Investigating Porifera and Cnidaria

Lab XI-1

EQUIPMENT AND MATERIALS

You'll need the following items to complete this lab session. (The standard kit for this book, available from *www.thehomescientist.com*, includes the items listed in the first group.)

MATERIALS FROM KIT

- Magnifier
- Pipettes
- Slide, deep cavity
- Teasing needles

MATERIALS YOU PROVIDE

- Culture: Daphnia or brine shrimp (optional)
- Culture: Hydra (optional)
- Microscope
- Microscope, stereo (optional)
- Slides, prepared, Hydra (budding, sections)
- Slide(s), prepared, sponge sections
- Specimen: Grantia (preserved)
- Vinegar, distilled white

BACKGROUND

In this lab session, we'll investigate *Porifera* (poor-ih-FUR-uh) and *Cnidaria* (nye-DAIR-ee-uh). Members of these two phyla are simple invertebrate animals.

Porifera, the sponges, are the simplest animals. They have no true tissues, no digestive tract, and no circulatory or nervous system. Instead, sponges depend on a constant flow of water through their bodies, from which they obtain oxygen and food (bacteria and other microorganisms) and into which they discharge their wastes. Water is taken in through pores called *ostia* (singular *ostium*) that cover the body of the sponge and exhausted through a larger opening at one end of the sponge called the *osculum*.

Structurally, sponges are quite simple, consisting of two layers of cells that contain a jelly-like, nonliving substance called *mesohyl* (formerly called *mesenchyme*). The outer and inner cell layers are called the *ectoderm* and the *endoderm*, respectively. Rigid filamentary structures called *spicules* provide structural support to the sponge. In most species, spicules are composed of stone-like calcium carbonate or glass-like silica. In a few species—the only natural sponges used as bath or kitchen sponges—the spicules are composed of softer fibers of a material called *spongin*.

The central cavity of a sponge, through which water flows from the ostia to the osculum, is called the *spongocoel*. In some species, the spongocoel is a single, large central cavity; in others, the spongocoel is complex, with numerous internal branches and channels. The spongocoel is lined with specialized cells called *choanocytes* (also called *collar cells*), whose central flagella create currents that drive water through the sponge. As the flagella draw water across the choanocytes, it passes through the coanocytes' surrounding collar of *microvilli* (singular *microvillum*), which trap and digest microorganisms present in the water.

Sponges reproduce asexually by fragmentation or by producing *gemmules*. A few sponge species reproduce asexually by budding, a process similar to the asexual budding reproduction used by some protista and cnidarians.

Fragmentation

In reproduction by fragmentation, fragments of the original sponge torn loose by wave action or predators may float freely until they attach themselves to a substrate and begin growing by producing new cells. Eventually, the "new" sponge may grow to the size of the original sponge or more.

Nineteenth century biologists discovered reproduction by fragmentation when they passed sponges through cheesecloth, breaking them up into small clusters of cells, and found that those clusters eventually grew into larger sponges. A sponge fragment can reproduce only if both *collencytes* (which produce mesohyl) and *archeocytes* (which produce all other cell types) are present in the fragment. Without the former, the sponge fragment cannot produce mesohyl; without the latter, it cannot produce any of the other cell types present in a complete sponge.

Gemmules

Gemmules can be thought of as "spores" that are produced by some sponges. A gemmule is a cluster of archeocytes surrounded by nutrients and enclosed by a protective membrane of spongin. Like spores, gemmules are extremely resistant to environmental extremes, capable of surviving conditions that would kill a live sponge.

Many species, primarily freshwater sponges, produce gemmules in huge numbers when the sponge is under extreme stress or dying. Other species produce gemmules routinely before the onset of winter. In either case, the gemmules bide their time until conditions are suitable and then germinate, producing young sponges.

Although sponges have no reproductive organs, they can reproduce sexually. In most species that reproduce sexually, individual sponges function as both male and female. Choanocytes produce cysts that contain sperm and archeocytes produce eggs. During reproduction, the cysts burst and the sperm are expelled through the osculum into the surrounding water. If another sponge of the same species encounters those sperm, it ingests the sperm, which subsequently fertilizes eggs present in the second sponge. Depending on the species, those fertilized eggs may be expelled into the surrounding water, but most species retain them until they hatch. The resulting larvae disperse and settle to the bottom, where they attach themselves to suitable substrates and grow into adult sponges.

Cnidaria—which include hydras, corals, sea anemones, jellyfish, and similar species—are one step up in complexity from sponges. Like sponges, cnidarians possess neither digestive tracts nor circulatory systems. Also like sponges, the bodies of cnidarians are made up of two layers of cells separated by a jelly-like material, which in cnidarians is called *mesoglea* rather than mesohyl.

Unlike sponges, cnidarians possess simple nervous systems that allow them to respond to external stimuli, and a few possess rudimentary sensory organs. Also unlike sponges, cnidarian cell layers are bound by intercellular connections and basement membranes. Cnidarians are unique in possessing *cnidocytes* (also called *cnidoblasts* or *nematocytes*), venomous cells that function like tiny poisoned harpoons for stunning and capturing prey and defense against predators. Some sessile cnidarians also use cnidocytes for attaching themselves to substrates. Cnidocytes are present in large numbers on the tentacles (called *cnidae*, singular *cnida*) of cnidarians.

Each cnidocyte cell contains an organelle called a *nematocyst* (also called a *cnidocyst*), which contains a barbed penetrator connected to a coiled hollow filament inside a capsule. The capsule is covered by a lid called an *operculum*, which has a trigger structure called a *cnidocil*. When the cnidocil contacts a prey organism, it causes the operculum to spring open, much like a missile silo cover. In about a microsecond, the spring-like filament ejects the penetrator from the capsule and into the prey. The barbed penetrator impales the prey and injects a neurotoxin, which quickly stuns and eventually kills the prey. The barbs on the penetrator prevent the prey from escaping while it is being subdued. After the prey is subdued, the cnidae (tentacles) draw the prey toward the mouth of the cnidarian, which engulfs the prey.

Cnidarians reproduce asexually and sexually, as detailed in Procedure XI-1-2.

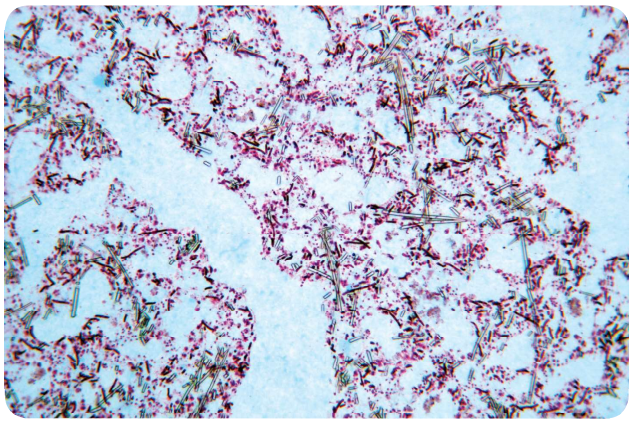
PROCEDURE XI-1-1: OBSERVING PORIFERA

As you do this procedure, record your observations in your lab notebook. Sketch or shoot images of the significant features you observe.

1. Use your naked eye and the magnifier to examine your *Grantia* specimen closely. Locate and identify the osculum. Examine the osculum closely with the magnifier, noting the spicules that surround the osculum and project through the outer surface of the sponge. On the body of the sponge, locate an ostium and examine it closely with the magnifier.

2. Examine a prepared slide of a section of *Grantia* or another sponge at low or medium magnification. Identify the following features: endoderm and ectoderm; mesohyl; spongocoel; choanocytes and flagella; and spicules. Figure XI-1-1 shows a sponge section at 100X.

Figure XI-1-1: *Sponge section, 100X*



3. Center a choanocyte in the field of view and change to high magnification. Examine the flagellum and microvilli. Observe several spicules and note their general appearance and the degree of variation in their structures. Figure XI-1-2 shows a Grantia spicule at 400X.

Figure XI-1-2: *Sponge (Grantia sp.) spicule detail, 400X*

4. If you have a prepared slide of a section of another sponge species, repeat steps 2 and 3 with that slide. Compare and contrast the appearance and structure of the spongocoel and choanocytes between the two species.

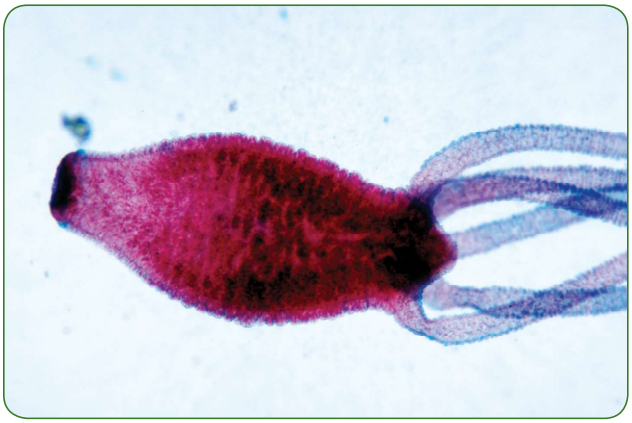
PROCEDURE XI-1-2: OBSERVING CNIDARIA

As you do this procedure, record your observations in your lab notebook. Sketch or shoot images of the significant features you observe.

1. Examine a prepared slide of a whole mount hydra at low magnification. At the posterior end (on the left in Figure XI-1-3), identify the basal disk, which the hydra uses to anchor itself to a substrate. At the anterior end, identify the mouth and cnidae (tentacles), shown in Figure XI-1-4.

> Hydras bridge the boundary between microorganisms and macroorganisms. Small specimens may be invisible without magnification, but larger specimens are easily visible to the naked eye. You may have to move the slide around to view the entire animal, even at low magnification.

Figure XI-1-3: *Hydra (Hydra sp.) wm body, 40X*



2. Change to medium magnification and examine the details of the cnidae (tentacles). Identify the nematocysts (bumps) on the cnidae. Figure X1-1-5 shows cnidae at 100X.

3. Examine prepared slides of a hydra in cross and longitudinal sections at low magnification. In both sections, locate and identify the outer epidermis, the inner gastrodermis, the jelly-like layer of mesoglea that separates the two dermal layers, and the gastrovascular cavity. Figure XI-1-6 shows a hydra cross-section at 100X.

Figure XI-1-4: *Hydra (Hydra sp.) wm mouth and cnidae, 40X*

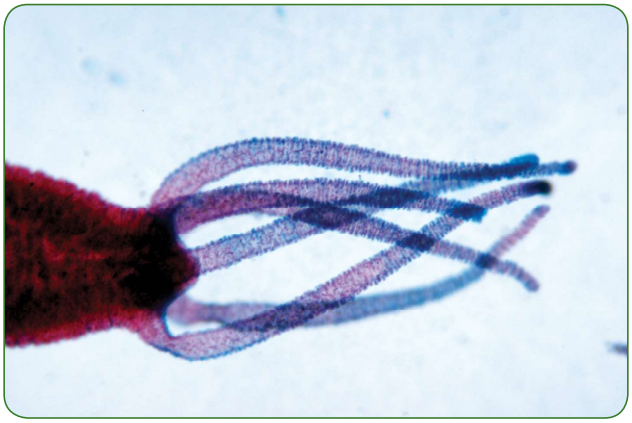


Figure XI-1-5: *Hydra (Hydra sp.) wm cnidae detail, 100X*

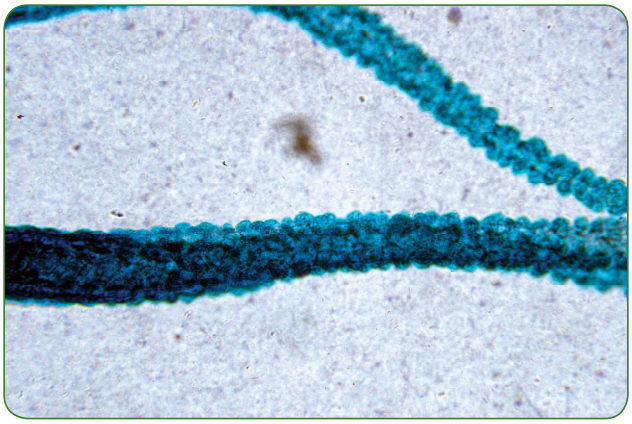


Figure XI-1-6: *Hydra cs, 40X*

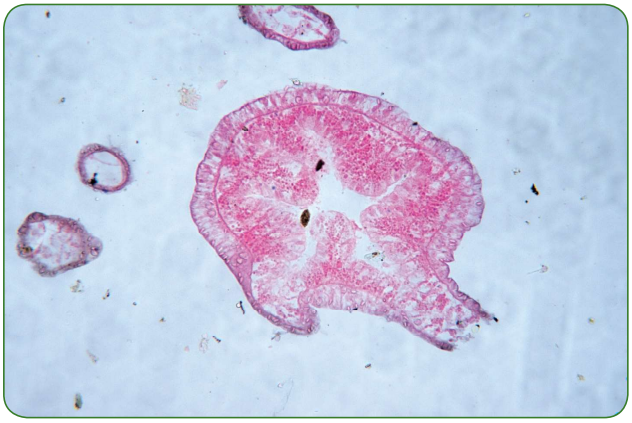


Figure XI-1-7: *Hydra budding, 40X*

4. If you have a longitudinal section slide, use low magnification to locate and identify the basal disk, mouth, and cnidae. Center a sectioned portion of a cnida in the field of view, change to medium magnification, and locate a sectioned nematocyst. Change to high magnification and examine the details of the nematocyst.

   Under benign conditions (plenty of food, no stress, and so on) most *Hydra* species reproduce asexually by budding. A small swelling in the body wall, called a bud, develops into a miniature hydra, which, when mature, detaches from the parent hydra and begins life as a new individual.

5. Examine a prepared slide of a hydra budding at low magnification, shown in Figure XI-1-7. If you have a longitudinal section slide available that shows a bud section, examine it and note the internal structure of the bud.

   Under harsher conditions, many hydras reproduce sexually. Sexual reproduction begins much like asexual reproduction, with a small bud developing in the body wall of the parent hydra. Rather than developing as a new individual, the bud develops into an ovary or testis. When mature, a testis releases sperm into the surrounding water. If one of those sperm encounters an ovary on another hydra, it penetrates the ovary and fertilizes the egg within. When the female parent dies, the eggs are released and settle to the bottom, where they remain dormant until conditions improve. At that point, the egg hatches releasing a juvenile hydra, called a nymph. In most *Hydra* species, individuals are either male or female, but in some species individuals are hermaphroditic (possess both male and female sex organs).

6. On your whole-mount or longitudinal section slide, examine the hydra to determine if an ovary, testis, or both are present. The ovary, if present, is a bump on the posterior (basal disk end) half of the body. The testis, if present, is a conical structure on the anterior (mouth end) half. If you have section slides available, examine the ovary and testis structures. Figure XI-1-8 shows a hydra ovary in cross-section at 400X; Figure XI-1-9 shows a testis in cross-section at 400X.

Figure XI-1-8: *Hydra ovary cs, 400X*

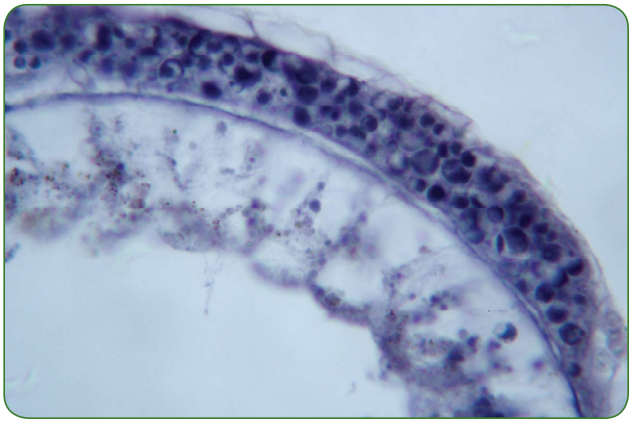
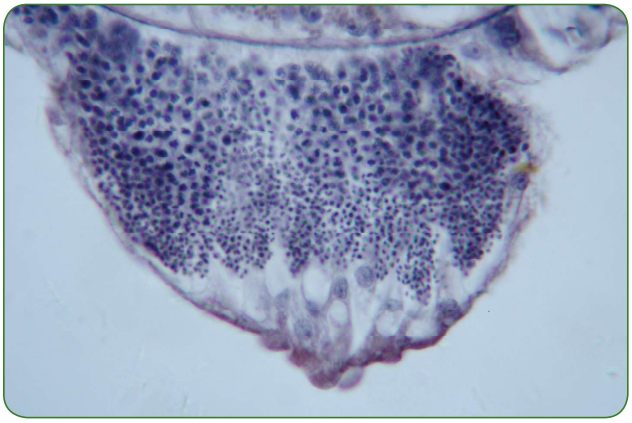


Figure XI-1-9: *Hydra testis cs, 400X*



The following part of this procedure is optional. It requires live hydras, either purchased or obtained from your pond-water microcosm. You'll also need a live *Daphnia* or brine shrimp culture to feed the hydras, which are very picky eaters.

Live hydras are relatively difficult to culture successfully and to observe. Hydras are shy and easily disturbed. Even healthy hydras may become unresponsive if the type of water, temperature, and so on is not exactly what they prefer. If they feel threatened, they may immediately draw in upon themselves, retracting their cnidae and forming what looks like a small hemispheric blob.

If you do this part of the exercise, we recommend you do so using purchased cultures. Follow the instructions supplied with the cultures to ensure that the hydras are healthy and active at the time you have scheduled the procedure.

7. Using a pipette, transfer some of a hydra culture that has gone unfed for a day or so to a deep cavity slide, filling the well about one-quarter full. Observe the slide with the magnifier or under a stereo microscope to verify that at least one hydra is present in the liquid. Observe its appearance and behavior.

Depending on the hydra culture you use, some of the hydras may be free-floating or they may all have attached themselves to substrates. If the latter, you can dislodge a hydra by drawing up the culture liquid into the pipette and expelling the liquid forcefully toward the hydra. When it loses its grasp on the substrate, draw it up with the pipette and transfer it to the cavity slide.

8. While observing the hydra, add a few drops of a *Daphnia* or brine shrimp culture to the well. If possible, introduce the prey far enough from the hydra to avoid disturbing it. Observe any activity that occurs.

When disturbed by feeding or other external stimuli, hydras need time to recover from the disturbance and return to their normal behavior. Allow at least several minutes for this to occur.

9. While observing the hydra, use a pipette to cause a gentle current in the liquid to impinge upon the hydra. Note how the hydra responds, if at all.

10. While observing the hydra, gently touch the tip of your teasing needle to the base of the hydra. Note how the hydra responds, if at all.

11. While observing the hydra, gently touch the tip of your teasing needle to a cnida of the hydra. Note how the hydra responds, if at all.

12. While observing the hydra, place the tip of your teasing needle close to but not in contact with the hydra. Observe until the hydra contacts the tip of the needle and note how the hydra responds to that contact.

13. While observing the hydra, slowly add distilled white vinegar dropwise to the well until an obvious response occurs. Note how the hydra responds.

14. When you complete your investigations, dispose of the hydras by flushing them. Do not return them to the original culture container.

REVIEW QUESTIONS

Q1: Because they are sessile, sponges were originally believed to be plants. What evidence did you observe in this lab session that establishes that sponges are in fact animals?

Q2: What purpose do the spicules of a sponge serve?

Q3: Compare and contrast the symmetries and structures of a sponge and a hydra.

Q4: Compare and contrast the characteristics of flagellated or ciliated protists and sponges.

Q5: What, if any, activities was the hydra engaged in when you initially observed it?

Q6: How did the hydra respond when you added the *Daphnia* or brine shrimp to the well? How does the hydra feed?

Q7: What response, if any, did you observe when you disturbed the hydra with a water current or the tip of your teasing needle?

Q8: What response, if any, did you observe when you added vinegar to the well?