NEMATODES
ANCYLOSTOMA DUODENALE

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NEMATODES

When we talk about nematodes, we take Caenorhabditis elegans .

Caenorhabditis elegans is one of the most important model organisms in modern biology. It is a tiny free-living nematode (roundworm) widely used in genetic, developmental, and biomedical research because of its simple body structure, transparent body, short life cycle, and well-mapped cell lineage.

Major achievements associated with *C. elegans* include:

- It was the first multicellular animal (metazoan) to have its entire genome sequenced.
- Research on this organism contributed to three Nobel Prize–winning discoveries:
- Because many of its genes are similar to human genes, *C. elegans* continues to be an essential organism for studying development, aging, neuroscience, and human diseases.

1. Programmed cell death (apoptosis) — understanding how cells naturally die during development.
2. RNA interference (RNAi) — a mechanism where RNA molecules silence specific genes.
3. Development and application of green fluorescent protein (GFP) as a marker to study gene expression in living organisms.

Classification of nematodes on the basis of the habitat of adult worm:

Sl. No.	Intestinal human nematodes	Somatic human nematodes
1.	Small intestine:	2. Lymphatics
	a. Ascaris lumbricoides (common roundworm) b. Ancylostoma duodenale (Old World hookworm) c. Necator americanus (American or New World hookworm) d. Strongyloides stercoralis e. Trichinella spiralis f. Capillaria philippinensis	a. Wuchereria bancrofti b. Brugia malayi c. Brugia timori

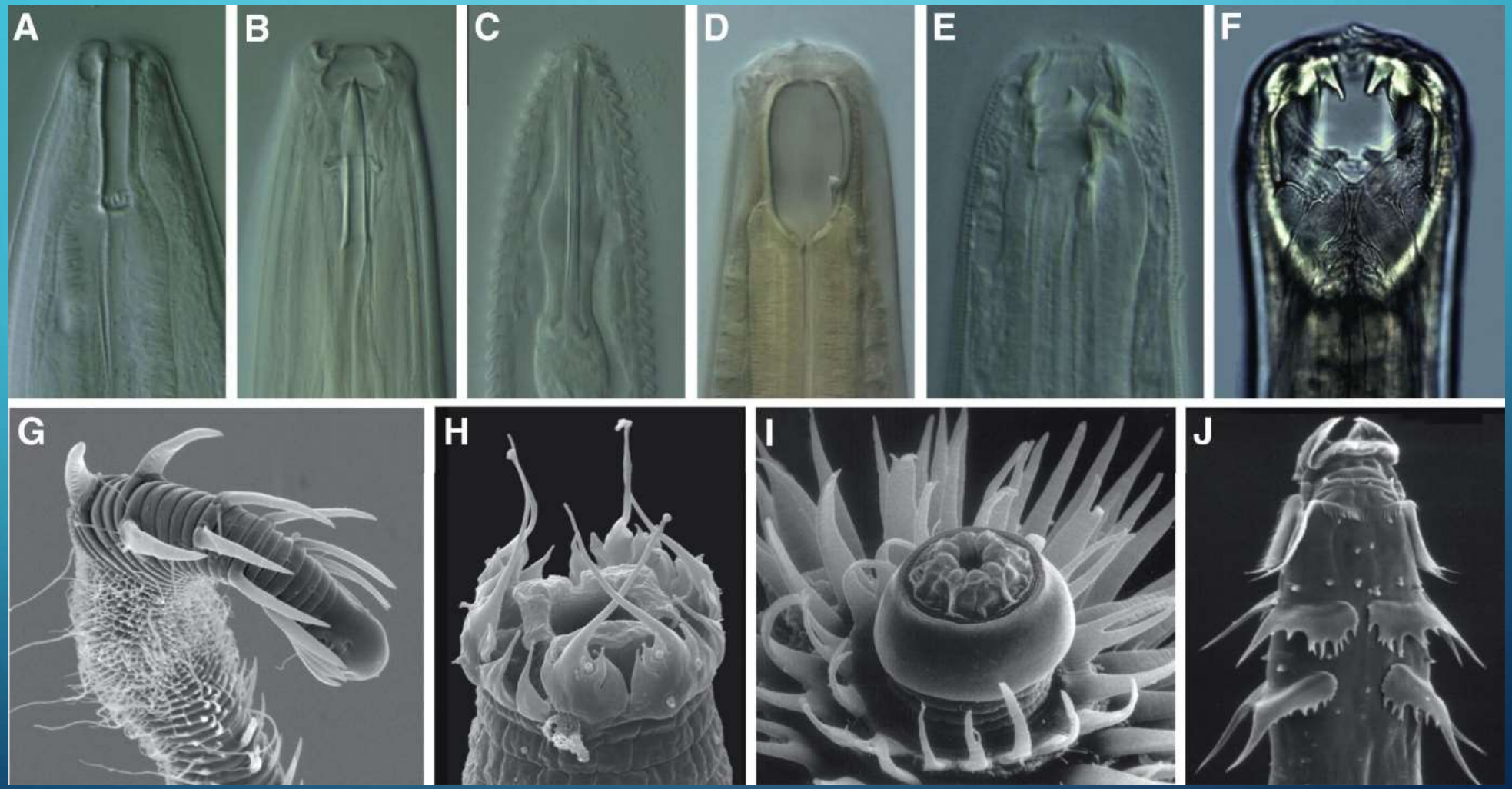
		3. Skin/ subcutaneous tissue
		a. Loa loa b. Onchocerca volvulus c. Dracunculus medinensis (guinea worm)
		4. Mysentery
		a. Mansonella ozzardi b. Mansonella perstans
5.	Large intestine	6. Conjunctiva
	a. Trichuris trichiura (whipworm) b. Enterobius vermicularis (thread or pin worm)	a. Loa loa

As their name suggests, nematodes typically possess a long, slender, thread-like body ("nema" is derived from the Greek word for thread), unlike the segmented bodies of earthworms. Nematodes are said to be the most worm-like of all *helminths*.

Their body structure consists essentially of a tube within a tube: the intestine and gonads are enclosed by the body wall, which contains dorsal and ventral longitudinal muscles, an epidermis, and a protective cuticle. Between the inner and outer tubes lies a pressurised, fluid-filled cavity that functions as a hydrostatic skeleton. This arrangement enables nematodes to move gracefully in sinusoidal waves while resting on one side.

In most nematode species, males and females are separate individuals, although some species are hermaphroditic, possessing both male and female reproductive organs within the same organism. Their size varies greatly, ranging from microscopic forms to giants measuring up to 7 metres (23 feet) in length, with the largest species occurring as parasites in whales.

Several species are commonly referred to as hookworms, lungworms, pinworms, threadworms, whipworms, and eelworms. These worms are responsible for numerous diseases, including filariasis, ascariasis, and trichinosis, and they also infect many domesticated animals and agricultural crops.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HOOKWORM

Hookworm have been known since very ancient times. They have been referred to in the Ebers Papyrus (Circa 1600 BC):

Two species of hookworms are known to be human parasites:

***1. Ancylostoma duodonale* and**

2. Necator americanus.

Ancylostoma duodenale

Ancylostoma duodenale **(Old World hookworm) in [*Greek ankylos – hooked, stoma – mouth*] is a parasitic nematode. It was originally described by Dubini in 1843 in Italy. The life cycle was worked out by Looss in 1898 in Egypt**

It is a parasitic nematode with a direct life cycle, infecting humans via skin penetration by filariform larvae (L3) from soil. Larvae migrate through the blood to the lungs, are swallowed, and mature into adults (8–13 mm) in the small intestine, attaching via two pairs of teeth to feed on blood. Eggs passed in faeces hatch and require warm, moist conditions to become infective.

MORPHOLOGY:

In infected individuals, adult worms are found in the small intestine, predominantly in the jejunum, less frequently in the duodenum, and only occasionally in the ileum.

Adult Worm:

- They are relatively stout cylindrical worm
- The worms are pale greyish or pinkish, but may appear reddish-brown due to ingested blood, with a slight bend at the anterior end (hook shape). This cervical curvature gave it the name hookworm.

- The mouth is not at the tip but directed dorsally. They possess a well-developed buccal capsule with six teeth, four hook-like teeth ventrally and two knob-like teeth with a median cleft dorsally.

Male worm:

- **Generally smaller than female, 8–11 mm in length, 0.4 mm thick, with a prominent posterior copulatory bursa, which is three-lobed.**

There are 13 fleshy chitinous rays, five each in lateral lobes and three in dorsal lobe. The dorsal ray is partially divided at the tip and each division is tripartite. The pattern of the rays helps in distinguishing between different species

- The cloaca into which the rectum and genital canal open isituated within the copulatory bursa.
- There are two long retractile bristle-like copulatory spicules, the tips of which projects from the bursa.

Female worm:

- The female worm is larger, and stouter, measuring 10–13 mm long and 0.6 mm thick.
- Its hind end is conoid, with a subterminal anus situated ventrally.

The vulva opens ventrally at the junction of the middle and posterior third of the body

- The vagina leads to two intricately coiled ovarian tubes, which occupy the hind and middle parts of the worm.

During copulation, the male attaches its copulatory organ bursa to the vulva. The copulating pair, therefore, presents a Y-shaped appearance

EGG:

The egg of hookworm is:

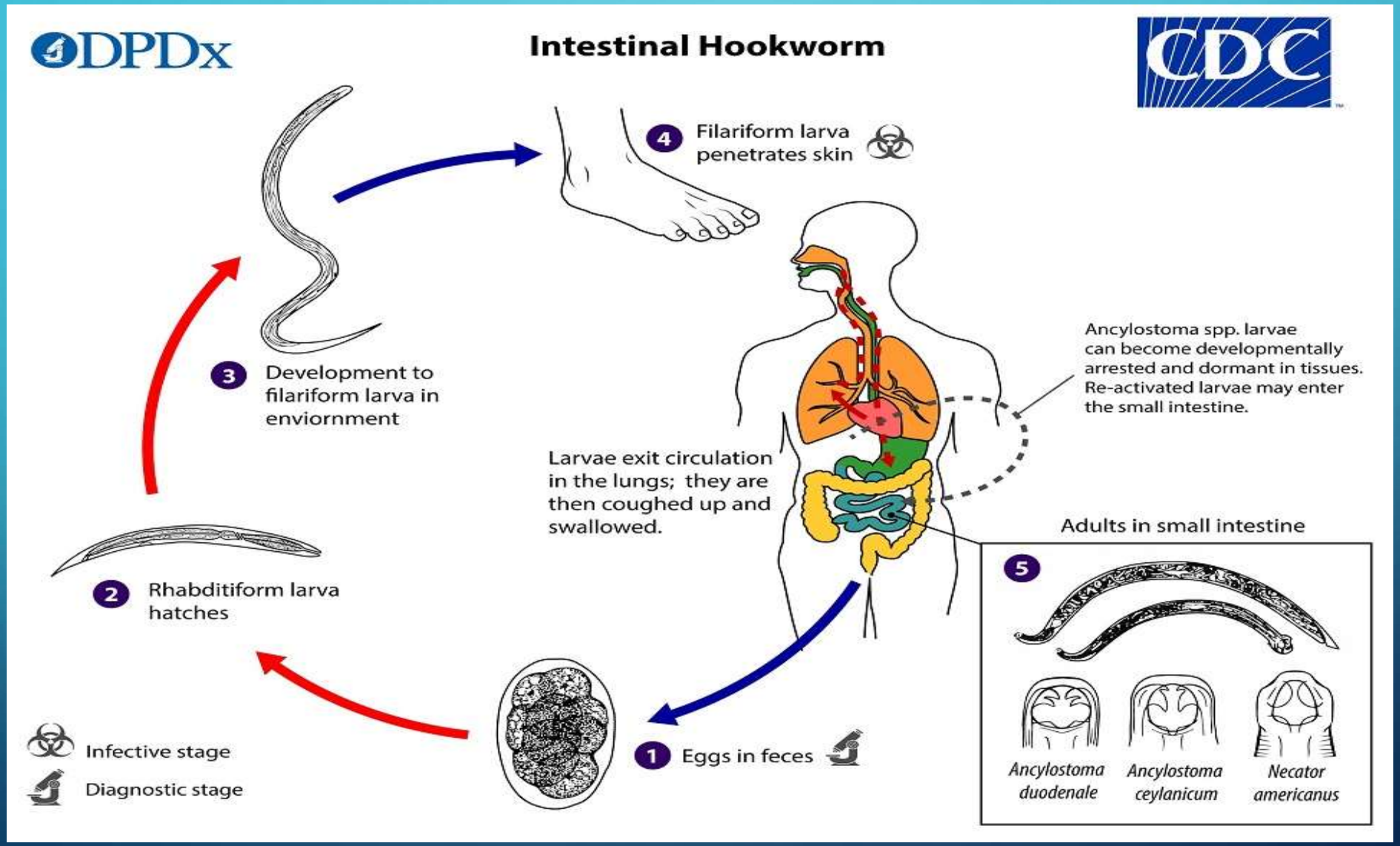
- Oval or elliptical, colourless and measuring up to 60 µm by 40 µm.
- Surrounded by thin transparent hyaline shell membrane.
- When released by the worm in the intestine, the egg contains an unsegmented ovum, but when passed in feces, the contains a segmented ovum, usually with four or eight blastomeres.

Life Cycle of *Ancylostoma duodenale:*

Life cycle of Ancylostoma duodenale is completed in a single host.

Definitive host : Humans are the only natural host. No intermediate host is required like other helminths.

Infective Form: Rhabditiform larvae moult twice to become **filariform (L3) larvae,** which are infective within 5–10 days.


DPDx
Intestinal Hookworm
CDC
4 Filariform larva penetrates skin
3 Development to filariform larva in enviornment
2 Rhabditiform larva hatches
1 Eggs in feces
Larvae exit circulation in the lungs; they are then coughed up and swallowed.
Ancylostoma spp. larvae can become developmentally arrested and dormant in tissues. Re-activated larvae may enter the small intestine.
Adults in small intestine
5
Ancylostoma duodenale
Ancylostoma ceylanicum
Necator americanus
Infective stage
Diagnostic stage

Adult worm inhabiting the small intestine of man attach themselves to the mucous membrane by means of their mouth parts.

The female worm lays eggs in the small intestine produce thousands of eggs (25,000 - 30,000/day).

The eggs containing segmented ova with four blastomeres, are passed out in the feces from the infected person. The eggs freshly passed in the feces are not infective for humans.

When deposited in the soil, the embryo develops inside the eggs. Its development takes place optimally in sandy loamy soil with decaying vegetation under the moist, warm, shaddy environment.

In about 2 days, a rhabditiform larva, measuring aboiut 250 µm in length, hatches out of the egg. It feeds on bacteria and other organic matters in the soil and grows in size.

It moults twice, on the 3rd and 5th days after hatching to become the 3rd stage infective filariform larva.

Filariform: Third-stage (L3) larvae are the non-feeding infective form with a sheath. It is about 500-600 µm long, with a sharp pointed tail.

They can live in the soil for 5-6 weeks, with their heads waving in the air, waiting for their hosts.

They can also ascend on blades of grass or other vegetation, being carried in capillary water films on their surface.

Mode of infection:

When a person walks barefooted on soil containing the filariform larva, they penetrate the skin and enter the subcutaneous tissue. The common sites of entry are the skin between the toes, the dorsum of the foot and the medial aspect of the sole.

In farm workers and miners, the larvae may penetrate the skin of the hands.

Rarely, infection may take palce by the oral route, the filariformlarva being carried on contaminated vegetables or fruits.

The larva may penetrate the buccal mucosa to reach the venous circulation and complete their migration via the lungs.

Inside the human body, the larvae are carried along the veneous circulation to the right side of the heart and to the lungs. Here, they escape from pulmonary capillaries into alveoli, migrate up th e respiratory tract to the pharynx, and are swallowed, reaching their final destination, small intestine

During migration or on reaching the esophagus, they undergo third moilting.

They feed, grow in size, and undergo a fourth and final moulting in the small intestine and develop the buccal capsule, by which the attach themselves to the small intestine and grow into adults.

There is no multiplication in the host and a single infective larva develops into a single adult, amle or female.

It takes usually about 6 weeks from the time of infection for the adult worms to become sexually mature and start laying eggs. But sometimes, there may be an arrest in development and the process may take much longer.

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4. Paniker's Textbook of Medical Parasitology- S. Ghosh