6 Simple Marine Animals

When you have completed this chapter, you should be able to:

DISCUSS nutrients and the digestion of food by animals.
EXPLAIN the importance of zooplankton in marine food chains.
DESCRIBE the three groups of protozoans and their life functions.
COMPARE and CONTRAST the sponges, rotifers, and bryozoans.

Look at the ocean scene shown above. Here, corals, sponges, sea urchins, fish, lobsters, and feather worms all live in a small area of the ocean. What do these organisms have in common? They are all animals. What is an animal? In general, an animal is a multicellular organism that consumes food and is able to move. There are at least 1 million species of animals on Earth. More than 100,000 of these animal species are known to inhabit the world’s oceans.

Along with the animals, there are marine creatures so small that you need a microscope to see them. Many of these microscopic organisms are unicellular. At one time, they were placed in the animal kingdom, along with the multicellular animals. Today, scientists place most unicellular animal-like organisms in the protist kingdom. In this chapter, you will continue your study of life in the sea as you meet the unicellular protists and some multicellular “simple” animals.

6.1 Nutrition in Animals
6.2 Zooplankton in the Sea
6.3 Protozoans
6.4 Sponges, Rotifers, and Bryozoans
Fish swim, snails crawl, worms burrow, and whales dive. These are only a few of the many activities that marine animals perform in their daily struggle for survival. Animals use energy to carry out these tasks, and they get the energy they need from food. The process by which organisms use food to perform their life activities is called nutrition.

Animals, unlike green plants and algae, cannot make their own food. Therefore, animals must take in food in order to satisfy their energy needs. Food contains useful chemical compounds called nutrients. The basic nutrients needed by animals to survive are sugars, starches, proteins, fats, minerals, vitamins, and water. The process by which animals break down and utilize these nutrients is called metabolism. As discussed in Chapter 4, the consumption of food by organisms is called heterotrophic nutrition; thus, animals are heterotrophs.

## Carbohydrates

Two nutrients that animals are able to derive energy from quickly are sugars and starches. Sugars and starches comprise the carbohydrates, compounds that contain the elements carbon, hydrogen, and oxygen in definite proportions. The molecular formula for the simple sugar glucose is \( \text{C}_6\text{H}_{12}\text{O}_6 \). That means there are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms in a molecule of glucose. Notice that the ratio of hydrogen atoms to oxygen atoms is the same as the ratio of hydrogen to oxygen found in water, that is, 2:1. You can see how carbohydrates got their name, for they can be considered “hydrated carbons.” The energy in glucose is found in the carbon–hydrogen bonds. A compound like glucose that contains the element carbon is classified as an organic compound.

When glucose is not being used in the body, it is changed into and stored as a starch. The chemical reaction by which glucose is changed into starch is called dehydration synthesis. During dehydration synthesis, one oxygen and two hydrogen atoms are removed from two glucose molecules, thus forming one molecule of water and one molecule of maltose. This reaction is as follows:
C₆H₁₂O₆ + C₆H₁₂O₆ → C₁₂H₂₂O₁₁ + H₂O

Glucose    Glucose    Maltose    Water

Glucose, a single sugar, is a monosaccharide. Maltose contains two glucose units, so it is a double sugar, or disaccharide. Double sugars have the formula C₁₂H₂₂O₁₁. Starch is produced when maltose combines with other glucose molecules. Thus, starch is a polysaccharide (meaning “many sugars”), because it contains a long chain of glucose units. The simplest formula for starch is (C₆H₁₀O₅)ₙ, where n represents the number of glucose units.

Starches can be changed back into molecules of glucose when an animal needs energy. The chemical reaction that changes starch back into glucose is called hydrolysis. During hydrolysis, the larger starch molecule is changed into smaller glucose molecules by the addition of water. Hydrolysis, a breaking-down process, occurs when food is digested. Energy comes from the breaking of chemical bonds. Dehydration synthesis, a building-up process, occurs during growth. Living cells carry out these important chemical reactions to satisfy their growth and energy needs. Notice that dehydration synthesis and hydrolysis are opposite chemical reactions.

Chemical reactions in living things cannot occur without enzymes. An enzyme is a protein (see section below) that regulates the speed of a chemical reaction without itself being changed. For example, the enzyme maltase aids the breakdown (hydrolysis) of the double sugar maltose into two units of the simple sugar glucose. The reaction is as follows:

\[
\text{maltase}
\]

C₁₂H₂₂O₁₁ + H₂O → C₆H₁₂O₆ + C₆H₁₂O₆

Maltose    Water    Glucose    Glucose

During hydrolysis, large molecules are acted on by enzymes and changed into small molecules, as follows: proteins, via protease, to amino acids; lipids, via lipase, to fatty acids and glycerol; and starch, via amylase, to glucose. Enzymes are also called organic catalysts.

**Lipids**

The high-energy nutrients known as fats and oils are called lipids. Unlike the 2:1 ratio in carbohydrates, the ratio of hydrogen atoms to oxygen atoms in lipids varies. Compare the formula for a lipid
molecule such as castor oil, \( \text{C}_{18}\text{H}_{34}\text{O}_3 \), with that of a carbohydrate molecule such as glucose, \( \text{C}_6\text{H}_{12}\text{O}_6 \). Which has more energy? Recall that energy is found in the carbon–hydrogen bonds. Notice that there are many more carbon–hydrogen bonds in a fat molecule than in a carbohydrate molecule. Because of its greater number of carbon–hydrogen bonds, a molecule of fat contains more energy than does a carbohydrate molecule. During hydrolysis, the carbon–hydrogen bonds in fats are broken and energy is released.

### Proteins

Living things need proteins for the growth and repair of their cells. Proteins are composed of smaller “building blocks” called amino acids. There are 20 different amino acids. Each amino acid molecule has an amino group (\( \text{NH}_2 \)) at one end and a carboxyl group (\( \text{COOH} \)) at the other end. Amino acids differ from one another based on structural differences in their “R (radical) groups.” Growth occurs by the process of dehydration synthesis, when amino acids join together inside the cell to make the proteins. When two amino acids join, they form a dipeptide; when more amino acids join, they form a polypeptide. (*Note*: Enzymes aid in dehydration synthesis, just as they do in hydrolysis.) The reaction that forms a dipeptide from two amino acids is as follows:

\[
\text{R–H–N–C–C–OH} + \text{R–H–N–C–C–OH} \rightarrow \text{R–H–N–C–C–N–C–C–OH} + \text{H}_2\text{O}
\]

### Minerals

Minerals are elements and compounds found in water and soil that do not contain the element carbon. Chemical substances that do not contain carbon are considered to be inorganic. Thus, the mineral known as table salt (\( \text{NaCl} \)) is a type of inorganic compound.

All living things require minerals for their normal growth and health. Marine plants absorb the minerals they need from water.
Animals that eat plants incorporate the plants’ minerals into their body tissues. The mineral calcium is needed for the growth of bones and teeth. Iron is found in red blood cells and is used to carry oxygen to, and carbon dioxide away from, cells. The muscles and nerves of animals require sodium and chloride ions to function. Phosphorus is an essential element in ATP, the energy compound, and in DNA, the genetic material. Another mineral, silica, the main ingredient in glass, is found in the cell walls of diatoms. Seafoods are rich in iodine, a mineral found in thyroxin, the hormone that regulates growth and metabolism in vertebrates.

**Vitamins**

Vitamins are organic compounds that are needed, in small amounts, to maintain good health. They aid in the functioning of enzymes. Vitamin C, found in fresh fruits and vegetables, is needed to prevent the vitamin deficiency disease called scurvy. Vitamin D, necessary for healthy bone growth, is produced in small amounts in marine mammals when ultraviolet light reacts with the fat located just under their skin. Marine plants are a rich source of other vitamins, including vitamins A, E, K, and the B vitamins.

**Water**

Water (H₂O), an inorganic compound, is the most abundant nutrient in the body. About 80 percent of an organism’s body weight is water. However, the exact amount of water in different organisms varies. For example, the human body is about 67 percent water, while jellyfish are about 95 percent water. Body fluids such as blood, lymph, sweat, and tears are made up almost entirely of water. Water takes part in important chemical reactions such as photosynthesis and hydrolysis. In addition, water contains and transports many dissolved and suspended substances within the bodies of organisms.

**6.1 Section Review**

1. Why are dehydration synthesis and hydrolysis necessary processes for living things?
2. Discuss the importance of minerals for animal nutrition.
3. Describe the role of water in living things.

6.2 ZOOPLANKTON IN THE SEA

Animals and animal-like organisms that float and drift on the ocean surface are considered to be part of the plankton population. (Remember that plankton means “wanderers.” The name is used because large masses of plankton are carried great distances by ocean currents.) Plankton include the unicellular protists and multicellular organisms such as the jellyfish. The plantlike plankton, which contain chlorophyll, are referred to as phytoplankton. The animal and animal-like plankton are called zooplankton. This category describes the organisms’ lifestyle; it does not represent a true taxonomic grouping.

Zooplankton vary in size. The jellyfish are the largest of the plankton species (see Chapter 7). However, most plankton species are microscopic. You can catch plankton by dragging a plankton net through the water. The best time for a field trip to net plankton is in the spring and early summer, when the longer days cause a rapid increase in plankton populations. By doing the lab investigation at the end of this chapter, you will learn that there are many different kinds of plankton that can be discovered from a plankton tow at the shore.

Zooplankton Diversity

Zooplankton are so varied that they are divided into two groups: the temporary zooplankton and the permanent zooplankton. The temporary zooplankton (also called meroplankton) are the embryos or larvae of fish, crabs, sponges, lobsters, clams, and other invertebrates. (See Figure 6-1.) These animals spend the early part of their life cycle floating and drifting near the surface of the ocean. When they mature, the temporary zooplankton settle to the bottom, where they develop into adults. As adults, they are no longer considered to be part of the plankton population.
The permanent zooplankton are those species that remain in the plankton population throughout their entire life cycle. (See Figure 6-2.) The foraminiferan (meaning “hole-bearing”), or foram for short, is a unicellular protist. Forams are encased in a shell, or test, made up of calcium carbonate (CaCO₃). Parts of a foram’s cytoplasm flow out through holes, or pores, in the shell and form a sticky surface for catching food. When a foram dies, its shell falls to the seafloor. Over many years, sediments of these shells accumulate, forming thick chalk deposits. Sometimes these seafloor deposits are lifted up to Earth’s surface. Chalk deposits in Georgia and Mississippi, and the white cliffs of Dover, in England, are examples of sediments formed mostly from the shells of forams.

Another type of permanent zooplankton is the radiolarian. The
unicellular radiolarian is transparent because its cell wall (like that of a diatom) is composed of silica. Notice the shapes of the radiolarians. Long spines branch out from a radiolarian’s body, like the spokes of a wheel, for added buoyancy and protection.

Of all the permanent zooplankton, the copepod is the most numerous. This tiny shrimplike animal, the size of a grain of sand, feeds on phytoplankton such as diatoms. In turn, the copepod is eaten by larger zooplankton, small fish, and whales. Thus, the copepod is an important link in many marine food chains.

Sea Soup

As noted above, for sea creatures ranging from the smallest of fish to the largest of whales, plankton is an important food source. In some ways, the ocean can be thought of as a thin soup, with plankton as the food particles suspended in it. Several species of whales feed by plowing through the water with their mouths open. The plankton are filtered out as water is forced from the whale’s mouth through huge fringed plates. Animals that strain their food from the water are called filter feeders. In the Antarctic, whales feed on large schools of shrimplike zooplankton called krill. The krill, which are only 4 to 5 cm long, are being considered as a potential food source for humans.

Bottom-dwelling mollusks living in shallow waters, such as mussels, clams, oysters, and scallops, depend on plankton as their main food source. These animals also filter plankton from the water. In the case of clams (and other bivalves), cells on the inside of the animal contain microscopic hairs called cilia. The cilia beat back and forth, causing currents of water to enter and leave the clam. In this way, the clam filters food out of the water as it passes through its body. Other invertebrates, such as shrimp, also feed on plankton.

Some newly hatched small fish that have used up the food supply in their yolk sac feed directly on plankton until they are large enough to eat other organisms. Larger fish and other animals, including humans, depend indirectly on plankton as a food source. In a marine food chain, each organism serves as food for another. However, the plankton form the foundation of it all. (See Chapter 21 for more information on marine food chains and food webs.)
6.2 SECTION REVIEW

1. How does a whale feed on zooplankton?
2. Describe how filter-feeding mollusks obtain their food.
3. Discuss and illustrate the role of plankton in a marine food chain.

6.3 PROTOZOA NS

Marine creatures can be found living anywhere from the ocean’s surface to its bottom. You learned that plankton are usually found near the surface. Zooplankton such as forams and radiolarians are both members of the larger group of unicellular animal-like organisms called protozoa. Thousands of species of protozoans are found living on the surface of marine substrates and in the bottom sediments. These one-celled organisms are classified within the protist kingdom, along with the algae. The protozoa are subdivided into three major groups: the Ciliophora, Zoomastigina, and Sarcodina.

The Ciliophora are the largest group of protozoa, composed of thousands of freshwater and marine species, all having cilia. Most members of this phylum, such as the *Spirostomum*, are free-swimming and use their cilia for locomotion. Others, such as the *Stylonychia*, use their cilia like tiny feet to crawl on substrates. A few, such as the *Vorticella*, live attached to a substrate, where they use their cilia for feeding rather than locomotion. (See Figure 6-3 on page 150.)

The Zoomastigina consist of a group of animal-like protists that move through the water by means of whiplike flagella. Members of this group live in freshwater, salt water, and also as parasites within the bodies of other organisms. Included in this group are the euglena and the dinoflagellates, which take in (as well as make their own) food. (See Chapter 4.)

The Sarcodina are the protozoan group that includes the forams and radiolarians, as well as the amebas. They live on the surface of substrates and move by means of cytoplasmic extensions called pseudopods (meaning “false feet”). This kind of movement, typical of the ameba, is called ameboid movement. The moving pseudopods are also used to surround and engulf food particles and living.
prey. Interestingly, there are cells in the human body that also show ameboid movement. For example, some kinds of white blood cells show ameboid movement when they engulf bacteria.

**Life Functions of Protozoans**

The protozoa are an amazing group of organisms. They carry out all necessary life functions within a single cell. Multicellular animals use large numbers of cells to perform their life functions. How, then, are protozoans able to carry out all the life functions—ingestion and digestion, respiration, transport, water balance and excretion, sensitivity, and reproduction—within a single cell?

**Ingestion and Digestion in Protozoa**

Look at the *Vorticella*, a ciliated protozoan shown in Figure 6-3. The *Vorticella* can be easily observed, because it is often found attached to a substrate. Organisms that live attached to substrates are called *sessile* organisms. How does the *Vorticella* carry out the life function
of ingestion, the taking in of food? Food is swept toward the Vorticella’s “mouth” (oral groove) by movements of its ring of cilia. (Protozoa that are motile actively catch and ingest their food.)

The large food particles ingested by the Vorticella enter its food vacuoles. There, they are broken down into smaller particles through the process called digestion. Food vacuoles are located in the cytoplasm, the fluidlike material that makes up much of the cell. Digestion that takes place inside a cell is called intracellular digestion.

Respiration in Protozoa

How do protozoa obtain energy for their cell’s activities? Like other organisms, protozoa take in oxygen and combine it with glucose to produce chemical energy, a process called respiration. The energy in glucose that cannot be directly used by a cell is transformed, in a series of enzyme-controlled reactions, to the usable form of chemical energy called adenosine triphosphate, or ATP. This process, which occurs inside the cell, is called cellular respiration (or aerobic respiration) and can be summarized by the following chemical equation:

$$C_6H_{12}O_6 + 6 O_2 \xrightarrow{enzymes} 6 CO_2 + 6 H_2O + 36 ATP$$

This equation can be put into words as follows: one molecule of glucose plus six molecules of oxygen (in the presence of enzymes) yields six molecules of carbon dioxide plus six molecules of water plus 36 molecules of adenosine triphosphate (ATP).

Oxygen enters the mitochondria, the energy factories of the cell, where it combines with glucose. For every molecule of glucose that is burned, or oxidized, in the cell, 36 molecules of ATP are produced. The ATP both stores and releases the chemical energy that is used by a cell to do work. For example, Vorticella uses the energy stored in ATP for contraction of its stalk and movement of its cilia.

In a unicellular organism, what structures are required to help carry out the function of respiration? Notice that Vorticella has a cell membrane, which permits oxygen to enter the cell from the surrounding water and allows the waste product of respiration, carbon dioxide, to exit the cell.
Transport in Protozoa

What causes oxygen and carbon dioxide to enter and leave the cell? The movement of substances into, out of, and within a cell is called transport. The concentration, or number, of oxygen molecules per unit area is greater outside the Vorticella cell (in the water) than inside the cell. Since the concentration of oxygen molecules is greater outside the Vorticella than inside it, oxygen molecules will move from outside to inside the cell. The movement of molecules from an area of higher concentration to an area of lower concentration is called diffusion. Diffusion is an example of passive transport, meaning no energy from ATP is used in the process.

Diffusion also explains the transport of carbon dioxide from the inside to the outside of a cell. As a result of cellular respiration, carbon dioxide accumulates as a waste product inside the cell. Therefore, the concentration of carbon dioxide is greater inside than outside the cell. The concentration of CO₂ is lower outside the Vorticella because it is diluted by the large volume of ocean water. Carbon dioxide diffuses from inside to outside the cell because of this concentration difference. Transport also occurs within the cell. Food vacuoles move about and distribute nutrients inside the cell as a result of the flowing of cytoplasm, a process called cyclosis.

Water Balance and Excretion in Protozoa

Being aquatic, Vorticella and other protozoans live in an environment where the concentration of water molecules is greater outside the cell than inside the cell. There is a lower concentration of water molecules inside the Vorticella, because dissolved substances inside its cell take the place of water molecules. This unequal concentration of water molecules causes them to move from outside the cell to inside the cell. The movement of water molecules from an area of higher concentration to an area of lower concentration across a cell membrane is called osmosis. Like diffusion, osmosis is an example of passive transport.

What prevents a protozoan from swelling up and bursting as a result of inward osmosis? Excess water is pumped out of the cell through a structure called the contractile vacuole. The forceful
closing of the contractile vacuole requires energy from ATP, so this process is an example of active transport.

Liquid wastes are also eliminated from the cell in a process called excretion. A contractile vacuole called the excretory vacuole carries out the life function of excretion. The elimination of excess water and liquid wastes from inside the cell enables the protozoan to maintain a proper water balance and a stable internal environment. In general, the ability of an organism to maintain a stable internal environment is called homeostasis.

**Sensitivity in Protozoa**

You blink when there is dust in your eye, sneeze when there is pollen in your nose, and jump when you are startled by a loud noise. These movements and reactions are called responses. To stay alive, organisms must be able to respond to changes in their environment. These changes, known as stimuli (singular, stimulus), are what cause an organism to respond. In the above examples, the dust, pollen, and noise are the stimuli.

The ability of an organism to respond to environmental stimuli is called sensitivity. How does a unicellular organism like the Vorticella carry out the life function of sensitivity? The Vorticella responds to the stimulus of touch by contracting its elongated stalk into a tight coil. Contraction occurs when other protozoa make contact with the Vorticella. Following contraction, the stalk rapidly uncoils. What is the adaptive value of this response? The contraction is an avoidance reaction that the Vorticella makes in response to a stimulus that may be harmful. Interestingly, the Vorticella also contracts spontaneously in the apparent absence of a mechanical stimulus, a behavior that is not fully understood at this time.

**Reproduction in Protozoa**

All life comes from existing life-forms. The production of offspring by living organisms is the life function called reproduction. In the Vorticella, one cell divides to form two cells, called the daughter cells. The production of offspring by a single parent is called asexual reproduction. Many unicellular organisms reproduce asexually.
Reproduction is controlled by the nucleus, which contains the hereditary material of the cell, called DNA (deoxyribonucleic acid). Before the cell divides, the nucleus duplicates itself to form two nuclei. During cell division, one nucleus moves into each of the newly formed cells. Division of a cell’s cytoplasm into two daughter cells of equal size is called binary fission. The offspring that result from binary fission are identical. Vorticella and other protozoans can also reproduce by budding. In budding, the division of the cytoplasm is uneven (but the DNA is the same). As a result, the new daughter cell, or bud, is smaller than the parent cell. Eventually, the bud breaks away and forms its own stalk. Asexual reproduction ensures the existence of another generation and also ensures genetic continuity from one generation to the next. (See Figure 6-4.)

Protozoa, such as the Vorticella, can also reproduce sexually. In sexual reproduction, two parents are needed to produce offspring. Among protozoans, two “parent” cells come into contact to exchange hereditary material, a process known as conjugation. As a result of the exchange of genetic material, the offspring of sexually reproducing parents are not identical to either parent. In protozoa, conjugation is not, strictly speaking, a reproductive process since there are still only two organisms after conjugation occurs. However, genetic material is exchanged between the two conjugating cells. This exchanged material adds genetic variability to a population that eventually increases in number through binary fission.
6.3 **Section Review**

1. In what kingdom are protozoa classified? Identify three main groups of protozoa.
2. How does a protozoan carry out the process of respiration?
3. Describe two ways that protozoa can reproduce.

6.4 **Sponges, Rotifers, and Bryozoans**

In this section, you will learn about three distinct phyla of marine invertebrates—the sponges, rotifers, and bryozoans. Although each group of species is unique enough to be placed in its own phylum, they do share some characteristics. Rotifers and bryozoans are both microscopic, but sponges can grow quite large. Sponges and bryozoans are both sedentary, but rotifers are capable of movement. However, the animals found in all three groups are multicellular, bottom-dwelling invertebrates.

**Sponges**

Animals that are composed of more than one cell are called multicellular. The sponge is a multicellular, primarily marine animal that has few specialized structures. Sponges have two layers of mostly undifferentiated cells: an inner layer called the endoderm and an outer layer called the ectoderm. Between the two layers is a jellylike material called the mesenchyme. (See Figure 6-5 on page 156.)

Sponges are classified in the phylum Porifera (meaning “pore bearing”). Since they inhabit the seafloor, from the intertidal zone down to the depths of the ocean, sponges are considered benthic, or bottom-dwelling, organisms.

**Life Functions of the Sponge**

How does the sponge feed if it can’t move? A sponge’s body contains many holes, or pores. Tiny food particles and plankton enter
through the small pores, called *ostia* (singular, ostium), which are surrounded by pore cells. Water and wastes exit through the large hole, called the *osculum* (plural, oscula), usually located at the top of the sponge. Inside the sponge are special *collar cells* that contain flagella, which beat back and forth. The coordinated movements of these flagella produce the currents that pump water into and out of the sponge.

Collar cells are also involved in food getting. Plankton, bacteria, and other tiny particles of food brought in on currents of water are trapped, ingested, and digested by the collar cells. Other cells, called amebocytes, which are found in the mesenchyme, also ingest and digest food. Digestion in the sponge occurs within food vacuoles inside the individual cells; as in the protozoa, it is intracellular.

How does a sponge take in oxygen and get rid of carbon dioxide? Since the cells of a sponge are in direct contact with water, gas
exchange occurs across cell membranes. The water that comes in through the ostia contains dissolved oxygen, which diffuses into the sponge’s cells. Carbon dioxide, the waste product of respiration, diffuses out of the cells and is expelled through the sponge’s oscula into the water.

Sponges are not very responsive. If you touch a living sponge, it will not move. Since the sponge lacks a nervous system, rapid reflex movements do not occur. However, the sponge has muscle-like cells called myocytes, located near the ostia and oscula. When the myocytes contract, the ostia close, preventing water from entering the pores. This ability to close the ostia is probably a defensive reaction that protects the sponge from taking in any toxic substances in the water.

**Life Cycle of the Sponge**

Sponges will attach to a variety of substrates, including rocks, mollusk shells, and the hulls of ships. How can a sponge find, and attach to, a substrate if it doesn’t swim? You can find the answer to this question by examining Figure 6-6. The life cycle of a sponge
Every year, scientists discover new species of organisms. After careful study of a new organism’s important characteristics, the scientists classify it in the appropriate taxonomic categories. Recently, however, researchers in Denmark discovered a unique, tiny marine animal that presented a challenge to taxonomy. “What is it?” the two Danish scientists asked themselves when they first saw the organism on the lip of a lobster. This tiny creature (about the size of a dot above the letter “i”) lives attached to the mouthparts of a lobster by means of an adhesive disk, where it feeds off scraps of food. The organism also has an unusual life cycle—it can be either male or female, and it can take part in sexual or asexual reproduction.

The scientists went about the job of trying to classify this organism. First, they knew it belonged to the animal kingdom, since it was multicellular, had the ability to move, and consumed food. Next, when they examined its body structure, they saw that it was an invertebrate. However, when they tried to determine which of the 35 known phylums it might belong to, they discovered that it didn’t resemble any of the organisms in these groups. So, they created a new phylum for it, called Cycliophora, which refers to its circular mouth.

So far, this exotic creature is the only member of phylum Cycliophora. But what is its name? The last step in classification of an organism is to identify it scientifically by genus and species. The Danish scientists named it *Symbion pandora* because it lives symbiotically (in close association) with another organism (the lobster) and because it exhibited an unexpected and complex life cycle (likened to the strange surprises found in the mythological Pandora’s box).

**QUESTIONS**

1. Using one or more complete sentences, explain how *Symbion pandora* was discovered.

2. Describe how the two scientists went about classifying this organism.

3. Why did the scientists feel it necessary to create a new phylum for this organism?
begins with adult sponges releasing eggs and sperm into the water. Typical of sexual reproduction in most animals, a single sperm unites with a single egg to produce a fertilized egg cell. This zygote represents the first stage in the development of the sponge. Next, the zygote divides to form two cells. The cells then divide again to form four cells. Cell division continues until a solid ball of cells is formed, called the morula. (Morula is the Latin word for “raspberry,” which is what the ball of cells looks like.) The rapid division of cells in this early stage of development is called cleavage, and the organism at this point is referred to as an embryo.

In time, a hollow area develops inside the embryo. This hollow ball of cells is now called a blastula. The cells of the blastula develop whiplike flagella, which enable the embryo to swim. At this stage in its development, the embryo is called a larva (plural, larvae), which refers to any free-living stage in the early development of an animal. The swimming larva becomes part of the plankton population. After the sponge larva makes contact with a hard substrate, such as the hull of a ship, it attaches to it and starts to develop into an adult sponge.

Individual sponges can be either male or female, or can have both male and female reproductive organs within them. Animals that possess both ovaries and testes are called hermaphrodites. Sponges that are hermaphrodites produce eggs and sperm at different times, thus ensuring that self-fertilization does not occur. Sponges can also reproduce asexually; pieces of a sponge may break off and then grow into a whole new sponge. This mode of reproduction, in which a whole body can be regrown from parts of the parent body, is called regeneration, and it occurs in some other invertebrates.

**Sponge Diversity**

Sponges are hardy creatures that are found in a variety of marine and freshwater habitats, ranging from warm tropical seas to cold polar waters. Some representative sponges are shown in Figure 6-7 on page 160. The bath sponge (Euspongia), which lives in warm tropical waters, may be most familiar to you. At one time, thousands of people were employed harvesting this sponge for commercial use in America and Europe. Today, sponge collecting is largely a tourist
industry. The market for sponges has declined sharply because synthetic sponges have largely replaced the use of natural ones.

While natural sponges now have limited commercial value, they play a very important role in the marine environment. Sponges are very efficient filter feeders. It is estimated that a single bath sponge can filter 100 liters of seawater in an hour. Sponges are also important in recycling minerals back into the water.

Sponges such as the yellow boring sponge (*Cliona*) grow on the shells of clams and other shellfish. The boring sponge is so named because it uses an acid to bore holes into shells in order to attach to them. You may have seen clamshells on the beach that were pockmarked with holes caused by *Cliona*. The sponge also recycles calcium carbonate, the mineral found in seashells, back into the water. Living things such as sponges that grow over the surfaces of substrates are called encrusting organisms.

Some sea stars, snails, and fish eat sponges, particularly the young sponges that have begun to colonize substrates. However, few animals eat sponges, because they often are composed of hard mineral matter, such as calcium carbonate or silica. Such sponges have a rigid structure, due to their skeleton of chalk or silicon spines called spicules. In contrast, some sponges, such as the natural bath sponge, have an elastic framework of protein fibers called spongini. When you squeeze one of these sponges, you can feel its elasticity.

Sponges show a variety of interesting shapes, sizes, and colors. The beautiful Venus’s flower basket (*Euplectella*), which lives at great depths, is a tubular sponge composed of a delicate network of glassy spicules. The vase sponge (*Ircinia*), found on sandy bottoms

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**Figure 6-7** Three representative types of sponges.
near coral reefs, grows vertically. And some basket sponges, found in tropical waters, grow so large that a person could sit inside of them.

**Rotifers**

Many species of microscopic organisms are composed of more than one cell. Look at the multicellular organism called the *rotifer* (meaning “wheel bearer”), shown in Figure 6-8. Dozens of rotifer species live in the moist sands along the shore and in the gravel of aquarium tanks. (Rotifers are also common in freshwater.) Rotifers, which are in their own unique phylum Rotifera, are able to change the shape of their body. For example, when they swim by means of their cilia, rotifers can telescope their bodies to facilitate movement.

Some rotifers are predatory, while others scavenge on debris. When attached to a substrate, the rotifer’s crown of beating cilia in its head region gives the animal the appearance of a miniature spinning wheel. The moving cilia create a water current that pulls floating food toward the rotifer’s mouth. Food enters the mouth and then passes through a food tube, or one-way digestive tract,
consisting of an esophagus, a stomach, and intestines. Food is digested in the stomach and intestines, and waste products are eliminated through the anus. How is digestion in rotifers and humans similar? In both, digestion occurs in a one-way tube, in which food enters at one end of the tube and wastes come out at the other end.

**Reproduction in the Rotifer**

How does the rotifer reproduce? The male rotifer produces sperm in its testes, the male reproductive organs. The female produces eggs in its ovary, the female reproductive organ. Sperm and egg cells (gametes) contain the hereditary material from each of the parents that is necessary for sexual reproduction. The gametes are released into the water, where they unite.

Sperm cells are able to move through water because each one possesses a tailike flagellum. The sperm cell unites with an egg cell to produce a zygote. After fertilization, the rotifer zygote gradually develops into an adult. Rotifers have external fertilization and external development, meaning both of these events take place outside the body of the female.

Rotifers can also reproduce by an asexual process called parthenogenesis. In this process, the female produces an egg, without fertilization, that has a complete (double) set of chromosomes. The egg develops into a female rotifer that can reproduce either sexually or parthenogenetically.

**Bryozoans**

Another benthic organism, which is sometimes mistaken for a sponge, is the **bryozoan** (meaning “moss animal”). The bryozoan, classified in its own phylum Bryozoa, is a microscopic multicellular animal that lives within a box- or vase-shaped compartment made of calcium carbonate or chitin (the material found in crab and lobster shells). Branching colonies composed of hundreds of individual bryozoans cover the surfaces of rocks, seaweeds, and shells. Colonies of different types of bryozoans have different shapes; the
two main types are encrusting bryozoans and erect bryozoans. (See Figure 6-9.)

**Life Functions of the Bryozoan**

The bryozoan feeds on plankton and organic debris, which it captures with its ciliated tentacles. Food is digested in a one-way digestive tract that consists of a mouth, stomach, and intestines. Wastes are eliminated through the anus. Bryozoans can reproduce asexually by budding, the process by which a smaller individual develops on, and then separates from, the larger parent body. This is a fast way to increase the bryozoan colony’s size. They can also reproduce sexually, by producing sperm and egg cells. Most bryozoans
are hermaphrodites; that is, they contain both ovaries and testes within the same individual. As a result, in some species of bryozoans, self-fertilization actually occurs.

6.4 Section Review

1. Draw and describe how a sponge filter feeds.
2. Draw and label the life cycle of a sponge.
3. Compare the structures of a bryozoan and a rotifer.
Laboratory Investigation 6

Observing Diverse Zooplankton

PROBLEM: What kinds of zooplankton can be found in seawater?

SKILL: Observing tiny organisms under the microscope.

MATERIALS: Compound microscope, zooplankton samples, medicine droppers, slides, coverslips.

PROCEDURE

1. Prepare a wet mount slide of plankton. Use a medicine dropper to put 1 or 2 drops of your plankton sample on a glass slide. Place a coverslip over the slide. Make sure the bottom of your slide is dry.

2. Place the slide on the stage of a microscope and observe under low power.

3. Focus with the coarse adjustment. Move the slide around until you see something that moves.

4. In your notebook, make sketches of each of the zooplankton you observe. Locate and sketch as many zooplankton as you can in the allotted time. You may want to ask your teacher to help you try to identify them.

OBSERVATIONS AND ANALYSES

1. Why might you have difficulty in finding zooplankton in a bucket of seawater?

2. How would you know that the organism you observed is a type of zooplankton or phytoplankton?

3. Why is it more difficult to find zooplankton under high power than under low power?
Chapter 6 Review

Answer the following questions on a separate sheet of paper.

Vocabulary
The following list contains all the boldface terms in this chapter.

benthic, binary fission, bryozoan, budding, cilia, collar cells, conjugation, contractile vacuole, diffusion, embryo, encrusting organisms, enzyme, filter feeders, foraminiferan, homeostasis, larva, osculum, osmosis, ostia, pseudopods, radiolarian, regeneration, rotifer, sessile, spicules, spongion, zooplankton

Fill In
Use one of the vocabulary terms listed above to complete each sentence.

1. Sponges often have a rigid structure due to their __________.
2. An animal’s early, free-living stage is called a __________.
3. Animals that strain tiny food from the water are __________.
4. Water is pumped out of a protozoan by its __________.
5. Bottom-dwelling organisms are referred to as __________.

Think and Write
Use the information in this chapter to respond to these items.

6. Compare the structure and function of the Vorticella’s cilia and a sponge’s flagellated collar cells. How are they similar?
7. Explain the difference between temporary and permanent zooplankton.
8. What is the main difference between binary fission and budding? For each method, name an organism that uses it.

Inquiry
Base your answers to questions 9 through 12 on the information below and on your knowledge of marine science.

A student performed an experiment to test the effect of salinity variations on the contraction rate of the stalked marine ciliate Vorticella, measured in contractions per minute. All factors except
salinity (such as water temperature, light, and so on) were kept constant for the control and experimental groups. The control group had a salinity of 3.5 percent (like that of seawater); the experimental groups had different salinities. Results are shown in the table below.

**THE EFFECT OF SALINITY VARIATIONS ON THE CONTRACTION RATE OF THE VORTICELLA (CONTRACTIONS PER MINUTE)**

<table>
<thead>
<tr>
<th>Number of Readings (Minutes)</th>
<th>3.5% Salinity (Control Group)</th>
<th>1.75% Salinity (Experimental Group 1)</th>
<th>0.87% Salinity (Experimental Group 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>6</td>
<td>6</td>
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<tr>
<td>4</td>
<td>4</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Average</td>
<td>4.5</td>
<td>6.3</td>
<td>7.6</td>
</tr>
</tbody>
</table>

9. What activity was measured in this experiment?  
   a. salinity  
   b. speed of the Vorticella  
   c. feeding rate of the Vorticella  
   d. contraction rate of the Vorticella

10. At which salinity were the Vorticella the least active?  
    a. 5 percent  
    b. 3.5 percent  
    c. 1.75 percent  
    d. 0.87 percent

11. Which is an accurate statement regarding the data in the table?  
    a. The average rate of the control group was higher than the average rate of either experimental group.  
    b. The average rate of each experimental group was higher than the average rate of the control group.  
    c. The highest contraction rate occurred at a salinity of 1.75 percent.  
    d. The lowest contraction rate occurred at a salinity of 1.75 percent.

12. What conclusion can be drawn based on the data in the table?  
    a. As salinity increases, the contraction rate also increases.  
    b. The contraction rate is not affected by a change in salinity.  
    c. As salinity decreases from 3.5 to 0.87 percent, the contraction rate increases.  
    d. The contraction rate will decrease if the salinity decreases below 0.87 percent.
**Multiple Choice**

*Choose the response that best completes the sentence.*

13. The ameboid movement of protozoans is carried out by their
   *a.* spicules  *b.* cilia  *c.* pseudopods  *d.* flagella.

14. The sponge is considered a “simple” animal because it
   *a.* lives on the bottom of the ocean  *b.* lacks a high degree
   of specialization  *c.* filter feeds  *d.* is generally small.

15. The group of marine protozoans that lacks microscopic hairs
   is the  *a.* ciliates  *b.* flagellates  *c.* amebas  *d.* sponges.

16. A life function carried out by protozoans but not by sponges is
   *a.* ingestion  *b.* respiration  *c.* locomotion  *d.* excretion.

17. A good place to find sponges locally is  *a.* floating on the
   ocean surface  *b.* under the sand  *c.* in the upper intertidal
   zone  *d.* attached to the bottom of a wharf piling.

18. A marine biology student looking for protozoans would most
   likely find them in  *a.* gravel from a marine aquarium
   *b.* a water sample from the ocean surface  *c.* a dried sponge
   *d.* a water sample from the surface of a marine aquarium.

19. A marine biology student added a drop of dilute HCl to a
   sponge and observed effervescence. The student should con-
   clude that  *a.* the internal skeleton is composed of calcium
   carbonate  *b.* the spicules contain silica  *c.* spongin was
   present  *d.* the sponge prefers an acid environment.

20. The inability of a sponge to make rapid, reflex movements is
   due to its lack of  *a.* contractile tissue  *b.* a nervous system
   *c.* a mechanism for respiration  *d.* a method of ingestion.

21. Protozoans are classified into three groups based on their
   being either ameboid, ciliated, or  *a.* larval  *b.* sessile
   *c.* flagellated  *d.* planktonic.

22. Cilia and flagella are mainly used by protozoans for
   *a.* locomotion  *b.* reproduction  *c.* digestion  *d.* fission.

23. Water and wastes exit a sponge's body through its
   *a.* ostia  *b.* amebocytes  *c.* osculum  *d.* myocytes.
**Research/Activity**

- Compare one of the body systems of a sponge or protozoan with that of a human. Describe how they are similar and/or different.

- Prepare a wet mount of marine aquarium gravel to observe living protozoans. Identify and draw the different types; then do library or Internet research to learn more about the species you observed. Write a report that you can present to your class or your school science fair.