



Academic Standard—4: Students recognize that plants and animals obtain energy in different ways, and they can describe some of the internal structures of organisms related to this function. They examine the similarities and differences between humans and other species. They use microscopes to observe cells and recognize cells as the building blocks of all life.

Also covers: Academic Standard 2 (Detailed standards begin on page IN8.)

Invertebrate Animals

chapter preview

sections

- 1 What is an animal?
- 2 Sponges, Cnidarians, Flatworms, and Roundworms
- 3 Mollusks and Segmented Worms
- 4 Arthropods and Echinoderms

Lab *Observing Complete Metamorphosis*

Lab *Garbage-Eating Worms*



Virtual Lab *How are mollusks, worms, arthropods, and echinoderms classified?*

Underwater Rhythmic Dancers

Corals and anemones sway with ocean currents. Other animals, like the lemon-peel nudibranch, move in ways that animals that have internal skeletons cannot move. They belong to a group of animals called invertebrates—animals without backbones.

Science Journal Describe similarities and differences between you and the nudibranch.

Start-Up Activities



How are animals organized?

Scientists have identified at least 1.5 million different kinds of animals. In the following lab, you will learn about organizing animals by building a bulletin board display.

1. Write the names of different groups of animals on large envelopes and attach them to a bulletin board.
2. Choose an animal group to study. Make an information card about each animal with its picture on one side and characteristics on the other side.
3. Place your finished cards inside the appropriate envelope.
4. Select an envelope from the bulletin board for a different group of animals. Using the information on the cards, sort the animals into groups.
5. **Think Critically** What common characteristics do these animals have? What characteristics did you use to classify them into smaller groups? Record your answers in your Science Journal.



Preview this chapter's content and activities at in6.msscience.com

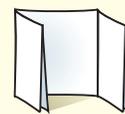
FOLDABLES™ Study Organizer

Invertebrates Make the following Foldable to compare and contrast the characteristics of water and land invertebrates.

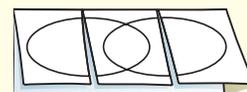
- STEP 1** Fold one sheet of paper lengthwise.



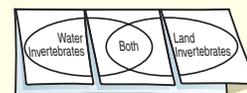
- STEP 2** Fold into thirds.



- STEP 3** Unfold and draw overlapping ovals. Cut the top sheet along the folds.



- STEP 4** Label the ovals as shown.



Construct a Venn Diagram As you read this chapter, list the characteristics unique to water invertebrates under the left tab, those unique to land invertebrates under the right tab, and those characteristics common to both under the middle tab.

What is an animal?

as you read

What You'll Learn

- **Identify** the characteristics of animals.
- **Differentiate** between vertebrates and invertebrates.
- **Explain** how the symmetry of animals differs.

Why It's Important

All animals have characteristics in common.

Review Vocabulary

organelle: structure in the cytoplasm of a eukaryotic cell that can act as a storage site, process energy, move materials, or manufacture substances

New Vocabulary

- symmetry
- invertebrate

Animal Characteristics

If you asked ten people for a characteristic common to all animals, you might get ten different answers or a few repeated answers. Look at the animals in **Figure 1**. What are their common characteristics? What makes an animal an animal?

1. Animals are many-celled organisms that are made of different kinds of cells. These cells might digest food, get rid of wastes, help in reproduction, or be part of systems that have these functions.
2. Most animal cells have a nucleus and organelles. The nucleus and many organelles are surrounded by a membrane. This type of cell is called a eukaryotic (yew ker ee AH tihk) cell.
3. Animals cannot make their own food. Some animals eat plants to supply their energy needs. Some animals eat other animals, and some eat both plants and animals.
4. Animals digest their food. Large food particles are broken down into smaller substances that their cells can use.
5. Most animals can move from place to place. They move to find food, shelter, and mates, and to escape from predators.

Figure 1 Animals come in a variety of shapes and sizes.



The lion's mane jellyfish can be found in the cold, arctic water and the warm water off the coasts of Florida and Mexico. Their tentacles can be up to 30 m long.

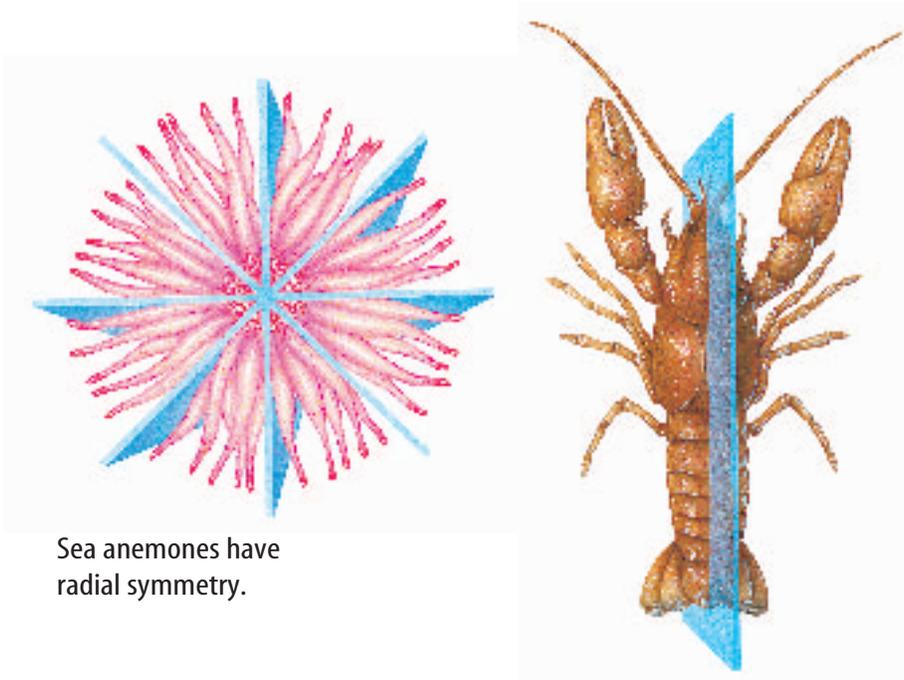


Monarch butterflies in North America migrate up to 5,000 km each year.



The platypus lives in Australia. It is an egg-laying mammal.

Figure 2 Most animals have radial or bilateral symmetry. Only a few animals are asymmetrical.



Sea anemones have radial symmetry.

Lobsters have bilateral symmetry.



Many sponges are asymmetrical.

Symmetry As you study the different groups of animals, you will look at their symmetry (SIH muh tree). **Symmetry** refers to the arrangement of the individual parts of an object that can be divided into similar halves.

Most animals have either radial symmetry or bilateral symmetry. Animals with body parts arranged in a circle around a central point have radial symmetry. Can you imagine being able to locate food and gather information from all directions? Aquatic animals with radial symmetry, such as jellyfish, sea urchins, and the sea anemone, shown in **Figure 2**, can do that. On the other hand, animals with bilateral symmetry have parts that are nearly mirror images of each other. A line can be drawn down the center of their bodies to divide them into two similar parts. Grasshoppers, lobsters, like the one in **Figure 2**, and humans are bilaterally symmetrical.

Some animals have an irregular shape. They are called asymmetrical (AY suh meh trih kul). They have bodies that cannot be divided into similar halves. Many sponges, like those also in **Figure 2**, are asymmetrical. As you learn more about invertebrates, notice how their body symmetry is related to how they gather food and do other things.

 **Reading Check** *What is symmetry?*



Indiana Academic Standard Check

6.4.3: Describe some . . . body plans . . . that contribute to their being able to make or find food and reproduce.



How is radial symmetry an advantage for aquatic animals?

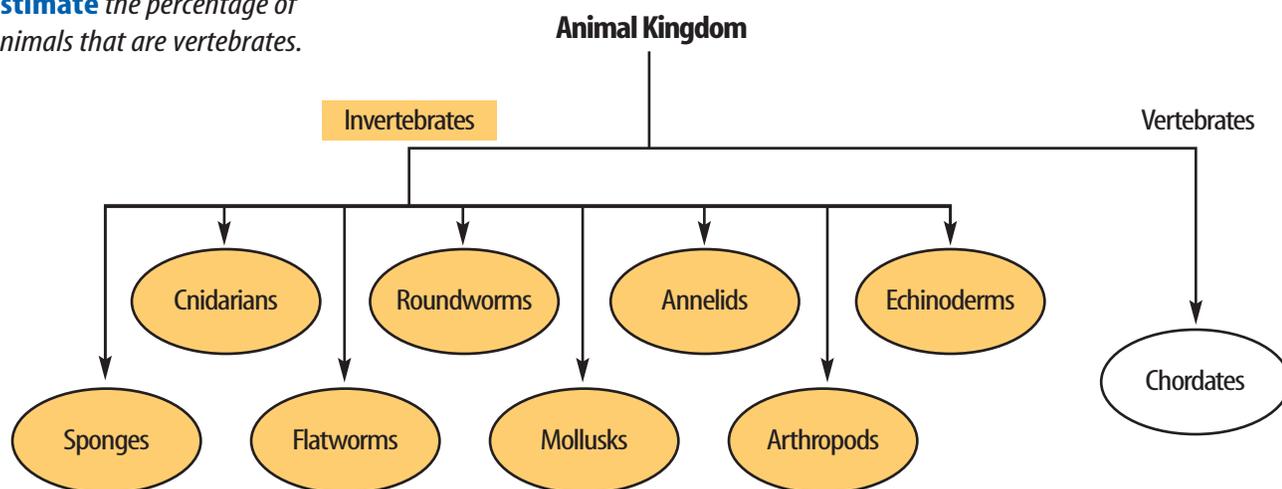
Animal Classification

Deciding whether an organism is an animal is only the first step in classifying it. Scientists place all animals into smaller, related groups. They can begin by separating animals into two distinct groups—vertebrates and invertebrates. Vertebrates (VUR tuh bruts) are animals that have a backbone. **Invertebrates** (ihn VUR tuh bruts) are animals that do not have a backbone. About 97 percent of all animals are invertebrates.

Scientists classify the invertebrates into smaller groups, as shown in **Figure 3**. The animals within each group share similar characteristics. These characteristics indicate that the animals within the group may have had a common ancestor.

Figure 3 This diagram shows the relationships among different groups in the animal kingdom.

Estimate the percentage of animals that are vertebrates.



section 1 review

Summary

Animal Characteristics

- Animals are made up of many different kinds of cells.
- Most animal cells have a nucleus and organelles.
- Animals cannot make their own food.
- Animals digest their food.
- Most animals can move from place to place.

Animal Classification

- Scientists place all animals into smaller, related groups.
- Two distinct groups of animals are the invertebrates and vertebrates.

Self Check

1. **Compare and contrast** invertebrate and vertebrate animals.
2. **Describe** the different types of symmetry. Name an animal that has bilateral symmetry.
3. **Think Critically** Most animals do not have a backbone. They are called invertebrates. What are some advantages that invertebrate animals might have over vertebrate animals?

Applying Skills

4. **Concept Map** Using the information in this section, make a concept map showing the steps a scientist might use to classify a newly discovered animal.

Also covers: 6.4.3 (Detailed standards begin on page IN8.)

Sponges, Cnidarians, Flatworms, and Roundworms

Runk/Schoenberger from Grant Heilman

Sponges

Can you tell the difference between an animal and a plant? Sounds easy, doesn't it? But for a long time, even scientists didn't know how to classify sponges. Originally they thought sponges were plants because they don't move to search for food. Sponges, however, can't make their own food as most plants do. Sponges are animals. Adult sponges are sessile (SE sul), meaning they remain attached to one place. Approximately 15,000 species of sponges have been identified.

Filter Feeders Most species of sponges live in the ocean, but some live in freshwater. Sponge bodies, shown in **Figure 4**, are made of two layers of cells. All sponges are filter feeders. They filter food out of the water that flows through their bodies. Microscopic organisms and oxygen are carried with water into the central cavity through pores of the sponge. The inner surface of the central cavity is lined with collar cells. Thin, whiplike structures, called flagella (flah JEH luh), extend from the collar cells and keep the water moving through the sponge. Other specialized cells digest the food, carry nutrients to all parts of the sponge, and remove wastes.

Body Support and Defense Not many animals eat sponges. The soft bodies of many sponges are supported by sharp, glass-like structures called spicules (SPIHK yewlz). Other sponges have a material called spongin. Spongin is similar to foam rubber because it makes sponges soft and elastic. Some sponges have both spicules and spongin to protect their soft bodies.

Figure 4 Red beard sponges grow where the tide moves in and out quickly.

as you read

What You'll Learn

- **Describe** the structures that make up sponges and cnidarians.
- **Compare** how sponges and cnidarians get food and reproduce.
- **Differentiate** between flatworms and roundworms.

Why It's Important

Studying the body plans in sponges, cnidarians, flatworms, and roundworms helps you understand the complex organ systems in other organisms.

Review Vocabulary

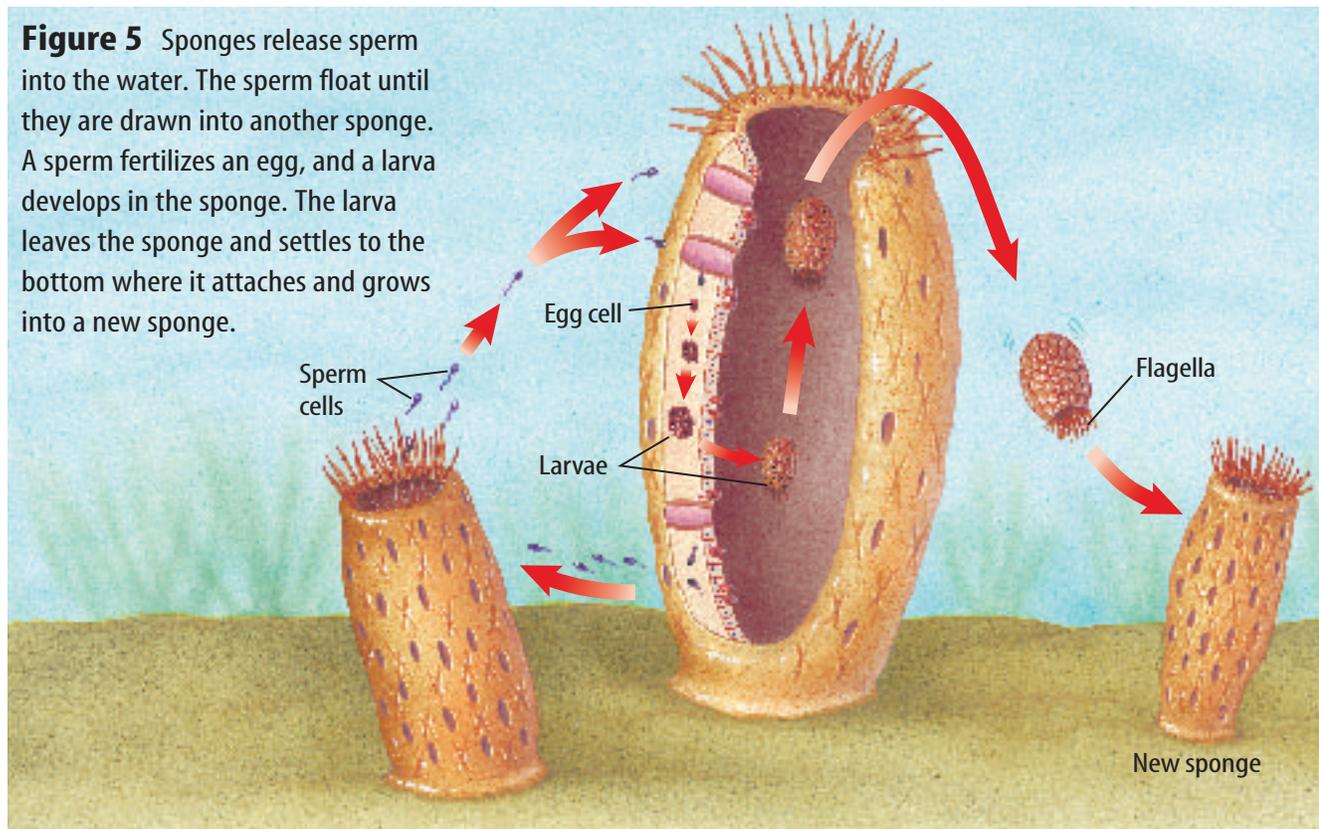
species: group of organisms that share similar characteristics and can reproduce among themselves to produce fertile offspring

New Vocabulary

- cnidarian
- medusa
- polyp



Figure 5 Sponges release sperm into the water. The sperm float until they are drawn into another sponge. A sperm fertilizes an egg, and a larva develops in the sponge. The larva leaves the sponge and settles to the bottom where it attaches and grows into a new sponge.



Sponge Reproduction Sponges can reproduce asexually and sexually. Asexual reproduction occurs when a bud on the side of the parent sponge develops into a small sponge. The small sponge breaks off, floats away, and attaches itself to a new surface. New sponges also may grow from pieces of a sponge. Each piece grows into a new, identical sponge.

Most sponges that reproduce sexually are hermaphrodites (hur MA fruh dites). This means that one sponge produces both eggs and sperm, as shown in **Figure 5**.

Cnidarians

Cnidarians (nih DAR ee uns), such as jellyfish, sea anemones, hydra, and corals, have tentacles surrounding their mouth. The tentacles shoot out stinging cells called nematocysts (NE ma toh sihsts) to capture prey, similar to casting a fishing line into the water to catch a fish. Because they have radial symmetry, they can locate food that floats by from any direction.

Cnidarians are hollow-bodied animals with two cell layers that are organized into tissues. The inner layer forms a digestive cavity where food is broken down. Oxygen moves into the cells from the surrounding water, and carbon dioxide waste moves out of the cells. Nerve cells work together as a nerve net throughout the whole body.



Spicules Sponge spicules of “glass” sponges are composed of silica. Other sponges have spicules made of calcium carbonate. Where do organisms get the silica and calcium carbonate that these spicules are made of? Write your prediction in your Science Journal.

Body Forms Cnidarians have two different body forms. The vase-shaped body of the sea anemone and the hydra is called a **polyp** (PAH lup). Although hydras are usually sessile, they can twist to capture prey. They also can somersault to a new location.

Jellyfish have a free-swimming, bell-shaped body that is called a **medusa** (mih DEW suh). Jellyfish are not strong swimmers. Instead, they drift with the ocean currents. Some cnidarians go through both a polyp and a medusa stage during their life cycles.

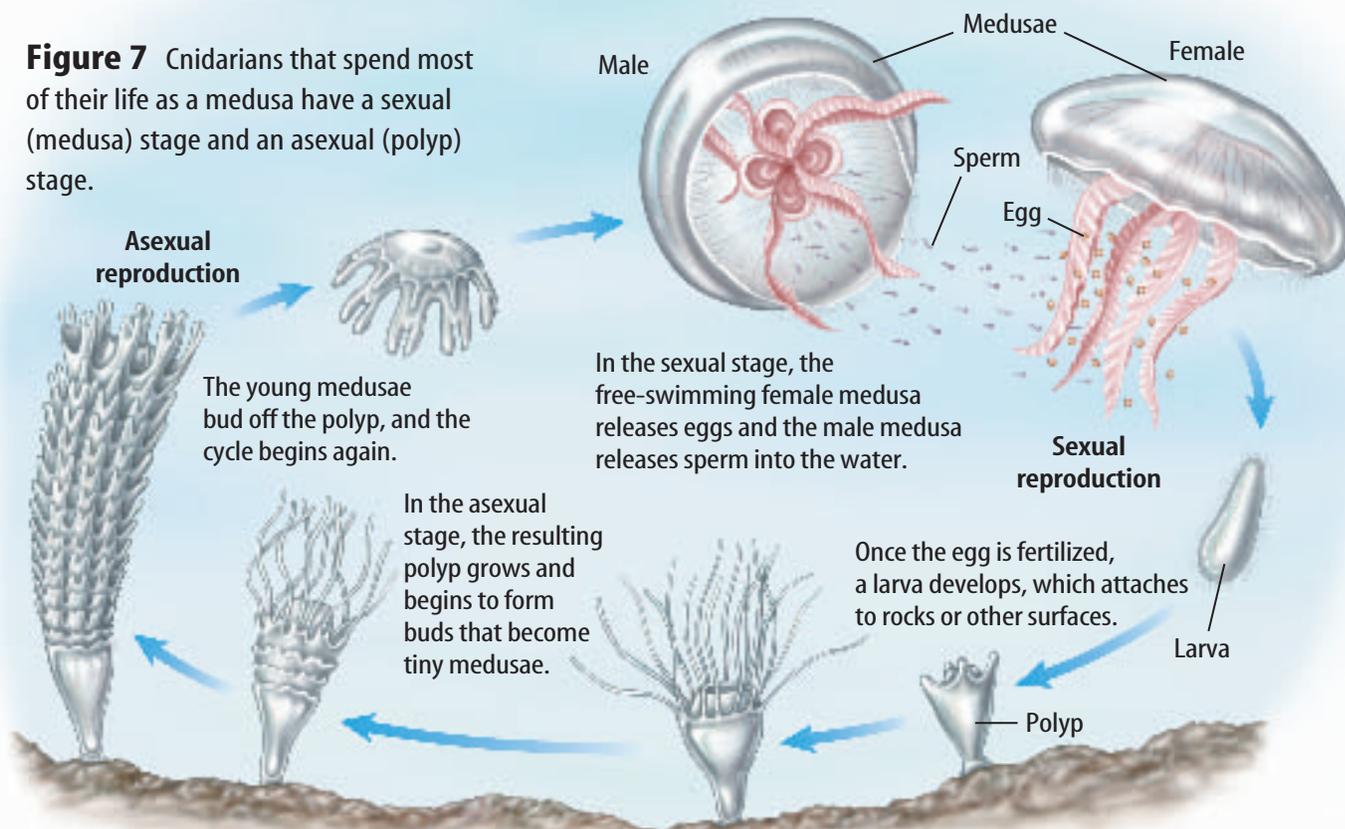


Cnidarian Reproduction Cnidarians reproduce asexually and sexually. Polyp forms of cnidarians, such as hydras, reproduce asexually by budding, as shown in **Figure 6**. The bud eventually falls off of the parent organism and develops into a new polyp. Some polyps also can reproduce sexually by releasing eggs or sperm into the water. The eggs are fertilized by sperm and develop into new polyps. Medusa forms of cnidarians, such as jellyfish, have a two-stage life cycle as shown in **Figure 7**. A medusa reproduces sexually to produce polyps. Then each of these polyps reproduces asexually to form new medusae.

Figure 6 Polyps, like these hydras, reproduce asexually by budding.

Compare the genetic makeups of the parent organism and the bud.

Figure 7 Cnidarians that spend most of their life as a medusa have a sexual (medusa) stage and an asexual (polyp) stage.



Flatworms

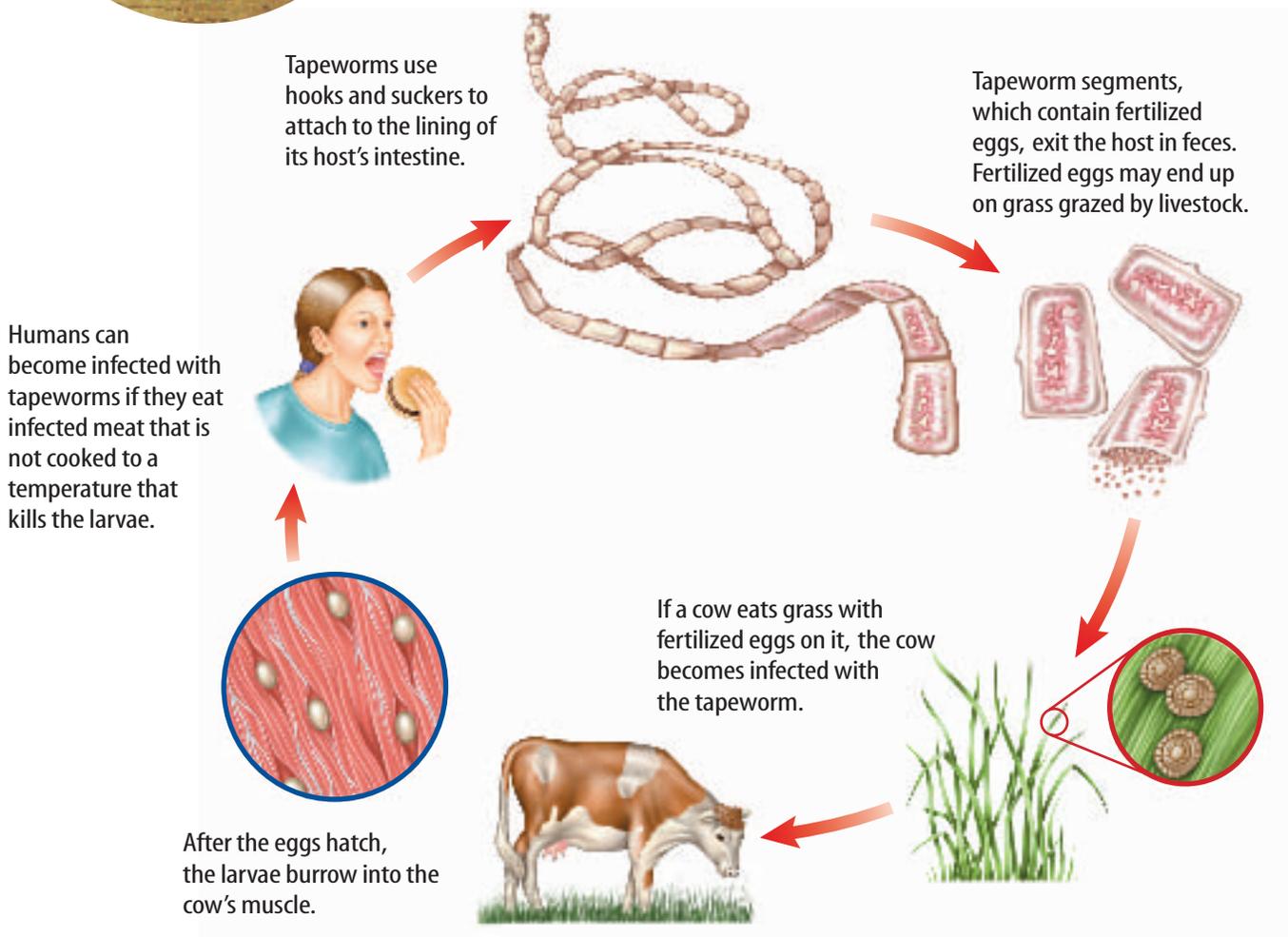
Unlike sponges and cnidarians, flatworms search for food. Flatworms are invertebrates with long, flattened bodies and bilateral symmetry. Their soft bodies have three layers of tissue organized into organs and organ systems. Planarians are free-living flatworms that have a digestive system with one opening. They don't depend on one particular organism for food or a place to live. However, most flatworms are parasites that live in or on their hosts. A parasite depends on its host for food and shelter.

Figure 8 Tapeworms are intestinal parasites that attach to a host's intestines with hooks and suckers. Their life cycle is shown here.



Tapeworms One type of parasitic flatworm is the tapeworm. To survive, it lives in the intestines of its host, including human hosts. The tapeworm lacks a digestive system so it absorbs nutrients from digested material in the host's intestine. In **Figure 8**, you can see the hooks and suckers on a tapeworm's head that attach it to the host's intestine.

A tapeworm grows by adding sections directly behind its head. Each body segment has both male and female reproductive organs. The eggs and sperm are released into the segment. After it is filled with fertilized eggs, the segment breaks off.



The segment passes with wastes out of the host's body. If another host eats a fertilized egg, it hatches and develops into a tapeworm. Tapeworm segments aren't ingested directly by humans. Most flatworms have an intermediate or middle host. For example, **Figure 8** shows how cattle are the intermediate host for tapeworms that infect humans.

 **Reading Check** *How can flatworms get into humans?*

Roundworms

If you have a dog, you may know already that heartworm disease, shown in **Figure 9**, can be fatal to dogs. In most areas of the United States, it's necessary to give dogs a monthly medicine to prevent heartworm disease. Heartworms are just one kind of the many thousands of roundworms that exist. Roundworms are the most widespread animal on Earth. Billions can live in an acre of soil. Many people confuse earthworms and roundworms. You will study earthworms in the next section.

A roundworm's body is described as a tube within a tube, with a fluid-filled cavity in between the two tubes. The cavity separates the digestive tract from the body wall. Roundworms are more complex than flatworms because their digestive tract has two openings. Food enters through the mouth, is digested in a digestive tract, and wastes exit through the anus.

Roundworms are a diverse group. Some roundworms are decomposers, others are predators, and some, like the heartworm, are animal parasites. Other roundworms are plant parasites.

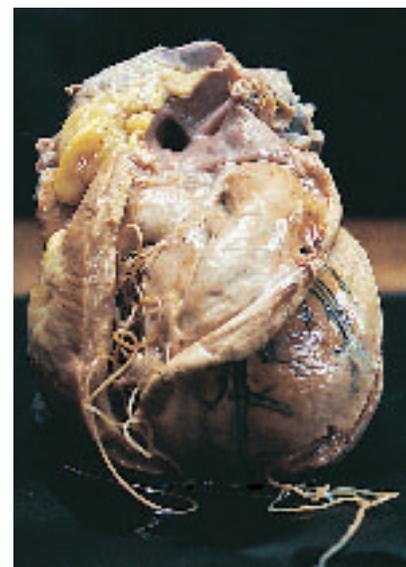


Figure 9 This dog heart is infested with heartworms. Heartworms are carried by mosquitoes. A heartworm infection can clog a dog's heart and cause death.

section 2 review

Summary

Sponges and Cnidarians

- Sponges are animals that remain attached to one place and can reproduce both sexually and asexually.
- Cnidarians are hollow-bodied animals with two cell layers that are organized into tissues.

Flatworms and Roundworms

- Flatworms have three layers of soft tissue organized into organs and organ systems.
- Most flatworms are parasitic.
- Roundworms are decomposers, predators, or parasites of plants and animals and are the most widespread animal on Earth.

Self Check

1. **Explain** how sponges and cnidarians get food.
2. **Compare and contrast** the body plan of flatworms to the body plan of roundworms.
3. **Infer** how spongin and spicules discourage predators from eating sponges.
4. **Think Critically** Some types of sponges and cnidarians reproduce asexually. Why is this beneficial to them?

Applying Math

5. **Solve an Equation** A sponge is 1 cm in diameter and 10 cm tall. It can move 22.5 L of water through its body in a day. Calculate the volume of water it pumps through its body in 1 min.

Also covers: 6.2.7, 6.4.1 (Detailed standards begin on page IN8.)

Mollusks and Segmented Worms

as you read

What You'll Learn

- **Identify** the characteristics of mollusks.
- **Compare** the similarities and differences between an open and a closed circulatory system.
- **Describe** the characteristics of segmented worms.
- **Explain** the digestive process of an earthworm.

Why It's Important

Organ systems and specialized structures allow mollusks and segmented worms to live in varied environments.

Review Vocabulary

organ: structure, such as the heart, made up of different types of tissue that work together

New Vocabulary

- mollusk
- mantle
- gill
- radula
- open circulatory system
- closed circulatory system

Mollusks

Imagine yourself walking along an ocean beach at low tide. On the rocks, you see small snails with conelike shells. In a small tidal pool, one arm of a shy octopus can be seen at the opening of its den. The blue-black shells of mussels are exposed along the shore as shown in **Figure 10**. How are these different animals related? What do they have in common?

Common Characteristics In many places snails, mussels, and octopuses—all mollusks (MAH lusks)—are eaten by humans. **Mollusks** are soft-bodied invertebrates that usually have a shell. They also have a mantle and a large, muscular foot. The **mantle** is a thin layer of tissue that covers the mollusk's soft body. If the mollusk has a shell, it is secreted by the mantle. The foot is used for moving or for anchoring the animal.

Between the mantle and the soft body is a space called the mantle cavity. Water-dwelling mollusks have gills in the mantle cavity. **Gills** are organs in which carbon dioxide from the animal is exchanged for oxygen in the water. In contrast, land-dwelling mollusks have lungs in which carbon dioxide from the animal is exchanged for oxygen in the air.



Figure 10 At low tide, many mollusks can be found along a rocky seashore.



Many species of conchs are on the verge of becoming threatened species because they are overharvested for food.



Scallops are used to measure an ecosystem's health because they're sensitive to water quality.

Figure 11 Many kinds of mollusks are a prized source of food for humans.

Name another mollusk, besides a conch or scallop, that is a source of food for humans.

Body Systems Mollusks have a digestive system with two openings. Many mollusks also have a scratchy, tonguelike organ called the **radula**. The radula (RA juh luh) has rows of fine, teethlike projections that the mollusk uses to scrape off small bits of food.

Some mollusks have an **open circulatory system**, which means they do not have vessels to contain their blood. Instead, the blood washes over the organs, which are grouped together in a fluid-filled body cavity.

Types of Mollusks

Does the animal have a shell or not? This is the first characteristic that scientists use to classify mollusks. Then they look at the kind of shell or they look at the type of foot. In this section, you will learn about three kinds of mollusks.

Gastropods The photo on the left in **Figure 11** shows a gastropod. Gastropods are the largest group of mollusks. Most gastropods, such as the snails and conchs, have one shell. Slugs also are gastropods, but they don't have a shell. Gastropods live in water or on land. All move about on a large, muscular foot. A secretion of mucus allows them to glide across objects.

Bivalves How many shells do you think a bivalve has? Think of other words that start with *bi-*. The scallop shown on the right in **Figure 11** is a bivalve. It is an organism with two shell halves joined by a hinge. Large, powerful muscles open and close the shell halves. Bivalves are water animals that also are filter feeders. Food is removed from water that is brought into and filtered through the gills.



Toxins Shellfish and crabs accumulate toxins during red tides when they feed on algae containing toxins. These toxins are dangerous to people. The threat of red tides has resulted in closures of both commercial and recreational shellfish harvesting. This causes substantial economic loss. In your Science Journal, write about what is being done to determine when it is safe to harvest shellfish.



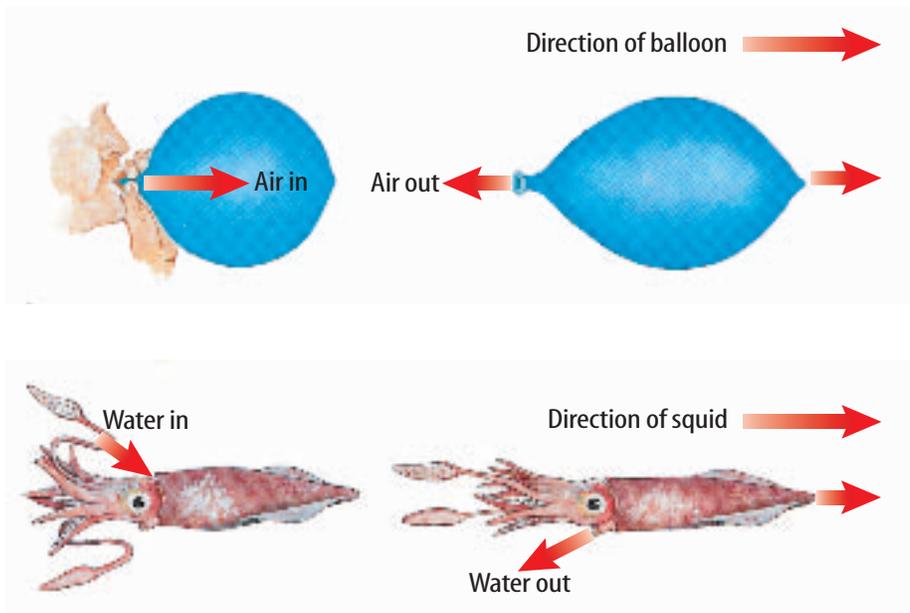
Topic: Red Tides

Visit in6.msscience.com for Web links to information about red tides.

Activity Explain what red tides are and why it is important to learn more about them. What is being done to try and predict when red tides will occur?



Figure 12 Living species of *Nautilus* are found in the western Pacific Ocean. The chambered nautilus, squid, and other cephalopods are able to move quickly using a water-propulsion system as shown to the right.



Cephalopods The most complex type of mollusks are cephalopods (SE fah lah pawdz). The chambered nautilus, shown in **Figure 12**, octopuses, squid, and cuttlefish are cephalopods. Most cephalopods have an internal plate instead of a shell. They have a well-developed head and a “foot” that is divided into tentacles with strong suckers. At the base of the tentacles is the mouth. They have a **closed circulatory system** in which blood is carried through blood vessels instead of surrounding the organs.

Cephalopods are adapted for quick movement in the ocean. They have a muscular envelope, called the mantle, surrounding their internal organs. Water enters the space between the mantle and the other body organs. When the mantle closes around the collar of the cephalopod, the water is squeezed rapidly through a funnel-like structure called a siphon. The rapid expulsion of water from the siphon creates a force that causes the animal to move in the opposite direction of the stream of water, as illustrated in **Figure 12**.

Segmented Worms

When you hear the word *worm*, you probably think of an earthworm. Earthworms, leeches, and marine worms are segmented worms, or annelids (A nul idz). Their body is made of repeating segments or rings that make these worms flexible. Each segment has nerve cells, blood vessels, part of the digestive tract, and the coelom (SEE lum). The coelom, or internal body cavity, separates the internal organs from the body wall. Annelids have a closed circulatory system and a complete digestive system with two body openings.

Mini LAB

Modeling Cephalopod Propulsion

Procedure

1. Blow up a **balloon**. Hold the end closed, but don't tie it.
2. Let go of the balloon.
3. Repeat steps 1 and 2 three more times.

Analysis

1. In your **Science Journal**, describe how the balloon moved when you let go.
2. If the balloon models an octopus or a squid as it swims through the water, infer how cephalopods can escape from danger.



Earthworms When did you first encounter earthworms? Maybe it was on a wet sidewalk or in a garden, as shown in **Figure 13**. Earthworms have more than 100 body segments. Each segment has external bristlelike structures called setae (SEE tee). Earthworms use the setae to grip the soil while two sets of muscles move them through the soil. As earthworms move, they take soil into their mouths. Earthworms get the energy they need to live from organic matter found in the soil. From the mouth the soil moves to the crop, where it is stored. Behind the crop is a muscular structure called the gizzard. Here, the soil and food are ground. In the intestine, the food is broken down and absorbed by the blood. Undigested soil and wastes leave the worm through the anus.



Figure 13 Earthworms are covered with a thin layer of mucus, which keeps them moist. Setae help them move through the soil.

Reading Check *What is the function of setae?*

Examine the earthworm shown in **Figure 14**. Notice the lack of gills and lungs. Carbon dioxide passes out and oxygen passes in through its mucous-covered skin. It's important not to pick up earthworms with dry hands because if this thin film of mucus is removed, the earthworm may suffocate.

Figure 14 Earthworms and other segmented worms have many organ systems including circulatory, reproductive, excretory, digestive, and muscular systems.

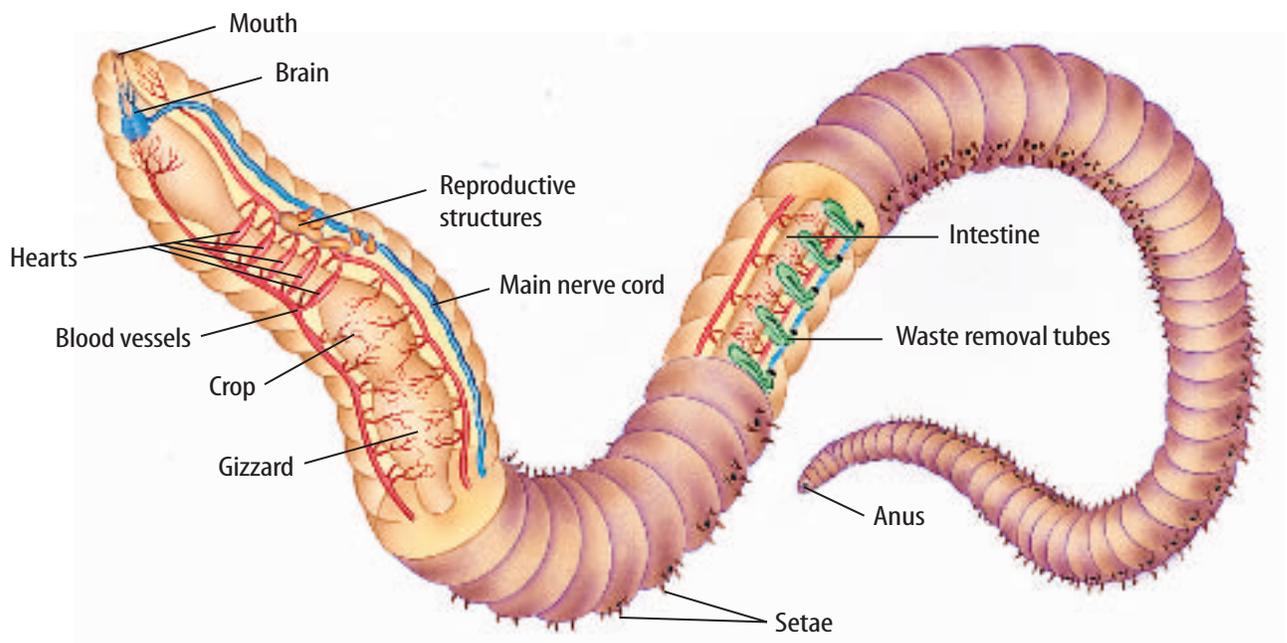




Figure 15 Leeches attach to fish, turtles, snails, and mammals and remove blood and other body fluids.

Leeches They can be found in freshwater, marine waters, and on land in mild and tropical regions. These segmented worms have flat bodies from 5 mm to 460 mm long with sucking disks on both ends. They use these disks to attach themselves to an animal, as shown in **Figure 15**, and remove blood. Some leeches can store as much as ten times their own weight in blood. It can be stored for months and released a little at a time into the digestive system. Although leeches prefer a diet of blood, most of them can survive indefinitely on small aquatic animals.

 **Reading Check** How do leeches attach themselves to an animal?

Marine Worms The animals in **Figure 16** are polychaetes (PAH lee keets), the largest and most diverse group of annelids. Of the 10,000 named species of annelids, more than 8,000 of them are marine worms. The word *polychaete* means “many bristles.” Most marine worms have bristles, or setae, along the sides of their body. Because of these bristles, marine worms are sometimes called bristle worms. Bristles are used for walking, swimming, or digging, depending on the type of marine worm.

Applying Science

How does soil management affect earthworms?

Some earthworms tunnel through the soil about 30 cm below the soil surface. Earthworms called night crawlers dig deep, permanent tunnels that are up to 1.8 m long. Earthworms’ tunnels loosen the soil, which allows better root growth by plants. It also increases air and water movement in the soil. As they tunnel, earthworms take in soil that contains organic matter such as plant material, microorganisms, and animal remains. This is their source of food. Microorganisms break down earthworms’ wastes, which adds nutrients to the soil. Earthworms are a food source for frogs, snakes, birds, and other animals.

Identifying the Problem

As earthworms tunnel through the soil, they also take in other substances found there. High levels of pesticides and heavy metals can build up in the bodies of earthworms.

Solving the Problem

1. One soil management technique is to place municipal sludge on farmland as fertilizer. The sludge might contain heavy metals and harmful organic substances. Predict how this could affect birds.
2. Is the use of sludge as a fertilizer a wise choice? Explain your answer.

Figure 16 More than 8,000 species of marine worms exist.



Some polychaetes, like this fire-worm, move around in search of food.



Polychaetes, like this sea mouse, have long bristles that look like hair.



Sessile polychaetes, like this tube-worm, filter food from the water.

Body Types Some marine worms are filter feeders. They either burrow into the mud or build their own tube cases and use their featherlike bristles to filter food from the water. Some marine worms move around eating plants or decaying material. Other marine worms are predators or parasites. The many different lifestyles of marine worms explain why there are so many different body types.

Although annelids do not look complex, they are more complex than sponges and cnidarians. In the next section, you will learn how they compare to the most complex invertebrates.



Indiana Academic Standard Check

6.4.9: Recognize and explain that two types of organisms may interact . . . as . . . predator/prey . . .



What organisms might be prey for leeches?

section 3 review

Summary

Mollusks

- Mollusks are soft-bodied invertebrates that have a mantle, a large, muscular foot, and usually have a shell.

Types of Mollusks

- Mollusks are separated into three groups—gastropods, bivalves, and cephalopods.

Segmented Worms

- Repeating body segments give segmented worms flexibility.
- Segmented worms have a coelom, or internal body cavity, that separates the internal organs from the body wall.

Self Check

1. **Explain** what gills are used for.
2. **Describe** how an earthworm feeds and digests its food.
3. **Identify** which type of circulatory system that a cephalopod develops.
4. **Think Critically** Why would it be beneficial to a leech to be able to store blood for months and release it slowly?

Applying Skills

5. **Communicate** Choose a mollusk or annelid and write about it in your Science Journal. Describe its appearance, how it gets food, where it lives, and other interesting facts.

Arthropods and Echinoderms

as you read

What You'll Learn

- **List** the features used to classify arthropods.
- **Explain** how the structure of the exoskeleton relates to its function.
- **Identify** features of echinoderms.

Why It's Important

Arthropods and echinoderms show great diversity and are found in many different environments.

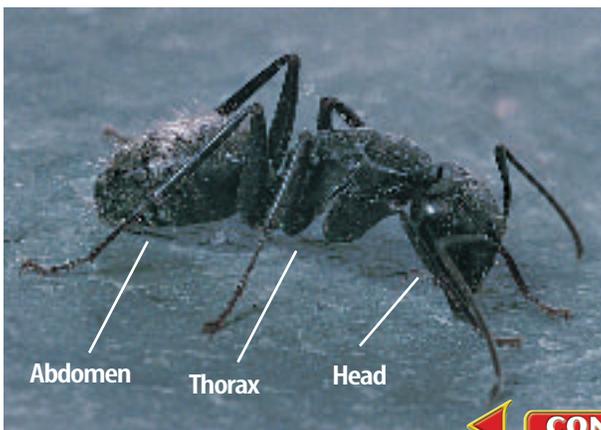
Review Vocabulary

regeneration: regrowth of a body or body part after injury or as a normal process

New Vocabulary

- arthropod
- exoskeleton
- appendage
- metamorphosis

Figure 17 About 8,000 species of ants are found in the world. Ants are social insects that live cooperatively in colonies.



Arthropods

More than a million species of arthropods (AR thruh pahdz) have been discovered. They are the largest and most diverse group of animals. The term *arthropod* comes from *arthros*, meaning “jointed,” and *poda*, meaning “foot.” **Arthropods** are animals that have jointed appendages (uh PEN dih juz). **Appendages** are structures such as claws, legs, and antennae that grow from the body.

Arthropods have a rigid body covering called an **exoskeleton**. It protects and supports the body and reduces water loss. The weight of the outer covering increases as the size of the animal increases. As the animal grows, the exoskeleton must be shed because it doesn't grow with the animal. This process is called molting. Weight and hardness of the exoskeleton could make it difficult to move, but the jointed appendages solve part of this problem.

Reading Check

What is the function of the exoskeleton?

Arthropods have bilateral symmetry and segmented bodies similar to annelids. In most cases, arthropods have fewer, more specialized segments. Instead of setae, they have appendages.

Insects If asked to name an insect, you might say bee, fly, beetle, or butterfly. Insects make up the largest group of arthropods. More than 700,000 species of insects have been classified, and scientists discover and describe more of them each year.

Insects, like the ant in **Figure 17**, have three body regions—head, thorax, and abdomen. Well-developed sensory organs, including the eyes and antennae, are located on the head. The thorax has three pairs of jointed legs and usually one or two pairs of wings. The wings and legs of insects are highly specialized. The abdomen is divided into segments and has neither wings nor legs attached, but reproductive organs are located there.

Circulatory System Insects have an open circulatory system. Oxygen is not transported by blood in the system, but food and waste materials are. Oxygen is brought directly to the insect's tissues through small branching tubes. These tubes connect to openings called spiracles (SPIHR ih kulz) located along the sides of the thorax and abdomen.

Metamorphosis The young of many insects don't look anything like the adults. This is because many insects completely change their body form as they mature. This change in body form is called **metamorphosis** (met uh MOR fuh sus). The two kinds of insect metamorphosis, complete and incomplete, are shown in **Figure 18**.

Butterflies, ants, bees, and beetles are examples of insects that undergo complete metamorphosis. Complete metamorphosis has four stages—egg, larva, pupa (PYEW puh), and adult. Notice how different each stage is from the others. Some insects, such as grasshoppers, cockroaches, termites, aphids, and dragonflies, undergo incomplete metamorphosis. They have only three stages—egg, nymph, and adult. A nymph looks similar to its parents, only smaller. A nymph molts as it grows until it reaches the adult stage. All the arthropods shown in **Figure 19** on the next two pages molt many times during their life.

Indiana Academic Standard Check

6.4.3: Describe some . . . body plans . . . that contribute to their being able to make or find food and reproduce.

✓ In which type of metamorphosis does the insect undergo extreme internal and external changes?

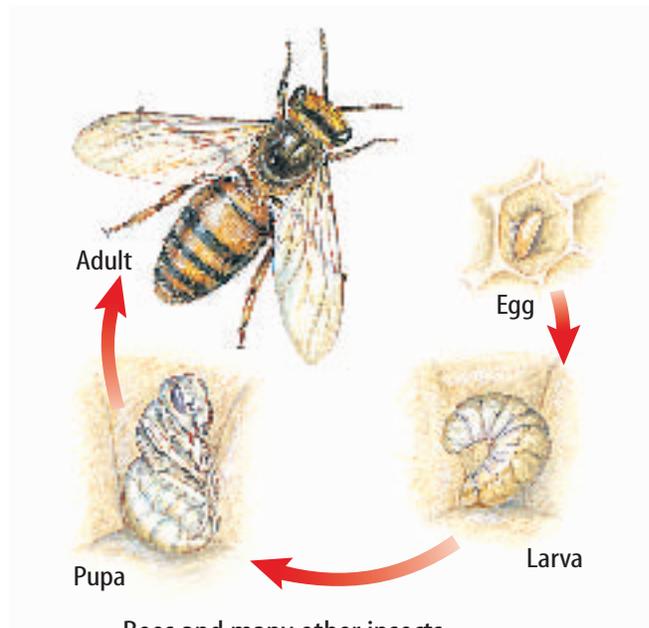
Scienceonline

Topic: Butterflies

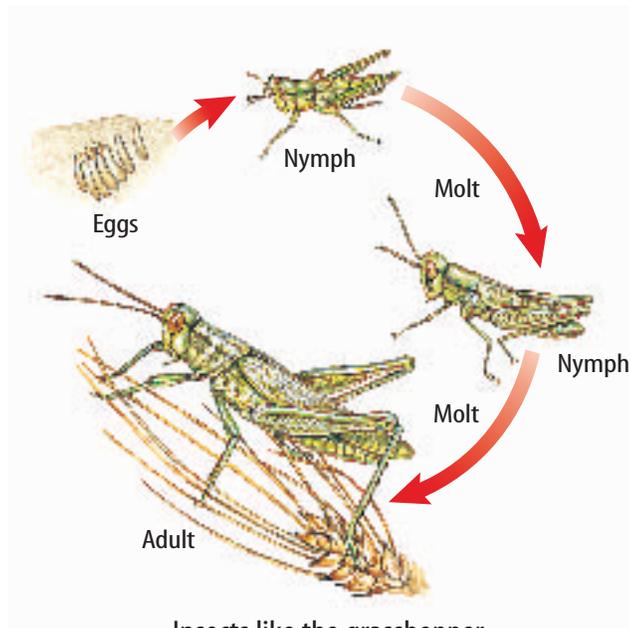
Visit in6.msscience.com for Web links to information about butterflies.

Activity What are some of the characteristics that are used to identify butterflies? Make a diagram of the life cycle of a butterfly.

Figure 18 Insect metamorphosis occurs in two ways. **State** the name given a moth larva.



Bees and many other insects undergo the four stages of complete metamorphosis.



Insects like the grasshopper undergo incomplete metamorphosis.

Figure 19

Arthropods are the most successful group of animals on Earth. Research the traits of each arthropod pictured. Compare and contrast those traits that enhance their survival and reproduction.



▲ **HUMMINGBIRD MOTH** When hovering near flowers, these moths produce the buzzing sound of hummingbirds. The wingspan of these moths can reach 6 cm.



◀ **KRILL** Living in the icy waters of the arctic and the antarctic, krill are an important component in the ocean food web. They range in length from 8 to 60 mm. Baleen whales can eat 1,000 kg of krill in one feeding.



◀ **GOOSENECK BARNACLES** These arthropods usually live on objects, such as buoys and logs, which float in the ocean. They also live on other animals, including sea turtles and snails.



◀ **DIVING BEETLE** These predators feed on other invertebrates as well as small fish. They can grow to more than 40 mm in length.



◀ **ALASKAN KING CRAB** These crabs live in the cold waters of the north Pacific. Here, a gauge of about 18 cm measures a crab too small to keep; Alaskan king crabs can stretch 1.8 m from tip to tip.



▲ **HORSESHOE CRAB** More closely related to spiders than to crabs, horseshoe crabs dig their way into the sand near the shore to feed on small invertebrates.

◀ **BUMBLEBEE** A thick coat of hair and the ability to shiver their flight muscles to produce heat allow bumblebees to fly in cold weather.

▶ **PILL BUG** Many people think that pill bugs—also known as sow bugs, rolpolies, or wood lice—are insects. Actually, they are crustaceans that live on land.



▶ **AMERICAN COCKROACH** This arthropod, which can grow to a length of almost 5 cm, is the largest house-infesting roach. It is common in urban areas around the world.



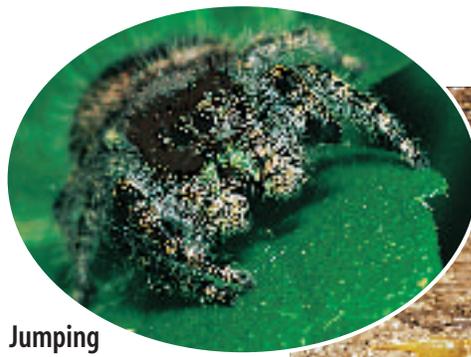
▲ **SPIDER MITE** These web-spinning arachnids are serious pests because they suck the juices out of plants. They damage houseplants, landscape plants, and crops. The spider mite above is magnified 14 times its normal size.



▲ **DADDY LONGLEGS** Moving on legs that can be as much as 20 times longer than their bodies, these arachnids feed on small insects, dead animals, and plant juices. Although they look like spiders, they belong to a different order of arachnids.



Orb weaver spider



Jumping spider

Scorpion



Figure 20 This orb weaver spider uses its web to catch prey. Then it wraps the prey in silk to eat later. Jumping spiders have four large eyes on their face and four smaller eyes on the top of their head. Scorpions usually hide during the day and hunt for their prey at night.

Identify an advantage that jumping spiders have because of all their eyes.

Arachnids Spiders, ticks, mites, and scorpions belong to a group of arthropods known as arachnids (uh RAK nudz). Arachnids have only two body regions—a cephalothorax (seh uh luh THOR aks) and an abdomen—instead of three. The cephalothorax is made of the fused head and thorax regions. All arachnids have four pairs of legs attached to the cephalothorax.

Spiders are predators. A spider uses a pair of fanglike appendages near its mouth to inject paralyzing venom into its prey. Then it releases substances into its prey that digest the victim, turning it into a liquid, and the spider drinks it. Some spiders, like the one in **Figure 20**, weave webs to trap their prey. Other spiders, like the jumping spider, chase and catch their prey. Other arachnids, like the scorpion, paralyze their prey with venom from their stinger.

 **Reading Check** How do spiders catch their prey?

Figure 21 Centipedes can have more than 100 segments. When a millipede feels threatened, it will curl itself into a spiral.

Centipedes and Millipedes As shown in **Figure 21**, centipedes and millipedes are long, thin, segmented animals. These arthropods have pairs of jointed legs attached to each segment. Centipedes have one pair of jointed legs per segment, and millipedes have two pairs. Centipedes are predators that use poisonous venom to capture their prey. Millipedes eat plants. Besides the number of legs, how else is the centipede different from the millipede?



Centipede



Millipede



Crustaceans Think about where you can lift the most weight—is it on land or in water? An object seems to weigh less in water because water pushes up against the pull of gravity. Therefore, a large, heavy exoskeleton is less limiting in water than on land. The group of arthropods called crustaceans includes some of the largest arthropods. However, most crustaceans are small marine animals that make up the majority of zooplankton. Zooplankton refers to the tiny, free-floating animals that are food for other marine animals.

Examples of crustaceans include crabs, crayfish, lobsters, shrimp, barnacles, water fleas, and sow bugs. Their body structures vary greatly. Crustaceans usually have two pairs of antennae attached to the head, three types of chewing appendages, and five pairs of legs. Many water-living crustaceans also have appendages called swimmerets on their abdomen. Swimmerets force water over the feathery gills where carbon dioxide from the crustacean is exchanged for oxygen in the water.

Echinoderms

Most people know what a starfish is. However, today they also are known as sea stars. Sea stars belong to a varied group of animals called echinoderms (ih KI nuh durmz) that have radial symmetry. Sea stars, brittle stars, sea urchins, sand dollars, and sea cucumbers are echinoderms. The name *echinoderm* means “spiny skin.” As shown in **Figure 22**, echinoderms have spines of various lengths that cover the outside of their bodies. Most echinoderms are supported and protected by an internal skeleton made up of bonelike plates. Echinoderms have a simple nervous system but don’t have heads or brains. Some echinoderms are predators, some are filter feeders, and others feed on decaying matter.



Sun star



Sea urchin



Sand dollar

Mini LAB

Observing Sow Bugs

Procedure



1. Place six **sow bugs** in a clean, **flat container**.
2. Put a damp **sponge** at one end of the container.
3. Cover the container for 60 s. Remove the cover and observe where the sow bugs are. Record your observations in your **Science Journal**.

Analysis

1. What type of habitat do the sow bugs seem to prefer?
2. Where do you think you could find sow bugs near your home?

Figure 22 Sun stars have up to twelve arms instead of five like many other sea stars. Sea urchins are covered with protective spines. Sand dollars have tube feet on their undersides.

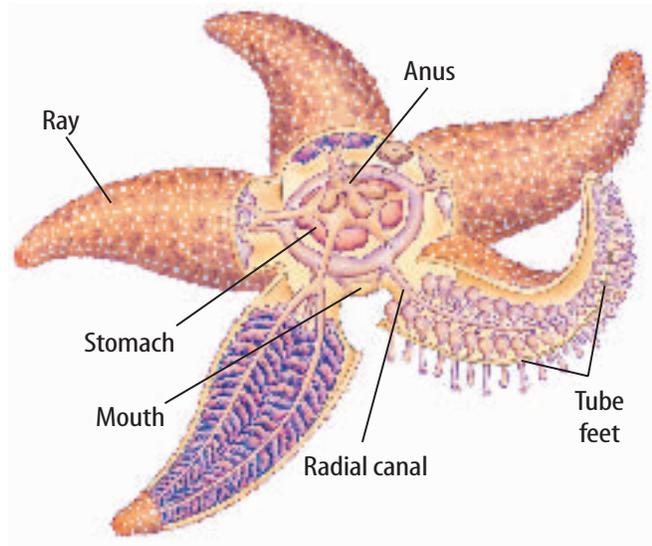


Figure 23 Echinoderms use their tube feet to move. Sea stars also use their tube feet to capture prey and pull apart the shells. Tube feet are connected to an internal system of canals and are able to act like suction cups.

Water-Vascular System All echinoderms have a water-vascular system. It is a network of water-filled canals and thousands of tube feet. The tube feet work like suction cups to help the sea star move and capture prey. **Figure 23** shows how these tube feet are used to pull open prey. Sea stars have a unique way of eating. The sea star pushes its stomach out of its mouth and into the opened shell of its prey. After the prey's body is digested and absorbed, the sea star pulls in its stomach.

Like some invertebrates, sea stars can regenerate lost or damaged parts. In an attempt to reduce the population of sea stars that ate their oysters, oyster farmers once captured sea stars, cut them into pieces, and threw them back into the bay. Within a short time, the sea star population was five times larger. The oyster beds were destroyed—not saved.

section 4 review

Summary

Arthropods

- Arthropods are the largest and most diverse group of animals.
- Arthropods have bilateral symmetry and segmented bodies.
- Many insect species go through metamorphosis as they mature.

Echinoderms

- Echinoderms have radial symmetry and a water-vascular system.
- Like some other invertebrates, sea stars can regenerate damaged parts.

Self Check

1. **List** the advantages and disadvantages of having an exoskeleton.
2. **Explain** why spiders and ticks aren't insects.
3. **Compare and contrast** centipedes and millipedes.
4. **Think Critically** What might happen to the sea star population after oyster beds are destroyed? Explain.

Applying Math

5. **Use Proportions** A flea that is 4 mm in length can jump 25 cm from a resting position. If this flea were as tall as you are, how far could it jump?

Observing Complete Metamorphosis

Many insects go through complete metamorphosis during their life cycles. Chemicals that are secreted by the body of the animal control the changes. How different are the body forms of the four stages of metamorphosis?

Real-World Question

What do the stages of metamorphosis look like for a mealworm?

Goals

- **Observe** metamorphosis of mealworms.
- **Compare** the physical appearance of the mealworms at each stage of metamorphosis.

Materials

large-mouth jar or old fish bowl
 bran or oatmeal
 dried bread or cookie crumbs mixed with flour
 slice of apple or carrot
 paper towel
 cheesecloth
 mealworms
 rubber band

Safety Precautions



WARNING: *Be careful when working with animals. Never touch your face during the lab. Wash your hands thoroughly after completing the lab.*

Procedure

1. Set up a habitat for the mealworms by placing a 1-cm layer of bran or oatmeal on the bottom of the jar. Add a 1-cm layer of dried bread or cookie crumbs mixed with flour. Then add another layer of bran or oatmeal.



2. Add a slice of apple or carrot as a source of moisture. Replace the apple or carrot daily.
3. Place 20 to 30 mealworms in the jar. Add a piece of crumpled paper towel.
4. Cover the jar with a piece of cheesecloth. Use the rubber band to secure the cloth to the jar.
5. **Observe** the mealworms daily for two to three weeks. Record daily observations in your Science Journal.

Conclude and Apply

1. **Draw and describe** the mealworms' metamorphosis to adults in your Science Journal.
2. **Describe** some of the advantages of an insect's young being different from the adults.
3. **Infer** where you might find mealworms or adult darkling beetles in your house.

Communicating Your Data

Draw a cartoon showing the different stages of metamorphosis from mealworm to adult darkling beetle. **For more help, refer to the Science Skill Handbook.**

Garbage-Eating Worms

Goals

- **Design** an experiment that compares the condition of soil in two environments—one with earthworms and one without.
- **Observe** the change in soil conditions for two weeks.

Possible Materials

worms (red wigglers)
 4-L plastic containers with drainage holes (2)
 soil (7 L)
 shredded newspaper
 spray bottle
 chopped food scraps including fruit and vegetable peels, pulverized eggshells, tea bags, and coffee grounds (Avoid meat and fat scraps.)

Safety Precautions



WARNING: *Be careful when working with live animals. Always keep your hands wet when handling earthworms. Don't touch your face during the lab. Wash your hands thoroughly after the lab.*

Real-World Question

Susan knows that soil conditions can influence the growth of plants. She is trying to decide what factors might improve the soil in her backyard garden. A friend suggests that earthworms improve the quality of the soil. How could Susan find out if the presence of earthworms has any value in improving soil conditions? How does the presence of earthworms change the condition of the soil?



Form a Hypothesis

Based on your reading and observations, state a hypothesis about how earthworms might improve the conditions of soil.



Test Your Hypothesis

Make a Plan

1. As a group, agree upon a hypothesis and decide how you will test it. Identify what results will support the hypothesis.
2. List the steps you will need to take to test your hypothesis. Be specific. Describe exactly what you will do in each step. List your materials.
3. Prepare a data table in your Science Journal to record your observations.
4. Read over the entire experiment to make sure that all the steps are in a logical order.
5. **Identify** all constants, variables, and controls of the experiment.

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. Carry out the experiment according to the approved plan.
3. While doing the experiment, record your observations and complete the data table in your Science Journal.

Analyze Your Data

1. **Compare** the changes in the two sets of soil samples.
2. **Compare** your results with those of other groups.
3. **Identify** the control in this experiment.
4. What were your variables?

Conclude and Apply

1. **Explain** whether the results support your hypothesis.
2. **Describe** what effect you think rain would have on the soil and worms.

Communicating Your Data

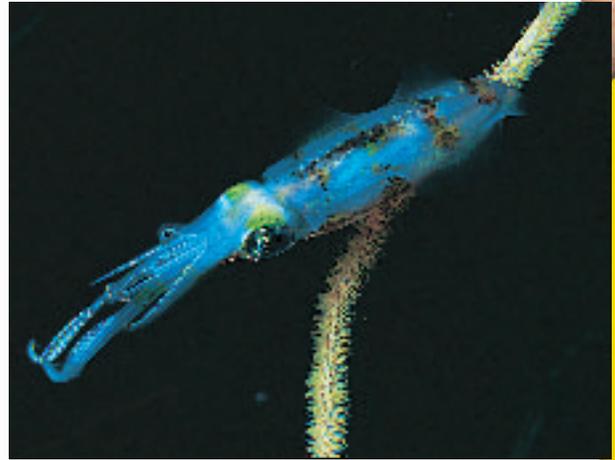
Write an informational pamphlet on how to use worms to improve garden soil. Include diagrams and a step-by-step procedure.



Squid Power

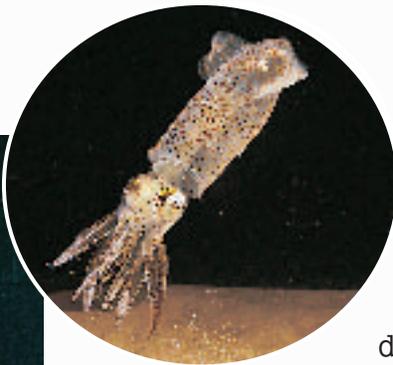
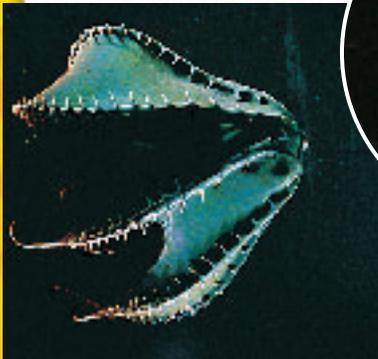
Did you know...

... **Squid can light up like a multi-colored neon sign** because of chemical reactions inside their bodies. They do this to lure prey into their grasp or to communicate with other squid. These brilliantly-colored creatures, often called fire squid, can produce blue-, red-, yellow-, and white-colored flashes in 0.3-s bursts every 5 s.



... **The scariest-looking squid is the vampire squid.**

It can wrap its webbed, spiked arms around itself like a cloak. Its fins look like pointed ears and its body is covered with light-producing organs that blink on and off. Imagine seeing that eerie sight in the dark depths of the ocean, nearly 1 km below the surface of the sea.



Applying Math

Scientists estimate that the adult vampire squid, which grows to about 15 cm in length, can swim at the rate of two body lengths per second. How fast is that in kilometers per hour?

... **Squid have blue blood**

because their oxygen is transported by a blue copper compound not by bright-red hemoglobin like in human blood.

... **Females of many species of squid die just after they lay eggs.**

In 1984, a giant squid washed ashore in Scotland, carrying more than 3,000 eggs.

Find Out About It

Scientists have never seen a living giant squid. Where would you look? At what depth? What kind of equipment would you use? To research these questions, visit in6.msscience.com/science_stats.

Reviewing Main Ideas

Section 1 What is an animal?

1. Animals are many-celled organisms that must find and digest their own food.
2. Invertebrates are animals without backbones, and vertebrates have backbones.
3. Symmetry is the way that animal body parts are arranged. The three types of symmetry are bilateral, radial, and asymmetrical.

Section 2 Sponges, Cnidarians, Flatworms, and Roundworms

1. Sponges have no tissues.
2. Adult sponges are sessile and obtain food and oxygen by filtering water.
3. Cnidarians are radially symmetrical, and most have tentacles with stinging cells to get food.
4. Flatworms and roundworms have bilateral symmetry. They have parasitic and free-living members.

Section 3 Mollusks and Segmented Worms

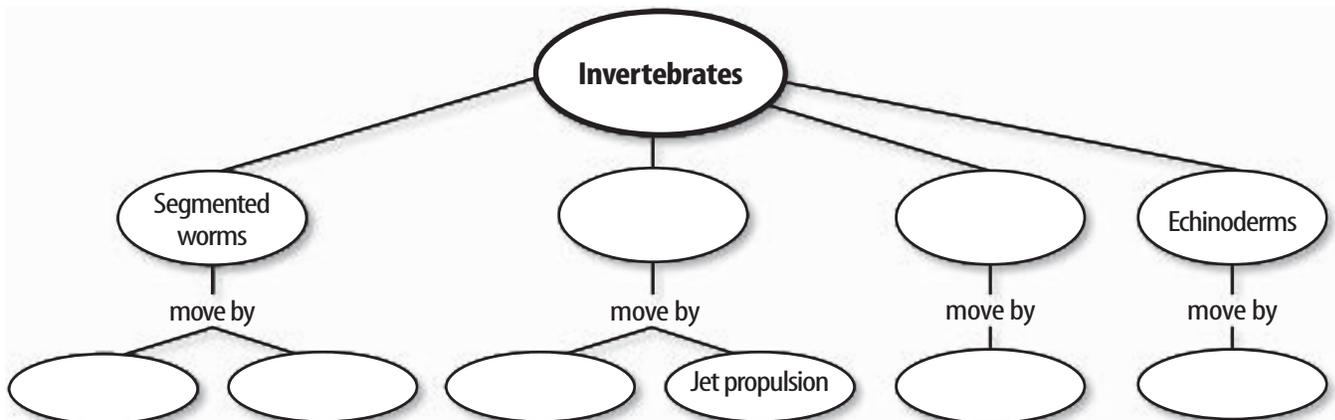
1. Mollusks are soft-bodied animals that usually have a shell and an open circulatory system.
2. Gastropods, bivalves, and cephalopods are types of mollusks.
3. Annelids have segmented bodies. A body cavity separates internal organs from the body wall.

Section 4 Arthropods and Echinoderms

1. Arthropods have exoskeletons that cover, protect, and support their bodies.
2. Arthropods develop either by complete metamorphosis or by incomplete metamorphosis.
3. Echinoderms are spiny-skinned invertebrates and have a water-vascular system.

Visualizing Main Ideas

Copy and complete the following concept map.



Using Vocabulary

appendage p.420	medusa p.411
arthropod p.420	metamorphosis p.421
closed circulatory system p.416	mollusk p.414
cnidarian p.410	open circulatory system p.415
exoskeleton p.420	polyp p.411
gill p.414	radula p.415
invertebrate p.408	symmetry p.407
mantle p.414	

For each set of vocabulary words below, explain the relationship that exists.

- medusa—polyp
- closed circulatory system—open circulatory system
- vertebrate—invertebrate
- arthropod—mollusk
- exoskeleton—mantle
- arthropod—appendage
- cnidarian—invertebrate
- mollusk—mantle
- medusa—cnidarian

Checking Concepts

Choose the word or phrase that best answers the question.

- Marine worms can live in all but which of the following?
 - mud burrows
 - tube cases
 - soil
 - salt water
- Butterflies, ants, bees, and beetles are examples of insects that undergo
 - incomplete metamorphosis.
 - complete metamorphosis.
 - no metamorphosis.
 - a molt from nymph to adult.

- The body plans of cnidarians are polyp and which of the following?
 - larva
 - medusa
 - pupa
 - bud
- Which of the following is a parasite?
 - sponge
 - planarian
 - tapeworm
 - jellyfish
- Which of the following groups of animals molt?
 - crustaceans
 - earthworms
 - sea stars
 - flatworms
- Which of these organisms has a closed circulatory system?
 - octopus
 - snail
 - oyster
 - sponge
- Radial symmetry is common in which group of invertebrates?
 - annelids
 - mollusks
 - echinoderms
 - arthropods
- Which of the following organisms has two body regions?
 - insect
 - mollusk
 - arachnid
 - annelid

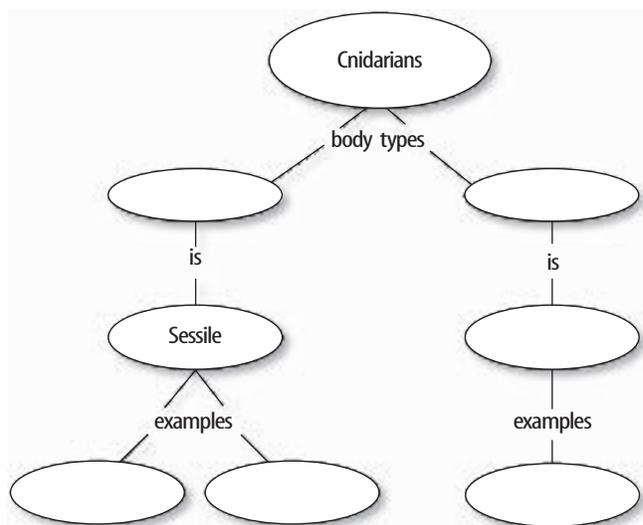
Use the photo below to answer question 18.



- What symmetry does the animal in the illustration above have?
 - asymmetry
 - bilateral
 - radial
 - anterior
- Which of the following do not belong to the same group?
 - snails
 - oysters
 - octopuses
 - sea stars

Thinking Critically

20. **Infer** Which aspect of sponge reproduction would be evidence that they are more like animals than plants?
21. **Explain** why it is an advantage for organisms to have more than one means of reproduction.
22. **Compare and contrast** the tentacles of cnidarians and cephalopods.
23. **Explain** the main differences between budding and regeneration.
24. **Infer** Centipedes and millipedes have segments. Why are they not classified as worms?
25. **Compare and contrast** the feeding habits of sponges and cnidarians.
26. **Draw Conclusions** Observe the conch in **Figure 11**. Infer why gastropods are sometimes called univalves? Use examples in your answer.
27. **Concept Map** Copy and complete the concept map below about cnidarian classification.



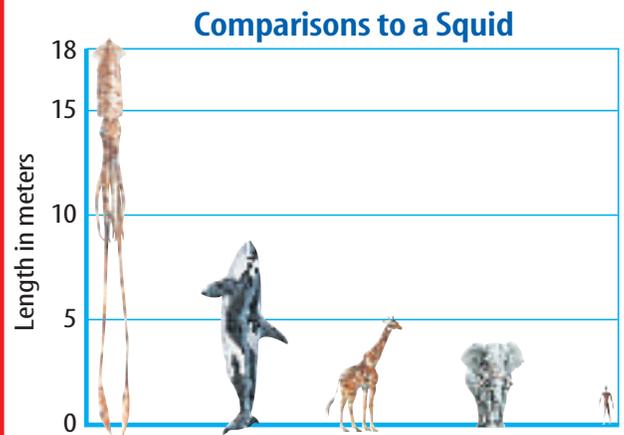
Performance Activities

28. **Diary** Pretend you are an earthworm. Write a diary with at least ten entries describing your daily life. Include how you move, how you get food, and where you live.

Applying Math

29. **Giant Squid Size** The largest giant squid recorded was 18 m long and weighed 900 kg. The best-preserved specimen is at the American Museum of Natural History. It is about 8 m long and has a mass of 114 kg. This is only a fraction of the largest specimen ever found. What is the fraction?

Use the following illustration to answer question 30.



30. **Squid Comparisons** Approximately how many times longer is a giant squid compared to a killer whale? A giraffe? An elephant? A human?
31. **Earthworm Feeding** If you have an apple that weighs 141 g and an earthworm that weighs 11 g, how many days would it take the earthworm to eat the apple? Assume the earthworm can eat its own weight each day.
32. **Insect Species** Approximately 91,000 species of insects and 24,000 species of beetles have been identified in the United States. Approximately what percentage of the identified species are beetles?



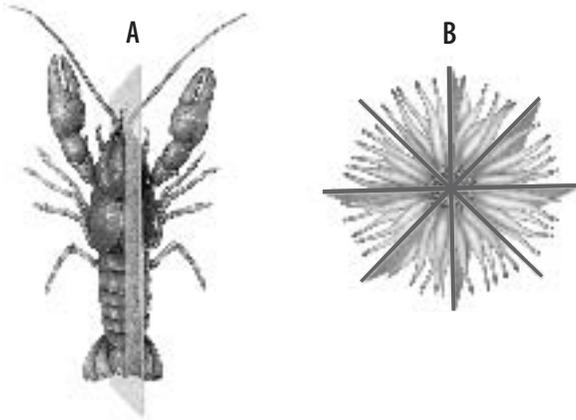
 The assessed Indiana standard appears above the question.

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Part 1 Multiple Choice

6.4.3

The illustration below shows two animals.



1. What symmetry does animal A represent?

- A asymmetry
- B bilateral
- C biradial
- D radial

6.4.3

2. Which has the same symmetry as animal B in the illustration above?

- A clam
- B cow
- C earthworm
- D sea urchin

6.4.3

3. Which is part of a cnidarian?

- A coelom
- B mantle
- C nematocyst
- D spicule

6.4.5

4. Which of the following is a characteristic of animals?

- A digest their own food
- B make their own food
- C have only one cell
- D have no organelles

5. The photo below shows an invertebrate animal.



What kind of invertebrate animal is this?

- A arthropod
- B echinoderm
- C mollusk
- D sponge



6. Which is a segmented worm?

- A heartworm
- B leech
- C planarian
- D tapeworm

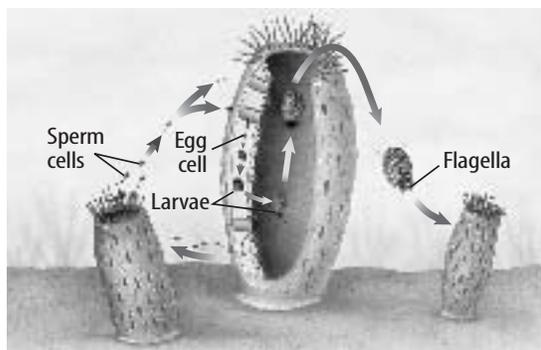
6.4.3

7. Which is a characteristic of an echinoderm?

- A two pairs of antennae
- B spiny skin
- C many setae along the sides of their body
- D move through water using a siphon

6.4.3

8. The illustration below is of a sponge's life cycle.



What type of reproduction is illustrated?

- A asexual
- B hermaphroditic
- C regeneration
- D sexual

Part 2 Critical Response

6.4.3

9. Describe how sponges feed on the microorganisms in the water around them.

10. Compare and contrast a closed circulatory system and an open circulatory system.

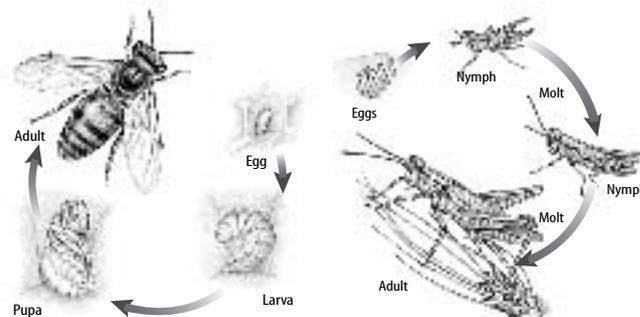
6.4.3

11. Describe the life cycle of a tapeworm.

12. Explain the process used by mollusks to take in oxygen.

6.4.3

13. The illustrations below show two insect life cycles.



Which diagram represents complete metamorphosis and which represents incomplete metamorphosis? How can you tell the difference?

Test-Taking Tip

Complete Answers Make sure each part of the question is answered when listing discussion points.

Question 10 This question asks you to compare and contrast. Make sure you list both similarities and differences.