The Sponges: Phylum Porifera

Note: These links do not work. Use the links within the outline to access the mages in the popup windows. This text is the same as the scrolling text in the popup windows.

. What is a sponge? (Page 1-3)

Phylogeny of Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/phylogeny.html

The sponges are thought to be a side branch of the animal family tree. Whereas almost all other animals are classified as Eumetazoa, sponges are found in an offshoot sometimes called the Parazoa. The phylogenetic chart shown here, reflects the view that sponges diverged from other metazoans quite early in the evolution of multicellded animals.

Choanoflagellates:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/choanoflagellates.html

A group of colonial protozoans, called the choanoflagellates, may be the ancestors of sponges. Each protozoan within the colony has a collar-like structure surrounding a long flagellum. As the flagellum beats, water and small food particles are swept into the collar and captured by the protozoan. Sponges have an inner layer of cells that closely resemble these protozoans, although the sponge has sufficient structure to be considered a multicellular animal rather than a colony of individual cells.

Pores:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/pores.html

Sponges are sessile and live their entire adult life attached to a solid substrate under water. The surface of the sponge is covered with small openings called pores that give sponges their Phylum name, Porifera. In a simple sponge, the pores lead into a central body cavity filled with water. Water enters this cavity through the pores and exits by a large vent. The pores are tiny, but the vent can be easily seen in a living sponge.

Sponge Layers:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/sponge_layers.html

The cellular structure of sponges is unusual. There are three layers of cells, but they are not as tightly connected to one another as in the tissues of other animals. The outer cell layer, the epidermis, forms a smooth protective covering with interspersed pores for water entry. The inner layer is composed of flagellated cells that have a collar surrounding the lower part of the flagellum and resemble the flagellated colonial protozoans described earlier. The beating flagella of the collar cells creates water flow through the sponge. The middle layer is the strangest of all. The cells within it, called amebocytes, are not connected to one another at all and crawl like an ameba through the jelly-like matrix of this layer.

Water Flow from Sponge Vent:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/water_flow.html

The continuous flow of water through the sponge serves as both a respiratory and excretory system by bringing oxygen rich water into the sponge and expelling harmful waste products that accumulate within the internal cavity. Since sponges are sessile, they cannot move from place to place to feed and must bring the food to them. This is also accomplished by water flow, since the incoming water current transports
Microscopic plants and animals into the sponge. In this living sponge, water can be seen emerging from the vent, also called the osculum.

**Sponge Pumping Dye:**
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/pumping_dye.html
Waste products must be expelled to a distance that prevents them from reentering and poisoning the sponge. The larger the sponge, the greater must be the distance. In this picture, a sponge is shown ejecting a green dye from its vent.

**Internal Canals:**

http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/internal_canals.html

Small sponges often have the simple path of water flow previously described and illustrated here by diagram A. In this simple system, water enters through the surface pores, passes through the internal cavity and exits through the vent. However, larger sponges need more surface area for contact of the sponge cells with water. They also require more collar cells to eject the larger volume water from the sponge. Hence a more complex system of water flow has evolved. In diagram B, water enters the sponge via pores, but then must pass through channels formed by folds in the body wall before entering the central cavity and finally exiting through the vent. These channels are lined with collar cells which propel the water along its path. In diagram C, an even more complex system is illustrated. Here, incoming water passes through a series of canals, small chambers, and larger chambers before exiting the sponge.

**Sponge Water Flow:**

http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/sponge_types.html

In these diagrams, the entire sponge is shown to illustrate water flow through the sponge body. These three diagrams show increasing complexity from left to right. The well known bath sponge is like the most complex of these. Can you see why a commercial sponge holds so much water?

**Spicules:**

http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/spicules.html

Although sponges lack internal organs, they do have a skeleton of sorts. This supporting structure is located within the middle layer of the sponge, embedded in the gel. The skeleton is usually composed of spicules shown in the upper left and bottom panels. Spicules are secreted by the amebocyte cells and can have a variety of shapes. They are composed of calcium carbonate or silica, depending on the species of sponge. Most sponges also have a network of the horny protein “spongin” as part of their skeletal structure and a few (such as bath sponges) have only spongin. The spongin matrix of a bath sponge is shown in the upper right panel.

**Placozoan:**

http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/placozoan.html

This strange animal is a Placozoan named *Trichoplax*. It was discovered in 1883 crawling on the glass side of a seawater aquarium in Austria. The animal is very flat, only three cell layers thick, but reaches a diameter of 2-3 mm. Note the lack of an internal cavity and the cilia that cover the body. The Placozoans have such a simple body plan that they were thought to be the larval stage of an unknown marine organism until they were seen producing eggs as an adult.

**Placozoan Locomotion:**

http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/placzoan_movie.html

Observe how this Placozoan changes shape as it glides along a surface. Placozoans eat algae growing in the salt water. They also have symbiotic bacteria within their middle cell layer. These unusual animals resemble sponges primarily in their simple structure and lack of true tissues or organs.
I. What are the kinds of sponges? (Page 4-5)

Live Glass Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/live_glass_sponge.html

This small glass sponge is attached to the shell of a scallop on the sea bottom.

Glass Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/glass_sponge.html

When a glass sponge has been cleaned and dried, only the skeleton remains. Note the intricate pattern formed by the fusion of silica spicules in this specimen.

Glass Spicules:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/glass_spicules.html

The image on the left contains a mass of shiny spicules from a glass sponge. A single spicule is shown on his right. Note that the spicule has 6 rays.

Calcareaous Spicules:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/calcareaous_spicules.html

This calcareaous sponge is shown before and after removing most of the living matter. In the right image, the calcium carbonate spicules are apparent. This species has a ring of long spicules surrounding the vent.

Calcareaous Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/calcareaous_sponge.html

Most calcareaous sponges are small and many, like the two shown here, have a tubular shape.

Tubular Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/tubular_sponges.html

These sponges are examples of the tubular or finger-like shape found in many siliceous sponges. The sponge on the left is commonly used in biology laboratories to study cell association. Its cells can be completely separated by passing pieces of the sponge through a mesh. If kept alive in a culture dish, the cells will slowly reassociate and form a new sponge. Only sponges are capable of this extreme form of regeneration.

Flattened Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/flatponge.html

Many siliceous sponges grow in a flattened form and spread over the surface of rocks, shells or other underwater objects.

Ball Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/ball_sponge.html

This Ball Sponge has a spherical shape and reaches a height of 10 cm. Its pores have unusual crater-like
openings.
Barrel Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/barrel_sponge.html

This barrel sponge is a good example of a very large siliceous sponge. It is said that scuba divers like to swim into the inside of these “barrels”.

Colorful Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/colorful_sponges.html

Sponges can assume an amazing variety of colors. The blue color of the sponge on the left is rare in invertebrate animals.

Encrusting Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/encrusting_sponges.html

Siliceous sponges are frequently found encrusting underwater objects. They may be easily seen at low tide as shown here.

Freshwater Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/freshwater_sponges.html

Freshwater sponges may be found in streams, lakes and ponds. They were once abundant, but are now less common due to pollution of their aquatic habitats. Sponges are especially sensitive to pollutants and their presence is a good indication of clean water. Freshwater sponges may grow in large mats, but more often occur as small masses on sticks, stones and other underwater objects. The sponge on the left is attached to a lead cat tail. The sponge on the right contains algae which accounts for its green color. This symbiotic relationship is common in freshwater sponges.

Elephant Ear Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/elephantear_sponge.html

This large horny sponge living on the sea bed is called the elephant’s ear.

Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/sponges.html

Well, here we have a variety of commercial sponges, but only one is a natural bath sponge. We humans have used the natural sponge model for some cheap, usually poor quality, imitations!

Bath Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/bath_sponges.html

Here are several types of natural sponge that are sold commercially. On the left are 3 fina silk sponges. On the right is a grass sponge and at the bottom a sponge called sea wool.

Live Bath Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/live_bath_sponge.html

This is a bath sponge that has just been removed from the water. It doesn’t look too appealing.

Dried Bath Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/bath_sponge_dried.html
As the bath sponge is dried, the surface changes in color and texture as seen at high magnification on the left. When cleaning and drying are complete, the spongin matrix of the sponge remains. So the sponge skeleton, on the right, is the commercial product.

II. Can sponges move? (Page 6)

Pore Contraction:  
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/pore_contraction.html

Openings into the sponge are formed by specialized cells that extend through the wall creating a pore. These cells can contract very slowly to close the pores. Such a response is usually due to changes in water quality. For example, an increase in water borne silt would stimulate pore closure thus protecting the sponge from becoming clogged with particulate matter.

Amebocytes:  
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/amebocytes.html

It is important to remember that amebocytes are highly mobile cells that can move easily through the gel comprising the middle layer of the sponge body wall. The collar cells on the inner layer can also move to a limited degree. This enables the water channels within the sponge to be remodeled as water currents and other environmental conditions change. We will return to the amebocytes later to see what other functions they perform.

V. How do sponges acquire and digest food? (Page 7)

Collar Cell:  
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/collar_cell.html

Sponges feed by filtering food particles from the incoming water current. Collar cells create the water flow by flagellar beating. As some of the water is drawn through tiny slits in the collar, food particles are filtered out and stick to the outer collar surface.

Phagocytosis of Food Particles:  
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/phagocytosis.html

Food particles on the collar slide down to the cell body and are engulfed by the collar cell. Food can also be captured by amebocytes which move inward to engulf particles lodged within the sponge canal. After capture, food particles are digested within the cells. Note that the collar cell may transfer food to the amebocytes before or after digestion.

Carniverous Sponge and Predators:  
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/carniverous_sponge.html

Well, there is an exception to everything. The sponge in the top panel is not a filter feeder, but actually captures prey. Sponges of this type live mainly in the deep ocean. They lack the internal system of water circulation that is typical of sponges and instead have long filaments bearing hooked spicules. Tiny animals, mainly crustaceans, become stuck to these spicules when they brush against them. Cells of the sponge then envelope and digest the prey.

It is much more common for sponges to be eaten by other marine animals. In the bottom panels we see two...
Common sponge predators, a sea star and brittle star, feeding on sponges.
V. How do sponges reproduce? (Page 8)

Budding Sponges:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/bud.html

Sponges often grow by branching as seen in the sponge on the left. These branches are often difficult to distinguish from asexual buds. The sponge on the right is clearly producing a bud.

Gemmule:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/gemmule.html

Gemmules form in freshwater sponges when conditions are harsh. A group of amebocytes congregate and form a protective covering strengthened with spicules. The released gemmules can survive conditions that kill the parent sponge, such as freezing. Thus, this type of asexual reproduction allows freshwater sponges to survive the winter.

Sponge Spawning:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/sponge_spawning.html

These two sponges are spawning by releasing a cloud of sperm through the vent. The sperm must enter another sponge of the same species for sexual reproduction to occur.

Egg Within Sponge:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/egg.html

Both sperm and eggs are formed within the gel of the sponge wall by transformation of another cell type.

Sponge Larva:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/larvae.html

Sponges, like all sessile animals, must send their offspring far enough away to avoid future competition. The sponge larva is a ball of cells bearing flagella. It swims to a new location, settles down and develops into a new sponge.

VI. Are sponges important to humans? (Page 9)

Sponge Fishing:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/sponge_fishing.html

Greek sponge fishers dive to bring up sponges from the sea floor. The living sponges are hung in the ship’s rigging until they die and decay. Further cleaning and drying is done ashore to prepare the fibrous sponge skeleton for market.

Island of Kalymnos:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/kalymnos.html

Today, the Greek fishing industry is centered on the island of Kalymnos.

The Sponge Industry:
Sponge fishing in the Caribbean still occurs around islands such as Barbados. Here, a Barbados worker is seen cleaning debris from the internal cavities of a bath sponge. The sponge industry remaining in the USA is centered in Tarpon Springs. Sponge growth here has been much reduced though, due to pollution of Tampa Bay and to physical damage by trawling.

**Sponge with No Predators:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/no_predators.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/no_predators.html)

This sponge has no observed predators. It contains a chemical that causes tubefoot retraction in the seastar, a major predator of other sponges. An extract from this sponge also has potent antibacterial, antifungal and anti-yeast activity.

**Bioerosion:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/bioerosion.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/bioerosion.html)

Some sponges attach to the shells of marine animals or underwater rock and excavate pits. A specialized type of sponge amebocyte removes small bits of shell which are ejected through the sponge vent with the outgoing water current. The pits in which the sponge lives provide some protection from predators. In this picture a yellow boring sponge is eroding a coralline rock.

**Sponge on Living Coral:**

While boring sponges perform a beneficial function in breaking down the skeleton of dead coral, sponges can also cause severe damage to living coral reefs. In the example shown here, an encrusting sponge has covered, and killed, part of a living coral.

**Boring Sponge:** [http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/mussel-borer.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/porifera/porifera_popups/mussel-borer.html)

In this picture, a boring sponge is living on a mussel shell. Most of the sponge is deep within the shell and only small projections of the sponge are visible. These projections are green due to the presence of symbiotic algae. This boring process is beneficial when returning the calcium of dead shells to the ocean, but a living mussel is often killed by the boring sponge.