Lab Topic 17

Animal Diversity I

Laboratory Objectives

After completing this lab topic, you should be able to:

1. Compare the anatomy of the representative animals, describing similarities and differences in organs and body form that allow the animal to carry out body functions.
2. Discuss the impact of molecular studies on traditional phylogenetic trees.
3. Discuss the relationship between body form and the lifestyle or niche of the organism.

For a 2-hour lab: You may choose to extend the two 3-hour labs to three 2-hour labs. If this is not possible, omit the sponge and clamworm.

Introduction

Animals are classified in the domain **Eukarya,** kingdom **Animalia.** They are multicellular organisms and are **heterotrophic,** meaning that they obtain food by ingesting other organisms or their by-products. Careful study of comparative anatomy, embryology, and most recently, genetic and molecular data, reveals many similarities in structure and development. Collectively, this evidence implies an ancestral evolutionary relationship among all animals. Animals are thought to have arisen about 565 million years ago, with most body forms appearing by the end of the Cambrian period (see Figure 15.3). Scientists recognize over 35 major groups of present-day animals based on differences in body architecture. In this and the following lab topic, you will investigate body form and function in examples of nine major groups of animals. You will use these investigations to ask and answer questions comparing general features of morphology and relating these features to the lifestyle of each animal.

Since the beginning of the scientific study of animals, scientists have attempted to sort and group closely related organisms. Taxonomists have divided the animal kingdom into two major groups: **Parazoa,** which includes the sponges, and **Eumetazoa,** which includes all other animals. This division is made because the body form of sponges is so different from that of other animals that most biologists think that sponges are not closely related to any other animal groups.

Animals in Eumetazoa (multicular animals) differ in physical characteristics, such as symmetry which may be **radial** (parts arranged around a central axis), or **bilateral** (right and left halves are mirror images). Other differences include the type of body cavity (coelom) and such basic embryological differences as the number of germ layers present in the embryo and

the embryonic development of the digestive tract. Some animals have a saclike body form with only one opening into a digestive cavity. Others have two outer openings, a mouth and an anus, and the digestive tract forms essentially a "tube within a tube." Those animals that are bilaterally symmetrical are divided into two major groups, depending on differences in early development and the origin of the mouth and the anus. An embryonic structure, the blastopore, develops into a mouth in the **protostomes** and into an anus in the **deuterostomes.**

In the study of the protists in Lab Topic 14, you learned that "traditional" phylogenetic trees have been challenged by the results of molecular studies, particularly evidence from ribosomal RNA (rRNA). This is true not only for protists, but also for animals. Particularly in the protostomes, molecular studies have led to a regrouping of many traditionally established phylogenetic relationships. For example, for over 200 years zoology publications have assumed that annelids (segmented worms in the phylum Annelida) and arthropods (e.g., insects) are closely related based on their segmented bodies. Zoologists also noted, however, that annelids have developmental patterns similar to several groups that are not segmented. For example, annelids are like molluscs (e.g., clams) in having a developmental stage called the "trochophore larva." Recent rRNA evidence helps to clarify this puzzle as it supports the hypothesis that annelids and molluscs are closely related, and separate from arthropods.

Molecular studies have led taxonomists to create two large groups within the protostomes, **Lophotrochozoa** and **Ecdysozoa.** Annelids, molluscs, and several more phyla not studied here are placed in the group or clade Lophotrochozoa. The name reflects the trochophore larvae found in annelids and molluscs. Also included in this clade are flatworms (phylum Platyhelminthes). Although flatworms lack such characteristics as a body cavity, the "tube-within-a-tube" body plan with mouth and anus, and elaborate internal organs, their rRNA indicates that they should be grouped with annelids and molluscs in the Lophotrochozoa clade. Ecdysozoa includes the roundworms or nematodes (phylum Nematoda), arthropods (phylum Arthropoda), and several other phyla. Animals in Ecdysozoa undergo molting (ecdysis) or the shedding of an outer body cover. In nematodes this covering is called the **cuticle.** In arthropods the covering is the **exoskeleton.**

Another surprising result of rRNA evidence is that the nature of the body cavity may not be a characteristic that indicates major phylogenetic branching. In traditional phylogenetic groupings, flatworms and nematodes were considered primitive, neither group having a true coelom. Ribosomal evidence has now moved nematodes to a different position with arthropods in the metazoan tree.

Figure 17.1a is a diagram showing organisms studied in Lab Topics 17 and 18 classified in the *traditional* organization of animal phylogeny. This phylogeny is based on *morphology* and *development.* Figure 17.1b is a diagram showing the *new molecular-based* phylogeny. The order of animals studied in Lab Topics 17 and 18 is based on Figure 17.1b, the molecular-based phylogeny. However, as you study the animals, note those morphological characteristics that were the basis of the traditional system of classification. These characteristics may give evidence of the influence of ecological events in the development of different morphologies. Be ready to discuss how these similarities or differences may have arisen secondarily or through secondary simplifications.

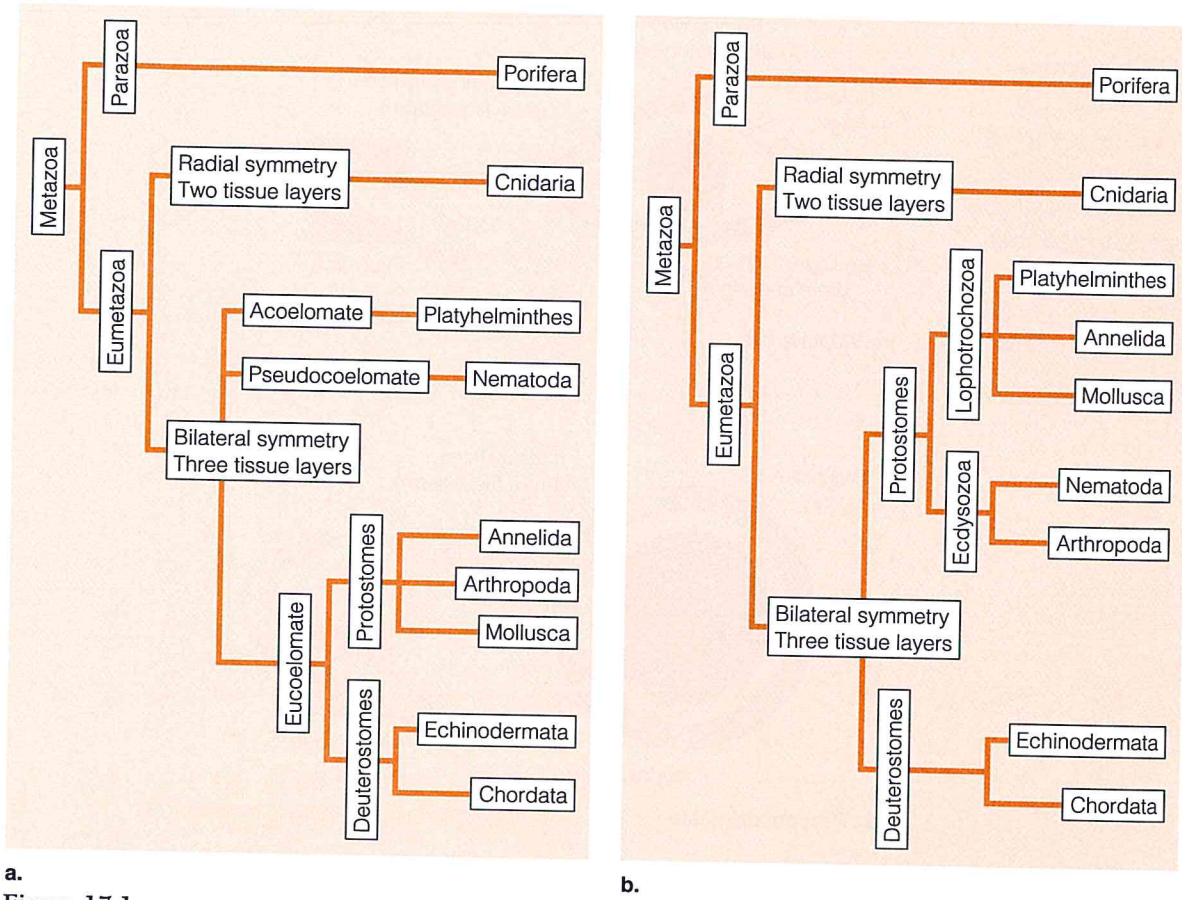


Figure 17.1.
Organization of animal phylogeny. (a) A traditional phylogeny based on morphology and embryology. (b) Proposed phylogeny based on new molecular evidence. Protostomes are grouped in Lophotrochozoa or Ecdysozoa.

Much work remains to resolve the branching order within the lophotrochozoan and ecdysozoan clades. Evidence is being collected from other studies such as gene sequencing (e.g., HOX genes—see your text). Thus far, these data are supporting the proposed groupings based on rRNA.

The animals you will study in Lab Topic 17 are the sponge, hydra, planarian, clamworm, earthworm, and clam (mussel). In Lab Topic 18, you will study the roundworm, crayfish, grasshopper, sea star, amphioxus (lancelet), and pig. As you study each animal, relate your observations to the unifying themes of this lab: *phylogenetic relationships* and criteria that are the basis for animal classification, the *relationship between form and function*, and the *relationship of the environment and lifestyle to form and function*. The questions at the end of the lab topics will help you do this.

In your comparative study of these organisms, you will investigate 13 characteristics. Before you begin the dissections, become familiar with the following characteristics and their descriptions:

1. *Symmetry.* Is the animal (a) radially symmetrical (parts arranged around a central axis), (b) bilaterally symmetrical (right and left halves are mirror images), or (c) asymmetrical (no apparent symmetry)?
2. *Tissue organization.* Are cells organized into well-defined tissue layers (structural and functional units)? How many distinctive layers are present?

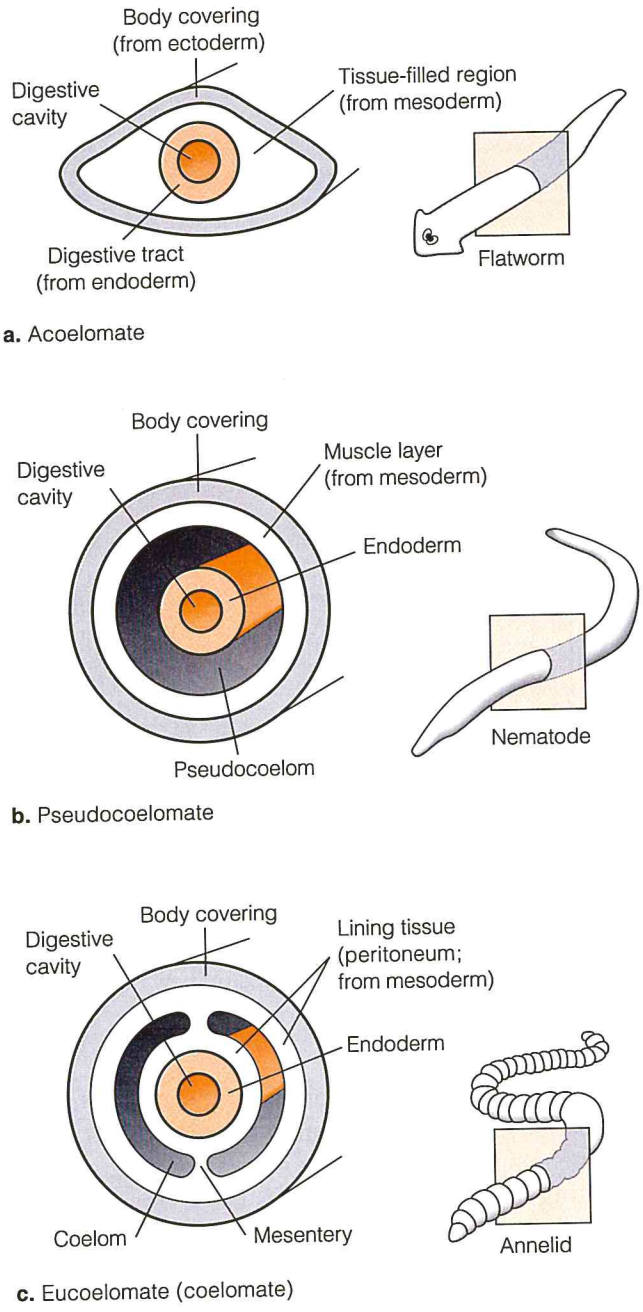


Figure 17.2.
Three types of body cavities.
(a) In acoelomate animals, the mesoderm fills the space where a cavity might be. (b) In pseudocoelomate animals, the body cavity lies between tissues derived from endoderm and mesoderm.
(c) In eucoelomate (coelomate) animals, the body cavity is lined with mesoderm.

3. *Body cavity.* Is a body cavity present? A body cavity—the space between the gut and body wall—is present only in three-layered organisms, that is, in organisms with the embryonic germ layers ectoderm, mesoderm, and endoderm. There are three types of body forms related to the presence of a body cavity and its type (Figure 17.2).
   a. Acoelomate, three-layered bodies without a body cavity. Tissue from the mesoderm fills the space where a cavity might be; therefore, the tissue layers closely pack on one another.
   b. Pseudocoelomate, three-layered bodies with a cavity between the endoderm (gut) and mesoderm (muscle).
   c. Eucoelomate (coelomate), three-layered bodies with the coelom, or cavity, *within* the mesoderm (completely surrounded by mesoderm).

In coelomate organisms, mesodermal membranes suspend the gut within the body cavity.

4. *Openings into the digestive tract.* Can you detect where food enters the body and digestive waste exits the body? Some animals have only one opening, which serves as both a mouth and an anus. Others have a body called a "tube within a tube," with an anterior mouth and a posterior anus.
5. *Circulatory system.* Does this animal have open circulation (the blood flows through coelomic spaces in the tissue as well as in blood vessels), or does it have closed circulation (the blood flows entirely through vessels)?
6. *Habitat.* Is the animal terrestrial (lives on land) or aquatic (lives in water)? Aquatic animals may live in marine (sea) or fresh water.
7. *Organs for respiration (gas exchange).* Can you detect the surface where oxygen enters the body and carbon dioxide leaves the body? Many animals use their skin for respiration. Others have special organs, including gills in aquatic organisms and lungs in terrestrial organisms. Insects have a unique system for respiration, using structures called *spiracles* and *tracheae.*
8. *Organs for excretion.* How does the animal rid its body of nitrogenous waste? In many animals, these wastes pass out of the body through the skin by diffusion. In others, there are specialized structures, such as Malpighian tubules, lateral excretory canals, lateral canals with flame cells, structures called *nephridia,* and kidneys.
9. *Type of locomotion.* Does the organism swim, crawl on its belly, walk on legs, burrow in the substrate, or fly? Does it use cellular structures, such as cilia, to glide its body over the substrate?
10. *Support systems.* Is there a skeleton present? Is it an endoskeleton (inside the epidermis or skin of the animal), or is it an exoskeleton (outside the body wall)? Animals with no true skeleton can be supported by water: Fluid within and between cells and in body chambers such as a gastrovascular cavity or coelom provides a "hydrostatic skeleton."
11. *Segmentation.* Can you observe linear repetition of similar body parts? The repetition of similar units, or segments, is called *segmentation.* Segments can be more similar (as in the earthworm) or less similar (as in a lobster). Can you observe any degree of segmentation? Have various segments become modified for different functions?
12. *Appendages.* Are there appendages (organs or parts attached to a trunk or outer body wall)? Are these appendages all along the length of the body, or are they restricted to one area? Are they all similar, or are they modified for different functions?
13. *Type of nervous system.* Do you see a brain and nerve cord? Is there more than one nerve cord? What is the location of the nerve cord(s)? Are sensory organs or structures present? Where and how many? What purpose do such structures serve (for example, eyes for light detection)?

As you carefully study or dissect each organism, refer to these thirteen characteristics, observe the animal, and record your observations in the summary table, Table 18.1, pp. 498–499. You may find it helpful to make sketches of difficult structures or dissections in the margin of your lab manual for future reference.

Before you begin this study, read Appendix C and become thoroughly familiar with dissection techniques, orientation terms, and planes and sections of the body.

Wear gloves while dissecting preserved animals.

EXERCISE 17.1

Phylum Porifera—Sponges (*Scypha*)

Materials

dissecting needle
compound microscope
stereoscopic microscope
preserved and dry bath sponges
prepared slide of *Scypha* in longitudinal section
preserved *Scypha* in watch glass

Scypha is the form most often studied in America. A European genus, Grantia, *is similar and can be substituted. You might substitute the small, common sponge* Leucosolenia. *It grows in a branching colony, whereas* Scypha *vases are unbranched. Also, the body form of* Leucosolenia *differs from that of* Scypha.

Using living materials rather than preserved ones throughout both Animal Diversity lab topics will enhance the learning experiences of your students. Check with local businesses (bait suppliers, pet stores, farmers' markets) about the availability of living specimens.

Introduction

Sponges are classified in a separate group, Parazoa, because of their unique body form. You will observe the unique sponge structure by observing first a preserved specimen and then a prepared slide of a section taken through the longitudinal axis of the marine sponge *Scypha* (Color Plate 50). You will observe other more complex and diverse sponges on demonstration.

Procedure

1. Obtain the preserved sponge *Scypha* and observe its external characteristics using the stereoscopic microscope, comparing your observations with Figure 17.3a.
   a. Note the vaselike shape of the sponge and the **osculum,** a large opening to the body at one end. The end opposite the osculum attaches the animal to the substrate.
   b. Note the invaginations in the body wall, which form numerous folds and channels. You may be able to observe needlelike **spicules** around the osculum and protruding from the surface of the body. These spicules are made of calcium carbonate: They give support and protection to the sponge body and prevent small animals from entering the sponge's internal cavity.
2. Using the compound microscope, examine a prepared slide of a sponge body in longitudinal section and compare it with Figure 17.3b.
   a. Again, locate the osculum. This structure is not a mouth, as its name implies, but an opening used as an outlet for the current of water passing through the body wall and the **central cavity,** or **spongocoel.** The water enters the central cavity from channels and pores in the body. The central cavity is not a digestive tube or body cavity, but is only a channel for water.

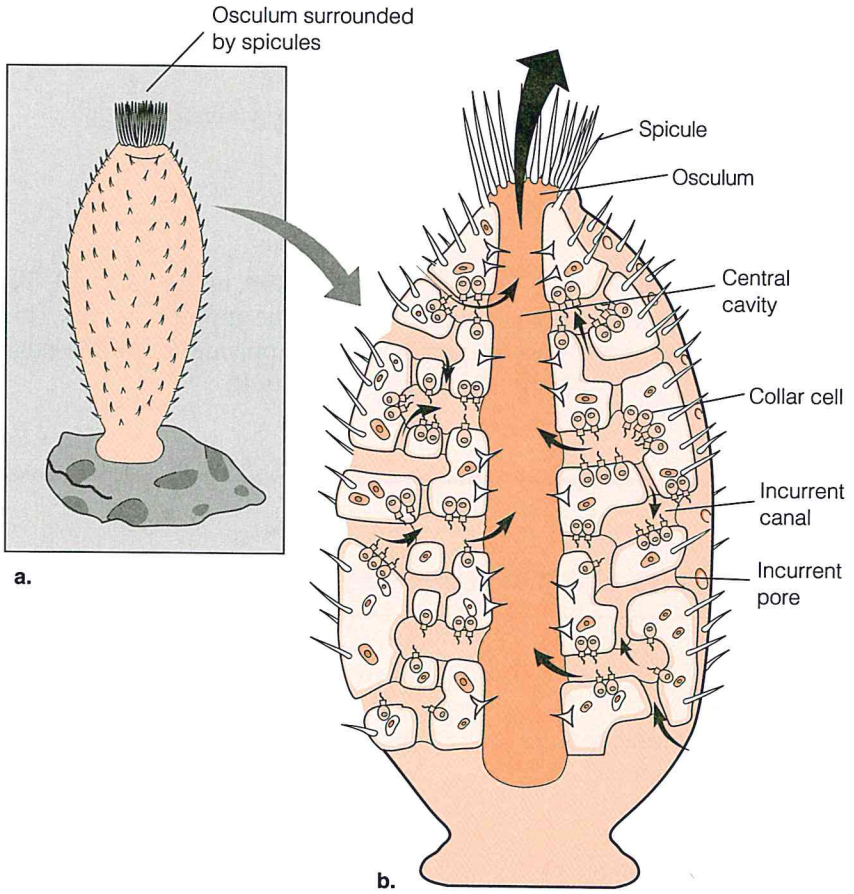


Figure 17.3.
The sponge *Scypha.* (a) The entire sponge; (b) a longitudinal section through the sponge.

b. Note the structure of the body wall. Are cells organized into definite tissue layers, or are they best described as a loose organization of various cell types? Various cells in the body wall carry out the functions of digestion, contractility, secretion of the spicules, and reproduction (some cells develop into sperm and eggs). One cell type unique to sponges is the **choanocyte,** or **collar cell.** These cells line the central cavity and the channels leading into it. Each collar cell has a flagellum extending from its surface. The collective beating of all flagella moves water through the sponge body. Small food particles taken up and digested by collar cells are one major source of nutrition for the sponge. How would you hypothesize about the movement of oxygen and waste throughout the sponge body and into and out of cells?

Oxygen and waste exchange takes place by diffusion directly between cells and the surrounding water.

3. Observe examples of more complex sponges on demonstration. (See Color Plate 51.) The body of these sponges, sometimes called "bath sponges," contains a complex series of large and small canals and chambers. The same cells that were described in *Scypha* are present in bath sponges, but, in addition to spicules, there is supportive material that consists of a soft proteinaceous substance called **spongin.** These sponges often grow to fit the shape of the space where they live, and observing

them gives you a good clue about the symmetry of the sponge body. How would you describe it?

Students should conclude that the sponge has no symmetry, neither radial nor bilateral.

Results

Complete the summary table, Table 18.1, pp. 498–499, in Lab Topic 18, filling in all information for sponge characteristics in the appropriate row. This information will be used to answer questions in the Applying Your Knowledge section at the end of Lab Topic 18, Animal Diversity II.

EXERCISE 17.2
Phylum Cnidaria—Hydras (*Hydra*)

Materials

stereoscopic microscope
compound microscope
living *Hydra* culture
water flea culture
dropper bottles of water, 1% acetic acid, and methylene blue
prepared slide of *Hydra* sections
watch glass
depression slide
pipettes and bulbs
microscope slide and coverslip

Introduction

Cnidarians are a diverse group of organisms, all of which have a **tissue grade** of organization, meaning that tissues, but no complex organs, are present. Included in this group are corals, jellies, sea anemones, and Portuguese men-of-war. Most species are marine; however, there are a few freshwater species. Two body forms are present in the life cycle of many of these animals—an umbrella-like, free-swimming stage, and a cylindrical, attached or stationary form. The stationary forms often grow into colonies of individuals. In this exercise you will observe some of the unique features of this group by observing the solitary, freshwater organism *Hydra* (Color Plate 52).

Procedure

Alice Lindahl (Utah State U.) suggests using the colonial brackish water hydroid Cordylophora lacustris *in place of hydra. This species is easy to maintain in culture. See the Preparation Guide.*

1. Place several drops of freshwater pond or culture water in a watch glass or depression slide. Use a dropper to obtain a living hydra from the class culture, and place the hydra in the drop of water. Using a stereoscopic microscope, observe the hydra structure and compare it with Figure 17.4a. Note any movement, the symmetry, and any body structures present. Note the **tentacles** that surround the "mouth," the only opening into the central cavity. Tentacles are used in capturing food and in performing a certain type of locomotion, much like a "handspring." To accomplish this motion, the hydra attaches its tentacles to the substrate and flips the basal portion of its body completely over, reattaching the base to a new position. If water fleas (*Daphnia*) are available, place one or two near the tentacles of the hydra and note the hydra's behavior. Set aside the hydra in the depression slide and return to it in a few moments.

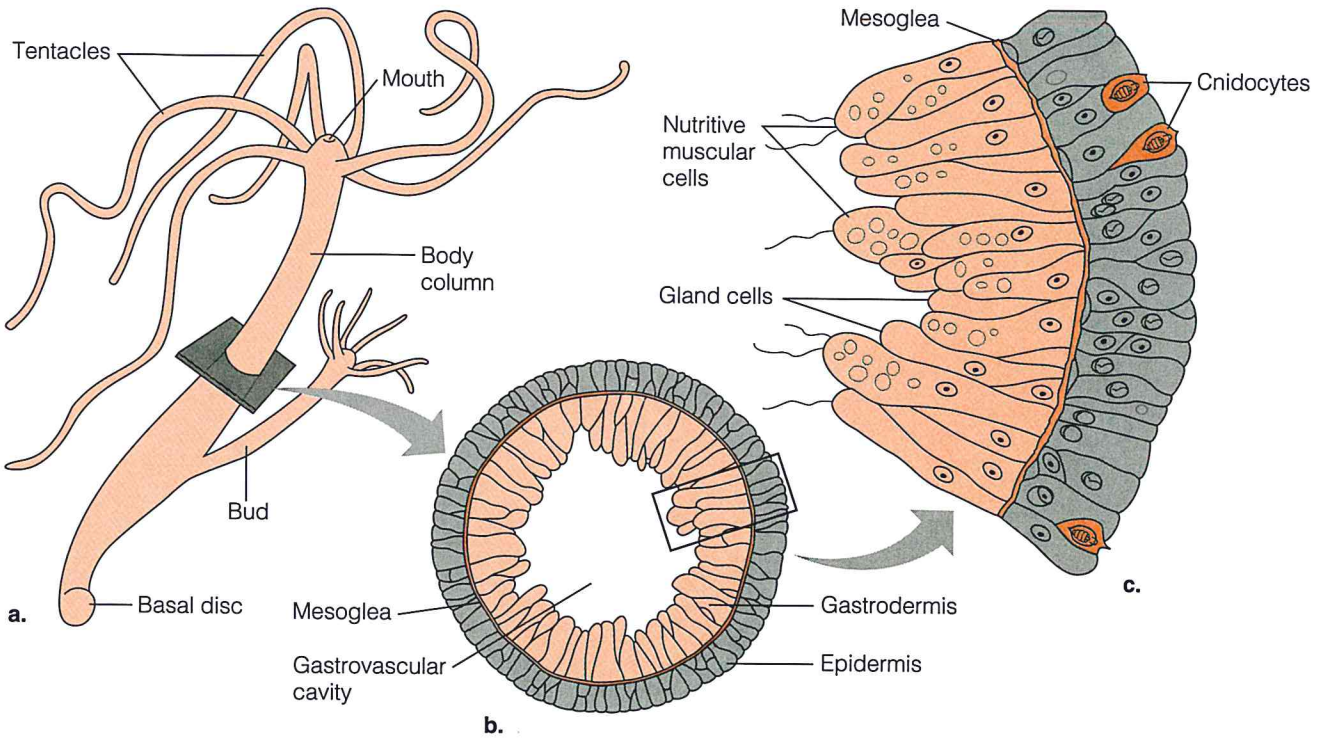


Figure 17.4.
Hydra. (a) A whole mount of *Hydra;* (b) enlargement showing a cross section through the body wall, revealing two tissue layers; and (c) further enlargement showing details of specialized cells in the body wall, including cnidocytes.

2. Study a prepared slide of *Hydra* sections using the compound microscope and compare your observations with Figure 17.4b and c.

   Are definite tissue layers present? If so, how many?

   Yes, two; mesoglea is not cellular.

   Given what you know of embryology, what embryonic layers would you guess give rise to the tissue layers of this animal's body?

   ectoderm and endoderm

3. Not visible with the microscope is a network of nerve cells in the body wall, which serves as the nervous system. There is no concentration of nerve cells into any kind of brain or nerve cord.
4. Observe the central cavity, called a **gastrovascular cavity.** Digestion begins in this water-filled cavity (**extracellular digestion**), but many food particles are drawn into cells in the **gastrodermis** lining the cavity, where **intracellular digestion** occurs.
5. Do you see signs of a skeleton or supportive system? How do you think the body is supported? Are appendages present?

   There is no supportive skeleton; the animal's body is supported by water in the tissues and in the gastrovascular cavity.

   If you define an appendage as any extension from the axial trunk, then the tentacles may be called appendages.

6. Recalling the whole organism and observing this cross section, are organs for gas exchange present? How is gas exchange accomplished?

   No organs exist for gas exchange, which takes place between cells and the surrounding water.

7. Do you see any organs for excretion?

   There are no special organs for excretion; waste diffuses directly out of cells into the surrounding water.

8. Are specialized cell types seen in the layers of tissues?

   a few

   Cnidarians have a unique cell type called **cnidocytes,** which contain a stinging organelle called a **nematocyst.** When stimulated, the nematocyst will evert from the cnidocyte with explosive force, trapping food or stinging predators. Look for these cells.

9. To better observe cnidocytes and nematocysts, turn your attention again to your living hydra and follow this procedure:
   a. Using a pipette, transfer the hydra to a drop of water on a microscope slide and carefully add a coverslip.
   b. Use your microscope to examine the hydra, first on low, then intermediate, and finally on high powers, focusing primarily on the tentacles. The cnidocytes will appear as swellings. If your microscope is equipped with phase contrast, switch to phase. Alternatively, add a drop of methylene blue to the edge of the coverslip. Locate several cnidocytes with nematocysts coiled inside.
   c. Add a drop of 1% acetic acid to the edge of the coverslip and, watching carefully using intermediate power, observe the rapid discharge of the nematocyst from the cnidocyte.
   d. Using high power, study the discharged nematocysts that will appear as long threads, often with large spines, or barbs, at the base of the thread.

Results

Complete the summary table, Table 18.1, recording all information for *Hydra* characteristics in the appropriate row. You will use this information to answer questions in the Applying Your Knowledge section at the end of Lab Topic 18, Animal Diversity II.

Discussion

What major differences have you detected between *Scypha* and *Hydra* body forms? List and describe them.

Scypha—*no symmetry, no tissue layers;* Hydra—*radial symmetry, two tissue layers*

EXERCISE 17.3
Phylum Platyhelminthes—Planarians (*Dugesia*)

Materials

stereoscopic microscope
compound microscope
living planarian
watch glass
prepared slide of whole mount of planarian
prepared slide of planarian cross sections

Introduction

The phylum Platyhelminthes (clade Lophotrochozoa) includes planarians, free-living flatworms; that is, they are not parasitic and their body is dorsoventrally flattened. They are found under rocks, leaves, and debris in freshwater ponds and creeks. They move over these surfaces using a combination of muscles in their body wall and cilia on their ventral sides (Color Plate 53).

Procedure

1. Add a dropperful of pond or culture water to a watch glass. Use a dropper to obtain a living planarian from the class culture. Using your stereoscopic microscope, observe the planarian. Describe its locomotion. Is it directional? What is the position of its head? Does its body appear to contract?

   Locomotion is directional with the head at the anterior end, slightly raised, usually turning from side to side. The body contracts in rhythmic muscular waves. The gliding motion may lead students to suggest that this comes about by the cilia on its ventral surface.

   As you observe the living planarian, you will see two striking new features with regard to symmetry that you did not see in the two phyla previously studied. What are they?

   (1) bilateral symmetry and (2) anterior/posterior axis with a head present (cephalization)

2. Add a *small* piece of fresh liver to the water near the planarian. The planarian may approach the liver and begin to feed by extending a long tubular **pharynx** out of the **mouth,** a circular opening on the ventral side of the body. If the planarian feeds, it will curve its body over the liver and extend the pharynx, which may be visible in the stereoscopic microscope.

   Keep a supply of liver in the freezer and dispense small pieces in watch glasses as needed.

   After observing the planarian's feeding behavior, return it to the culture dish, if possible, without the liver.

3. Using the lowest power on the compound microscope, observe the prepared slide of a whole planarian and compare it with Figure 17.5.

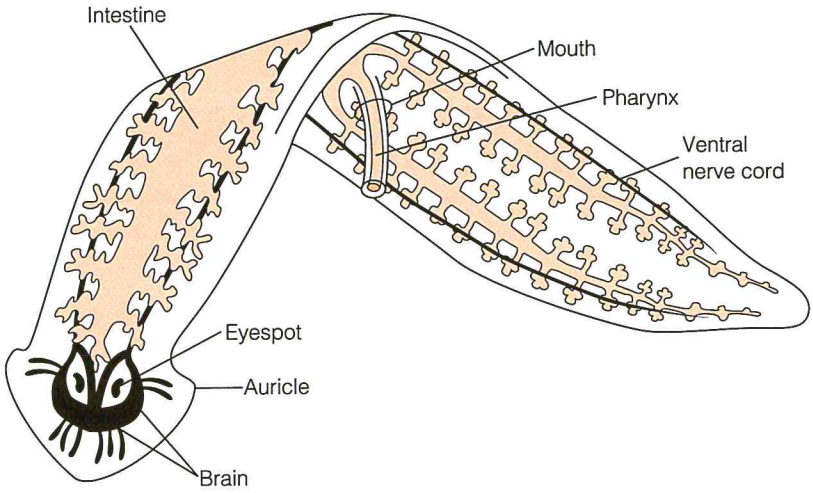


Figure 17.5.
A planarian. The digestive system consists of a mouth, a pharynx, and a branched intestine. A brain and two ventral nerve cords (plus transverse nerves connecting them, not shown) make up the nervous system.

Do not observe these slides using high power! The high power objective may crack the coverslip, resulting in damage to the lens.

Examine the body for possible digestive tract openings. How many openings to the digestive tract are present?

one

Observe again the pharynx and the mouth. The pharynx lies in a **pharyngeal chamber** inside the mouth. The proximal end of the pharynx opens into a dark-colored, branched intestine. If the intestine has been stained on your slide, you will see the branching more easily.

4. Continue your study of the whole planarian. The anterior blunt end of the animal is the head end. At each side of the head is a projecting **auricle.** It contains a variety of sensory cells, chiefly of touch and chemical sense. Between the two auricles on the dorsal surface are two pigmented **eyespots.** These are pigment cups into which retinal cells extend from the brain, with the photosensitive end of the cells inside the cup. Eyespots are sensitive to light intensities and the direction of a light source but can form no images. Beneath the eyespots are two cerebral ganglia that serve as the **brain.** Two ventral nerve cords extend posteriorly from the brain. These are connected by transverse nerves to form a ladderlike **nervous system.**
5. Study the prepared slide of cross sections of a planarian. You will have several sections on one slide. One section should have been taken at the level of the pharynx and pharyngeal chamber. Do you see a body cavity in any of the sections? (The pharyngeal chamber and spaces in the gut are not a body cavity.) What word describes this body cavity condition (see Figure 17.2a)?

acoelomate; no body cavity in flatworms

a. How many tissue layers can be detected? Speculate about their embryonic origin.

Three. The outer layer is the skin or epidermis derived from ectoderm. There is a layer surrounding the digestive tract derived from endoderm. The space between the two layers is filled with additional tissues from mesoderm.

Flatworms are the first group of animals to have three well-defined embryonic tissue layers, enabling them to have a variety of tissues and organs. Reproductive organs and excretory organs consisting of two lateral excretory canals and "flame cells" that move fluid through the canals are derived from the embryonic mesoderm. Respiratory, circulatory, and skeletal systems are lacking.

b. How do you think the body is supported?

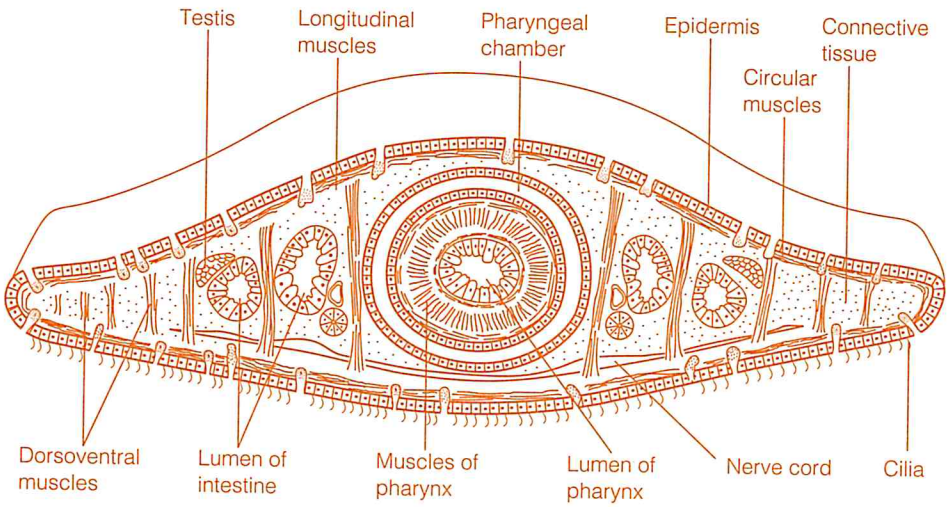
by surrounding water and the water in the body tissues

c. How does gas exchange take place?

by diffusion from water through tissues

Results

1. Diagram the flatworm as seen in a cross section at the level of the pharynx. Label the **epidermis, muscle** derived from **mesoderm,** the lining of the digestive tract derived from **endoderm,** the **pharynx,** and the **pharyngeal chamber.**
2. Complete the summary table, Table 18.1, recording all information for planarian characteristics in the appropriate row. You will use this information to answer questions in the Applying Your Knowledge section at the end of Lab Topic 18, Animal Diversity II.



Discussion

One of the major differences between Cnidaria and Platyhelminthes is radial versus bilateral symmetry. Discuss the advantage of radial symmetry for sessile (attached) animals and bilateral symmetry for motile animals.

Radial symmetry allows an animal to interact with its surroundings equally in any direction (which is good if the animal is attached), while bilateral symmetry allows an animal to move head first, with all sensory organs directed into the new environment.

EXERCISE 17.4

Phylum Annelida—Clamworms (*Nereis*) and Earthworms (*Lumbricus terrestris*)

The phylum Annelida (clade Lophotrochozoa) includes a diverse group of organisms inhabiting a variety of environments. Examples range in size from microscopic to several meters in length. Most species are marine, living free in the open ocean or burrowing in ocean bottoms. Others live in fresh water or in soils. One group of annelids, the leeches, are parasitic and live on the blood or tissues of their hosts. In this exercise, you will study the clamworm, a marine annelid, and the earthworm, a terrestrial species. Keep in mind features that are adaptations to marine and terrestrial habitats as you study these organisms.

Lab Study A. Clamworms (*Nereis*)

Materials

dissecting tools
dissecting pan
preserved clamworm
disposable gloves
dissecting pins

Introduction

You may choose to have students work in pairs for this exercise. One student can dissect Nereis *while the other dissects the earthworm. Each then demonstrates their worm to their partner.*

Species of *Nereis* (clamworms) are commonly found in mud flats and on the ocean floor. These animals burrow in sediments during the day and emerge to feed at night. As you observe the clamworm, note features that are characteristic of all annelids, as well as features that are special adaptations to the marine environment (Color Plate 54).

Procedure

1. Observe the preserved, undissected clamworm and compare it with Figure 17.6. How would you describe the symmetry of this organism?

   bilateral symmetry

2. Determine the anterior and posterior ends. At the anterior end, the well-differentiated head bears **sensory appendages.** Locate the mouth, which leads into the digestive tract.

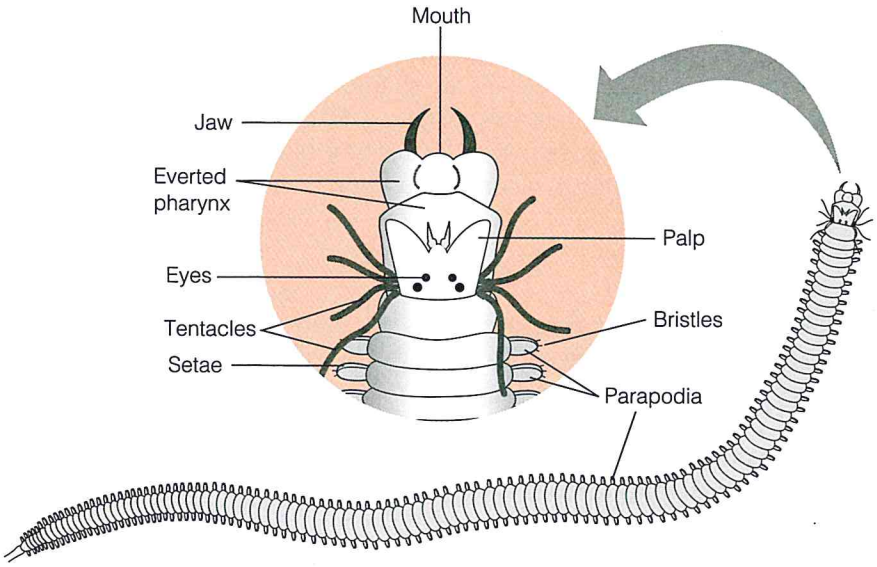


Figure 17.6.
The clamworm, *Nereis*. The head has sensory appendages, and each segment of the body bears two parapodia with setae.

3. A conspicuous new feature of these organisms is the presence of **segmentation,** the division of the body along its length into segments. Posterior to the head region, the segments bear fleshy outgrowths called **parapodia.** Each parapodium contains several terminal bristles called **setae.** In Lab Study B, you will see that the earthworm has setae but does not have parapodia. Suggest functions for parapodia and setae in the marine clamworm.

   Both of these structures aid in locomotion in the clamworm. The parapodia are paddlelike extensions used for swimming. The setae aid in movement in the burrow. (Students will be asked to speculate about the role of parapodia in gas exchange later.)

4. Holding the animal in your hand and using sharp-pointed scissors, make a middorsal incision the full length of the body. Carefully insert the tip of the scissors and lift up with the tips as you cut. Pin the opened body in the dissecting pan but do not put pins through the head region.
5. Locate the **intestine.** Do you see the "tube-within-a-tube" body plan?

   The tubular digestive tract extending the length of the tubular body appears to be a "tube within a tube."

6. Two **muscle layers,** one inside the skin and a second lying on the surface of the intestine, may be visible with the stereoscopic microscope. With muscle in these two positions, what kind of coelom does this animal have (see Figure 17.2c)?

   With muscle lying inside the epidermis (skin) and outside the endodermis (gut), this is a true coelom (eucoelom).

7. Continuing your observations with the unaided eye and the stereoscopic microscope, look for **blood vessels,** particularly a large vessel lying on the dorsal wall of the digestive tract. This vessel is contractile and propels the blood throughout the body. You should be able to observe

smaller lateral blood vessels connecting the dorsal blood vessel with another on the ventral side of the intestine. As you will see, in the earthworm these connecting vessels are slightly enlarged as "hearts" around the anterior portion of the digestive tract (around the esophagus). This is not as obvious in *Nereis*. What is this type of circulatory system, with blood circulating through continuous closed vessels?

closed circulation

8. Gas exchange must take place across wet, thin surfaces. Do you see any organs for gas exchange (gills or lungs, for example)? How do you suspect that gas exchange takes place?

There are no lungs or gills. Gas exchange takes place through the skin, and this surface area is expanded in the parapodia.

9. Do you see any signs of a skeleton? What would serve as support for the body?

The body is supported by water in a hydrostatic skeleton.

10. Clamworms and earthworms have a small bilobed brain (a pair of ganglia) lying on the surface of the digestive tract at the anterior end of the worm. You can see this more easily in an earthworm.

Lab Study B. Earthworms (*Lumbricus terrestris*)

Materials

dissecting instruments
compound microscope
stereoscopic microscope
preserved earthworm
prepared slide of cross section of earthworm

Introduction

You may choose to have students first observe behavior, such as locomotion, in a live earthworm, then narcotize the worm by placing it in a 5% ethanol solution for 20 to 30 minutes. Most systems, especially the circulatory system, are more easily studied in living worms.

Lumbricus species, commonly called *earthworms*, burrow through soils rich in organic matter. As you observe these animals, note features that are adaptations to the burrowing, terrestrial lifestyle.

Procedure

1. Obtain a preserved earthworm and identify its anterior end by locating the mouth, which is overhung by a fleshy dorsal protuberance called the **prostomium.** The anus at the posterior end has no such protuberance. Also, a swollen glandular band, the **clitellum** (a structure that secretes a cocoon that holds eggs), is located closer to the mouth than to the anus (Figure 17.7).
   a. Using scissors, make a middorsal incision along the anterior third of the animal, as you did for *Nereis*. You can identify the dorsal surface in a couple of ways. The prostomium is dorsal, and the ventral surface of the worm is usually flattened, especially in the region of the clitellum. Cut to the prostomium. Pin the body open in a dissecting pan near the edge. You may need to cut through the septa that divide the body cavity into segments.

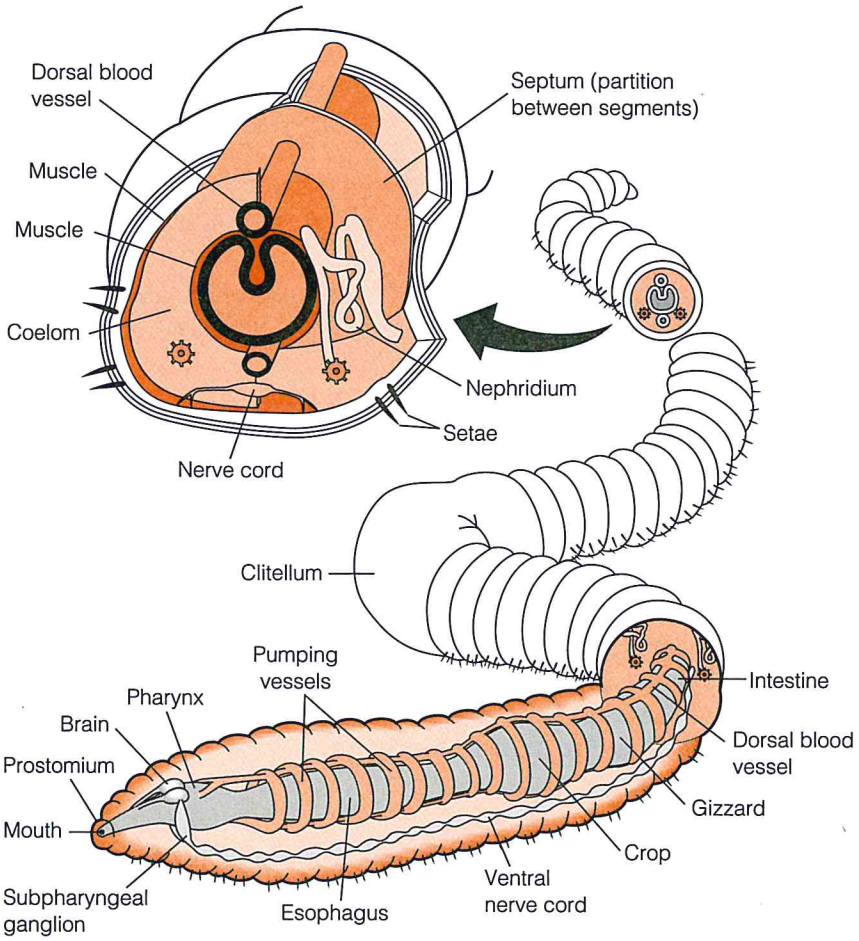


Figure 17.7.
The earthworm. The small brain leads to a ventral nerve cord. A pair of nephridia lie in each segment.

b. Using a stereoscopic microscope or hand lens, look for the small **brain** just behind the prostomium on the surface of the digestive tract. Note the two nerves that pass from the brain around the pharynx and meet ventrally. These nerve tracts continue posteriorly as a **ventral nerve cord** lying in the floor of the coelom.

c. Look for the large **blood vessel** on the dorsal wall of the digestive tract. You may be able to see the enlarged lateral blood vessels (**hearts**) around the anterior portion of the digestive tract.

d. Identify (from anterior to posterior) the **pharynx, esophagus, crop** (a soft, swollen region of the digestive tract), **gizzard** (smaller and more rigid than the crop), and **intestine.**

e. Excretion in the clamworm and earthworm is carried out by organs called **nephridia.** A pair of these minute, white, coiled tubes is located in each segment of the worm body. Nephridia are more easily observed in the earthworm than in *Nereis* and should be studied here. To view these organs, cut out an approximately 2-cm-long piece of the worm posterior to the clitellum and cut it open along its dorsal surface. Cut through the septa and pin the piece to the dissecting pan near the edge to facilitate observation with the stereoscopic microscope. The coiled tubules of the nephridia are located in the coelomic cavity, where waste is collected and discharged to the outside through a small pore.

2. Using the compound microscope, observe the prepared slide of a cross section of the earthworm.
   a. Locate the **thin cuticle** lying outside of and secreted by the **epidermis.** Recall the habitat of this organism and speculate about the function of the cuticle.

      The cuticle helps to prevent water loss in the terrestrial environment.

   b. Confirm your decision about the type of coelom by locating **muscle layers** inside the epidermis and also lying on the surface of the **intestine** near the body cavity.

      true coelom, or eucoelomic body cavity

   c. Locate the **ventral nerve cord,** lying in the floor of the coelom, just inside the muscle layer.

Results

Complete the summary table, Table 18.1, recording all information for clamworm and earthworm characteristics in the appropriate row. You will use this information to answer questions in the Applying Your Knowledge section at the end of Lab Topic 18, Animal Diversity II.

Discussion

A major new feature observed in the phylum Annelida is the segmented body. Speculate about possible adaptive advantages provided by segmentation.

Locomotion is improved in earthworms, compared to nematodes, by dividing the hydrostatic skeleton into compartments, facilitating peristaltic contractions. Segmentation also permits the development of segments into parts that perform specific functions for the animal.

EXERCISE 17.5
Phylum Mollusca—Clams

Materials

dissecting instruments
dissecting pan
preserved clam or mussel
disposable gloves

Consider using fresh materials available from grocery stores, fish markets, or farmers' markets.

Introduction

Second only to the phylum Arthropoda in numbers of species, the phylum Mollusca (clade Lophotrochozoa) includes thousands of species living in many diverse habitats. Most species are marine. Others live in fresh water or on land. Many mollusks are of economic importance, being favorite human foods. Most mollusks share four characteristic features: (1) a hard external **shell** for protection; (2) a thin structure called the **mantle,** which

secretes the shell; (3) a **visceral mass** in which most organs are located; and (4) a muscular **foot** used for locomotion.

In this exercise, you will dissect a clam, a molluscan species with a shell made of two parts called **valves.** Most clams are marine, although many genera live in freshwater lakes and ponds (Color Plate 55).

You can use freshwater mussels for this dissection. The descriptions will be the same.

Wear gloves while dissecting preserved animals.

Procedure

1. Observe the external anatomy of the preserved clam. Certain characteristics will become obvious immediately. Can you determine symmetry, support systems, and the presence or absence of appendages? Are there external signs of segmentation? Record observations in Table 18.1.
2. Before you continue making observations, determine the dorsal, ventral, anterior, posterior, right, and left regions of the animal. Identify the two valves. The valves are held together by a **hinge** near the **umbo,** a hump on the valves. The hinge and the umbo are located **dorsally,** and the valves open **ventrally.** The umbo is displaced **anteriorly.** Hold the clam vertically with the umbo away from your body, and cup one of your hands over each valve. The valve in your right hand is the right valve; the valve in your left hand is the left valve. The two valves are held together by two strong **adductor** muscles inside the shell. Compare your observations with Figure 17.8.

Be cautious as you open the clam! Hold the clam in the dissecting pan in such a way that the scalpel will be directed toward the bottom of the pan.

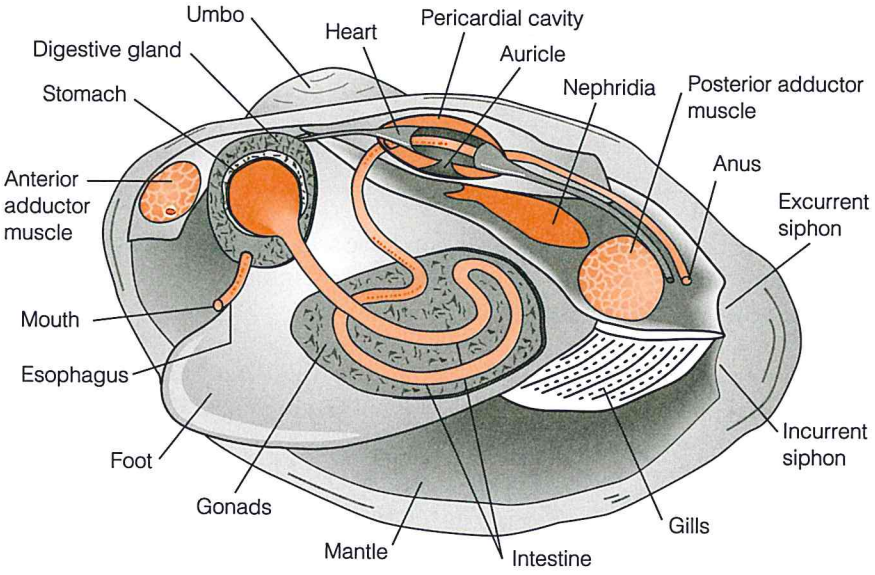


Figure 17.8.
Anatomy of a clam. The soft body parts are protected by the shell valves. Two adductor muscles hold the valves closed. Most major organs are located in the visceral mass. In this diagram, the left mantle, left pair of gills, and half of the visceral mass have been removed.

3. To study the internal anatomy of the clam, you must open it by prying open the valves. (A wooden peg may have been inserted between the two valves.) Insert the handle of your forceps or scalpel between the valves and twist it to pry the valves farther open. Carefully insert a scalpel blade, directed toward the dorsal side of the animal, into the space between the left valve and a flap of tissue lining the valve. The blade edge should be just ventral to (that is, below) the anterior adductor muscle (see Figure 17.8). The flap of tissue is the left **mantle.** Keeping the scalpel blade pressed flat against the left valve, carefully loosen the mantle from the valve and press the blade dorsally. You will feel the tough **anterior adductor muscle.** Cut through this muscle near the valve.
4. Repeat the procedure at the posterior end and cut the posterior adductor muscle. Lay the clam on its right valve and carefully lift the left valve. As you do this, use your scalpel to loosen the mantle from the valve. If you have been successful, you should have the body of the clam lying in the right valve. It should be covered by the mantle. Look for pearls between the mantle and the shell. How do you think pearls are formed?

   A grain of sand or a parasite becomes trapped between the mantle and the shell. The mantle secretes pearly layers around it.

5. Look at the posterior end of the animal where the left and right mantle come together. Hold the two mantle flaps together and note the two gaps formed. These gaps are called **incurrent** (ventral) and **excurrent** (dorsal) **siphons.** Speculate about the function of these siphons.

   Water, food, and oxygen are carried into the animal through the incurrent siphon. Water and waste pass out of the animal through the excurrent siphon.

6. Lift the mantle and identify the **visceral mass** and the **muscular foot.**
7. Locate the **gills,** which have a pleated appearance. One function of these structures is obvious, but they have a second function as well. As water comes into the body (how would it get in?), it passes through the gills, and food particles are trapped on the gill surface. The food is then moved anteriorly (toward the mouth) by coordinated ciliary movements.
8. Locate the **mouth** between two flaps of tissue just ventral to the anterior adductor muscle. Look just above the posterior adductor muscle and locate the **anus.** How is it oriented in relation to the excurrent siphon?

   The anus is just dorsal to the excurrent siphon in such a position that waste can quickly exit the body.

9. Imagine that this is the first time you have seen a clam. From the observations you have made, what evidence would indicate whether this animal is aquatic or terrestrial?

   The presence of gills and a mantle forming siphons to move water supports the conclusion that the habitat of this organism is aquatic.

10. The **heart** of the clam is located in a sinus, or cavity, just inside the hinge, dorsal to the visceral mass (see Figure 17.8). This cavity, called the *pericardial cavity,* is a reduced **true coelom.** The single ventricle of the heart actually surrounds the **intestine** passing through this cavity. Thin auricles, usually torn away during the dissection, empty into the heart via openings called **ostia.** Blood passes from **sinuses** in the body into the auricles. What type of circulatory system is this?

    This is an open circulatory system: Blood does not circulate through continuous closed channels; blood vessels are not continuous.

11. Ventral to the heart and embedded in mantle tissue are a pair of greenish brown tissue masses, the **nephridia,** or kidneys. The kidneys remove waste from the pericardial cavity.
12. Open the visceral mass by making an incision with the scalpel, dividing the mass into right and left halves. Begin this incision just above the foot and cut dorsally. You should be able to open the flap produced by this cut and see organs such as the **gonads, digestive gland, intestine,** and **stomach.** Clam chowder is made by chopping up the visceral mass.
13. It is difficult to observe the nervous system in the clam. It consists of three ganglia, one near the mouth, one in the foot, and one below the posterior adductor muscle. These ganglia are connected by nerves.

Now that you have dissected the clam, you should have concluded that there is no sign of true segmentation. Also, appendages (attached to a trunk or body wall) are absent.

Results

Complete Summary Table 18.1, recording all information for clam characteristics in the appropriate row. Use this information to answer questions in the Applying Your Knowledge section at the end of Lab Topic 18, Animal Diversity II.

Discussion

List several features of clam anatomy that enable it to survive in a marine environment.

The heavy shell protects the animal from damaging waves on shores or water pressures in deep seas. The gills allow the animal to filter food and obtain oxygen from water. The muscular foot allows the animal to burrow into sand.

By the end of today's laboratory period, you should have completed observations of all animals described in Animal Diversity I. The next lab topic, Animal Diversity II, is a continuation of this investigation and will present similar laboratory objectives. In Animal Diversity II, you will continue asking questions and making comparisons as you did in Animal Diversity I. By the end of the two lab topics, you should be able to use what you have learned about the animals to discuss and answer questions about the unifying themes of these laboratory topics.

Applying your Knowledge

A hydra (*Chlorophyra viridissima*) is bright green, and yet it does not synthesize chlorophyll. Think about the structure of the hydra and its feeding and digestive habits. What do you think is the origin of the green pigment in this species?

Gastrodermal cells in this hydra species bear green algae that give the hydra the green color. This is a case of symbiotic mutualism. The algae are held in vacuoles in the gastrodermal cells, but they are not digested. Students may speculate that gastrodermal cells engulf algae, but do not digest them. This will help them remember that digestion is both extracellular (in the gastrodermal cavity) and intracellular in many cnidarians.

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Website

Includes descriptions of many invertebrates and vertebrates, links to insect keys, references:

http://animaldiversity.ummz.umich.edu/site/index.html

LAB TOPICS 17 AND 18

Animal Diversity I and II Teaching Plan for Laboratories

See pp. 502–508 at the end of Lab Topic 18 for the integrated Teaching Plan for Lab Topics 17 and 18.

If students do not have time to complete the last exercise, they may continue this study at the beginning of lab next week.

The last 10 minutes of this lab period may be used for students to review the animals studied as they complete Table 18.1.