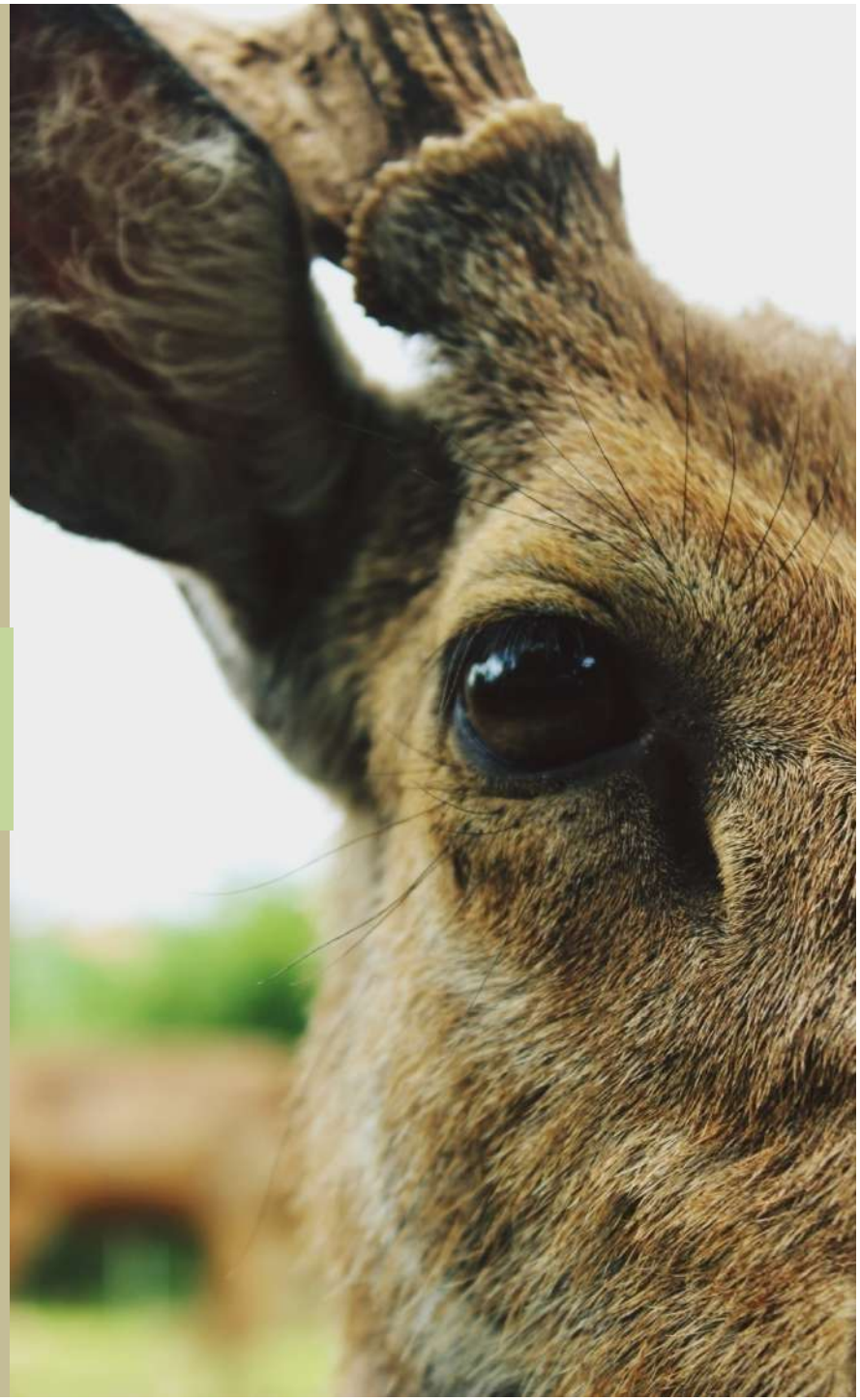
TAKSONOMI HEWAN

CHAPTER 6:
ANNELIDA & NEMATODA



Husni Mubarok, S.Pd., M.Si.
Tadris Biologi
IAIN Jember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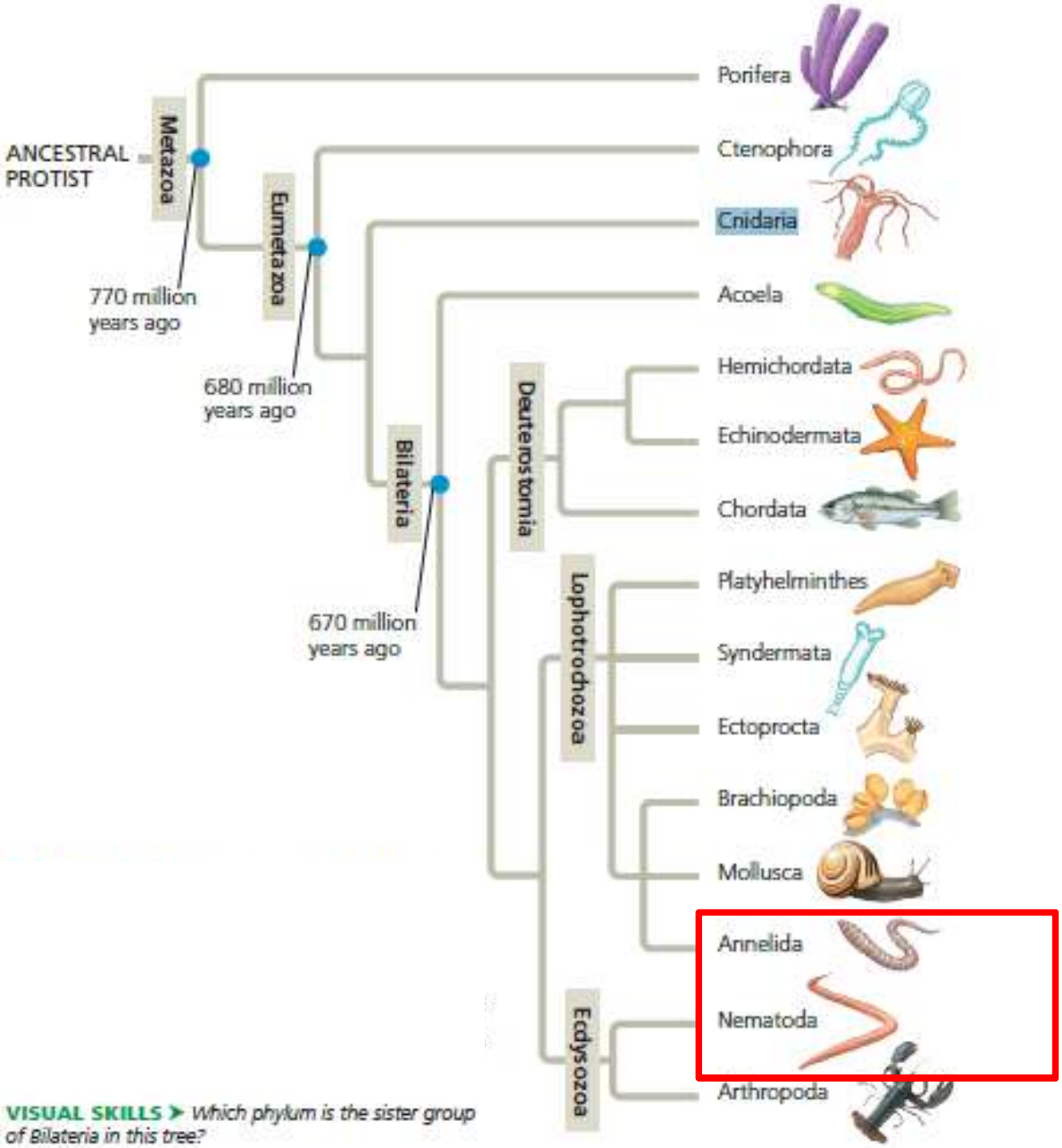
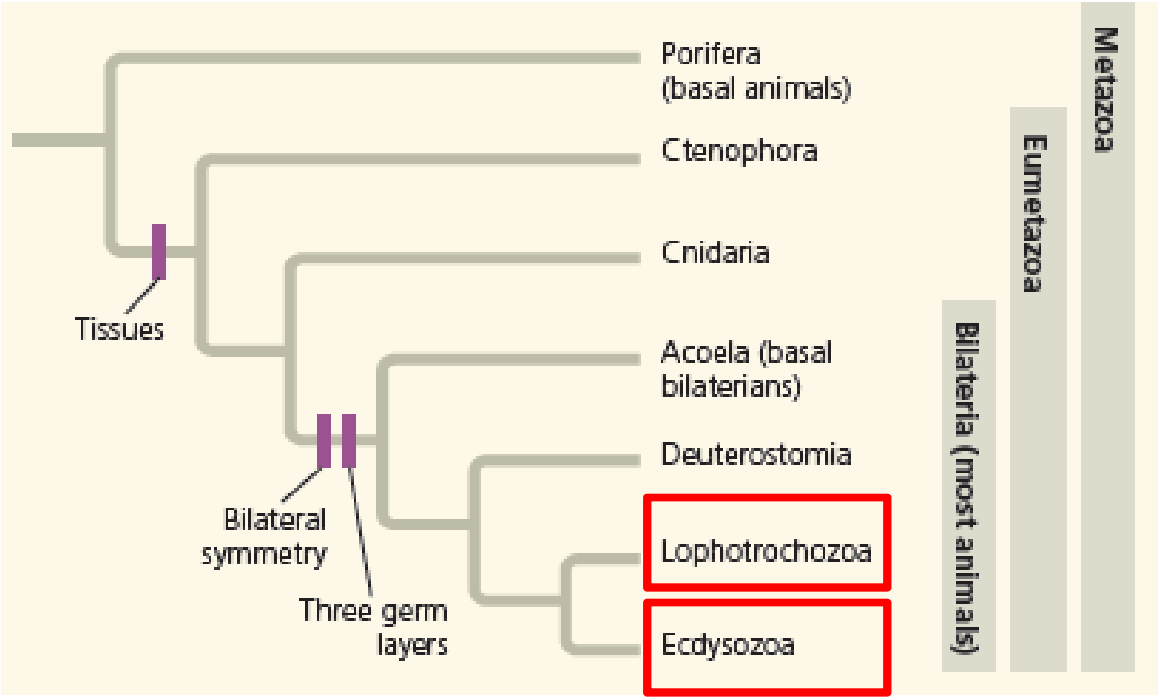


VISUAL SKILLS ➤ *Which phylum is the sister group of Bilateria in this tree?*



Bilaterians also diversified in two major clades that are composed entirely of invertebrates:
ECDYSOZOA and LOPHOTROCHOZOA

Lophotrochozoa

Some lophotrochozoans develop a structure called a ***lophophore***, **a crown of ciliated tentacles that functions in feeding**

Ecdysozoa

Secrete **external skeletons (exoskeletons)**
The stiff covering of a cricket and the flexible cuticle of a nematode
It molts, squirming out of its old exoskeleton and secreting a larger one
The process of shedding the old exoskeleton is called ***ecdysis***

Nematoda (25,000 species)

A roundworm

- Disebut jg **cacing gilig**, nematoda melimpah & bervariasi di **habibat tanah & akuatik**
- Beberapa spesies **parasit** pd tumbuhan & hewan
- Karakter pembeda: **Kutikula (Cuticle)** yg menyelimuti tubuh

Annelida (16,500 species)

- Disebut jg **cacing bersegmen (karakter pembeda dr cacing-cacing lain)**
- Cacing tanah paling representatif
- Spesies ada yg hidup di laut dan air tawar

PLOS ONE

CORRECTION

Correction: A Higher Level Classification of All Living Organisms

Michael A. Ruggiero, Dennis P. Gordon, Thomas M. Orrell, Nicolas Bailly, Thierry Bourgoin, Richard C. Brusca, Thomas Cavalier-Smith, Michael D. Guiry, Paul M. Kirk

OPEN ACCESS

Citation: Ruggiero MA, Gordon DP, Orrell TM, Bailly N, Bourgoin T, Brusca RC, et al. (2015) Correction: A Higher Level Classification of All Living Organisms. PLoS ONE 10(6): e0130114. doi:10.1371/journal.pone.0130114

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Rank
Superkingdom
Kingdom
Subkingdom
Infrakingdom
Superphylum
Phylum
Subphylum
Infraphylum
Superclass
Class
Subclass
Infraclass
Superorder
Order

Main ranks are in bold type; unnamed taxa are not counted.

doi:10.1371/journal.pone.0130114.t001

KLASIFIKASI ANNELIDA & NEMATODA

Phylum Annelida

Class N.
N.

Class Clitellata

Subclass
N.N.

Order Branchiobdellida

Subclass
Hirudinea

Order Acanthobdellida

Order Arhynchobdellida

Order Rhynchobdellida

Subclass Oligochaeta

Superorder N.N.

Order N.N. (*Jennaria*)

Order Enchytraeida

Order Haplotaxida

Order Lumbriculida

Order Tubificida

Superorder Metagynophora

Order Moniligastrida

Order Opistophora

Class Polychaeta

Subclass
N.N.

Order N.N. (e.g., Nerillidae)

Subclass Echiura

Order Echiuroinea

Order Heteromyota

Order Xenopneusta

Subclass Errantia

Order Amphinomida

Order Eunicida

Order Phyllodocida

Order Myzostomida

Subclass Sedentaria

Infraclass Canalipalpata

Order Sabellida

Order Spionida

Order Terebellida

Infraclass Scolecida (e.g., Arenicolidae)

Phylum Nematoda

Class Chromadorea

Subclass Chromadoria

Order Chromadorida

Order Desmodorida

Order Desmoscolecida

Order Selachinematida

Subclass Plectia

Superorder Monhysterica

Order Monhysterida

Superorder Plectica

Order Benthimermithida

Order Leptolaimida

Order Plectida

Superorder Rhabditica

Order Diplogasterida

Order Drilonematida

Order Panagrolaimida

Order Rhabditida

Order Spirurida

Superorder Teratocephalica

Order Teratocephalida

Class Dorylaimea

Subclass Bathyodontia

Order Bathyodontida

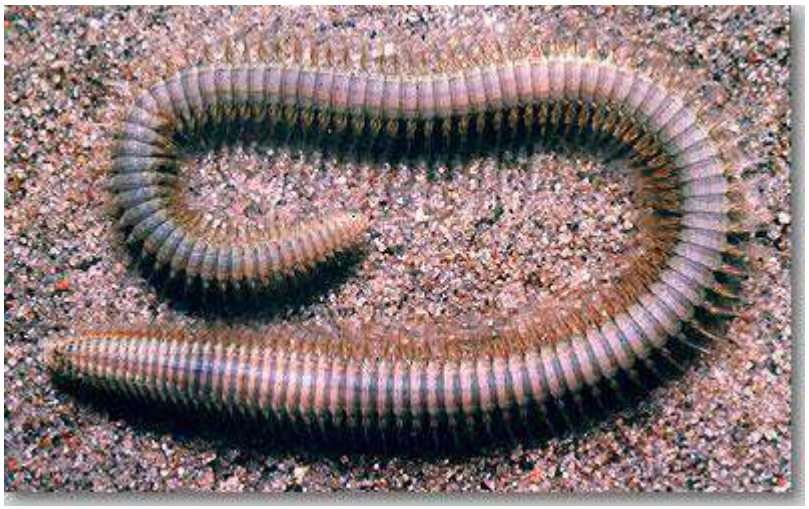
Order Mermithida

Order Mononchida

	Subclass Dorylaimia	
		Order Dorylaimida
		Subclass Trichocephalia
		Order Dioctophymatida
		Order Marimermithida
		Order Muspiceida
		Order Trichocephalida
	Class Enoplea	
	Subclass Enoplia	
		Order Alaimida
		Order Enoplida
		Order Ironida
		Order Rhaptothyreida
		Order Trifusiida
		Order Tripyloidida
		Subclass Oncholaimia
		Order Oncholaimida
	Subclass Triplonchia	
		Order Triplonchida
		Order Tripylida

PHYLUM ANNELIDA

Annelida = Annuli (rings)



BODY FORM

- Unique annelid head: Two-part head, composed of **PROSTOMIUM** and **PERISTOMIUM** followed by a segmented body
- Paired epidermal **SETAE** (hair made from chitin) present (lost in leeches = Lintah), **PARAPODIA** present in the ancestral condition
- Marine, freshwater, and terrestrial
- Most free-living, some symbiotic, some ectoparasitic
- Body bilaterally symmetrical, **METAMERIC,** terminal portion called the **PYGIDIUM**
- Triploblastic body; **PERITONEUM** (a layer of mesodermal epithelium)

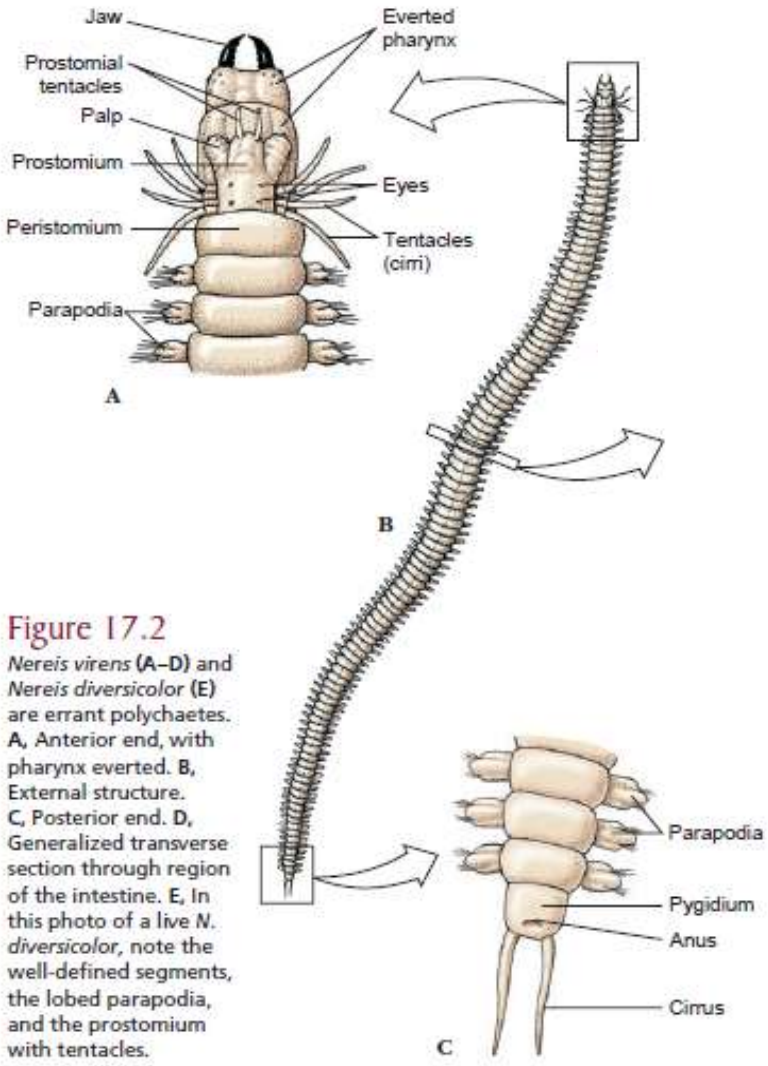
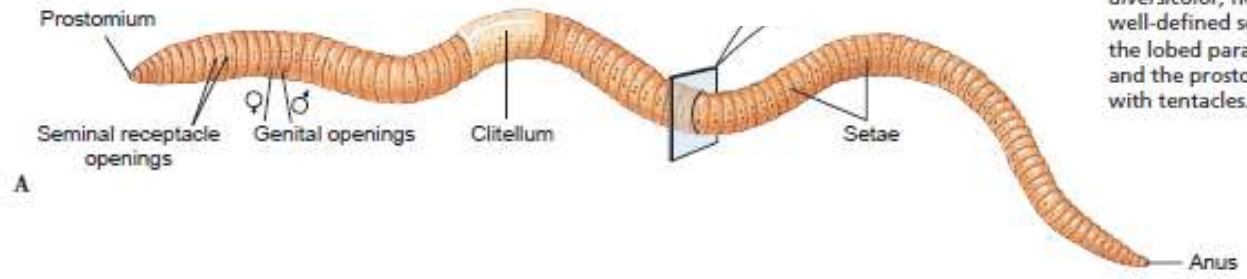
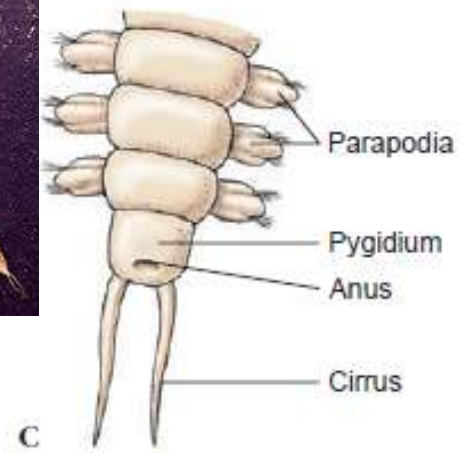


Figure 17.2
Nereis virens (A–D) and *Nereis diversicolor* (E) are errant polychaetes. A, Anterior end, with pharynx everted. B, External structure. C, Posterior end. D, Generalized transverse section through region of the intestine. E, In this photo of a live *N. diversicolor*, note the well-defined segments, the lobed parapodia, and the prostomium with tentacles.



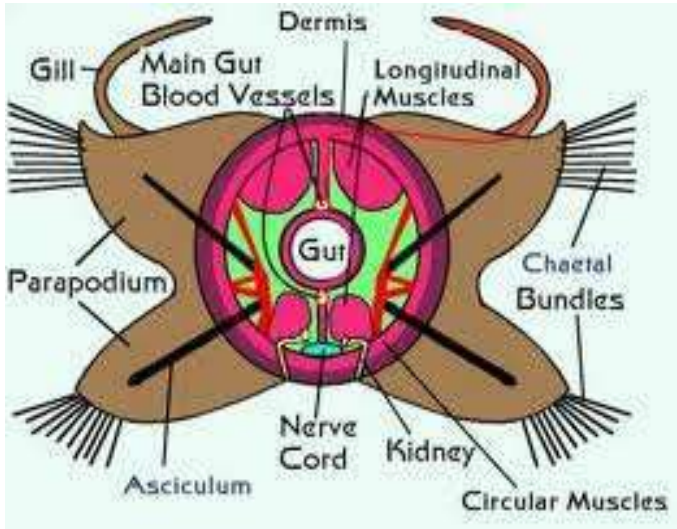
BODY FORM

- **PARAPODIA** present in some groups
- One or many pairs of chitinous bristles called setae (chaetae) → produced by epidermis → repetead in each segmen → used as anchors while burrowing, to prevent capture, some used for swimming or as protection or camoflage



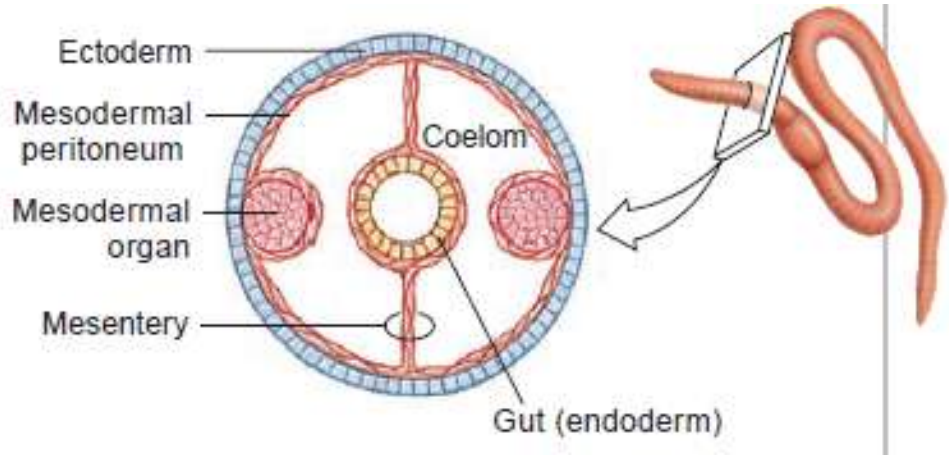
Functions:

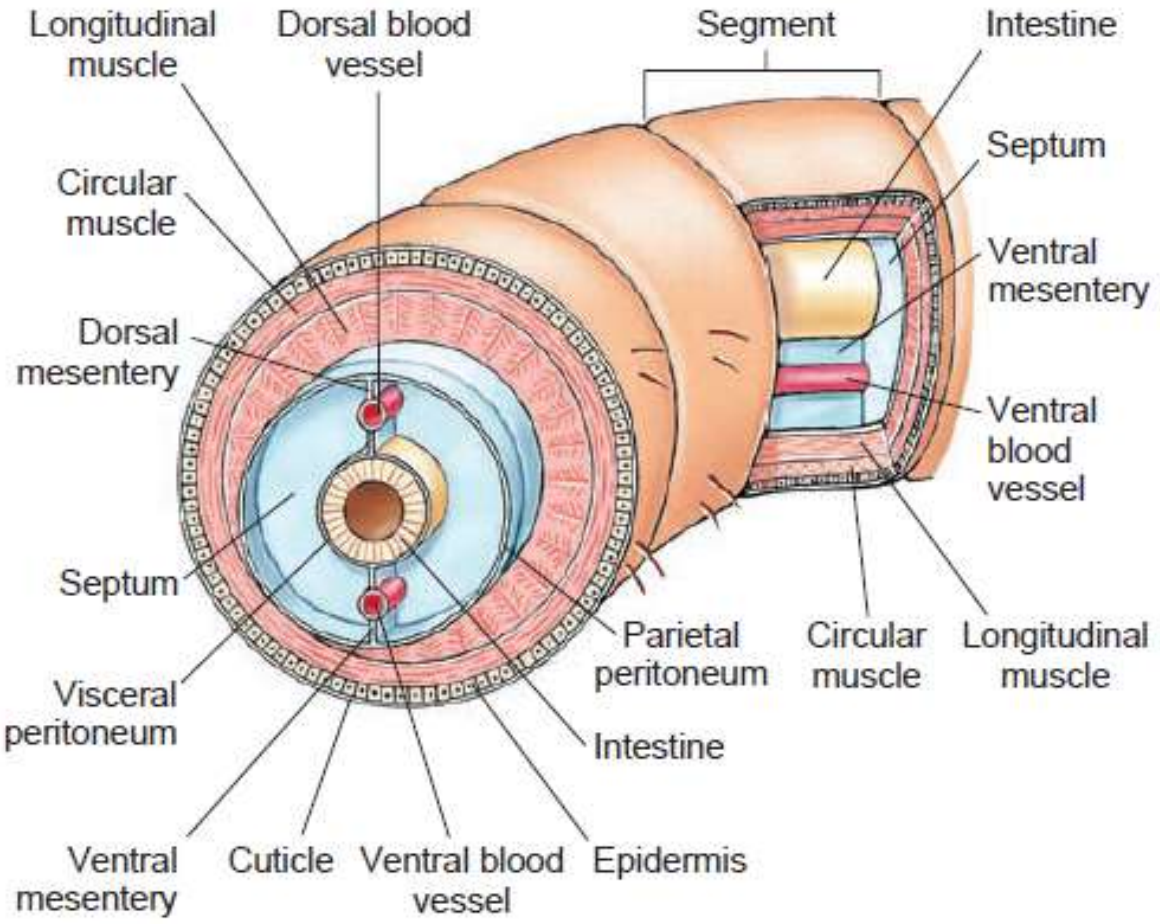
- Morphology needs for classification
- Highly vasculized- exchange of gases
- Locomotory function



BODY FORM

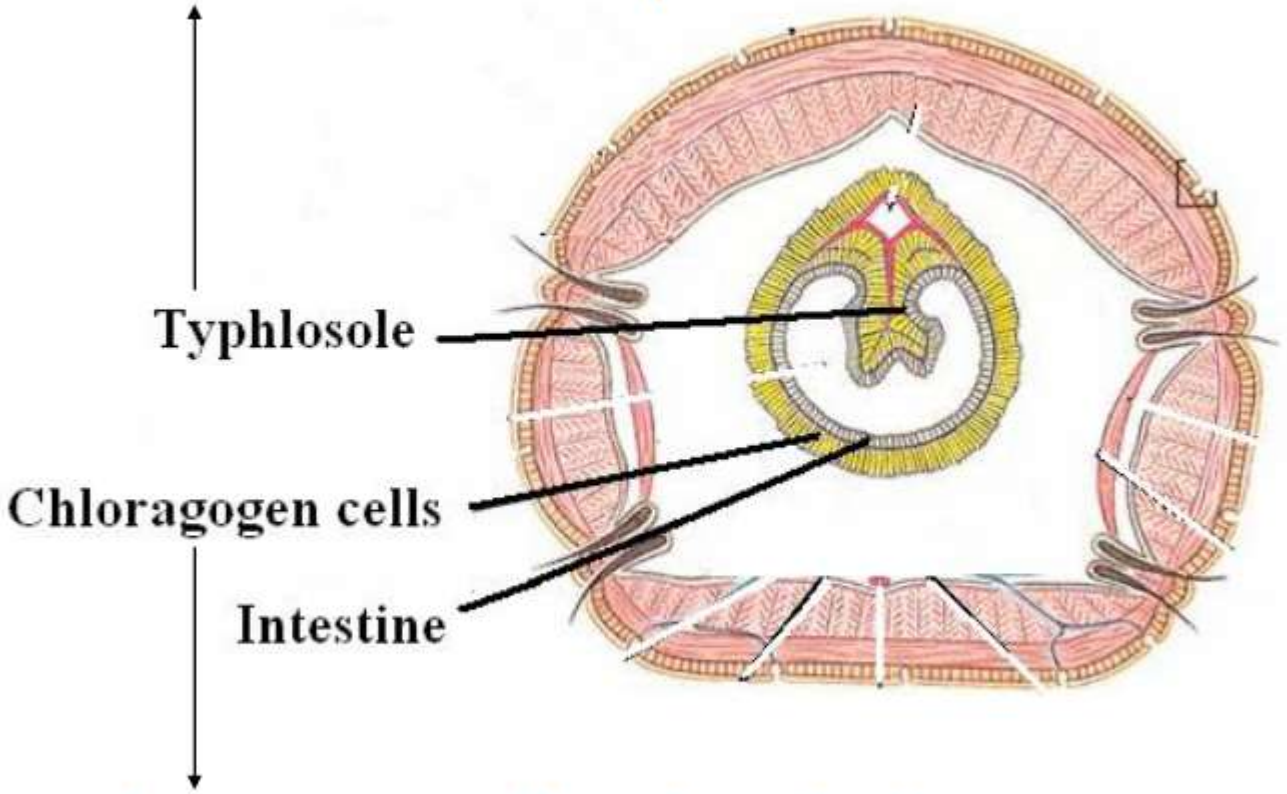
- **Coelom** (schizocoel) well developed and divided by septa, except in leeches; **coelomic fluid functions as hydrostatic skeleton**
- Epidermis a single layer of cells (columnar epithelium)
- Epithelium secretes outer **transparent moist cuticle**





BODY FORM

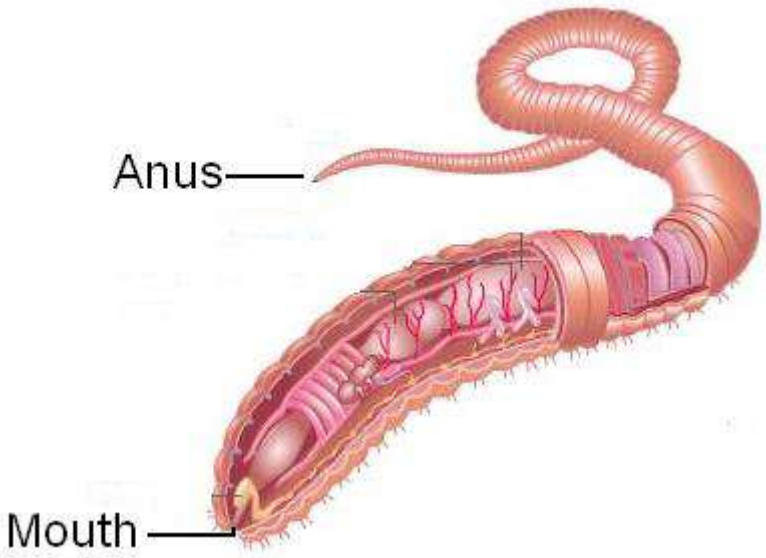
To increase the surface area of the intestine for absorption

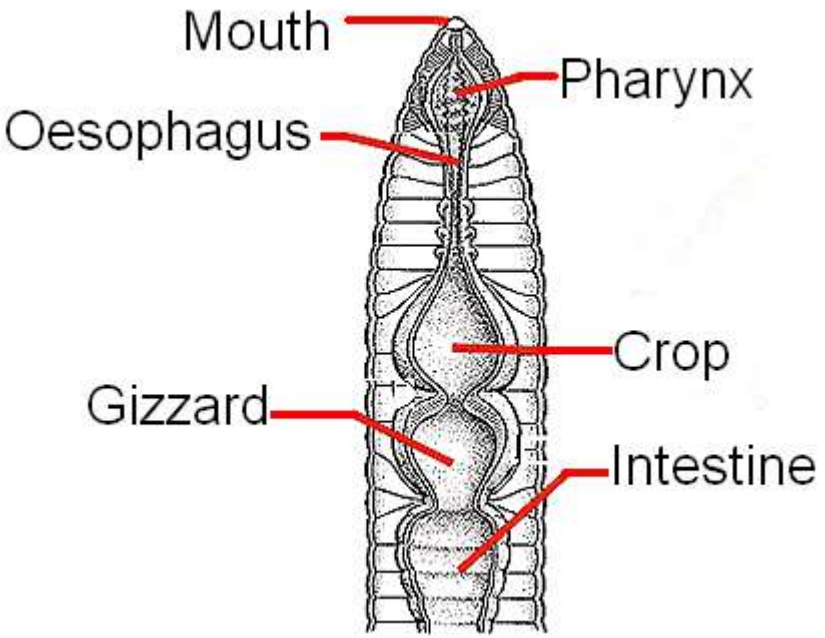


An accessory digestive gland; the site of glycogen synthesis

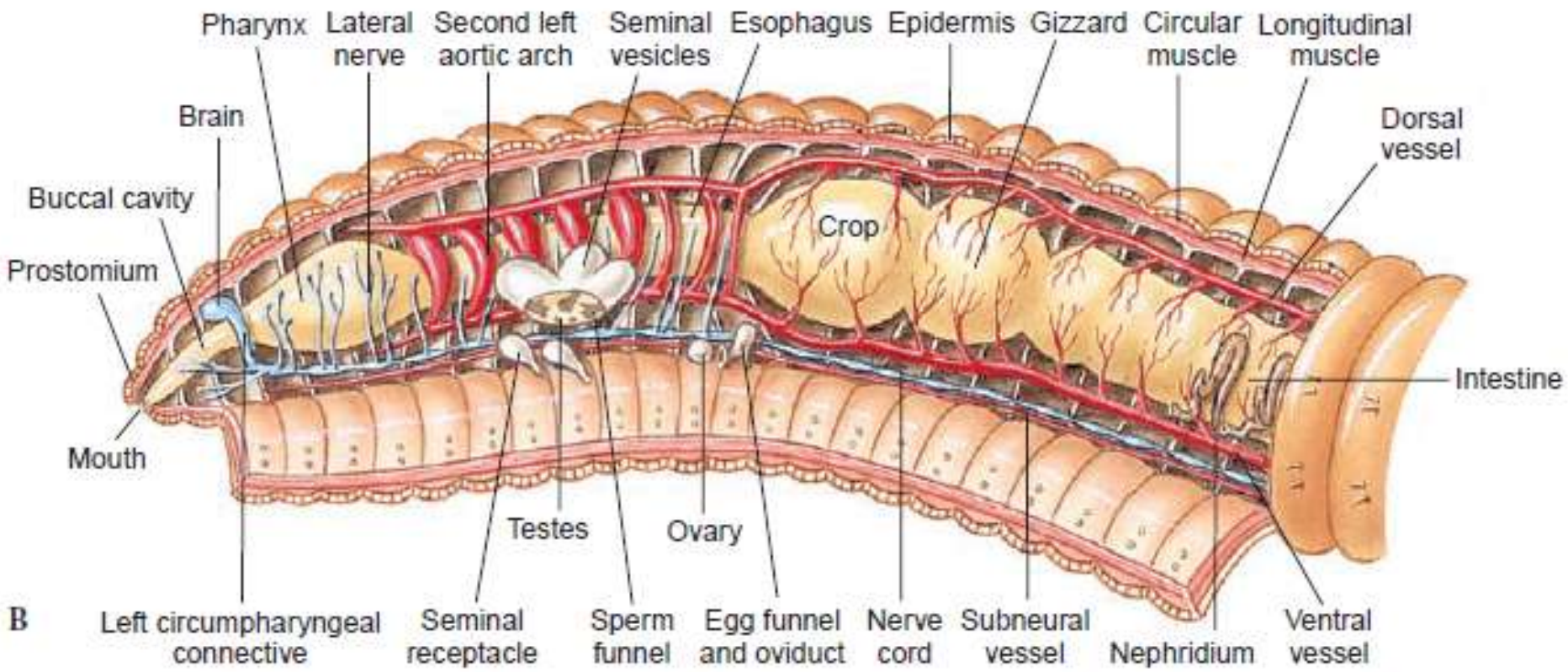
DIGESTIVE SYSTEM

- Digestive system **complete** and not segmentally arranged
- **Mouth, pharynx, esophagus, intestine, rectum, anus**.
- Bucal cavity, Crop, Gizzard
- Pharynx is associated with **salivary glands** (that secrete hirudin anticoagulant in Hirudinea)
- Esophagus may lead to a crop then gizzard and associated with calciferous glands- for control of Ca ion concentrationin oligochaeta

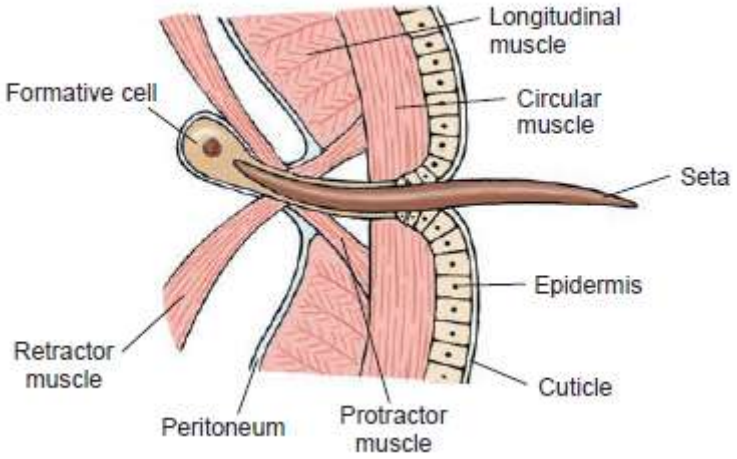


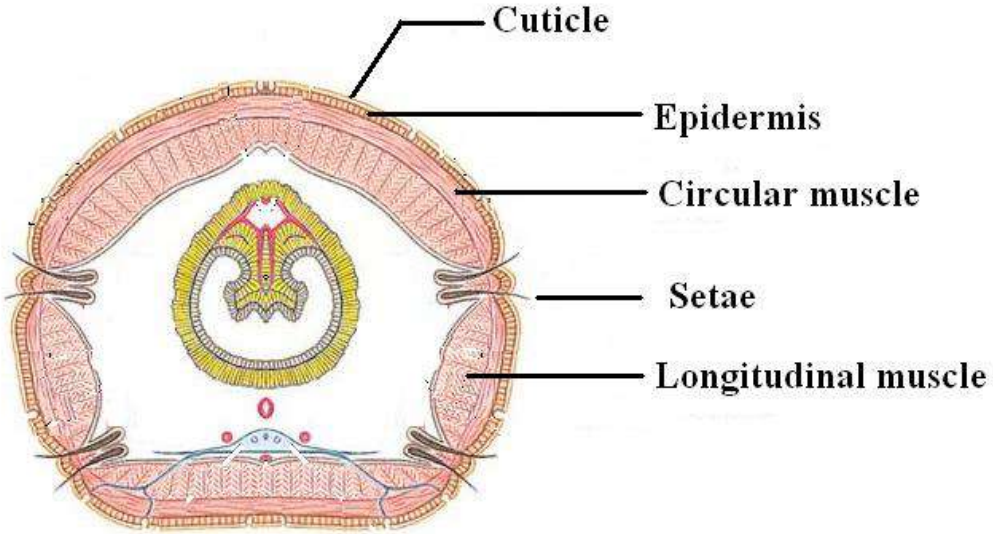


DIGESTIVE SYSTEM

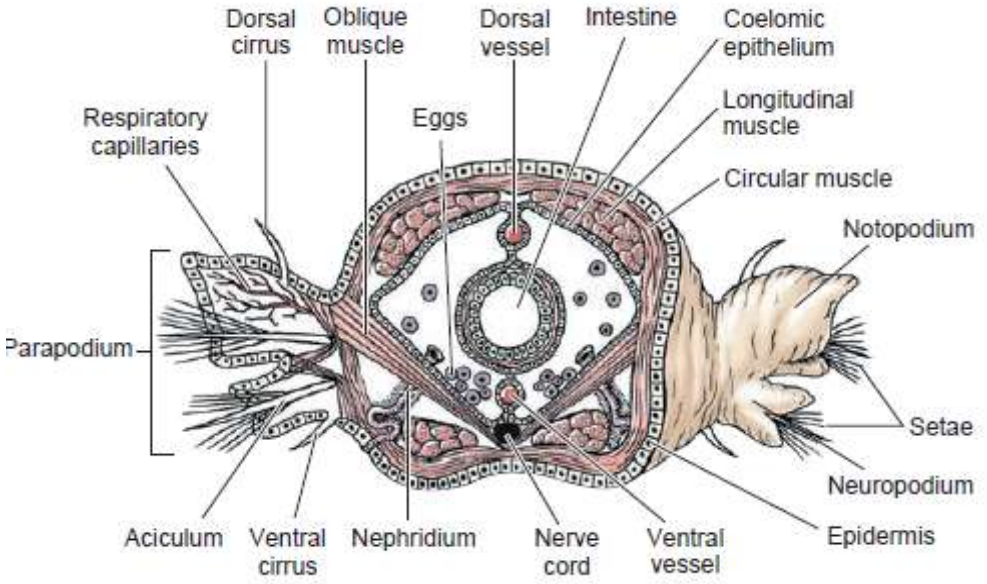


MUSCULAR SYSTEM





- Body wall with **outer circular** and **inner longitudinal** muscle layers
- Longitudinal body-wall muscles causes **a segment to shorten and to become larger in diameter**
- Contraction of the circular muscles causes it **to lengthen and become thinner**
- **Peristaltic contractions** -a type of locomotion produced by rhythmic waves of muscle contractions passing from head to tail



NERVOUS SYSTEM

- Nervous system with a **double ventral nerve cord** and a **pair of ganglia** with **lateral nerves** in **each segment**
- Brain a **pair of dorsal cerebral ganglia** with connectives to ventral nerve cord
- Cerebral ganglia (brain) located above buccal cavity
- Sensory system of **tactile (touch)** organs, **taste buds**, **statocysts** (in some), **photoreceptor cells**, and **eyes with lenses** (in some)
- Specialization of head region into differentiated organs, such as tentacles, palps, and eyespots of polychaetes

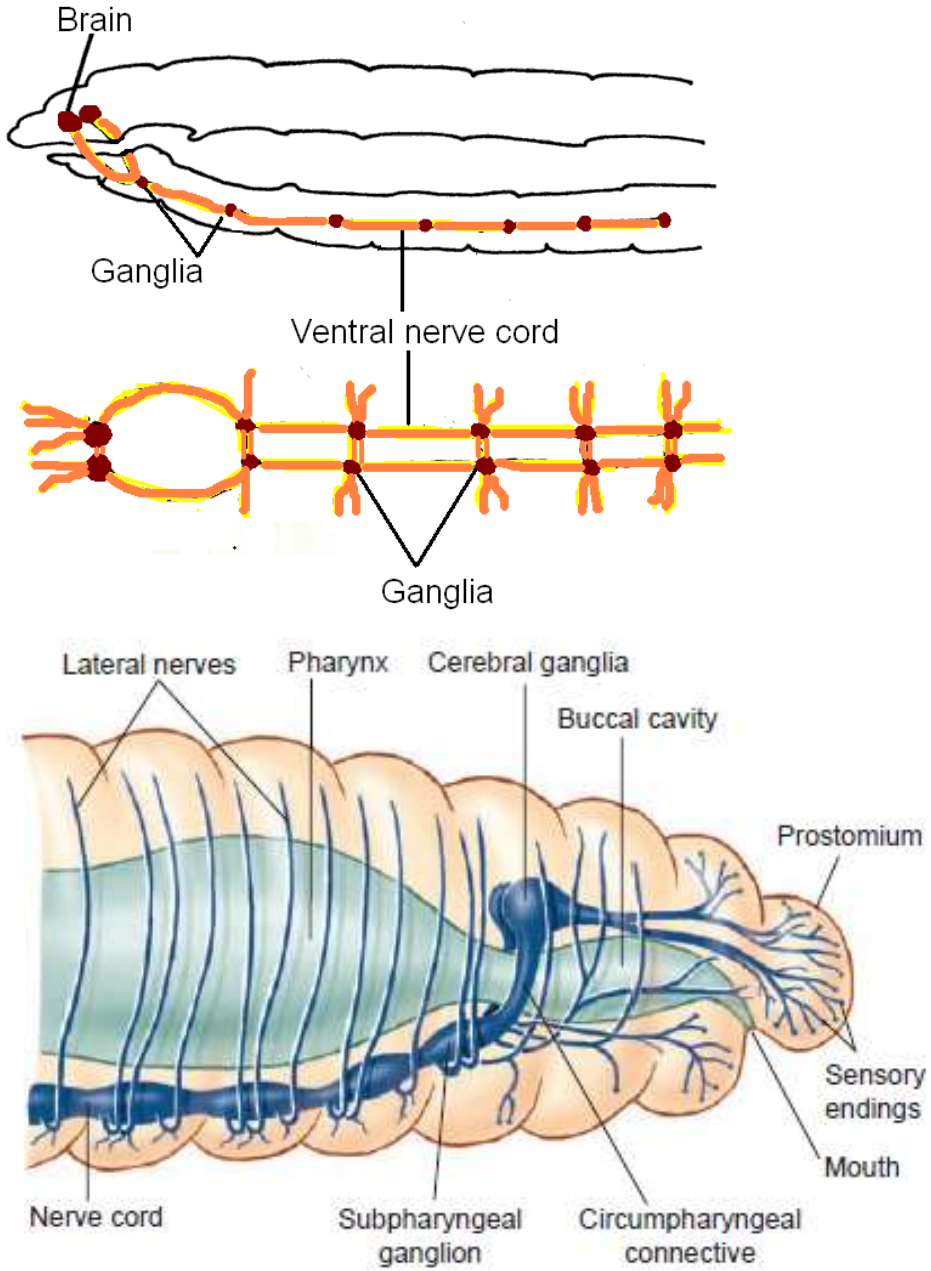


Figure 17.19
Anterior portion of earthworm and its nervous system. Note concentration of sensory endings in this region.

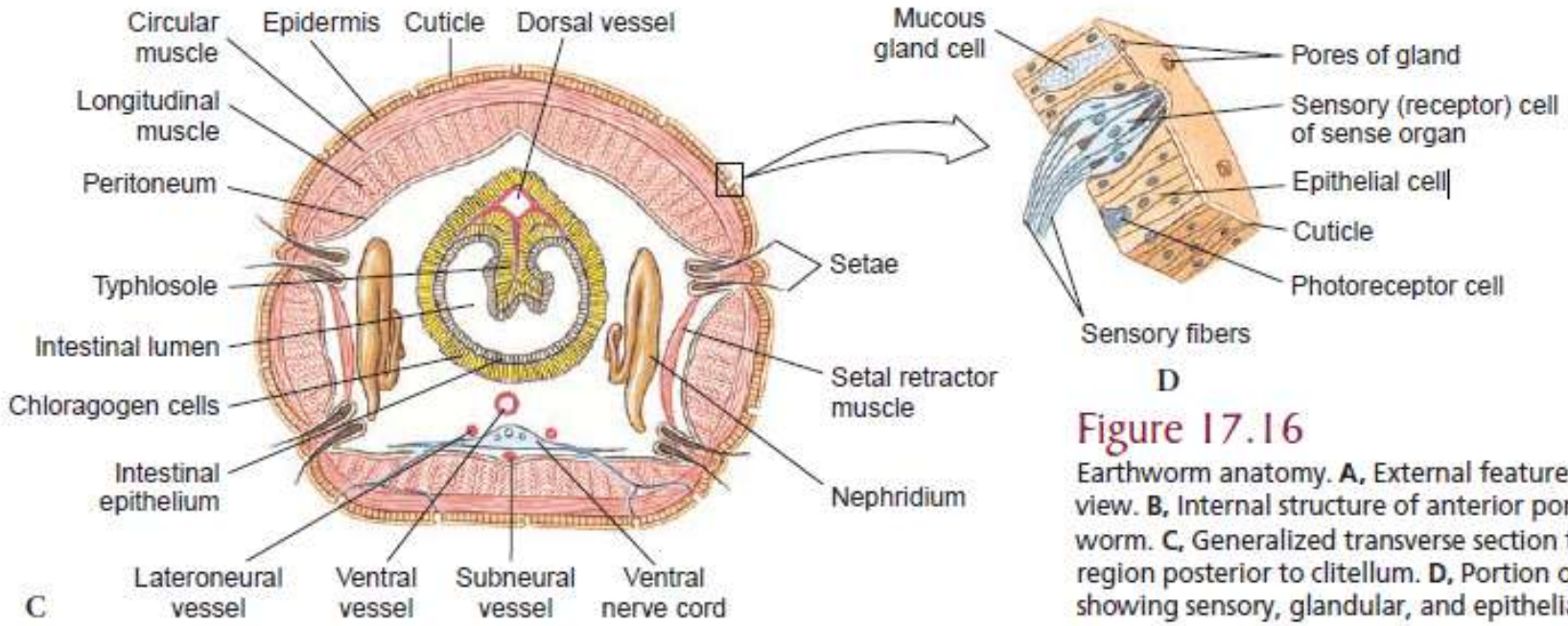
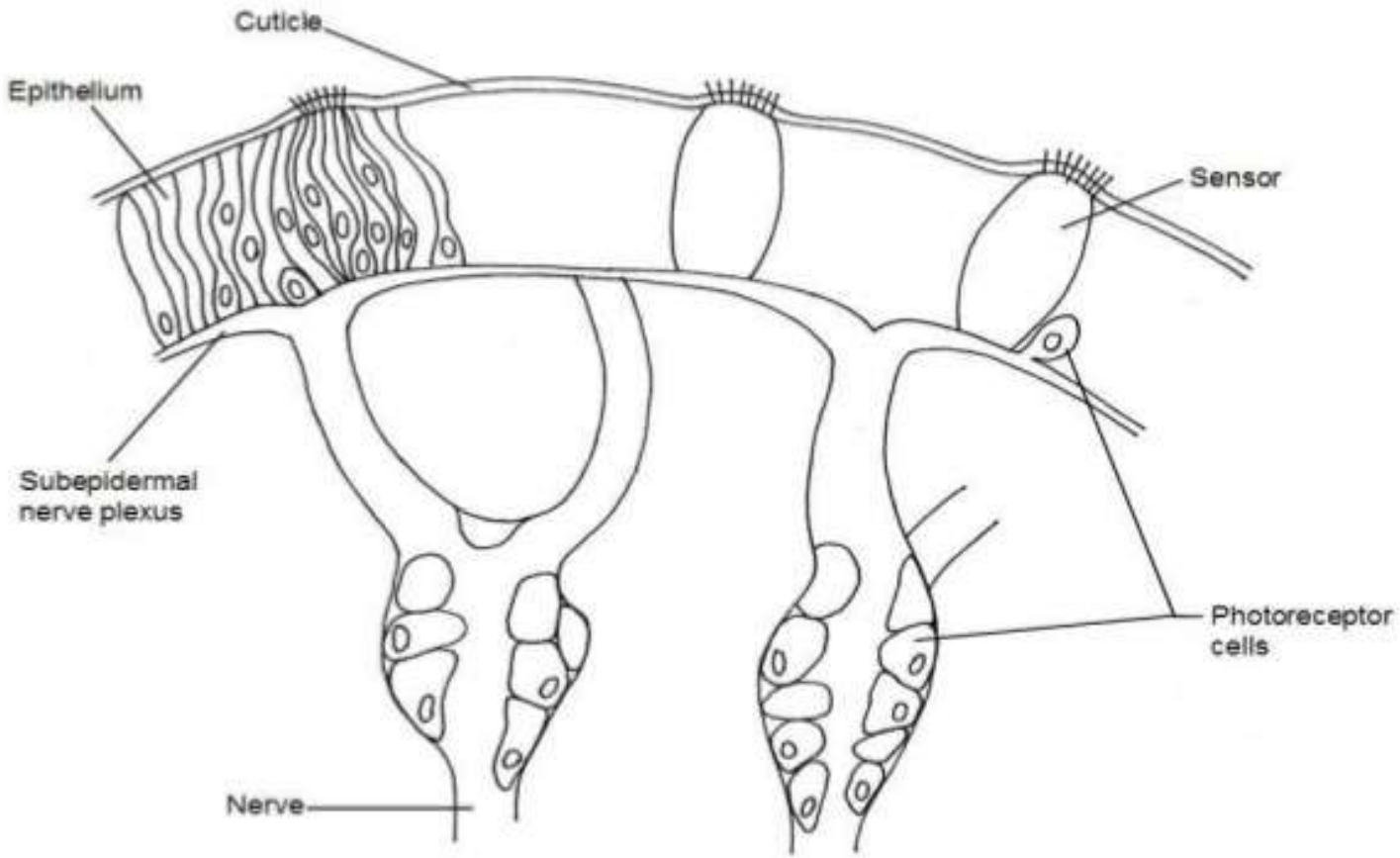


Figure 17.16

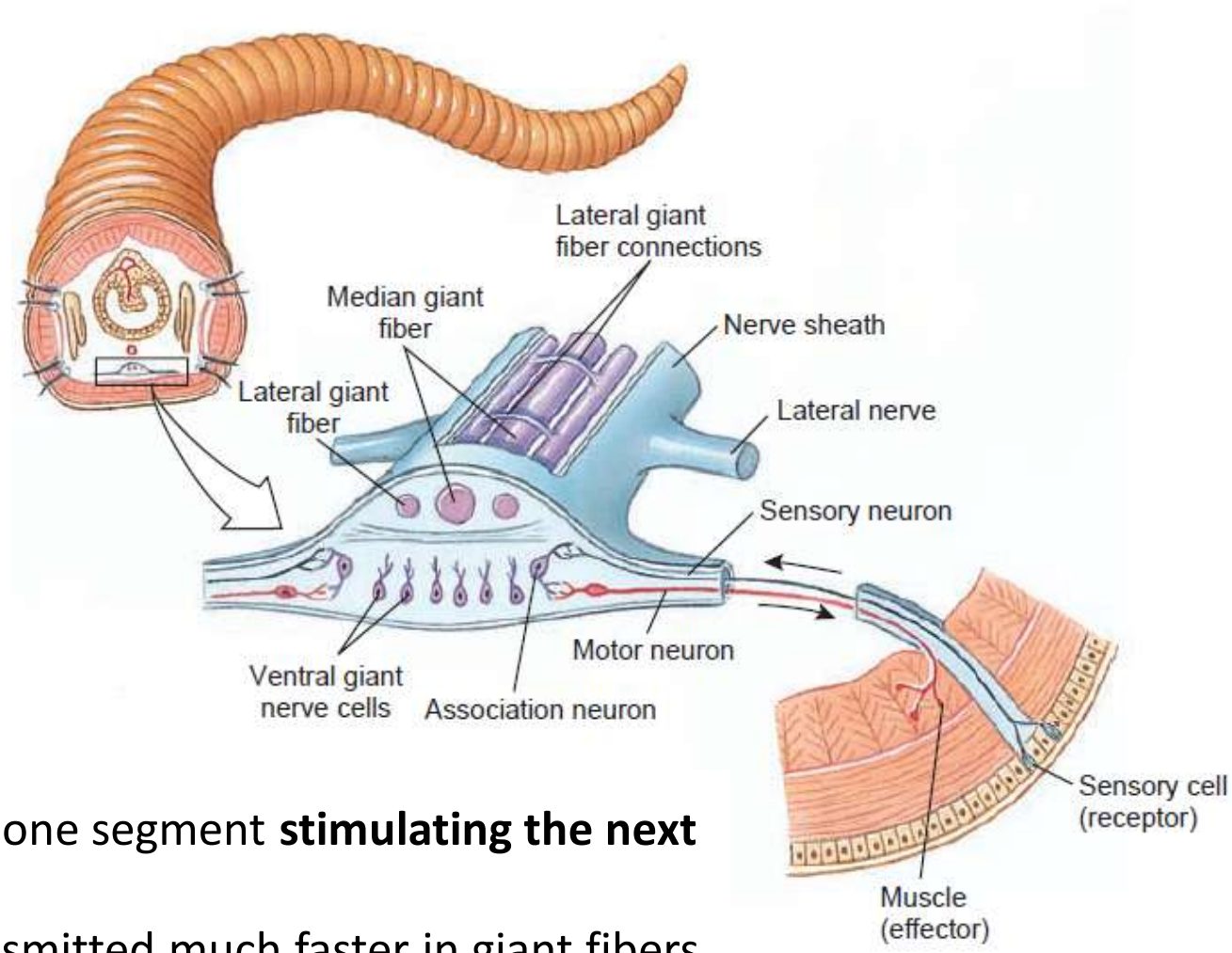
Earthworm anatomy. **A,** External features, lateral view. **B,** Internal structure of anterior portion of worm. **C,** Generalized transverse section through region posterior to clitellum. **D,** Portion of epidermis showing sensory, glandular, and epithelial cells.

Photoreceptor cells in Prostomium



NERVOUS SYSTEM

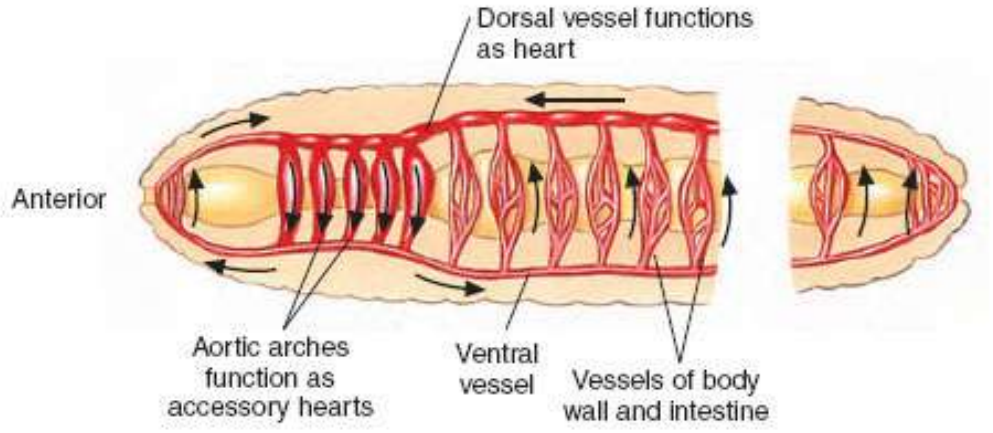
- Portion of nerve cord of earthworm
- Simple reflex arc
- **3 dorsal giant fibers** that are adapted for rapid reflexes and escape movements.

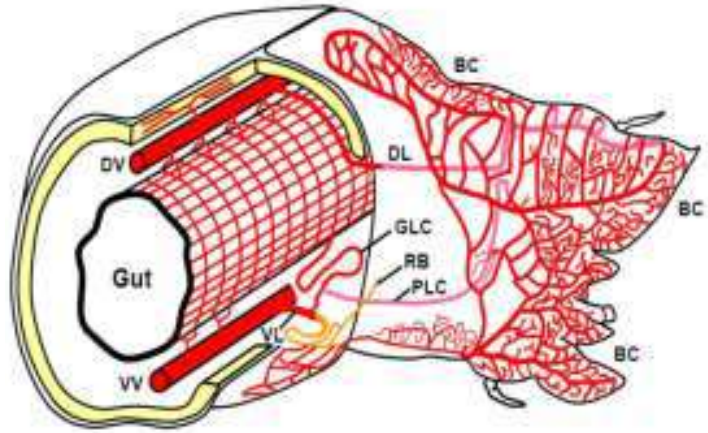


- The stretching of one segment **stimulating the next to Stretch**
- Impulses are transmitted much faster in giant fibers than in regular nerves so that all segments can contract simultaneously when quick withdrawal into a burrow is necessary.

CIRCULATORY SYSTEM

- Circulatory system **closed** with **muscular blood vessels**
- **Capillary systems** in the tissues
- **SINGLE DORSAL VESSEL** runs above the alimentary canal from the pharynx to the anus
- It is a pumping organ, provided with valves, and it functions as a **true heart**
- This vessel receives blood from vessels of the **body wall & digestive** tract and pumps it anteriorly into **FIVE PAIRS OF AORTIC ARCHES** (to maintain a steady pressure of blood in the ventral vessel)
- **SINGLE VENTRAL VESSEL** serves as an **AORTA** . It receives blood from the **aortic arches** and delivers it to the brain and rest of the body, providing segmental vessels to the walls, nephridia, and digestive tract.





CIRCULATORY SYSTEM

- Blood pigment mostly **hemoglobin** but some polychaeta have **chlorocruorin** or **hemoerythrin** as blood pigments (both Fe containing pigments)
- Circulatory system much reduced or absent in Hirudinea **with coelomic fluid** used for circulation
- Amebocytes in blood plasma

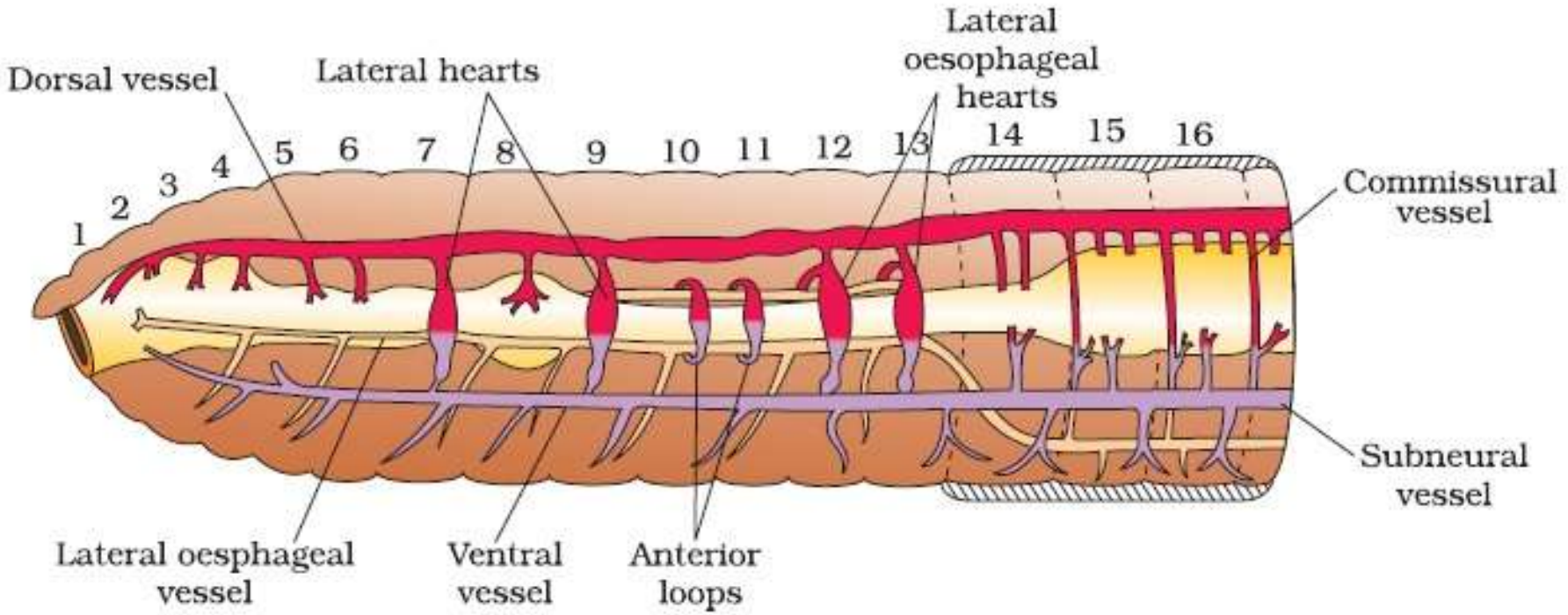
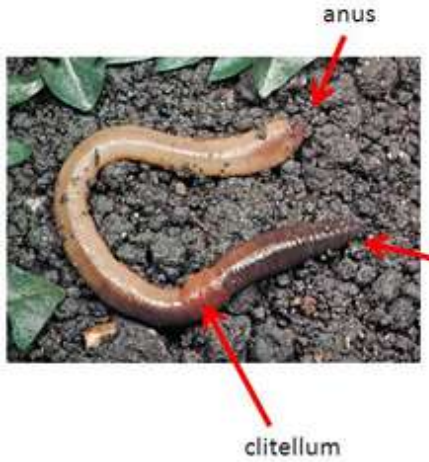
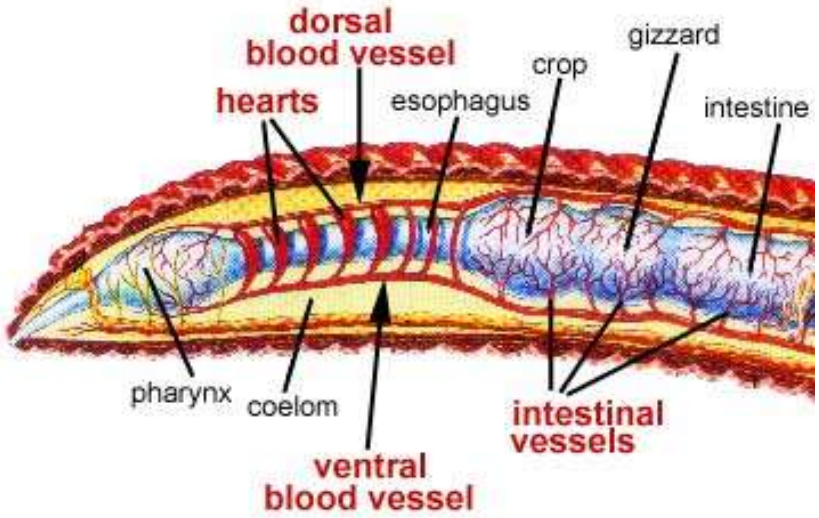


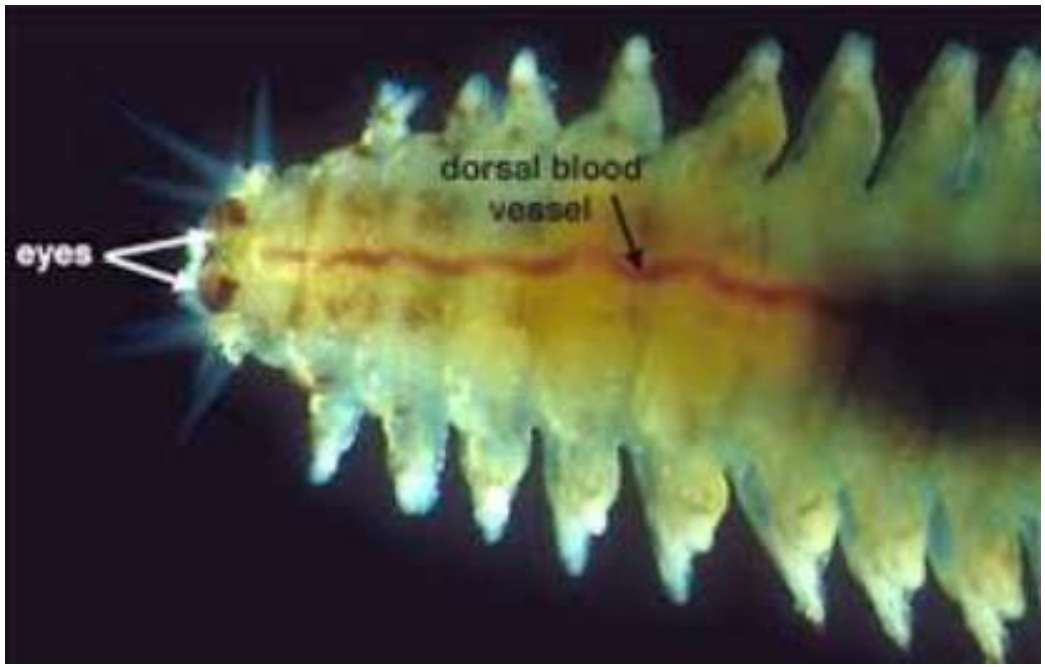
Figure 7.11 Closed circulatory system





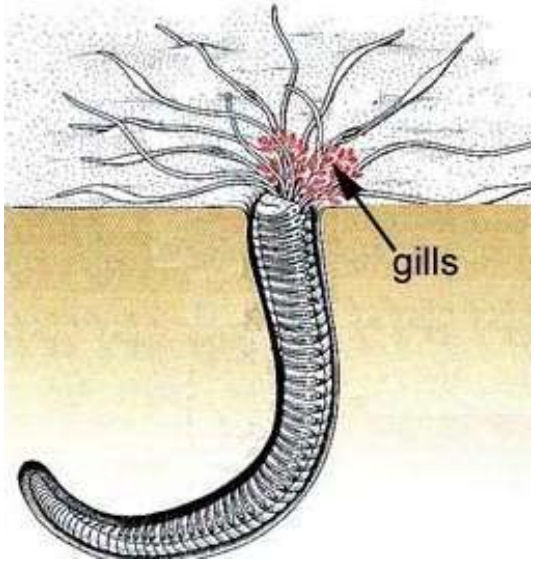
Functions:
Clitellum – involved in reproduction – holds the eggs
Dorsal blood vessel – transports blood

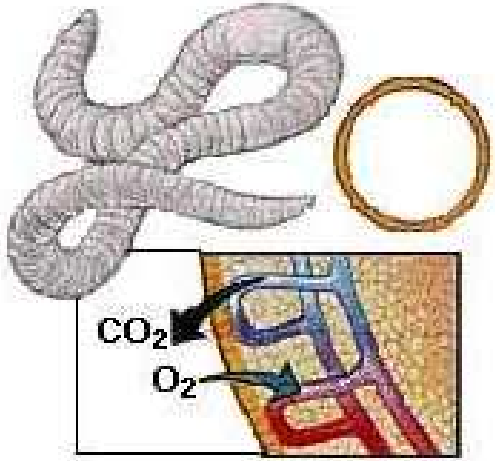
May be different picture



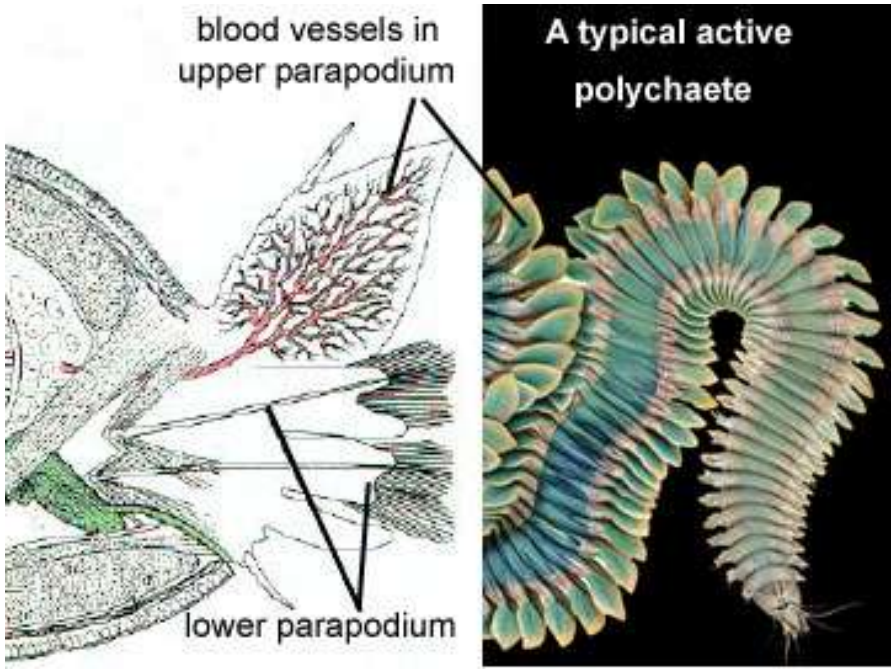
RESPIRATORY SYSTEM

- Respiratory gas exchange through **skin**, **gills, or parapodia**
- Through body wall in most species
- Body wall is richly supplied with capillaries to absorb and transport oxygen
- Some marine forms respire through **parapodia**
- A few species have gills



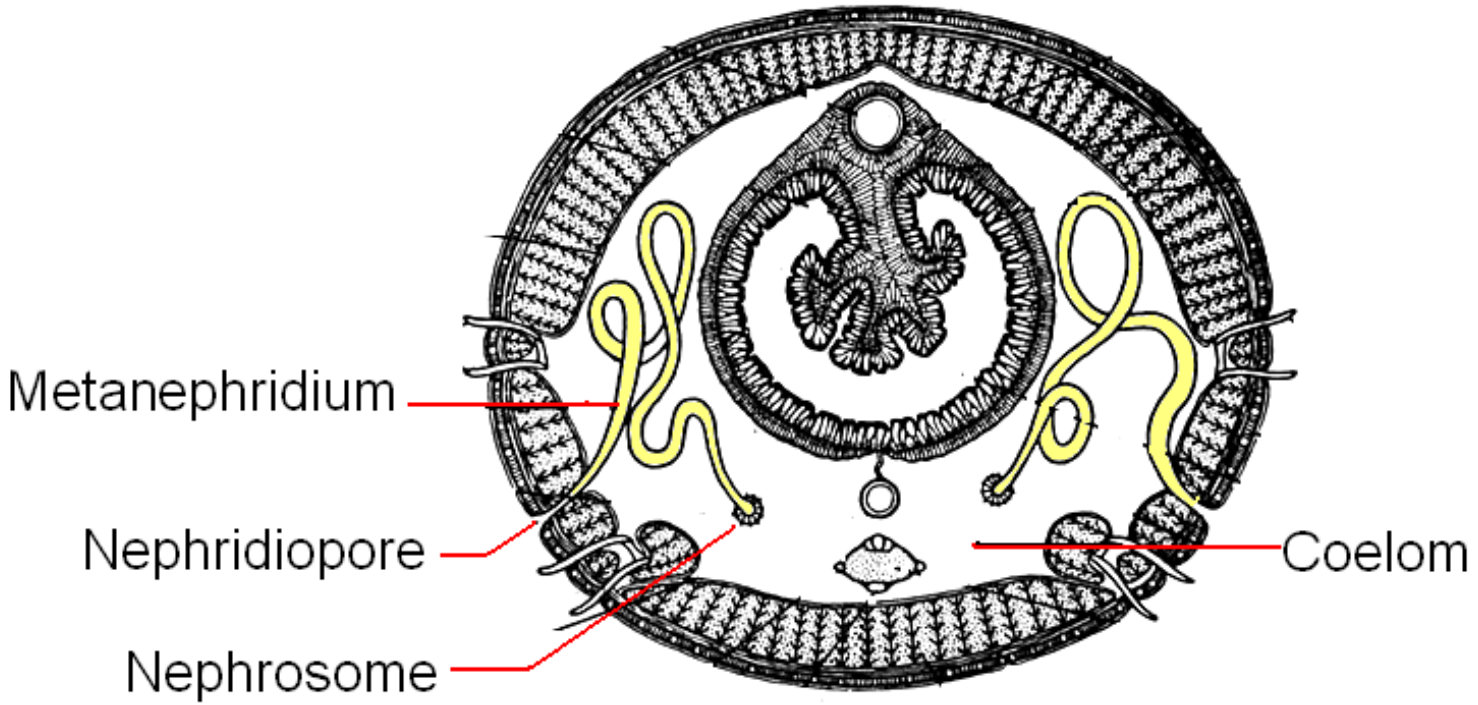


(b) Entire outer skin



EXCRETORY SYSTEM

- Excretory system typically a **pair of NEPHRIDIA/ NEPHRIDIUM (metanephridium in Earthworm)** for each segment
- Nephridia **remove waste from blood as well as** from coelom
- **NEPHROSOME** withdraws dissolved waste from the central body and the blood stream and Eject out of the animal via the paired **NEPHRIDIOPORES**



EXCRETORY SYSTEM

- **In Earthworm**
- Each segment (except the first three and the last one) bears a pair of **Metanephridia**
- **Each metanephridium** occupies parts of two successive segments
- **Nephrostome (ciliated funnel),** lies just anterior to an intersegmental septum.
- Several complex loops of increasing size compose the nephridial duct, which terminates in a *bladderlike* structure leading to an opening, the **nephridiopore**
- The nephridiopore opens to the outside near the ventral row of setae.
- Wastes from the coelom are drawn into the nephrostome and tubule, where they are joined by salts and organic wastes transported from blood capillaries in the glandular part of the nephridium.
- Waste is discharged to the outside through a nephridiopore.

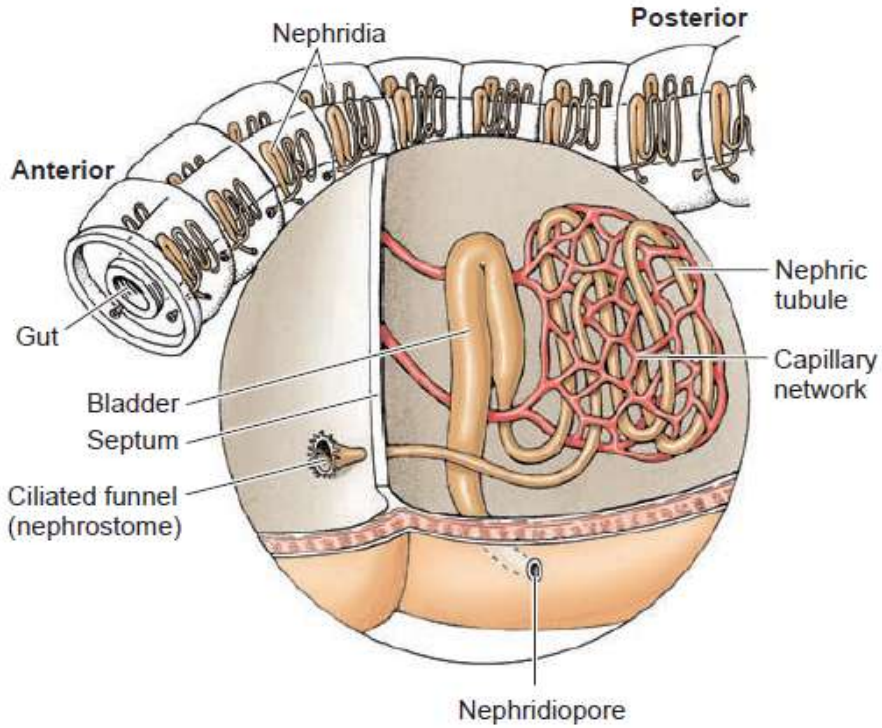
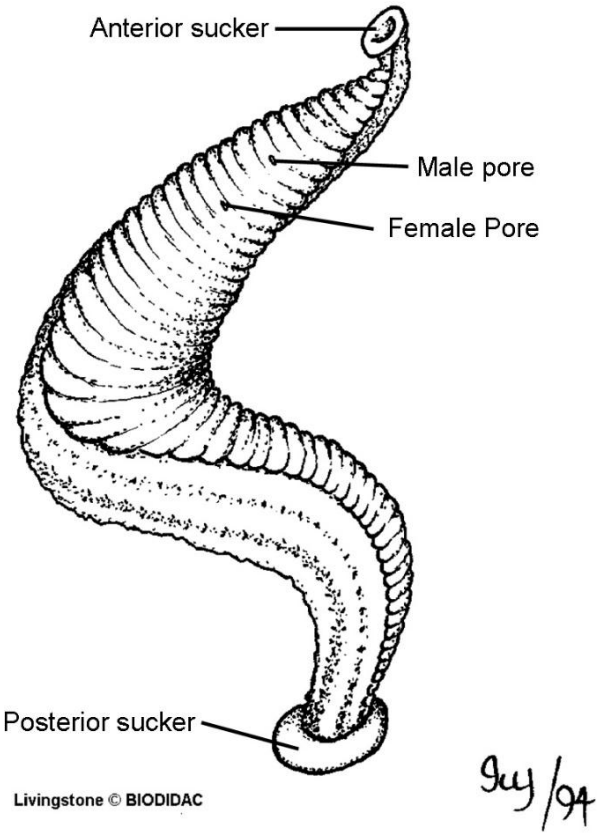


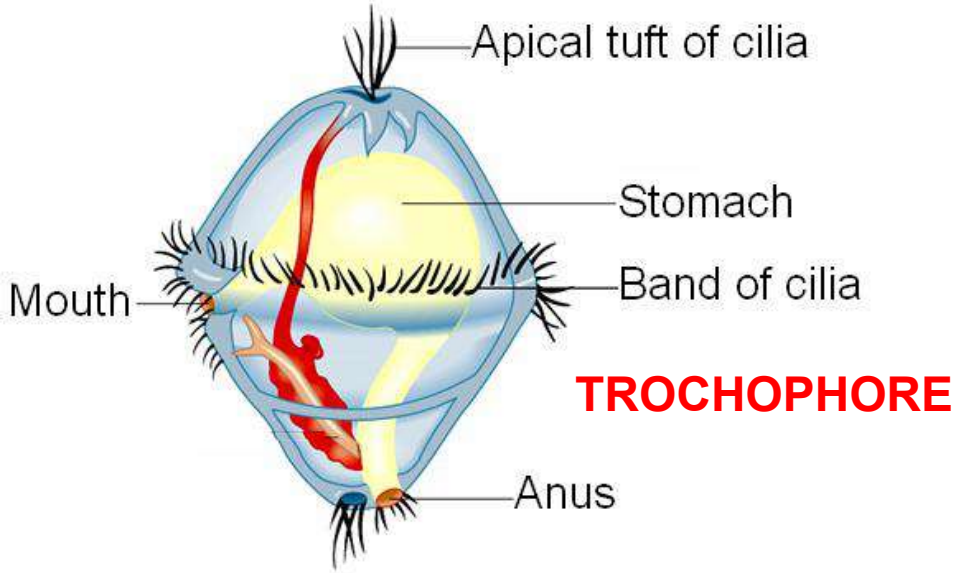
Figure 17.18

Nephridium of earthworm. Wastes are drawn into the ciliated nephrostome in one segment, then passed through the loops of the nephridium, and expelled through the nephridiopore of the next segment.

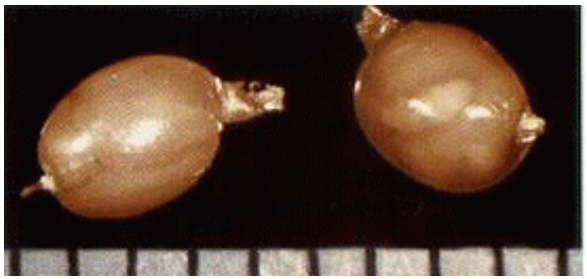
REPRODUCTION SYSTEM

- **Asexual reproduction** by fission and fragmentation (except in Leeches); capable of complete regeneration, asexual reproduction by budding in some
- **Sexual reproduction**: Hermaphroditic or separate sexes; larvae, if present, are **TROCHOPHORE** type (cilliated larva); spiral cleavage and mosaic development; Fertilization internal, developmemt inside a **COCOON**



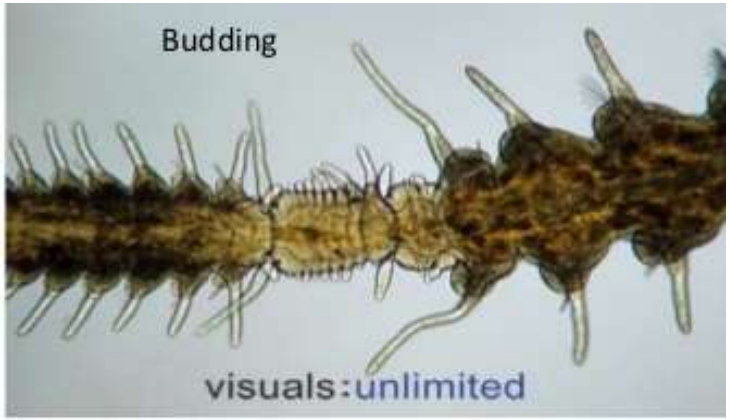


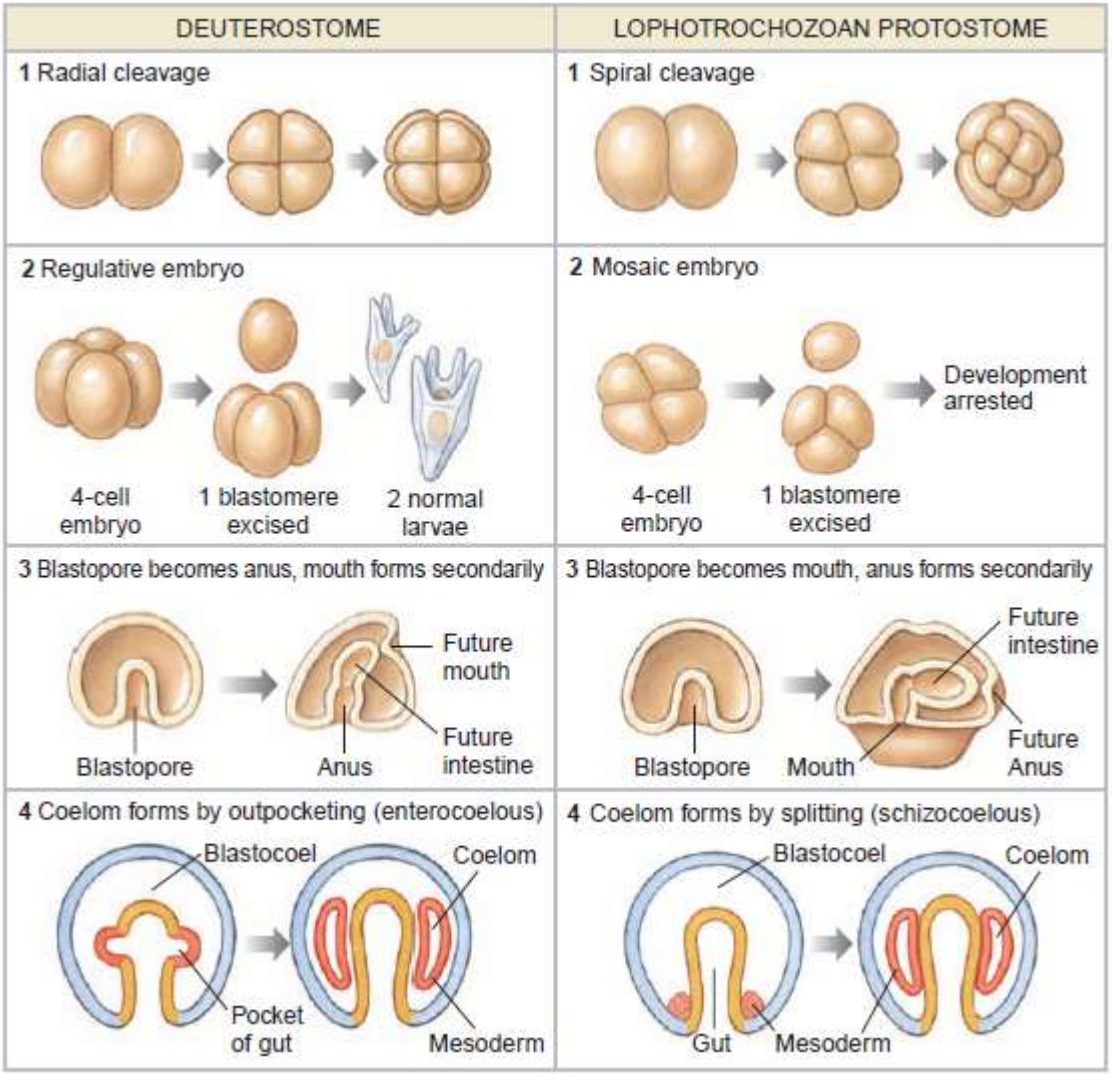
TROCHOPHORE



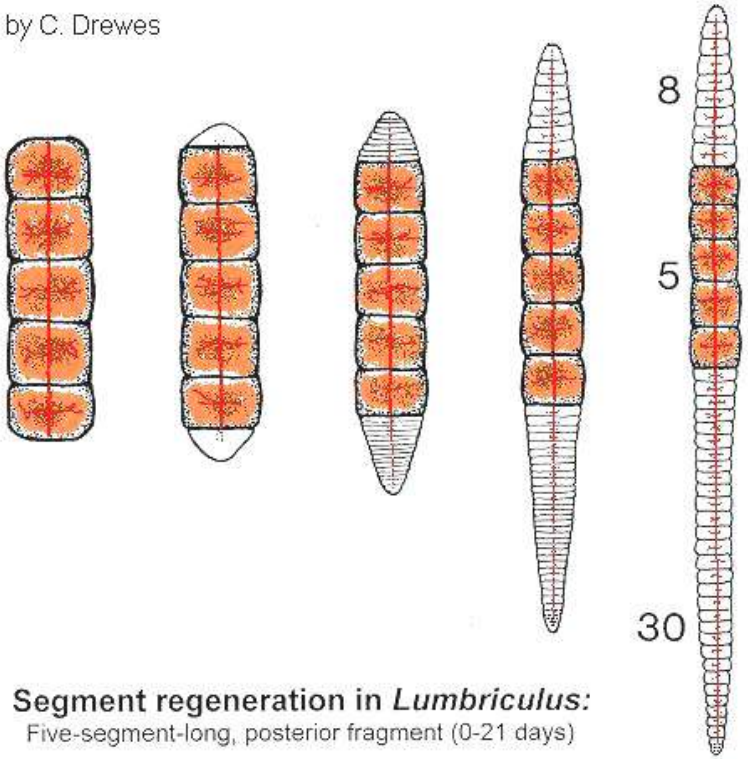
COCOON

Mating Earthworm

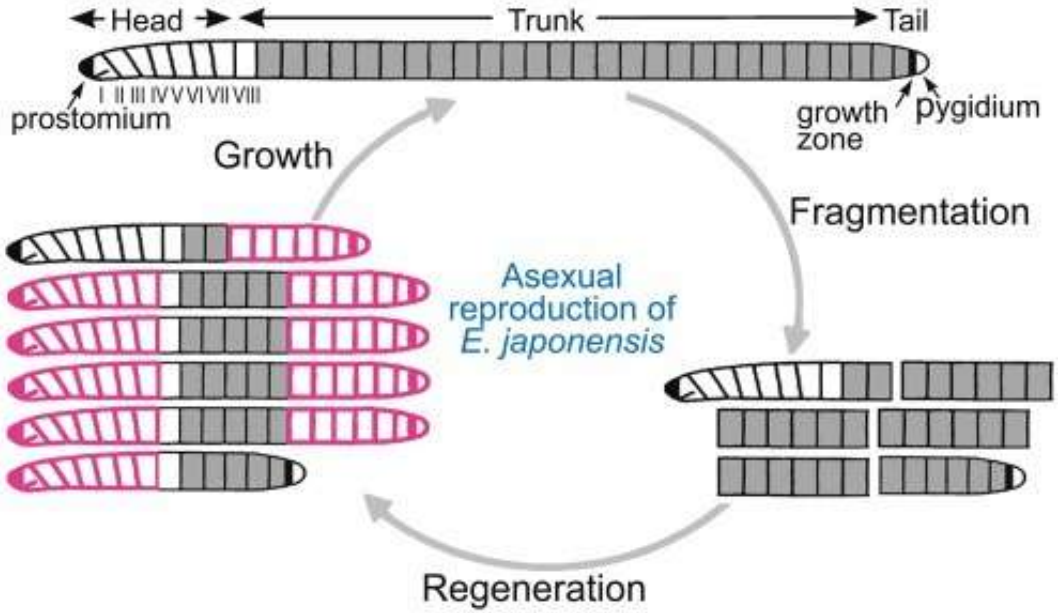




by C. Drewes



Segment regeneration in *Lumbriculus:*
Five-segment-long, posterior fragment (0-21 days)



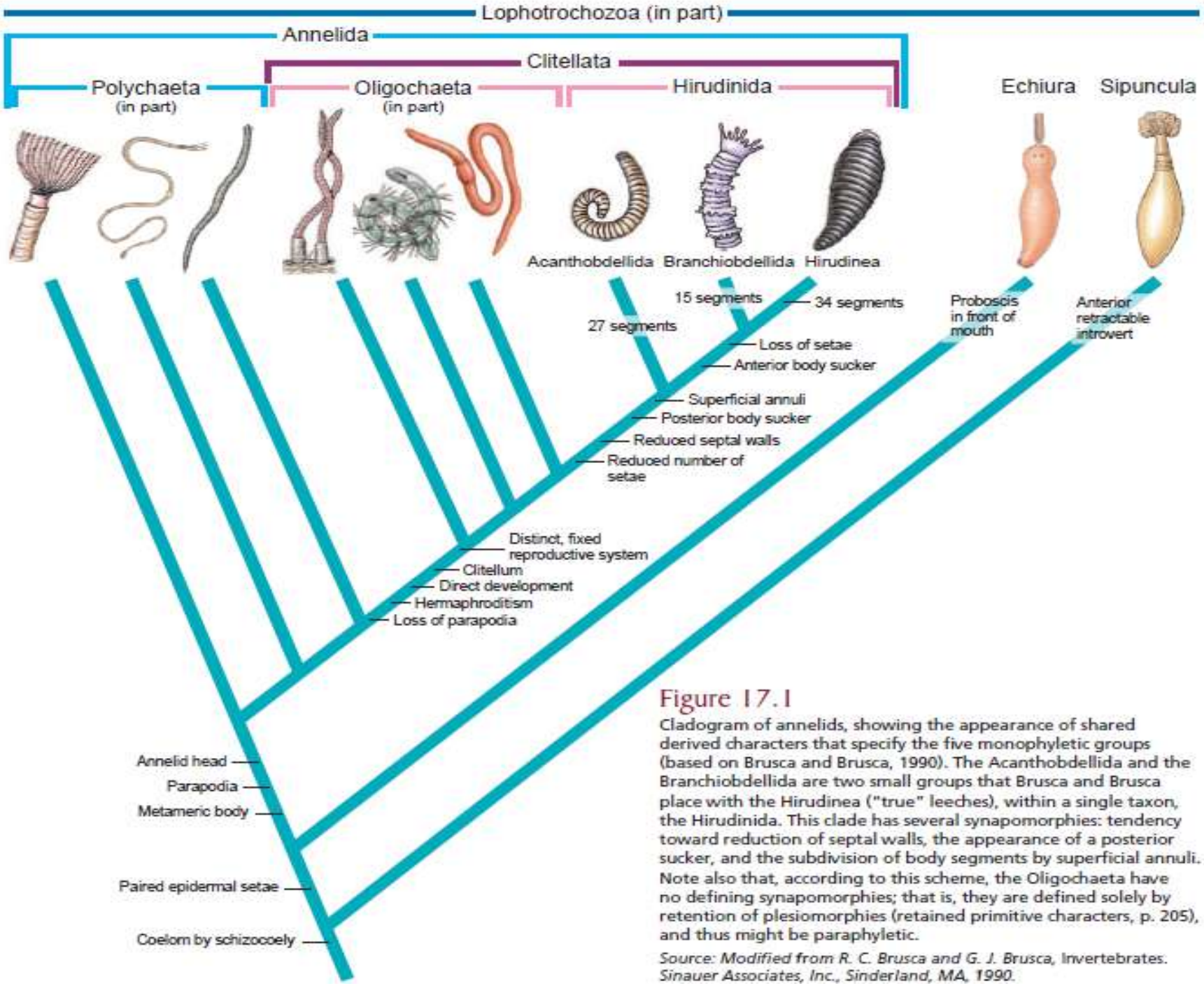


Figure 17.1

Cladogram of annelids, showing the appearance of shared derived characters that specify the five monophyletic groups (based on Brusca and Brusca, 1990). The Acanthobdellida and the Branchiobdellida are two small groups that Brusca and Brusca place with the Hirudinea ("true" leeches), within a single taxon, the Hirudinida. This clade has several synapomorphies: tendency toward reduction of septal walls, the appearance of a posterior sucker, and the subdivision of body segments by superficial annuli. Note also that, according to this scheme, the Oligochaeta have no defining synapomorphies; that is, they are defined solely by retention of plesiomorphies (retained primitive characters, p. 205), and thus might be paraphyletic.

Source: Modified from R. C. Brusca and G. J. Brusca, Invertebrates. *Sinauer Associates, Inc., Sinderland, MA, 1990.*

Class Polychaeta

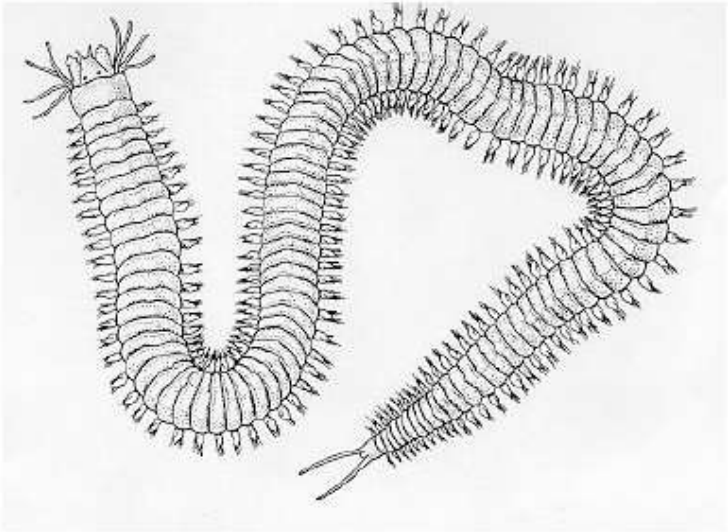
Polychaetes - "many bristles"

- Class Polychaeta are the most diverse group of the Annelida.
- It contains over 5,500 species.
- They are predominantly marine animals.
- They represent a major evolutionary branch of annelids.

Class Polychaeta

Characteristics of Class Polychaeta

They have a pair of lateral out growths in each segment called "parapodia."

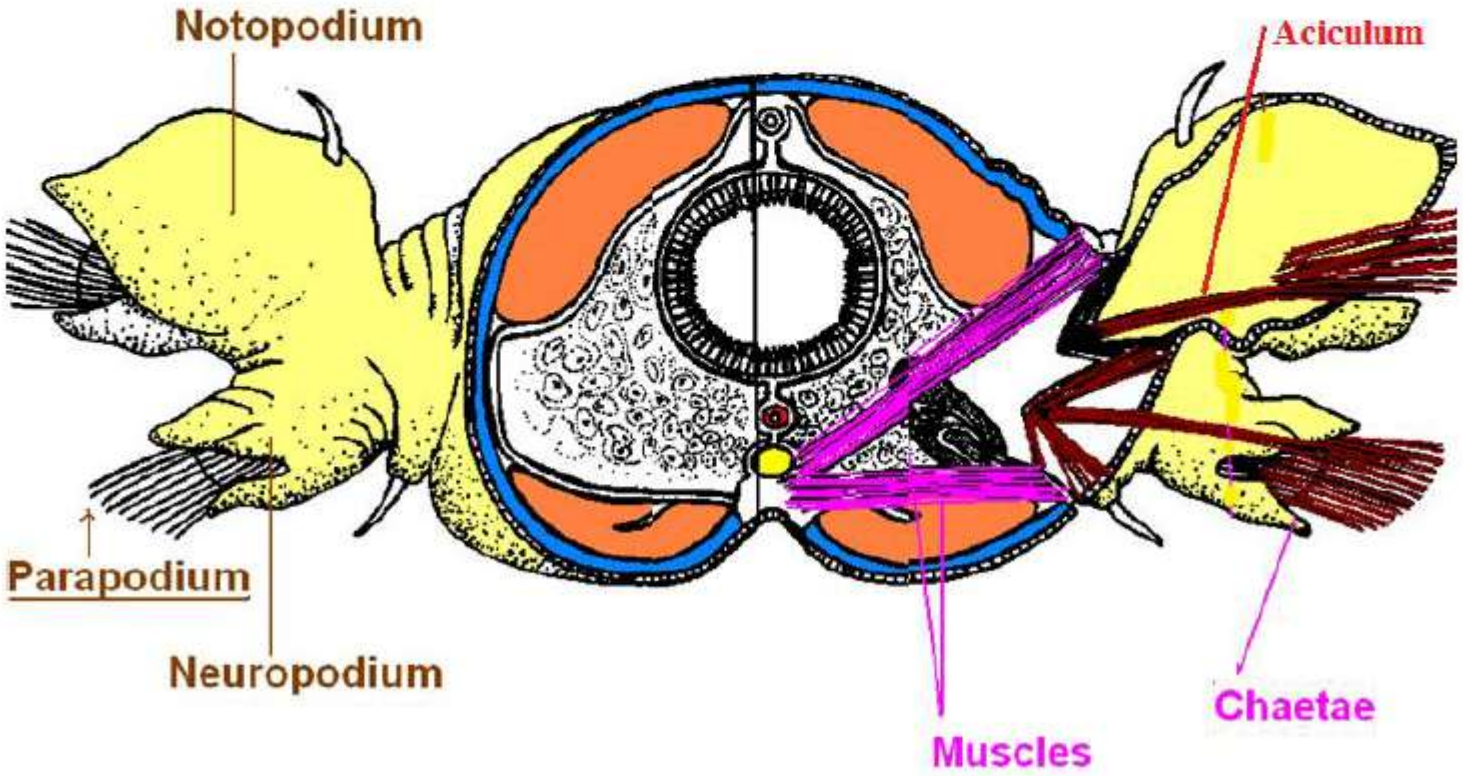


Nereis virens
(Clam worm)

Class Polychaeta

Parapodia when supported by chitinous rods (aciculum) help for locomotion

In addition, chaetae project from each parapodium



Class Polychaeta

Polychaetes do not have permanent gonads.

Adults produce gametes in temporary swellings.

Gametes are released in the peritonium. From there, They are expelled through nephrosomes or through body wall directly into the sea.

Fertilization takes place externally.

The egg develops into ciliated larva called trochophore .

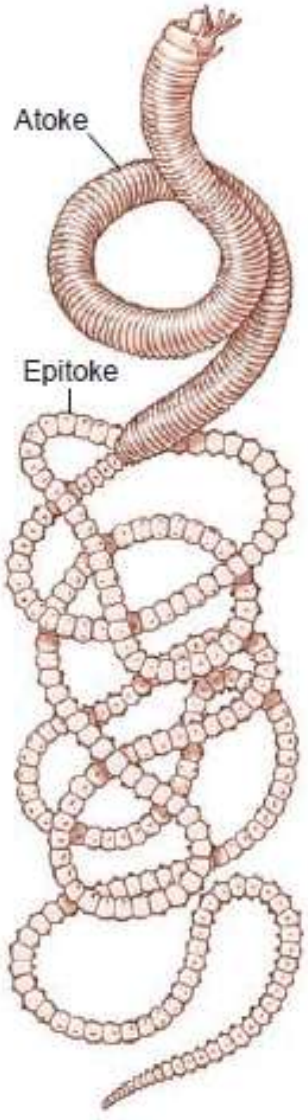
Class Polychaeta

Trochophore larva lives in water.

- **Feeds on suspended algae.**

- **Develops into juvenile worms.**

- **Then, settle down to become the adult.**



- **Some polychaetes show <u>asexual fragmentation</u> (epitoky)**

***Eunice viridis,* the Samoan palolo worm.**

- The posterior segments make up the epitokal region, consisting of segments
- packed with gametes. Each segment has an eyespot on the ventral side. Once a
- year the worms swarm, and the epitokes detach, rise to the surface, and discharge
- their ripe gametes, leaving the water milky. By the next breeding season, the epitokes are regenerated.

Class Polychaeta

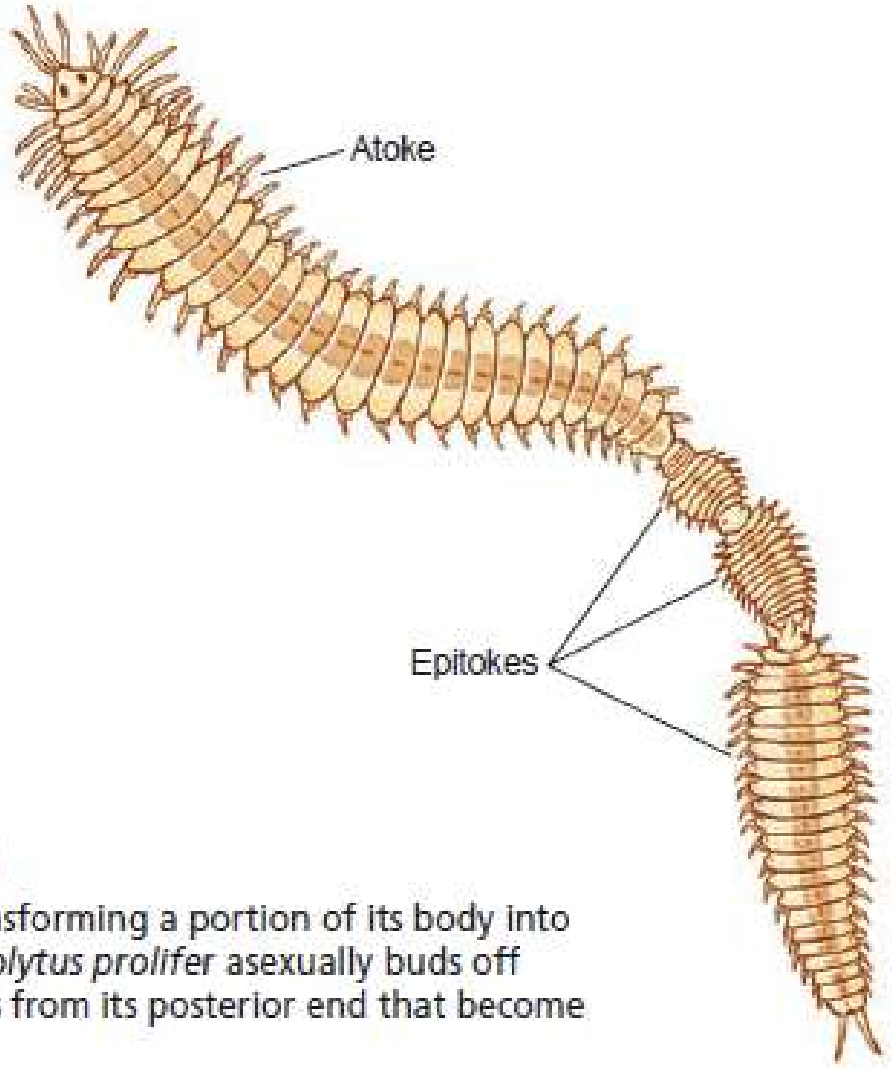


Figure 17.8

Rather than transforming a portion of its body into an epitoke, *Autolytus prolifer* asexually buds off complete worms from its posterior end that become sexual epitokes.

Class Polychaeta

Free moving, predatory polychaetes

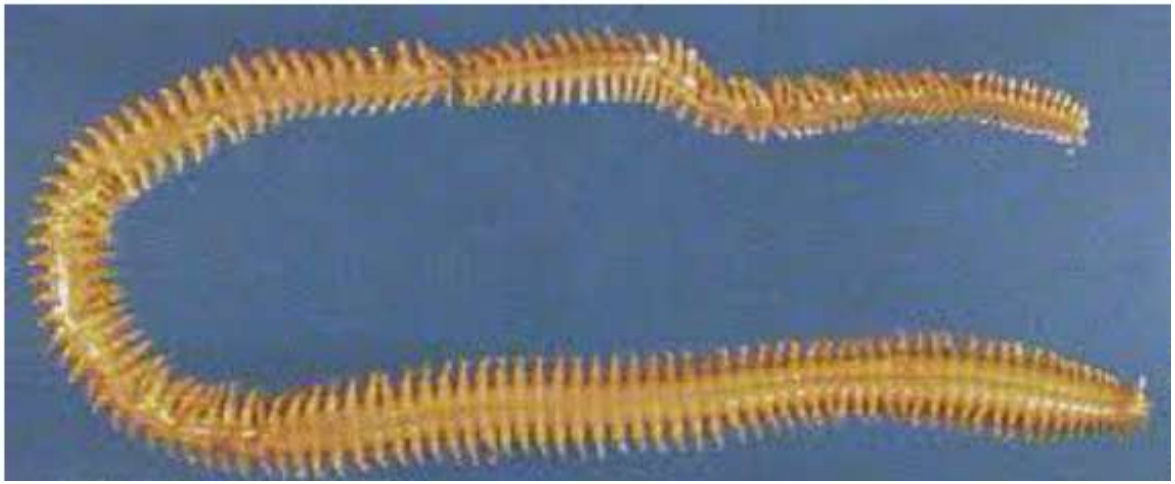
Errentia

They have well developed -

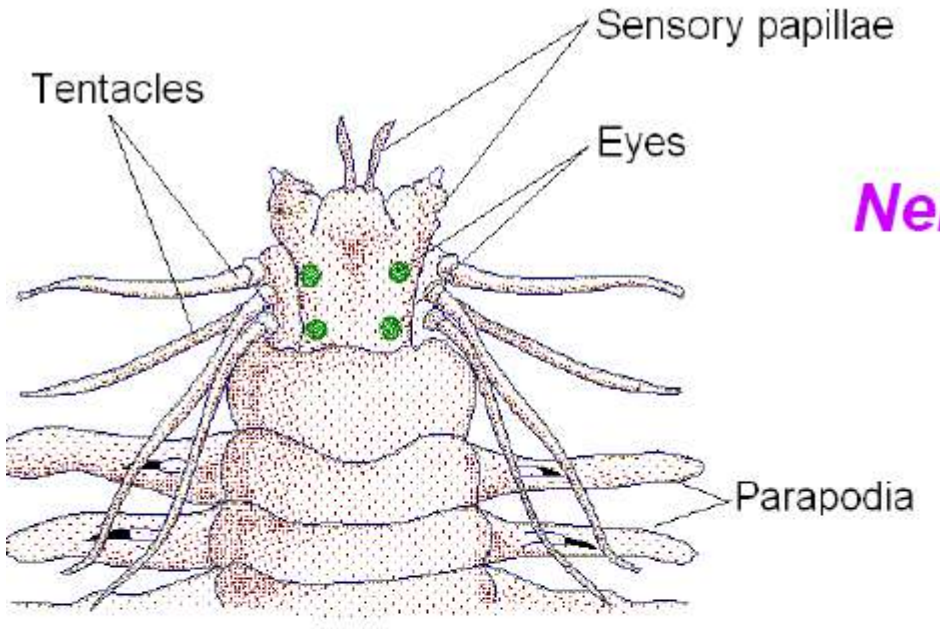
- **head**
- **parapodia - used in creeping.**

They are more active live in burrows.

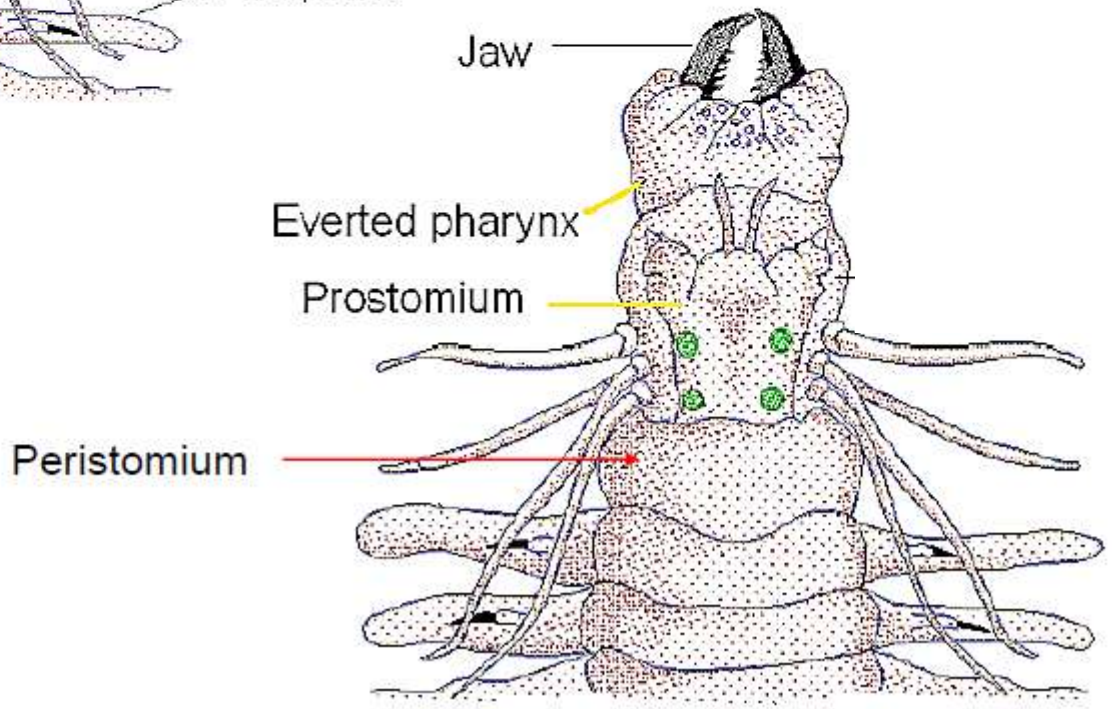
Nereis virens
(clam worm)



Class Polychaeta



***Nereis virens* - Clam worm**



Class Polychaeta

Sedentary polychaetes - Sedentaria

They build

- leatherly/ calcarious tubes

- holes or burrows
  - Provide a place for protection

They are suspension feeders –

- feed by filtering the water for suspended food.

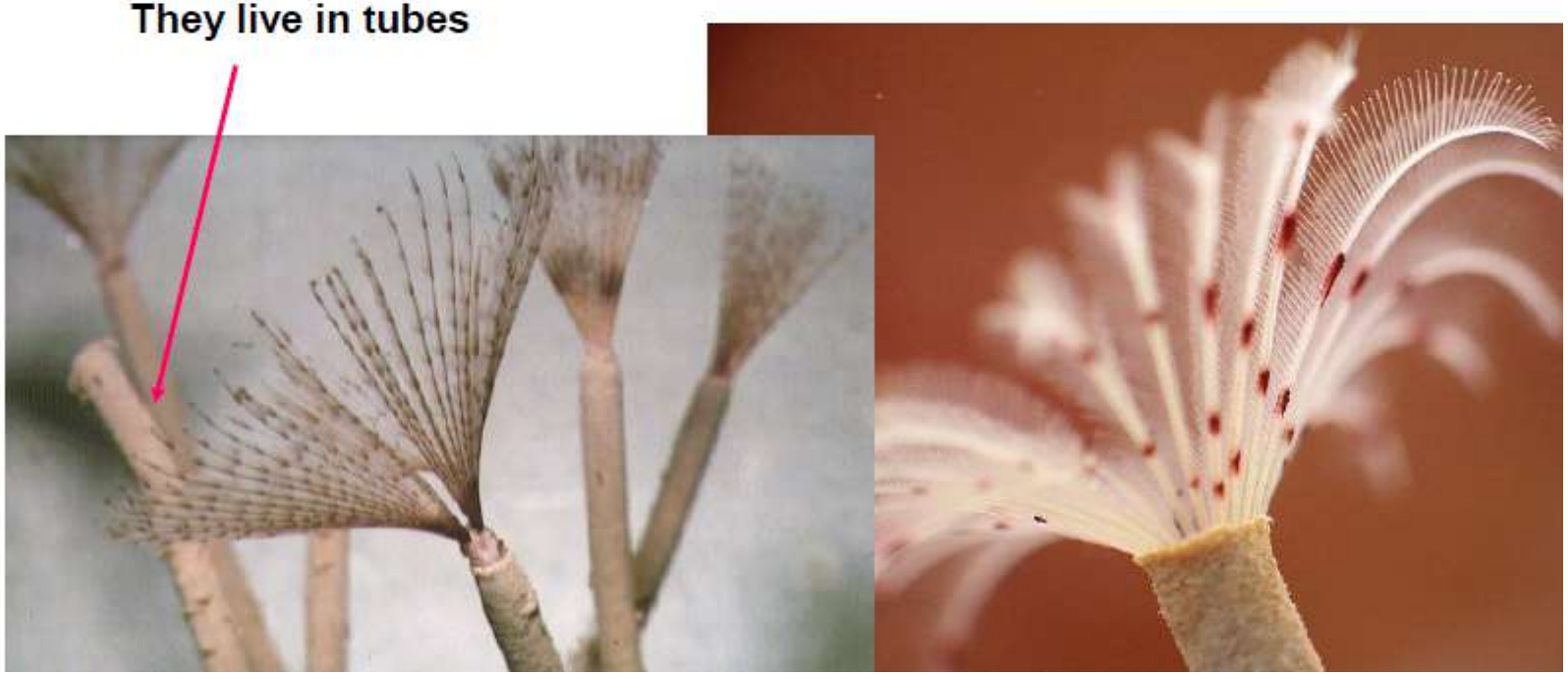
Class Polychaeta

Fan worms – *Sabella* – *A ciliary feeder*

They have tentacular crown of radioles (arms).

It opens like a fan and withdraw into tube-

- In order to obtain suspended food.



Class Polychaeta

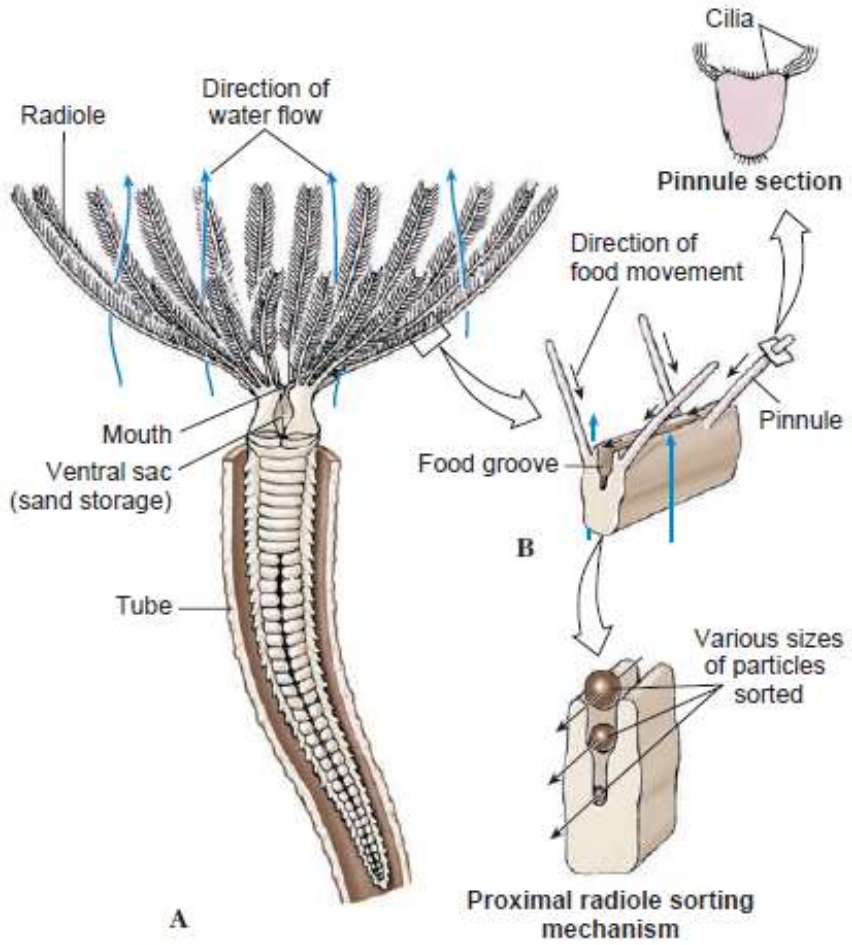


Figure 17.11

Sabella, a polychaete ciliary feeder, extends its crown of feeding radioles from its leathery secreted tube, reinforced with sand and debris. **A,** Anterior view of the crown. Cilia direct small food particles along grooved radioles to mouth and discard larger particles. Sand grains are directed to storage sacs and later are used in tube building. **B,** Distal portion of radiole showing ciliary tracts of pinnules and food grooves.

Class Polychaeta

A

B

Figure 17.4

Tube-dwelling sedentary polychaetes. **A,** Christmas-tree worm, *Spirobranchus giganteus,* live in a calcareous tube. On its head are two whorls of modified tentacles (radioles) used to collect suspended food particles from the surrounding water. Notice the finely branched filters visible on the edge of one radiole. **B,** Sabellid polychaetes, *Bispira brunnea,* live in leathery tubes.

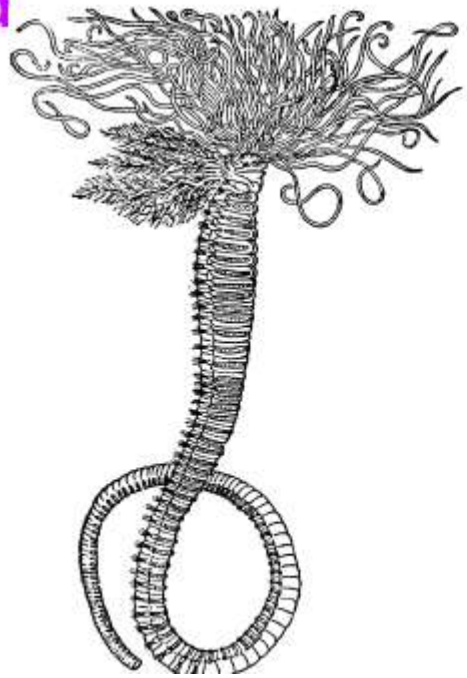
Class Polychaeta

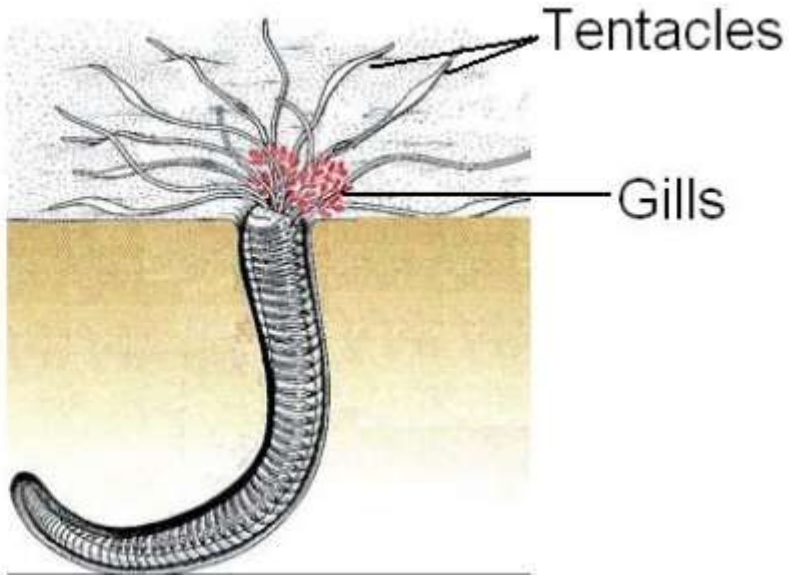
Amphitrite

Sand/mud burrowers

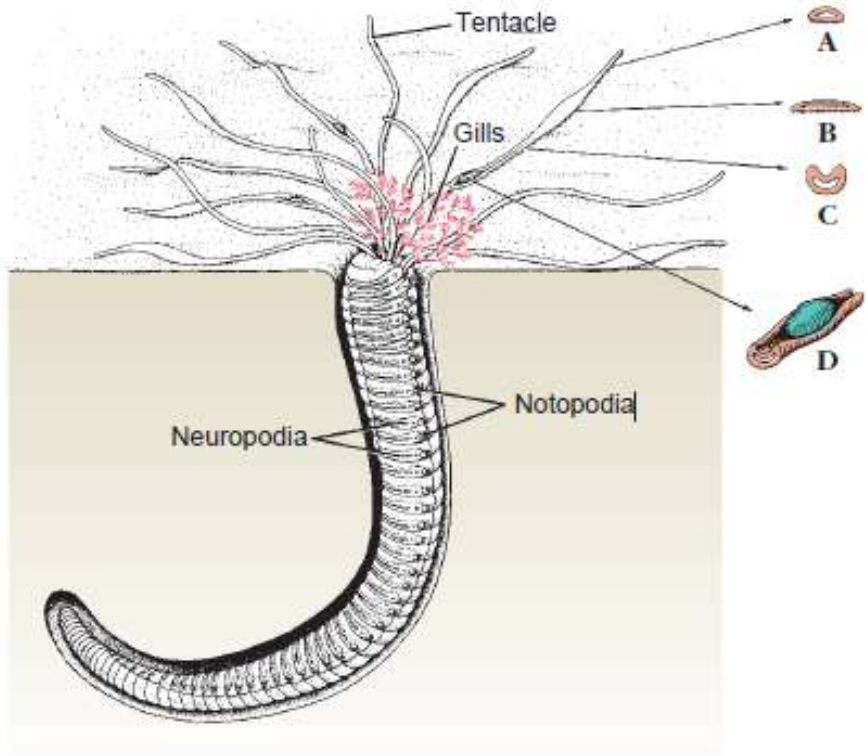
-Burrow into mud in shallow water

- have long grooved tentacles to collect food





Class Polychaeta



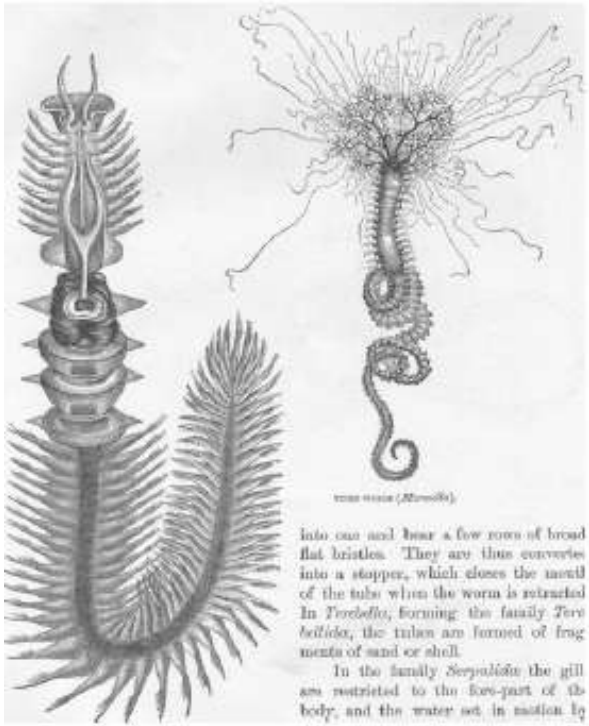
Amphitrite, which builds its tubes in mud or sand, extends long grooved tentacles out over the mud to pick up bits of organic matter. The smallest particles are moved along food grooves by cilia, larger particles by peristaltic movement. Its plumelike gills are blood red.

A, Section through exploratory end of tentacle
B, Section through tentacle in area adhering to substratum.
C, Section showing ciliary groove.
D, Particle being carried toward mouth.

Class Polychaeta

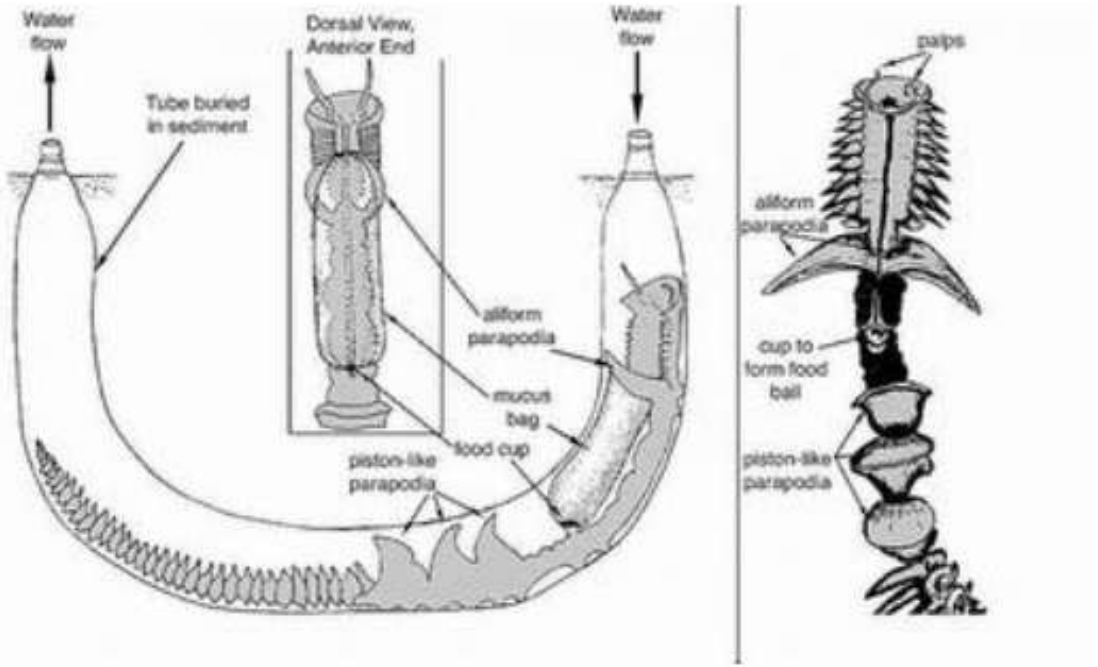
Chaetopterus (Parchment tube worm)

Live in leathery "U" shape tubes

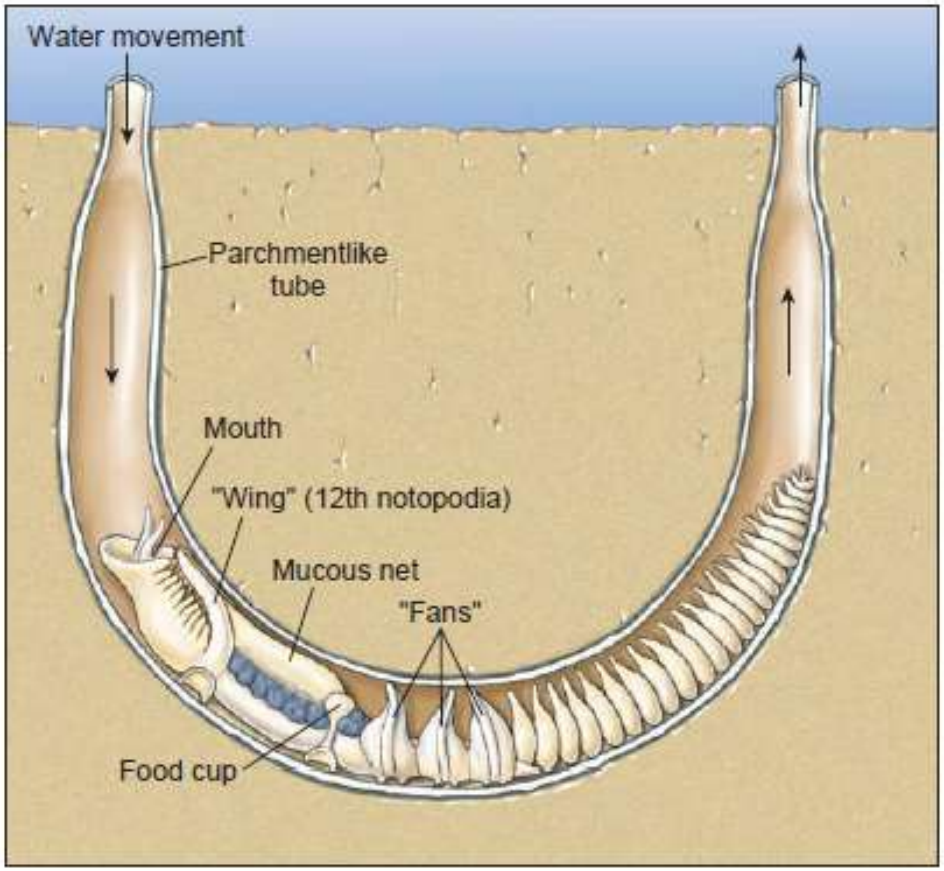


into one and bear a few rows of broad flat bristles. They are thus converted into a stopper, which closes the mouth of the tube when the worm is retracted. In *Terebella*, forming the family *Terebellidæ*, the tubes are formed of fragments of sand or shell.

In the family *Serpulidæ* the gill are restricted to the fore-part of the body, and the water set in motion by

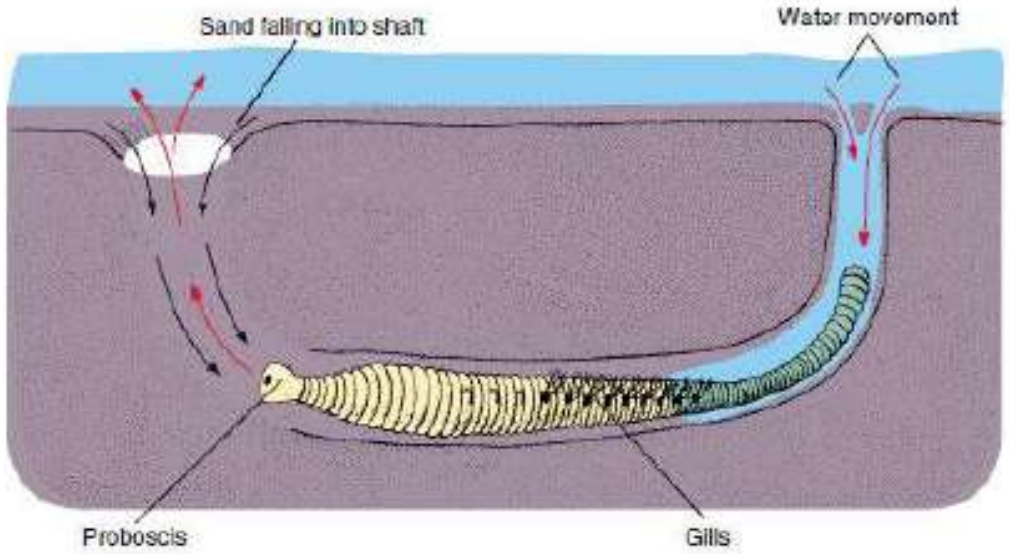


Class Polychaeta



- *Chaetopterus,* a sedentary polychaete, lives in a U-shaped tube in the sea bottom
- It pumps water through the parchmentlike tube (of which one-half has been cut away here) with its three pistonlike fans.
- The fans beat 60 times per minute to keep water currents moving
- The winglike notopodia of the twelfth segment continuously secrete a mucous net that strains out food particles.
- As the net fills with food,the food cup rolls it into a ball, and when the ball is large enough (about 3 mm), the food cup bends forward and deposits the ball in a ciliated groove to be carried to the mouth and swallowed.

Class Polychaeta



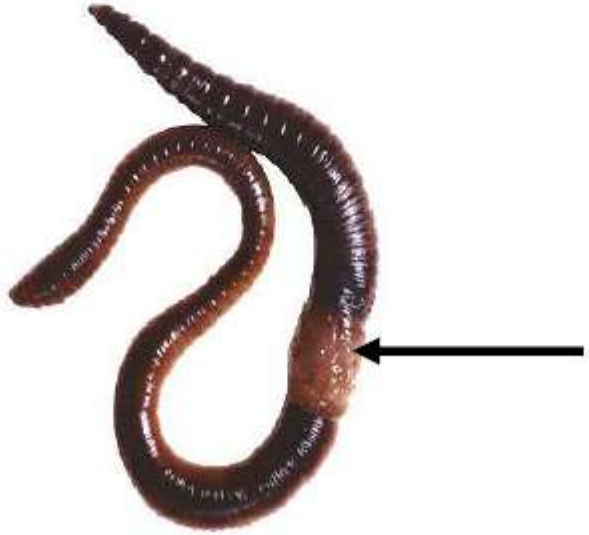
- *Arenicola*, the lugworm, lives in an L-shaped burrow in intertidal mudflats. It burrows by successive eversions and retractions of its proboscis. By peristaltic movements it keeps water filtering through the sand. The worm then ingests the food-laden sand.

Class Clitellata

- They do not have parapodia or cephalic appendages.
- Setae are reduced or no setae.
- Have permanent gonads.
- They are hermaphrodite.
- Direct development (no larval stages).

Class Clitellata

- They have a glandular epidermal area of the body called clitellum. (usually in adults)



Class Clitellata

Clitellum - rests about 14-16 segments from the head.

Importance of clitellum during reproduction;

1. secrete mucous – it helps to hold two mating individuals; helps transfer of sperm

2. secrete a cocoon - for embryo to develop

3. secrete albumin - for developing embryo in the cocoon

Subclass Oligochaeta

(Oligo = few, Chaeta = bristle)

Earthworm - *Lumbricus*

They are the second most numerous group of annelids (3,100 species).

Oligochaeta live in marine, freshwater and terrestrial habitats.

- Most common in fresh water or on land.

Subclass Oligochaeta

Aquatic (freshwater) Oligochaetes

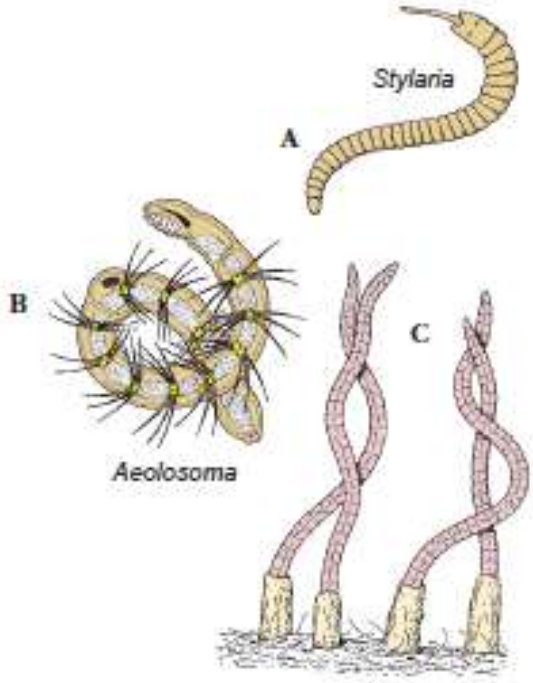
Stylaria

Tubifex

They are benthic creepers or burrowers in soft mud.

- smaller in size and setae are prominent.

They are source of food for fish



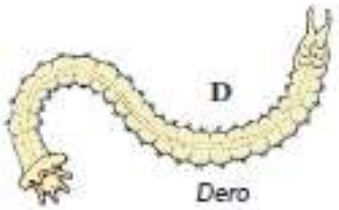


Figure 17.22
Some freshwater oligochaetes. **A**, *Stylaria* has the prostomium drawn out into a long snout. **B**, *Aeolosoma* uses cilia around the mouth to sweep in food particles, and it buds off new individuals asexually. **C**, *Tubifex* lives head down in long tubes. **D**, *Dero* has ciliated anal gills.

Subclass Oligochaeta

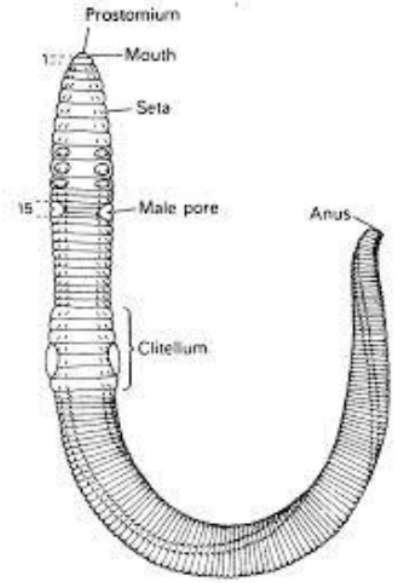
Terrestrial oligochaetes - Earthworms

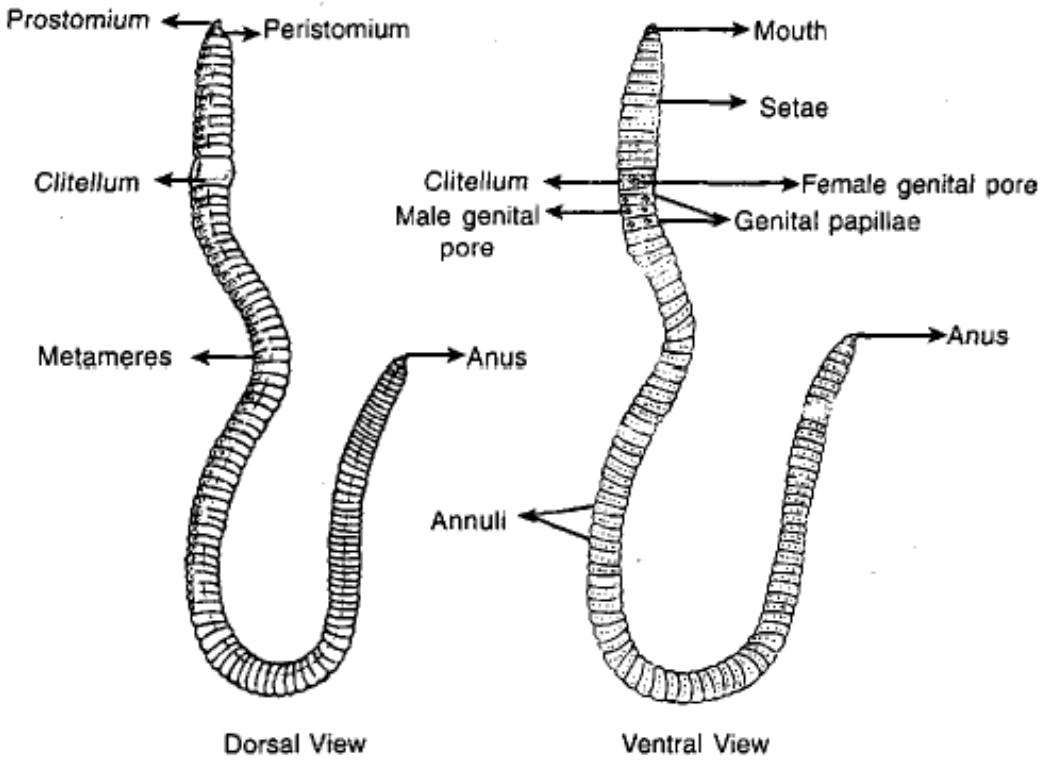
- They have 150-250 or more segments.
- Each segment has four pairs of setae.
- They burrow in moist soil protruding one end of the body from the burrow.
- Move by peristaltic waves –

Subclass Oligochaeta

Two earthworms line up in a head to tail fashion.

Mucous is secreted by the glandular epidermis of the clitellum.





Two animals exchange sperms and store in the seminal receptacle of the partner animal (10th segment).

Subclass Oligochaeta

- A mucous tube forms around the clitellum of both animals and fills with albumin.

- It dries up (cocoon) and slips towards anterior of each animal from clitellum after mating.

- While the cocoon passes over female pore (14^{th} segment), it receives ova (eggs) into the capsule.

- This followed by receiving sperms of the mating partner from seminal receptacle in 10^{th} segment into the capsule.

Subclass Oligochaeta

- The cocoon is dropped on to the soil from the head end of the animal.

Young earthworms emerge from the cocoon.

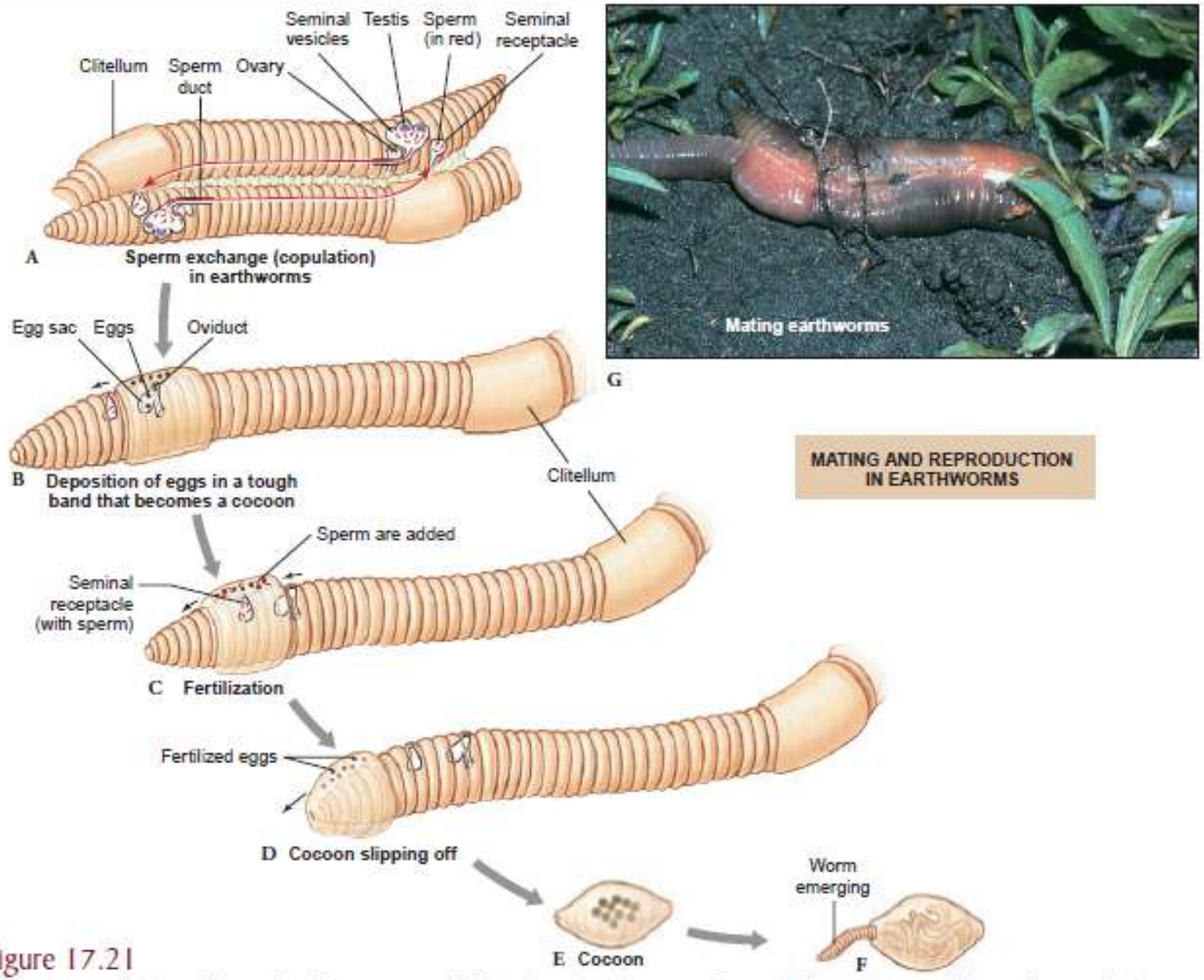


Figure 17.21

Earthworm copulation and formation of egg cocoons. **A,** Mutual insemination; sperm from genital pore (segment 15) pass along seminal grooves to seminal receptacles (segments 9 and 10) of each mate. **B** and **C,** After worms separate, the clitellum secretes first a mucous tube and then a tough band that forms a cocoon. The developing cocoon passes forward to receive eggs from oviducts and sperm from seminal receptacles. **D,** As cocoon slips off over anterior end, its ends close and seal. **E,** Cocoon is deposited near burrow entrance. **F,** Young worms emerge in 2 to 3 weeks. **G,** Two earthworms in copulation. Their anterior ends point in opposite directions as their ventral surfaces are held together by mucous bands secreted by the clitella.

Subclass Hirudinea

There are about 500 - 600 species, commonly known as leeches.

Occur in fresh water, marine and terrestrial environments.

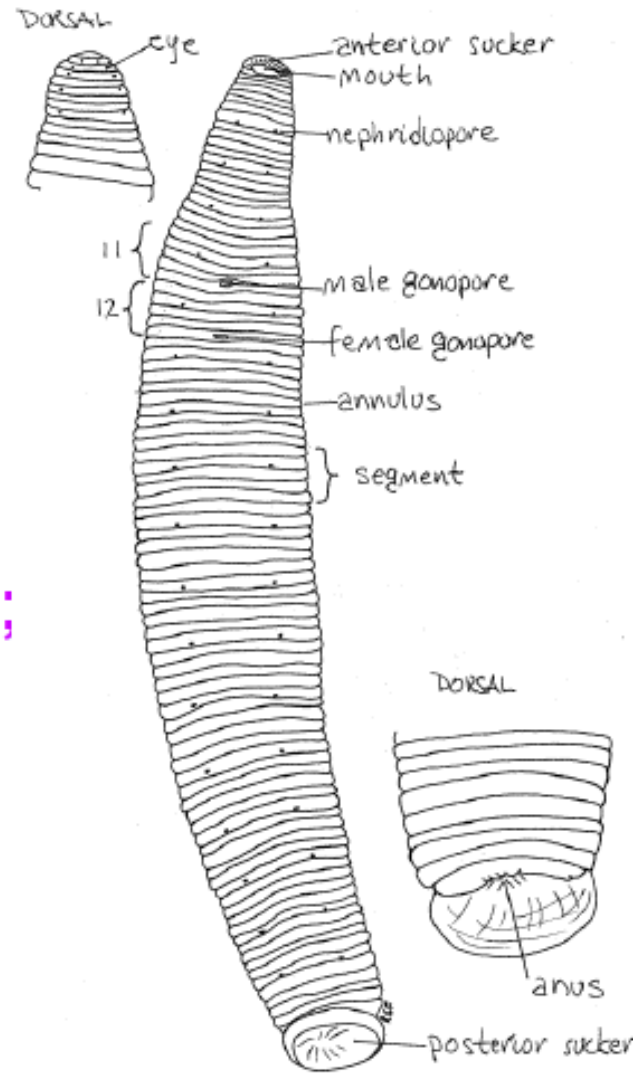
Subclass Hirudinea

- **Leeches have no chaetae.**

- **Body consists 33 segments.**
- **Each segment has 2-3 annuli.**

- **Internal septa absent.**

Parasitic leeches **have two suckers; small anterior sucker & large posterior sucker.**



Subclass Hirudinea

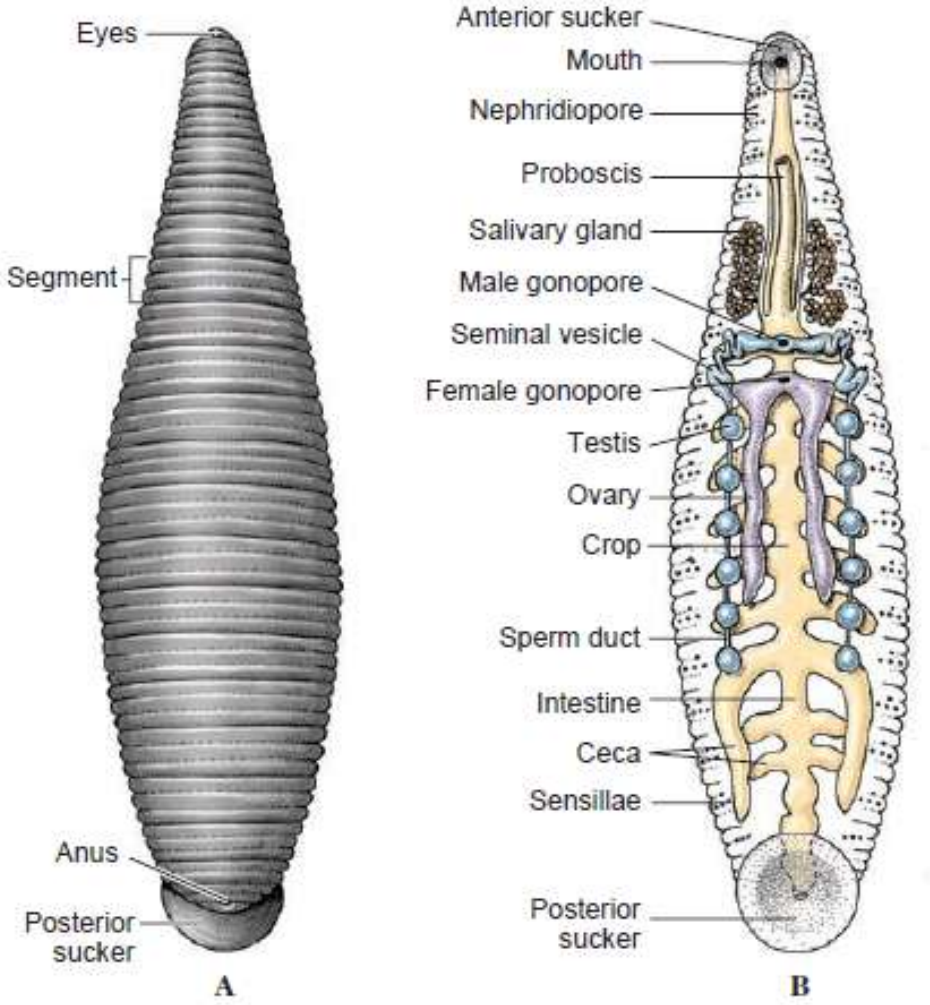


Figure 17.24
Structure of a leech, *Placobdella*. **A,** External appearance, dorsal view. **B,** Internal structure, ventral view.

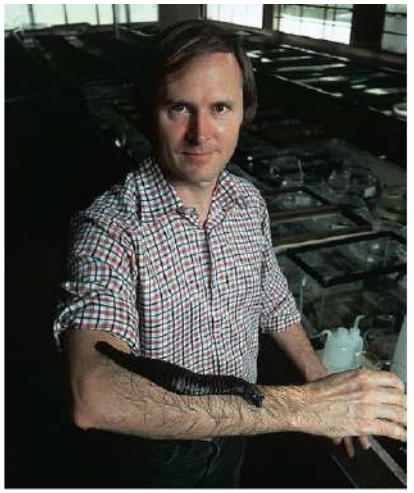
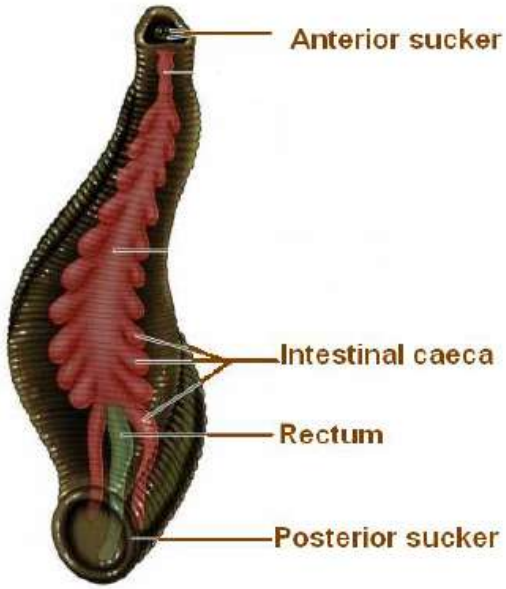


Figure 17.23
The world's largest leech, *Haementeria ghilianii*, on the arm of Dr. Roy K. Sawyer, who found it in French Guiana, South America.

Figure 17.25
Hirudo medicinalis feeding on blood from human arm.

Subclass Hirudinea

Coelom is greatly reduced.

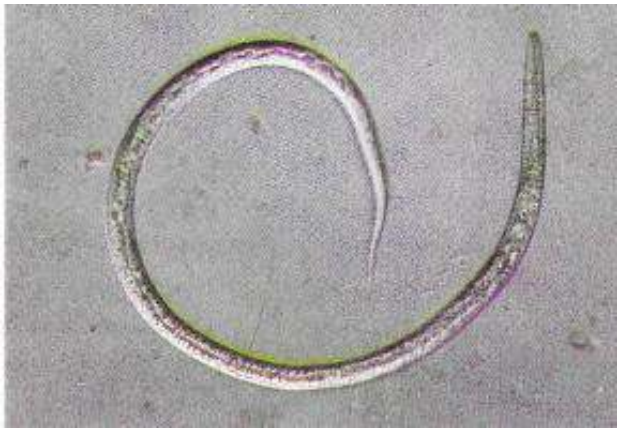


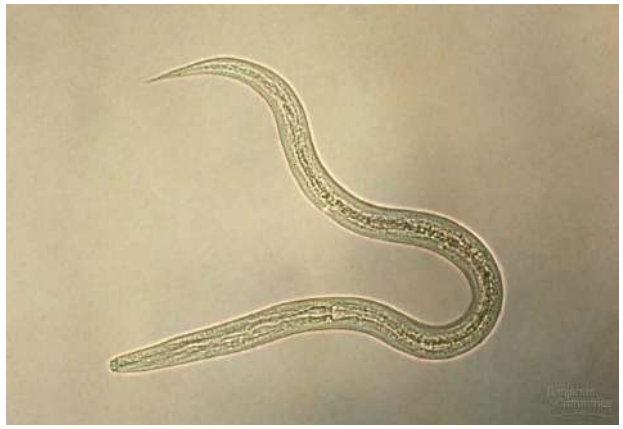
Hermophrodite but, cross fertilization take place between two animals. Fertilization internal but, developmemt inside a cocoon.

PHYLUM NEMATODA

Nematodes resembles a tiny thread

Greek word "*nema*" *means* "thread"

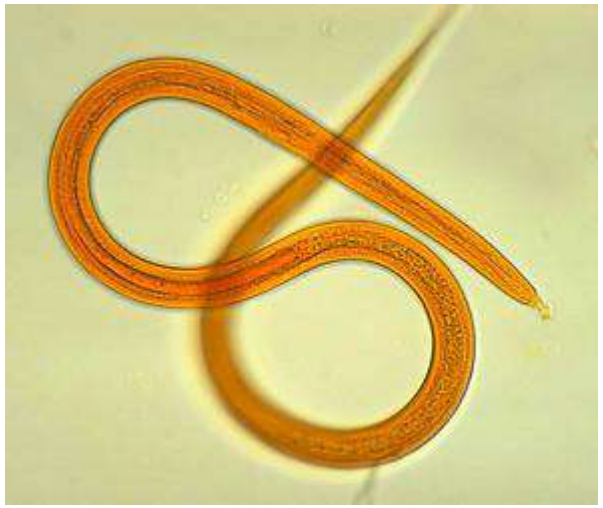




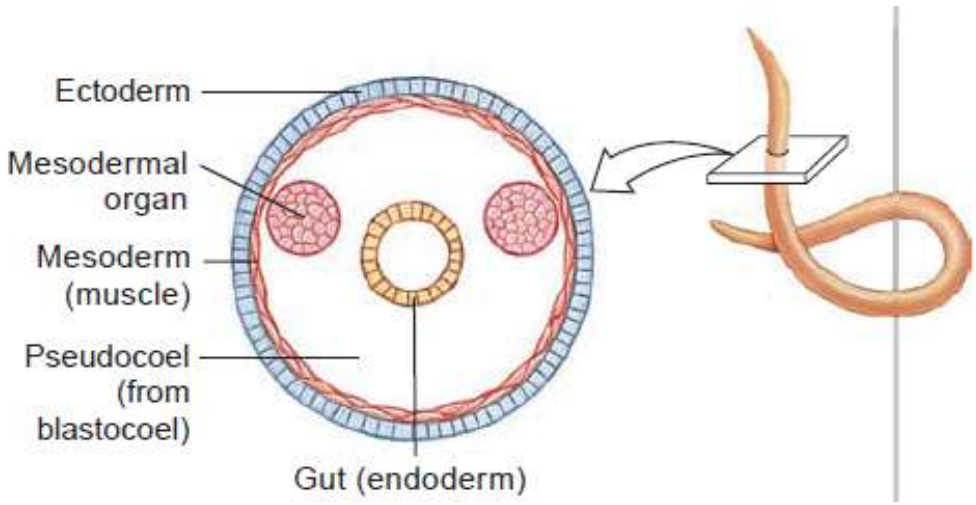
Also refer as "Roundworms"

BODY FORM

- Long, narrow, cylindrical, tapers at both ends
- Many are microscopic, average size 1 mm –5 mm (mostly < 5 cm) but extend to 1 m (parasitic)
- They are unsegmented worms, flexible, nonliving cuticle; their lack of motile cilia or flagella (except in one species)



- Bilateral symmetry
- Triploblastic
- Nematodes have a **Pseudocoelom** (tube-within-a-tube)
- Pseudocoelomis a closed fluid-filled space that acts as a **Hydrostatic Skeleton**
- It helps in circulation and dispersal of nutrients



BODY FORM

- Their outer body covering is a relatively thick
- **Cuticle** secreted by the underlying epidermis (**hypodermis**) (Shed during juvenile growth stages - **characters Ecdysozoa**)
- The hypodermis is syncytial
- **Function Cuticle**:
  1. Serving to contain the high hydrostatic pressure (turgor) exerted by fluid in the pseudocoel
  2. Protecting the worm from hostile environments such as dry soils or the digestive tracts of their hosts
  3. As a as sensory array it detects changes
- The several layers of the cuticle are primarily of **collagen (protein)**
- The cuticle not only covers the entire external surface, but it also lines the **buccal cavity, esophagus, rectum, cloaca, vagina, and excretory pore**
- Cuticle consists of 4 basic layers: **Epicuticle, Exocuticle, Mesocuticle,** and **Endocuticle**

BODY FORM

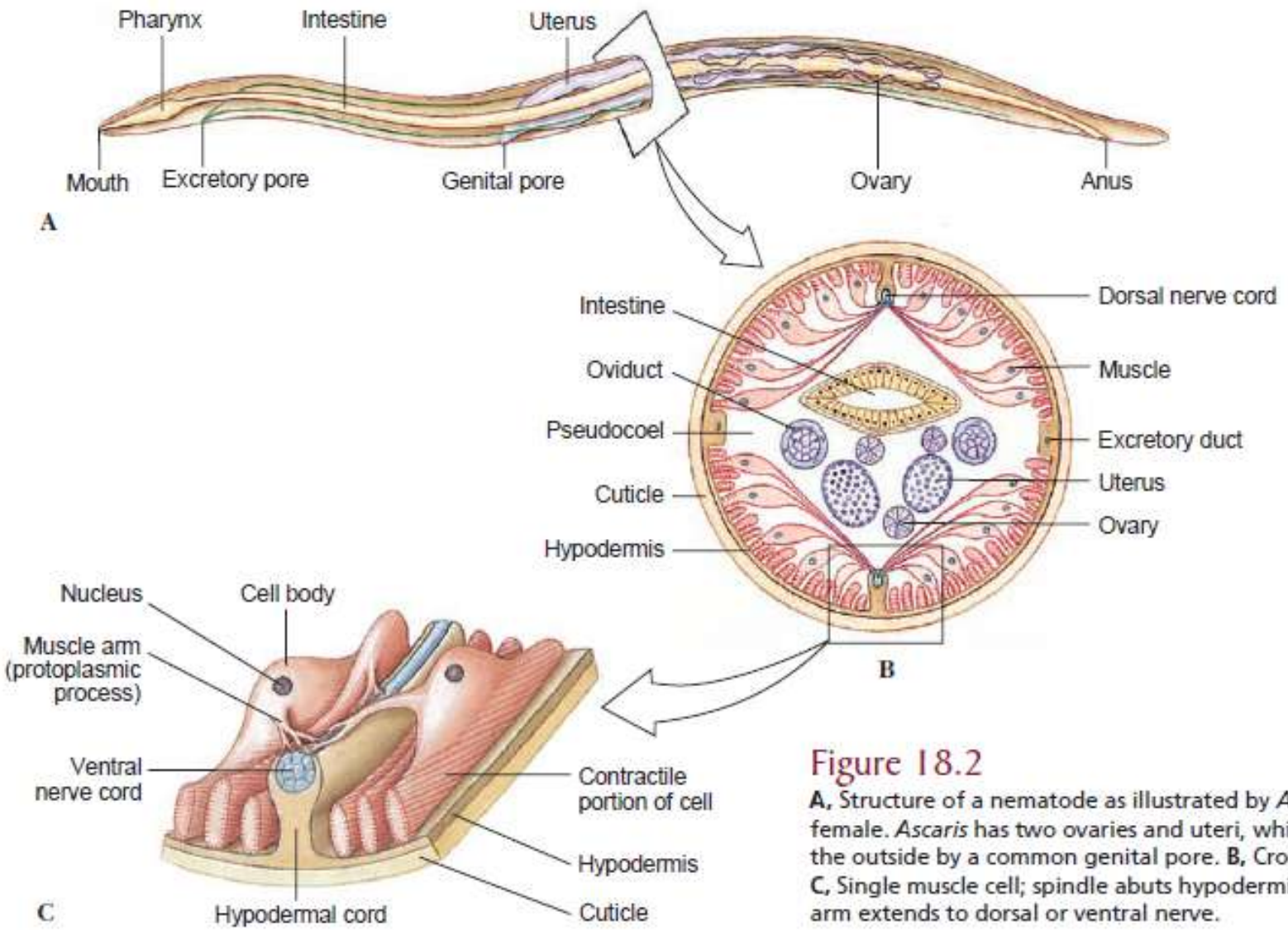


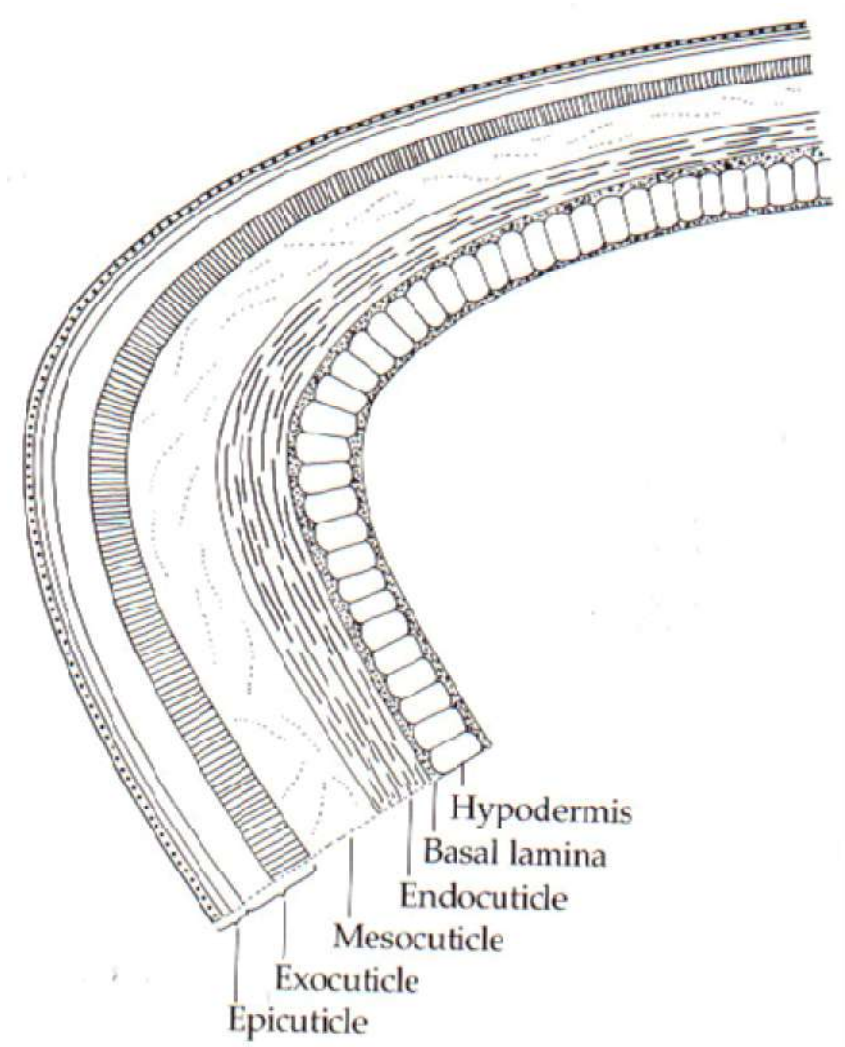
Figure 18.2

A, Structure of a nematode as illustrated by *Ascaris* female. *Ascaris* has two ovaries and uteri, which open to the outside by a common genital pore. **B,** Cross section. **C,** Single muscle cell; spindle abuts hypodermis, muscle arm extends to dorsal or ventral nerve.

BODY FORM

1. **Epicuticle -** thin; with a carbohydrate containing glycocalyx; acts as a protective barrier
2. **Exocuticle**
3. **Mesocuticle -** consists of obliquely oriented, collagenous, fibrous sublayers that vary in number and angular arrangement to each other; they sublayers can shift their angles of orientation, thus providing flexibility to the cuticle
4. **Endocuticle -** fibrous, but orientation of the fibers is not distinct

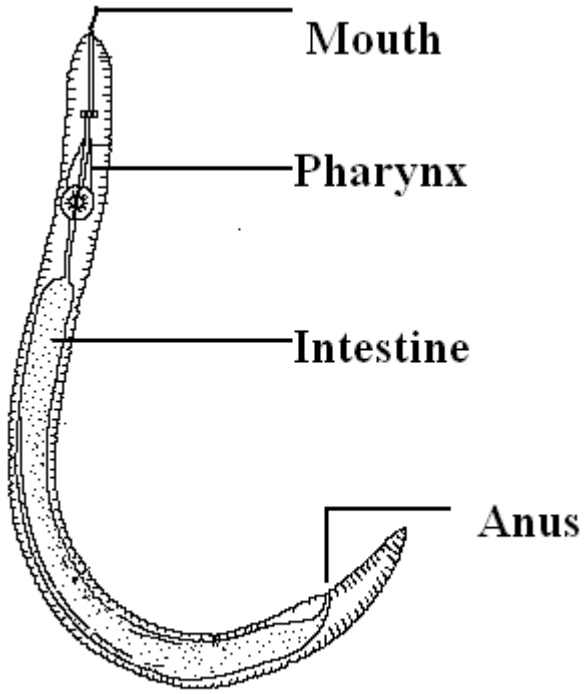
A basal lamina separates the cuticle from the underlying hypodermis



DIGESTIVE SYSTEM

Complete Digestive System
Food processing occurs within the alimentary canal, running lengthwise through the body.

The alimentary canal of nematodes consists of ***a mouth, a muscular pharynx, a long nonmuscular intestine, a short rectum, and a terminal anus.***

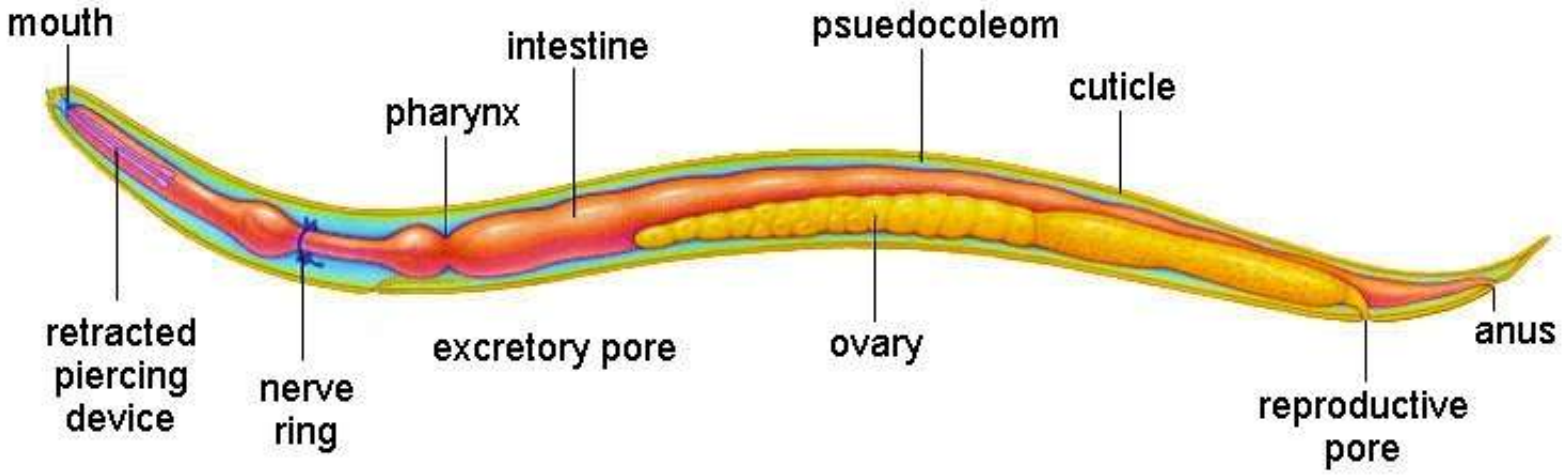


Their digestive system can be divided into Three parts:

1. **The Stomodeum** consists of the "mouth and lips", buccal cavity, and the pharynx (esophagus).
2. **The Intestine** functions by digesting, absorbing water and nutrients, and eliminating the residues of digestion
3. **The Proctodeum** serves as the anus and is where waste is excreted.

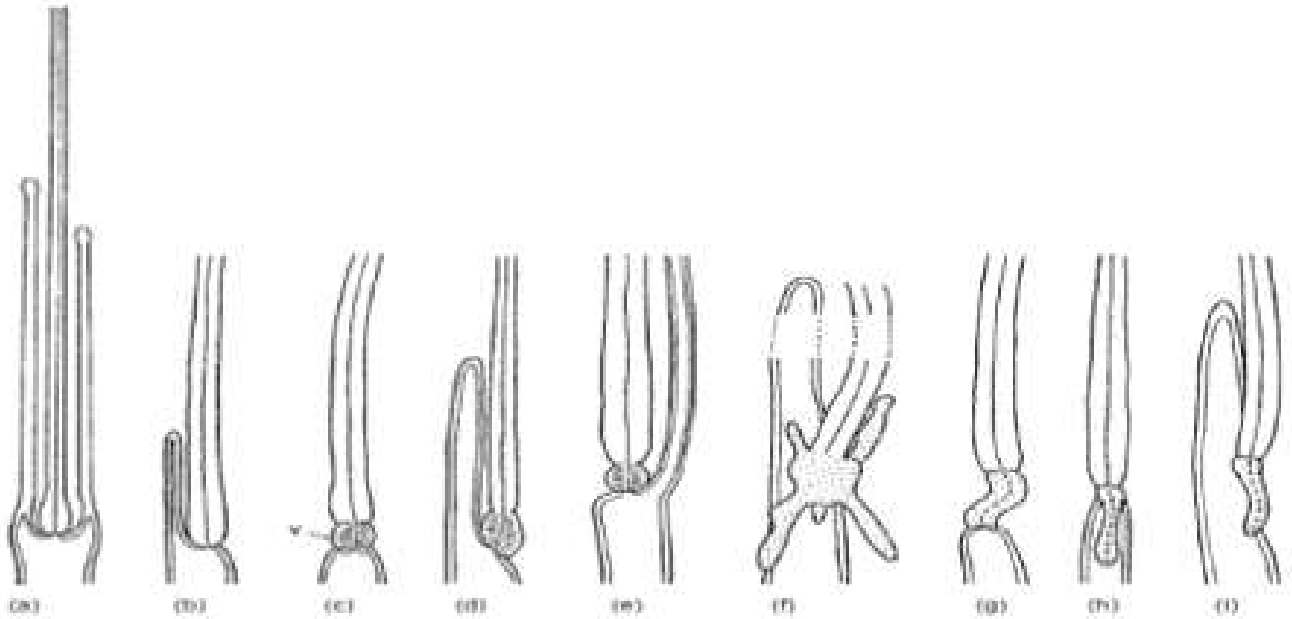
DIGESTIVE SYSTEM

- Food is sucked into the pharynx when the muscles in its anterior portion contract rapidly and open the lumen.
- Relaxation of the muscles anterior to the food mass closes the lumen of the pharynx, forcing the food posteriorly toward the intestine.
- The intestine is one celllayer thick. Food matter moves posteriorly by body movements and by additional food being passed into the intestine from the pharynx.
- **Defecation** is accomplished by muscles that simply pull the anus open, and expulsive force is provided by the high pseudocoelomic pressure that surrounds the gut.



DIGESTIVE SYSTEM

VARIATIONS IN ESOPHAGI IN SPECIES OF ASCARIDOID NEMATODES



Nematodes shown are of genera (*a) Crossophorus, (b) Angusticaecum, (c) Toxocara, (d) Porrocaecum, (e) Paradujardinia, (f) Multicaecum, (g) Anisakis, (h) Raphidascaris, (i) Contracaecum. v, ventriculus.*

THE NEMATODE LIFESTYLES

FREE-LIVING LIFESTYLE

- Eating habits:
  - Herbivores – eat plants
  - Carnivores – eat animals
  - Omnivores – eat both plants & animals
  - Saprophagous -Eat dead organic matter (from animals only), Yummy
- Free-living; and have the eating habits mentioned on the previous slide.
  - The free-living nematodes are important because they add organic matter to the soil and putting holes in the soil to better allow water movement through the soil.

THE NEMATODE LIFESTYLES

PARASITIC LIFESTYLE

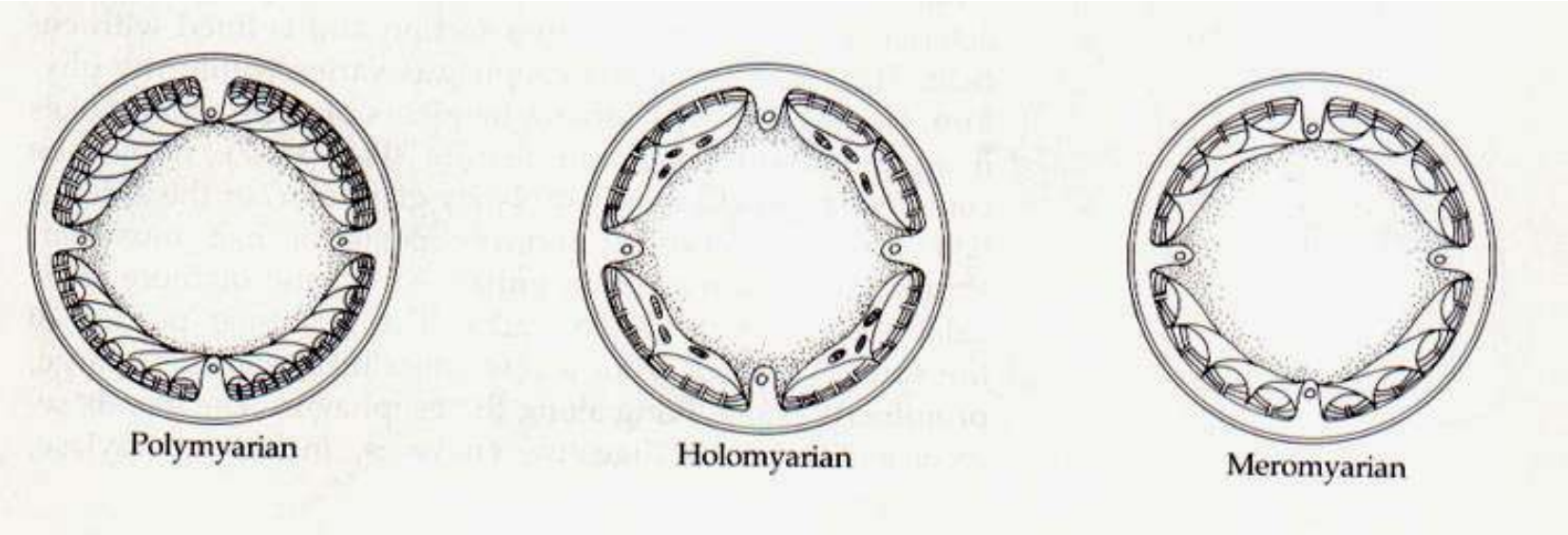
- Parasitic – feed off of a host.
  - These worms feed of the blood or tissue fluids of their hosts.
  - We will learn about four types of parastic nematodes: **filarial worms, hookworms, trichina worms, and ascaris worms**.
    - Interesting tidbits:
      - The filarial worms cause the disease elephantitis, pictured to the left.
      - Trichina worms cause trichinosis – the horrid disease contracted from eating undercooked pig products.

MUSCULAR SYSTEM

- The nematode body wall **has only longitudinal muscles**
- Remember longitudinal means lengthwise, so they only run from the anterior to the posterior end of the worm.
- These muscles are **used for movement**.
- When these muscles contract it causes the thrashing movements from head to tail.
- They **lack circular muscles** so they cannot crawl as we saw the leech do on dry surfaces

- Each muscle cell has a contractile **fibrillar portion (or spindle)** and a **noncontractile sarcoplasmic portion (cell body).**
- **The spindle** is striated with bands of **actin and myosin**
- **The cell bodies** contain the **nuclei and** are a **major depot for glycogen** storage in the worm

MUSCULAR SYSTEM



An arrangement of multiple longitiudinal rows of muscle cells in each:

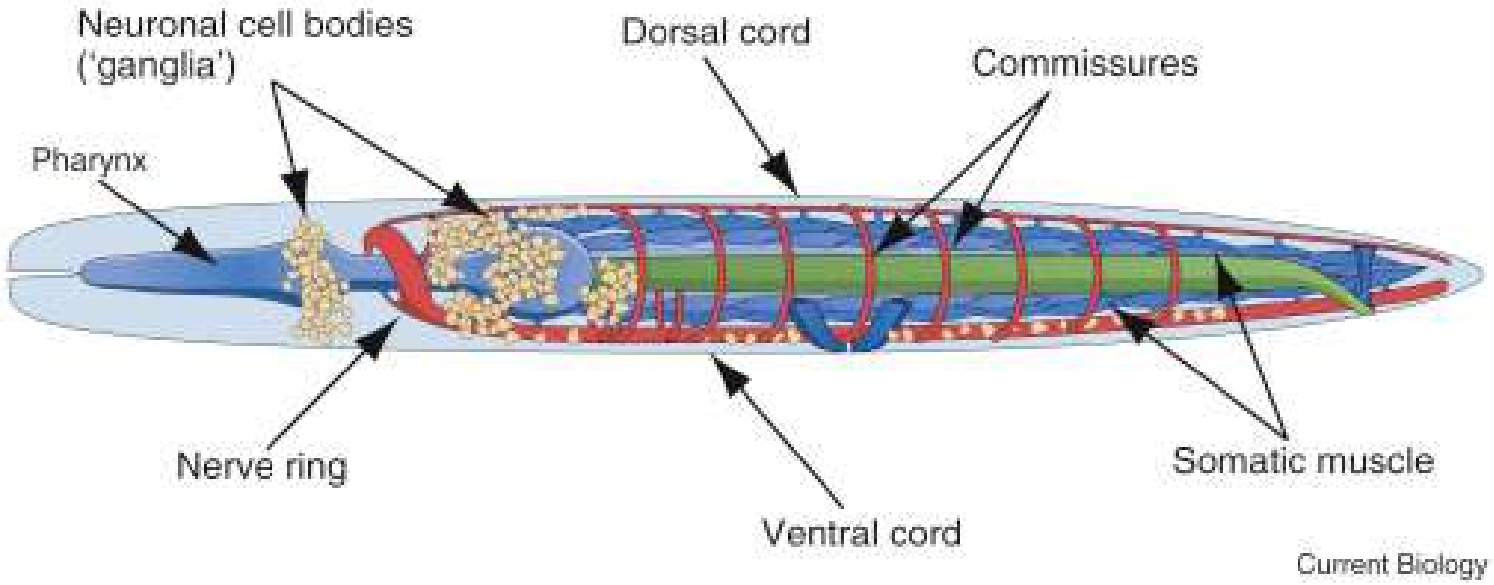
1. Quadrant is termed **POLYMYARIAN**
2. One with no more than2 rows of cells is called **HOLOMYARIAN**
3. One with 2 to 5 rows is **MEROMYARIAN**

NERVOUS SYSTEM

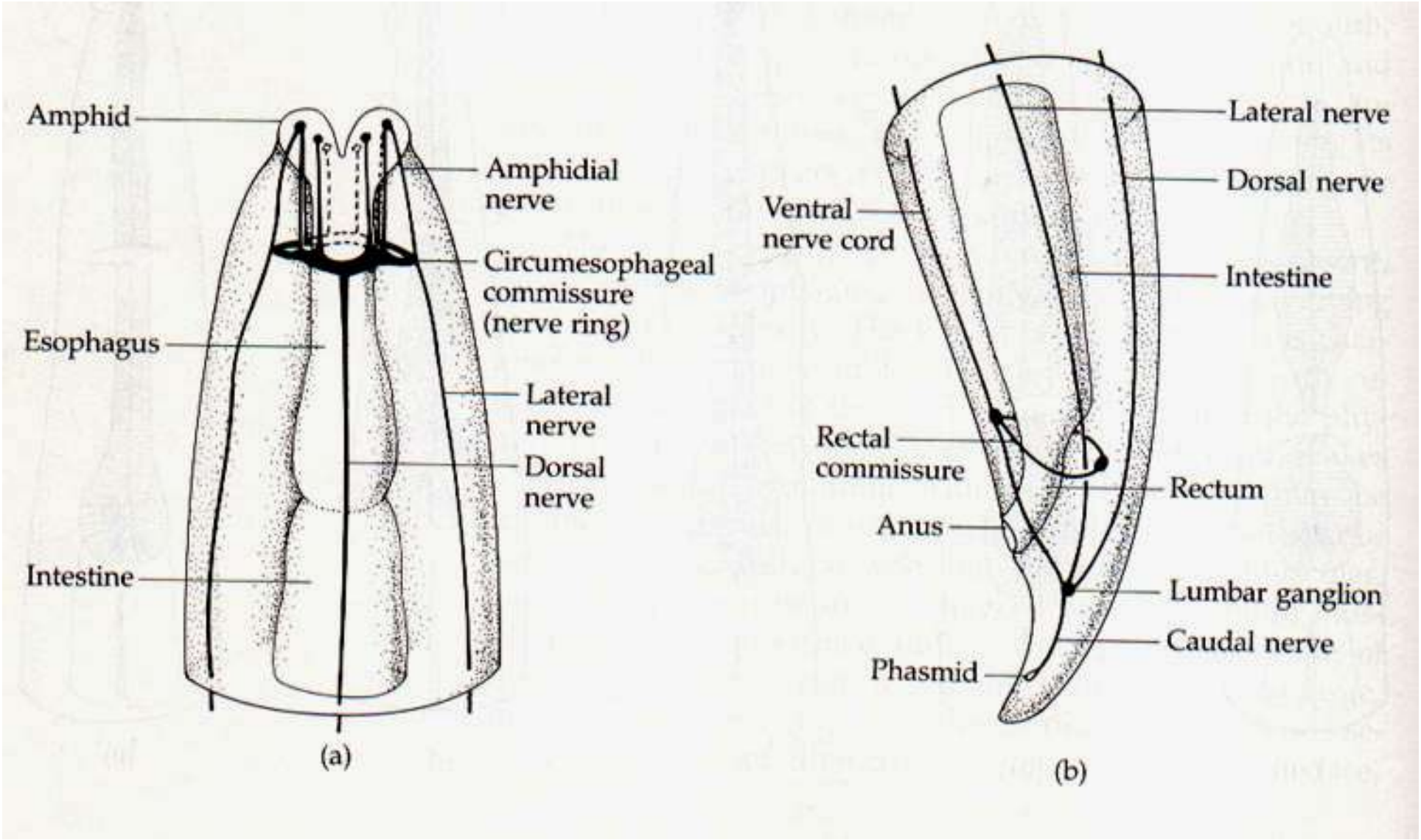
There are 2 major nerve centers in nematodes:

1. The **circumesophageal commissure,** or **nerve ring**
2. The **rectal commissure**

- Associated with the nerve ring are ganglia from which longitudinal nerves emanate
- From the ventral longitudinal nerve is born the rectal commissure



NERVOUS SYSTEM



NERVOUS SYSTEM

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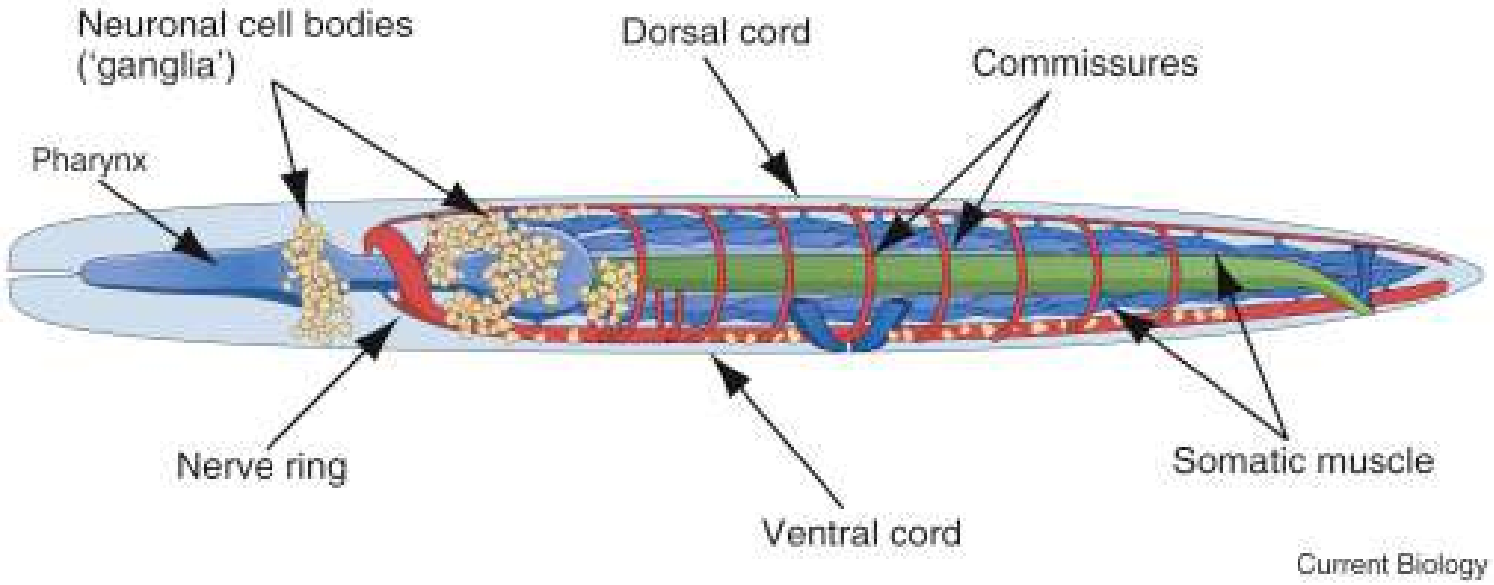
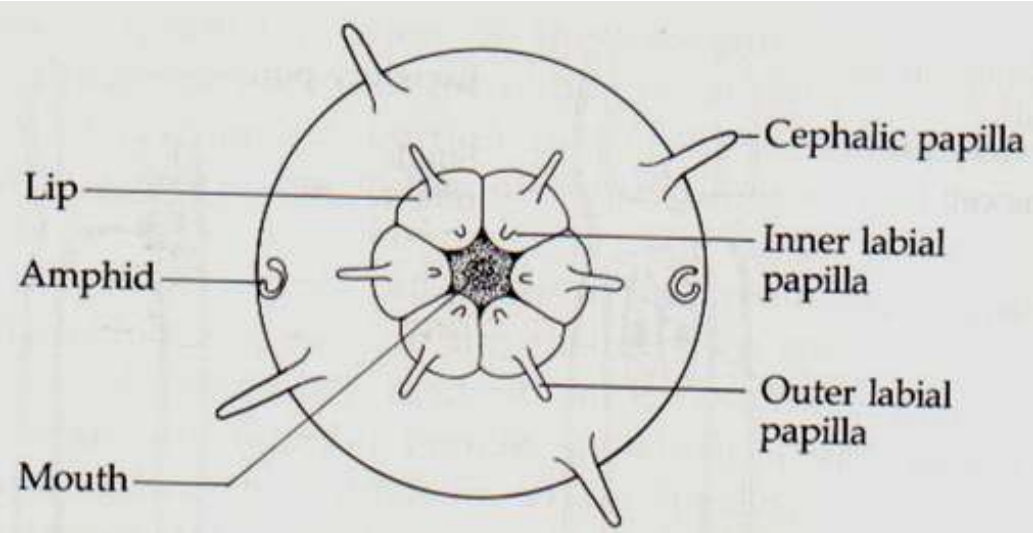


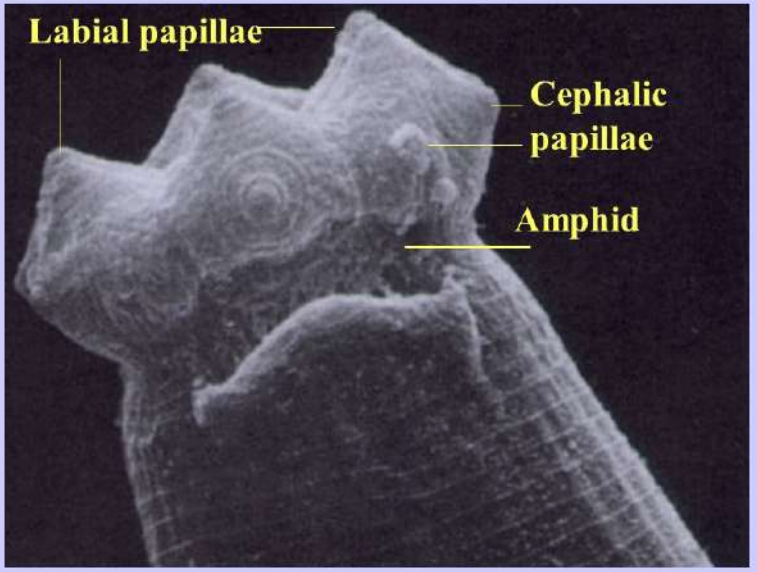
NERVOUS SYSTEM

- Parasitic nematodes possess both **MECHANORECEPTORS** and **CHEMORECEPTORS**

MECHANORECEPTORS

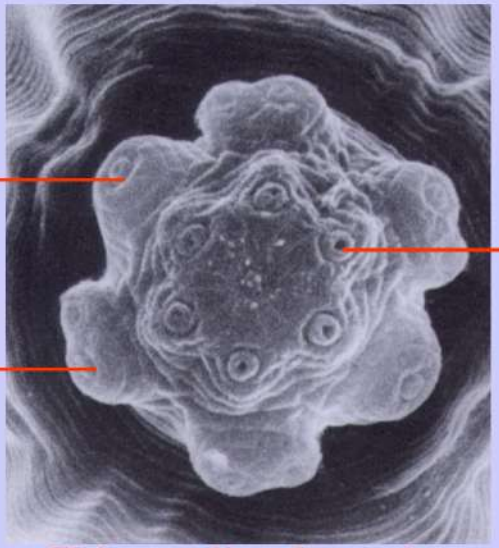
- Located around the mouth are papillae of 2 types: **LABIAL PAPILLAE** on the lips surrounding the mouth and **CEPHALIC PAPILLAE** behind the lips
- Other papillae may be found at different levels of the nematode body, e.g. **CAUDAL PAPILLAE,** observed in many males; aids in copulation





Discolaimoides head

NERVOUS SYSTEM



Chitwoodius face view

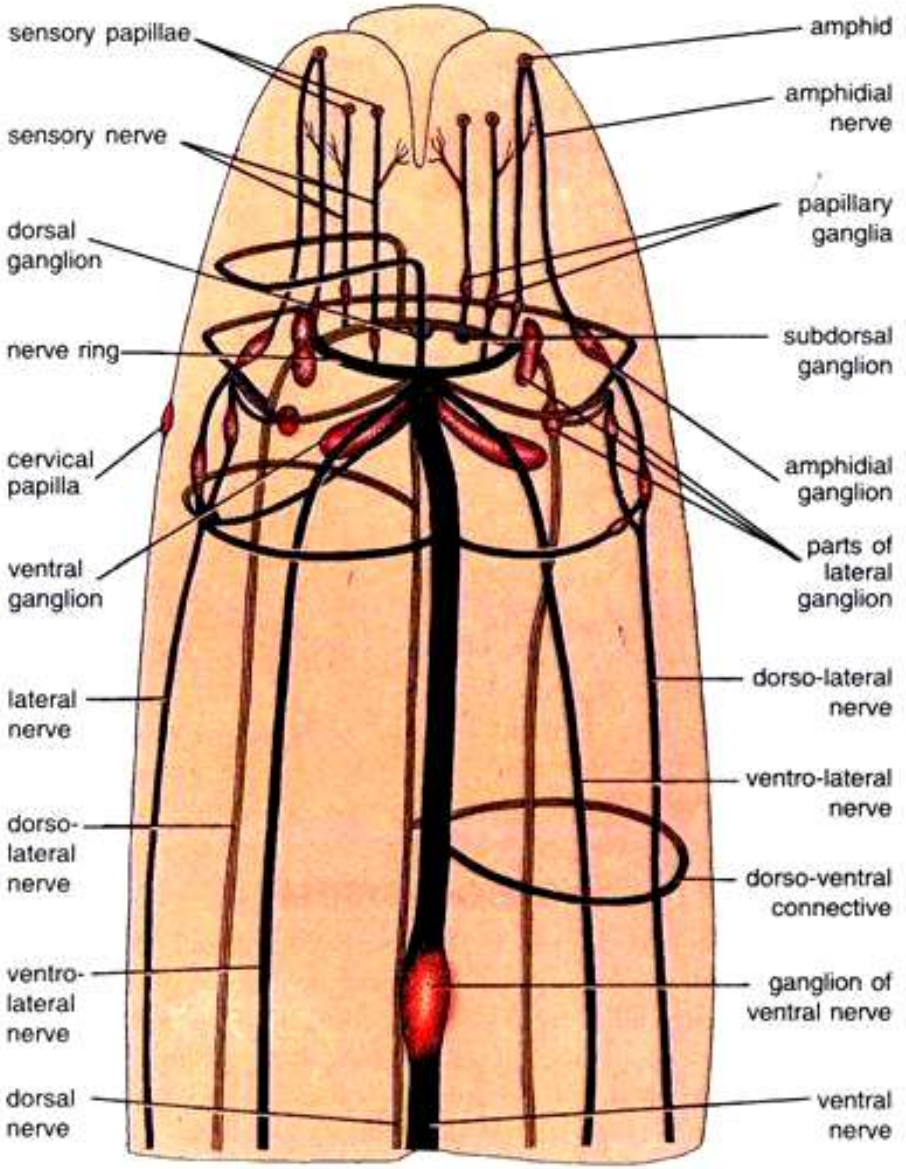


Fig. 46.8. *Ascaris lumbricoides*. Ventral view of anterior end showing central nervous system.

NERVOUS SYSTEM

CHEMORECEPTORS

- **Amphids** are chemoreceptors located in shallow anterior depressions or pits
- Amphids are usually **reduced** in nematode parasites of animals

- **Phasmids** are a set of chemoreceptors at the posterior end
- Most **parasitic** nematodes bear a bilateral pair of phasmids

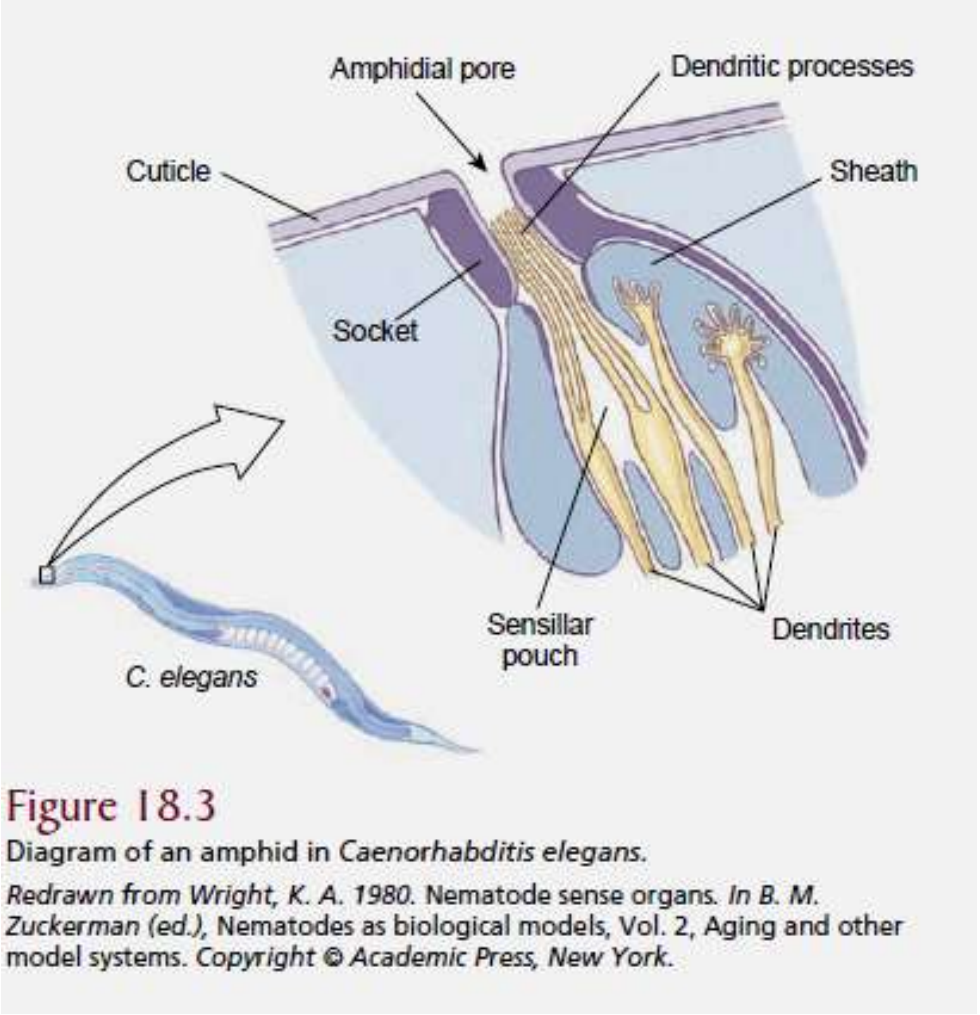
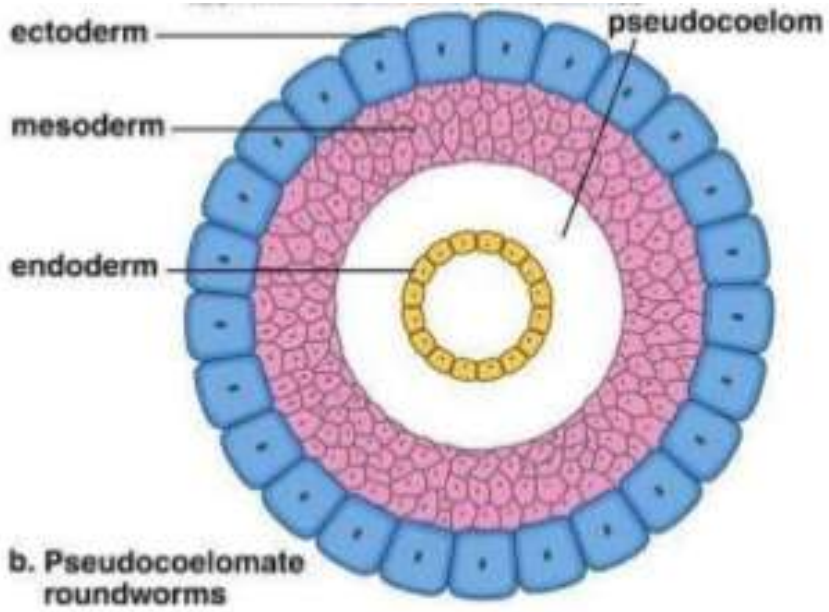


Figure 18.3
Diagram of an amphid in *Caenorhabditis elegans*.
Redrawn from Wright, K. A. 1980. Nematode sense organs. *In B. M. Zuckerman (ed.),* Nematodes as biological models, Vol. 2, Aging and other model systems. *Copyright © Academic Press, New York.*

CIRCULATORY SYSTEM

The circulatory system is obviously not present in the organisms in this phylum, therefore, the species in this phylum obtain a **pseudocoelom**, which is basically the body cavity of any multicellular organism **filled with superfluous amount of fluids**, and also transports the specific nutrients, oxygen, etc.



So, because there is an absent of the circulatory system, the metabolic waste is excreted by two ducts that the species have.

RESPIRATORY SYSTEM

Diffusion of oxygen and carbon dioxide through body wall

- Adults of many **parasitic** nematodes have an **anaerobic energy**
- Metabolism (Krebs cycle and cytochrome system characteristic of aerobic metabolism are absent).
- They derive energy through glycolysis and probably through some incompletely known electron-transport sequences
- Some free-living nematodes and free-living stages of parasitic nematodes are obligate **aerobes** and have a Krebs cycle and cytochrome system.

EXCRETORY SYSTEM

- Have ventral glands (called **RENETTES**) posterior to the pharynx that **absorb waste from the pseudocoelom and empties the waste through the excretory pore.**
- Parasitic nematodes have a more **advanced excretory system**.

- Excretory system is one of the most simplest system of nematodes.
- Waste is turned into ammonia and is excreted through the body.
- The major nitrogenous waste product is ammonia.
- The excretory products of nematodes are numerous like amino acid , peptides, uric acid , fatty acid
- The excretory pore is located in the anterior mid ventral line close to the nerve ring.
- Parasitic worms tend to have a glandular process to excrete.
- Nonparasitic worms tend to have a much more tubular method of releasing their salty waste.

EXCRETORY SYSTEM

Excretory system is varied and in some groups it is completely absent as in Dorylamoidea , whereas *Longidorous macrosoma* belonging to this group has well developed excretory system.

The division of excretory system is as follows:

1.Glandular Type :

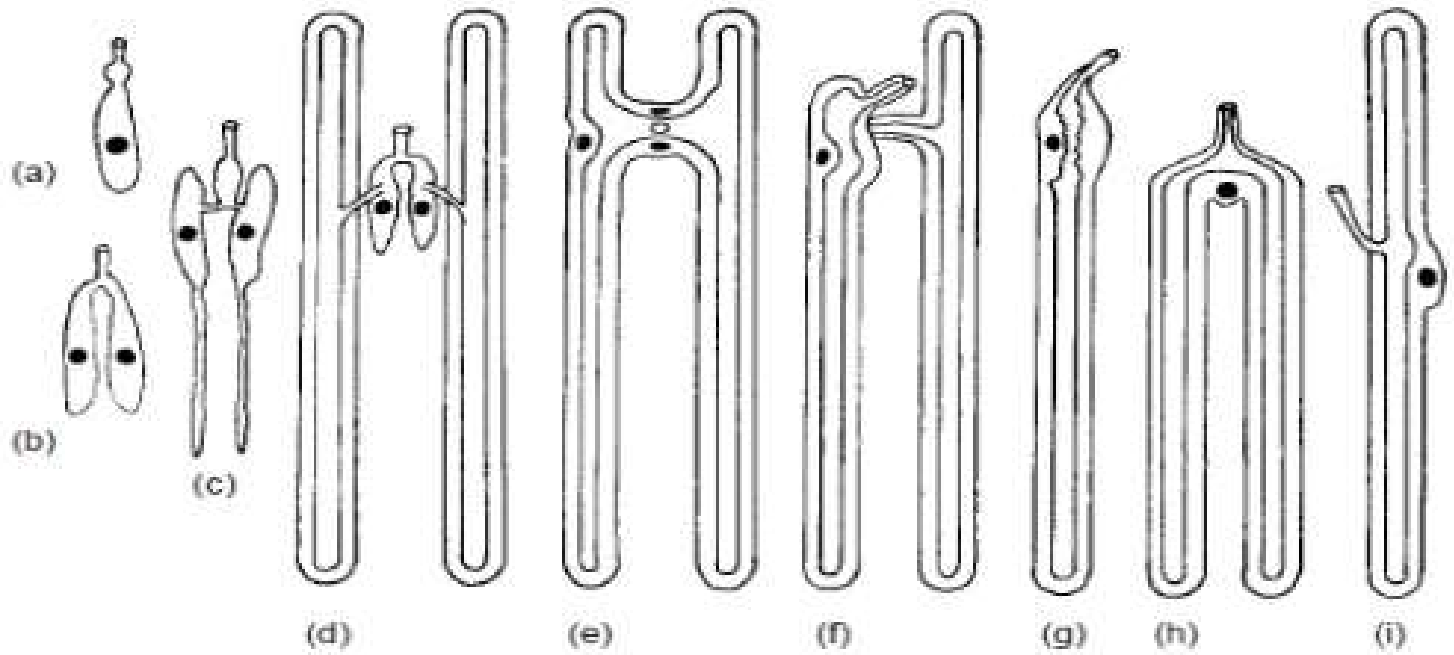
- Present in class Adenophorea

2.Tubular Type

- Present in class Secernentea

EXCRETORY SYSTEM

EXCRETORY SYSTEMS

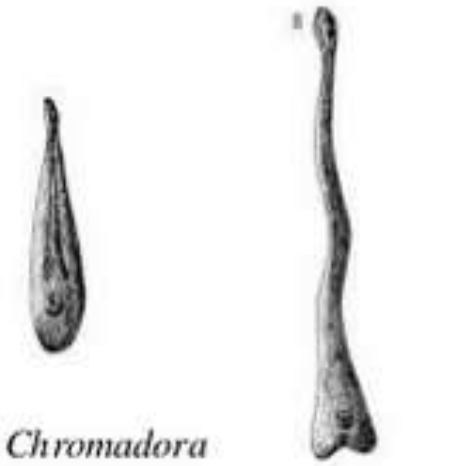


(*a)* Single renette in a dorylaimid; *(b)* two celled renette in *Rhabdias spp.; (c)* larval *Ancylostoma* spp.; (*d) rhabditoid type; (e) oxyuroid* type; (*f) Ascaris spp.; (g) Anisakis spp.;* (*h) Cephalobus spp.; (i) Tylenchus spp.*

EXCRETORY SYSTEM

1. Glandular Type

- Primitive and basic type.
- Consists of a simple single ventral gland cell without collecting tubules..
- This gland is connected to the excretory pore by a duct that terminates in a pouch like structure known as ampulla.
- Example: *Chromadora*
- In Enoplia , *Phanodermopsis* the single cell is lobed
- In *Plectus*, the duct is very elongated.



Chromadora

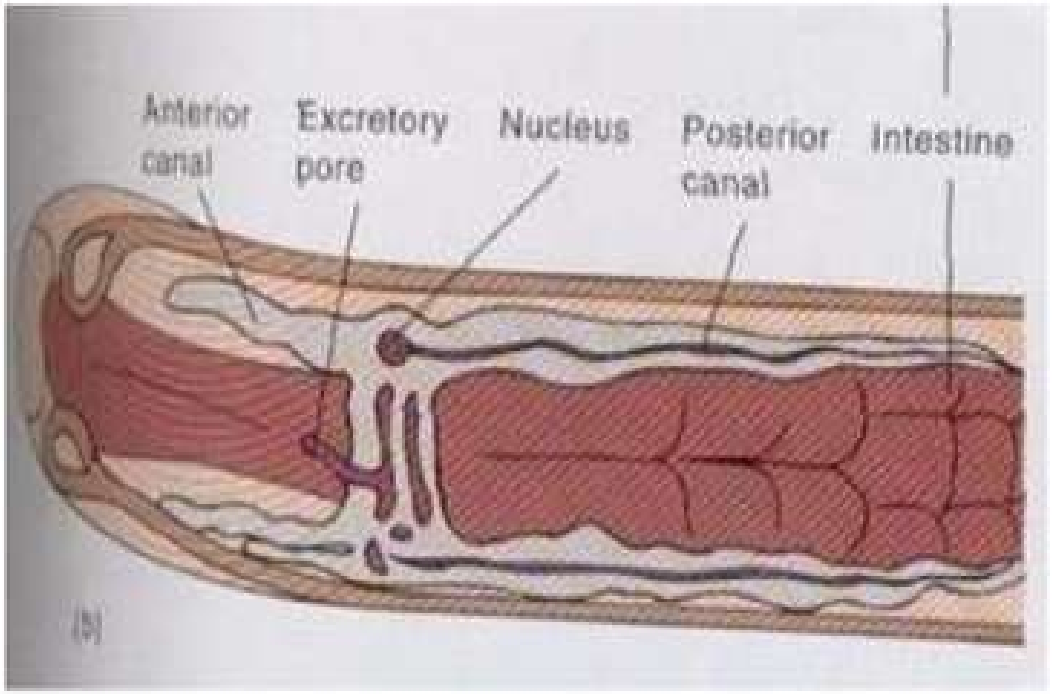
Phanodermopsis

Plectus

EXCRETORY SYSTEM

2.Canalicular or Tubular Type

- Consists of four cuticularised canals.
- Two are anterior and another two are posterior canals.
- These are joined by a transverse duct.
- A terminal duct arises and opens on ventral side via the excretory pore.
- Example Tylenchids , Rhabditids

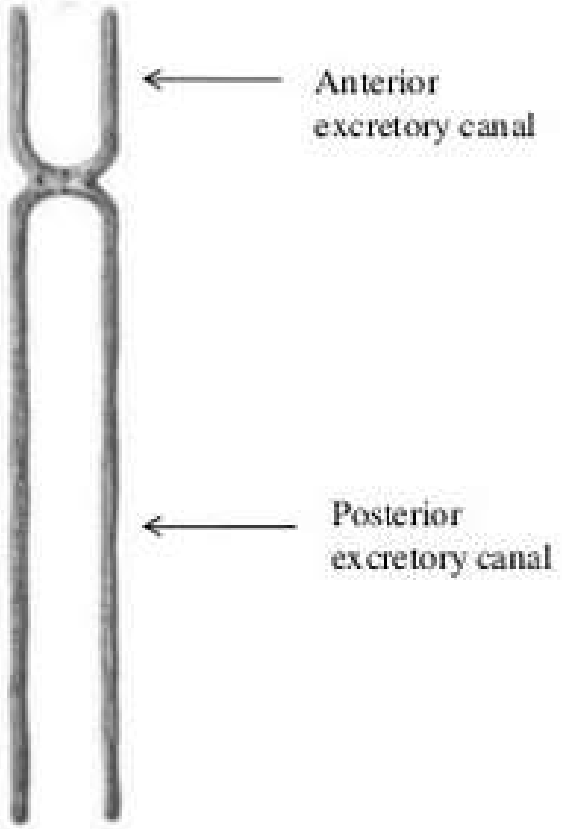


EXCRETORY SYSTEM

Modifications of the Excretory System

1. H shaped/ Oxyuroid Type:

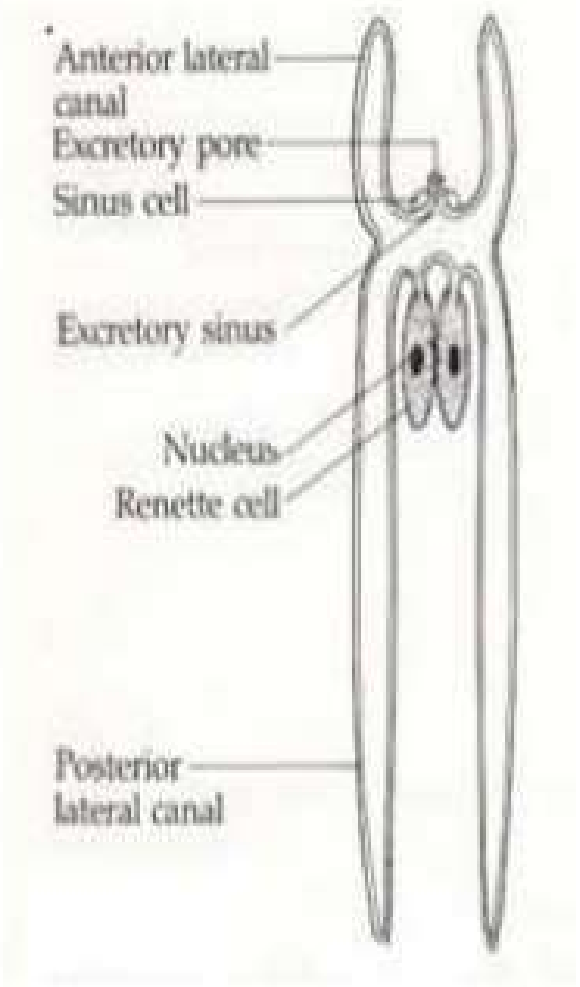
- Four excretory canals are present.
- The anterior canals are slightly shorter than the posterior ones.
- Canals extend throughout the length of the body.
- Excretory sinus is present.
- No excretory gland cells are present.
- Example: Oxyurids



EXCRETORY SYSTEM

2. Rhabditoid Type:

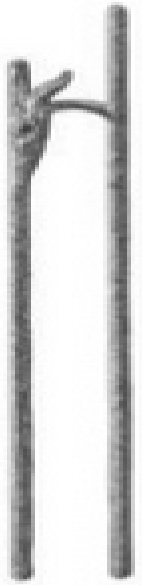
- Four cuticularised canals are present.
- Excretory gland cell is present.
- It is filled with secretory granules.
- Excretory duct connected with sinus.
- Excretory pore is present.
- Example : *Rhabditis*



EXCRETORY SYSTEM

3. Ascaroid Type

- All four excretory canals are present .
- Left anterior canal is shorter then posterior one.
- Excretory cell is present.
- Excretory duct is present.
- Example: *Ascaris*



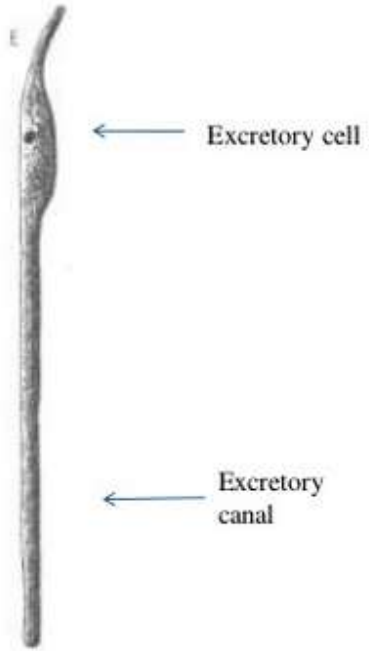
4. Cephaloboid Type:

- Also called as inverted U shaped type.
- No excretory gland cell is present.
- Two excretory canals with only one extending anteriorly.
- A terminal cuticularised duct connected with sinus and opens to exterior via excretory pore.
- Example: *Cephalobus*

EXCRETORY SYSTEM

5. Anisakid Type:

- Asymmetrical type.
- Anterior canals absent.
- Gland cell is absent.
- Only posterior canal is present.
- Excretory cell is present.
- Example : *Anisakis*

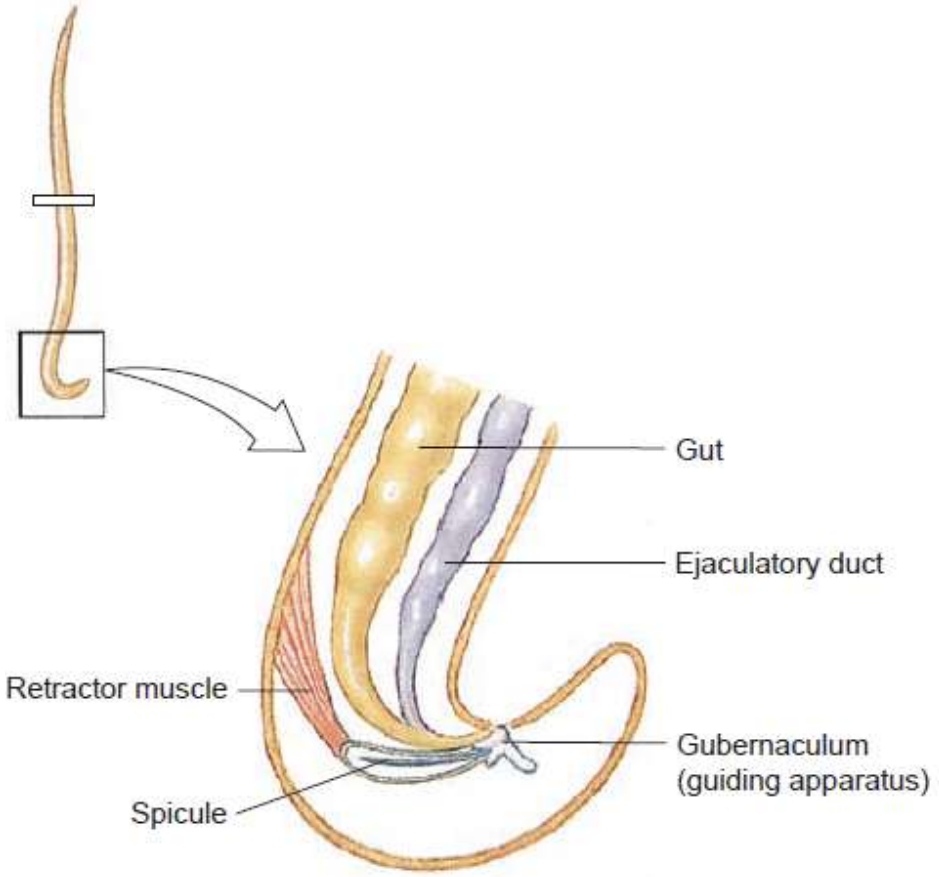


6. Tylenchid Type:

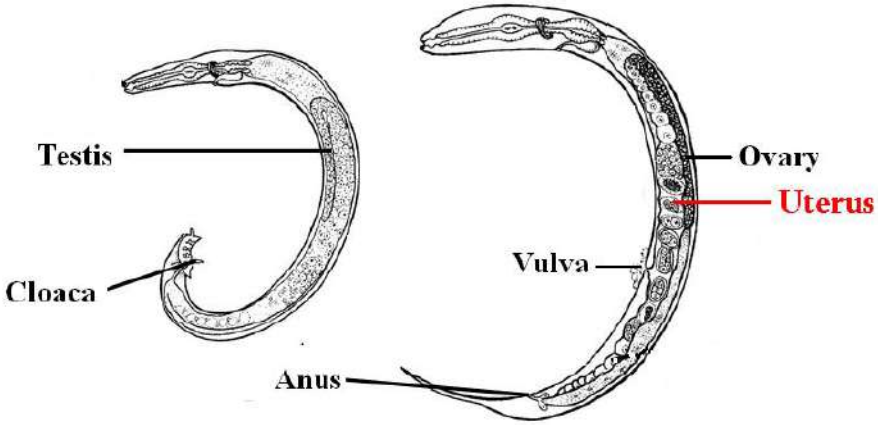
- A single tube runs throughout the body length.
- It is found in either of the lateral hypodermal chords.
- Excretory sinus connected with canal.
- No gland cell.
- Excretory duct which opens via excretory pore
- Example : Tylenchids

REPRODUCTION SYSTEM

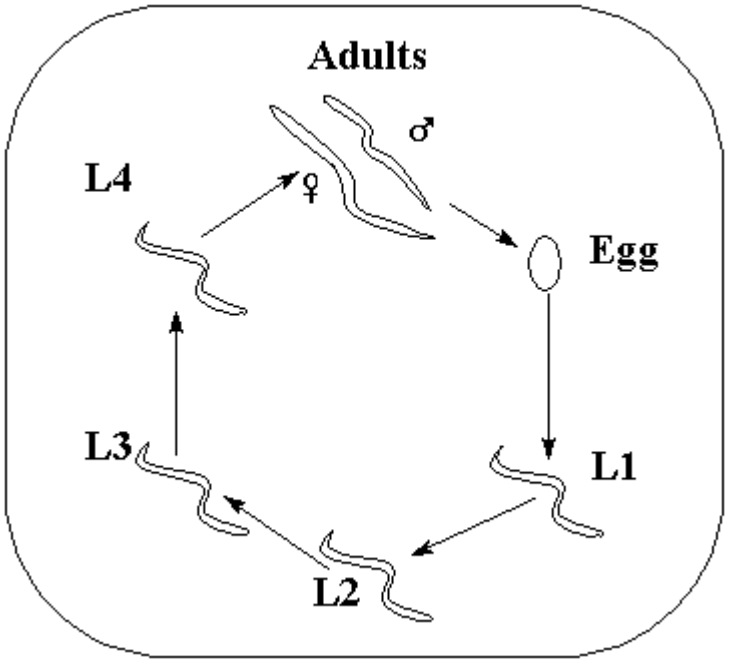
- Most nematodes are dioecious
- Males are smaller than females, and their posterior end usually bears a pair of **COPULATORY SPICULES**
- Fertilization is internal, and eggs are usually stored in the uterus until deposition.
- Development among free-living forms is typically direct.
- The four juvenile stages (L1-L4) are each separated by a molt, or shedding, of the cuticle.
- Many parasitic nematodes have free-living juvenile stages.
- Others require an intermediate host to complete their life cycles.

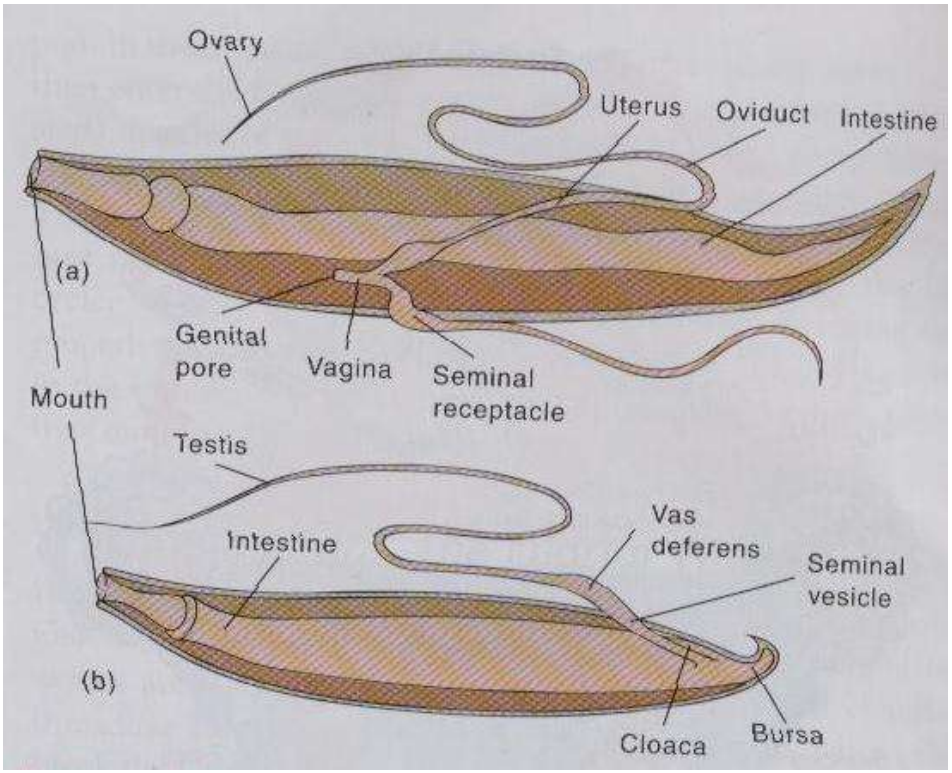


REPRODUCTION SYSTEM



Male and Female animals are separated





Female Reproductive System

- Consists of a pair of ovaries attached to an oviduct that has a swollen proximal end that forms a seminal receptacle.
- Each oviduct becomes a tubular uterus, and the two uteri come together to form a vagina that opens to the outside through a genital pore.

REPRODUCTION SYSTEM

Male Reproductive System

- Most male nematodes have only a single testis attached to the vas deferens which expands into a seminal vesicle which connects to the cloaca.
  - What are all these things?
    - Vas deferens – aka sperm duct, releases sperm
    - Seminal vesicle – stores sperm cells
    - Cloaca – hole that sperm is ejected from
  - They also have a flap of tissue called the bursa that aids in the transfer of sperm to the female genital pore.

REPRODUCTION SYSTEM

Molting

- Nematodes undergo 4 molts each of which involves: formation of new cuticle, loosening of the old cuticle, rupturing of the old cuticle, and escape of the larva
- This sequence of events is controlled by **exsheathing fluid** secreted by the larva
- In some nematodes, there is a lag phase at some stage of development, during which a phase of the life cycle is temporarily arrested
- This phenomenon is called **hypobiosis (developmental arrest) -** it is thought to be an adaptation that allows the larva to withstand adverse environmental conditions while awaiting the access of a new host

REPRODUCTION SYSTEM

Larval Forms

- Larval stages preceding each molt of the 4 molts in the life cycle of parasitic nematodes are generally referred to as first-, second-, third, and fourth-stage larvae (e.g., L_1, L_2, L_3, L_4)
- The first stage larva being the stage prior to the first molt
- However various other designations also are used for specific nematode larval forms

REPRODUCTION SYSTEM

Larval Forms

- **Rhabditiform larva -** The first stage larva of *Strongyloides* and hookworms; the esophagus of this small larva is joined to a terminal esophageal bulb by a narrow isthmus

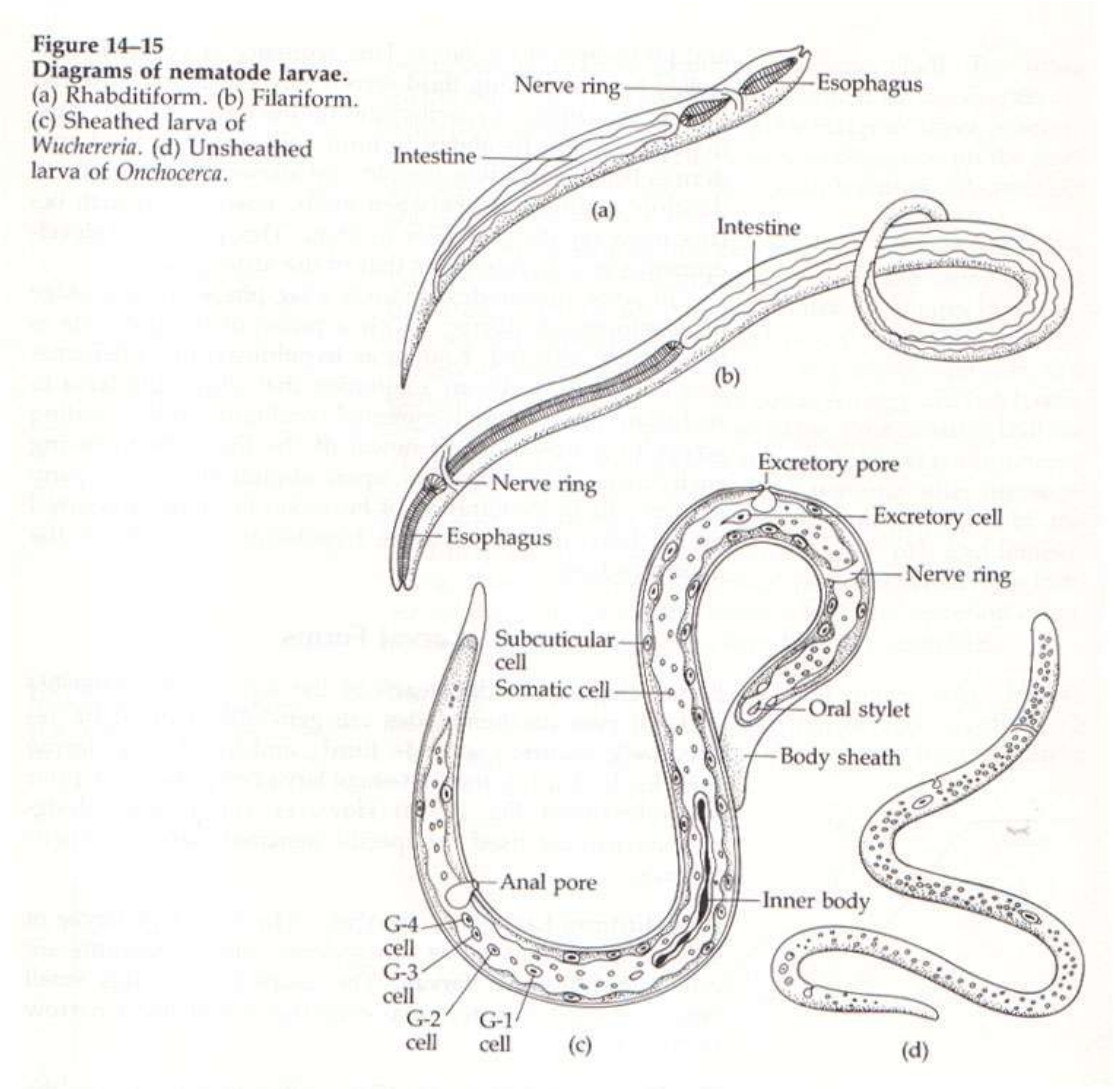


Figure 14–15
Diagrams of nematode larvae.
(a) Rhabditiform. (b) Filariform. (c) Sheathed larva of *Wuchereria*. (d) Unsheathed larva of *Onchocerca*.

REPRODUCTION SYSTEM

Larval Forms cont.

- **Filariform larva -** after molting twice, the rhabditiform larva of *Strongyloides* and hookworms usually retain the remnants of their last cuticle and becom ensheathed, 3rd stage or **filariform larva**

- The esophagus is typically elongate and cylindrical and has no terminal bulb
- This larva is usually the stage that is infective to the definitive host

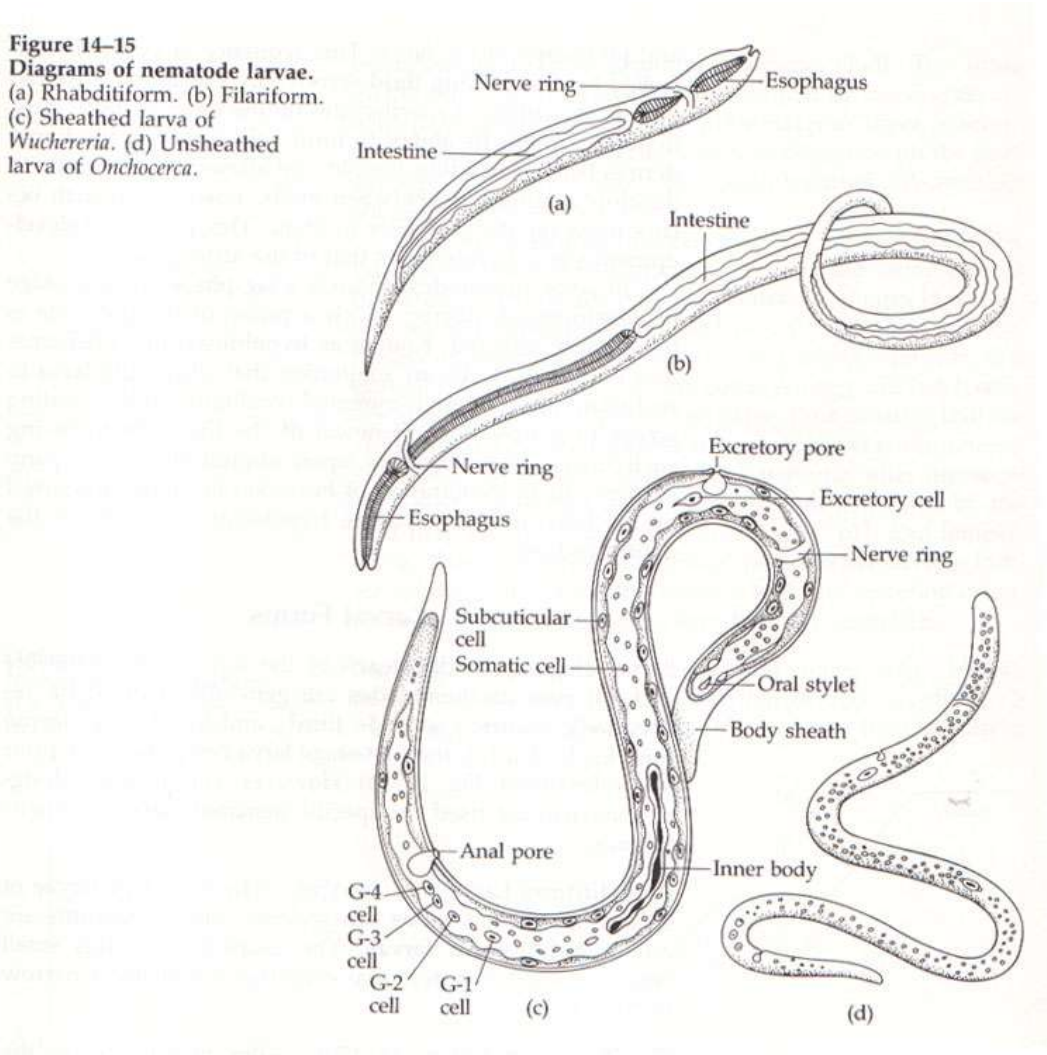


Figure 14–15
Diagrams of nematode larvae. (a) Rhabditiform. (b) Filariform. (c) Sheathed larva of *Wuchereria*. (d) Unsheathed larva of *Onchocerca*.

REPRODUCTION SYSTEM

- **Microfilaria** - the prelarvae of filarial worms (e.g. *Wuchereria bancrofti*)are known as **microfilariae**

- The larval body surface is covered by a thin layer of flattened epidermal cells
- The primordia of various adults structures are visible within the pseudocoelom

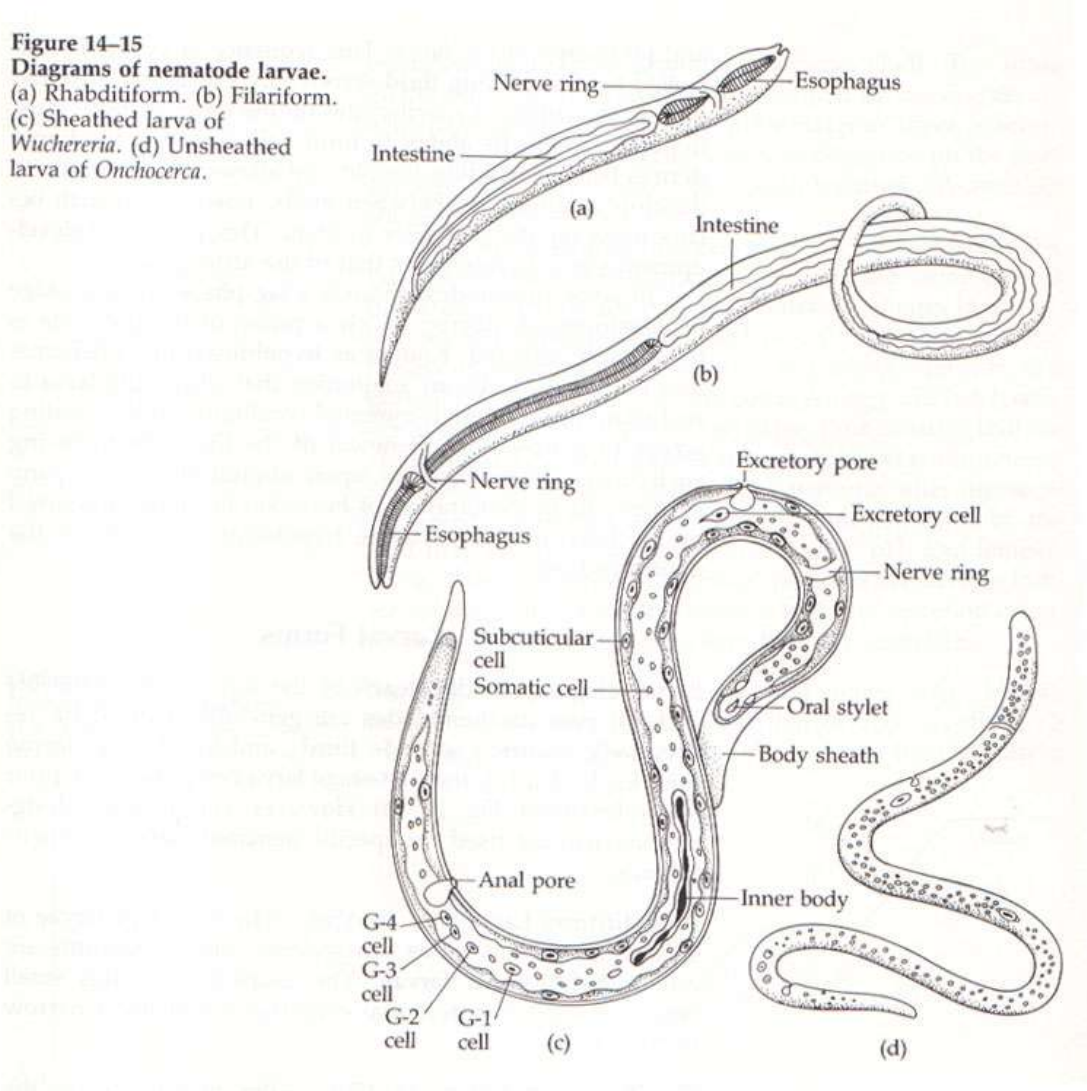


Figure 14–15
Diagrams of nematode larvae.
(a) Rhabditiform. (b) Filariform. (c) Sheathed larva of *Wuchereria*. (d) Unsheathed larva of *Onchocerca*.

Nematoda

Level of Organization	Organ-system
Tissue Layers	Triploblastic
Digestive System	Alimentary Canal
Excretory System	Protonephridia or absent
Circulatory System	None
Respiratory System	None, body surface
Nervous System	Pair of cerebral ganglia with long nerve cords
Body Cavity	False (not completely lined with mesoderm)
Asexual Reproduction	None
Sexual Reproduction	Complicated life cycles

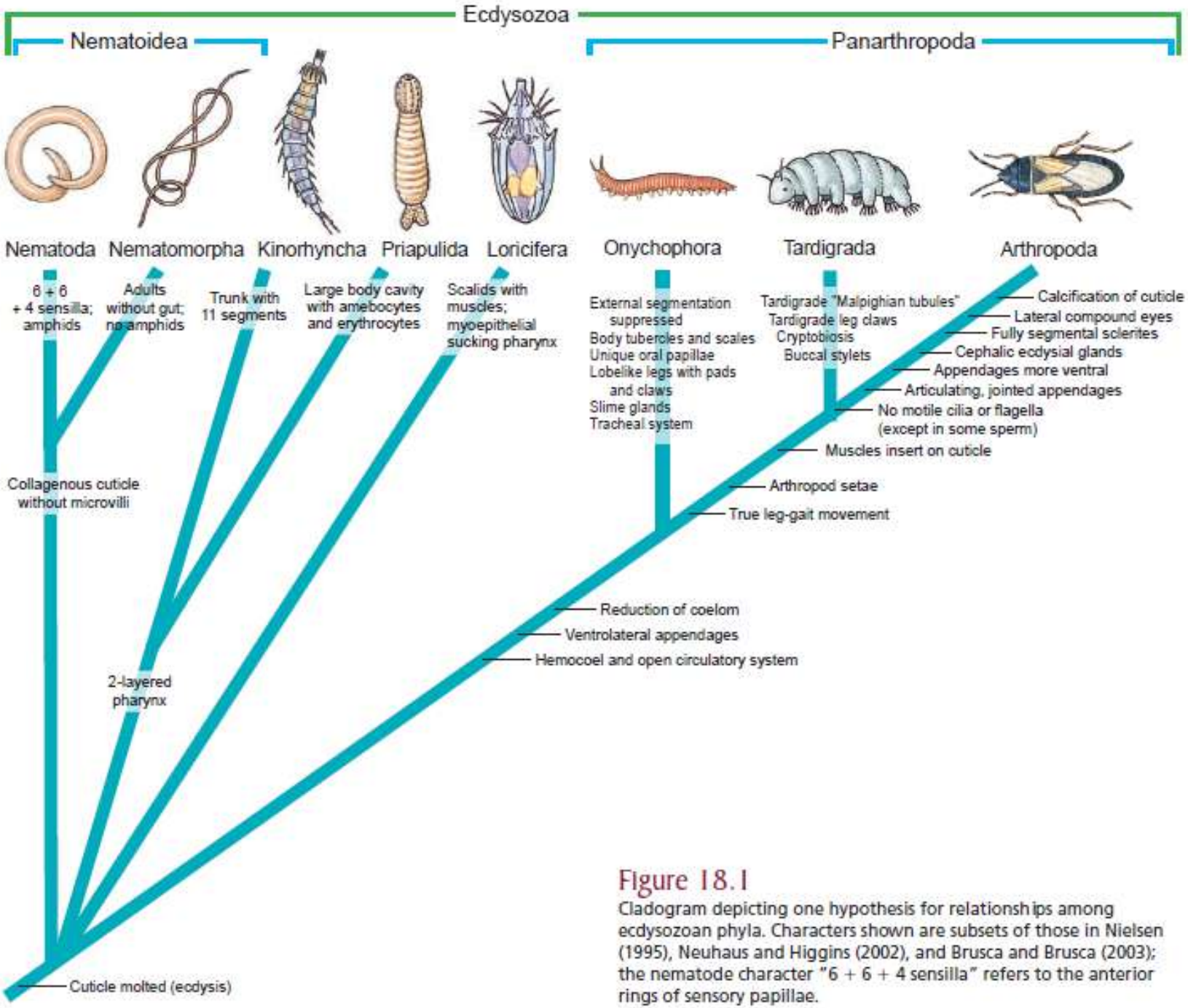


Figure 18.1

Cladogram depicting one hypothesis for relationships among ecdysozoan phyla. Characters shown are subsets of those in Nielsen (1995), Neuhaus and Higgins (2002), and Brusca and Brusca (2003); the nematode character "6 + 6 + 4 sensilla" refers to the anterior rings of sensory papillae.

Free-living Nematodes

Feed on algae, fungi, small animals, dead organisms and living tissues.

Caenorhabditis elegans, which lives in the soil is a model organism.

Free-living nematodes

- serve as bio-indicators
- decomposition of organic material and the recycling of nutrients in soil.

Insect Parasitic Nematodes

They are Beneficial use as biological control of insect pests

***Enterobius vermicularis* – Pinworm**

Adult nematodes live in the large intestine

- **White colour**
- **Females with pointed posterior**

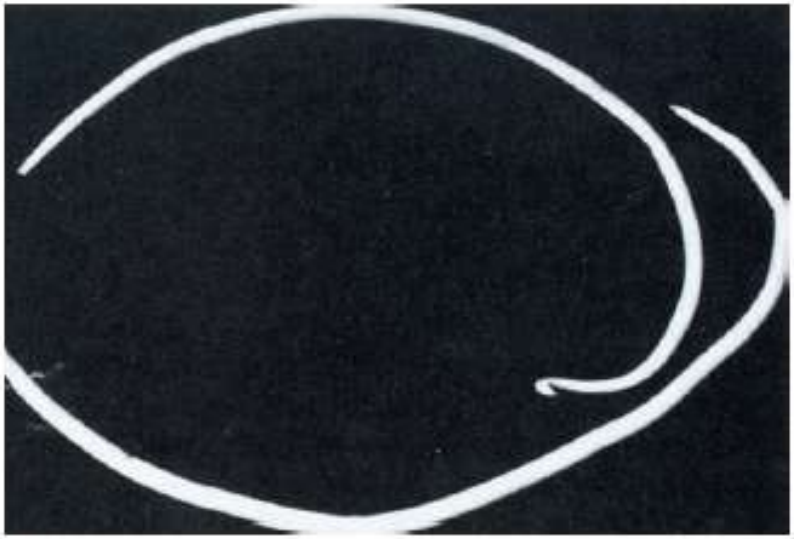
Female lays eggs around the edges of the anus

Ascaris lumbricoides - Adult nematodes live in the intestine.

A female may produce 100,000 eggs which are passed with the feces.

Common Parasitic Nematodes of Humans in North America

Common and Scientific Names	Mode of Infection; Prevalence
Hookworm (*Ancylostoma duodenale* and *Necator americanus*)	Contact in soil with juveniles that burrow into skin; common in southern states
Pinworm (*Enterobius vermicularis*)	Inhalation of dust with ova and by contamination with fingers; most common worm parasite in United States
Intestinal roundworm (*Ascaris lumbricoides*)	Ingestion of embryonated ova in contaminated food; common in rural areas of Appalachia and southeastern states
Trichina worm (*Trichinella spp.*)	Ingestion of infected muscle; occasional in humans throughout North America
Whipworm (*Trichuris trichiura*)	Ingestion of contaminated food or by unhygienic habits; usually common wherever *Ascaris* is found



A

B

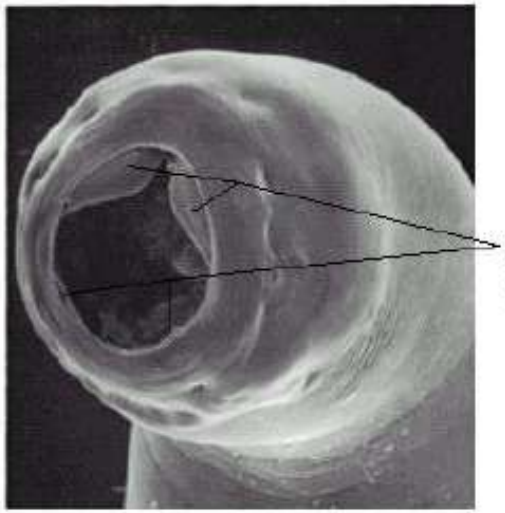
Figure 18.5

A, Intestinal roundworm *Ascaris lumbricoides,* male and female. Male, *top,* is smaller and has characteristic sharp kink in the end of the tail. Females of this large nematode may be over 30 cm long. **B,** Intestine of a pig, nearly completely blocked by *Ascaris suum.* Such heavy infections are also fairly common with *A. lumbricoides* in humans.

Hookworms

Hookworm

Ancylostoma duodenalae



Necator americanus

A

B

Figure 18.6

A, Mouth of hookworm displaying cutting plates. **B,** Section through anterior end of hookworm attached to dog intestine. Note cutting plates pinching off mucosa from which the thick muscular pharynx sucks blood. Esophageal glands secrete anticoagulant to prevent blood from clotting.

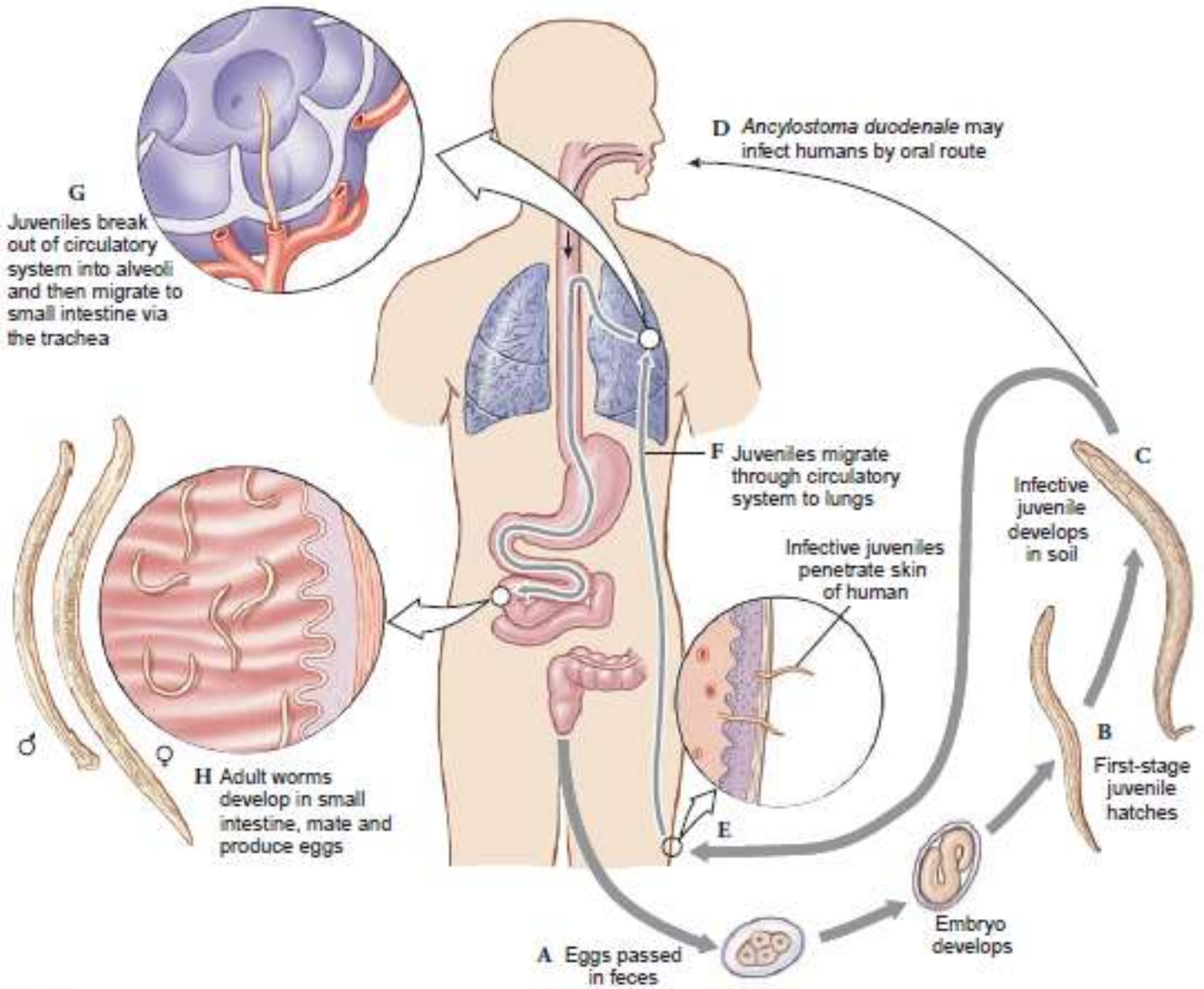


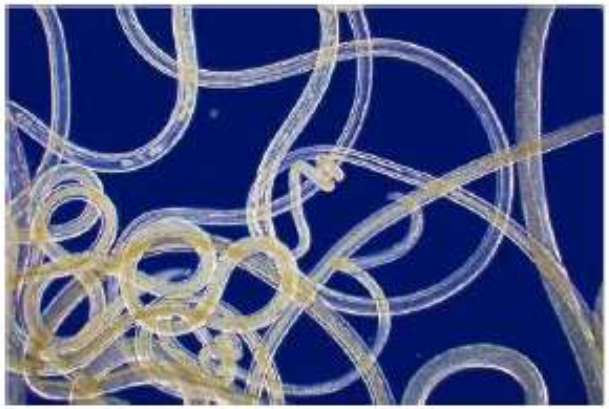
Figure 18.7

The life cycle of hookworms: a shelled embryo develops into a first-stage juvenile which is followed by two molts. The resulting third-stage juvenile enters developmental arrest until it reaches a new host (**A** to **C**). Human infection may be via the mouth (**D**) or skin (**E**). Juveniles migrate through the circulatory system to lungs (**F**), enter alveoli (**G**), and then reach the intestine where they mate (**H**).

Drawing by William Ober and Claire Garrison.

Wuchereria bancrofti - filarial nematode
(long and thin worms)

lymphatic filariasis, elephantiasis.



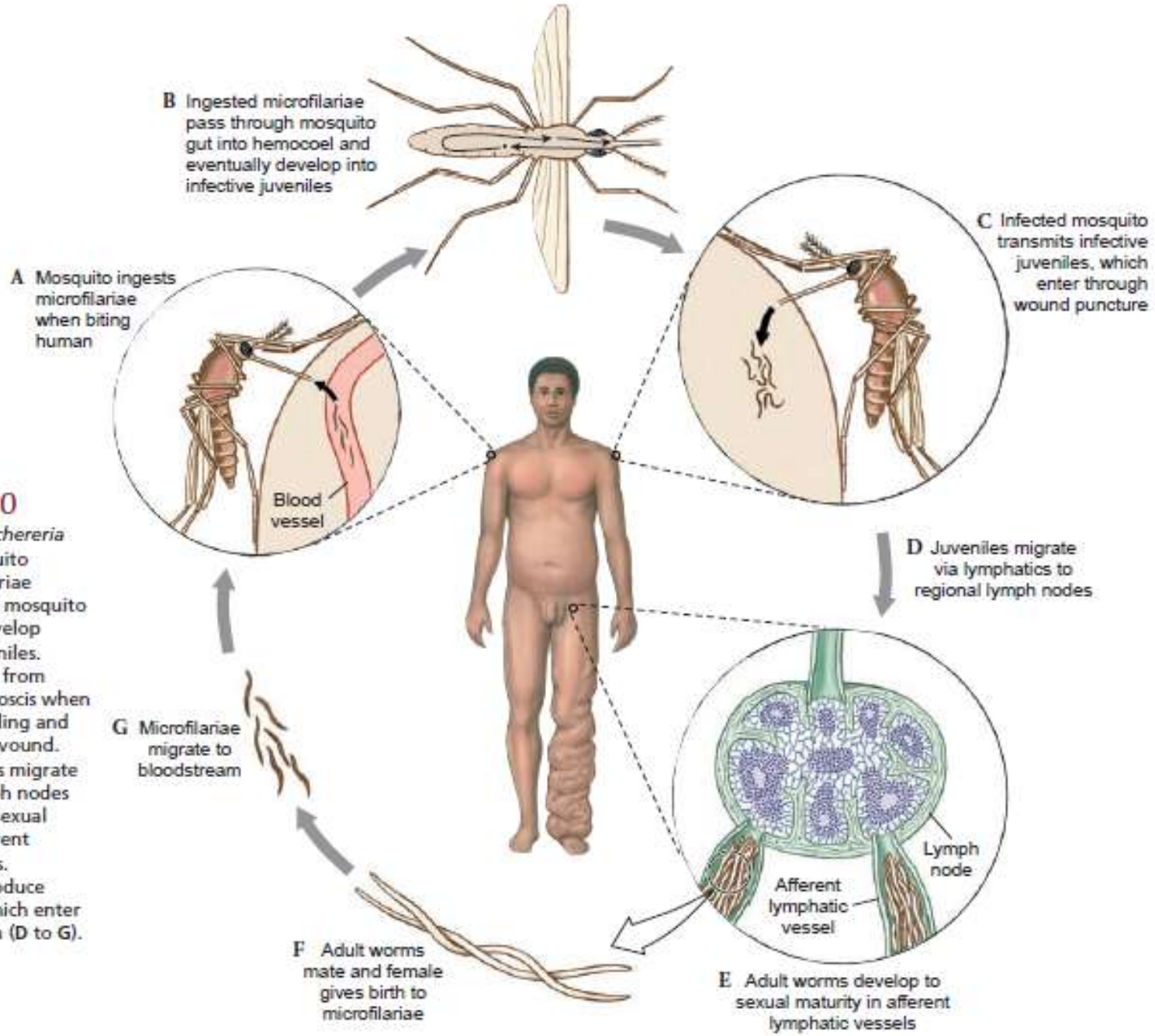


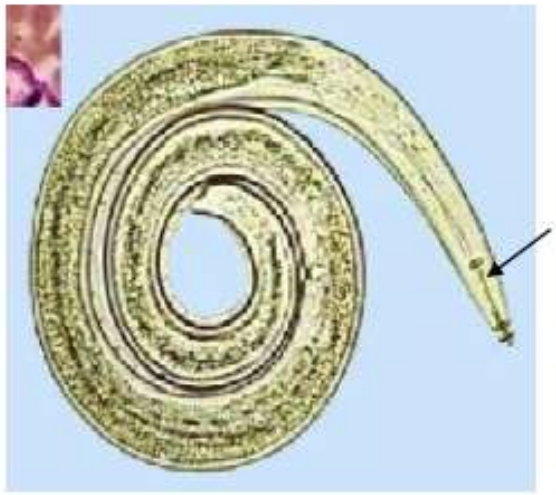
Figure 18.10

Life cycle of *Wuchereria bancrofti:* mosquito ingests microfilariae which penetrate mosquito gut wall and develop to infective juveniles. Juveniles escape from mosquito's proboscis when the insect is feeding and then penetrate wound. (**A** to **C**, Juveniles migrate to regional lymph nodes and develop to sexual maturity in afferent lymphatic vessels. Adult worms produce microfilariae, which enter blood circulation (**D** to **G**).

Trichinella spiralis - Trichinosis in humans

Cyst in pork

- Plant parasitic nematodes damage to crops
- Soil is an excellent habitat for plant parasitic nematodes



“ Ada kehidupan dalam kehidupan kita, bahkan di tempat yang tidak kita bayangkan sebelumnya“

TUGAS

TULIS DI BUKU TUGAS

1. Peranan Annelida & Nematoda bagi manusia