



6



chapter s i x

Sponges *Phylum Porifera*



The Advent of Multicellularity

Sponges are the simplest multicellular animals. Because the cell is the elementary unit of life, organisms larger than unicellular protozoa arose as aggregates of such building units. Nature has experimented with producing larger organisms without cellular differentiation—certain large, single-celled marine algae, for example—but such examples are rarities. There are many advantages to multicellularity as opposed to simply increasing the mass of a single cell. Since it is at cell surfaces that metabolic exchange takes place, dividing a mass into smaller units greatly increases the surface area available for metabolic activities. It is impossible to maintain a workable surface-to-mass ratio by simply increasing the size of a single-celled organism. Thus, multicellularity is a highly adaptive path toward increasing body size.

Strangely, while sponges are multicellular, their organization is quite distinct from other metazoans. A sponge body is an assemblage of cells embedded in a gelatinous matrix and supported by a skeleton of minute needlelike spicules and protein. Because sponges neither look nor behave like other animals, it is understandable that they were not completely accepted as animals by zoologists until well into the nineteenth century. Nonetheless, molecular evidence suggests that sponges share a common ancestor with other metazoa.

A Caribbean demosponge,
Aplysina fistularis.

Sponges belong to phylum Porifera (po-rif'-er-a) (*L. poros*, pore, + *fera*, bearing). Sponges bear myriads of tiny pores and canals that constitute a filter-feeding system adequate for their inactive life habit. They are sessile animals and depend on water currents carried through their unique canal systems to bring them food and oxygen and to carry away their body wastes. Their bodies are little more than masses of cells embedded in a gelatinous matrix and stiffened by a skeleton of minute **spicules** of calcium carbonate or silica and collagen (p. 56). They have no organs or true tissues, and even their cells show a certain degree of independence. As sessile animals with only negligible body movement, they have not evolved a nervous system or sense organs and have only the simplest of contractile elements.

So, although they are multicellular, sponges share few of the characteristics of other metazoan phyla. For this reason they are often called Parazoa (*Gr. para*, beside or alongside of, + *zōon*, animal).

Sponges vary in size from a few millimeters to the great loggerhead sponges, which may reach 2 m or more across. Many sponge species are brightly colored because of pigments in their dermal cells. Red, yellow, orange, green, and purple sponges are not uncommon. However, color fades quickly when sponges are removed from water. Some sponges, including the simplest, are radially symmetrical, but many are quite irregular in shape. Some stand erect, some are branched or lobed, and others are low, even encrusting, in form (figure 6.1). Some bore holes into shells or rocks.

Sponges are an ancient group, with an abundant fossil record extending back to the early Cambrian period and even, according to some claims, the Precambrian. Living poriferans traditionally have been assigned to three classes: Calcarea (with calcareous spicules), Hexactinellida (six-rayed siliceous spicules), and Demospongiae (with a skeleton of siliceous

spicules or spongin [a specialized collagen] or both). A fourth class (Sclerospongiae) was created to contain sponges with a massive calcareous skeleton and siliceous spicules. Some zoologists maintain that known species of sclerosponges can be placed in the traditional classes of sponges (Calcarea and Demospongiae); thus, we do not need a new class.

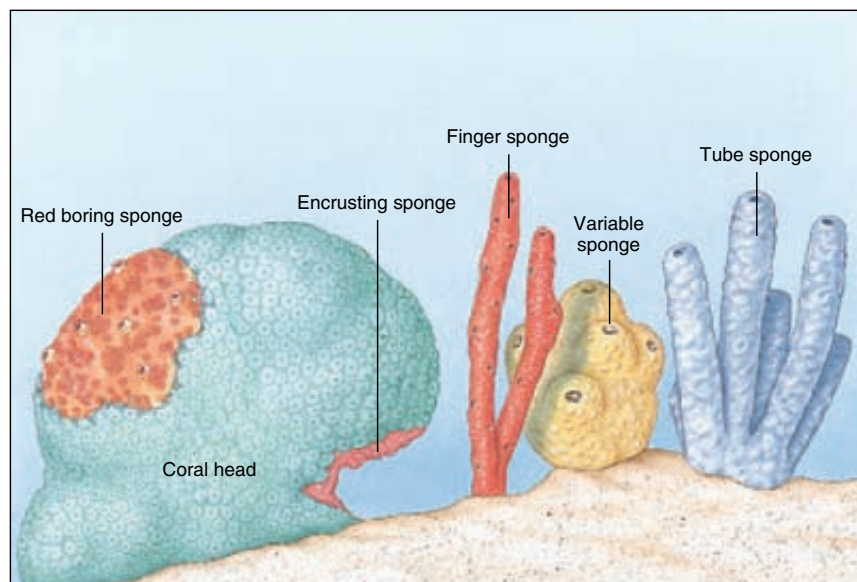
Ecological Relationships

Most of the 5000 or more sponge species are marine, although some 150 species live in fresh water. Marine sponges are abundant in all seas and at all depths, and a few even exist in brackish water. Although their embryos are free swimming, adults are always attached, usually to rocks, shells, corals, or other submerged objects (figure 6.2). Some bottom-dwelling forms even grow on sand or mud. Their growth patterns often depend on shape of the substratum, direction and speed of water currents, and availability of space, so that the same species may differ markedly in appearance under different environmental conditions. Sponges in calm waters may grow taller and straighter than those in rapidly moving waters.

Many animals (crabs, nudibranchs, mites, bryozoans, and fish) live as commensals or parasites in or on sponges. Larger sponges particularly tend to harbor a large variety of invertebrate commensals. On the other hand, sponges grow on many other living animals, such as molluscs, barnacles, brachiopods, corals, or hydroids. One sponge has been described that preys on shrimp. Some crabs attach pieces of sponge to their carapace for camouflage and for protection, since most predators seem to find sponges distasteful. Certainly one reason for the success of sponges as a group is that they have few enemies. Because of a sponge's elaborate skeletal framework and often noxious odor, most potential predators find sampling a sponge

figure 6.1

Some growth habits and forms of sponges.



position in animal kingdom

Multicellular organisms (metazoa) are typically divided into three grades: (1) Mesozoa (a single phylum), (2) Parazoa (phylum Porifera, sponges; and phylum Placozoa), and (3) Eumetazoa (all other phyla). Space limitations preclude covering the very small phyla Mesozoa and Placozoa in this text.

Although Mesozoa and Parazoa are multicellular, their plan of organization is distinct from that in the eumetazoan phyla. Such cellular layers as they possess are not homologous to the germ layers of the Eumetazoa, and neither group has developmental patterns resembling those of other metazoa. The name Parazoa means the “beside-animals.”

biological contributions

1. Although the simplest in organization of all metazoa, these groups do compose a higher level of morphological and physiological integration than that found in protozoan colonies. Mesozoa and Parazoa may be said to belong to a **cellular level of organization**.
2. Sponges (poriferans) have several types of cells differentiated for various functions, some of which

are organized into **incipient tissues** of a low level of integration.

3. Developmental patterns of poriferans are different from those of other phyla, and their embryonic layers are not homologous to the germ layers of Eumetazoa.
4. Sponges have developed a unique system of **water currents** on which they depend for food and oxygen.



figure 6.2

This orange demosponge, *Mycale laevis*, often grows beneath platelike colonies of the stony coral, *Montastrea annularis*. The large oscula of the sponge are seen at the edges of the plates. Unlike some other sponges, *Mycale* does not burrow into the coral skeleton and may actually protect the coral from invasion by more destructive species. Pinkish radioles of a Christmas tree worm, *Spirobranchus giganteus* (phylum Annelida, class Polychaeta), also project from the coral colony. An unidentified reddish sponge can also be seen further to the right of and below the Christmas tree worm.

about as pleasant as eating a mouthful of glass splinters embedded in evil-smelling gristle. Some reef fishes, however, do graze on shallow-water sponges.

Form and Function

The only body openings of these unusual animals are pores, usually many tiny ones called **ostia** for incoming water, and one to a few large ones called **oscula** (sing., **osculum**) for

water outlet. These openings are connected by a system of canals, some of which are lined with peculiar flagellated collar cells called **choanocytes**, whose flagella maintain a current of environmental water through the canals. Water enters the canals through a multitude of tiny incurrent pores (**dermal ostia**) and leaves by way of one or more large oscula. Choanocytes not only keep the water moving but also trap and phagocytize food particles that are carried in the water. Cells lining the passageways are very loosely organized. Collapse of the canals is prevented by the skeleton, which, depending on the species, may be composed of needlelike calcareous or siliceous spicules, a meshwork of organic spongin fibers, or a combination of the two.

Sessile, or almost sessile, animals make few movements and therefore need little in the way of nervous, sensory, or locomotor parts. Sponges apparently have been sessile from their earliest appearance and have never acquired specialized nervous or sensory structures, and they have only the very simplest of contractile systems.

Types of Canal Systems

Most sponges have one of three types of canal systems—**asconoid**, **syconoid**, or **leuconoid** (figure 6.3).

Asconoids—Flagellated Spongocoels

Asconoid sponges have the simplest organization. They are small and tube shaped. Water enters through microscopic dermal pores into a large cavity called a **spongocoel**, which is lined with choanocytes. Choanocyte flagella pull water through the pores and expel it through a single large osculum (figure 6.3). *Leucosolenia* (Gr. *leukos*, white, + *solen*, pipe) is an asconoid type of sponge. Its slender, tubular individuals

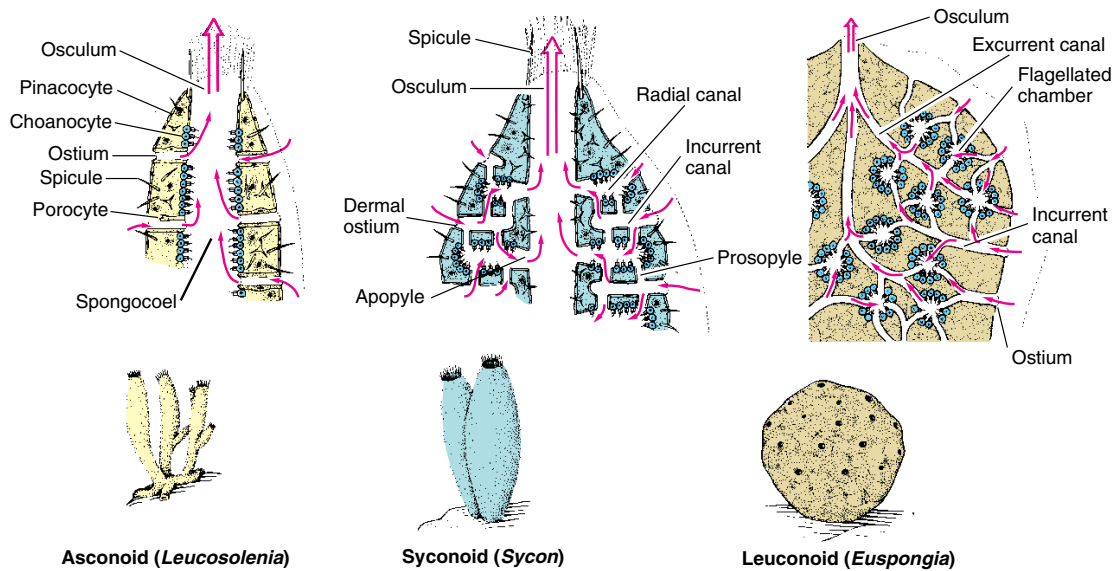


figure 6.3

Three types of canal systems. The degree of complexity from simple asconoid to complex leuconoid type has involved mainly the water canal and skeletal systems, accompanied by outfolding and branching of the collar-cell layer. The leuconoid type is considered the major plan for sponges because it permits greater size and more efficient water circulation.

characteristics of phylum porifera

1. Multicellular; body a loose aggregation of cells of mesenchymal origin
2. Body with **pores (ostia)**, **canals**, and **chambers** that serve for passage of water
3. All aquatic; mostly marine
4. Symmetry radial or none
5. **Epidermis of flat pinacocytes**; most interior surfaces lined with **flagellated collar cells (choanocytes)** that create water currents; a gelatinous protein matrix called mesohyl (mesoglea) contains amoebocytes, collencytes, and skeletal elements
6. Skeletal structure of **fibrillar collagen** (a protein) and **calcareous** or **siliceous crystalline spicules**, often combined with variously modified **collagen (spongin) fibrils**
7. No organs or true tissues; digestion intracellular; excretion and respiration by diffusion
8. Reactions to stimuli apparently local and independent; nervous system probably absent
9. All adults sessile and attached to substratum
10. Asexual reproduction by buds or gemmules and sexual reproduction by eggs and sperm; free-swimming ciliated larvae

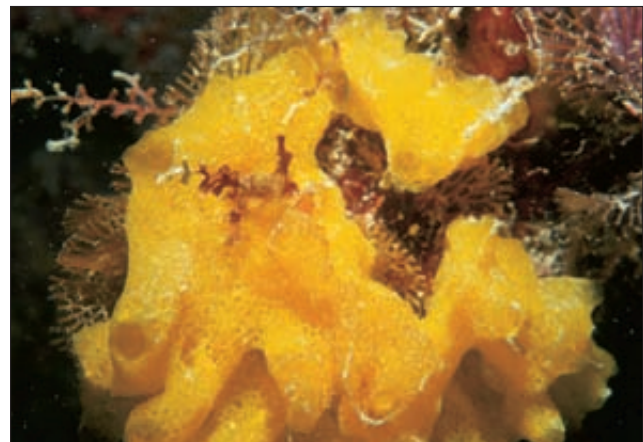


figure 6.4

Clathrina canariensis (class Calcarea) is common on Caribbean reefs in caves and under ledges.

grow in groups attached by a common **stolon**, or stem, to objects in shallow seawater. *Clathrina* (*L. clathri*, lattice work) is an asconoid with bright yellow, intertwined tubes (figure 6.4). Asconoids are found only in the Calcarea.

Syconoids—Flagellated Canals

Syconoid sponges look somewhat like larger editions of asconoids, from which they were derived. They have a tubular body and single osculum, but the body wall, which is thicker

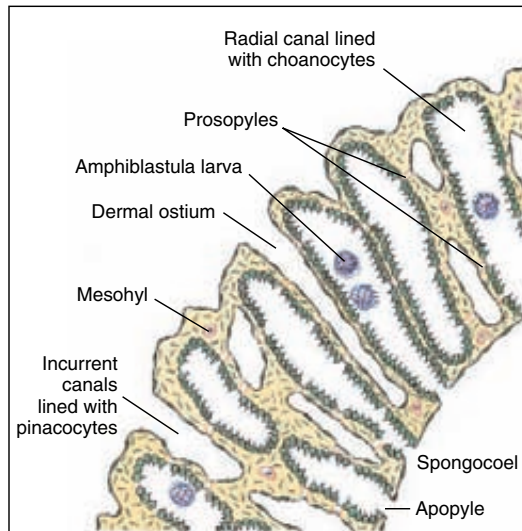


figure 6.5

Cross section through wall of sponge *Sycon*, showing canal system.

and more complex than that of asconoids, receives water through **incurrent canals** that deliver it to the choanocyte-lined **radial canals**, which empty into the spongocoel (figures 6.3 and 6.5). The spongocoel in syconoids is lined with epithelial-type cells, rather than choanocytes as found in asconoids. Syconoids are found in Calcareia. *Sycon* (Gr. *sykon*, a fig) is a commonly studied example of the syconoid type of sponge (figure 6.5).

Leuconoids—Flagellated Chambers

Leuconoid organization is the most complex of the sponge types and permits an increase in sponge size. Most leuconoids form large masses with numerous oscula (see figure 6.2). Clusters of flagellated chambers are filled from incurrent canals and discharge water into excurrent canals that eventually lead to the osculum (see figure 6.3). Most sponges are of the leuconoid type, which occurs in most Calcareia and in all other classes.

These three types of canal systems—asconoid, syconoid, and leuconoid—demonstrate an increase in complexity and efficiency of the water-pumping system, but they do not imply an evolutionary or developmental sequence. The leuconoid grade of construction has evolved independently many times in sponges. Possession of a leuconoid plan is of clear adaptive value; it increases the proportion of flagellated surfaces compared with the volume, thus providing more collar cells to meet food demands.

Types of Cells

Sponge cells are loosely arranged in a gelatinous matrix called **mesohyl** (also called mesoglea, or mesenchyme) (figure 6.6).

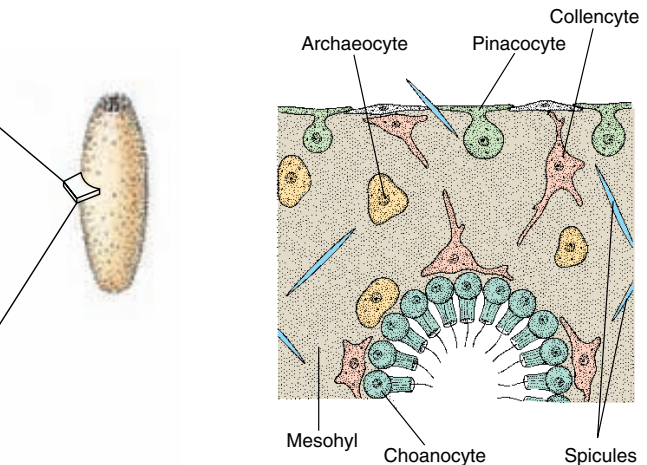


figure 6.6

Small section through sponge wall, showing four types of sponge cells. Pinacocytes are protective and contractile; choanocytes create water currents and engulf food particles; archaeocytes have a variety of functions, including phagocytosis of food particles and differentiation into other cell types; collencytes appear to have a contractile function.

The mesohyl is the “connective tissue” of the sponges; in it are found various ameboid cells, fibrils, and skeletal elements. Several types of cells occur in sponges.

Pinacocytes

The nearest approach to a true tissue in sponges is arrangement of the **pinacocyte** (figure 6.6) cells of the external epithelium. These are thin, flat, epithelial-type cells that cover the exterior surface and some interior surfaces. Some are T-shaped, with their cell bodies extending into the mesohyl. Pinacocytes are somewhat contractile and help regulate the surface area of the sponge. Some pinacocytes are modified as contractile **myocytes**, which are usually arranged in circular bands around the oscula or pores, where they help regulate the rate of water flow. Myocytes contain microfilaments similar to those found in muscle cells of other animals.

Porocytes

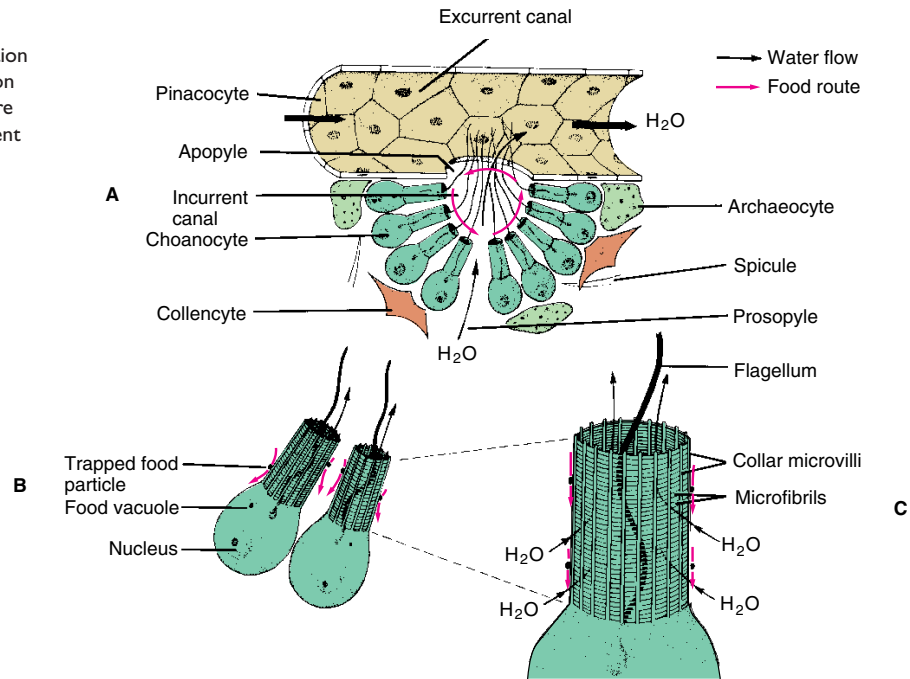
Tubular cells that pierce the wall of asconoid sponges, through which water flows, are called **porocytes** (see figure 6.3).

Choanocytes

Choanocytes, which line flagellated canals and chambers, are ovoid cells with one end embedded in mesohyl and the other exposed. The exposed end bears a flagellum surrounded by a collar (figures 6.6 and 6.7). Electron microscopy shows that the collar is made up of adjacent microvilli, connected to each other by delicate microfibrils, so that the collar forms a fine filtering device for straining food particles from the water (figure

figure 6.7

Food trapping by sponge cells. **A**, Cutaway section of canals showing cellular structure and direction of water flow. **B**, Two choanocytes. **C**, Structure of the collar. Small red arrows indicate movement of food particles.



6.7B and C). The beat of a flagellum pulls water through the sievelike collar and forces it out through the open top of the collar. Particles too large to enter the collar become trapped in secreted mucus and slide down the collar to the base where they are phagocytized by the cell body. Larger particles have already been screened out by the small size of the dermal pores and prosopyles. Food engulfed by the cells is passed on to a neighboring archaeocyte for digestion.

Archaeocytes

Archaeocytes are ameboid cells that move about in the mesohyl (see figure 6.6) and carry out a number of functions. They can phagocytize particles at the external epithelium and receive particles for digestion from choanocytes. Archaeocytes apparently can differentiate into any of the other types of more specialized cells in the sponge. Some, called **sclerocytes**, secrete spicules. Others, called **spongocytes**, secrete the spongin fibers of the skeleton, and **collencytes** secrete fibrillar collagen.

Types of Skeletons

Its skeleton gives support to a sponge, preventing collapse of canals and chambers. The major structural protein in the animal kingdom is collagen, and fibrils of collagen are found throughout the intercellular matrix of all sponges. In addition, various Demospongiae secrete a form of collagen traditionally known as spongin. Demospongiae also secrete siliceous spicules. Calcareous sponges secrete spicules composed mostly of crystalline calcium carbonate that have one, three, or four rays (figure 6.8).

Glass sponges have siliceous spicules with six rays arranged in three planes at right angles to each other. There are many variations in the shape of spicules, and these structural variations are of taxonomic importance.

Sponge Physiology

Sponges feed primarily on particles suspended in water pumped through their canal systems. Detritus particles, planktonic organisms, and bacteria are consumed nonselectively in the size range from 50 μm (average diameter of ostia) to 0.1 μm (width of spaces between the microvilli of the choanocyte collar). Pinacocytes may phagocytize particles at the surface, but most larger particles are consumed in the canals by archaeocytes that move close to the lining of the canals. The smallest particles, accounting for about 80% of the particulate organic carbon, are phagocytized by choanocytes. Digestion is entirely **intracellular** (occurs within cells), a chore performed by the archaeocytes.

Sponges consume a significant portion of their nutrients in the form of organic matter dissolved in water circulating through the system. Such material is apparently taken up by pinocytosis (or potocytosis).

There are no respiratory or excretory organs; these functions are performed by diffusion. Contractile vacuoles have been found in archaeocytes and choanocytes of freshwater sponges.

All life activities of the sponge depend on the current of water flowing through the body. A sponge pumps a remarkable amount of water. Some large sponges can filter 1500 liters of water a day. At least some sponges can crawl (move laterally

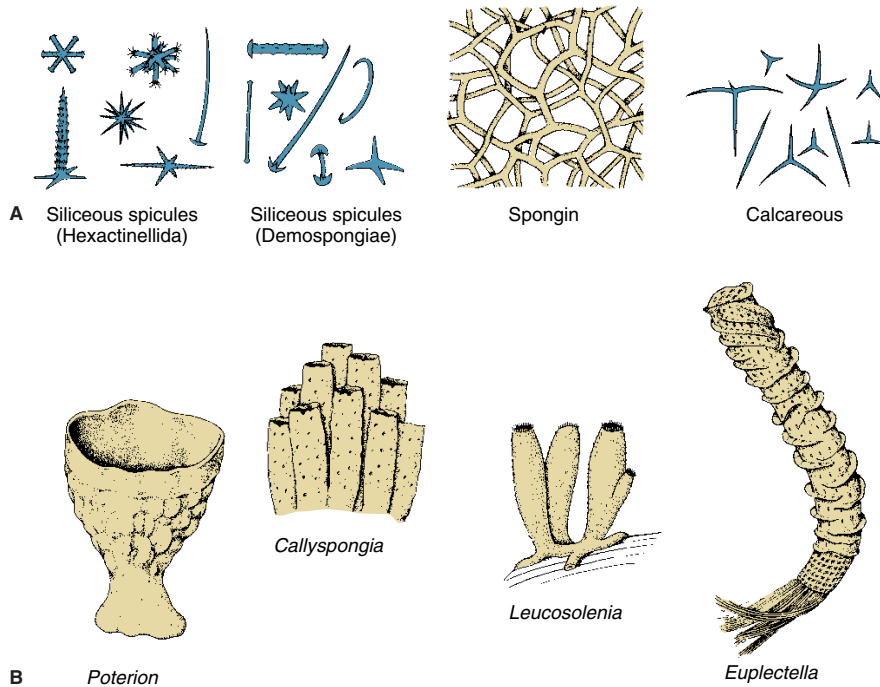


figure 6.8

A, Types of spicules found in sponges. There is amazing diversity, beauty, and complexity of form among the many types of spicules. **B**, Some examples of sponge body forms.

over their supporting substratum) at speeds of up to 4 mm per day. This ability may give them an advantage over more sessile encrusting organisms in competition for space.

Reproduction and Development

All sponges are capable of both sexual and asexual reproduction. In **sexual reproduction** most sponges are **monoecious** (have both male and female sex cells in one individual). Sperm arise from transformation of choanocytes. In Calcarea and at least some Demospongiae, oocytes also develop from choanocytes; in other demosponges oocytes apparently are derived from archaeocytes. Sperm are released into the water by one individual and are taken into the canal system of another. There choanocytes phagocytize them, then transform into carrier cells and carry the sperm through the mesohyl to the oocytes.

Other sponges are oviparous, and both oocytes and sperm are expelled free into the water. The free-swimming larva of most sponges is a solid-bodied **parenchymula** (figure 6.9). The outwardly directed, flagellated cells migrate to the interior after the larva settles and become the choanocytes in the flagellated chambers. In sexual reproduction ova are fertilized by motile sperm in the mesohyl; there the zygotes develop into flagellated larvae, which break loose and are carried away by water currents.

The loose organization of sponges is ideally suited for regeneration of injured and lost parts, and for asexual reproduction. Sponges reproduce asexually by forming external buds that detach or remain to form colonies. In addition to external buds, which all sponges can form, freshwater sponges and some marine sponges reproduce asexually by the regular formation of internal buds called **gemmules** (figure 6.10). These dormant masses of encapsulated archaeocytes are produced

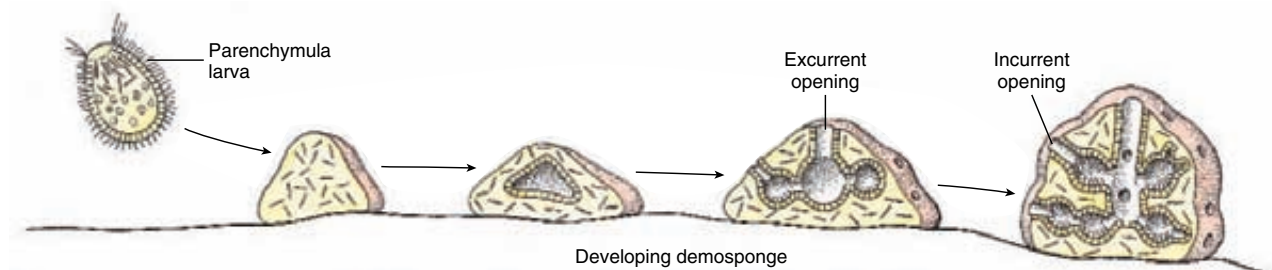


figure 6.9

Development of demosponges.

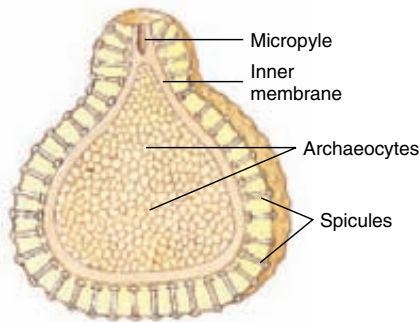


figure 6.10

Section through a gemmule of a freshwater sponge (Spongillidae). Gemmules are a mechanism for survival of the harsh conditions of winter. On return of favorable conditions, the archaeocytes exit through the micropyle to form a new sponge. The archaeocytes of the gemmule give rise to all cell types of the new sponge.

during unfavorable conditions. They can survive periods of drought and freezing and more than three months in the absence of oxygen. Later, with the return of favorable conditions for growth, archaeocytes in the gemmules escape and develop into new sponges.

Brief Survey of Sponges

Class Calcarea (Calcispongiae)

Calcarea are calcareous sponges, so called because their spicules are composed of calcium carbonate. Spicules are straight monaxons or have three or four rays (see figure 6.8A). The sponges tend to be small—10 cm or less in height—and tubular or vase shaped. They may be asconoid, syconoid, or leuconoid in structure. Although many are drab, some are bright yellow, red, green, or lavender. *Leucosolenia*, *Clatrina* (see figure 6.4), and *Sycon* are common examples.

Class Hexactinellida (Hyalospongiae)

Glass sponges are nearly all deep-sea forms. Most are radially symmetrical and range from 7 to 10 cm to more than 1 m in length. One distinguishing feature, reflected in the class name, is the skeleton of six-rayed siliceous spicules bound together in an exquisite glasslike latticework (see figure 6.8A).

Their tissue structure differs so dramatically from other sponges that some scientists advocate placing hexactinellids in a subphylum separate from other sponges. The body of hexactinellids is composed of a single, continuous syncytial tissue called a **trabecular reticulum**. The trabecular reticulum is the largest, continuous syncytial tissue known in Metazoa. It is bilayered and encloses a thin, collagenous mesohyl between the layers, as well as cellular elements such as archaeocytes, sclerocytes, and **choanoblasts**. Choanoblasts are associated with flagellated chambers, where the layers of the trabecular

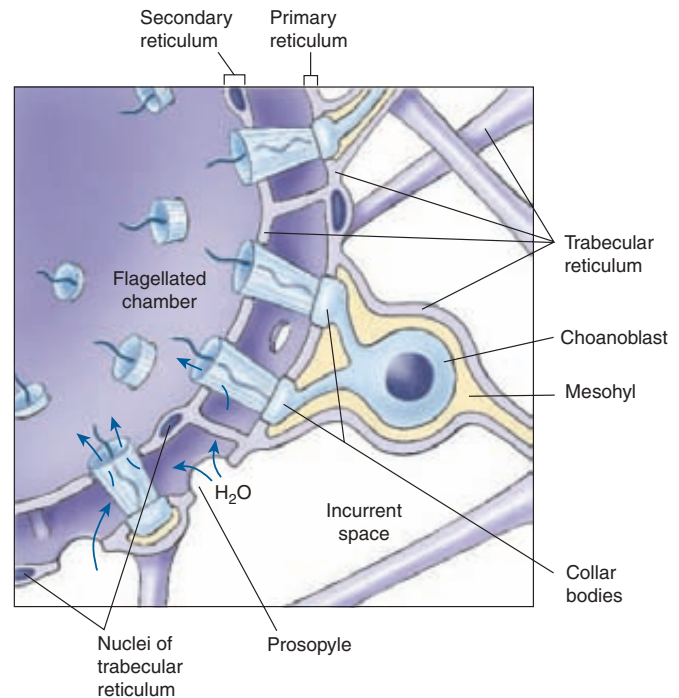


figure 6.11

Diagram of part of a flagellated chamber of hexactinellids. The primary and secondary reticula are branches of the trabecular reticulum, which is syncytial. Cell bodies of the choanoblasts and their processes are borne by the primary reticulum and are embedded in a thin, collagenous mesohyl. Processes of the choanoblasts end in collar bodies, whose collars extend up through the secondary reticulum. Flagellar action propels water (arrows) to be filtered through the mesh of collar microvilli.

reticulum separate into a **primary reticulum** (incurrent side) and a **secondary reticulum** (excurrent, or atrial side) (figure 6.11). The spherical choanoblasts are borne by the primary reticulum, and each choanoblast has one or more processes extending to **collar bodies**, the bases of which are also supported by the primary reticulum. Each collar and flagellum extends into the flagellated chamber through an opening in the secondary reticulum. Water is drawn into the space between primary and secondary reticula through prosopyles in the primary reticulum, then through the collars into the lumen of the flagellated chamber. Collar bodies do not participate in phagocytosis, but rather that process is accomplished by the primary and secondary reticula.

The latticelike network of spicules found in many glass sponges is of exquisite beauty, such as that of *Euplectella* (NL. from Gr. *eupлектos*, well-plaited), a classic example of Hexactinellida.

Class Demospongiae

Demospongiae comprise approximately 80% of all sponge species, including most larger sponges. Their skeletons may be of siliceous spicules, spongin fibers, or both. All members of



A



B



C

figure 6.12

Marine Demospongiae on Caribbean coral reefs. **A**, *Pseudoceratina crassa* is a colorful sponge growing at moderate depths. **B**, *Ectyoplasia ferox* is irregular in shape and its oscula form small, volcano-like cones. It is toxic and may cause skin irritation if touched. **C**, *Monanchora unguifera* with commensal brittle star, *Ophiothrix suensoni* (phylum Echinodermata, class Ophiuroidea).

the class are leuconoid, and all are marine except one family, the freshwater Spongillidae. Freshwater sponges are widely distributed in well-oxygenated ponds and streams, where they are found encrusting plant stems and old pieces of submerged wood. They resemble a bit of wrinkled scum, pitted with pores, and are brownish or greenish in color. Freshwater sponges die and disintegrate in late autumn, leaving gemmules to survive the winter.

Marine Demospongiae are varied in both color and shape. Some are encrusting; some are tall and fingerlike; and some are shaped like fans, vases, cushions, or balls (figure 6.12). Some sponges bore into and excavate molluscan shells and coral skeletons. Loggerhead sponges may grow several meters in diameter. So-called bath sponges belong to the group called horny sponges, which have only spongin skeletons. They can be cultured by cutting out pieces of the individual sponges, fastening them to a weight, and dropping them into the proper water conditions. It takes many years for them to grow to market size. Most commercial “sponges” now on the market are synthetic, but the harvest and use of bath sponges persist.

Phylogeny and Adaptive Radiation

Phylogeny

Sponges originated before the Cambrian period. Two groups of calcareous sponglike organisms occupied early Paleozoic

reefs. The Devonian period saw rapid development of many glass sponges. The possibility that sponges arose from choanoflagellates (protozoa that bear collars and flagella) earned support for a time. However, many zoologists object to that hypothesis because sponges do not acquire collars until later in their embryological development. The outer cells of the larvae are flagellated but not collared, and they do not become collar cells until they become internal. Also, collar cells are found in certain corals and echinoderms, so they are not unique to the sponges.

However, these objections are countered by evidence based on the sequences of ribosomal RNA. This evidence supports the hypothesis of a common ancestor for choanoflagellates and metazoans. It suggests also that sponges and Eumetazoa are sister groups, with Porifera having split off before the origin of the radiates and placozoans, but sharing a common ancestor.

Adaptive Radiation

Porifera are a highly successful group that includes several thousand species and a variety of marine and freshwater habitats. Their diversification centers largely on their unique water-current system and its various degrees of complexity. Proliferation of flagellated chambers in leuconoid sponges was more favorable to an increase in body size than that of asconoid and syconoid sponges because facilities for feeding and gaseous exchange were greatly enlarged.

classification of phylum porifera

Class Calcarea (cal-ca´re-a) (L. *calcis*, lime, + Gr. *spongos*, sponge) (**Calcispongiae**). Have spicules of calcium carbonate that often form a fringe around the osculum; spicules needle-shaped or three- or four-rayed; all three types of canal systems (asconoid, syconoid, leuconoid) represented; all marine. Examples: *Sycon*, *Leucosolenia*, *Clatrina*.

Class Hexactinellida (hex-ak-tin-el´i-da) (Gr. *bex*, six, + *aktis*, ray) (**Hyalospongiae**). Have six-rayed, siliceous spicules extending at right angles from a central point; spicules often united to form network; body often cylindri-

cal or funnel shaped. Flagellated chambers in simple syconoid or leuconoid arrangement. Habitat mostly deep water; all marine. Examples: Venus' flower basket (*Euplectella*), *Hyalonema*.

Class Demospongiae (de-mo-spun´je-e) (tolerated misspelling of Gr. *desmos*, chain, tie, bond, + *spongos*, sponge). Have skeleton of siliceous spicules that are not six-rayed, or spongin, or both. Leuconoid-type canal systems. One family found in fresh water; all others marine. Examples: *Thenea*, *Cliona*, *Spongilla*, *Myenia*, and all bath sponges.

summary

Sponges (phylum Porifera) are an abundant marine group with some freshwater representatives. They have various specialized cells, but these cells are not organized into tissues or organs. They depend on the flagellar beat of their choanocytes to circulate water through their bodies for gathering food and exchange of respiratory gases. They are supported by secreted skeletons of fibrillar collagen, colla-

gen in the form of large fibers or filaments (spongin), calcareous or siliceous spicules, or a combination of spicules and spongin in most species.

Sponges reproduce asexually by budding, fragmentation, and gemmules (internal buds). Most sponges are monoecious but produce sperm and oocytes at different times. Embryogenesis is unusual, with a migration of

flagellated cells at the surface to the interior (parenchymella). Sponges have great regenerative abilities.

Sponges are an ancient group, remote phylogenetically from other metazoa, but molecular evidence suggests that they are the sister group to Eumetazoa. Their adaptive radiation is centered on elaboration of the water circulation and filter-feeding system.

review questions

1. Give six characteristics of sponges.
2. Briefly describe asconoid, syconoid, and leuconoid body types in sponges.
3. What sponge body type is most efficient and makes possible the largest body size?
4. Define the following: ostia, osculum, spongocel, mesohyl.
5. Define the following: pinacocytes, choanocytes, archaeocytes, sclerocytes, collencytes.
6. What material is found in the skeleton of all sponges?
7. Describe the skeletons of each of the classes of sponges.
8. Describe how sponges feed, respire, and excrete.
9. What is a gemmule?
10. Describe how gametes are produced and the process of fertilization in most sponges.
11. What is the largest class of sponges, and what is its body type?
12. What are possible ancestors to sponges? Justify your answer.
13. It has been suggested that despite being large, multicellular animals, sponges function more like protozoa. What aspects of sponge biology support this statement and how? Consider, for example, nutrition, reproduction, gas exchange, and cellular organization.

selected references

See also general references on page 406.

Bergquist, P. R. 1978. Sponges. Berkeley, California, University of California Press.

Excellent monograph on sponge structure, classification, evolution, and general biology.

Bond, C. 1997. Keeping up with the sponges.

Nat. Hist. **106**:22–25. *Sponges are not fixed in permanent position; they can crawl on their substrate. Haliclona loosanoffi can move over 4 mm/day.*

Gould, S. J. 1995. Reversing established orders. Nat. Hist. **104**(9):12–16.

Describes several anomalous animal relationships, including the sponge that preys on shrimp.

Leys, S. P. 1999. The choanosome of hexactinellid sponges. Invert. Biol. **118**: 221–235. *Choanosomes are flagellated chambers and associated tissues. This author supports the position that Hexactinellida should constitute a separate subphylum. She includes an excellent description of trabecular reticulum.*

Reiswig, H. M., and T. L. Miller. 1998. Freshwater sponge gemmules survive months of anoxia. Invert. Biol. **117**:1–8. *Hatchability of gemmules kept in the absence of oxygen was equal to controls, but they would not hatch unless oxygen was present.*

Wood, R. 1990. Reef-building sponges. Am. Sci. **78**:224–235. *The author presents evidence that the known sclerosponges belong to either the Calcarea or the Demospongiae and that a separate class Sclerospongiae is not needed.*

Wyeth, R. C. 1999. Video and electron microscopy of particle feeding in sandwich cultures of the hexactinellid sponge, *Rhabdocalypus dawsoni*. Invert. Biol. **118**:236–242. *Phagocytosis is not by choanoblasts but by trabecular reticulum, especially primary reticulum. He places Hexactinellida in subphylum Symplasma and the rest of Porifera in subphylum Cellularia.*

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