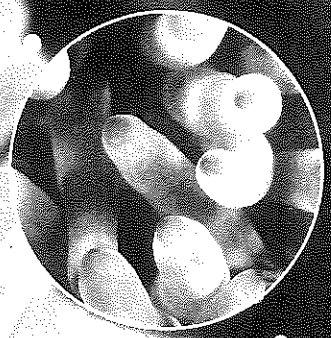
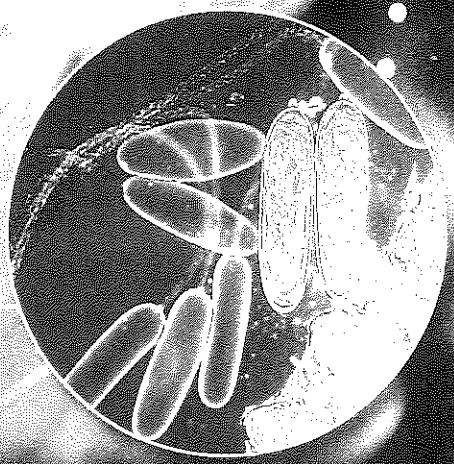
Sea anemone

Sea anemone tentacles





Nematocysts
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THEME FOCUS Patterns

Animals have a wide variety of characteristics, including body plans and adaptations.

BIG Idea **Animal phylogeny is determined in part by animal body plans and adaptations.**

Reading Preview

Essential Questions

- How do adaptations enable animals to live in different habitats?
- How is structure and function related in animals?
- What are the stages of embryonic development in animals?

Review Vocabulary

protist: diverse group of unicellular or multicellular eukaryotes that lack complex organ systems and live in moist environments

New Vocabulary

invertebrate
exoskeleton
endoskeleton
vertebrate
hermaphrodite
zygote
internal fertilization
external fertilization
blastula
gastrula
endoderm
ectoderm
mesoderm

Multilingual eGlossary

Animal Characteristics

Key Idea **Animals are multicellular, eukaryotic heterotrophs that have evolved to live in many different habitats.**

Real-World Reading Link When you think of animals, you might think of creatures that are furry and fuzzy. However, animals can have other outer coverings, such as feathers on birds and scales on fishes. Some animals even might be mistaken for plants.

General Animal Features

Recall that biologists have created an evolutionary tree to organize the great diversity of living things. The ancestral animals at the beginning of the evolutionary tree are eukaryotic and multicellular—they are made up of many cells. The tiger in **Figure 1** and all other present-day animals might have evolved from choanoflagellates (KOH uh noh FLA juh layts), which are protists that formed colonies in the sea 570 million years ago. Choanoflagellates, such as the ones shown in **Figure 1,** might have been the earliest true animals. As animals evolved from this multicellular ancestor, they developed adaptations in structure that enabled them to function in numerous habitats. These features mark the branching points of the evolutionary tree and are discussed in the next section. In this section, you will learn about the characteristics that all animals have in common.

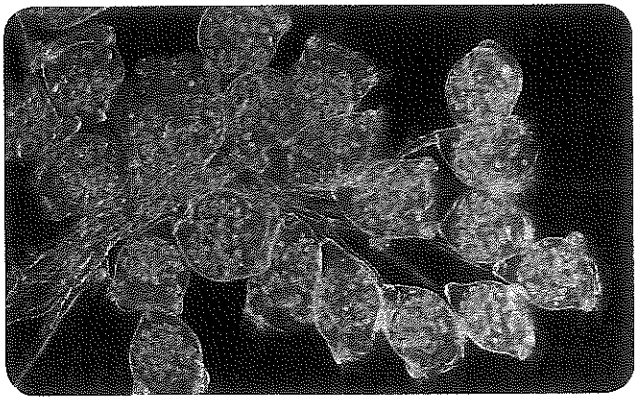
Feeding and Digestion

Animals are heterotrophic, so they must feed on other organisms to obtain nutrients. A sea star obtains its food from a clam it has pried open, and a butterfly feeds on nectar from a flower. The structure or form of an animal's mouth parts determines how its mouth functions. You can investigate how some animals obtain food by performing **MiniLab 1.** After obtaining their food, animals must digest it. Some animals, such as sponges, digest their food inside specific cells. Others, such as earthworms and humans, digest their food in internal body cavities or organs.

Figure 1 Present-day animals, such as this Bengal tiger, might have evolved from choanoflagellates such as this colony of *Zoothamnium*.

Bengal tiger

LM Magnification: 50×



Colony of *Zoothamnium*

(l)E. Hanumantha Rao/Photo Researchers; (r)Roland Birke/Photolibrary/Getty Images

Support

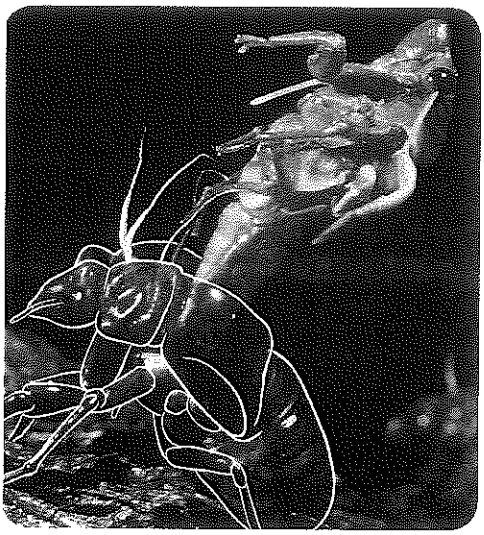
Just as animals digest their food in different ways, they support their bodies in different ways. Between 95 and 99 percent of animal species are **invertebrates**–animals without backbones. The bodies of many invertebrates are covered with **exoskeletons**, which are hard or tough outer coverings that provide a framework of support. Exoskeletons also protect soft body tissues, prevent water loss, and provide protection from predators. As the animal grows, like the cicada in **Figure 2**, it must shed the old exoskeleton and make a new one. This process is called molting.

Some invertebrates, such as sea urchins and sea stars, have internal skeletons called **endoskeletons.** If an animal has an endoskeleton and a backbone, it is called a **vertebrate.** An endoskeleton grows with the animal, like the squirrel in **Figure 2.** The material making up the endoskeleton varies. Sea urchins and sea stars have endoskeletons made of calcium carbonate, sharks have endoskeletons made of cartilage, and fishes, amphibians, reptiles, birds, and mammals have endoskeletons made of bone. An endoskeleton protects internal organs, provides support for the body, and can provide an internal brace for muscles to pull against.

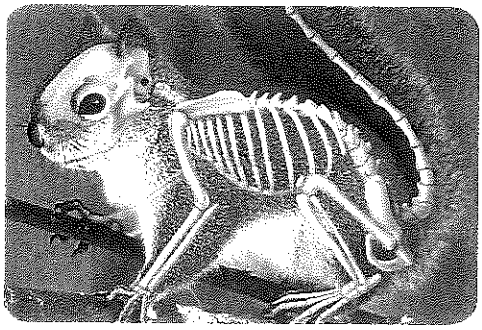
Reading Check **Distinguish** between vertebrates and invertebrates.

Habitats

Animal bodies have a variety of adaptations, such as those for feeding, digestion, and support. These body variations enable animals to live in numerous habitats. Vertebrates and invertebrates live in oceans, in freshwater, and on land. They can be found in deserts, grasslands, rain forests, polar regions, and all other land biomes and aquatic ecosystems.



Cicada



Squirrel

Figure 2 A cicada must shed its old exoskeleton (outlined in white) in order to grow. A squirrel has an endoskeleton that grows as the squirrel grows.
Infer *how an exoskeleton might be a disadvantage for animals.*

MiniLab 1

Investigate Feeding in Animals

MiniLab

How do animals obtain food? Small aquatic animals called hydras consume brine shrimp as their food source.

Procedure

1. Read and complete the lab safety form.
2. Obtain several **hydras** in a **plastic Petri dish** containing **water.**
3. Add several **brine shrimp** to the dish. Using a **hand lens or stereomicroscope,** observe the activity of the hydras.
4. Record your observations.

Analysis

1. **Draw Conclusions** Based on your observations, how do the hydras react to the food?
2. **Infer** What factors in their environment might influence how the hydras find food?

(t)Judy Davidson/Photo Researchers; (b)Rod Planck/Photo Researchers

Animal Cell Structure

No matter where an animal lives or what adaptations it has, its cells do not have cell walls. Recall that plants also are multicellular organisms, but their cells have cell walls. The cells of all animals, except sponges, are organized into structural and functional units called tissues. A tissue is a group of cells that is specialized to perform a specific function. For example, nerve tissue is involved in the transmission of nerve impulses throughout the body and muscle tissue enables the body to move.

CAREERS IN BIOLOGY

Systematist Using observation, inference, and the latest technology, a systematist classifies new species based on evolutionary relationships.

Connection to History Beginning with Aristotle in the fourth century B.C. and continuing into the nineteenth century, living organisms were classified into two kingdoms–Animalia (animals) and Plantae (plants). In 1866, Ernst Haeckel, a German scientist, proposed adding a third kingdom called Protista. The organisms in this kingdom are mainly unicellular eukaryotes. Some protists have cell walls, while others do not, making them neither plant nor animal. During the 1960s, as more was learned about cell structure, bacteria and fungi were placed into their own kingdoms. **Figure 3** illustrates how the classification of living things continues to develop.

Movement

The evolution of nerve and muscle tissues enables animals to move in ways that are more complex and faster than organisms in other kingdoms. This is one notable characteristic of the animal kingdom. A gecko running across a ceiling, a mosquito buzzing around your ear, and a school of minnows swimming against the current are all exhibiting movements unique to animals. Some animals are stationary as adults, yet most have a body form that can move during some stage of development.

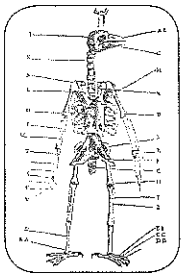
Figure 3

History of Classification

The process of scientifically classifying organisms began in 350 B.C. when Aristotle, a Greek philosopher, placed organisms into two large groups—plant and animal. Advances in scientific knowledge and technology helped develop the classification system we use today.

1735 Biologist Carolus Linnaeus devises a classification system for all organisms using Latin binomial nomenclature.

1500 | 1600 | 1700 | 1800



1555 The book *L'Histoire de la Nature des Oyseaux* (Natural History of Birds) uses body form and structures to classify species.

1682 Naturalist John Ray establishes the use of species as the basic unit of classification.

1859 Naturalist Charles Darwin proposes the classification of organisms based on their shared ancestry.

(t)Sheila Terry/Photo Researchers; (b)©Corbis

Reproduction

Most animals reproduce sexually, although some species can reproduce asexually. Most commonly in sexual reproduction, male animals produce sperm and female animals produce eggs. Some animals, such as earthworms, are **hermaphrodites** (hur MAF ruh dites), which produce both eggs and sperm in the same animal body. In general, hermaphrodites produce eggs and sperm at different times, so another individual of the same species still is needed for sexual reproduction.

Fertilization occurs when the sperm penetrates the egg to form a fertilized egg cell called the **zygote** (ZI goht). Fertilization can be internal or external. **Internal fertilization** occurs when the sperm and egg combine inside the animal's body. For example, male turtles fertilize the eggs of the female internally. **External fertilization** occurs when egg and sperm combine outside the animal's body. This process requires an aquatic environment for the sperm to swim to the egg. In many fishes, the female lays eggs in the water and the male sheds sperm over the eggs, as shown in **Figure 4.**

Recall that asexual reproduction means that a single parent produces offspring that are genetically identical to itself. Although few animal species reproduce asexually, when they do, they use one or more methods to do so. Some of the common methods of asexual reproduction follow.

- budding–an offspring develops as a growth on the body of the parent
- fragmentation–the parent breaks into pieces and each piece can develop into an adult animal
- regeneration–a new organism can regenerate, or regrow, from the lost body part if the part contains enough genetic information
- parthenogenesis (par thuh noh JE nuh sus)–a female animal produces eggs that develop without being fertilized

Reading Check **Infer** the advantages and disadvantages of asexual reproduction in animals.

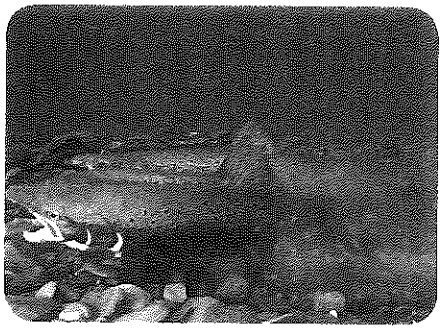
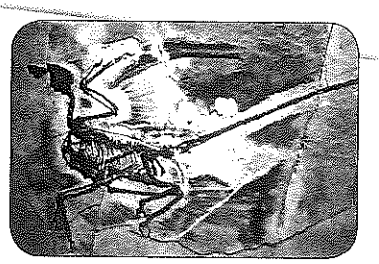


Figure 4 Fertilization is external in some fishes. In the photo, strands of sperm are being shed over eggs laid in the water.
Infer *why animals lay a large number of eggs when fertilization is external.*



1977 Microbiologist Carl Woese uses ribosomal RNA to show the evolutionary relationships among organisms.

2003 Paleontologists find feathered dinosaur fossils that might alter the classification of some species.

1900

2000

1891 Marine zoologist Mary Jane Rathbun begins establishing the basic taxonomic information on crustaceans.

1982 Biologist Lynn Margulis is instrumental in reorganizing and improving the classification of organisms into the current five kingdoms.

2009 A partial skull fossil of *Homo floresiensis* causes debate among scientists as they work to determine if it is an early *Homo sapiens* or a new species.

Early development In most animals, the zygote undergoes mitosis and a series of cell divisions to form new cells. After the first cell division, in which the zygote forms two cells, the developing animal is called an embryo. The embryo continues to undergo mitosis and cell division, forming a solid ball of cells. These cells continue to divide, forming a fluid-filled ball of cells called the **blastula** (BLAS chuh luh), as shown in **Figure 5.** During these early stages of development, the number of cells increases, but the total amount of cytoplasm in the embryo remains the same as that in the original cell. Therefore, the total size of the embryo does not increase during early development.

In animals such as lancelets, the outer blastula is a single layer of cells, while in animals such as frogs, there might be several layers of cells surrounding the fluid. The blastula continues to undergo cell division. Some cells move inward to form a **gastrula** (GAS truh luh), a two-cell-layer sac with an opening at one end. A gastrula looks like a double bubble, one bubble inside another bubble.

Look again at **Figure 5.** Notice how the diagrams of the two-cell stage, the 16-cell stage, and the blastula differ from the photographs of these same stages. The diagrams illustrate early development in embryos that develop inside the adult animal. The photographs illustrate early development in embryos that develop outside of the adult animal. The large ball that does not divide is the yolk sac. It provides food for the developing embryo.

Reading Check **Explain** the differences between the blastula and the gastrula.

VOCABULARY

Word Origin

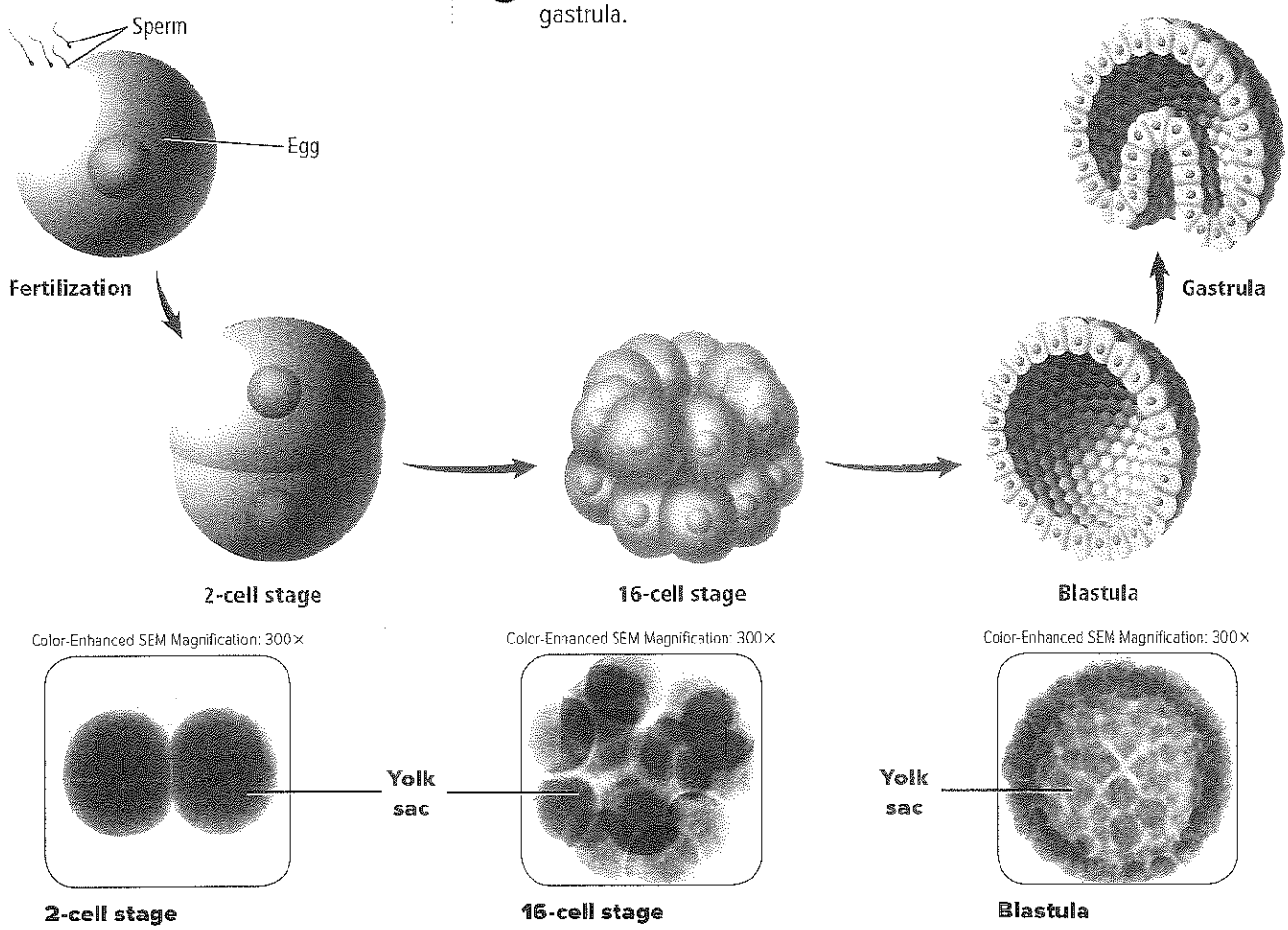
Gastrula

gastr- prefix; from Greek; meaning *stomach* or *belly*

-ula suffix; from Latin; meaning *resembling*

Figure 5 The fertilized eggs of most animals follow a similar pattern of development. Beginning with one fertilized egg cell, cell division occurs and a gastrula is formed.

Animation



Science Source/Photo Researchers

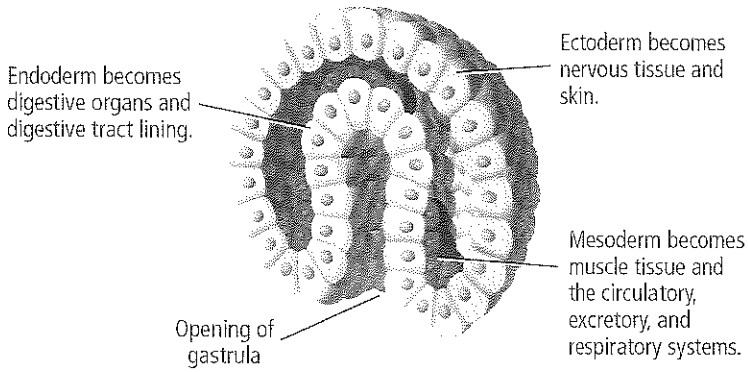


Figure 6 As development continues, each cell layer differentiates into specialized tissues.

Tissue development Notice in **Figure 6** that the inner layer of cells in the gastrula is called the **endoderm**. The endoderm cells develop into the digestive organs and the lining of the digestive tract. The outer layer of cells in the gastrula is called the **ectoderm.** The ectoderm cells in the gastrula continue to grow and become the nervous tissue and skin.

Cell division in some animals continues in the gastrula until another layer of cells, called the **mesoderm,** forms between the endoderm and the ectoderm. In some animals, the mesoderm forms from cells that break away from the endoderm near the opening of the gastrula. In more highly evolved animals, the mesoderm forms from pouches of endoderm cells on the inside of the gastrula. As development continues, mesoderm cells become muscle tissue, the circulatory system, the excretory system, and, in some species of animals, the respiratory system.

Remember that Hox genes might be expressed in ways that give proteins new properties that cause variations in animals. Much of the variation in animal bodies is the result of changes in location, number, or time of expression of Hox developmental genes during the course of tissue development.

Launch Lab

Review **Based on what you have read about animal characteristics, how would you now answer the analysis questions?**

Section 1 Assessment

Section Summary

- Animals are heterotrophs and must get their nutrients from other organisms.
- Animals have diverse means of support and live in diverse habitats.
- Animal cells do not have cell walls, and most have cells that are organized into tissues.
- Most animals undergo sexual reproduction, and most can move.
- During embryonic development, animal cells become tissue layers, which become organs and systems.

Understand Main Ideas

1. **Infer** why colonial organisms that lived grouped together might have been one of the first steps toward multicellular organisms in the course of evolution.
2. **Infer** how an exoskeleton enables invertebrates to live in a variety of habitats.
3. **Describe** how the evolution of nerve and muscle tissue is related to one of the main characteristics of animals.
4. **Diagram** how an animal zygote becomes a gastrula.

Think Critically

5. **Model** the stages of cell differentiation in embryonic development by comparing them to pushing in the end of a balloon. Draw a diagram of this process and label it with the stages of cell differentiation.

MATH in Biology

6. Biologists have observed that it is common for an animal that doubles its mass to increase its length 1.26 times. Suppose an animal has a mass of 2.5 kg and is 30 cm long. If this animal grows to a mass of 5 kg, how long will it be?

Online Quiz

Reading Preview

Essential Questions

- How are animal body plans related to phylogeny?
- How are body cavities related to animal phylogeny?
- What are the two types of coelomate development?

Review Vocabulary

phylogeny: evolutionary history of a species based on comparative relationships of structures and comparisons of modern life-forms with fossils

New Vocabulary

symmetry
radial symmetry
bilateral symmetry
anterior
posterior
cephalization
dorsal
ventral
coelom
pseudocoelom
acoelomate
protostome
deuterostome

Multilingual eGlossary

Animal Body Plans

MAIN Idea **Animal phylogeny can be determined, in part, by body plans and the ways animals develop.**

Real-World Reading Link People often classify or group things based on what they have in common. If you want to rent an action movie, you would look in the action movie section at the store. You would not find comedies or dramas in this section. In biology, animals generally are classified into groups because they have some of the same features.

Evolution of Animal Body Plans

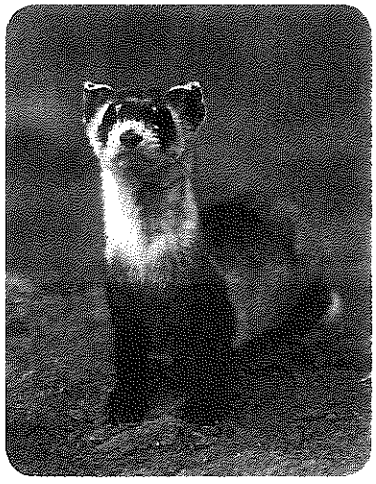
Recall that the evolutionary tree is organized like a family tree, and the phylogeny of animals is represented by the branches. For example, all of the mammals in **Figure 7** belong on the chordate branch of the tree. The trunk represents the earliest animals and the branches represent the probable evolution of the major phyla of animals from a common ancestor, as shown in **Figure 8.**

Anatomical features in animals' body plans mark the branching points on the evolutionary tree. For example, animals without tissues are grouped separately from animals with tissues, and animals without segments are grouped separately from animals with segments. The relationships among animals on this tree are inferred by studying similarities in embryological development and shared anatomical features. This traditional phylogeny, with animals classified into 35 phyla, is still used by most taxonomists. However, molecular data suggest other relationships among animals. Recent molecular findings, based on comparisons of DNA, ribosomal RNA, and proteins, indicate that the relationships between arthropods and nematodes and between flatworms and rotifers might be closer than anatomical features suggest.

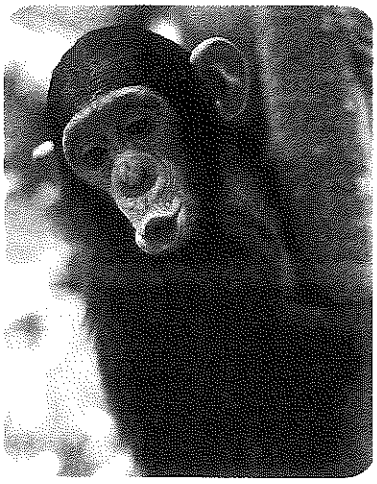
Reading Check **Summarize** the structure of an evolutionary tree.

Figure 7 Although these animals look very different from each other, they all have features that place them on the chordate branch of the evolutionary tree.

Mouse



Ferret



Chimpanzee

(l)CDC/James Gathany; (c)©D. Robert & Lori Franz/Corbis; (r)Digital Vision/PunchStock

Development of Tissues

As animals evolved from the first multicellular forms, the first anatomical feature to indicate a major change in body plan was the development of tissues. Therefore, tissues mark the first branching point on the evolutionary tree. Notice in **Figure 8** that the only animals without tissues are sponges. These animals descended from a common ancestor that lacked tissues, and they are on the no-true-tissue branch of the evolutionary tree. Follow the tissue branch of the evolutionary tree, and you will see that all other phyla have tissues.

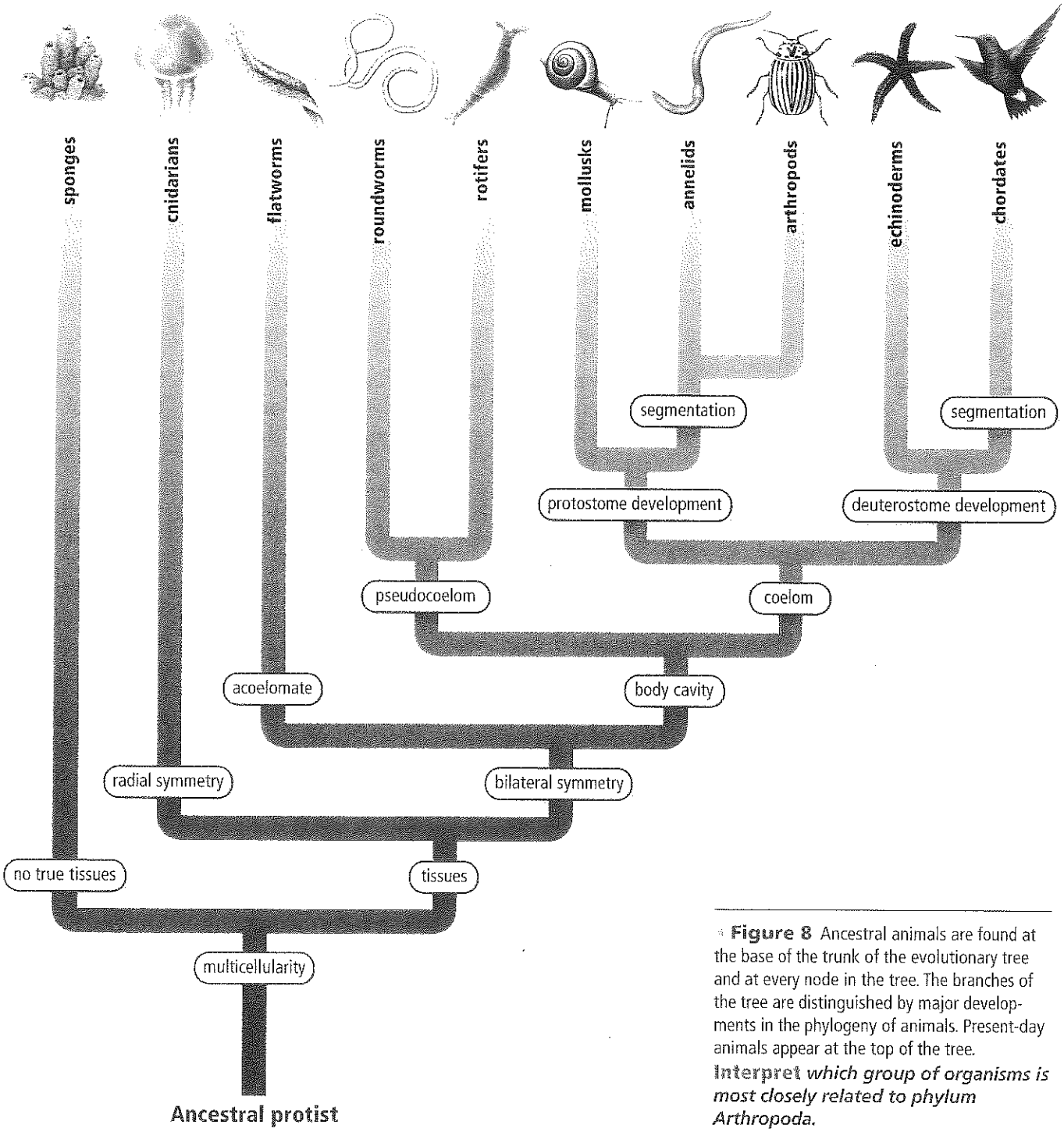
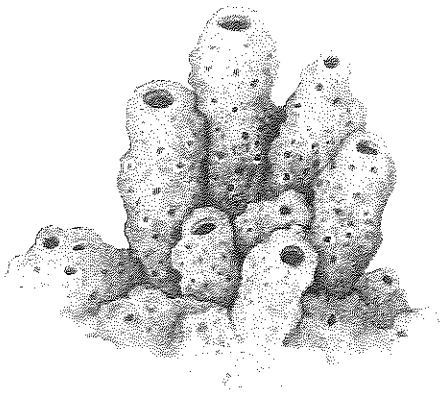
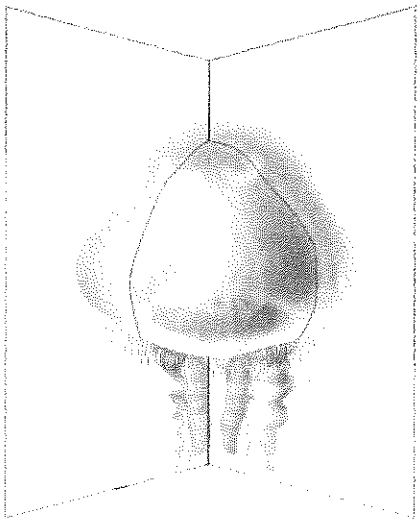


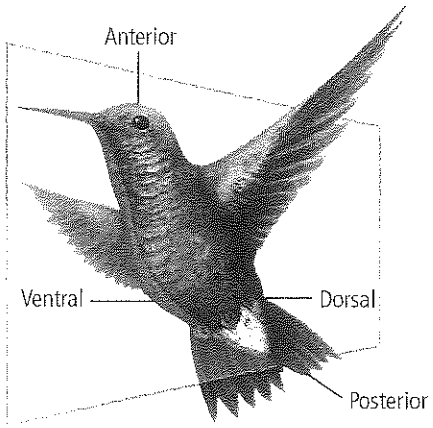
Figure 8 Ancestral animals are found at the base of the trunk of the evolutionary tree and at every node in the tree. The branches of the tree are distinguished by major developments in the phylogeny of animals. Present-day animals appear at the top of the tree.
Interpret *which group of organisms is most closely related to phylum Arthropoda.*



Sponge—asymmetry



Jellyfish—radial symmetry



Hummingbird—bilateral symmetry

Figure 9 Animals have different arrangements of body structures. The sponge has an irregular shape and is asymmetrical. The jellyfish has radial symmetry, and the hummingbird has bilateral symmetry.

List *objects in the classroom that have bilateral symmetry.*

Personal Tutor

BrainPOP

VOCABULARY

SCIENCE USAGE v. COMMON USAGE

Plane

Science usage: an imaginary line that divides a body form into two parts *The dog can be divided into its ventral and dorsal parts by a plane.*

Common usage: an aircraft *The pilot flew the plane from Cleveland to Chicago.*

Symmetry

Move along the tissue branch on the evolutionary tree in **Figure 8,** and you will find the next branching point to be symmetry. **Symmetry** (SIH muh tree) describes the similarity or balance among body structures of organisms. The type of symmetry an animal has enables it to move in certain ways.

Asymmetry The sponge in **Figure 9** has no tissue and has asymmetry. It is irregular in shape and has no symmetry or balance in its body structures. In contrast, animals with tissues have either radial or bilateral symmetry.

Radial symmetry An animal with **radial** (RAY dee uhl) **symmetry** can be divided along any plane, through a central axis, into roughly equal halves. The jellyfish in **Figure 9** has radial symmetry. Its tentacles radiate from its mouth in all directions, a body plan adapted to detecting and capturing prey moving in from any direction. Jellyfishes and most other animals with radial symmetry develop from only two embryonic cell layers–the ectoderm and the endoderm.

Bilateral symmetry The bird in **Figure 9** has bilateral symmetry. In contrast to radial symmetry, **bilateral** (bi LA tuh rul) **symmetry** means the animal can be divided into mirror image halves only along one plane through the central axis. All animals with bilateral symmetry develop from three embryonic cell layers–the ectoderm, the endoderm, and the mesoderm.

Cephalization Animals with bilateral symmetry also have an **anterior,** or head end, and a **posterior,** or tail end. This body plan is called **cephalization** (sef uh luh ZA shun)–the tendency to concentrate nervous tissue and sensory organs at the anterior end of the animal. Most animals with cephalization move through their environments with the anterior end first, encountering food and other stimuli. In addition to cephalization, animals with bilateral symmetry have a **dorsal** (DOR sul) surface, also called the backside, and a **ventral** (VEN trul) surface, also called the underside or belly.

Body Cavities

In order to understand the next branching point on the evolutionary tree, it is important to know about certain features of animals with bilateral symmetry. Body plans of animals with bilateral symmetry include the gut, which is either a sac inside the body or a tube that runs through the body, where food is digested. A saclike gut has one opening, a mouth, for taking in food and disposing of wastes. A tubelike gut has an opening at both ends, mouth and an anus, and is a complete digestive system that digests, absorbs, and stores food, and disposes of waste.

Coelomates Between the gut and the outside body wall of most animals with bilateral symmetry is a fluid-filled body cavity. One type of fluid-filled cavity, the **coelom** (SEE lum), shown in **Figure 10,** has tissue formed from mesoderm that lines and encloses the organs in the coelom. You have a coelom, as do insects, fishes, and many other animals. Therefore, you are a coelomate. The coelom was a key adaptation in the evolution of larger and more specialized body structures. Specialized organs and body systems that formed from mesoderm developed in the coelom. As more efficient organ systems evolved, such as the circulatory system and muscular system, animals could increase in size and become more active.

Pseudocoelomates Follow the body cavity branch on the evolutionary tree in **Figure 8** until you come to the pseudocoelomates, which are animals with pseudocoeloms. A **pseudocoelom** (soo duh SEE lum) is a fluid-filled body cavity that develops between the mesoderm and the endoderm rather than developing entirely within the mesoderm as in coelomates. Therefore, the pseudocoelom, as shown in **Figure 10,** is lined only partially with mesoderm. The body cavity of pseudocoelomates separates mesoderm and endoderm, which limits tissue, organ, and system development.

Acoelomates Before the body cavity branch on the evolutionary tree in **Figure 8,** notice that the branch to the left takes you to the acoelomate animals. **Acoelomates** (ay SEE lum ayts), such as the flatworm in **Figure 10,** are animals that do not have a coelom. The body plan of acoelomates is derived from ectoderm, endoderm, and mesoderm--the same as in coelomates and pseudocoelomates. However, acoelomates have solid bodies without a fluid-filled body cavity between the gut and the body wall. Nutrients and wastes diffuse from one cell to another because there is no circulatory system.

Personal Tutor

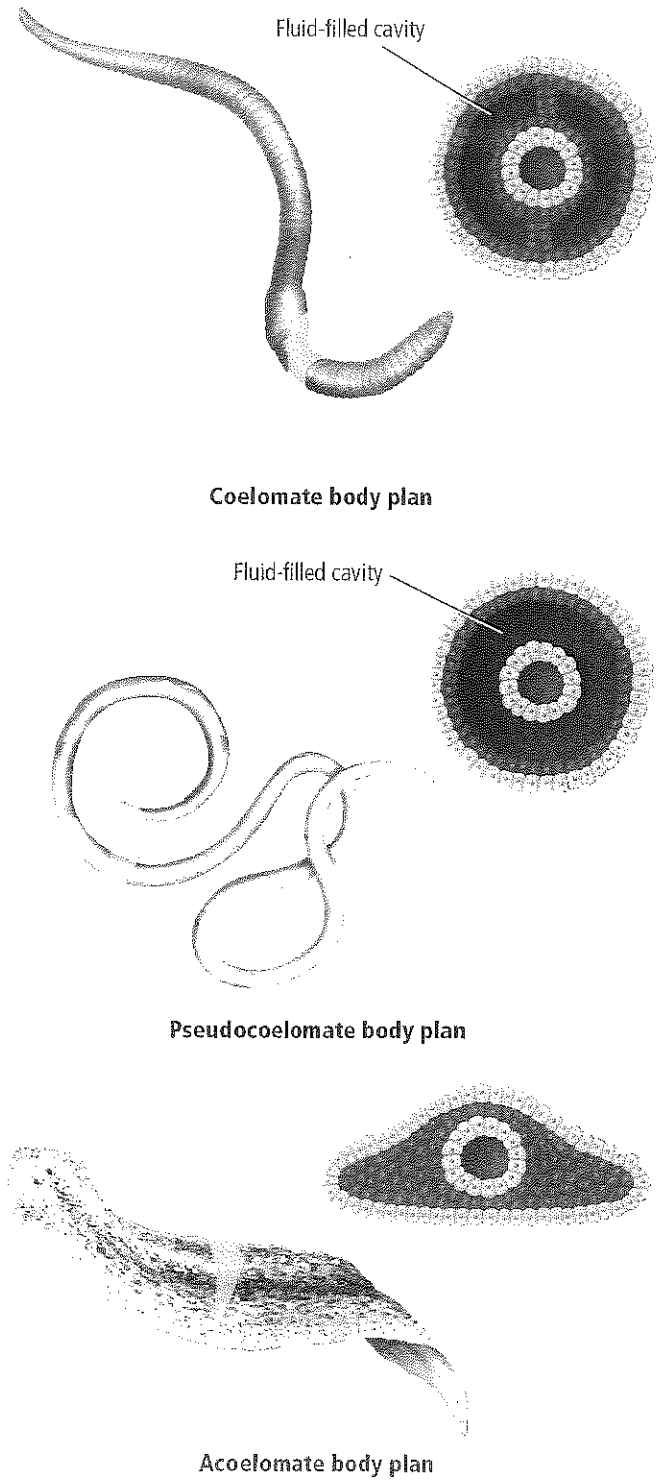


Figure 10 An earthworm has a coelom, a fluid-filled body cavity surrounded completely by mesoderm. The pseudocoelom of a roundworm develops between the mesoderm and endoderm. A flatworm has a solid body without a fluid-filled cavity.

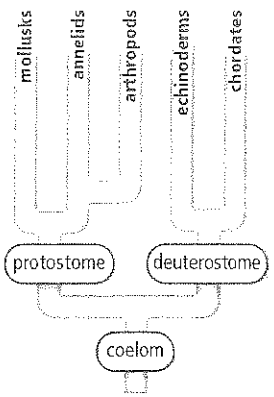


Figure 11 This part of the evolutionary tree shows that protostomes and deuterostomes are branches of coelomate animals.

Development in Coelomate Animals

The evolutionary tree in **Figure 11** begins at the coelomate branch. Notice that two major lines of development have been identified in coelomate animals. One is protostome development, which occurs in animals such as snails, earthworms, and spiders. The other is deuterostome development, which occurs in animals such as sea urchins, dogs, and birds. Biologists can tell if animals are closely related based on their patterns of embryonic development.

Protostomes In organisms that are **protostomes** (PROH tuh stohms), the mouth develops from the first opening in the gastrula. As protostomes develop, the final outcome for each cell in the embryo cannot be altered. If one cell of the embryo is removed, the embryo will not develop into a normal larva, as shown in **Figure 12.** In addition, in the eight-cell stage of embryonic development, the top four cells are offset from the bottom four cells, giving the embryo a spiral appearance. As the embryo continues to develop, the mesoderm splits down the middle. The cavity between the two pieces of mesoderm becomes the coelom.

Deuterostomes In organisms that are **deuterostomes** (DEW tihr uh stohms), the anus develops from the first opening in the gastrula. The mouth develops later from another opening of the gastrula. During the development of deuterostomes, the final outcome for each cell in the embryo can be altered. In fact, each cell in the early embryo, if removed, can form a new embryo, as shown in **Figure 12.** In contrast to protostome development, in the eight-cell stage of embryonic deuterostome development the top four cells are directly aligned on the bottom four cells. As the embryo develops, the coelom forms from two pouches of mesoderm.

Reading Check **Determine** whether you are classified as a protosome or a deuterostome. Explain.

MiniLab 2

Examine Body Plans

MiniLab

What is the importance of a body plan? One way to classify animals is by body plan. Looking at cross sections of different animals can help you distinguish between the different body plans.

Procedure

1. Read and complete the lab safety form.
2. Obtain **prepared slides of cross sections of an earthworm and a hydra.** Using a **microscope,** observe each slide under low-power magnification.
3. Sketch each cross section.
4. Obtain **labeled diagrams of cross sections of each animal** from your teacher. Make a list of how your sketches are like the diagrams and another list of how they are different.

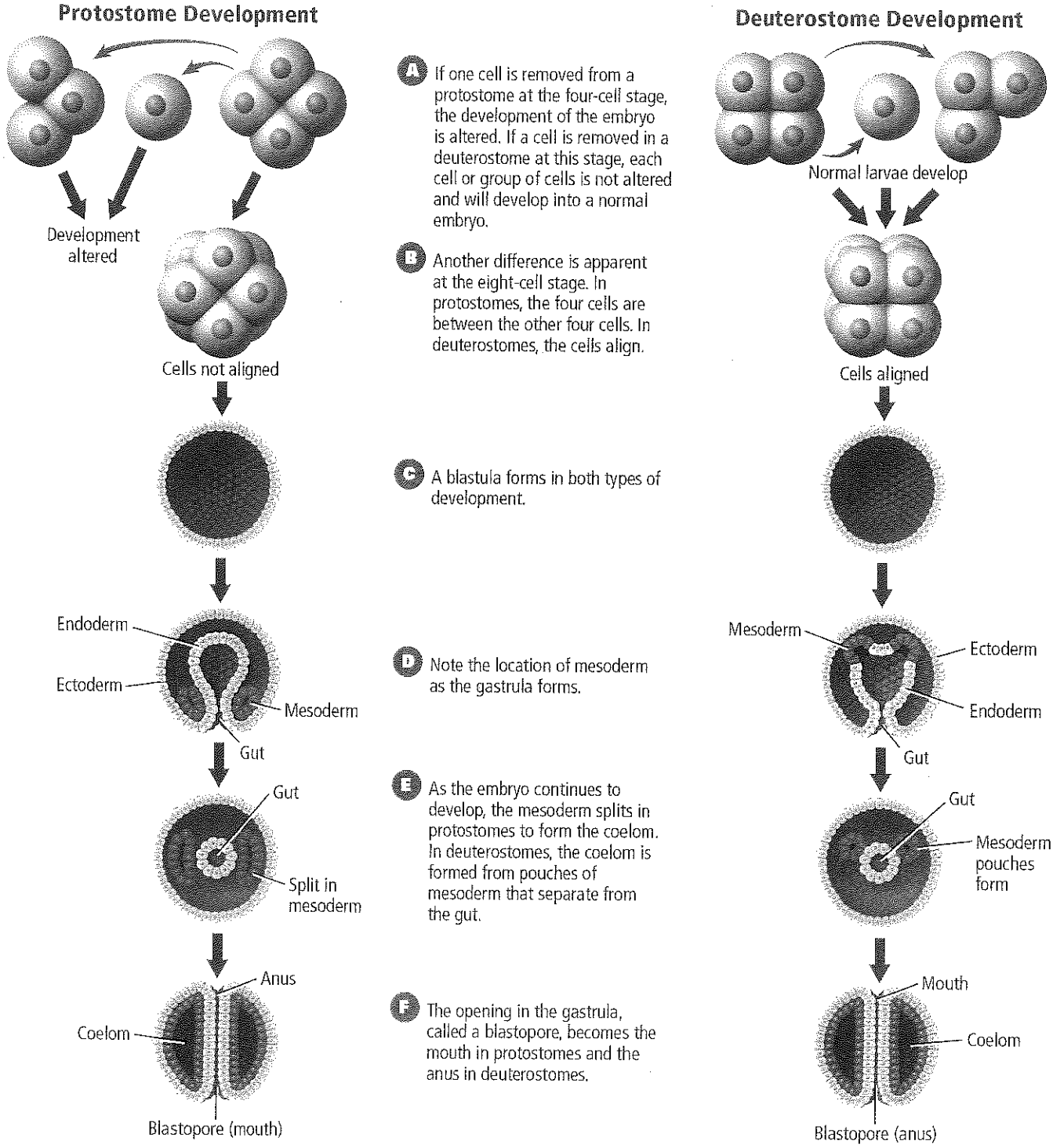
Analysis

1. **Compare and contrast** each animal's type of body cavity. Are they acoelomate or coelomate? What do your observations tell you about the phylogeny of these animals?
2. **Infer** how the body plan of each animal is related to how each of these animals obtains food.

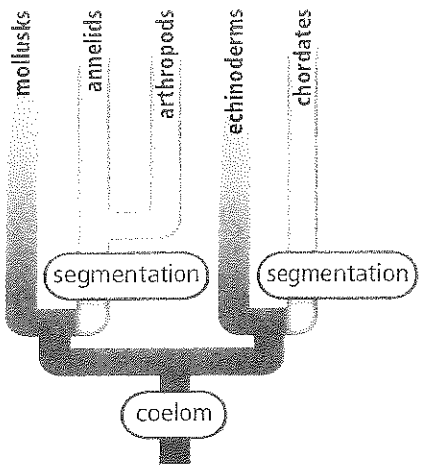
Visualizing Protostome and Deuterostome Development

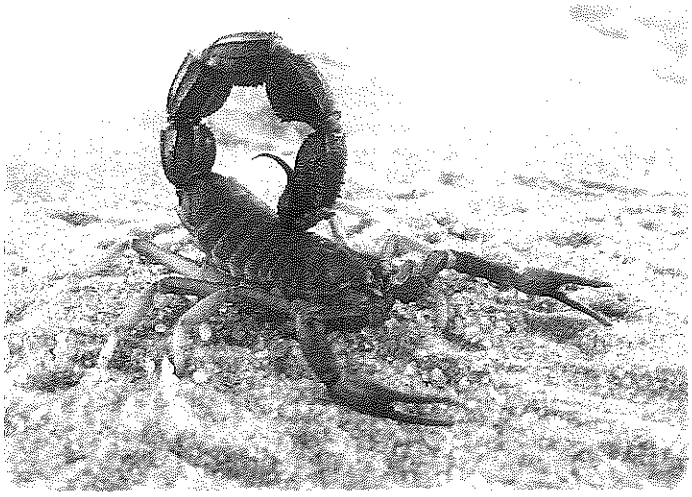
Figure 12

Developmental differences characterize protostome and deuterostome development.



Animation





Scorpion

Figure 13 Segmentation enables a scorpion to move its stinger in different directions to attack prey or for defense.

Segmentation

Examine the next branching point on the evolutionary tree in **Figure 13.** Segmentation is an important feature in the evolution of coelomate animals. Just as a chain is constructed from a series of links, segmented animals can be "put together" from a succession of similar parts.

The segmentation, such as that seen in scorpions, has two advantages. First, segmented animals can survive damage to one segment because other segments might be able to carry out the damaged section's function. Second, movement is more effective because segments can move independently. Therefore, the scorpion in **Figure 13** has more flexibility and can move in ways that are very complex. Segments allow the scorpion to arch its tail over its back to sting prey.

Section 2 Assessment

Section Summary

- Animal phylogeny can be compared to a tree with branches.
- The branches of a phylogenetic evolutionary tree show the relationships among animals.
- Animal phylogeny can be determined, in part, by the animal's type of body cavity or lack of a body cavity.
- After gastrulation, two types of development can occur in coelomate animals.
- Segmentation is an important feature in some coelomate animals.

Understand Main Ideas

1. **Explain** how body symmetry is related to the phylogeny of animals.
2. **Name** the features marking the main branching points on the evolutionary tree of animals.
3. **Illustrate** how body cavities distinguish branches of development of animals with bilateral symmetry.
4. **Compare and contrast** deuterostome and protostome development.

Think Critically

5. **Diagram** animals not shown in **Figure 9** that have radial and bilateral symmetry. Indicate the type of symmetry by showing planes passing through the animals. Label each animal as having either radial or bilateral symmetry.

WRITING IN Biology

6. Write a paragraph summarizing the differences among coelomates, pseudocoelomates, and acoelomates.

Online Quiz

Section 3

Reading Preview

Essential Questions

- What are the characteristics of sponges and cnidarians?
- How are sponges and cnidarians alike and different?
- What is the ecological importance of sponges and cnidarians?

Review Vocabulary

diploid: cell with two of each kind of chromosome

New Vocabulary

filter feeder
sessile
cnidocytes
nematocyst
gastrovascular cavity
nerve net
polyp
medusa

Multilingual eGlossary

Sponges and Cnidarians

MAIN Idea **Sponges and cnidarians were the first animals to evolve from a multicellular ancestor.**

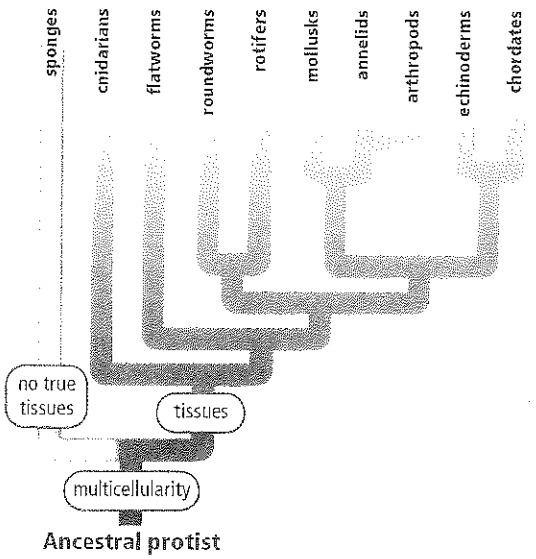
Real-World Reading Link Have you ever double-bagged your groceries? If so, you have an idea of how a sponge is structured—a layer, or sac, of cells within another sac of cells. These sacs of cells are among the first animals to evolve from the common ancestor of all animals.

Sponges

If you examine a living sponge, you might wonder how these animals do so much with so little. They have no tissues, no organs, and most have no symmetry. You can break apart a sponge into its individual cells and those cells will come together again to form a sponge. Other animals cannot do this.

Locate sponges on the evolutionary tree in **Figure 14.** They are in the phylum Porifera (po RIF uh ruh), which contains between 5000 and 10,000 members. Most live in marine environments. Biologists hypothesize that sponges evolved from the colonial choanoflagellates because sponges have cells that look similar to these protist cells.

Body structure Notice the asymmetrical appearance and bright colors of the sponge in **Figure 14.** It is difficult to think that these are animals, especially if you see one washed up on a beach where it might appear as a black blob. Recall that tissues form from ectoderm, endoderm, and mesoderm in a developing embryo. Sponge embryos do not develop endoderm or mesoderm, and, therefore, sponges do not develop tissues. How does a sponge's body function without tissues?



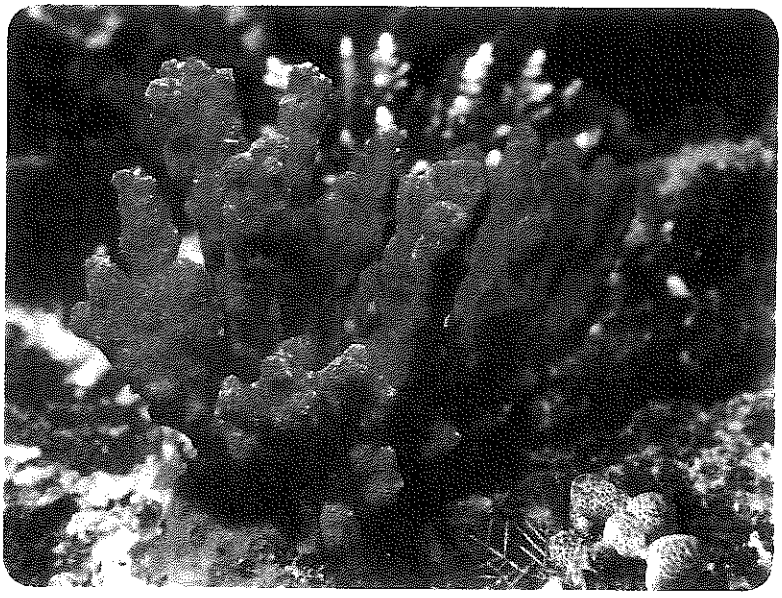


Figure 14 The sponges in the photograph are animals that take in and digest food, grow, and reproduce, even though they lack true tissues.

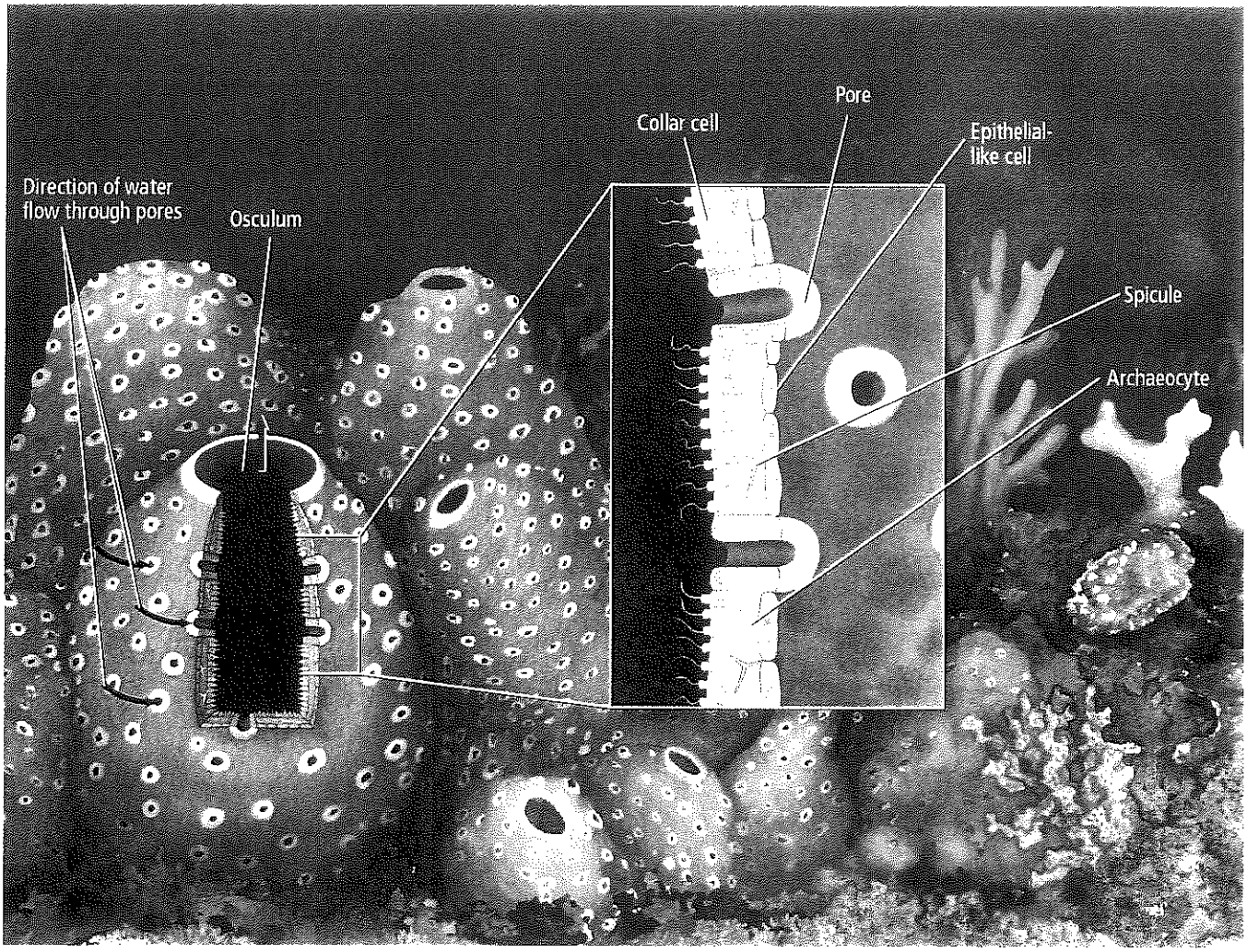


Figure 15 Sponges have no tissues or organs and have a body made of two layers of cells.

Animation

Study Tip

Think Aloud Read the text and captions aloud. As you read, say aloud your questions and comments. For instance, when you come to the mention of **Figure 15,** look at the figure and say how it relates to the text.

Two layers of independent cells with a jellylike substance between the layers accomplish all of the life functions of sponges. As illustrated in **Figure 15,** epithelial-like cells cover the sponge and protect it. Collar cells with flagella line the inside of the sponge. As collar-cell flagella whip back and forth, water is drawn into the body of the sponge through pores. These pores give sponges their phylum name Porifera, which means "pore-bearer." Water and waste materials are expelled from the sponge through the osculum (AHS kyuh lum), which is the mouthlike opening at the top of the sponge.

Feeding and digestion When an organism, such as a sponge, gets its food by filtering small particles from water, it is called a **filter feeder.** Even though this might sound like a process that is not very active, consider that a sponge only 10 cm tall can filter as much as 100 L of water each day. Although sponges have free-swimming larvae, the adults move very little. Adaptations for filter-feeding are common in animals that are **sessile** (SES sul), meaning they are attached to and stay in one place. As nutrients and oxygen dissolved in water enter through the pores in a sponge's body, food particles cling to the cells. Digestion of nutrients takes place within each cell.

Reading Check **Infer** why filter feeding is an adaptive advantage for sponges.

Demosponge

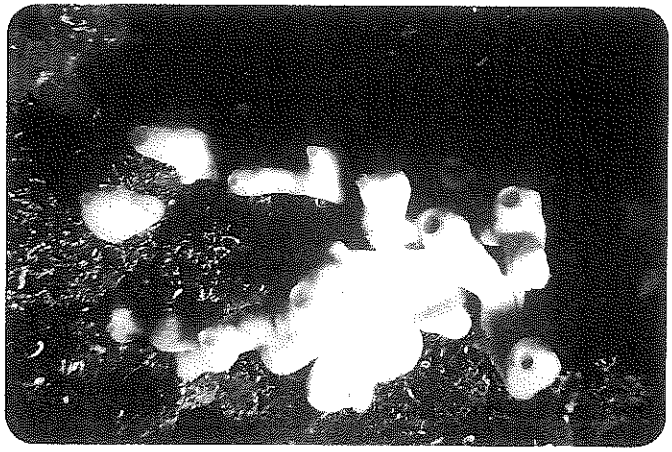
Figure 16 Bath sponges are harvested from the sea and processed for human use.

Support Within the jellylike material that lies between the two cell layers of a sponge are amoeba-like cells—cells that can move and change shape. These amoeba-like cells are called archaeocytes (ar kee OH sites) and are illustrated in **Figure 15.** These cells are involved in digestion, production of eggs and sperm, and excretion. Archaeocytes also can become specialized cells that secrete spicules (SPIH kyuhls), the support structures of sponges. Spicules are small, needlelike structures made of calcium carbonate, silica, or a tough fibrous protein called spongin.

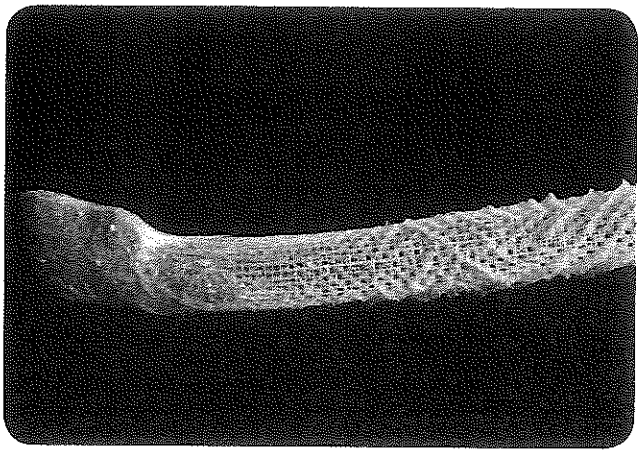
Sponge diversity Biologists place sponges into three classes based on the type of support system each has. Most sponges belong to class Demospongiae (deh muh SPUN jee uh), the demosponges, and have spicules composed of spongin fibers, silica, or both. Natural bath sponges, like the ones in **Figure 16,** have spongin support. Class Calcarea (kal KER ee uh) consists of sponges with spicules composed of calcium carbonate. Calcareous sponges, like the one in **Figure 17,** often have a rough texture because the calcium carbonate spicules can extend through the outer covering of the sponge. The sponges in class Hexactinellida (heks AK tuh nuh LEE duh) are called glass sponges and have spicules composed of silica. These spicules join together to form a net-like skeleton that often looks like spun glass as illustrated in **Figure 17.**

BrainPOP

Figure 17 Calcareous sponges are small and have a rough texture. The skeletons of glass sponges look like brittle spun glass.



Calcareous sponge



Glass sponge skeleton

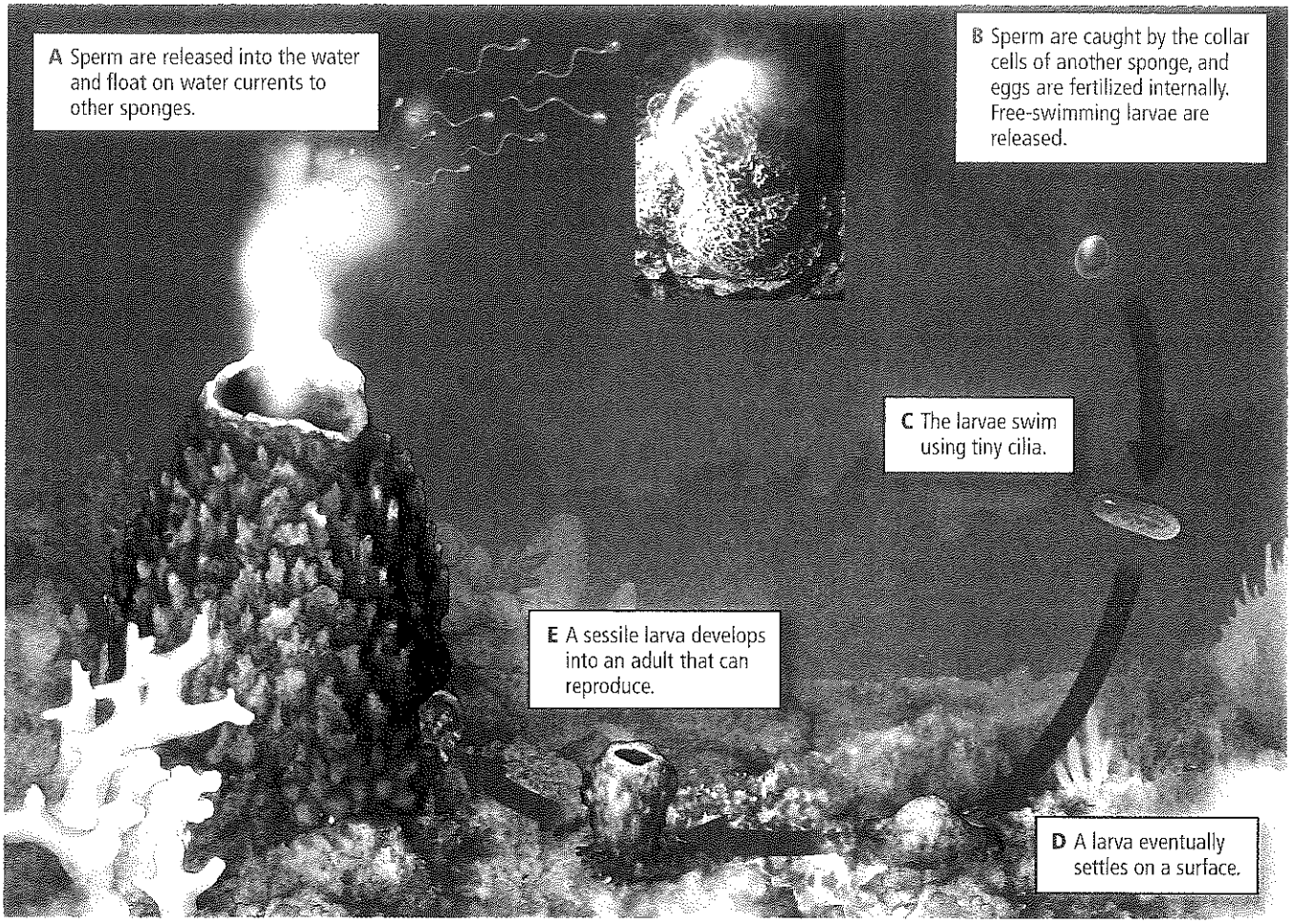


Figure 18 Sexual reproduction in sponges requires water currents to carry sperm from one sponge to another.
Evaluate ***whether fertilization is internal or external in sponge sexual reproduction.***

Response to stimuli Sponges do not have nervous systems. They do have epithelial-like cells that detect external stimuli, such as touch or chemical signals, and respond by closing their pores to stop water flow.

Reproduction Sponges can reproduce asexually by fragmentation, through budding, or by producing gemmules (JEM yewlz). In fragmentation, a piece of sponge that is broken off due to a storm or other event develops into a new adult sponge. In budding, a small growth, called a bud, forms on a sponge, drops off, and settles in a spot where it grows into a new sponge. Some freshwater sponges form seedlike particles called gemmules during adverse conditions like droughts or freezing temperatures. Gemmules contain sponge cells protected by spicules that will survive and grow again when favorable conditions occur.

Most sponges reproduce sexually, as illustrated in **Figure 18.** Some sponges have separate sexes, but most sponges are hermaphrodites. Recall that a hermaphrodite is an animal that can produce both eggs and sperm. During reproduction, eggs remain within a sponge, while sperm are released into the water. Sperm released from one sponge can be carried by water currents to the collar cells of another sponge. The collar cells then change into specialized cells that carry the sperm to an egg within the sponge body. After fertilization occurs, the zygote develops into a larva that is free-swimming and has flagella. The larva eventually attaches to a surface, then develops into an adult.

Reading Check **Describe** the methods by which sponges reproduce.

VOCABULARY

ACADEMIC VOCABULARY

Survive
to remain alive
Sponge gemmules survive despite adverse conditions.

Franco Banfi/WaterFrame/Getty Images

Sponge ecology Although spicules and toxic or distasteful compounds in sponges discourage most potential predators, sponges are food for some tropical fishes and turtles. Sponges also are common habitats for a variety of worms, fishes, shrimp, and colonies of symbiotic green algae. Some sponges even live on and provide camouflage for mollusks, as shown in **Figure 19.**

Sponges also are beneficial to humans. Sponges with spicules made of spongin fibers like the one shown in **Figure 20,** often are used for household scrubbing purposes. Medical research is focusing on sponge chemicals that appear to discourage prey and prevent infection. Ongoing studies of these sponge chemicals as possible pharmaceutical agents have shown that they might have antibiotic, anti-inflamatory, or antitumor possibilities. They also might have potential importance as respiratory, cardiovascular, and gastrointestinal medicines.

Connection to For example, in 2011, the Food and Drug Administration approved a drug derived from a compound produced by *Halichondria okadai,* a sponge found off of the coast of Japan. The drug, which inhibits the growth of cancer cells, is used in the treatment of late-stage breast cancer. After discovering the compound in the sponges in 1986, scientists worked to synthesize it in the lab so it could be tested and, later, mass produced. Another sponge, *Tectitethya crypta,* produces two chemicals that have been used as the models to produce antiviral drugs, including the HIV drug AZT, and anti-cancer drugs. One of the anti-cancer drugs created as a result of the discovery was the first drug that came from a marine source to be approved for cancer treatment.

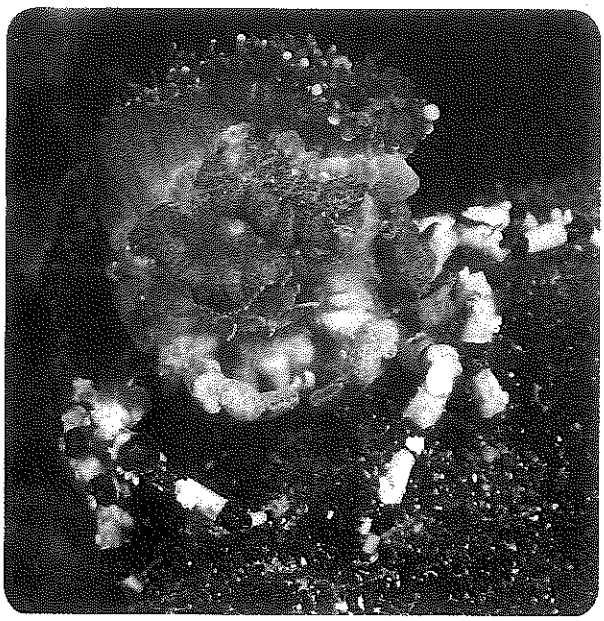
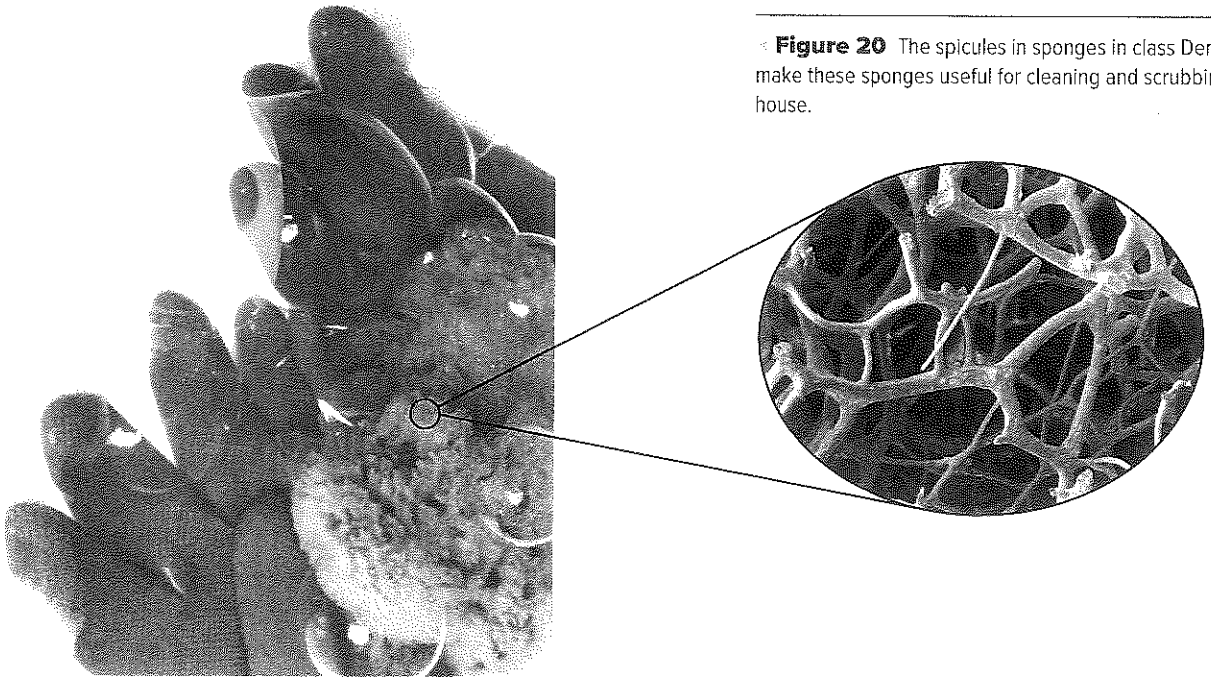
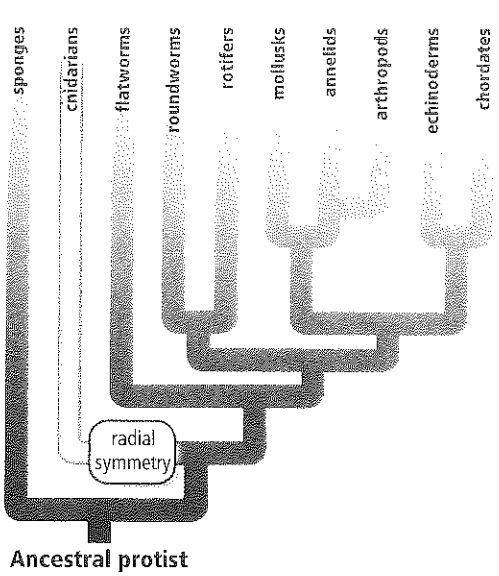


Figure 19 This crab hides from predators by carrying a living sponge on its back. The crab uses two pairs of legs to hold the sponge in place.

Figure 20 The spicules in sponges in class Demospongiae make these sponges useful for cleaning and scrubbing around the house.



Discodermia




Jellyfish—free floating

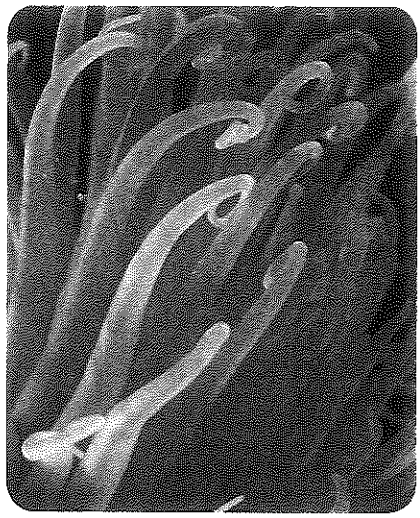
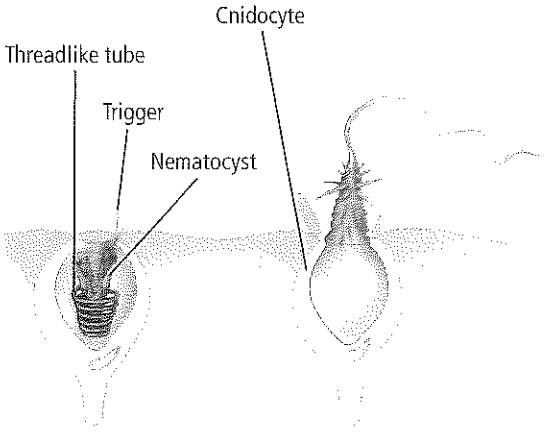

Sea anemone—sessile

Figure 21 Cnidarians have radial symmetry and can be free floating or sessile.
Explain how radial symmetry helps a cnidarian obtain food.

Figure 22 Stinging cells that contain nematocysts are discharged from the tentacles of cnidarians when prey touches them.



Cnidarians

Imagine that you go snorkeling around a coral reef, and you wear a bodysuit to protect yourself from the stings of jellyfishes that float on the water. Later, when you go ashore to visit a tidepool, you might see colorful sea anemones that look somewhat like flowers. The jellyfish and sea anemone in **Figure 21** belong to phylum Cnidaria (ni DARE ee uh). This phylum consists of about 10,000 species, most of which are marine.

Body structure Like sponges, cnidarians (ni DARE ee uns) have one body opening and most have two layers of cells. However, in cnidarians, the two cell layers are organized into tissues with specific functions. The outer layer functions in protecting the internal body, while the inner layer functions mainly in digestion. Because cnidarians have tissues, they also have symmetry. As shown in **Figure 21**, cnidarian bodies have radial symmetry. Recall that radial symmetry enables slow moving or sessile animals to detect and capture prey from any direction. Cnidarians are adapted to aquatic floating or sessile attachment to surfaces under the water.

Feeding and digestion Cnidarian tentacles are armed with stinging cells called **cnidocytes** (NI duh sites). Cnidarians get their name from these stinging cells. Cnidocytes contain nematocysts, as shown in **Figure 22.** A **nematocyst** (nih MA tuh sihst) is a capsule that holds a coiled, threadlike tube containing poison and barbs.

Connection to Physics A nematocyst works like a tiny but very powerful harpoon. Remember that osmosis is the diffusion of water through a selectively permeable membrane. The pressure provided by this flow of water is called osmotic pressure. The water inside an undischarged nematocyst is under an osmotic pressure of more than 150 atmospheres. This pressure is about 20 times the pressure in an inflated bicycle tire.

In response to being touched or to a chemical stimulus, the permeability of the nematocyst membrane increases, allowing more water to rush in. As the osmotic pressure increases, the nematocyst discharges forcefully. A barb is capable of penetrating a crab shell.

Nematocyst discharge is one of the fastest cellular processes in nature. It happens so quickly–in just 3/1000ths of a second–that it is impossible to escape after touching these cells. After capture by nematocysts and tentacles, the prey is brought to the mouth of the cnidarian.

The inner cell layer of cnidarians surrounds a space called the **gastrovascular** (gas troh VAS kyuh lur) **cavity,** illustrated in **Figure 23.** Cells lining the gastrovascular cavity release digestive enzymes over captured prey. Undigested materials are ejected through the mouth. Recall that digestion occurs within each cell of a sponge. However, in cnidarians, digestion takes place in the gut cavity, a major evolutionary adaptation.

Response to stimuli In addition to cells adapted for digestion, cnidarians have a nervous system consisting of a **nerve net** that conducts impulses to and from all parts of the body. The impulses from the nerve net cause contractions of musclelike cells in the two cell layers. The movement of tentacles during prey capture is the result of contractions of these musclelike cells. Cnidarians have no blood vessels, respiratory systems, or excretory organs. Look at **Table 1** to compare the structures and functions of sponges and cnidarians.

Reading Check **Contrast** a cnidarian's response to stimuli from a sponge's response.

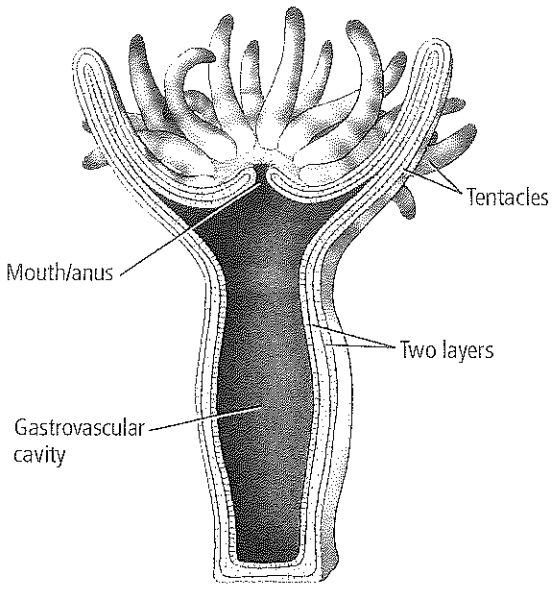


Figure 23 A cnidarian's mouth leads directly into its gastrovascular cavity. Because the digestive tract has only one opening, wastes are expelled through the mouth.

Table 1 **Comparison of Sponges and Cnidarians** Interactive Table

	Sponges	Cnidarians
Example		
Body Plan	• Generally has asymmetry	• Has radial symmetry
Feeding and digestion	• Filter feed • Digestion takes place within individual cells	• Capture prey with nematocysts and tentacles • Digestion takes place in gastrovascular cavity
Movement	• Sessile	• Aquatic floating or sessile
Response to stimuli	• No nervous system • Cells react to stimuli	• Simple nervous system consisting of a nerve net
Reproduction	• Hermaphrodites reproduce sexually • Asexual reproduction by fragmentation, budding, or gemmule production	• Separate sexes reproduce sexually • Polyp stage reproduces asexually by budding

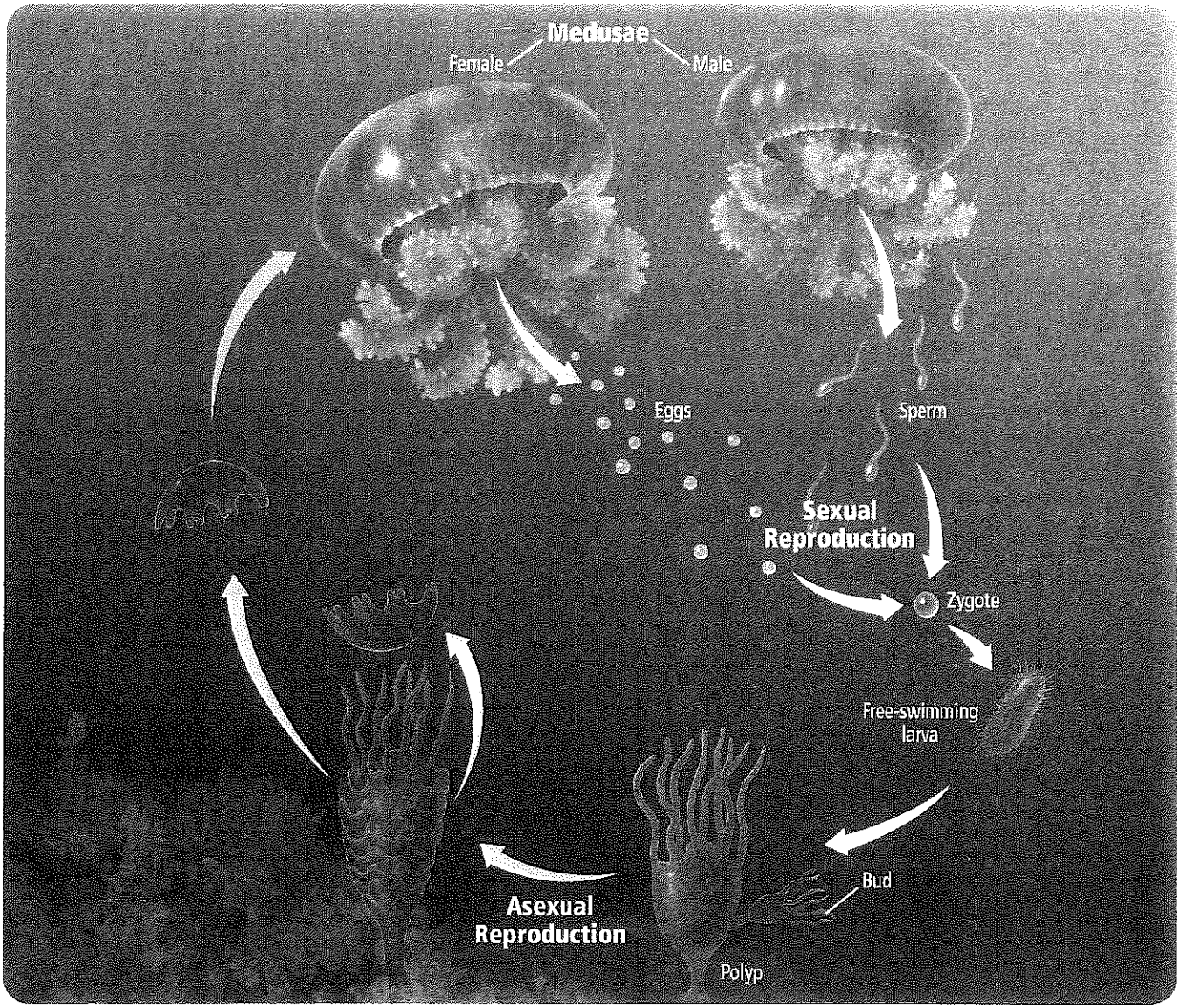


Figure 24 Jellyfishes reproduce by alternating sexual and asexual stages of their life cycle.

Animation

Reproduction In addition to stinging cells, cnidarians have another adaptation not seen in most animals of recent origin. Most cnidarians have two body forms: a **polyp** (PAH lup) with a tube-shaped body and a mouth surrounded by tentacles, and a **medusa** (mih DEW suh) (plural, medusae) with an umbrella-shaped body and tentacles that hang down. The mouth of a medusa is on the ventral surface between the tentacles.

The two body forms of cnidarians can be observed in the life cycle of jellyfishes, illustrated in **Figure 24.** To reproduce, jellyfishes in the medusa stage release eggs and sperm into the water where fertilization occurs. The resulting zygotes eventually develop into free-swimming larvae that settle and grow into polyps. These polyps reproduce asexually to form new medusae. It would be easy to confuse the life cycle of cnidarians with the alternation of generations in plants. However, in plants, one generation is diploid and the other is haploid. In cnidarians, both the medusae and polyps are diploid animals.

Reading Check **Compare** the larvae of sponges and cnidarians.

CAREERS IN BIOLOGY

Marine Ecologist Using submersibles and deep-sea robots, a marine ecologist studies the relationships between marine animals and their environments.

Cnidarian diversity There are four main classes of cnidarians: Hydrozoa, the hydroids; two classes of jellyfishes, Scyphozoa and Cubozoa (the box jellyfishes); and Anthozoa, the sea anemones and corals.

Hydroids Most of the approximately 2700 known species of hydroids have both polyp and medusa stages in their life cycles. Most hydroids form colonies, such as the Portuguese man-of-war in **Figure 25.** Another well-known hydroid is the freshwater hydra, which is unusual because it has only a polyp stage.

Jellyfishes There are about 200 known species of jellyfishes. They are transparent or translucent in appearance and float near the water's surface. The medusa is the dominant body form, although a polyp stage does exist. They are called jellyfishes because the substance between the outer body covering and the inner body wall is jellylike. The structure of the inner and outer body layers with the jellylike structure between can be compared to a jelly sandwich. The box jellyfishes take their name from the boxlike medusae that are their dominant form. The stings of some box jellyfish species can be fatal to humans.

Sea anemones and corals Generally colorful and inviting, sea anemones and corals still possess stinging cells like all cnidarians. The 6200 known species of sea anemones and corals are different from the jellyfishes because the polyp stage is the dominant stage of their life cycles. Recent research indicates that these anthozoans might have bilateral symmetry. This would alter the evolutionary tree because this adaptation usually is seen only in animal groups that evolved later than cnidarians.

Sea anemones live as individual animals, while corals live in colonies of polyps. Corals secrete protective calcium carbonate shelters around their soft bodies. The living portion of a coral reef is a thin, fragile layer growing on top of the shelters left behind by previous generations. Coral reefs form from these shelters over thousands of years.

Coral polyps extend their tentacles to feed, as shown in **Figure 26.** They also harbor symbiotic photosynthetic protists called zooxanthellae (zoh oh zan THEH lee). The zooxanthellae produce oxygen and food that corals use, while using carbon dioxide and waste materials produced by the corals. These protists are primarily responsible for the bright colors found on healthy coral reefs.

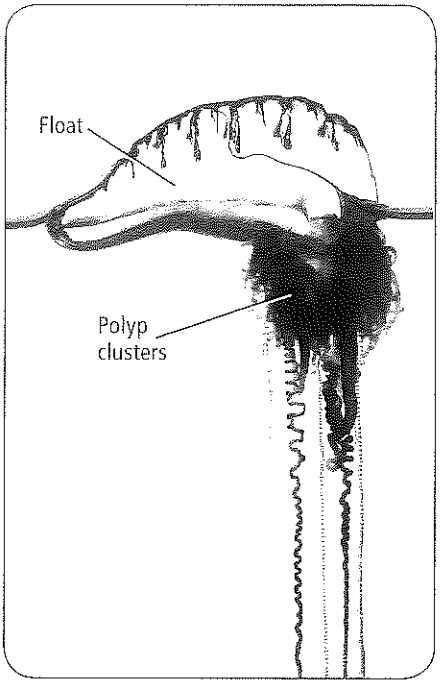
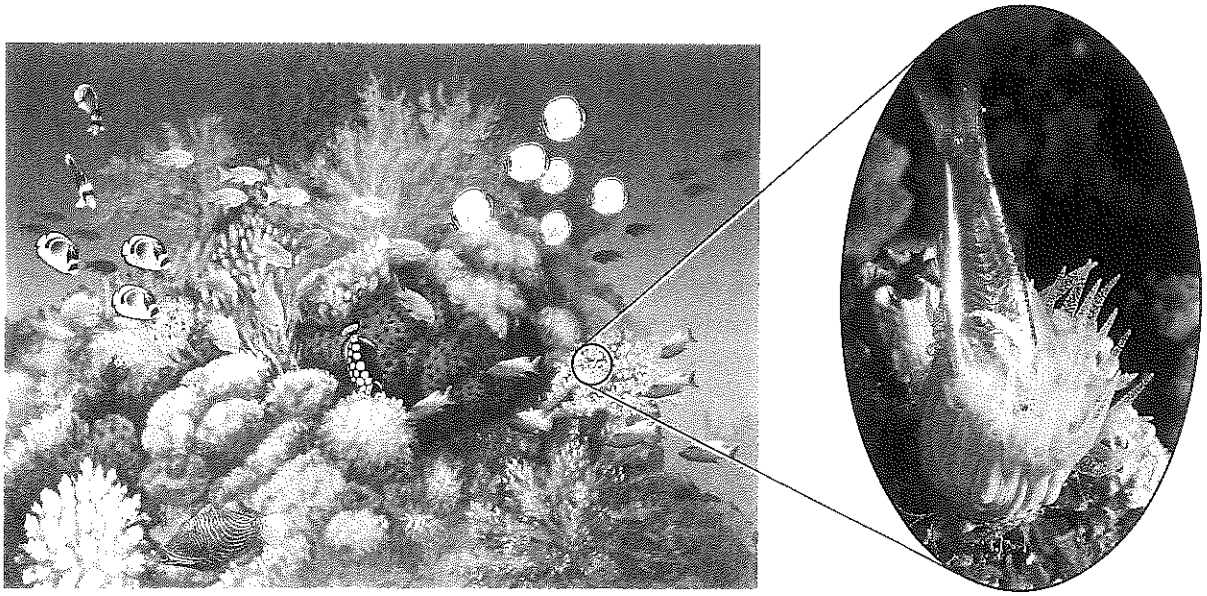


Figure 25 This Portuguese man-of-war is composed of a colony of hydroids. One hydroid polyp forms the large float, while other hydroid polyps cluster beneath the float.

Figure 26 Coral polyps capture food by extending their tentacles.



(t)Georgette Douwma/Photo Researchers; (b)Jeff Rotman/Photo Researchers

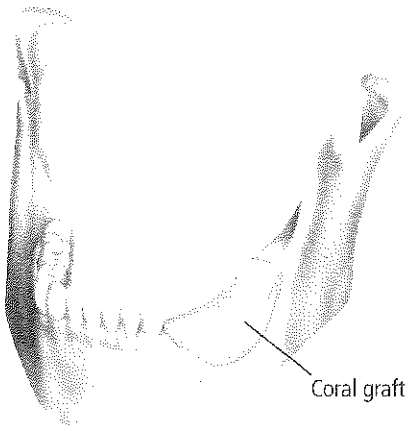


Figure 27 Surgeons use treated hydroxyapatite to make implants for reconstructing facial bones, such as this jaw.

The health of a coral reef depends on proper water temperature, adequate light, and appropriate water depth. If these environmental conditions deteriorate in areas where there are reefs, the health of the reef might also deteriorate. You can examine this problem in **Data Analysis Lab 1.**

Cnidarian ecology Mutualism, a relationship in which both organisms benefit, is common in cnidarians. One species of sea anemone wraps itself around hermit crabs' shells; the anemones obtain food scraps and the crabs are protected. Some sea slugs feed on cnidarians and incorporate the unfired nematocysts into their bodies for their own defense. As shown in the photo at the beginning of the chapter, clown fishes are protected by the tentacles of anemones. One theory as to how clown fishes are protected from the tentacles of anemones is that the fish incorporates mucus from an anemone into its own mucous coating, which prevents the nematocysts from discharging.

People benefit from cnidarians in many ways. Some people enjoy visiting a coral reef. In the medical field, some stony coral species are used in surgical procedures. A calcium phosphate mineral in coral called hydroxyapatite (hi DROX ee ap uh TITE) can be treated so that it has the same structure and chemical composition as human bone. Small pieces of coral are implanted as bone grafts, especially in face and jaw reconstruction and in arm and leg surgery. The grafts anchor to the adjacent bone, as shown in **Figure 27,** and are eventually replaced by new human bone growth.

DATA ANALYSIS LAB 1

Based on Real Data*

Interpret Data

Where are coral reefs being damaged?

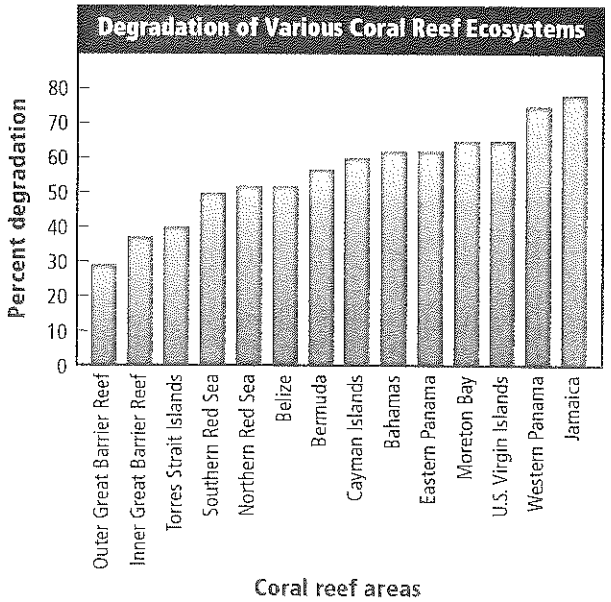
Some corals have ejected their symbiotic algae and become bleached, or lost their coloring. Coral reef bleaching is a common response to reef ecosystem damage. However, some corals appear to be recovering from bleaching.

Data and Observations

The graph indicates the percentage of the damage that has occurred to specific reefs.

Think Critically

1. **Interpret** What part of the world has suffered the most damage to its coral reefs? What part of the world has suffered the least damage to its reefs?
2. **Model** On a world map, locate the coral reefs noted in the graph. Color code the map based on the percent of degradation.



*Data obtained from: Pandolfi, J.M. et al., 2003. Global trajectories of the long-term decline of coral reef ecosystems. *Science* 301 (5635): 955–958.

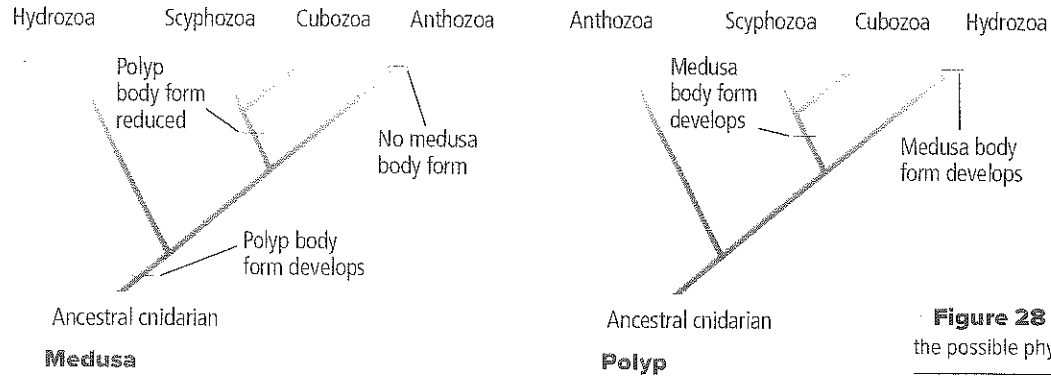


Figure 28 The two cladograms illustrate the possible phylogeny of cnidarians.

Evolution of cnidarians There are two major interpretations of the phylogeny of cnidarians. The fact that cnidarians have two body forms, medusa and polyp, raises the question of whether the ancestral cnidarian had a medusa or a polyp body form. The cladograms in **Figure 28** present both interpretations.

In the cladogram on the left, the ancestral cnidarian has a medusa body form. As cnidarians evolved, a polyp stage developed. The life cycles of hydrozoans have both polyp and medusa stages. As the scyphozoans and cubozoans developed, the medusa stage became the dominant stage in their life cycles. The most highly evolved cnidarians, the anthozoans, have no medusa stage.

In the cladogram on the right, the ancestral cnidarian has a polyp body form. The anthozoans evolved first, and the polyp stage is the dominant stage of their life cycles. The medusa stage evolved independently in hydrozoans and in scyphozoans and cubozoans. Notice how the classes of cnidarians are arranged in each cladogram.

Section 3 Assessment

Section Summary

- Sponges can be described according to animal features they do not have and according to features they do have.
- Sponges do not have tissues, but carry out the same life functions as other animals.
- Cnidarians have unique features that other animals do not have.
- Cnidarians have more highly evolved body forms and structures than sponges.
- Sponges and cnidarians are important to the ecology of their habitats and to humans.

Understand Main Ideas

1. **Explain** why sponges and cnidarians were the first animals to evolve.
2. **Describe** the differences between the body plans of sponges and cnidarians.
3. **List** two characteristics that are unique to sponges and two characteristics that are unique to cnidarians.
4. **Demonstrate** your knowledge of cnidarians by describing how they affect other marine organisms.

Think Critically

5. **Hypothesize** how nematocysts are an adaptive advantage for cnidarians.

MATH in Biology

6. Review the text under the heading *Cnidarian diversity*. Make a circle graph that shows the proportions of each of the three groups of cnidarians to the total numbers of cnidarians. In addition to the groups in this section, there are 900 species of other cnidarians. Analyze this information and hypothesize why one group is so much smaller than the others.

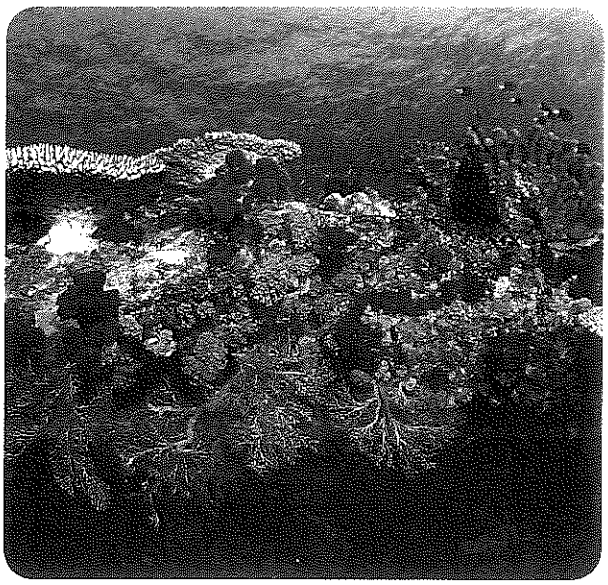
Online Quiz

Biology & Society

Beautiful and Endangered: Coral Reefs

Coral reefs dot the coasts around the world and cover over 284,000 square kilometers. People are fascinated by beautiful and delicate corals and by the populations that inhabit reef ecosystems. Ironically, human behaviors have contributed to the endangerment of coral reefs.

What are coral reefs? Not all corals form reefs, but those that do begin the process when individual polyps attach to rocks. They do this by secreting a calcium carbonate exoskeleton that cements the polyps in place. As the polyps die over time, the exoskeletons are left behind and a coral reef forms. Many corals have a symbiotic relationship with the alga zooxanthellae. These algae provide the corals with nutrients gained through photosynthesis, and they use the carbon dioxide produced by the corals.



This healthy coral reef shows no sign of bleaching, disease, or pollution.

Why are coral reefs important? Coral reefs form some of the most diverse ecosystems in the world. About 25 percent of all marine species live in coral reefs, and scientists estimate that reefs also support millions of undiscovered species. The biodiversity of reefs is valuable and irreplaceable.

What is happening to coral reefs? Coral reefs face natural threats, including extreme weather conditions and predation. Many coral reefs have been damaged by human activities, such as fishing practices that employ dynamite or poison. Some polluted runoff stimulates the growth of nonbeneficial algae, which smothers corals. Tourist activities like diving and snorkeling also damage corals. Some divers and snorkelers break off pieces of coral to sell or to take home as souvenirs. Other divers collect live corals to sell for use in aquariums.

Sometimes, corals become so stressed that they expel their symbiotic algae. This is a phenomenon known as "bleaching" because the stressed corals lose their bright colors and appear white. Scientists do not yet completely understand why coral bleaching occurs. They think one of the main causes is rising ocean temperatures. Other possible factors include pollution, bacteria, solar radiation, and changes in salinity. Coral reefs that expel their algae are more likely to become diseased, and the corals will die unless the symbiotic algae are replaced.

VISUAL COMMUNICATION

Make a Movie Research with your classmates what can be done to help keep coral reefs from becoming extinct. Write a script for a short movie about coral reefs. Include facts about what they are, why they are in danger, and what people can do to help. Include visuals such as photographs, maps, and costumes.

WebQuest

BIOLAB

Design Your Own

FIELD INVESTIGATION: WHAT CHARACTERISTICS DO ANIMALS HAVE?

Background: **A small pond is an ecosystem in which organisms interact to accomplish essential life functions. They exhibit a wide variety of body plans, obtain food in different ways, and use various methods of movement.**

Question: *What kinds of animals live in ponds?*

Materials

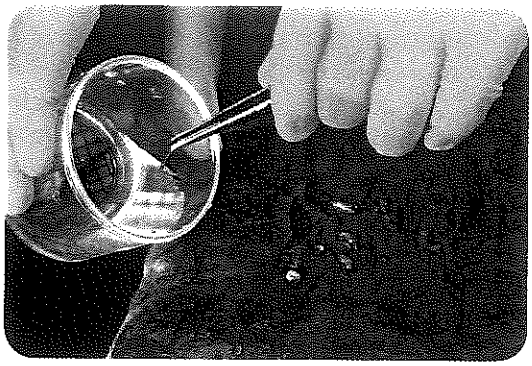
wading boots
tweezers
aquarium
Petri dishes
dissecting microscopes
Choose other materials that would be appropriate for this lab.

Safety Precautions

WARNING: ***Handle living animals with care.***

Plan and Perform the Experiment

1. Read and complete the lab safety form.
2. Locate a pond to use for your observations and collections. Make sure you have permission to use the pond.
3. Determine methods to observe and record animals that you see at the pond that you do not collect.
4. Design and construct a data table to record your observations.
5. Make sure your teacher approves your plan before you proceed.
6. **Cleanup and Disposal** Wash your hands after handling any live organisms. Return the animals and any pond water to the pond. Wash and return all reusable lab materials and correctly dispose of other materials used in the lab as directed by your teacher.



Analyze and Conclude

1. **Use Scientific Explanations** How were you able to determine if the organisms you observed were animals?
2. **Summarize** the adaptations used for obtaining food that you observed. Were any of the adaptations similar to those you observed in **MiniLab 1?**
3. **Compare and contrast** the methods of movement used by each of the animals you observed.
4. **Interpret Data** Look at drawings or photographs of the animals you observed. What do these illustrations tell you about the body plan of each organism? What gut type does each animal have?
5. **Error Analysis** What other types of observations could you make to verify your conclusions about each organism?

WRITING in Biology

Make a Booklet Choose one of the animals you observed in your pond study. Develop an illustrated booklet that shows how this animal obtains food, how it reproduces, its body plan, and its stages of development. Share the information with your class.

Chapter 24 Study Guide

THEME FOCUS Patterns All animals show some form of symmetry such as radial, bilateral, or asymmetrical symmetry.

BIG Idea Animal phylogeny is determined in part by animal body plans and adaptations.

Section 1 Animal Characteristics

invertebrate (p. 693)
exoskeleton (p. 693)
endoskeleton (p. 693)
vertebrate (p. 693)
hermaphrodite (p. 695)
zygote (p. 695)
internal fertilization (p. 695)
external fertilization (p. 695)
blastula (p. 696)
gastrula (p. 696)
endoderm (p. 697)
ectoderm (p. 697)
mesoderm (p. 697)

Key Idea Animals are multicellular, eukaryotic heterotrophs that have evolved to live in many different habitats.

- Animals are heterotrophs and must get their nutrients from other organisms.
- Animals have diverse means of support and live in diverse habitats.
- Animal cells do not have cell walls and most have cells that are organized into tissues.
- Most animals undergo sexual reproduction and most can move.
- During embryonic development, animal cells become tissue layers, which become organs and systems.

Section 2 Animal Body Plans

symmetry (p. 700)
radial symmetry (p. 700)
bilateral symmetry (p. 700)
anterior (p. 700)
posterior (p. 700)
cephalization (p. 700)
dorsal (p. 700)
ventral (p. 700)
coelom (p. 701)
pseudocoelom (p. 701)
acoelomate (p. 701)
protostome (p. 702)
deuterostome (p. 702)

Key Idea Animal phylogeny can be determined, in part, by body plans and the ways animals develop.

- Animal phylogeny can be compared to a tree with branches.
- The branches of a phylogenetic evolutionary tree show the relationships among animals.
- Animal phylogeny can be determined, in part, by the animal's type of body cavity or lack of a body cavity.
- After gastrulation, two types of development can occur in coelomate animals.
- Segmentation is an important feature in some coelomate animals.

Section 3 Sponges and Cnidarians

filter feeder (p. 706)
sessile (p. 706)
cnidocyte (p. 710)
nematocyst (p. 710)
gastrovascular cavity (p. 711)
nerve net (p. 711)
polyp (p. 712)
medusa (p. 712)

Key Idea Sponges and cnidarians were the first animals to evolve from a multicellular ancestor.

- Sponges can be described according to animal features they do not have and according to features they do have.
- Sponges do not have tissues, but carry out the same life functions as other animals.
- Cnidarians have unique features that other animals do not have.
- Cnidarians have more highly evolved body forms and structures than sponges.
- Sponges and cnidarians are important to the ecology of their habitats and to humans.

Vocabulary eGames

Chapter 24 Assessment

Section 1

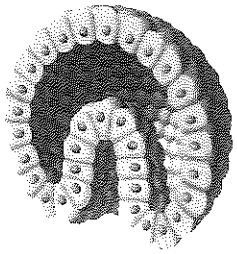
Vocabulary Review

Match the definitions below with the correct vocabulary terms from the Study Guide page.

1. a hard outer covering that provides support
2. fluid-filled ball of cells formed by miotic cell division of the embryo
3. an animal that produces both eggs and sperm

Understand Main Ideas

Use the diagram below to answer question 4.



4. The embryo is in which stage of development?
   A. gastrula
   B. blastula
   C. egg cell
   D. zygote
5. Which material is not found in endoskeletons?
   A. calcium carbonate
   B. bone
   C. silica
   D. cartilage
6. Hox genes are active during which process?
   A. cell differentiation
   B. movement
   C. digestion
   D. neural stimulation

Constructed Response

7. MAIN Idea Select an animal and describe its adaptations and characteristics specific to its environment.
8. **Open Ended** Describe the advantages and disadvantages of internal and external fertilization.

Think Critically

9. **Interpret** this statement by Hans Spemann, a biologist who studied embryonic development: "We are standing and walking with parts of our body which could have been used for thinking had they developed in another part of the embryo."
10. **Hypothesize** what might happen to an embryo that suffers damage to some mesoderm cells.

Section 2

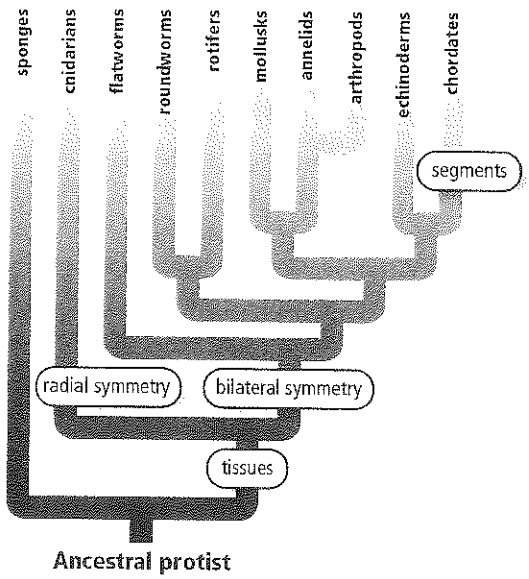
Vocabulary Review

Distinguish between the vocabulary terms in each pair.

11. bilateral symmetry and radial symmetry
12. ventral and dorsal
13. coelom and pseudocoelom

Understand Main Ideas

Use the diagram below to answer questions 14 and 15.

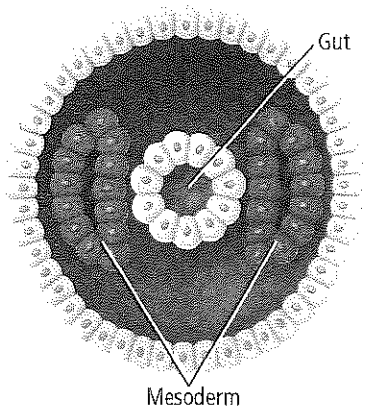


14. THEME FOCUS Patterns Based on the evolutionary tree above, which statement is true?
   A. True tissues evolved after bilateral symmetry.
   B. Segments evolved after bilateral symmetry.
   C. The common animal ancestor was a sponge.
   D. Most animals have radial symmetry.
15. On the evolutionary tree, which animals are related most closely?
   A. an annelids and mollusks
   B. flatworms and annelids
   C. roundworms and annelids
   D. annelids and echinoderms

Online Test Practice

16. CAREERS IN BIOLOGY An embryologist, a scientist who studies embryos, discovers a new marine animal. When one cell is removed during its early development, this cell develops into a complete animal. This animal is which of the following?
A. acoelomate
B. deuterostome
C. protostome
D. pseudocoelomate

Use the diagram below to answer question 17.



17. What does the location of the mesoderm indicate about this embryo?
A. The cells are directly aligned.
B. The outcome of each cell can be changed.
C. The mouth develops from the gastrula opening.
D. The coelom forms from pouches of mesoderm.

18. The evolution of an internal body cavity had adaptive advantage in all the following areas except for which?
A. circulation
B. movement
C. feeding
D. muscular system

19. Based on the evolutionary tree in **Figure 8,** what characteristics does an annelid have that a flatworm does not?
A. a coelom, a body cavity, bilateral symmetry, and no tissues
B. a coelom and segmentation
C. a coelom, protostome development, and segmentation
D. a pseudocoelom, a body cavity, and bilateral symmetry

20. What is the lighter undersurface of a frog called?
A. dorsal surface
B. ventral surface
C. anterior surface
D. posterior surface

Constructed Response

21. **Open Ended** Construct a working model of cell differentiation using clay, salt dough, or other materials. Make the first stage, then make that stage into the next, and that stage into the next until you have completed the steps.

22. **Open Ended** Describe three examples not discussed in this chapter of each type of symmetry.

Think Critically

23. THINK Biologists have recently determined that some sea anemones seem to possess bilateral symmetry. Hypothesize how this changes ideas for how and when bilateral symmetry evolved.

24. **Explain** how segmentation and exoskeletons gave some animals an adaptive advantage over those that were not segmented and did not have exoskeletons.

Section 3

Vocabulary Review

For each set of terms below, choose the term that does not belong and explain why it does not belong.

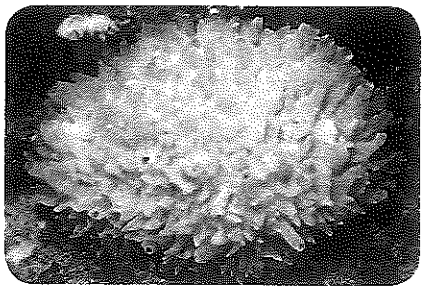
25. cnidocyte, nematocyst, cnidarian, spicule

26. pores, gemmule, filter feeder, nematocyst

27. alternation of generations, polyp, spongin, medusa

Understand Main Ideas

Use the photo below to answer question 28.

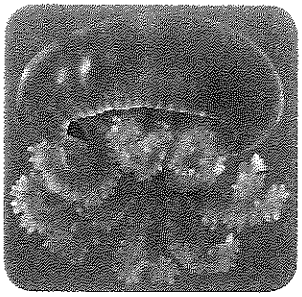


28. The animal in the photo above possesses which characteristic?
A. cephalization
B. cnidocytes
C. bilateral symmetry
D. asymmetry

Online Test Practice

29. Cnidarians evolved directly from which group?
   A. sponges
   B. multicellular choanoflagellates
   C. flatworms
   D. animals with bilateral symmetry

Use the image below to answer question 30.



30. How does the animal shown in the image reproduce?
   A. fragmentation
   B. external fertilization
   C. internal fertilization
   D. regeneration

31. Which is not a characteristic of sponges?
   A. filter feeding
   B. digestion inside cells
   C. asymmetry
   D. tissues

32. Which pair of words is mismatched?
   A. sponges, filter feeding
   B. cnidarians, nematocysts
   C. sponges, free swimming larva
   D. cnidarians, spicules

Constructed Response

33. **Open Ended** Examine the classified section in the newspaper to see how it is organized. Then use your knowledge of cnidarians to write an ad to describe an ideal jellyfish homesite.

Think Critically

34. Evaluate the importance of sponges and cnidarians in animal phylogeny.

35. **Create** Make a concept map using the following words: coral, polyp, cnidocyte, reef, calcium carbonatea and zooxanthellae.

Summative Assessment

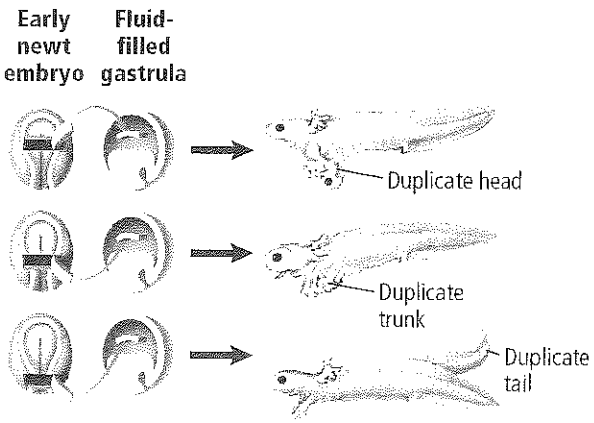
36. Imagine you are working in a university laboratory. You are given an unknown invertebrate and told to determine its phylogeny. What characteristics would you use to accomplish this?

37. Biology Write an editorial for a newspaper advocating protection for coral reefs. Explain the dangers that corals are facing, and make suggestions about what could be done to preserve and protect reefs.

Document-Based Questions

Transplantation experiments with early embryos of newts show that when tissue responsible for tail development was added into a different fluid-filled gastrula, it caused the effects shown below.

Data obtained from: Niehrs, C. 2003. A tale of tails. *Nature* 424: 375–376.



38. When a section from the top of the area was transplanted, where did the new tissue grow?

39. When a section from the bottom of the area was transplanted, where did the new tissue grow?

40. Make a summary statement that describes where new tissue grew when portions of the embryo responsible for tail development were transferred to fluid in the gastrula.

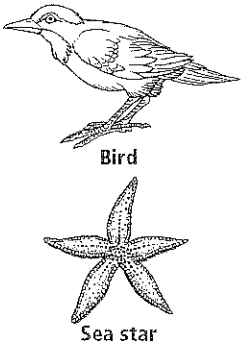
Standardized Test Practice

Cumulative

Multiple Choice

1. Which color of flower is most likely to attract nocturnal pollinators such as bats and moths?
   A. blue
   B. red
   C. violet
   D. white

Use the illustration below to answer questions 2 and 3.



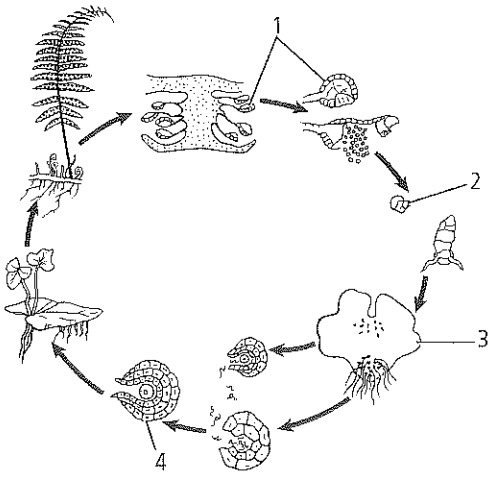
2. How would you describe the body symmetry of the animals shown in the above illustration?
   A. Both have bilateral symmetry.
   B. Both have radial symmetry.
   C. The sea star has bilateral symmetry and the bird has radial symmetry.
   D. The sea star has radial symmetry and the bird has bilateral symmetry.

3. How does the body shape of the sea star help with its survival?
   A. It enables the sea star to capture many kinds of prey.
   B. It enables the sea star to capture prey from many directions.
   C. It enables the sea star to move through the water quickly.
   D. It enables the sea star to move through the water feebly.

4. Which structure in nonvascular plants is similar to roots in vascular plants?
   A. chloroplast
   B. mucilage
   C. rhizoid
   D. sporophyte

5. Which hormone stimulates the ripening of fruit?
   A. auxin
   B. cytokinins
   C. ethylene
   D. gibberellins

Use the diagram below to answer question 6.



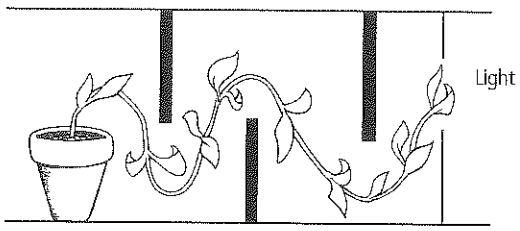
6. At which stage of the fern life cycle does the chromosome number change from haploid to diploid?
   A. 1
   B. 2
   C. 3
   D. 4

7. Which is the role of sclerenchyma cells in plants?
   A. gas exchange
   B. photosynthesis
   C. food storage
   D. support

8. What evidence would help scientists determine that colonial organisms were an early step in the evolution of multicellularity?
   A. similarities in DNA or RNA of early multicellular organisms and colonial unicellular organisms
   B. differences in DNA or RNA of early multicellular organisms and colonial unicellular organisms
   C. similarities of early multicellular organisms and present-day multicellular organisms
   D. differences between early multicellular organisms and present-day multicellular organisms

Short Answer

Use the diagram below to answer question 9.

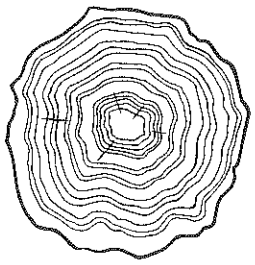


9. A student conducted an experiment using the above set up. Explain the purpose of this experiment.

10. Which type of fossils would tell a paleontologist the most about the soft tissues of an animal?

11. Explain why most spore-producing plants live in moist areas.

Use the diagram below to answer question 12.



12. How is the age of a tree estimated? What is the approximate age of this tree?

13. Name four flower adaptations that attract insects.

14. What are three kinds of evidence that can be used to confirm whether animals with different body structures are related closely?

Extended Response

15. *Plasmodium* is a sporozoan that causes the disease malaria. Identify the different stages of the sporozoan that occur in mosquitoes. Assess the importance of the stages of the life cycle that occur in mosquitoes.

16. Why does Mendel's law of segregation only apply to organisms that reproduce sexually?

17. Summarize egg development and fertilization in flowering plants.

Essay Question

Pollen analysis, or palynology, is an important tool used in archaeology. Palynologists take samples of soil from archaeological sites and analyze the pollen from different soil layers. By examining the changes in pollen types over time, palynologists can learn about historical land use. The pollen in the soil indicates how the land was used–whether it was cultivated, a forest was cleared, or if it was abandoned.

Using the information in the paragraph above, answer the following question in essay format.

18. Scientists have been trying to find the origin of corn. They know that corn was domesticated from a plant called *teosinte* that grew somewhere in the central valley of Mexico between 12,000 and 6,000 years ago. It often is hard to find intact corncobs because they do not fossilize well. How could a palynologist help determine the origin of corn?

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Review Section . . .	23.1	24.2	24.2	21.2	22.3	23.1	22.1	24.1, 24.3	22.3	14.1	23.1	22.2	23.2	24.1	19.2	10.2	23.2	23.3