EXERCISE 12

# The Annelids
## Phylum Annelida
## A Protostome Eucoelomate Group

The annelids include a variety of earthworms, leeches, and marine polychaetes. Their various adaptations allow for freshwater, marine, terrestrial, and parasitic living. They are typically elongate, wormlike animals; are circular in cross section; and have muscular body walls. The most distinguishing characteristic that sets them apart from other wormlike creatures is their **segmentation.** They are often referred to collectively as the "segmented worms." This repetition of body parts, also called **metamerism** (me-ta′me-ri′sum; Gr. *meta*, between, + *meros*, part), not only is external but also is seen internally in the serial repetition of body organs. Development of segmentation is of significance in the general evolutionary trend toward specialization, for along with segmentation comes the opportunity for segments to become specialized for certain functions. Such specialization is not as noticeable in annelids as in arthropods, but the introduction of metamerism coincided with the rapid evolution of advanced organization seen in arthropods and chordates, the only other phyla emphasizing segmentation.

Division of the coelomic cavity into fluid-filled compartments also has increased the usefulness of hydrostatic pressure in the locomotion of annelids. By shifting coelomic fluid from one compartment to another through perforations in the dividing septa, differential turgor can be effected, permitting a preciseness of body movement not possible in pseudocoelomates. The coordination between their well-developed neuromuscular system and more efficient hydrostatic skeleton makes annelids proficient in swimming, creeping, and burrowing.

Annelids have a complete mouth-to-anus digestive tract with muscular walls, so that digestive tract movements are independent of body movements. There is a well-developed closed circulatory system with pumping vessels, a high degree of cephalization, and an excretory system of nephridia. Some annelids have respiratory organs.

### Class Oligochaeta—Earthworms

### *Lumbricus*, Common Earthworm

Phylum Annelida
Class Oligochaeta
Order Haplotaxina
Family Lumbricidae
Genus *Lumbricus*
Species *Lumbricus terrestris*

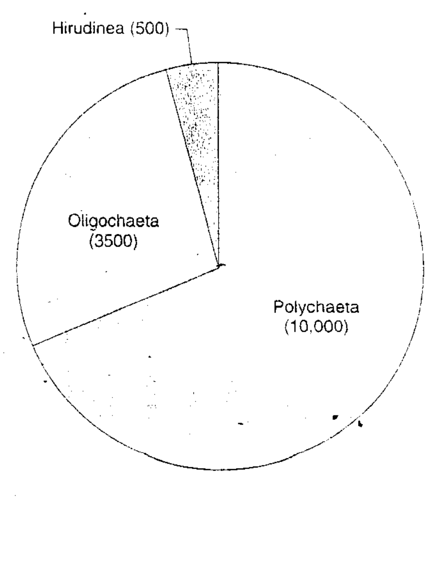
### Where Found

Earthworms prefer moist, rich soil that is not too dry or sandy. They are found all over the earth. They are chiefly nocturnal and come out of their burrows at night to forage. A good way to find them is to search with a flashlight around the rich soil of lawn shrubbery. Large "night crawlers" are easily found this way, especially during warm, moist nights of spring and early summer. *Lumbricus terrestris* (L. *lumbricum*, earthworm), named by Linnaeus, is one of the most common earthworms in Europe, Asia, and North America and has been introduced all over the world.

### Behavior

Wet the center of a paper towel with pond or dechlorinated water, leaving the rest of the paper

Phylum Annelida



**dry. Place a live earthworm on the moist area. Using the following suggestions, observe its behavior.**

Is the skin of the worm dry or moist? ________ Do you find any obvious respiratory organs? ________ Where do you think exchange of gases occurs? ________ Would this necessitate a dry or damp environment? ________ ________ Does the worm respond positively or negatively to moisture? ________ ________

Notice the mechanics of crawling. Its body wall contains well-developed layers of circular and longitudinal muscles. As it crawls, notice the progressing peristaltic waves of contraction. These are produced by alternate contraction and relaxation of longitudinal and circular muscles in the body wall acting against noncompressible coelomic fluid. An earthworm's body is divided internally into segments by septa. When longitudinal muscles of a segment contract, the segment becomes shorter and thicker because the volume within each body segment remains constant. Conversely, when circular muscles contract, the segment elongates. Do the waves of circular muscle contraction move anteriorly or posteriorly when the worm as a whole is moving forward? ________ How far apart (what proportion of total body length) are the waves of contraction? ________ Watch the anterior end as the worm advances. Do short and thick or long and thin regions advance the head end forward? ________

Run a finger along the side of the worm. Do you detect the presence of small setae (bristles)? How might these setae be used? ________

How does the animal respond when you gently touch its anterior end? ________ Its posterior end? ________ Draw the towel to the edge of the desk and see what happens when the worm's head projects over the edge of the table. Is it positively or negatively thigmotactic (responsive to touch)? ________ Turn the worm over and see if it can right itself, and how.

Can you devise a means of determining whether an earthworm is positively or negatively geotactic (responsive to gravity)?

**Place the earthworm on a large plate of wet glass. Does this difference in substratum affect its locomotion? Is friction important in earthworm locomotion?**

Does the earthworm have eyes or other obvious sensory organs? ________ Can you devise a means of determining whether it responds positively or negatively to light?

## Written Report

**On p. 198, record the responses of the earthworm. Comment on hydrotaxis, locomotion, thigmotaxis, phototaxis, and the importance of friction.**

## External Structure

**Anesthetize an earthworm by immersing it for 30 to 40 minutes in 7% ethanol.* When the worm is completely limp, transfer it to a dissecting tray that has been dampened with water. Examine the worm with a dissecting microscope or hand lens as necessary.**

What are the most obvious differences between the earthworm and the clamworm? List two or three here. ________ ________

The first four segments make up the head region. The first segment is the **peristomium.** It bears the **mouth,** which is overhung by a lobe, the **prostomium.** The earthworm's head, lacking specialized sense organs, is not a truly typical annelid head.

Find the **anus** in the last segment. Observe the saddlelike **clitellum** (L. *clitellae,* packsaddle), which in mature worms secretes egg capsules, into which eggs are laid. In what segments does it occur? ________

How many pairs of setae are on each segment, and where are they located? ________ Use a hand lens or dissecting microscope to determine this. What does the name "Oligochaeta" mean? ________ "Polychaeta"? ________ Are these names well chosen?

There are many external openings other than mouth and anus. Earthworms are monoecious. Note **male pores** on the ventral surface of somite 15. These are conspicuous openings of sperm ducts, from which spermatozoa are discharged. Note two long **seminal grooves** extending between the male pores and the clitellum. These guide the flow of spermatozoa during copulation. Use a small hand lens to look for small **female pores** on the ventral side of segment 14. Here the oviducts discharge eggs. You may not be able to see the openings of 2 pairs of **seminal receptacles** in grooves between segments 9 and 10 and between 10 and 11 or paired excretory openings, **nephridiopores,** located on the lateroventral surface of each segment (except the first 3 and the last).

A **dorsal pore** from the coelomic cavity is located at the anterior edge of the middorsal line on each segment from 8 or 9 to the last. Many earthworms eject a malodorous coelomic fluid through the dorsal pores in response to mechanical or chemical irritation or when subjected to extremes of heat or cold. Dorsal pores may also help regulate the turgidity of the animal. How would loss of coelomic fluid affect the animal's escape mechanism (quick withdrawal into its burrow)? ________ How does lack of dorsal pores in its anterior segments protect its burrowing ability? ________

*Prepared by diluting 74 ml of 95% ethanol with 1 L of water.

Complete the external ventral view of the earthworm on p. 197. Draw in and label prostomium, peristomium, mouth, setae, male pores, female pores, seminal grooves, clitellum, and anus.

## Internal Structure and Function

Reanesthetize the earthworm in 7% ethanol, if necessary. Place the anesthetized worm dorsal side up in a dissecting pan and straighten it by passing one pin through the fourth or fifth segment (just behind the peristomium) and another pin through any segment near the posterior end of the worm. With a razor blade or new scalpel blade, and beginning at about the fortieth segment (just behind the clitellum), cut through the body wall at a point just to one side of the dark middorsal line (the **dorsal blood vessel**). Use fine-tipped scissors to complete the middorsal cut all the way to the head, pulling up on the scissors as you proceed to avoid damaging internal organs. Keep your incision slightly to one side of the dorsal blood vessel. With a pipette, squirt some isotonic salt solution on the internal organs to keep them moist. Now, starting at the posterior end of the incision, pin the animal open. You will need to break the septa (partitions between the metameres) with a needle as you proceed anteriorly. When you have finished, remove all the pins except those anchoring the worm at the anterior end. Stretch out the worm by pulling gently on the posterior end and repin, placing the pins at an oblique angle. If you are using a dissecting microscope rather than a hand lens, you may need to position the worm to one side of the dissecting tray for viewing. Now flood the tray with enough isotonic saline (0.6% NaCl) to cover the earthworm completely.

Note peristaltic movements of the **digestive tract,** which propel food posteriorly. Find 3 pairs of cream-colored **seminal vesicles** in somites 9 to 12 (Figure 12-3), 2 pairs of glistening white **seminal receptacles** in somites 9 and 10, and a pair of delicate, almost transparent, tubular **nephridia** in the coelomic cavity of each segment. Note the **dorsal vessel** riding on the digestive tract. In which direction is blood flowing in this vessel? ____________ A total of 5 pairs of pulsating **aortic arches,** sometimes called "hearts," surround the **esophagus** in somites 7 to 11 (some of these arches are covered by the seminal vesicles).

**Digestive System.** Identify the **mouth;** the muscular **pharynx** attached to the body by **dilator muscles** for sucking action (the muscles, torn by the dissection, give the pharynx a hairy appearance); the slender **esophagus** in somites 6 to 13, which is hidden by the aortic arches and seminal vesicles; the large, thin-walled **crop** (15, 16) for food storage; the muscular **gizzard** (17, 18) for food grinding; the **intestine** for digestion and absorption; and the **anus.** Two or three pairs of yellowish to brownish **calciferous glands** lie on both sides of the esophagus (usually partly concealed by the seminal vesicles). They are believed to remove excess calcium and carbonates taken in with the soil; these ions are accumulated as calcite crystals and passed out with the feces. Bright yellow or green **chloragogue** cells often cover the intestine and much of the dorsal vessel. They are known to store glycogen and lipids but probably have other functions as well, similar to those of the vertebrate liver. Make an off-center longitudinal cut into the intestine in the region of the clitellum to expose the **typhlosole** (Gr. *typlos,* blind, + *sōlēn,* channel), a ridge-like structure projecting into the lumen of the intestine. The typhlosole increases the surface available for digestive enzyme production and absorption.

**Circulatory System.** An earthworm has a **closed** circulatory system. Note that both **dorsal vessel** and **aortic arches** (identified earlier) are contractile, with the dorsal vessel being the chief pumping organ and the arches maintaining a steady flow of blood into the **ventral vessel** beneath the digestive tract.

Retract the digestive tract. Lift up the white nerve cord in the ventral wall. Note the **subneural vessel** clinging to its lower surface and a pair of **lateroneural vessels,** with one located on each side of the nerve cord. Be able to trace blood flow from the dorsal vessel to the intestinal wall and back, to the epidermis and back, and to the nerve cord and back.

**Reproductive System.** An earthworm is monoecious; it has both male and female organs in the same individual, but cross-fertilization occurs during copulation. The **male organs** (Figure 12-3) consist of three pairs of **seminal vesicles** (sperm sacs in which spermatozoa mature and are stored before copulation) which are attached in somites 9, 11, and 12; they lie close to the esophagus. Two pairs of small, branched **testes** are housed in reservoirs in the seminal vesicles, and 2 small sperm ducts connect the testes with **male pores** in somite 15; however, both testes and ducts are too small to be found easily. The **female organs** are also small. Two pairs of small, round **seminal receptacles,** easily seen in somites 9 and 10, store spermatozoa after copulation. You should be able to find the paired **ovaries** that lie ventral to the third pair of seminal vesicles. The paired **oviducts** with ciliated funnels that carry eggs to the female pores in the next segment will probably not be seen.

**Earthworm Copulation.** When mating, two earthworms, attracted to each other by glandular secretions, extend their anterior ends from their burrows and, with heads pointing in opposite directions, join their ventral surfaces in such a way that the seminal receptacle

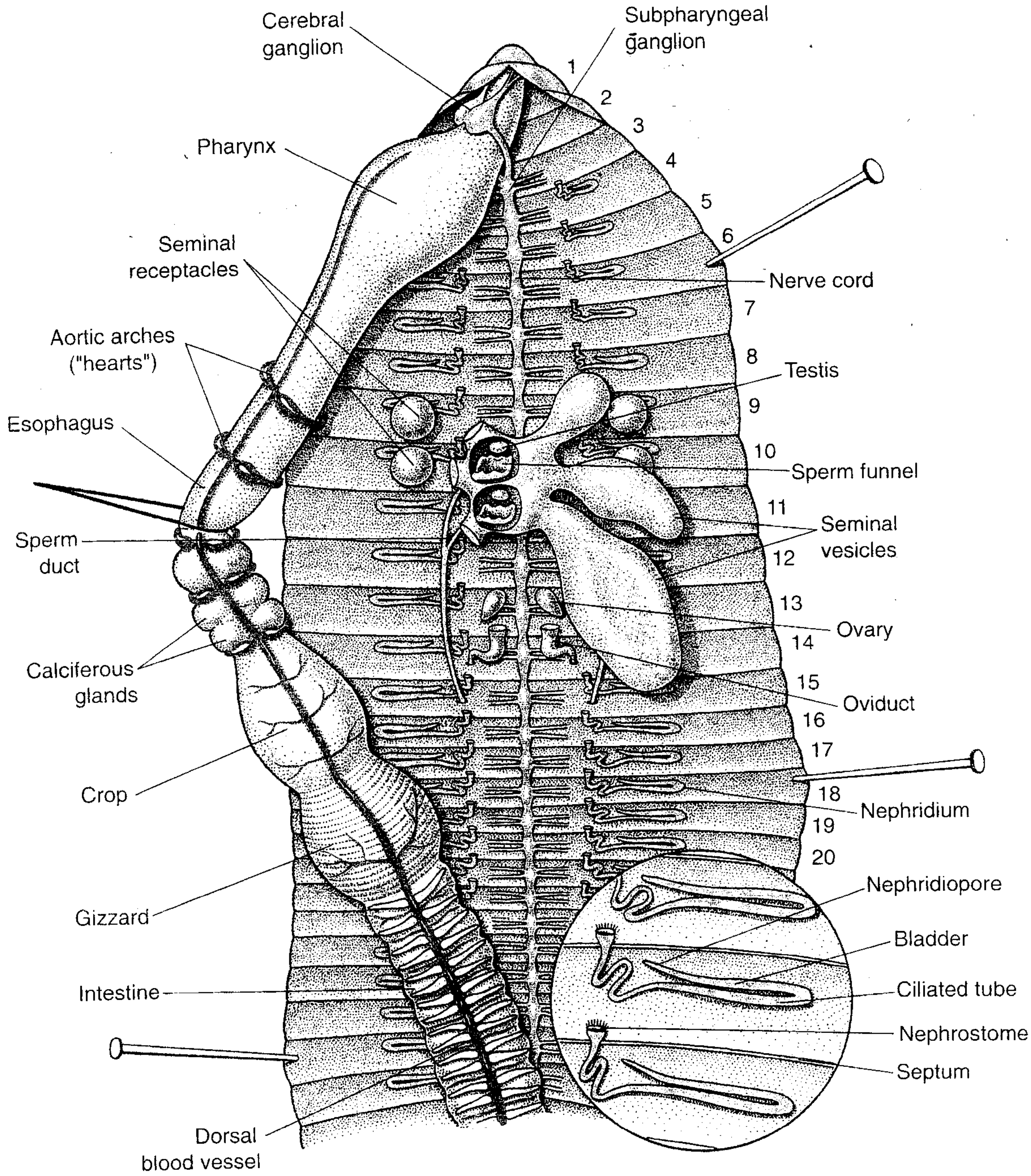



Figure 12-3
Internal structure of *Lumbricus,* dorsal view.

openings of one worm lie in opposition to the clitellum of the other (Figure 12-4). Each worm secretes quantities of mucus, so that each is enveloped in a slime tube extending from segment 9 to the posterior end of the clitellum. Seminal fluid discharged from the sperm ducts of each worm is carried along the seminal grooves by contraction of longitudinal muscles and enters the seminal receptacles of the mate. After copulation the worms separate, and each clitellum produces a secretion that finally hardens over its outer surface. The worm moves backward, drawing the hardened tube over its head (Figure 12-4C). As it is moved forward, the tube receives eggs from the oviducts, sperm from the seminal receptacles, and a nutritive albuminous fluid from skin glands. Fertilization occurs in the cocoon. As the worm withdraws, the cocoon closes and is deposited on the ground. Young worms hatch in 2 to 3 weeks.

**Excretory System.** A pair of tubular **nephridia** lies in each somite except the first three and the last one. Each nephridium begins with a ciliated, funnel-shaped **nephrostome,** which projects through the anterior septum of the segment and opens into the next anterior segment.

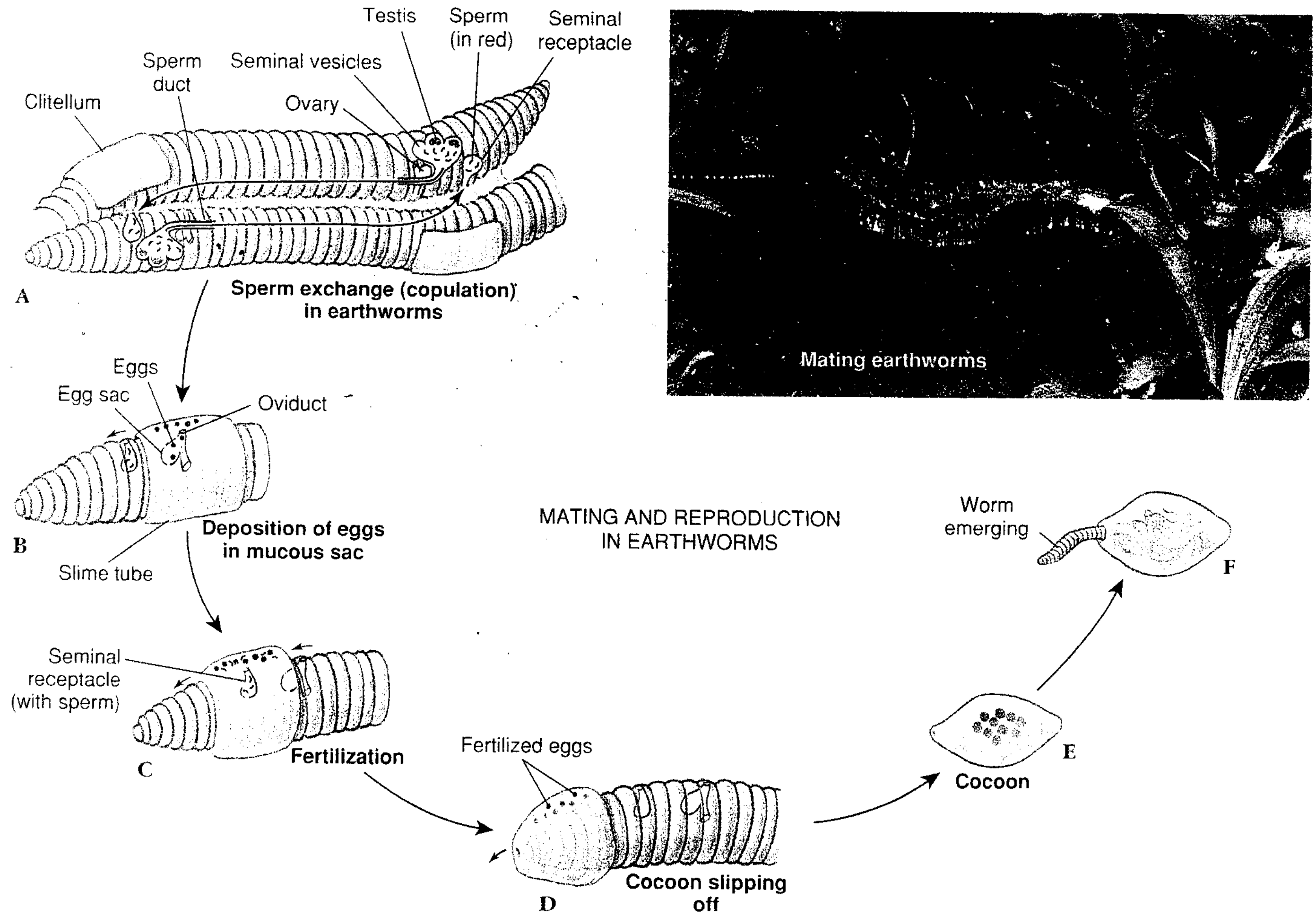



Figure 12-4

Earthworm copulation and formation of egg cocoons. **A,** Mutual insemination; sperm from genital pore (somite 15) pass along seminal grooves to seminal receptacles (somites 9 and 10) of each mate. **B** and **C,** After worms separate, a slime tube formed over the clitellum 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.

Use a dissecting microscope to examine a nephridium. They are largest in the region just posterior to the clitellum. With fine-tipped scissors, carefully remove a nephridium, along with a small portion of the septum through which the nephrostome projects. Mount on a slide with a drop or two of saline solution, cover with a coverslip, and examine with a compound microscope.

Note the slender tubule passing from the nephrostome to the looped nephridium. Note ciliary activity in one narrow portion of the tubule. You may also see parasitic nematodes in the large bladder segment of the tubule. Coelomic fluid is drawn by ciliary activity into the nephrostome and then flows through the narrow tubule, where ions, especially sodium and chloride, are reabsorbed. Urine, containing wastes, collects in the bladder, which empties to the outside through a **nephridiopore.**

## Nervous System

If you have not already done so, extend the dorsal incision to the first somite.

Find a small pair of white **cerebral ganglia** (the brain), lying on the anterior end of the pharynx and partially hidden by dilator muscles; small white **nerves** from the ganglia to the prostomium; a pair of **circumpharyngeal connectives,** extending from the ganglia and encircling the pharynx to reach the **subpharyngeal ganglia** under the pharynx; and a **ventral nerve cord,** extending posteriorly from the subpharyngeal ganglia for the entire length of the animal. Remove or lay aside the digestive tract and examine the nerve cord with a hand lens to see in each body segment a slightly enlarged **ganglion** and **lateral nerves.**

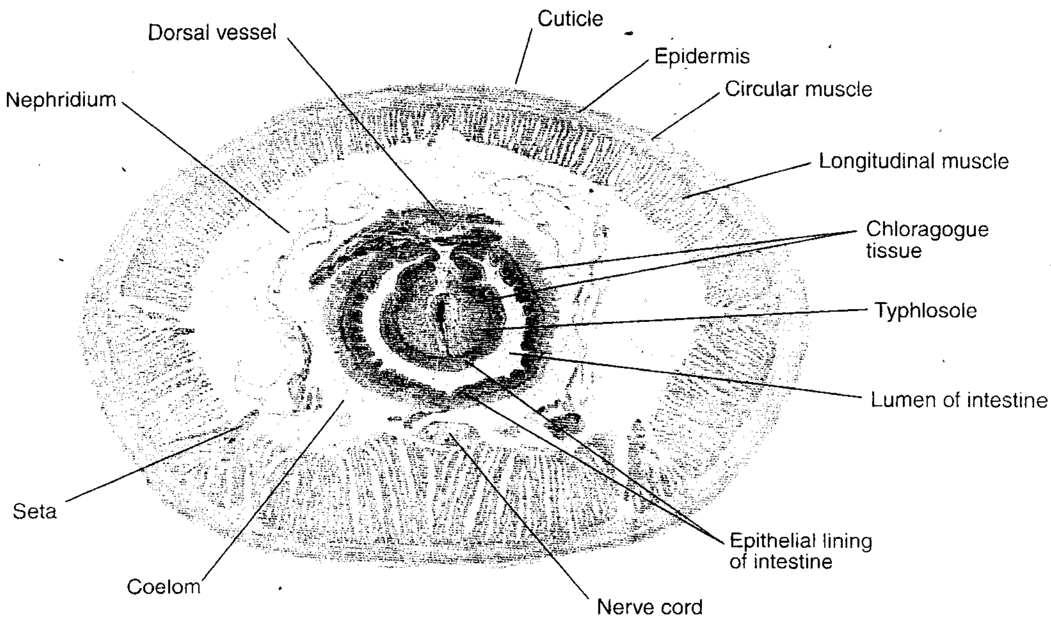



Figure 12-5
Cross section of an earthworm through the intestinal region.

## Oral Report

Be prepared to (1) demonstrate your dissection to your instructor, (2) point out both external and internal structures you have studied, and (3) explain their functions.

## Histology of Cross Section (Figure 12-5)

Examine a stained slide with low power. Note the tube-within-a-tube arrangement of intestine and body wall. Identify the following.

**Cuticle.** Thin, noncellular, and secreted by the epidermis.

**Epidermis.** (Ectodermal.) Columnar epithelium containing mucous gland cells. Mucus prevents the skin from drying out.

**Circular Muscle Layer.** Smooth muscle fibers running around the circumference of the body. How does their contraction affect body shape? ____________

**Longitudinal Muscle Layer.** Thick layer of obliquely striated fibers that run longitudinally. The muscle layers may be interrupted by the setae and dorsal pore.

**Peritoneum.** (Mesodermal.) The peritoneum (Gr. *peritonaios*, stretched around), a thin epithelial layer lining the body wall and covering the visceral organs (Figure 12-6). Peritoneum lining the body wall is called parietal (L. *paries*, wall) peritoneum. Peritoneum covering the digestive tract and other visceral organs is called visceral (L. *viscera*, bowels) peritoneum.

**Setae.** If present, they are brownish spines in a sheath secreted by epidermis. They are moved by tiny muscles (Figure 12-6).

**Coelom.** Space between the **parietal peritoneum,** which lines the body wall, and the **visceral peritoneum,** which covers the intestine and other organs.

**Alimentary Canal.** The intestine is surrounded by chloragogue tissue. Chloragogue tissue plays a role in intermediary metabolism similar to that of the liver in vertebrates. Inside the chloragogue layer is a layer of **longitudinal muscle.** Why does it appear as a circle of dots? ____________ Next is a **circular muscle layer,** followed by a layer of ciliated columnar epithelium (endodermal), which lines the intestine. Intestinal contents are moved along by peristaltic movement. Is such movement possible without longitudinal and circular muscles? ____________ Is peristalsis possible in the intestine of the flatworm or *Ascaris?* ____________

**Ventral Nerve Cord.** Use high power to identify three **giant fibers** in the dorsal side of the nerve cord, as well as nerve cells and fibers in the rest of the cord.

**Blood Vessels.** Identify the **dorsal** vessel above the typhlosole, **ventral** vessel below the intestine, **subneural** vessel below the nerve cord, and **lateral neurals** beside the nerve cord.

Some slides may also reveal parts of **nephridia, septa, mesenteries,** and other structures.

## Drawings

Sketch and label a cross section of the earthworm as it appears on your slide. Use separate paper.