LABORATORY 25

Diversity—Porifera, Cnidaria, and Wormlike Invertebrates

OVERVIEW

Multicellular organisms, or **metazoans,** comprise all of what are generally included in the kingdom Animalia (single-celled animals or protozoans are included in the kingdom Protista). Metazoans with poorly defined tissues and no internal organs are called **parazoans.** Two phyla, Placozoa and Porifera, are composed of parazoans. All other metazoans are **eumetazoans**—animals with internal organs and a digestive cavity with at least one opening, the mouth.

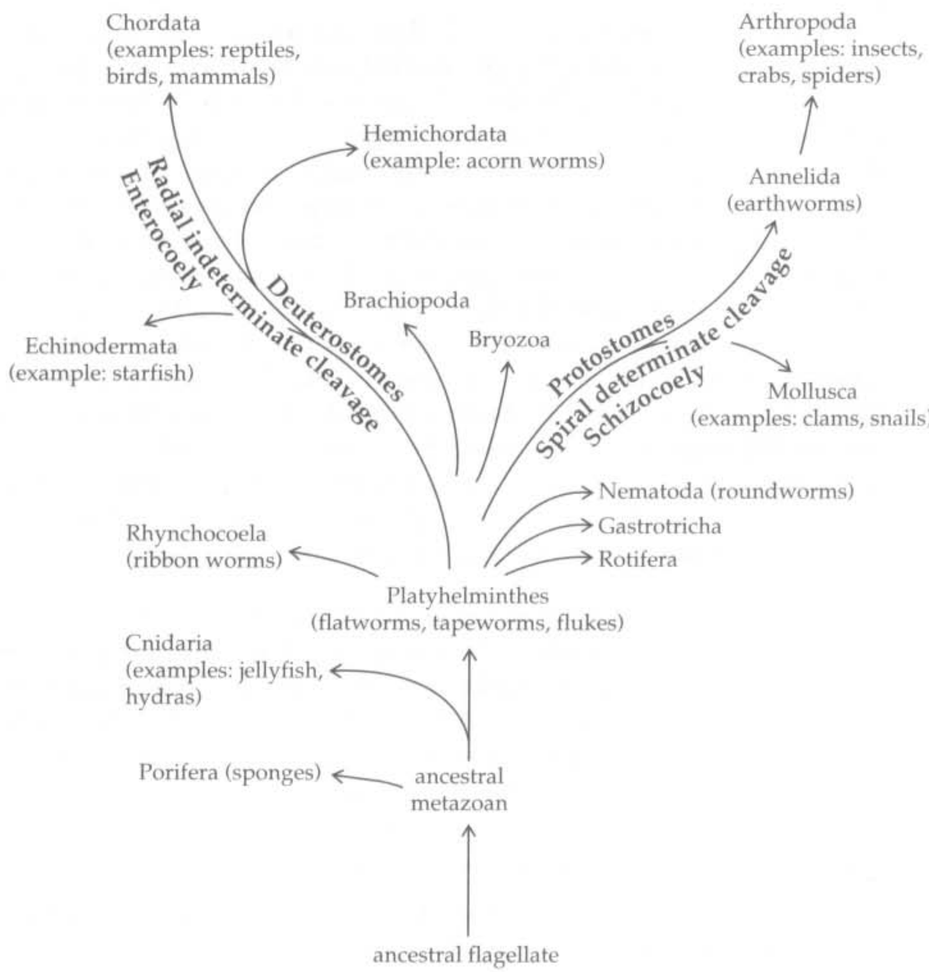


Figure 25-1 *Evolutionary "family tree" of the animal kingdom. (Adapted from Robert D. Barnes,* Invertebrate Zoology, *5/e, p. 61, Saunders, Philadelphia, 1986.)*

The phylogenetic relationships among various groups of metazoan organisms within the kingdom Animalia can best be studied by visualizing an evolutionary "family tree" that positions animals according to their relatedness to other organisms. Comparisons of anatomical, biochemical, physiological, and developmental similarities, together with fossil evidence, allow systematists to clarify phylogenetic relationships and to construct this "family tree." The tree presented in Figure 25-1 is one, but by no means the only, possible view of evolutionary relationships among the major animal phyla.

During this laboratory, you will survey six phyla of **invertebrates**—animals generally characterized as lacking a "backbone," or vertebral column. Our survey will focus on their diversity of form and function, proceeding from the relatively simple sponges (phylum Porifera) to the phylum Cnidaria, and then to wormlike animals in the phyla Platyhelminthes, Rhynchocoela, Nematoda, and Annelida.

STUDENT PREPARATION

Prepare for this laboratory by reviewing the text pages indicated by your instructor. Familiarizing yourself in advance with the information and procedures covered in this laboratory will give you a better understanding of the material and improve your efficiency.

EXERCISE A Phyla Porifera and Placozoa

Phylum Porifera The sponges, phylum Porifera, are the least complex of all multicellular animals. They are **asymmetrical,** with poorly defined tissues and no organs. In fact, if the cells of a sponge are separated, the cells become amoeboid and reaggregate and redifferentiate into a new sponge without regard to their previous roles.

The body of a sponge is organized around a system of water canals. Water is drawn through small pores into a central cavity, the **spongocoel,** and then flows out through a larger opening, the **osculum.** Cells of the sponge body are differentiated by function. Flattened **epithelial cells** cover the outer surface to form the **pinacoderm.** On the inner surface, special flagellated cells called **choanocytes,** or "collar cells," strain extremely small particles from the water and thus serve in **filter-feeding.** In the middle jellylike layer, wandering **amoebocytes** secrete a skeleton composed of calcium carbonate ($CaCO_3$), silicon dioxide (SiO_2), or a protein called spongin. Calcareous and siliceous sponges are hard due to the presence of tiny rodlike skeletal elements called **spicules.** The natural sponges you might buy for bathing or to wash your car are soft and are made of a skeletal network of spongin fibers.

Most sponges are marine, but a few live in fresh water. As adults, all are **sessile** (attached to a substrate). They can reproduce asexually by budding or fragmentation and sexually by production of eggs and sperm. Most sponges are **hermaphroditic** (or monoecious): each individual has both male and female gonads. The zygote develops into a free-swimming, flagellated larva—a free-swimming hollow ball of flagellated cells that resembles the embryonic blastula of other organisms. When the larva settles and attaches to a substrate, the external cells lose their flagella and move to the interior in a process of cellular reorganization much like that of gastrulation (see Laboratory 19) in other animals.

Phylum Placozoa A second group of parazoans, phylum Placozoa, is usually included with the sponges as one of the early branches of the animal kingdom. This phylum contains only two species. One of these, *Trichoplax adhaerens,* is a multicellular marine organism composed of two irregularly shaped, flattened layers of cells that enclose an inner layer of loose, contractile mesenchyme cells. Originally, *Trichoplax* was believed to be the larval form of an unidentified adult animal, but scientists now believe that it may represent the most primitive living metazoan.

Objectives

- [ ] Describe why sponges are considered to represent a level of organization between that of a colony and that of a true multicellular organism.

- ☐ List the cell types present in the body of a sponge and describe their functions.
- ☐ Explain how sponges feed.
- ☐ Differentiate between mineralized and proteinaceous sponge skeletons.

Procedure

1. Examine the examples of sponges on demonstration.

a. Which of the forms displayed have mineralized skeletons (calcium or silicon salts)?

____

b. Which have fibrous (protein) skeletons? ______________________________

2. Obtain a piece of sponge from one of the samples of *Grantia* and use your dissecting microscope to search for the tiny pores (**ostia**) through which water is taken into the body cavity (**spongocoel**) (Figure 25A-1).

c. What is the function of the larger pore (osculum)? ______________________________

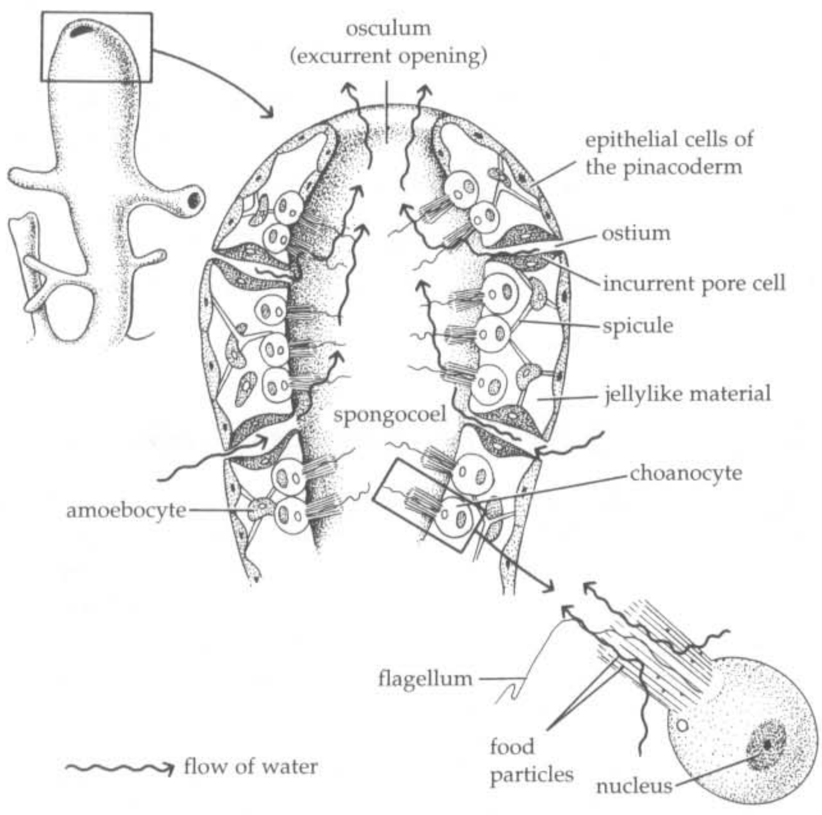


Figure 25A-1 *A simple sponge. Choanocytes (collar cells) with their flagella help maintain a flow of water into the central cavity of the sponge through small pores, the ostia. Particles of food and organic debris are filtered from the water by the choanocytes, becoming trapped in the delicate cytoplasmic collar surrounding the base of the cell's flagellum. Amoebocytes then carry food particles to nonfeeding cells; digestion takes place within the cells and not within the body cavity. Water is released through a larger opening, the osculum.*

The asconoid *body form, shown here, is the most primitive among the sponges. In asconoid sponges, choanocytes line a single, unpartitioned spongocoel. In other sponges* (synconoid *type), choanocytes line canals that extend from the spongocoel. In* leuconoid *sponges, the choanocytes are distributed along the surfaces of numerous smaller chambers that branch off canals leading from the spongocoel. This arrangement allows leuconoid sponges to become very large and to exhibit great variety of shape.*

3. In a prepared slide of *Grantia,* identify the choanocytes (collar cells) lining the spongocoel.
   d. What functions do these cells perform?

   ____

   e. What type of structure do you see extending from the choanocytes? ______________

   f. How would this structure aid the choancytes in carrying out their main functions?

   ____

   g. Describe the region that separates the two cellular layers of the sponge.

   ____

   h. Are there any cells in this region? ______

4. On a separate sheet of paper, make a drawing of *Grantia*. Indicate the direction of water flow through the sponge. Label the following structures: choanocyte, amoebocyte, flagellum, ostium, osculum. Insert the drawing into your laboratory manual.
5. Obtain a small piece of *Spongilla* and place it on a glass slide, but do not add a coverslip. View the slide using the light microscope at scanning power (4×).
6. Remove the slide from the microscope and add a drop of bleach solution or vinegar to the sponge. Let the slide sit for 5 minutes.
7. Place a coverslip over the sponge material. Use a paper towel to soak up any excess fluid before returning the slide to the microscope. View at 10× and 40×.
   i. Describe what you see. ______________

   j. What do you think these structures are? ______________

   k. Why did you add the vinegar or bleach solution? What did it do to the sponge material?

   ____

EXERCISE B Phyla Cnidaria and Ctenophora

Phylum Cnidaria Organisms in the phylum Cnidaria, and all those that are higher on the phylogenetic tree, have distinct cell layers and are **symmetrical.** Symmetry implies a higher degree of complexity and organization than the asymmetrical organization characteristic of the sponges (Figure 25B-1).

Organisms in the phylum Cnidaria are generally radially symmetrical. They are **diploblastic,** composed of two true tissue layers, the outer **epidermis** and the inner **gastrodermis,** separated by a gelatinous matrix called the **mesoglea.** The mesoglea may be thin or relatively thick and may be either cellular or without cells. Cnidarians are named for special cells called **cnidocytes,** which contain stinging organelles, the **nematocysts.**

Two body forms are found among cnidarians—the **polyp** and the **medusa** (Figure 25B-2). A single species may exhibit one or both of these body forms. Polyps may be free-living or attached to a substrate, whereas medusas are swimming forms. In colonial cnidarians, polyps and medusas may live together and share the functions of food gathering (by polyps) and reproduction (by medusas).

Both the polyp and medusa have tentacles armed with cnidocytes for capturing food and gathering it into their mouths. Most cnidarians feed on zooplankton, small animals and larvae that move passively with water currents. Food is ingested and wastes are voided through the mouth, the only opening into the digestive cavity. A digestive cavity with a single opening is called a **gastrovascular cavity.** In cnidarians, it also serves a circulatory function since its branches are close to all tissues. Neurons usually form a network of fibers at the interface of the epidermal and gastrodermal layers. This "nerve net" controls the limited behaviors permitted by the longitudinal epidermal fibers and the water-filled gastrovascular cavity that acts as a supporting **hydrostatic skeleton.**

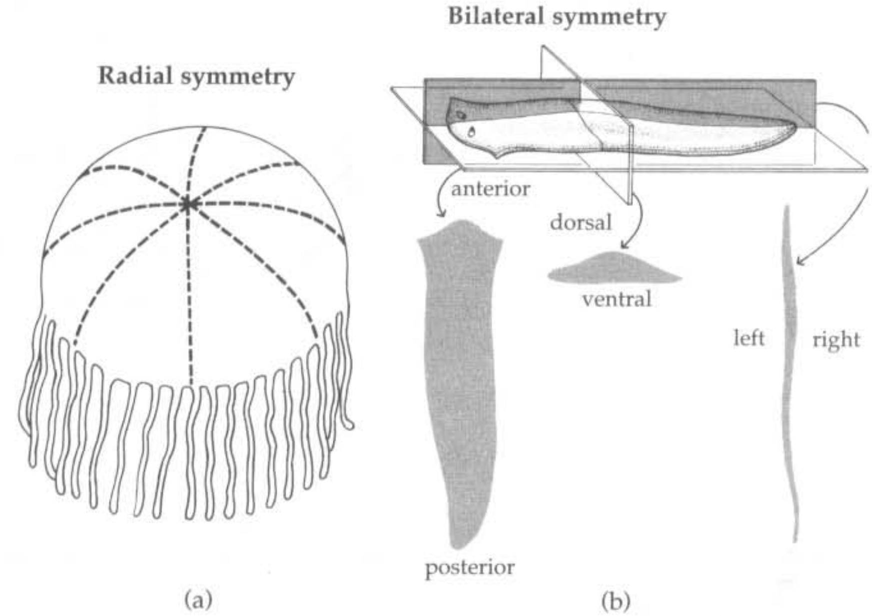


Figure 25B-1 *(a) If a radially symmetrical animal is bisected in a particular plane, the shapes of the sections will be the same. (b) If a bilaterally symmetrical organism, which has dorsal, ventral, anterior, posterior, and right and left sides, is sectioned in different planes, the sections will not always be the same shape.*

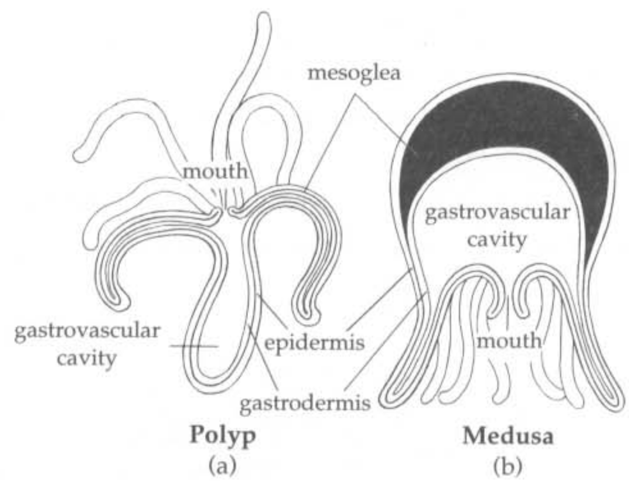


Figure 25B-2 *Two body forms are found among the cnidarians, the polyp (a) and the medusa (b). A single species may exhibit one or both of these body forms during its life cycle.*

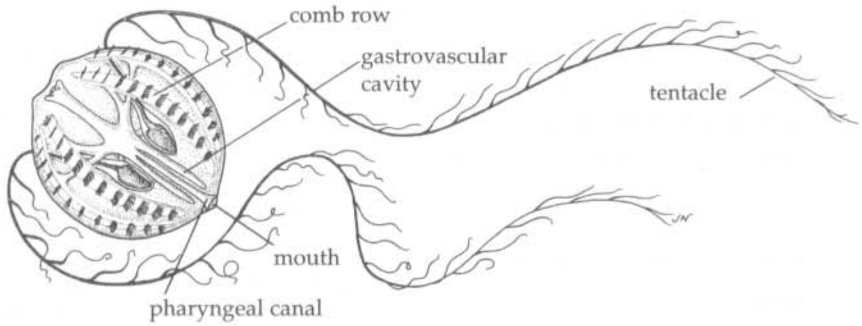
Cnidarians are found in both marine and freshwater environments. Reproduction occurs both asexually by budding or fragmentation and sexually by the production of eggs and sperm. Free-swimming, ciliated **planula larvae** are characteristic of most cnidarians.

Representatives of the three classes of cnidarians include the **hydrozoans,** the jellyfishes (**scyphozoans**), and the corals and sea anemones (**anthozoans**). About 9,000 living species are known today, and there is also a rich fossil record of this phylum extending back to the Cambrian period.

Phylum Ctenophora Ctenophores probably evolved from the cnidarians or, at least, both groups share a common ancestry. Ctenophores, commonly called jellies or sea walnuts, are diploblastic and have a globular, medusoid-like body with a thick, transparent mesoglea that contains fibers, amoebocytes, and muscle cells. No nematocysts are present, except in a single species.

The spherical ctenophore body is biradially symmetrical. The mouth is on the lower side and the body is divided into equal sections by eight rows of ciliated "combs" (transverse plates of long, fused cilia), the combs arranged one behind the other to form comb rows (Figure 25B-3). In many comb jellies, two long tentacles protrude from epidermal pouches on the side opposite the mouth. Ctenophores are carnivorous and can evert their tentacles to trap small planktonic organisms by

Figure 25B-3 *A ctenophore.*



means of special adhesive cells (colloblasts). Ctenophores that lack tentacles simply catch food with their mouths.

The phylum Ctenophora contains approximately 50 species, all of which are marine. They usually range in size from several millimeters to about the diameter of a golf ball.

Objectives

- ☐ Relate the name Cnidaria to the special structures of organisms in this phylum.
- ☐ Describe the general form of a polyp.
- ☐ Describe the general form of a medusa.
- ☐ Give an example of a cnidarian exhibiting an alternation of polyp and medusa forms and of a cnidarian that exhibits only a single body form.
- ☐ Indicate how ctenophores are similar to, and differ from, cnidarians.
- ☐ Describe the distinguishing characteristics of the phylum Ctenophora.

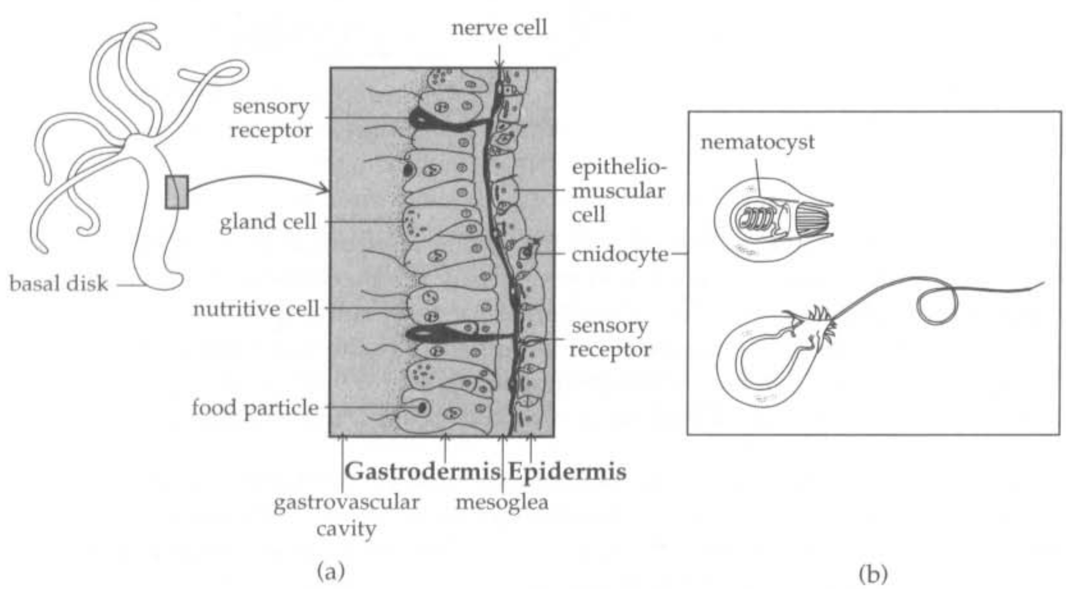


Figure 25B-4 *(a) Longitudinal section through a* Hydra *showing two tissue layers and specialized cells, including cnidocytes. (b) The cnidocyte is filled with a nematocyst that discharges a filament in response to a chemical or mechanical stimulus.*

Procedure

1. Study the live hydrozoan, *Hydra,* using a dissecting microscope. Note the general **polyp** body plan (Figure 25B-4). In this species, no medusa is present during the life cycle. Reproduction is either asexual by budding or sexual by production of eggs and sperm. Identify the mouth, tentacles, and basal disk. Touch one of the tentacles gently with a dissecting needle. What happens?
2. Watch the *Hydra* move (be patient and avoid jarring your microscope). Locomotion is mainly by contraction of muscle fibers in the outer tissue layer. The basal disk detaches from the substrate, and nematocysts help "glue" tentacles to the substrate so the polyp can somersault. In some cases, an air bubble in cells of the basal disk allows the *Hydra* to float. *Hydra* uses regular bursts of contraction and extension to sample the environment and search for food.
3. What color is your *Hydra?* Some species are green, which might suggest that they should be included among the plants. Symbiotic green algae in the cells lining the gastrovascular cavity, however, are the source of the green color. This type of symbiosis is not uncommon in cnidarians.
4. Recall that cnidarians such as *Hydra* have stinging organelles called nematocysts. What do they use these for? Have you seen any evidence that these structures were needed for locomotion? ______ Do you think they would be of use in capturing prey? ______

   Hydra eat small protozoans and larvae of other organisms or even other small organisms such as *Daphnia* or brine shrimp. Formulate a hypothesis that predicts how *Hydra* will behave when it comes into contact with prey (food). Is there a preference for certain types of food; large or small, dead or alive, fast moving or slow moving?

   HYPOTHESIS:

   NULL HYPOTHESIS:

   What do you **predict** will happen when *Hydra* is fed?

   Design an experimental procedure to test your hypothesis. Identify the **independent variable** in this investigation.

   Identify the **dependent variable** in this investigation.

   PROCEDURE:

RESULTS: Determine how *Hydra* feeds. Is there any evidence that *Hydra* uses stinging cells to obtain food? Does body shape change during feeding? How do the tentacles function? Are all tentacles used or just a few?

Do your results support your hypothesis?

Your null hypothesis?

Was your prediction correct?

What do you **conclude** about the food preferences of *Hydra?*

5. Examine a prepared slide of *Obelia,* also a hydrozoan, under low power (10×). *Obelia* is a **colonial** cnidarian with a life cycle that alternates between an asexual polyp and a sexual medusa (Figure 25B-5). The colony is composed of two types of polyps connected by a branching "stem." Feeding polyps have tentacles, whereas reproductive individuals do not. Nutrients are supplied to the reproductive polyps through the stem. Identify the feeding polyps and the reproductive polyps.

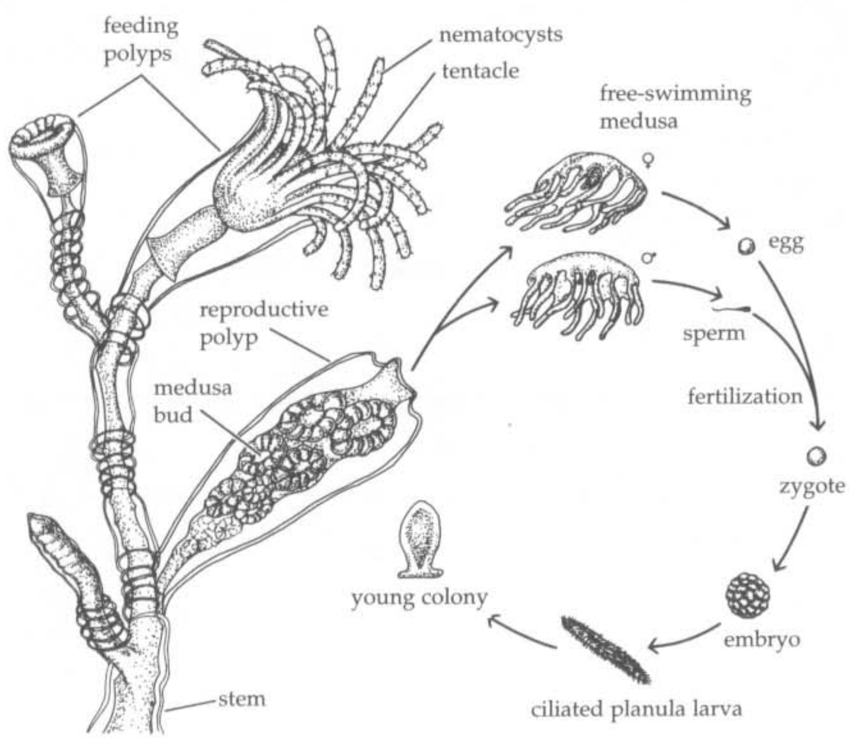


Figure 25B-5 Obelia, *a representative colonial cnidarian containing both feeding polyps and reproductive polyps. When mature, medusas are released from the reproductive polyps. As they swim, medusas release gametes that unite to form a diploid zygote. The zygote develops into a swimming larval form, the planula, which eventually settles onto a substrate and attaches itself. There it differentiates into a new colony of polyps.*

6. Adjust your microscope to high power (40×) and examine the nematocysts located within cnidocytes along the tentacles of a feeding polyp. These tiny, hairlike barbs are used to snare and paralyze small prey. Immobilized organisms are then taken into the gastrovascular cavity through the mouth opening between the tentacles.

7. Notice the two distinct tissue layers in *Obelia*. Gastrodermal cells lining the digestive cavity are separated from epidermal cells covering the outer surface of the polyp by a jellylike layer, the mesoglea. This layer contains wandering amoebocytes, which secrete materials that compose the mesoglea.

8. Examine a reproductive polyp at high power. Does it contain ringlets of cells along its longitudinal axis? These cells are the beginnings of medusas and are called, collectively, medusa buds.

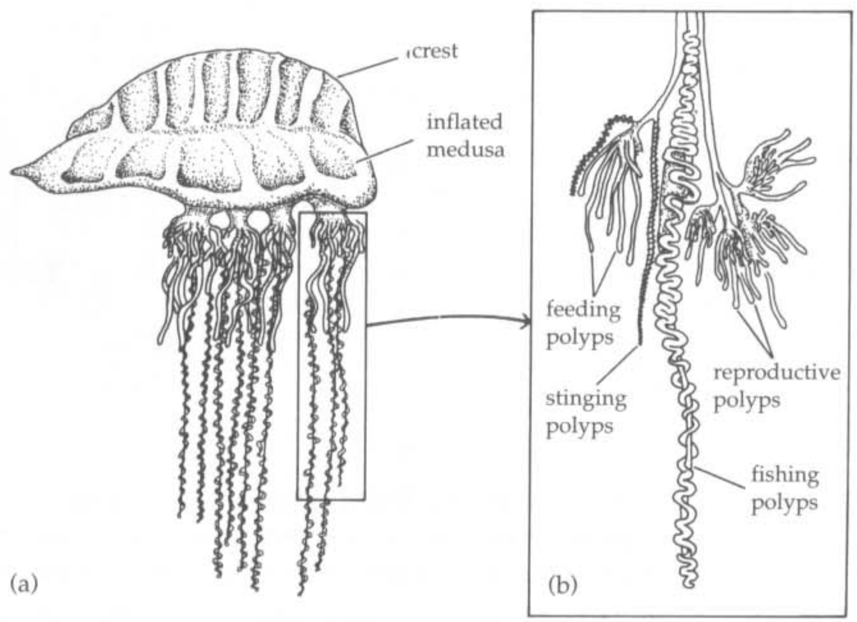
   a. *What part do medusa buds play in the life cycle (Figure 25B-5)?* ______________________

   b. *Of what advantage is the colonial life form adopted by* Obelia? ______________________

   ____

9. Examine the Portuguese man-of-war (*Physalia*) on demonstration or study Figure 25B-6. This is a free-living, complex hydrozoan colony composed of both medusas and polyps. The most obvious individual in the colony is a modified medusa that forms the large, crested, gas-filled float. Feeding polyps hang from this float trailing tentacles as far as 60 feet (18 meters) from the colony. Particularly venomous nematocysts may kill invertebrates and small fish (and can be extremely painful to humans).

Figure 25B-6 *The Portuguese man-of-war is a colonial organism composed of (a) an inflated medusa and (b) many types of polyps, which have feeding and reproductive functions.*



10. Study the plastic mount of the scyphozoan jellyfish *Aurelia* on demonstration (Figure 25B-7). The common mouth/anus is in the middle, surrounded by tentacles or arms. Gonads surround pouches of the gastric system whose radial canals extend to the edge of the umbrella (as a sort of gastrovascular circulatory cavity). The jellylike mesoglea forms the mass of the tissue making up the bell.

    Located at the outer margin of the bell are smaller tentacles and sense organs that determine position (**statocysts**). All exposed areas bear stinging cells.

    The jellyfish, like the hydrozoans, have an alternation of generations, but the medusa, which is a free-swimming jellyfish, is the predominant and most obvious form.

11. Examine the preserved and dissected sea anemones on demonstration or study Figure 25B-8. Note the internal structures displayed. A distinctive feature of anemones is the presence of a **pharynx** and sheets of tissue called **mesenteries** formed from infoldings of the body wall

Figure 25B-7 *The scyphozoan jellyfish,* Aurelia, *ventral view. Note that the margin of the bell is free of the ring of tissue (velum) present in hydrozoan medusas, which may otherwise resemble scyphozoan jellyfish in form.*

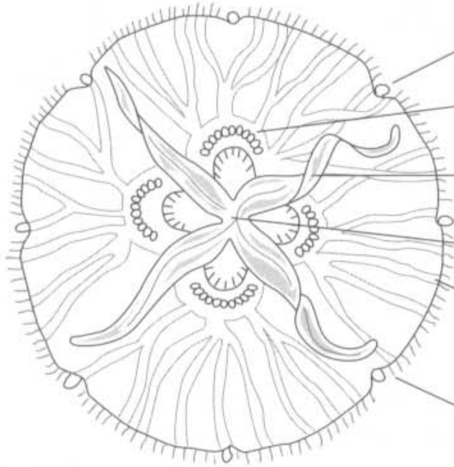
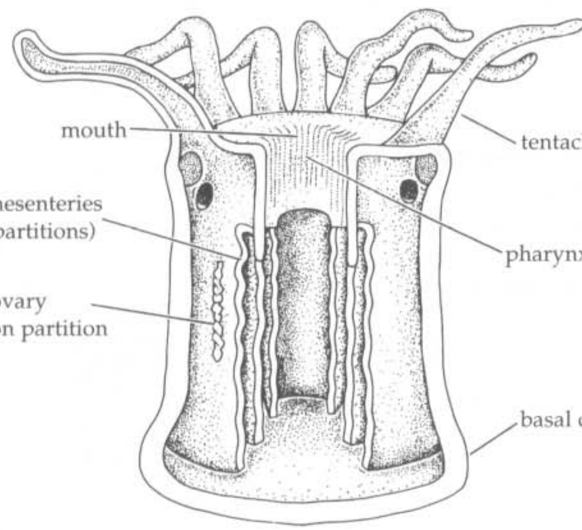


Figure 25B-8 *Diagrammatic representation of the internal structure of a sea anemone.*



around the mouth. Sea anemones feed on small fish and other invertebrates. They may reproduce asexually by fragmentation or sexually by production of gametes. **Anthozoans** such as the sea anemone exist only in the polyp form.

c. How does the sea anemone polyp resemble the hydrozoan polyp?

____

12. Examine the corals on demonstration. Corals are also anthozoans existing only in the polyp form. A colony of polyps secretes a calcareous skeleton around the component individuals. Look closely at the coral. Do you see tiny holes? These are the holes through which the living polyps extend while feeding and reproducing. Sea fans and sea whips are "soft corals"; they are composed of a proteinaceous skeleton rather than a calcareous one.

d. How does the structure of the soft corals resemble that of the other corals?

____

13. Study the comb jelly, *Pleurobranchia*, on demonstration or examine Figure 25B-3. Note the comb rows, mouth, pharyngeal canal, and tentacles.

e. How would you distinguish organisms in the phylum Cnidaria from organisms in the phylum Ctenophora?

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EXERCISE C Wormlike Animals: Platyhelminthes, Rhynchocoela, Nematoda, Annelida

"Worms" and all remaining phyla of animals consist of organisms that are **triploblastic** and possess bilateral symmetry at some time in their life history.

The representatives of the four diverse phyla of wormlike organisms considered in this exercise exhibit many important evolutionary advances. One of these is the **mesoderm,** a third distinct embryonic tissue layer between the ectoderm and endoderm (hence the term "triploblastic"). Your study of representatives of the four "worm" phyla will show additional advances in organization and function.

PART I Phylum Platyhelminthes: Flatworms

"Flatworms"—flattened, unsegmented worms—include **planarians,** class Turbellaria; **flukes,** class Trematoda; and **tapeworms,** class Cestoda. All members of the classes Trematoda and Cestoda are parasitic. They are **acoelomate** (have no coelom), with body organs embedded in their mesodermal tissues. Platyhelminthes exhibit the first extensive **organ-system** level of development.

Free-living flatworms, the turbellarians, are small, and most are marine, living on or in bottom sediments. Locomotion is by cilia and, in some larger flatworms, undulating muscular movements may help. The nervous system includes a small anterior ganglionic "brain" and longitudinal nerve cords. "Eyespots" consist of concentrations of pigment (melanin) that shade photoreceptive neurons (**ocelli**). The turbellarian digestive tract is a blind sac with no anus—the mouth is used for both ingestion and egestion. Primitive osmoregulatory structures, **protonephridia** (flame cells), are also present. Turbellarians are hermaphroditic and larvae are free-swimming.

Adult flukes, the trematodes, are all parasites, either external or internal. Flukes are flattened and have a ventral sucker or other adhesive organ for attaching to their host. In some trematodes, a second sucker is associated with the anterior mouth. Most flukes are hermaphroditic. The life cycle may involve one to four hosts—intermediate hosts (hosts that harbor the immature stages) may be invertebrates, but the definitive host (the host that harbors the sexually mature stage) is always a vertebrate.

Tapeworms, the cestodes, are intestinal parasites of vertebrates and are highly adapted for a hostile environment, where they nonetheless enjoy a rich food supply provided by their host. Like flukes, tapeworms are hermaphroditic, and their life cycle may involve an intermediate host in which a "bladder worm" stage encysts, awaiting ingestion by the definitive host.

Objectives

- ☐ State the evolutionary advances demonstrated by members of the phylum Platyhelminthes.
- ☐ Describe how the tapeworm is adapted for parasitism.

Procedure

1. The planarian *Dugesia* lives in ponds and streams under submerged rocks and logs. Place a living specimen of *Dugesia* into a Petri dish with some pond water. Examine it using your dissecting microscope. On a separate piece of paper, make diagrams of its dorsal and ventral surfaces.
2. Draw a dotted line on your diagrams to indicate the plane of symmetry. Indicate which end is anterior and which is posterior.

   a. Which type of symmetry do flatworms exhibit? ____________________

3. Place a few pieces of fresh (or dried) liver or egg yolk into your Petri dish and observe how *Dugesia* feeds.

   b. Which organ is used in feeding? ____________ *What do you observe?* ____________

   c. How do planarians rid themselves of solid wastes? ____________________

4. Cephalization (development of a head), a central nervous system, and an excretory system are first seen in the phylum Platyhelminthes. Figure 25C-1 will assist you in labeling the sensory lobes (auricles), eyespots ("eyes"), and pharynx and internal anatomy of *Dugesia.*

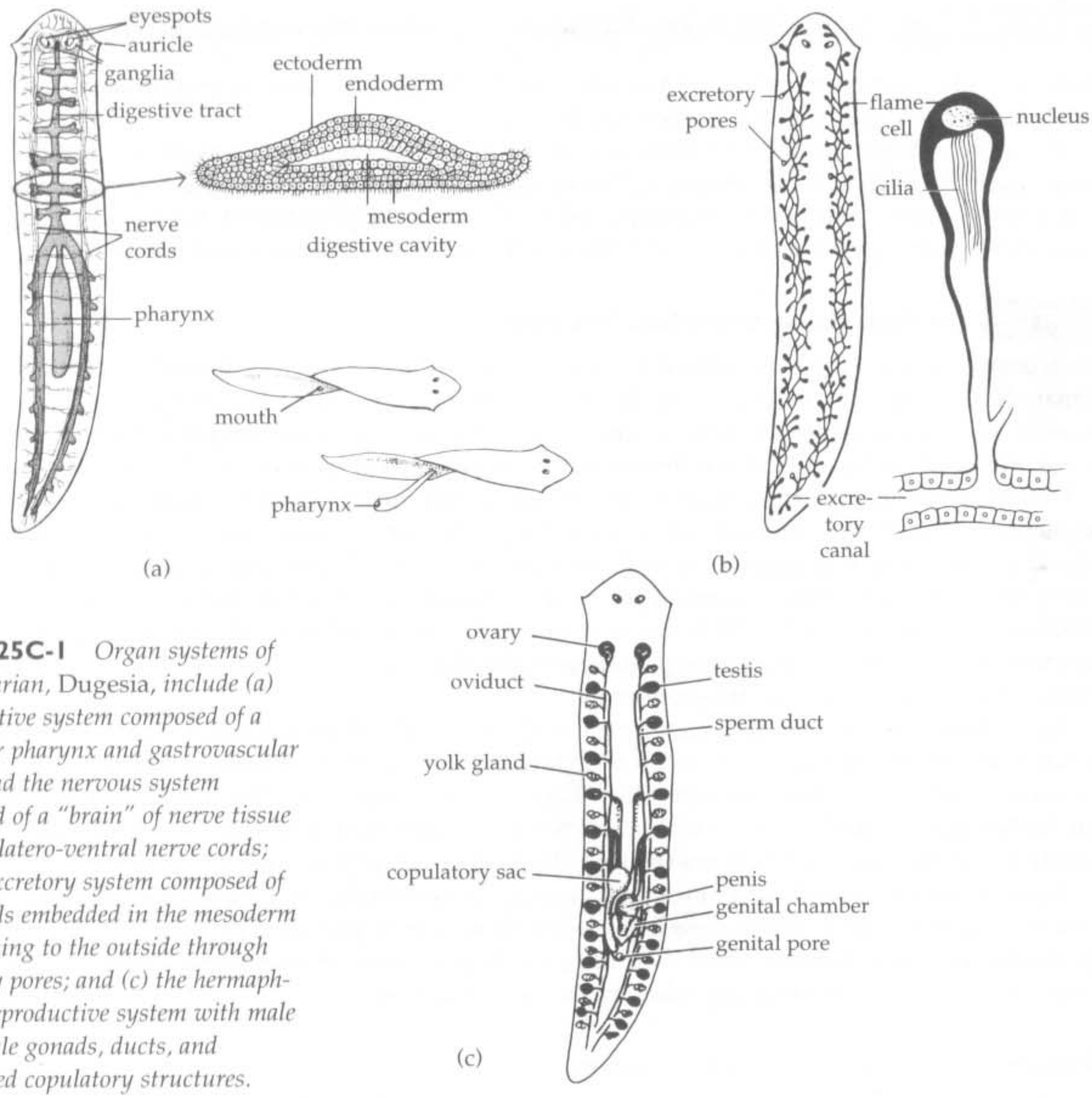


Figure 25C-1 *Organ systems of the planarian,* Dugesia, *include (a) the digestive system composed of a muscular pharynx and gastrovascular cavity and the nervous system composed of a "brain" of nerve tissue and two latero-ventral nerve cords; (b) the excretory system composed of flame cells embedded in the mesoderm and opening to the outside through excretory pores; and (c) the hermaphroditic reproductive system with male and female gonads, ducts, and specialized copulatory structures.*

5. Cephalization allows for forward movement. This is an important advance because it allows animals to hunt prey and to react, moving away or toward environmental stimuli. Sensory cells aid in these behaviors.

   Sensory cells are distributed over the entire surface of *Dugesia.* They are slender pointed cells that lie with their ends projecting from the body surface between the epithelial cells. Some of the sensory cells are concentrated in the auricles and are used to gather tactile information. The two "eyes" are sensory organs specialized for light reception. Each consists of a pigmented black cup lined by sensory cells that continue as nerves to the "brain," a ganglion-like collection of nerve cells in the head. The pigmented cup shades the sensory cells from light in all directions but one and allows *Dugesia* to respond to light.

   Planarians demonstrate **taxis,** locomotion either directly toward or away from a stimulus. Eyespots allow them to move either toward light (a positive phototaxis) or away from light (a negative phototaxis). Formulate a hypothesis that predicts how planaria will respond to light.

HYPOTHESIS:

NULL HYPOTHESIS:

What do you **predict** about the taxis of *Dugesia?* Is it toward light (positive) or away from light (negative)?

Identify the **independent variable** in this investigation.

Identify the **dependent variable** in this investigation.

Use the following experimental procedure to test your hypothesis. Modify the procedure if necessary.

PROCEDURE:

1. Draw a line across the middle of the bottom of a Petri dish. Mark one side "light," and the other "dark."
2. Put enough pond water in the dish to keep the animal happy.
3. Cover one half of the lid with aluminum foil.
4. Introduce a *Dugesia* anywhere in the Petri dish. Put on the lid so that the aluminum foil covers the side of the bottom marked "dark."
5. Place the dish directly under a moderate light source and leave it for about 10 minutes.
6. Remove the *Dugesia* with an eye dropper.
7. Sprinkle a small amount of carmine powder over the water and allow it to settle.
8. Gently swirl the dish so that the carmine comes in contact with all parts of the mucous trail left by the planarian on the bottom of the dish.
9. In one smooth motion, decant (pour out) the water and unattached carmine particles.
10. You now have a visual record of the movements of *Dugesia* during the experiment.

RESULTS: What do you observe about the movement of the planarian under the experimental conditions?

Do your results support your hypothesis?

What do you **conclude** about the function of the "eyes" in planaria?

Your null hypothesis?

Was your prediction correct?

6. Examine a microscope slide of the human liver fluke *Chlonorchis sinensis* (Figure 25C-2). Note the anterior sucker and the two blind intestinal sacs extending from the pharynx and esophagus. Much of the central part of the body is occupied by the uterus. The single ovary and paired testes are located in the posterior third of the body.

   d. Notice that there are no sense organs in trematodes. Why not?

   ____

   e. What is the intermediate host of Chlonorchis? ____________________

   The definitive host? ____________________

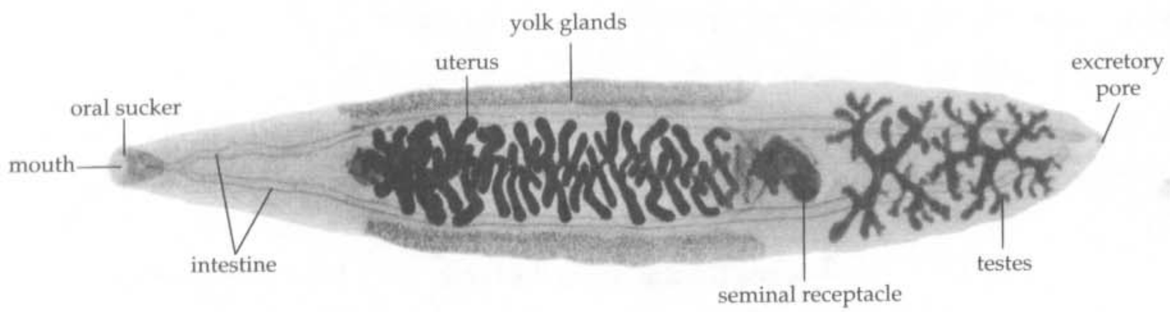


Figure 25C-2 *In the life cycle of* Chlonorchis, *snails ingest the eggs of this parasite, which then hatch and develop into intermediate larval forms within the host. The larvae develop into tadpole-like swimming forms that bore through the flesh of the snail and escape into the water. There they swim until they find a fish of the appropriate type, bore into its flesh, lose their tails, and become encysted in muscle tissue. In a human who eats raw, infected fish, the larvae encyst in liver tissue and become adults. Eggs of the parasite are excreted in the feces. If raw sewage finds its way into bodies of water, snails may continue the* Chlonorchis *life cycle by ingesting the eggs.*

7. Examine preserved specimens of **tapeworms** on demonstration. The adult tapeworm (Taenia) lives in the cavity of the human intestine and the intestine of domesticated animals such as dogs and cats. An anterior region of the "worm," the **scolex,** is modified to anchor the organism in the intestinal tissue of the host. Behind the scolex is a chain of segmentlike reproductive structures, called **proglottids.** This chain may reach a length of 20 feet or 6 meters and may consist of over 1,000 proglottids. New proglottids are constantly formed by budding in the "neck" region behind the scolex. Mature proglottids detach from the posterior end and are voided with the feces of the host. They may then be passed to other individuals through food contamination.

8. Observe a prepared slide of portions of *Taenia* at 10× to observe the general size and shape of different regions; then use high power (40×) to see the detailed structure of the scolex and proglottids (Figure 25C-3).

   f. Describe the structure of the scolex and state how it is adapted for attachment to the host.

   ____

The disk-shaped structure surrounded by hooks at the tip of the scolex does not contain a mouth—tapeworms have no digestive system. Instead, food molecules are taken directly from the intestine of the host through the integument of the parasite.

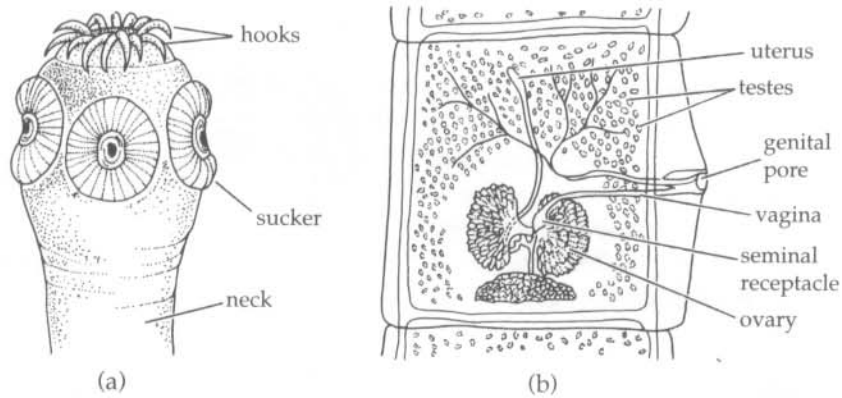


Figure 25C-3 Taenia, *the tapeworm. (a) The scolex. (b) Internal view of a mature proglottid showing the male and female reproductive organs present in each proglottid.*

g. *Tapeworms are covered by a thick cuticle secreted by the epidermis. Of what advantage would this be to an organism living inside an intestine?*

____

h. *Do all of the proglottids on the slide appear to be about the same size and have the same internal structure?* ______ *Which proglottids were formed first?* ____________________

____

i. *What are the reproductive structures apparent in the proglottids on your slide (Figure 25C-3b)?*

____

j. *What advantage does a hermaphroditic species have over a species with separate sexes?*

____

✓ PART 2 Phylum Rhynchocoela: Ribbon Worms

Organisms in the phylum **Rhynchocoela,** or Nemertea (nemertines), are called "**ribbon worms**" or "proboscis worms." Ribbon worms are long and often flattened, with a remarkable eversible **proboscis** usually equipped with a barb for food gathering. The proboscis is actually a long tube coiled in a body cavity called the **rhynchocoel** (it is much like the finger of a rubber glove that is pushed inside the glove, springing out when the glove is squeezed). Muscles attached to the proboscis are used to evert it (Figure 25C-4).

The phylum Rhynchocoela may be an offshoot of the Platyhelminthes; however, the ribbon worms exhibit evolutionary advances over the flatworms. For the first time in our consideration of the phyla, we observe **two digestive openings,** a **mouth** and an **anus;** and a **closed circulatory system** composed of two lateral vessels connected anteriorly and posteriorly. In addition, a **dorsal nerve cord** and two **lateral nerve cords,** somewhat similar to the nervous system of the flatworms, are found in members of this group. The ribbon worms are the first phylum to possess excretory cells, or **protonephridia,** that are truly excretory rather than simply osmoregulatory (as are the characteristic flame cells of the flatworms). Sexes are separate in most nemertines, and fertilization is external.

Objectives

- ☐ State two evolutionary advances characteristic of the phylum Rhynchocoela.
- ☐ Describe the general structure of a ribbon worm.

Procedure

Examine preserved specimens of ribbon worms. *Describe their general appearance.*

____

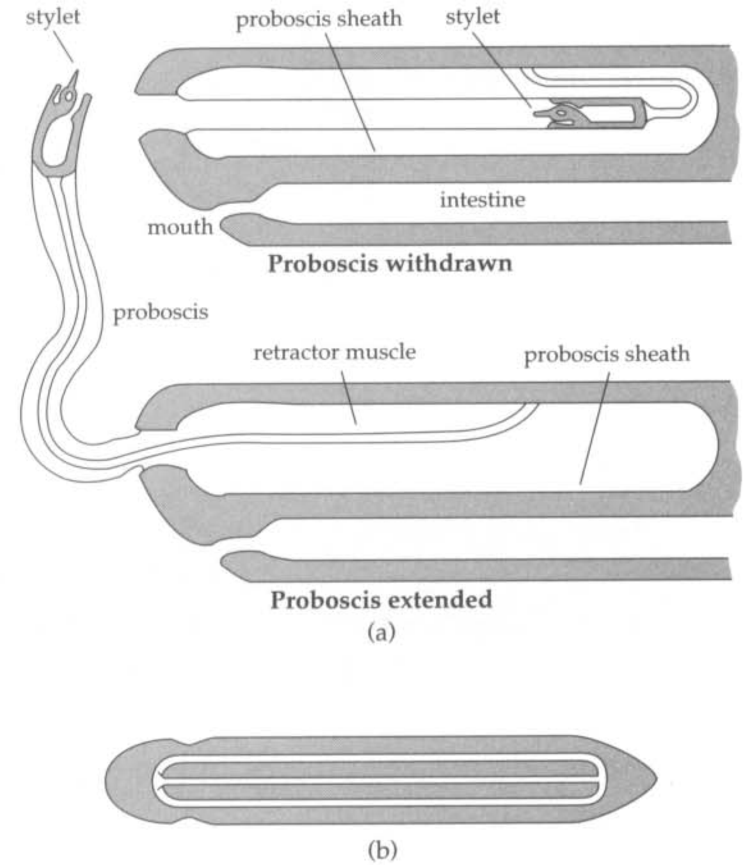


Figure 25C-4 *(a) Diagrams of the anterior end of a ribbon worm showing the proboscis withdrawn and extended. The proboscis is rapidly extended by hydrostatic pressure and the prey is impaled by the stylet or tangled in the proboscis. (b) Diagram of the circulatory system with one dorsal and two lateral vessels.*

PART 3 Phylum Nematoda (Roundworms) and Other Wormlike Phyla

Gastrotrichs, rotifers, kinorhynchs, nematodes (roundworms), horsehair worms, and a few other minor wormlike groups form an assemblage of small, generally free-living animals with an anterior mouth and sense organs, but no well-defined head (Figure 25C-5).* Cilia are reduced and the body is covered with a secreted cuticle. The digestive tract is usually complete and has a specialized "pharynx." Most of these organisms have protonephridia. Many of the nematodes and rotifers have a constant number of nuclei in various organs, and mitosis ceases following embryonic development. The sexes are separate in most of

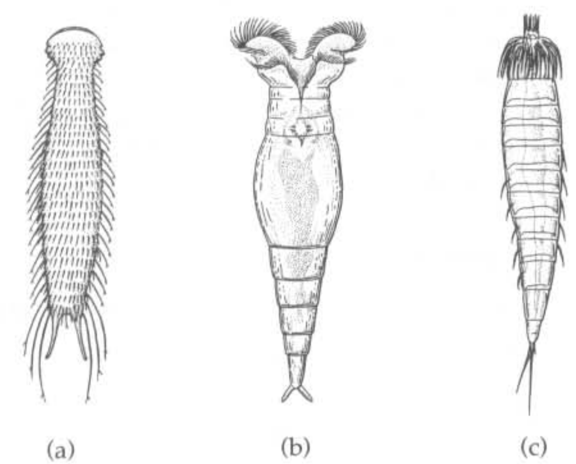


Figure 25C-5 *Representatives of wormlike phyla: (a) gastrotrich (phylum Gastrotricha), (b) rotifer (phylum Rotifera), (c) kinorhynch (phylum Kinorhyncha).*

**Because of their similarities, these animals are sometimes grouped together as the Aschelminthes.*

these wormlike organisms. Here, we will consider only the most diverse group of these animals, the phylum Nematoda (roundworms) with about 12,000 known species.

The **roundworms** or **nematodes** are unsegmented worms that may be either free-living or parasitic. Many free-living forms are inhabitants of the soil. Parasitic forms invade plant bodies and destroy tissues. Common animal parasites include hookworms, intestinal roundworms (*Ascaris*), *Trichinella*, and pinworms.

In contrast to the acoelomate flatworms and ribbon worms, organisms in this phylum have a type of body cavity (**coelom**). A true coelom is completely lined by mesoderm and will not be found until we progress to organisms in more advanced phyla. In nematodes, the coelom is called a **pseudocoelom** because it appears to be only partially lined by mesoderm (Figure 25C-6).

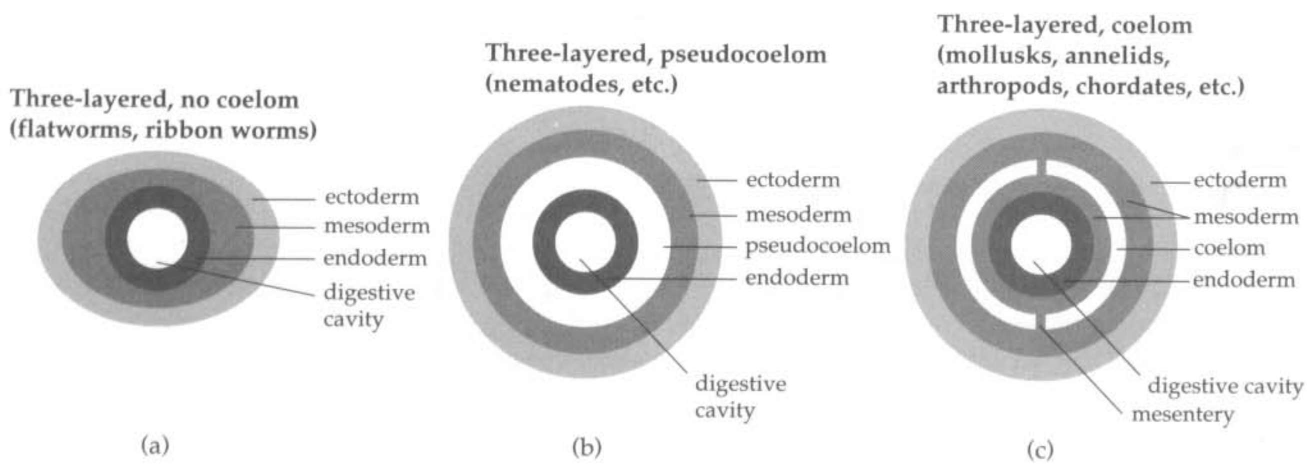


Figure 25C-6 *(a) Acoelomate animals, such as platyhelminths, have only one body cavity—the digestive cavity; body organs are embedded in mesoderm. (b) Other animals, for example, nematodes, have a second body cavity, a pseudocoelom. (c) A true coelom (defined as a second body cavity completely lined with mesoderm) is found in annelids and almost all other higher phyla. Why is a pseudocoelom not a true coelom?*

Organisms in this phylum also have a true gut with two openings—a mouth and an anus, allowing regions of the digestive tract to assume specialized functions.

Objectives

- ☐ State two evolutionary advances in the phylum Nematoda.
- ☐ Describe the generalized structure of a free-living nematode.
- ☐ Describe the modifications for parasitism observed among the nematodes.

Procedure

A free-living nematode, the vinegar eel *Turbatrix*, lives at the bottom of casks of vinegar, where it feeds on bacteria and yeast.

1. Place a few drops of the vinegar eel culture onto a clean microscope slide. Add one drop of 0.2% neutral red to increase the contrast of the mount and add a coverslip. Examine a vinegar eel at 10× to observe its overall shape, and then use high power (40×) to see details of its internal anatomy. If your vinegar eels are moving about too rapidly for you to see them well, touch the edge of a paper towel to the coverslip to draw off some of the culture solution.

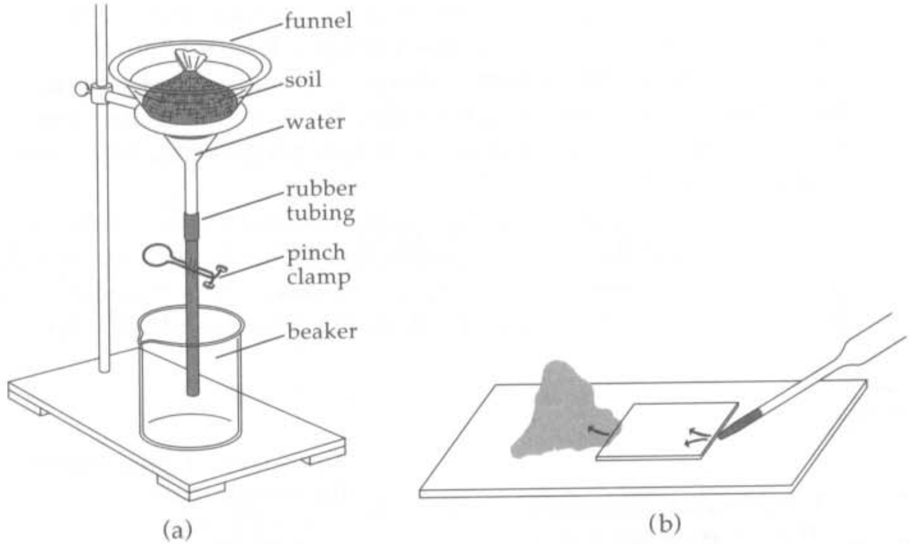


Figure 25C-7 *(a) Apparatus used to collect nematodes in soil samples. (b) Staining a wet mount slide with methylene blue. Place a drop of stain to one side of the coverslip. Apply a small piece of paper towel to the other side (this helps "draw" the stain beneath the coverslip).*

2. Beginning at the anterior (rounded) end of a worm, locate the digestive tract, which begins at a narrow slit, the mouth, and empties immediately into a featherlike pharynx. The remainder of the tract, the **intestine,** begins with a bulbous region and tapers gradually to the posterior. On a separate piece of paper, make a sketch of as much of the internal anatomy as you can see and label the structures you draw.

3. Nematodes are commonly **dioecious**—sexes are separate. Reproductive organs of the female vinegar eel may be visible. Female nematodes have a very prominent elongate **uterus** in their midsection; it may obscure much of your view of the digestive tract. The uterus may contain tiny offspring hatched within it.

   During copulation, male nematodes expel sperm from a posterior opening, the anus, from which they also excrete wastes.

4. Use high power (40×) to examine slides of the parasitic nematode, *Trichinella;* you will see adults and encysted larvae in the muscle tissue of the pig. Like other nematodes, this organism is covered by a thick protective cuticle. *Trichinella* larvae encysted in meat are ingested by a host, either pig or human. Inside the intestine of the host, larvae are released from their cysts (Figure 25C-8a) and develop into adults; they mate and produce more larvae. These larvae invade the body tissues and migrate to the muscles where they encyst. Large infections can produce considerable muscle damage leading to weakness and even death. The disease produced by this infection is called **trichinosis.**

   a. How do the larval forms differ in appearance from adults? ______________________

   b. Why is it important that pork be cooked well, or not eaten rare? ______________________

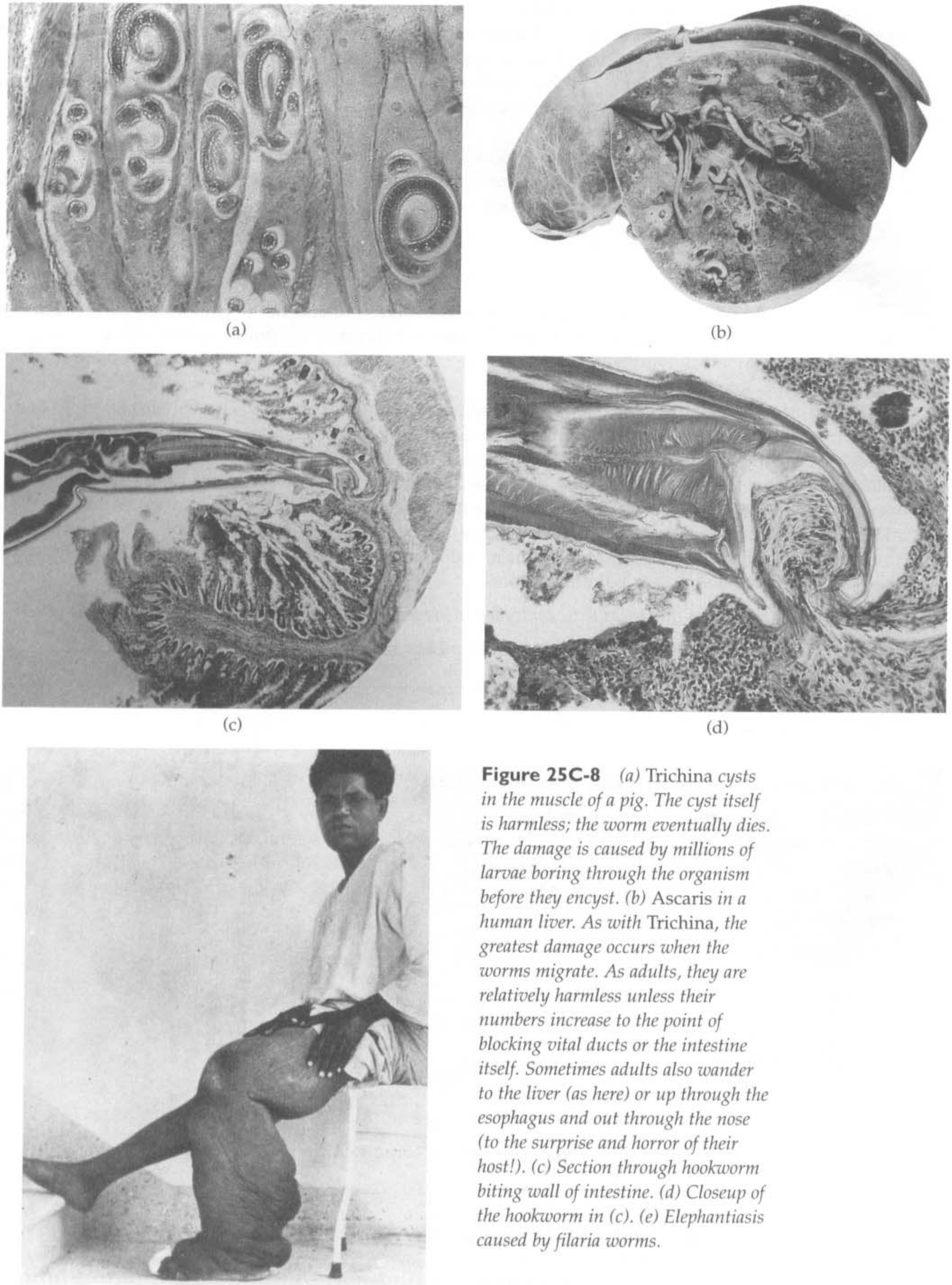
5. On a separate sheet of paper, describe the events that begin with eating infected pork and lead to the harboring of *Trichinella* parasites in muscle tissues. Make a drawing of the life cycle of *Trichinella* to assist you in writing your explanation.

More than 50 different types of roundworms have been found in humans. *Ascaris lumbricoides* live in the intestine and can grow to more than a foot in length (Figure 25C-8b). A female can lay up to 200,000 eggs per day. *Ascaris* eggs are found in human feces.

The worms hatch in the intestine but leave immediately, burrowing through the body to the lungs. From here they work they way up the bronchial tubes to the mouth and are then swallowed back into the stomach and return to the intestine.

c. List several ways in which a human could become infected by Ascaris. ______________________

____



(a)

(b)

(c)

(d)

(e)

Figure 25C-8 *(a)* Trichina *cysts in the muscle of a pig. The cyst itself is harmless; the worm eventually dies. The damage is caused by millions of larvae boring through the organism before they encyst. (b)* Ascaris *in a human liver. As with* Trichina, *the greatest damage occurs when the worms migrate. As adults, they are relatively harmless unless their numbers increase to the point of blocking vital ducts or the intestine itself. Sometimes adults also wander to the liver (as here) or up through the esophagus and out through the nose (to the surprise and horror of their host!). (c) Section through hookworm biting wall of intestine. (d) Closeup of the hookworm in (c). (e) Elephantiasis caused by filaria worms.*

Hookworms attach to the lining of the intestine (Figure 25C-8c, d) and feed on blood and tissue fluids. Eggs pass from the intestine in the feces. Larvae hatching from the eggs burrow into the ground, where they eat and grow until they are capable of infecting other humans. The larvae (0.05 cm) bore through body tissue (usually through bare feet that touch contaminated soil). After entering the skin, the worms take the same path as *Ascaris*. Hookworm infections can be very debilitating, often leading to extreme weakness and stunted growth.

Filaria worms differ from *Ascaris* and hookworms. They require an intermediate host—a mosquito. Filaria live in the lymph glands of their human hosts. Adult females are 3 to 4 inches long. A female gives birth to larvae, microfilaria, that enter the blood vessels.

d. What is the relation of lymph channels to the bloodstream?

____

The larvae, if picked up by a mosquito, can be transferred to another person bitten by the same mosquito. The larvae penetrate the skin near the bite and travel to the lymph nodes where, in large numbers, they may block lymph channels, causing severe swelling of affected body parts (Figure 25C-8e). This condition is known as **elephantiasis.**

The **guinea worm** is perhaps one of the most bizarre human parasites. The female can grow to more than a meter in length but is only 0.5 mm wide. Guinea worms are common in Egypt, Arabia, India, and Africa. The worms coil into a blisterlike formation near the skin's surface. When an infected individual enters cold water, the blister opens and larvae escape. Larvae swim in the water until they find their intermediate host—*Cyclops*, a tiny crustacean about 2 mm long. Larvae develop into adults within the tissues of *Cyclops*. Ingesting *Cyclops* in unfiltered water can then spread the guinea worm to other humans.

Chemicals can be used to treat infections and doctors can extract the worms from blisters by winding them around a needle—a very painful solution.

e. How could infections of this parasite be controlled in areas where water is contaminated? (Note that in some countries, religious beliefs dictate how water is obtained or used.) ____________________

____

EXTENDING YOUR INVESTIGATION: NEMATODE DIVERSITY

One of the richest sources of nematodes, by far, is the soil. It is easy to collect soil nematodes. Do you think different types would be found in different kinds of soil? Do roundworms prefer more acidic or more basic soil? Do you find more roundworms in areas of open soil or in areas covered by vegetation? Formulate a hypothesis to investigate how different environments support different sizes of nematode populations in the soil.

HYPOTHESIS:

NULL HYPOTHESIS:

What do you **predict** you will find if you sample some soil from your local environment?

Identify the **independent variable** in this investigation.

Identify the **dependent variable** in this investigation.

Use the following procedure to test your hypothesis.

PROCEDURE:

1. Set up an apparatus similar to the one shown in Figure 25C-7a.
2. Collect soil and wrap it in a triple layer of cheesecloth to form a small sack. Secure the ends of the cheesecloth together with a rubber band.
3. Place enough water in the funnel to cover the bag of soil. Let stand for 24 hours. The nematodes will crawl into the water and will eventually sink into the neck of the funnel.
4. Obtain a plastic cup or beaker and open the pinch clamp for a few seconds in order to collect a small amount of water.
5. Make a wet-mount slide by using a single drop of water from a Pasteur pipette. *Hint:* You may wish to stain your preparation with methylene blue (see Figure 25C-7b). *Do you see any nematodes?* _______ *How many?* _______ How do they move? _______________
6. Sample at least three drops of water. One milliliter contains approximately 15 drops. How may nematodes/milliliter (mL) are found in your soil sample? Record your results below.

RESULTS: Describe the diversity of nematodes present in your soil sample.

Do your results support your hypothesis?

Your null hypothesis?

Was your prediction correct?

What do you **conclude** about the presence of nematodes in the soil sample you collected?

✓ PART 4 Phylum Annelida: Segmented Worms

Phylum Annelida contains the segmented worms, almost all of which are free-living. Note that we have now reached a branching point in the family tree of animal phyla. The annelids, and all organisms above them in the phylogenetic tree, have true coeloms. The annelid coelom is formed by a splitting of the embryonic mesoderm and is said to be **schizocoelous** (*schizo-* means split). This type of coelom is also found among arthropods and mollusks. Note that these three groups are on the same branch of the phylogenetic tree (Figure 25-I). Organisms on the other side of the branch point are also coelomate, but their coelom is formed by an outpocketing, or evagination, of the primitive gut, or *enteron*. Hence the resulting coelomic cavity is said to be **enterocoelous.** This type of coelom is found among the echinoderms and chordates.

The coelom of annelids is compartmentalized into segments by **septa.** Coelomic fluid within the body cavity acts like a **hydrostatic skeleton** against which muscles work to change body shape. Like nematodes, annelids have a one-way digestive tract with a mouth, anus, and several specialized regions.

A dorsal mass of nerve cells forming a ganglion or "brain" and a ventral nerve cord provide a primitive nervous system. The circulatory system is closed, blood being confined to vessels.

Marine **polychaetes** (sand worms), **oligochaetes** (freshwater annelids and earthworms), and **leeches** are among the most common annelids. There are over 8,700 known species of annelid worms.

The polychaetes (class Polychaeta) make up the largest group of annelids. Most are marine and are an important food source for fish and crustaceans. Polychaetes have **parapodia,** fleshy appendages on the body segments. The polychaetes have well-developed sense organs on their heads, including eyes, antennae, and chemoreceptors. Some polychaetes build tubes to live in. Many of these sedentary forms use tentacles covered with cilia to trap food such as tiny animals and decaying organic matter and transport it to the mouth. Others pump water through their burrows and filter food from the water.

Most leeches (class Hirudinea) live in fresh water. They are parasitic or predaceous, feeding on tissue fluids, blood, or small invertebrates. Leeches lack the setae characteristic of other members of the phylum.

Objectives

- ☐ Explain why annelids are found on a separate branch of a typical phylogenetic tree.
- ☐ Define "coelom" and relate this term to the other five phyla studied during this laboratory.
- ☐ Describe the hydrostatic skeleton of the earthworm.
- ☐ Explain how the circular and longitudinal muscle layers surrounding the earthworm gut allow the organism to move.

Procedure

1. Study the anterior end of a living or preserved earthworm, class Oligochaeta. The first part of the worm is the **prostomium.** It is above and anterior to the mouth. The terminal end of the worm, bearing the anus, is the **pygidium.** Find the mouth, a crescent-shaped opening partly covered by the prostomium, and the anus, an oval opening in the posterior extremity of the last segment. A glandular area, the **clitellum,** is located near the anterior end of the worm. It is formed from several swollen segments and secretes mucus for copulation and cocoon formation.

2. Note that the surface of the body is distinctly marked by transverse grooves that encircle it. These grooves divide the body into **segments.**

a. Do the segmental grooves completely encircle the body in every region of the earthworm?

____

b. How many segments are present in the specimen you observed? ____________________

Do all earthworms have the same number of segments? ____________________

The body is covered by the **cuticle,** a delicate, iridescent, nonliving membrane secreted by the epidermis. The cuticle contains numerous pores that provide an exit for the mucus secreted by underlying cells. The mucus spreads over the entire surface of the cuticle and provides the proper conditions for respiration through the cuticle.

Every segment except the first and last is provided with four pairs of chitinous bristles called **setae** that are used for locomotion. Pass your finger back and forth on the ventral and lateral surfaces of the specimen. You should be able to feel the setae projecting from the surface.

With a sharp scalpel and a fine pair of scissors, carefully cut open the earthworm lengthwise along the dorsal surface. Pin the body wall to the dissection pan or board. Observe that the body wall is separated from the intestine, the central dark tube in the posterior part of the body, by a space, the **coelom.** Refer to Figure 25C-9 and identify and study the following parts.

Prostomium The most anterior segment is incomplete and lies in front of the mouth, which opens beneath it into the first segment of the body.

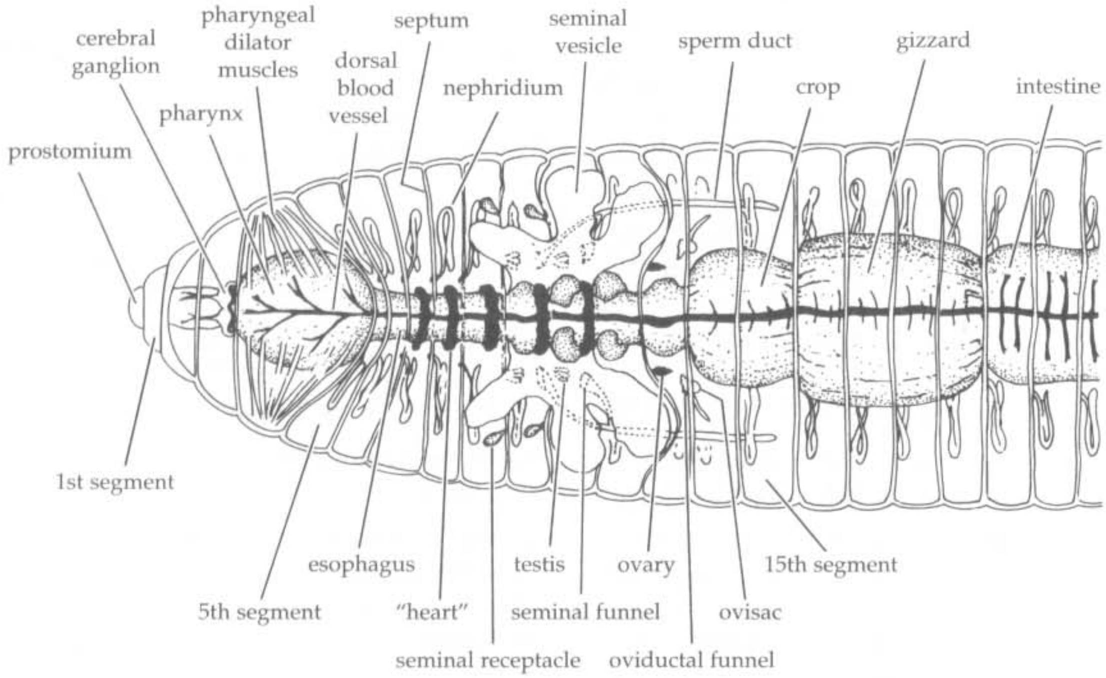


Figure 25C-9 *Internal structures of the earthworm (dorsal view). (After Robert D. Barnes,* Invertebrate Zoology, *6/e, p. 559, Saunders, Philadelphia, 1986.)*

Pharynx Find this portion of the digestive tube in segments 1 through 6. The anterior part, the buccal pouch or mouth cavity, occupies the first two segments. The pharynx acts as a suction pump to ingest loose soil when dilator muscle fibers attached to the body wall contract and expand the pharynx. Subsequently, when the mouth is closed, the muscular walls of the pharynx contract and force the contents posteriorly.

Cerebral ganglion Look for a small whitish, bilobed structure, the so-called brain (cerebral ganglion), embedded in the muscle tissue on the dorsal anterior surface of the pharynx. Locate the ventral nerve cord running beneath the gut. It is attached to the cerebral ganglion by a pair of connections encircling the esophagus.

Esophagus Observe this thin-walled narrow channel that extends from the pharynx to segment 13 or 14. Most of the esophagus is hidden by the overlying seminal vesicles and aortic loops.

Crop and **gizzard** These expanded portions of the food tube lie in segments 14 through 20, just posterior to the seminal vesicles. The gizzard, located posterior to the crop, is more muscular. Food accumulated in the crop is passed to the gizzard to be ground with the help of sand and soil particles.

Intestine The remainder of the digestive tract, fairly uniform in appearance, is the intestine.

Seminal vesicles You will find these prominent whitish bodies in segments 9 through 13. Earthworms are hermaphroditic; however, copulation, with mutual transfer of sperm, is the characteristic method of reproduction. Two worms align with their ventral surfaces opposed and with their anterior ends facing opposite directions. The worms are held together by mucus secreted by the **clitellum,** a reproductive region consisting of five or six segments beginning at about segment 32 in *Lumbricus,* and sometimes by special genital setae. Sperm, released from the genital pores, pass down a pair of grooves on the ventral surface and enter the seminal receptacles of the other worm (the grooves are covered over with mucus, thus keeping the sperm from the two worms separate). Copulation takes 2 to 3 hours.

A few days after copulation, the clitellum secretes a dense cocoon material. Albumin is also secreted inside the cocoon. The secretions form a band which encircles the body and eventually begins to slip forward. Eggs from the female genital pores and sperm from the seminal receptacles are deposited inside the cocoon as it slips toward the anterior end, where the open ends seal as it is shed. Fertilization and development take place within the cocoon.

Dorsal blood vessel Identify the very fine, dark, reddish-brown tube that runs longitudinally along the mid-dorsal line of the intestine. Follow it anteriorly. In the region of the seminal vesicles, partially concealed, it gives rise to five large lateral branches, the aortic loops ("hearts") that encircle the digestive tract and attach to the ventral blood vessel. Blood moves anteriorly in the pulsating dorsal vessel and posteriorly in the ventral vessel. In the earthworm, hemoglobin is dissolved in the circulating blood. Three of the four blood pigments found in metazoan animals are present in the phylum Annelida.

3. Study a prepared slide of a cross section of the earthworm. Use low power (10×) to locate each of the following structures and label them on Figure 25C-10.

a **Intestine** The horseshoe-shaped space at the center of the section is the cavity (lumen) of the intestine. The dark-staining tissue surrounding the lumen contains gut-epithelial cells, which absorb food molecules from the gut. Locate the dorsal fold in the intestine or **b** **typhlosole,** which increases the surface area for digestion and the uptake of the products of digestion.

c **Muscle tissue** Two thin bands of muscle tissue surround the gut and are associated with the movement of food through the gut. These are of mesodermal origin.

d **Chlorogen tissue** Special digestive cells (lighter staining cells around the intestine), performing some of the functions carried out by the liver of higher organisms, including the storage of glycogen and fat, the synthesis of urea, and the removal of silicates.

e **Coelom** The large space bordering the digestive tract, lined by a sheet of mesoderm called the peritoneum. The fluid-filled space is called a **hydrocoel.**

f **Nerve cord** Flattened, oval structure in the interior of the coelom. Recall from your dissection that it is a ventral nerve cord.

g **Blood vessels** One or two large blood vessels should be apparent next to the nerve cord. A fairly large dorsal vessel can be seen above the intestine. Anteriorly, this vessel gives rise to several stout lateral loops ("hearts") that encircle the intestine.

h **Nephridium** Inside each coelomic segment is a pair of excretory organs, the nephridia. Open ciliated funnels on the end of the nephridia filter the coelomic fluid and then carry it to the outside through excretory pores in the next most posterior segment. During the passage of fluid through these ducts, water can be reabsorbed and the contents modified as in the kidney tubule of vertebrates.

i **Longitudinal** and **j** **circular muscle bands** Two bands of muscular tissue are located on the inside of the body wall. Increase the magnification to observe the muscle arrangement in greater detail. Identify the longitudinal bundles and circular bands of muscle tissue. Because the earthworm is segmented—its body is made up of a number of separate sections or compartments—the contraction of these muscles, acting in concert with the supporting hydrocoel present in each segment, can produce local movements that are quite different from the "lashing" activities of the vinegar eel. In general, contraction of the longitudinal muscles shortens (or bends) the worm while contraction of the circular muscles lengthens it. However, one part of the earthworm may be shortening or remain immobile while another part is lengthening. If live worms are available, observe their movements.

k **Epidermis** Thin tissue surrounding the muscles. It secretes the **l** **cuticle** (body covering) and the slime trail upon which the earthworm glides. Respiration occurs by diffusion of gases through the epidermis.

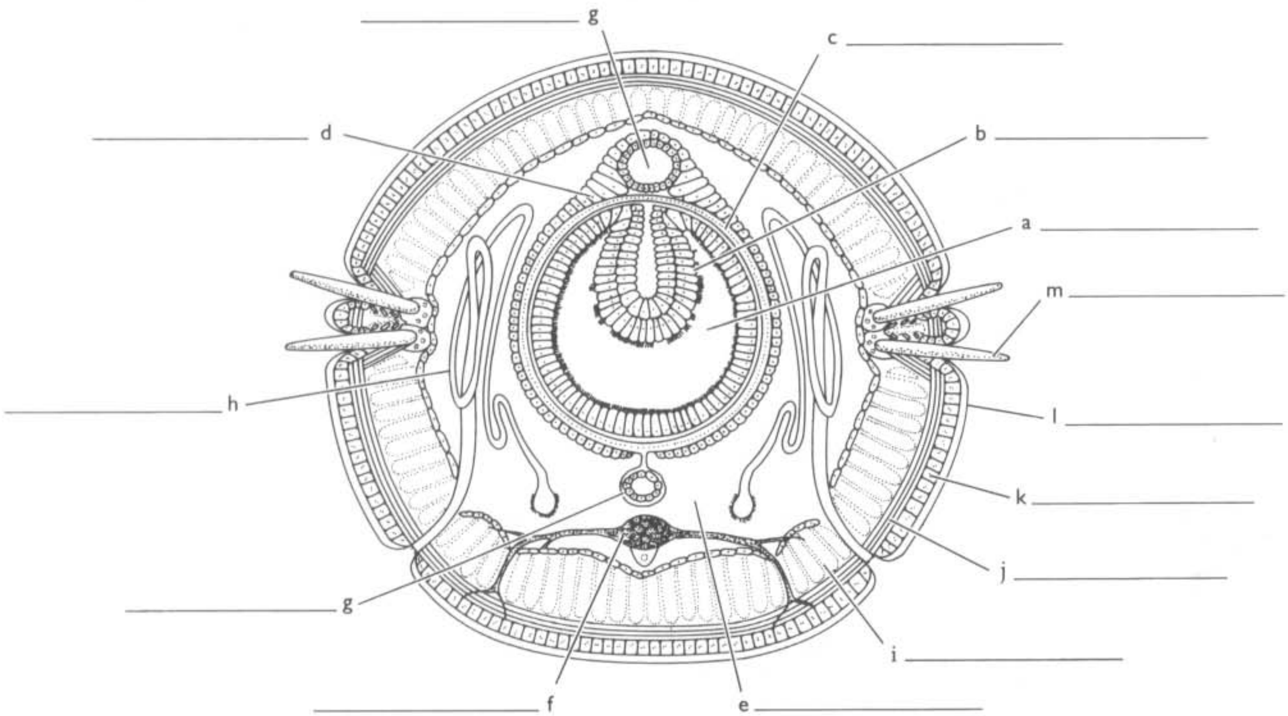


Figure 25C-10 *Label the structures visible in the earthworm cross section.*

m Seta Setae may be present in pairs as short stalks penetrating the integument. They are used to anchor one part of the worm's body while it moves another part forward.

c. What does the coelom of a living earthworm contain? ______________________

d. What is the function of its coelom? ______________________________________

4. Look at the preserved and live specimens of other representative annelids on demonstration.

Laboratory Review Questions and Problems

1. Define each of the following terms and describe how each is related to the others: Metazoa, Parazoa, Eumetazoa, and Protozoa.

2. Summarize your observations of the Cnidaria and Ctenophora by completing the following table.

	Hydrozoans	Scyphozoans	Anthozoans	Ctenophorans
Polyp or medusa as predominant form				
Presence or absence of cnidocytes				
Distinguishing characteristics				
Examples				

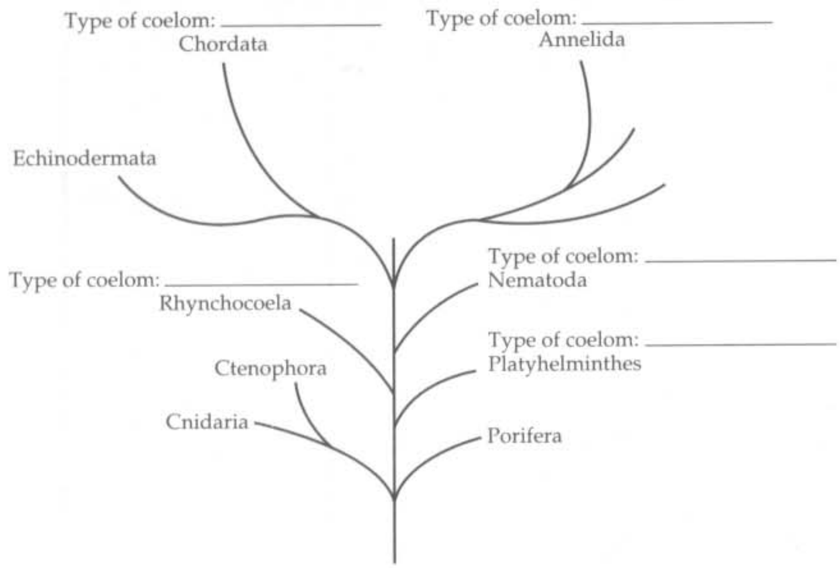
3. Why is the phylum of organisms containing hydrozoans, jellyfishes, corals, and sea anemones named Cnidaria?

4. What type of symmetry is characteristic of the ctenophores? Do they possess nematocysts like the Cnidaria?

5. Describe the type of symmetry and the type of body cavity in the phylum Platyhelminthes.

6. How does the function of protonephridia in ribbon worms and flatworms differ? How does the structure of the digestive tract in these two groups of organisms differ?

7. Fill in the "family tree" below to clarify your understanding of how coelom type is used to classify animals. Draw a line to divide the true coelomates from the other organisms.



8. How are the coeloms of flatworms, ribbon worms, roundworms, and segmented worms constructed? How does this relate to the way in which the family tree of animals is constructed (see Figure 25-I)?

9. The organization of body tissues into layers allows us to distinguish between the parazoans and the eumetazoans that are diploblastic and triploblastic. On the family tree in question 7, draw circles around the groups of organisms that have the same number of tissue layers. Indicate how many tissue layers each group has, using the correct terms.

10. Symmetry differs among organisms. Draw a line on the tree in question 7 to separate asymmetrical animals from bilateral animals.

11. From your answers to previous questions and from your textbook reading, fill in the following summary table. Compare the characteristics of the major phyla you have studied and identify any evolutionary trends.

	Porifera	Cnidaria	Platyhelminthes	Nematoda	Annelida	Evolutionary Trend
Number of tissue layers						
Type of digestive cavity						
Type of coelom (if present)						
Type of reproduction (sexual/asexual)						
Larva (if discussed)						
Nervous system (form and location)						
Type of circulation (open or closed)						
Type of excretory organs (structure; osmoregulatory or excretory functions)						
Type of symmetry						