eggs per day, which are shed along with faeces in unembryonated form.

They are non infective

Stage II: Development in soil

Embryonation occurs in soil as optimum temperature of 20-25C with sufficient moisture and O2

Infective larva develops within egg in about 3-6 weeks.

Stage III: Human infection and liberation of larvae

Human get infection with ingestion of embryonated egg contaminated food and water

Within embryonated state inside egg, first stage larvae develops into second stage larvae. This second stage larvae is known as Rhabtitiform larvae

Second stage larve is stimulated to hatch out by the presence of alkaline pH in small intestine and solubilization of its outer layer by bile.

Stage IV: migration of larvae through lungs

Hatched out larvae penetrates the intestinal wall and carried to liver through portal circulation

It then travels via blood to heart and to lungs by pulmonary circulation within 4-7 days of infection.

The larvae in lungs molds twice, enlarge and breaks into alveoli.

Stage V: Re-entry to stomach and small intestine

From alveoli, the Larvae then pass up through bronchi and into trachea and then swallowed.

The larvae passes down the oesophagus to the stomach and reached into small intestine once again.

Small intestine is the normal habitat of Ascaris and it colonises here.

Within intestine parasite molds twice and mature into adult worm.

Sexual maturation occurs with 6-10 weeks and the mature female discharges its eggs in intestinal lumen and excreted along with faeces, continuing the life cycle.

The life span of parasite is 12-18 months

Pathogenesis:

1. Mode of transmission:

faeco-oral route, by contaminated vegetables or water.

2. Pathogenesis:

Infection of A. lumbricoides in man is known as Ascariasis. There are two phase in ascariasis.

Phase I: migrating larvae

The migrating larvae causes pathological lesions. The severity of lesions depends upon the sensitivity of host, nutritional status of host and number of migrating larvae.

During migration and molding through lungs, larvae may causes pneumonia with low grade fever, cough and other allergic symptoms.

Phase II: Adult worm

Few worm in intestine produce no major symptoms and but some time give abdominal pain especially in children.

The adult worm produce trauma in host tissue and the wandering adults may block the appendical lumen or common bile duct and even small intestine.

Large number of adult worms affects the nutritional status of host by robbing the nutrition leading to malnutrition and growth retardation in children.

The metabolites of living or dead worm are toxic and immunogenic.

lumbricoides also produces various allergic toxin, which manifests fever, conjunctivitis and irritation.

Clinical manifestation:

Most of the Ascaris infection is asymptomatic.

Symptomatic ascariasis; two types

Intestinal Ascariasis

Pulmonary Ascariasis

1. Intestinal ascariasis;

Nausea,Vomiting ,Colicky abdominal pain ,Abdominal distention

Weight loss and diarrhea ,Malbasorption of nutrition

Growth retardation

Heavy worm in children leads to intussusception and total obstruction

Complications: Appendicitis, Biliary colic and perforation of bile duct, Hepatomegaly

2. Pulmonary ascariasis;

Transient eosinophilic pneumonitis (loeffler's disease); elevated IgE

Bronchospasm

Dyspnea and wheezing

Fever

Non-productive cough and chest pain

Lab diagnosis:: Specimen: stool, sputum

Microscopy: examination of stool by saline emulsion or concentration by floatation methods employed to unembryonated egg :X-ray

Serodiagnosis: Indirect haemagglutination test, Immuno-fluorescence assay

Ultrasonography and CT scan

Other test: blood count shown peripheral eosinophilia

Treatment and prophylaxis:

Mebendazole: drug of choice, (100mg twice a day for 3 days)

Albendazole: 500mg single dose

Pyrantel pamoate: single dose of 10mg/kg weight

Piperazine citrate

Control Measures:

- Isolation of the Hospitalized Patient: Standard precautions are recommended.
- Sanitary disposal of human feces stops transmission.
- Children's play areas should be given special attention.
- Vegetables cultivated in areas where human feces are used as fertilizer must be thoroughly cooked or soaked in a dilute iodine solution before eating.
- Household bleach is ineffective.

life cycle, pathogenicity of Wuchheria bancrofti

Copulation

The adult Wuchereria bancrofti resides in the lymphatics of the human host (Fig. 8). Male and female parasites live together; coiled with each other so strongly that it becomes very difficult to separate them.

Copulation between male and female adults takes place in the lymph glands of human beings.

During copulation, male adults of Wuchereria bancrofti grasp females with the help of coiled tail region.
The sensillae and copulatory spicules located around the cloacal region of males help them to open the vulva and vagina of females and transfer the sperms. Reports are available which evidently prove the involvement of sex pheromones in attracting mates. In addition, evidences suggest that males possess a chemosensory apparatus required for recognition of such signals

2 Release of Microfilariae

The females of Wuchereria bancrofti are ovo-viviparous. Thus, instead of laying eggs like many other
nematodes, they liberate numerous active embryos, called juveniles or microfilariae in the lymphatic channels

Structure of Embryos or Microfilariae

Microfilariae are very active in habit and are microscopic. The peculiar morphological characteristics of the larvae are presented in Table

Characteristic Features	*Microfilaria bancrofti*
Shape	Elongated, filiform with blunt head and pointed tail (Fig. 10)
Length	200 to 300 µm approx.
Width	6 to 7 µm wide
Colour	Colourless or transparent
Covering	A hyaline/transparent sheath

The detailed stained structure of the microfilaria shows the following features:

(a) Hyaline sheath:

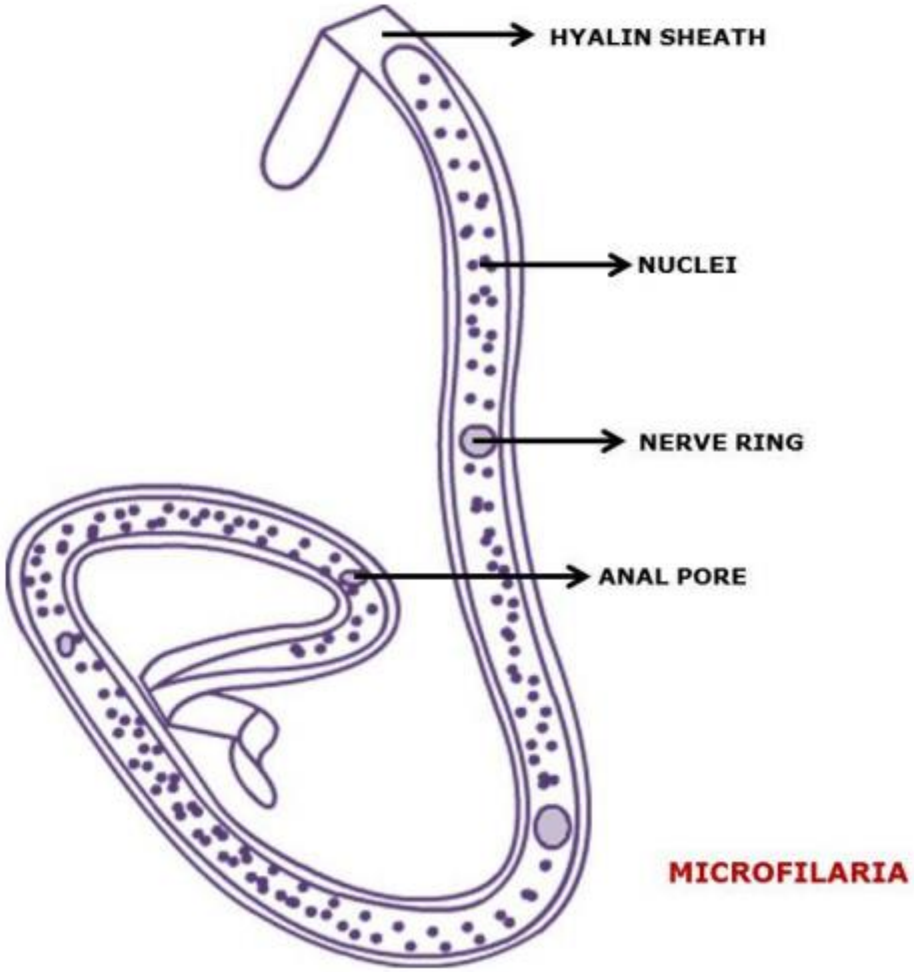
The body of microfilariae is covered with a transparent sac called hyaline sheath. It is made up of flattened epithelial cells. The sheath being 359 µm long, is larger than the size of microfilariae .The ends of the sheath project beyond the ends of the embryo so that they can move easily within it.

(b) Subcuticular cells:

Cuticula is lined by special cells, called subcuticular cells which are visible only when stained with vital stains.

(c) Nuclei:

Another diagnostic feature of microfilariae is the presence of numerous nuclei in their cytoplasm. These nuclei appear as granules and are clearly visible after staining . However certain areas lack these nuclei which serve as the distinguishing feature of microfilariae.


HYALIN SHEATH
NUCLEI
NERVE RING
ANAL PORE
MICROFILARIA

These areas signify the following regions of microfilariae :
(i) Anterior end, called cephalic space
(ii) Tail end, called anal space (terminal 5%)
Further, granules are broken at definite places, which help in the identification of species. These are:
(i) Nerve ring – visible as oblique space
(ii) Excretory system – Anterior V-spot representing the rudimentary excretory system
(iii) Anus or cloaca – Posterior V-spot representing the opening of digestive system

Circulation of Microfilariae in Human beings

The microfilariae released by adult Wuchereria bancrofti into the lymph vessels are very active andquickly enter the main lymphatic trunks. Eventually, they find their way into the circulating blood . Though, generally, they move with the blood stream, but they are capable of moving against the blood stream too. Ultimately, microfilariae migrate to deeper blood vessel and stay there for further development. The microfilariae need a lower temperature for their further development and thus, they stay in human beings as newly emerged larvae. The average life span of microfilariae in human body is approximately 70 days. For further development, the larvae need their intermediate host, i.e. Culex mosquito. If they are not sucked by these mosquitoes, they die and disintegrate in the human body.

Nocturnal Periodicity of Microfilaria bancrofti:

during day time the microfilariae reside in the large and deeper blood vessels of various organs, such as lungs, kidneys, heart and large arteries. However, during night, they appear in the peripheral blood vessels, especially between 10 pm to 4 am, to be sucked by Culex.

This is called nocturnal periodicity. Similarly, in Pacific islands, Aedes polynesiensis is the intermediate host of Wuchereriabancrofti which can feed on human blood throughout the day and night. Thus, in those regions, the microfilariae do not exhibit any periodicity and are found in the peripheral blood throughout.

How does Wuchereria recognize its environment? It has been reported that Wuchereria bancrofti lacks visual abilities and depends on its sensory receptors to detect chemicals in its environment and pheromones released by other members of its species.

Moreover, tactile papillae present on various parts of the body assist them for tactile communication with the environment and food. The periodicity of the worm is correlated with the lifestyle patterns of its human host.

Through its chemosensory abilities, the worm detects the difference in oxygen levels between arterial and venous blood vessels which is indicative of decreased oxygen intake and lessened host activity. These conditions signify the night time and the feeding time of Culex mosquito. Thus, when Wuchereria bancrofti senses even a small difference in the oxygen content between venous and arterial blood vessels, it migrates to the peripheral circulation.

It increases the chance of ingestion by Culex leading to dispersal to other hosts (Ash and Schacher, 1971; Cox and Chappell, 1993; Napier, 1994).

Development of Microfilariae in Culex Mosquito

When female Culex adults suck the blood of an infected individual, the sheathed microfilariae are also ingested with the blood. They reach the stomach of mosquito where they lose their sheaths.

Within 1-2 hrs, the microfilariae (without any sheath) penetrate the wall of stomach and migrate to the muscles of thorax or wings for further development.

Microfilaria in the mosquito body passes through three larval stages, which takes approximately 2 weeks.

First stage larva: In the next 2 days of their migration to the thoracic muscles, the slender unsheathed microfilaria develops into first stage larva. It measures 124 to 250 µm in length, 10 to 17 µm in breadth and is much thicker, shorter and sausage-shaped with spiky tail

Second stage larva: Within next 3-7 days, the first stage larva sheds its cuticle, thickens, enlarges and metamorphoses into second stage larva. It measures approximately 225 to 330 µm in length and 15 to 30 µm in breadth.

Third stage larva: The second stage larva enters into the third stage on 10-11th day of development. This is almost five times to that of second stage and measures about 1,500 to 2,000 µm in length and 18 to 23 µm in width. The spiky tail degenerates, while various organs; such as digestive and genital organs; and the body cavity are well developed.

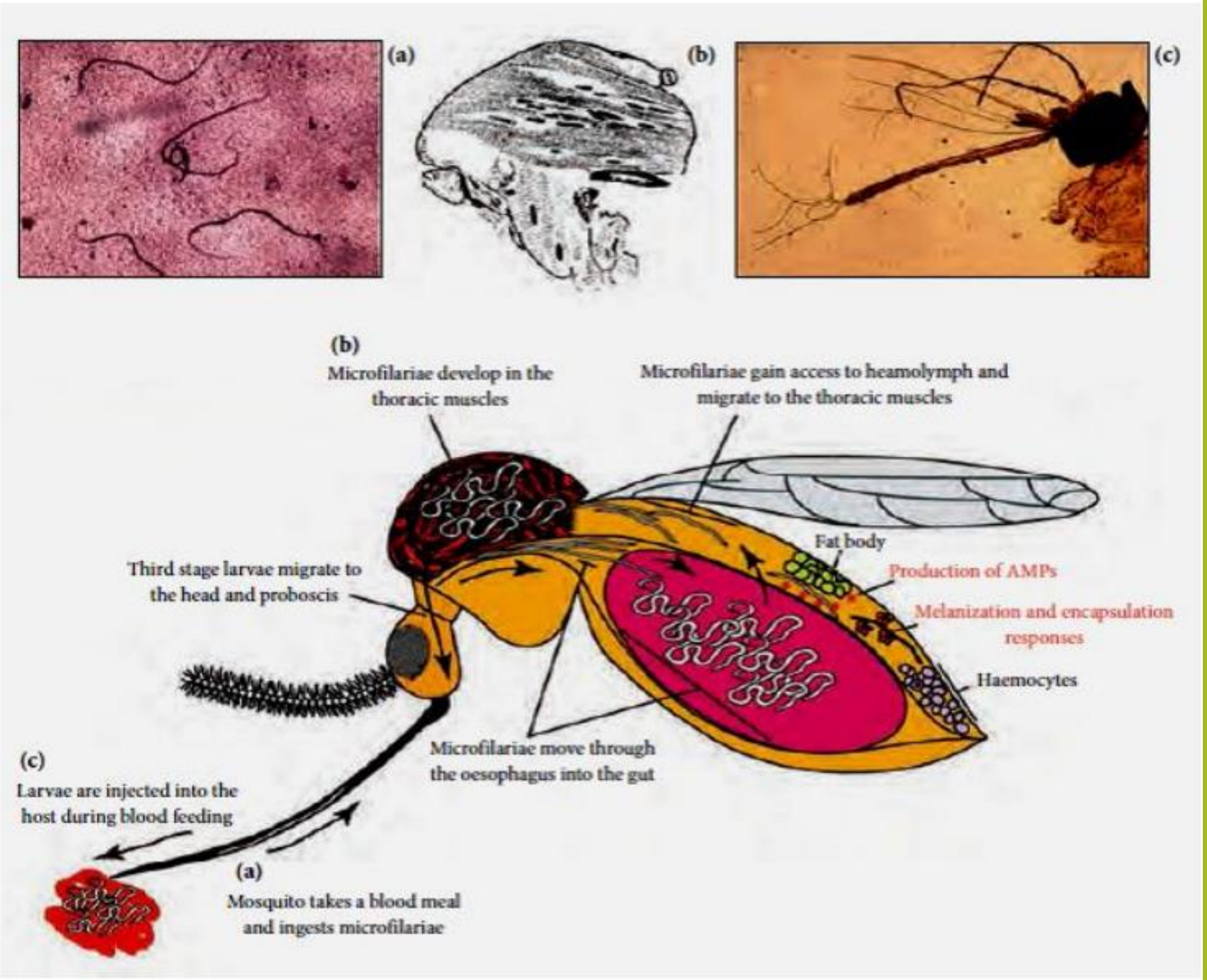
The third stage larva is infective to man: On about 14th day, it migrates to the proboscis of the mosquito. It cannot develop further in the mosquito as it needs higher temperature for maturation into adult. The third stage larva waits for the new human host for its development.

Microfilariae of Wuchereria bancrofti;

(a)L1 in human blood;

(b) (b) L2 in the thoracic muscles of mosquito;

(c) L3 emerging from the proboscis of mosquito



Larval Stage	Duration of Development	Length	Width
First Stage	2 days	124 - 250 µm	10 - 17 µm
Second Stage	3-7 days	225 - 330 µm	15 - 30 µm
Third Stage	10-11 days	1,500 - 2,000 µm	18 - 23 µm

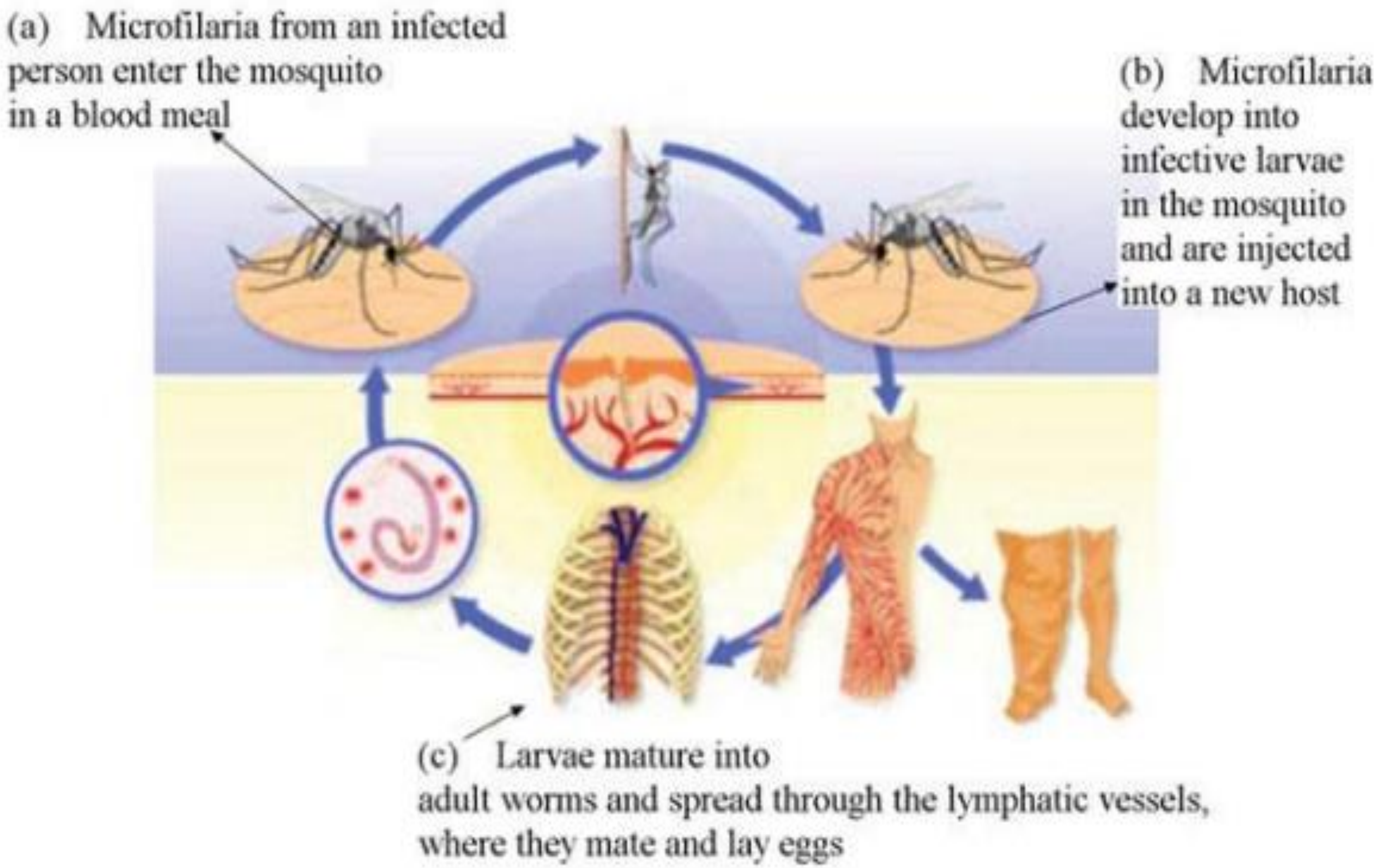
Larval stages of Wuchereria bancrofti in mosquito body

Maturation of Microfilaria into Adult

The infection of Microfilaria bancrofti takes place to a new human host when the infected Culex mosquito sucks the blood of a healthy human being. While sucking blood, the female Culex mosquito releases the third stage larva on the skin of the host near the site of puncture.

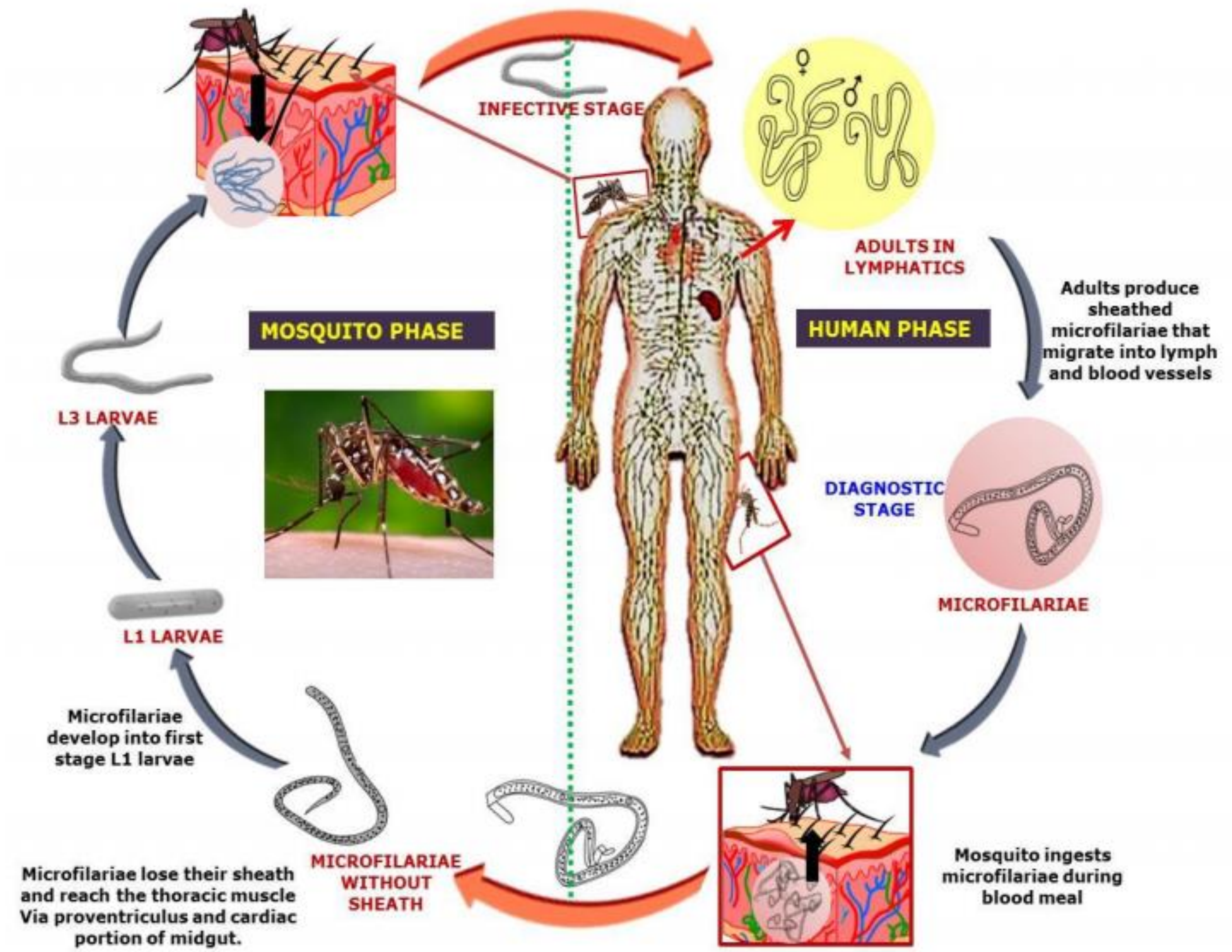
The larvae get attracted by the warmth of human body and invade the skin either through the puncture or on their own. The larvae migrate through the subcutaneous tissues, reach the lymphatic vessels and accumulate at a particular lymphatic region; especially inguinal, scrotal and abdominal lymphatics. The larvae accumulated in the lymphatics go through two moults and begin to grow into mature adults.
After approximately 5-18 months, they gain sexual maturity .

The male and female live together in coiled forms and undergo copulation. Female Wuchereria bancrofti gives birth to new generation of microfilariae and whole cycle repeats .



A diagrammatic sketch of the life cycle of Wuchereria bancrofti

Detailed Life cycle of Wuchereria bancrofti



Factors Affecting the Transmission of Filarial Worm

The transmission of M. bancrofti is considered to be less efficient than that of other vector-borne parasites, for example as compared to the transmission of malaria parasite and dengue virus. This is because of various factors that limit the transmission of filarial worm.

(a) Number of ingested microfilariae: The microfilariae do not multiply in the mosquito body. Therefore, the number of L3 which a mosquito has and can transmit is limited by the number of microfilariae ingested by mosquitoes.

(b) Longevity of mosquito: The development of microfilariae in the body of a mosquito takes about 12- 14 days. Consequently, only those mosquito adults that have more than 15-20 days of longevity will contribute to transmission of the parasites. The adults that die before the development of L3 cannot play a role in the transmission cycle.

(c) Release of microfilariae: As the mosquito does not inject L3 into the human body but deposit them on the skin near the puncture, the larvae cannot enter the human body until they find their way into the bite wound.
(d) Biting rate of the mosquito: The rate of transfer of microfilariae from a human host to a mosquito vector is proportional to the biting rate of the mosquito. The higher is the biting rate of mosquito; more is the probability of a mosquito picking up microfilariae leading to increased transmission.
(e) Prevalence of disease: The spread of the disease in a community depends upon the intensity of infection and the number of infectious hosts available who should have appreciable density of circulating microfilariae in their peripheral blood.

Impact on mosquitoes: The filarial development in mosquitoes can result in their mortality, if the blood sucked by mosquitoes has large number of microfilariae, as they can cause considerable damage to the mosquito's gut and thoracic muscles. Moreover, the emergence of L_3 from the flight muscles can result in irreparable damage to the muscles, hampering the mosquito from flying and causing its death.

(g) Environmental conditions: The transmission of the microfilariae also depends upon the local environmental conditions such as, rainfall, temperature, humidity and soil type which affect the breeding sites and the survival of adult mosquitoes.

It is clear from the above factors that the intensity of filarial worm transmission depends on the number of infectious hosts carrying microfilariae, biting rate of the mosquitoes and the proportion of surviving mosquitoes carrying L_3 larvae.

Thus, in order to disrupt filarial worm transmission and to ensure that no new infection occurs, the intensity of microfilariae or the vector density must be brought down below a threshold which varies because of the heterogeneity of the vector–parasite relationship.

The relationship between a host, vector and a parasite can be evaluated by following indices.

(a) Transmission potential of a mosquito:

It is calculated as: Mean number of infective larvae (L3) per infective mosquito X The estimated biting rate of the vector for a given period. As transmission potential during a month varies seasonally with biting density, the annual transmission potential is a useful indicator of the risk for lymphatic Filariasis transmission.

(a) Vector infection rate:

This is the percentage of mosquitoes infected with filarial worms and is calculated as follows:

$$\frac{\text{Number of mosquitoes with any stage of microfilariae} \times 100}{\text{Number of mosquitoes dissected}}$$

(c) **Vector infective rate:** The percent mosquitoes infected with L3 infective stage is calculated as follows:

$$\frac{\text{Number of mosquitoes with L3 stage of the worm} \times 100}{\text{Number of mosquitoes dissected}}$$

(d) Monthly infective biting rate: The estimated number of infective mosquitoes biting a human per month are:

Vector infective rate X Monthly vector-biting rate

(e) Annual infective biting rate: The estimated number of infective mosquitoes biting a human per year is calculated as

Vector infective rate X Annual vector-biting rate

(f) Monthly transmission potential: It indicates the infection risk per month and includes the number of infective larvae rather than the infective mosquitoes. It is calculated as:

$$\frac{\textit{Total number of infective larvae (L3)} \times \textit{Monthly vector-biting rate}}{\textit{Number of mosquitoes dissected}}$$

(g) **Annual transmission potential**: It is indicative of the infection risk per year and is calculated from:

$$\frac{\textit{Total number of infective larvae (L3)} \times \textit{Monthly vector-biting rate}}{\textit{Number of mosquitoes dissected}}$$

Summary of Characteristic Features in the Life Cycle of Wuchereria bancrofti

Feature	Characteristic
Mode of infection	Through the bite of mosquitoes
Vector for transmission	Female mosquitoes; *Aedes*, *Culex* and *Anopheles* In India: *Culex pipiens fatigans*
Infective stage	Third stage larva of *Microfilaria bancrofti*
Portal of entry	Skin
Migration of larva	Peripheral blood vessels to deeper blood vessels in various organs
Site of localisation	Lymphatic system, most commonly inguinal region
Pathogenic stage	Adult *Wuchereria;* sometimes Microfilaria
Pathogenesis	Adult – Lymphangitis, lymphadenitis, enlargement of limbs due to blockage of lymph flow – elephantiasis, hydrocoele, chyluria Microfilaria – Eosinophilia, hepatosplenomegaly, enlargement of lymph nodes
Diagnostic stage	Microfilariae

Diagnosis

A blood smear is a simple and fairly accurate diagnostic tool, provided the blood sample is taken during the period in the day when the juveniles are in the peripheral circulation.

Technicians analyzing the blood smear must be able to distinguish between W. bancrofti and other parasites potentially present.

A polymerase chain reaction test can also be performed to detect a minute fraction, as little as 1 pg, of filarial DNA.

Some infected people do not have microfilariae in their blood. As a result, tests aimed to detect antigens from adult worms can be used.

Ultrasonography can also be used to detect the movements and noises caused by the movement of adult worms.

Dead, calcified worms can be detected by X-ray examinations.

TREATMENT

The severe symptoms caused by the parasite can be avoided by cleansing the skin, surgery, or the use of anthelmintic drugs, such as diethylcarbamazine, ivermectin, or albendazole. The drug of choice is diethylcarbamazine, which can eliminate the microfilariae from the blood and also kill the adult worms with a dose of 6 mg/kg/day for 12 days, semiannually or annually.

A polytherapy treatment that includes ivermectin with diethylcarbamazine or albendazole is more effective than either drug alone.

Protection is similar to that of other mosquito-spread illnesses; one can use barriers both physical (a mosquito net), chemical (insect repellent), or mass chemotherapy as a method to control the spread of the disease.

Mass chemotherapy should cover the entire endemic area at the same time. This will significantly decrease the overall microfilarial titer in blood in mass, hence decreasing the transmission through mosquitoes during their subsequent bites.

Antibiotic active against the Wolbachia symbionts of the worm have been tested as treatment. Wolbachia-free worms immediately become sterile, and later die prematurely.

Prevention

Prevention focuses on protecting against mosquito bites in endemic regions. Insect repellents and mosquito nets are useful to protect against mosquito bites. Public education efforts must also be made within the endemic areas of the world to successfully lower the prevalence of W. bancrofti infections.[citation needed]

Eradication

The WHO is coordinating an effort to eradicate filariasis. The mainstay of this programme is the mass use of antifilarial drugs on a regular basis for at least five years.

In April 2011, Sri Lanka was certified by the WHO as having eradicated this disease.

Summary

Wuchereria bancrofti is one of the most dreadful nematodes largely confined to the tropical and sub-tropical regions of the world affecting more than 120 million people.

- It is an endoparasite and is commonly found in the lymphatic vessels and lymph nodes of human beings particularly in the groin regions.
- Male and female Wuchereria are separate and exhibit distinct sexual dimorphism.
- Wuchereria bancrofti is a digenetic parasite and requires two hosts to complete its life cycle. Man is the only primary host, while a large number of species of mosquito belonging to the genus; Culex, Aedes and Anopheles act as secondary hosts

- In India, Culex pipiens fatigans is the principal intermediate host which is a nocturnal feeder.
- Copulation between male and female adults takes place in the lymph glands of man.
- The female Wuchereria are ovo-viviparous and liberate numerous microfilariae in her lifetime.
- The microfilariae are covered with a hyaline sheath and possess numerous nuclei which areabsent from head, anal region, nerve ring and excretory pore of the body.
- The microfilariae enter the circulating blood and do not undergo any further development in the
- human beings as they need a lower temperature for their development.
- In India, microfilariae exhibit nocturnal periodicity as during night, they appear in the peripheralblood vessels, especially between 10 pm to 4 am, to be sucked by Culex; while during day time they reside in the large and deeper blood vessels of various organs

- When mosquitoes suck the blood of an infected individual, the sheathed microfilariae are ingested with the blood and reach the stomach of mosquito.
- Within 1-2 hrs they lose their sheaths and penetrate the wall of stomach migrating to thoracic muscles or wing muscles for further development.

- Within next 14 days, the microfilariae pass through three larval stages, third larval stage being theonly infective stage which migrates to the proboscis of mosquito.
- Infection to a new host takes place when the infected mosquito bites a human being.
- The larvae are deposited on the human skin from where they enter human body generally through the site of mosquito bite.

- The larvae accumulate in the lymph glands and attain sexual maturity within 5-18 months. The intensity of filarial worm transmission depends on the number of infectious hosts carrying microfilariae, biting rate of the mosquitoes and the proportion of surviving mosquitoes inhabiting
- L3 larvae.

THANK YOU