

Chapter 14

Classifying and Exploring Life



What are living things, and how can they be classified?

Inquiry

Dropped Dinner Rolls?

At first glance, you might think someone dropped dinner rolls on a pile of rocks. These objects might look like dinner rolls, but they're not.

- What do you think the objects are? Do you think they are alive?
- Why do you think they look like this?
- What are living things, and how can they be classified?



Get Ready to Read

What do you think?

Before you read, decide if you agree or disagree with each of these statements. As you read this chapter, see if you change your mind about any of the statements.

- 1 All living things move.
- 2 The Sun provides energy for almost all organisms on Earth.
- 3 A dichotomous key can be used to identify an unknown organism.
- 4 Physical similarities are the only traits used to classify organisms.
- 5 Most cells are too small to be seen with the unaided eye.
- 6 Only scientists use microscopes.



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Assessment



Review



Concepts in Motion



Inquiry



Multilingual eGlossary



Lesson 1

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- What characteristics do all living things share?

Vocabulary

organism p. 421

cell p. 422

unicellular p. 422

multicellular p. 422

homeostasis p. 425

 **Multilingual eGlossary**

Characteristics of Life



Inquiry

What's missing?

This toy looks like a dog and can move, but it is a robot. What characteristics are missing to make it alive? Let's find out.




Is it alive?



Living organisms have specific characteristics. Is a rock a living organism? Is a dog? What characteristics describe something that is living?

- 1 Read and complete a lab safety form.
- 2 Place three pieces of **pasta** in the bottom of a **clear plastic cup**.
- 3 Add **carbonated water** to the cup until it is 2/3 full.
- 4 Observe the contents of the cup for 5 minutes. Record your observations in your Science Journal.

Think About This

1. Think about living things. How do you know they are alive?
2. Which characteristics of life do you think you are observing in the cup?
3.  **Key Concept** Is the pasta alive? How do you know?



Characteristics of Life

Look around your classroom and then at **Figure 1**. You might see many nonliving things, such as lights and books. Look again, and you might see many living things, such as your teacher, your classmates, and plants. What makes people and plants different from lights and books?

People and plants, like all living things, have all the characteristics of life. All living things are organized, grow and develop, reproduce, respond, maintain certain internal conditions, and use energy. Nonliving things might have some of these characteristics, but they do not have all of them. Books might be organized into chapters, and lights use energy. However, only those things that have all the characteristics of life are living. *Things that have all the characteristics of life are called **organisms**.*



Reading Check How do living things differ from nonliving things?

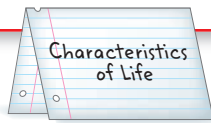


Figure 1 A classroom might contain living and nonliving things.



FOLDABLES®

Fold a sheet of paper into a half book. Label it as shown. Use it to organize your notes on the characteristics of living things.



Organization

Your home is probably organized in some way. For example, the kitchen is for cooking, and the bedrooms are for sleeping. Living things are also organized. Whether an organism is made of one **cell**—the *smallest unit of life*—or many cells, all living things have structures that have specific functions.

*Living things that are made of only one cell are called **unicellular** organisms.* Within a unicellular organism are structures with specialized functions just like a house has rooms for different activities. Some structures take in nutrients or control cell activities. Other structures enable the organism to move.

*Living things that are made of two or more cells are called **multicellular** organisms.* Some multicellular organisms only have a few cells, but others have trillions of cells. The different cells of a multicellular organism usually do not perform the same function. Instead, the cells are organized into groups that have specialized functions, such as digestion or movement.

Growth and Development

The tadpole in **Figure 2** is not a frog, but it will soon lose its tail, grow legs, and become an adult frog. This happens because the tadpole, like all organisms, will grow and develop. When organisms grow, they increase in size. A unicellular organism grows as the cell increases in size. Multicellular organisms grow as the number of their cells increases.


Figure 2 A tadpole grows in size while developing into an adult frog.

Growth and Development

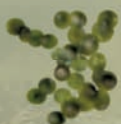


Concepts in Motion

Animation

 **Visual Check** What characteristics of life can you identify in this figure?


1 A frog egg develops into a tadpole.



2 As the tadpole grows, it develops legs.



Changes that occur in an organism during its lifetime are called development. In multicellular organisms, development happens as cells become specialized into different cell types, such as skin cells or muscle cells. Some organisms undergo dramatic developmental changes over their lifetime, such as a tadpole developing into a frog.

 **Reading Check** What happens in development?

Reproduction

As organisms grow and develop, they usually are able to reproduce. Reproduction is the process by which one organism makes one or more new organisms. In order for living things to continue to exist, organisms must reproduce. Some organisms within a population might not reproduce, but others must reproduce if the species is to survive.

Organisms do not all reproduce in the same way. Some organisms, like the ones in **Figure 3**, can reproduce by dividing and become two new organisms. Other organisms have specialized cells for reproduction. Some organisms must have a mate to reproduce, but others can reproduce without a mate. The number of offspring produced varies. Humans usually produce only one or two offspring at a time. Other organisms, such as the frog in **Figure 2**, can produce hundreds of offspring at one time.

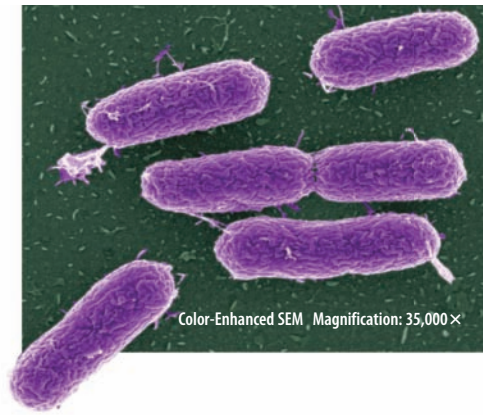
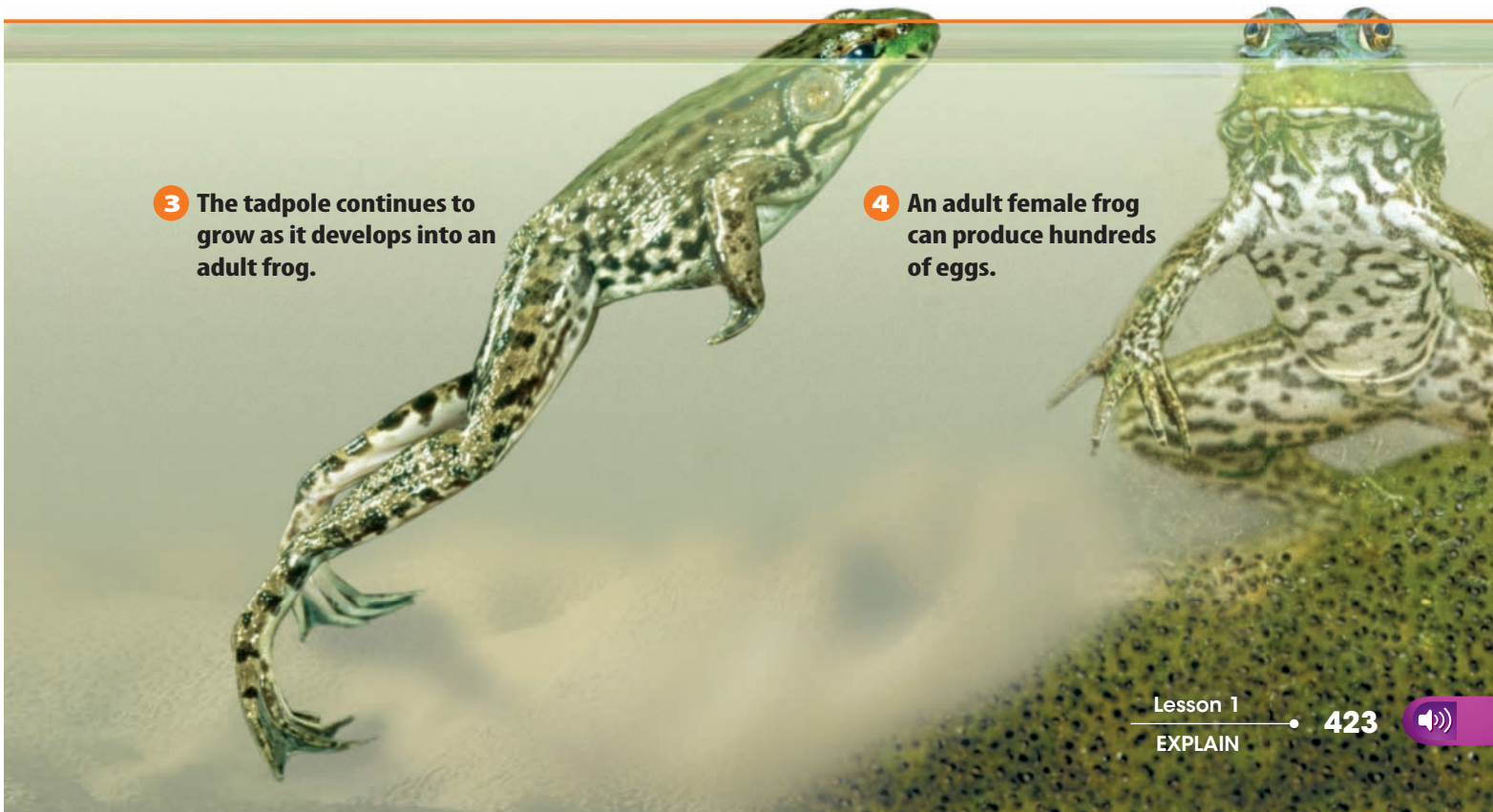


Figure 3 Some unicellular organisms, like the bacteria shown here, reproduce by dividing. The two new organisms are identical to the original organism.

3 The tadpole continues to grow as it develops into an adult frog.

4 An adult female frog can produce hundreds of eggs.



Responses to Stimuli

If someone throws a ball toward you, you might react by trying to catch it. This is because you, like all living things, respond to changes in the environment. These changes can be internal or external and are called stimuli (STIHM yuh li).

Internal Stimuli

You respond to internal stimuli (singular, stimulus) every day. If you feel hungry and then look for food, you are responding to an internal stimulus—the feeling of hunger. The feeling of thirst that causes you to find and drink water is another example of an internal stimulus.

External Stimuli

Changes in an organism's environment that affect the organism are external stimuli. Some examples of external stimuli are light and temperature.

Many plants, like the one in **Figure 4**, will grow toward light. You respond to light, too. Your skin's response to sunlight might be to darken, turn red, or freckle.

Some animals respond to changes in temperature. The response can be more or less blood flowing to the skin. For example, if the temperature increases, the diameter of an animal's blood vessels increases. This allows more blood to flow to the skin, cooling an animal.

Figure 4 The leaves and stems of plants like this one will grow toward a light source.



Inquiry

MiniLab

20 minutes

Did you blink?




Like all living organisms, you respond to changes, or stimuli, in your environment. When you react to a stimulus without thinking, the response is known as a reflex. Let's see what a reflex is like.

- 1 Read and complete a lab safety form.
- 2 Sit on a chair with your hands in your lap.
- 3 Have your partner gently toss a **soft, foam ball** at your face five times. Your partner will warn you when he or she is going to toss the ball. Record your responses in your Science Journal.
- 4 Have your partner gently toss the ball at your face five times without warning you. Record your responses.
- 5 Switch places with your partner, and repeat steps 3 and 4.



Analyze and Conclude

1. **Compare** your responses when you were warned and when you were not warned.
2. **Decide** if any of your reactions were reflex responses, and explain your answer.
3.  **Key Concept** Infer why organisms have reflex responses to some stimuli.



Homeostasis

Have you ever noticed that if you drink more water than usual, you have to go to the bathroom more often? That is because your body is working to keep your internal environment under normal conditions. *An organism's ability to maintain steady internal conditions when outside conditions change is called **homeostasis*** (hoh mee oh STAY sus).

The Importance of Homeostasis

Are there certain conditions you need to do your homework? Maybe you need a quiet room with a lot of light. Cells also need certain conditions to function properly. Maintaining certain conditions—homeostasis—ensures that cells can function. If cells cannot function normally, then an organism might become sick or even die.

Methods of Regulation

A person might not survive if his or her body temperature changes more than a few degrees from 37°C. When your outside environment becomes too hot or too cold, your body responds. It sweats, shivers, or changes the flow of blood to maintain a body temperature of 37°C.

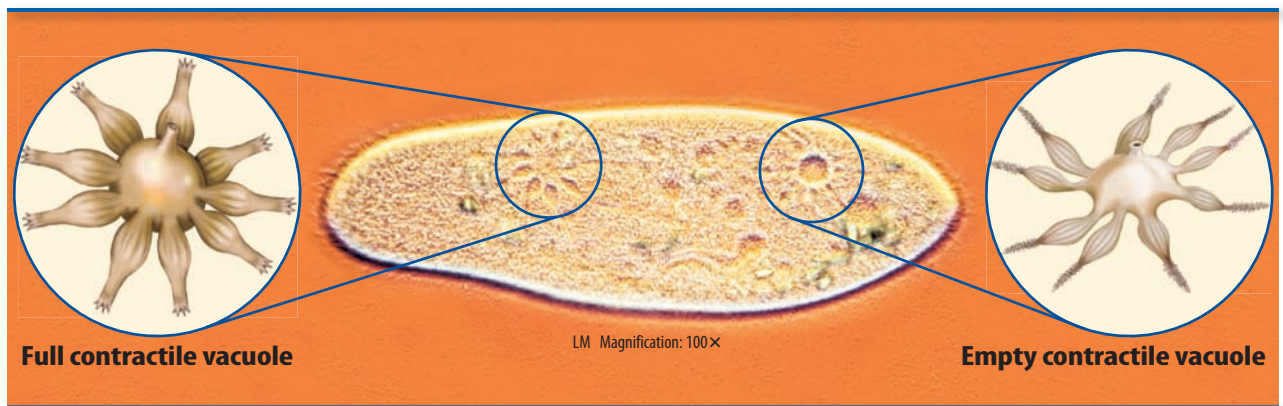
Unicellular organisms, such as the paramecium in **Figure 5**, also have ways of regulating homeostasis. A structure called a contractile vacuole (kun TRAK tul • VA kyuh wohl) collects and pumps excess water out of the cell.

WORD ORIGIN

homeostasis

from Greek *homoios*, means “like, similar”; and *stasis*, means “standing still”

Figure 5 This paramecium lives in freshwater. Water continuously enters its cell and collects in contractile vacuoles. The vacuoles contract and expel excess water from the cell. This maintains normal water levels in the cell.



There is a limit to the amount of change that can occur within an organism. For example, you are able to survive only a few hours in water that is below 10°C. No matter what your body does, it cannot maintain steady internal conditions, or homeostasis, under these circumstances. As a result, your cells lose their ability to function.



Reading Check Why is maintaining homeostasis important to organisms?



Energy

Everything you do requires energy. Digesting your food, sleeping, thinking, reading and all of the characteristics of life shown in **Table 1** on the next page require energy. Cells continuously use energy to transport substances, make new cells, and perform chemical reactions. Where does this energy come from?

For most organisms, this energy originally came to Earth from the Sun, as shown in **Figure 6**. For example, energy in the cactus came from the Sun. The squirrel gets energy by eating the cactus, and the coyote gets energy by eating the squirrel.



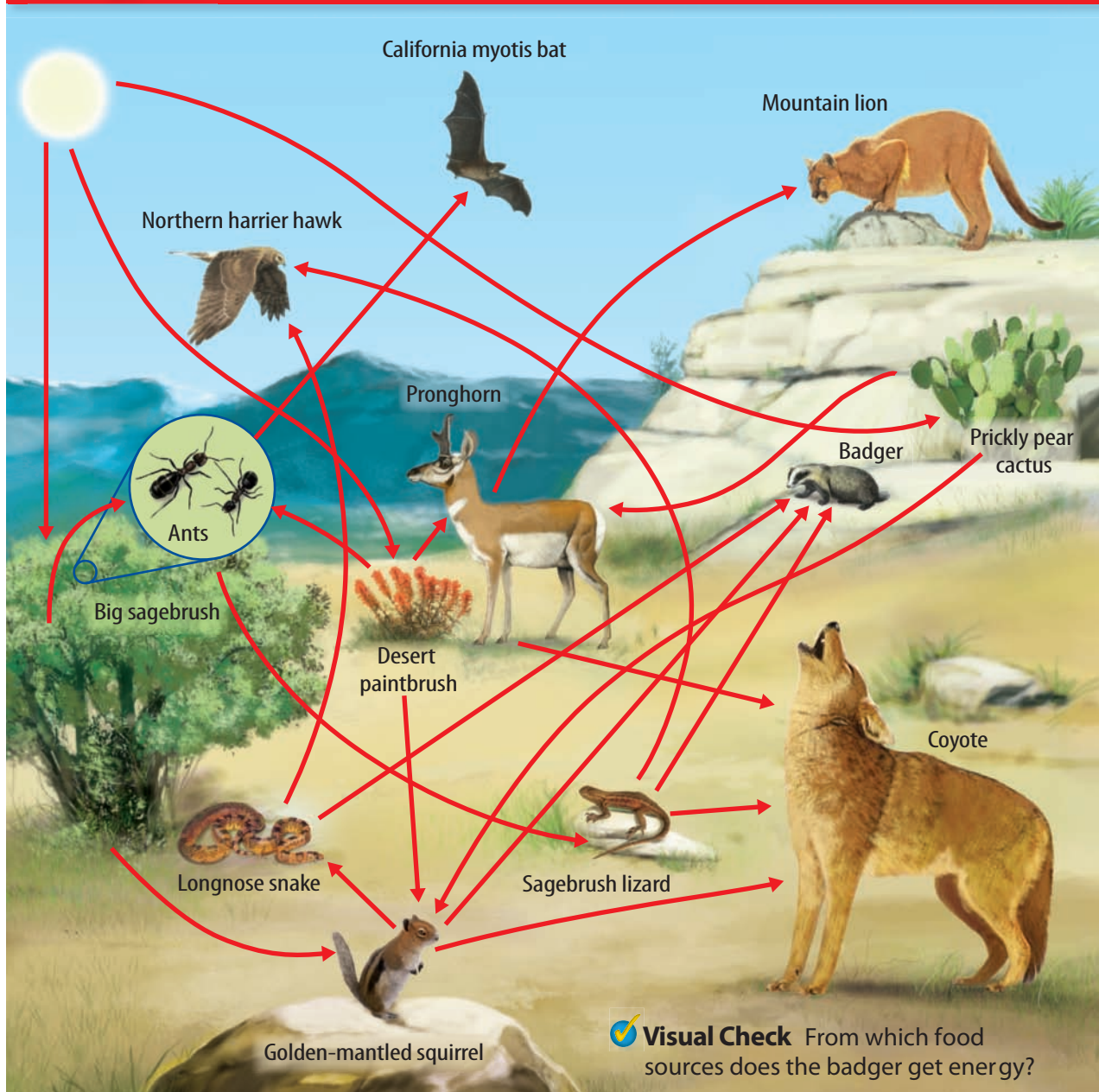
Key Concept Check What characteristics do all living things share?

Energy Use



Review

Personal Tutor









Visual Check From which food sources does the badger get energy?

Figure 6 All organisms require energy to survive. In this food web, energy passes from one organism to another and to the environment.



Table 1 Characteristics of Life

Characteristic	Definition	Example
Organization	Living things have specialized structures with specialized functions. Living things with more than one cell have a greater level of organization because groups of cells function together.	
Growth and development	Living things grow by increasing cell size and/or increasing cell number. Multicellular organisms develop as cells develop specialized functions.	
Reproduction	Living things make more living things through the process of reproduction.	
Response to stimuli	Living things adjust and respond to changes in their internal and external environments.	
Homeostasis	Living things maintain a stable internal conditions.	
Use of energy	Living things use energy for all the processes they perform. Living things get energy by making their own food, eating food, or absorbing food.	



Lesson 1 Review



Assessment

Online Quiz

Visual Summary



An organism has all the characteristics of life.



Unicellular organisms have specialized structures, much like a house has rooms for different activities.



Homeostasis enables living things to maintain a steady internal environment.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

1. All living things move.
2. The Sun provides energy for almost all organisms on Earth.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

- 1 A(n) _____ is the smallest unit of life.
- 2 **Distinguish** between unicellular and multicellular.
- 3 **Define** the term *homeostasis* in your own words.

Understand Key Concepts

- 4 Which is NOT a characteristic of all living things?
A. breathing C. reproducing
B. growing D. using energy
- 5 **Compare** the processes of reproduction and growth.
- 6 **Choose** the characteristic of living things that you think is most important. Explain why you chose that characteristic.
- 7 **Critique** the following statement: A candle flame is a living thing.

Interpret Graphics

- 8 **Summarize** Copy and fill in the graphic organizer below to summarize the characteristics of living things.



- 9 **Describe** all the characteristics of life that are represented in the figure below.



Critical Thinking

- 10 **Suggest** how organisms would be different if they were not organized.
- 11 **Hypothesize** what would happen if living things could not reproduce.



The Amazing Adaptation of an Air-Breathing Catfish

Discover how some species of armored catfish breathe air.

Have you ever thought about why animals need oxygen? All animals, including you, get their energy from food. When you breathe, the oxygen you take in is used in your cells. Chemical reactions in your cells use oxygen and change the energy in food molecules into energy that your cells can use. Mammals and many other animals get oxygen from air. Most fish get oxygen from water. Either way, after an animal takes in oxygen, red blood cells carry oxygen to cells throughout its body.

Adriana Aquino is an ichthyologist (IHK thee AH luh jihst) at the American Museum of Natural History in New York City. She discovers and classifies species of fish, such as the armored catfish in family Loricariidae from South America. It lives in freshwater rivers and pools in the Amazon. Its name comes from the bony plates covering its body. Some armored catfish can take in oxygen from water and from air!

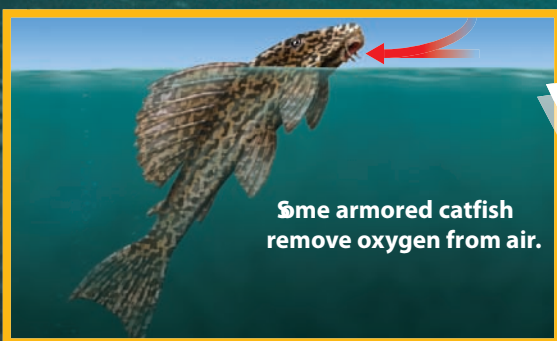
Some armored catfish live in fast-flowing rivers. The constant movement of the water evenly distributes oxygen throughout it. The catfish can easily remove oxygen from this oxygen-rich water.

But other armored catfish live in pools of still water, where most oxygen is only at the water's surface. This makes the pools low in oxygen. To maintain a steady level of oxygen in their cells, these fish have adaptations that enable them to take in oxygen directly from air. These catfish can switch from removing oxygen from water through their gills to removing oxygen from air through the walls of their stomachs. They can only do this when they do not have much food in their stomachs. Some species can survive up to 30 hours out of water!



Meet an Ichthyologist

Aquino examines hundreds of catfish specimens. Some she collects in the field, and others come from museum collections. She compares the color, the size, and the shape of the various species. She also examines their internal and external features, such as muscles, gills, and bony plates.



Some armored catfish remove oxygen from air.

It's Your Turn

BRAINSTORM Work with a group. Choose an animal and list five physical characteristics. Brainstorm how these adaptations help the animal be successful in its habitat. Present your findings to the class.



Lesson 2

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- What methods are used to classify living things into groups?
- Why does every species have a scientific name?

Vocabulary

binomial nomenclature p. 433

species p. 433

genus p. 433

dichotomous key p. 434

cladogram p. 435

 **Multilingual eGlossary**

 **Video** **BrainPOP®**

Classifying Organisms

Inquiry

Alike or Not?

In a band, instruments are organized into groups, such as brass and woodwinds. The instruments in a group are alike in many ways. In a similar way, living things are classified into groups. Why are living things classified?




How do you identify similar items?

Do you separate your candies by color before you eat them? When your family does laundry, do you sort the clothes by color first? Identifying characteristics of items can enable you to place them into groups.

- 1 Read and complete a lab safety form.
- 2 Examine twelve **leaves**. Choose a characteristic that you could use to separate the leaves into two groups. Record the characteristic in your Science Journal.
- 3 Place the leaves into two groups, *A* and *B*, using the characteristic you chose in step 2.
- 4 Choose another characteristic that you could use to further divide group *A*. Record the characteristic, and divide the leaves.
- 5 Repeat step 4 with group *B*.

**Think About This**

1. What types of characteristics did other groups in class choose to separate the leaves?
2.  **Key Concept** Why would scientists need rules for separating and identifying items?


Classifying Living Things

How would you find your favorite fresh fruit or vegetable in the grocery store? You might look in the produce section, such as the one shown in **Figure 7**. Different kinds of peppers are displayed in one area. Citrus fruits such as oranges, lemons, and grapefruits are stocked in another area. There are many different ways to organize produce in a grocery store. In a similar way, there have been many different ideas about how to organize, or classify, living things.

A Greek philosopher named Aristotle (384 B.C.–322 B.C.) was one of the first people to classify organisms. Aristotle placed all organisms into two large groups, plants and animals. He classified animals based on the presence of “red blood,” the animal’s environment, and the shape and size of the animal. He classified plants according to the structure and size of the plant and whether the plant was a tree, a shrub, or an herb.



Figure 7 The produce in this store is classified into groups.

 **Visual Check** What other ways can you think of to classify and organize produce?



SCIENCE USE V. COMMON USE

kingdom

Science Use a classification category that ranks above phylum and below domain

Common Use a territory ruled by a king or a queen

Determining Kingdoms

In the 1700s, Carolus Linnaeus, a Swedish physician and botanist, classified organisms based on similar structures. Linnaeus placed all organisms into two main groups, called **kingdoms**. Over the next 200 years, people learned more about organisms and discovered new organisms. In 1969 American biologist Robert H. Whittaker proposed a five-kingdom system for classifying organisms. His system included kingdoms Monera, Protista, Plantae, Fungi, and Animalia.

Determining Domains

The classification system of living things is still changing. The current classification method is called systematics. Systematics uses all the evidence that is known about organisms to classify them. This evidence includes an organism’s cell type, its habitat, the way an organism obtains food and energy, structure and function of its features, and the common ancestry of organisms. Systematics also includes molecular analysis—the study of molecules such as DNA within organisms.

Using systematics, scientists identified two distinct groups in Kingdom Monera—Bacteria and Archaea (ar KEE uh). This led to the development of another level of classification called domains. All organisms are now classified into one of three domains—Bacteria, Archaea, or Eukarya (yew KER ee uh) —and then into one of six kingdoms, as shown in **Table 2**.









 **Key Concept Check** What evidence is used to classify living things into groups?

Table 2 Domains and Kingdoms 						
Domain	Bacteria	Archaea	Eukarya			
Kingdom	Bacteria	Archaea	Protista	Fungi	Plantae	Animalia
Example						
Characteristics	Bacteria are simple unicellular organisms.	Archaea are simple unicellular organisms that often live in extreme environments.	Protists are unicellular and are more complex than bacteria or archaea.	Fungi are unicellular or multicellular and absorb food.	Plants are multicellular and make their own food.	Animals are multicellular and take in their food.



Scientific Names

Suppose you did not have a name. What would people call you? All organisms, just like people, have names. When Linnaeus grouped organisms into kingdoms, he also developed a system for naming organisms. This naming system, called binomial nomenclature (bi NOH mee ul · NOH mun klay chur), is the system we still use today.

Binomial Nomenclature

Linnaeus's naming system, **binomial nomenclature**, gives each organism a two-word scientific name, such as *Ursus arctos* for a brown bear. This two-word scientific name is the name of an organism's species (SPEE sheez). A **species** is a group of organisms that have similar traits and are able to produce fertile offspring. In binomial nomenclature, the first word is the organism's genus (JEE nus) name, such as *Ursus*. A **genus** is a group of similar species. The second word might describe the organism's appearance or its behavior.

How do species and genus relate to kingdoms and domains? Similar species are grouped into one genus (plural, genera). Similar genera are grouped into families, then orders, classes, phyla, kingdoms, and finally domains, as shown for the grizzly bear in Table 3.

WORD ORIGIN

genus

from Greek *genos*, means
"race, kind"

Table 3 The classification of the brown bear or grizzly bear shows that it belongs to the order Carnivora.

Table 3 Classification of the Brown Bear		
Taxonomic Group	Number of Species	Examples
Domain Eukarya	About 4–10 million	
Kingdom Animalia	About 2 million	
Phylum Chordata	About 50,000	
Class Mammalia	About 5,000	
Order Carnivora	About 270	
Family Ursidae	8	
Genus <i>Ursus</i>	4	
Species <i>Ursus arctos</i>	1	

Visual Check What domain does the brown bear belong to?





▲ **Figure 8** These trees are two different species. *Pinus alba* has long needles, and *Tsuga canadensis* has short needles.

FOLDABLES®

Make a horizontal two-tab book to compare two of the tools scientists use to identify organisms—dichotomous keys and cladograms.



Uses of Scientific Names

When you talk about organisms, you might use names such as bird, tree, or mushroom. However, these are common names for a number of different species. Sometimes there are several common names for one organism. The animal in **Table 3** on the previous page might be called a brown bear or a grizzly bear, but it has only one scientific name, *Ursus arctos*.

Other times, a common name might refer to several different types of organisms. For example, you might call both of the trees in **Figure 8** pine trees. But these trees are two different species. How can you tell? Scientific names are important for many reasons. Each species has its own scientific name. Scientific names are the same worldwide. This makes communication about organisms more effective because everyone uses the same name for the same species.



Key Concept Check Why does every species have a scientific name?





Classification Tools

Suppose you go fishing and catch a fish you don't recognize. How could you figure out what type of fish you have caught? There are several tools you can use to identify organisms.

Dichotomous Keys

A **dichotomous key** is a series of descriptions arranged in pairs that leads the user to the identification of an unknown organism. The chosen description leads to either another pair of statements or the identification of the organism. Choices continue until the organism is identified. The dichotomous key shown in **Figure 9** identifies several species of fish.

Dichotomous Key

1. a. This fish has a mouth that extends past its eye. It is an arrow goby.	1a 
b. This fish does not have a mouth that extends past its eye. Go to step 2.	
2. a. This fish has a dark body with stripes. It is a chameleon goby.	2a 
b. This fish has a light body with no stripes. Go to step 3.	
3. a. This fish has a black-tipped dorsal fin. It is a bay goby.	3a 
b. This fish has a speckled dorsal fin. It is a yellowfin goby.	3b 

▲ **Figure 9** Dichotomous keys include a series of questions to identify organisms.



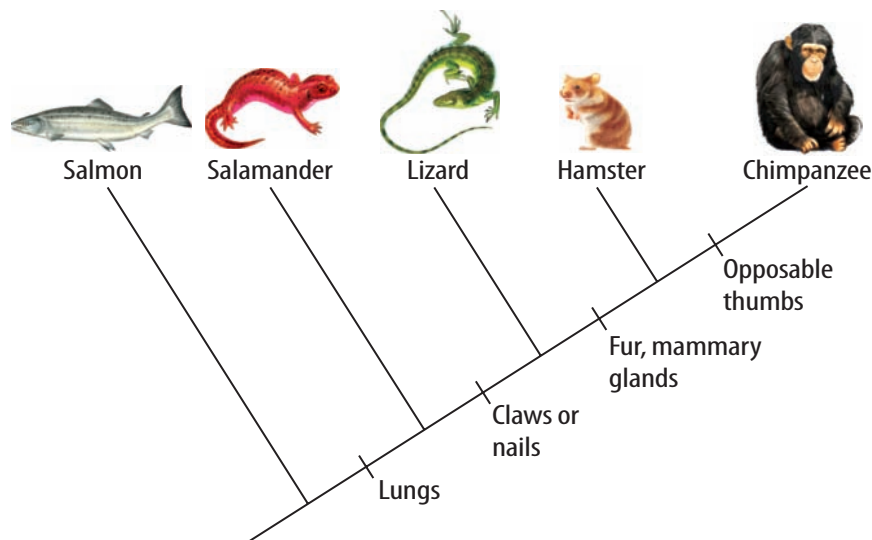


Figure 10 A cladogram shows relationships among species. In this cladogram, salamanders are more closely related to lizards than they are to hamsters.

 **Concepts in Motion**

Animation

Cladograms

A family tree shows the relationships among family members, including common ancestors. Biologists use a similar diagram, called a cladogram. A **cladogram** is a branched diagram that shows the relationships among organisms, including common ancestors. A cladogram, as shown in **Figure 10**, has a series of branches. Notice that each branch follows a new characteristic. Each characteristic is observed in all the species to its right. For example, the salamander, lizard, hamster, and chimpanzee have lungs, but the salmon does not. Therefore, they are more closely related to each other than they are to the salmon.

Inquiry

MiniLab

20 minutes

How would you name an unknown organism?

Assign scientific names to four unknown alien organisms from a newly discovered planet.

- 1** Use the table to assign scientific names to identify each alien.
- 2** Compare your names with those of your classmates.



Analyze and Conclude

- 1. Explain** why you chose the two-word names for each organism.
- 2. Compare** your names to those of a classmate. Explain any differences.
- 3. Key Concept** Discuss how two-word scientific names help scientists identify and organize living things.

Prefix	Meaning	Suffix	Meaning
mon-	one	-antennus	antenna
di-	two	-ocularus	eye
rectanguli-	square	-formus	shape
trianguli-	triangle	-uris	tail

Lesson 2 Review



Assessment

Online Quiz



Inquiry

Virtual Lab

Visual Summary



All organisms are classified into one of three domains: Bacteria, Archaea, or Eukarya.



Every organism has a unique species name.



A dichotomous key helps to identify an unknown organism through a series of paired descriptions.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think **NOW?**

You first read the statements below at the beginning of the chapter.

3. A dichotomous key can be used to identify an unknown organism.
4. Physical similarities are the only traits used to classify organisms.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

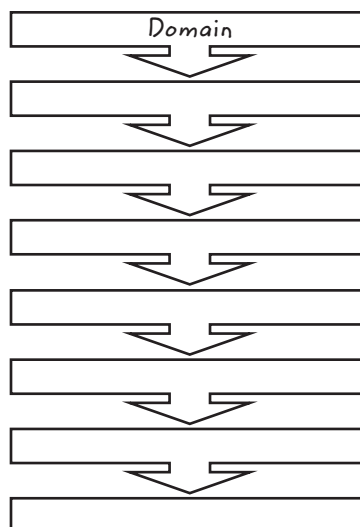
- 1 A naming system that gives every organism a two-word name is _____.
- 2 Use the term *dichotomous key* in a sentence.
- 3 Organisms of the same _____ are able to produce fertile offspring.

Understand Key Concepts

- 4 Describe how you write a scientific name.
- 5 Compare the data available today on how to classify things with the data available during Aristotle's time.
- 6 Which is NOT used to classify organisms?
 - A. ancestry
 - B. habitat
 - C. age of the organism
 - D. molecular evidence

Interpret Graphics

- 7 Organize Information Copy and fill in the graphic organizer below to show how organisms are classified.



Critical Thinking

- 8 Suggest a reason scientists might consider changing the current classification system.
- 9 Evaluate the importance of scientific names.

How can you identify a beetle?

A dichotomous key is one of the tools scientists use to identify an unknown organism and **classify** it into a group. To use a dichotomous key, a scientist examines specific characteristics of the unknown organism and compares them to characteristics of known organisms.


Learn It

Sorting objects or events into groups based on common features is called classifying. When classifying, select one feature that is shared by some members of the group, but not by all. Place those members that share the feature in a subgroup. You can **classify** objects or events into smaller and smaller subgroups based on characteristics.

Try It

- 1 Use the dichotomous key to identify beetle A. Choose between the first pair of descriptions. Follow the instructions for the next choice. Notice that each description either ends in the name of the beetle or instructs you to go on to another set of choices.
- 2 In your Science Journal, record the identity of the beetle using both its common name and scientific name.
- 3 Repeat steps 1 and 2 for beetles B, C, and D.

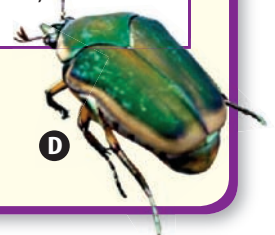
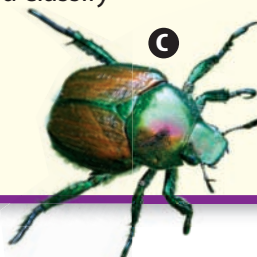
Apply It

- 4 Think about the choices in each step of the dichotomous key. What conclusion can be made if you arrive at a step and neither choice seems correct?
- 5 Predict whether a dichotomous key will work if you start at a location other than the first description. Support your reasoning.
- 6  **Key Concept** How did the dichotomous key help you classify the unknown beetles?



Dichotomous Key

- | | |
|-----|---|
| 1A. | The beetle has long, thin antennae. Go to 5. |
| 1B. | The beetle does not have long, thin antennae. Go to 2. |
| 2A. | The beetle has short antennae that branch. Go to 3. |
| 2B. | The beetle does not have short antennae that branch. It is a stag beetle, <i>Lucanus cervus</i> . |
| 3A. | The beetle has a triangular structure between wing covers and upper body. It is a Japanese beetle, <i>Popillia japonica</i> . |
| 3B. | The beetle does not have a triangular structure. Go to 4. |
| 4A. | The beetle has a wide, rounded body. It is a June bug, <i>Cotinis nitida</i> . |
| 4B. | The beetle does not have a wide, rounded body. It is a death watch beetle, <i>Xestobium rufovillosum</i> . |
| 5A. | The beetle has a distinct separation between body parts. Go to 6. |
| 5B. | The beetle has no distinct separation between body parts. It is a firefly, <i>Photinus pyralis</i> . |
| 6A. | The beetle has a black, gray, and white body with two black eyespots. It is an eyed click beetle, <i>Alaus oculatus</i> . |
| 6B. | The beetle has a dull brown body with light stripes. It is a click beetle, <i>Chalcolepidius limbatus</i> . |



Lesson 3

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- How did microscopes change our ideas about living things?
- What are the types of microscopes, and how do they compare?

Vocabulary

light microscope p. 440

compound microscope p. 440

electron microscope p. 441

 **Multilingual eGlossary**

Exploring Life

Inquiry

Giant Insect?

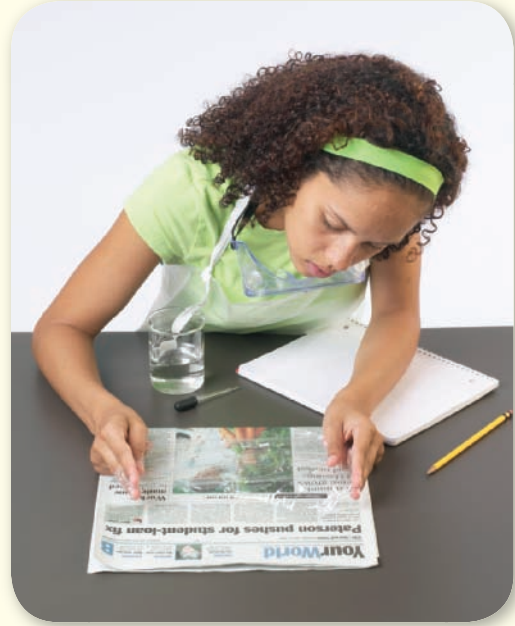
Although this might look like a giant insect, it is a photo of a small tick taken with a high-powered microscope. This type of microscope can enlarge an image of an object up to 200,000 times. How can seeing an enlarged image of a living thing help you understand life?




Can a water drop make objects appear bigger or smaller?

For centuries, people have been looking for ways to see objects in greater detail. How can something as simple as a drop of water make this possible?

- 1 Read and complete a lab safety form.
- 2 Lay a sheet of **newspaper** on your desk. Examine a line of text, noting the size and shape of each letter. Record your observations in your Science Journal.
- 3 Add a large drop of **water** to the center of a piece of **clear plastic**. Hold the plastic about 2 cm above the same line of text.
- 4 Look through the water at the line of text you viewed in step 2. Record your observations.



Think About This

1. Describe how the newsprint appeared through the drop of water.
2.  **Key Concept** How might microscopes change your ideas about living things?

The Development of Microscopes

Have you ever used a magnifying lens to see details of an object? If so, then you have used a tool similar to the first microscope. The invention of microscopes enabled people to see details of living things that they could not see with the unaided eye. The microscope also enabled people to make many discoveries about living things.

In the late 1600s the Dutch merchant Anton van Leeuwenhoek (LAY vun hook) made one of the first microscopes. His microscope, similar to the one shown in **Figure 11**, had one lens and could magnify an image about 270 times its original size. Another inventor of microscopes was Robert Hooke. In the early 1700s Hooke made one of the most significant discoveries using a microscope. He observed and named cells. Before microscopes, people did not know that living things are made of cells.



Key Concept Check How did microscopes change our ideas about living things?

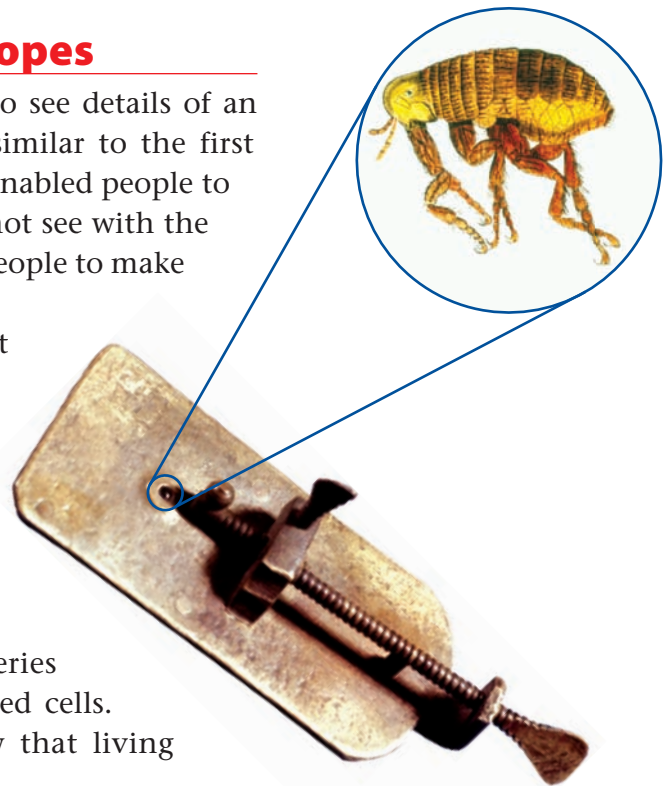


Figure 11 Anton van Leeuwenhoek observed pond water and insects using a microscope like the one shown above.

Math Skills

Use Multiplication

The magnifying power of a lens is expressed by a number and a multiplication symbol (\times). For example, a lens that makes an object look ten times larger has a power of $10\times$. To determine a microscope's magnification, multiply the power of the ocular lens by the power of the objective lens. A microscope with a $10\times$ ocular lens and a $10\times$ objective lens magnifies an object 10×10 , or 100 times.

Practice

What is the magnification of a compound microscope with a $10\times$ ocular lens and a $4\times$ objective lens?



Review

- Math Practice
- Personal Tutor

Types of Microscopes

One characteristic of all microscopes is that they magnify objects. Magnification makes an object appear larger than it really is. Another characteristic of microscopes is resolution—how clearly the magnified object can be seen. The two main types of microscopes—light microscopes and electron microscopes—differ in magnification and resolution.

Light Microscopes

If you have used a microscope in school, then you have probably used a light microscope. **Light microscopes use light and lenses to enlarge an image of an object.** A simple light microscope has only one lens. A light microscope that uses more than one lens to magnify an object is called a **compound microscope**. A compound microscope magnifies an image first by one lens, called the objective lens. The image is then further magnified by another lens, called the ocular lens. The total magnification of the image is equal to the magnifications of the ocular lens and the objective lens multiplied together.

Light microscopes can enlarge images up to 1,500 times their original size. The resolution of a light microscope is about 0.2 micrometers (μm), or two-millionths of a meter. A resolution of 0.2 μm means you can clearly see points on an object that are at least 0.2 μm apart.

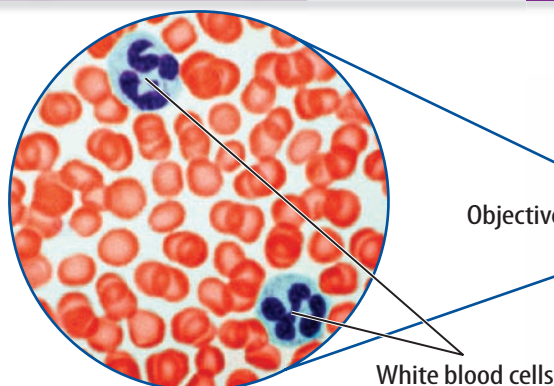
Light microscopes can be used to view living or nonliving objects. In some light microscopes, an object is placed directly under the microscope. For other light microscopes, an object must be mounted on a slide. In some cases, the object, such as the white blood cells in **Figure 12**, must be stained with a dye in order to see any details.



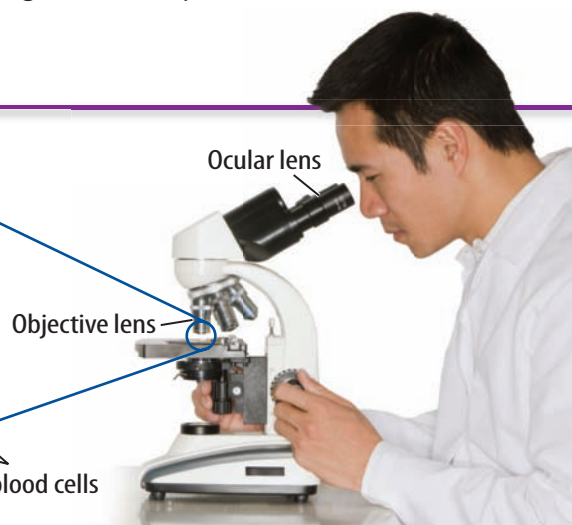
Reading Check What are some ways an object can be examined under a light microscope?

Compound Light Microscope

Figure 12 This is an image of a white blood cell as seen through a compound light microscope. The image has been magnified 1,000 times its original size.



Stained LM Magnification: 1000 \times




Electron Microscopes

You might know that electrons are tiny particles inside **atoms**. **Electron microscopes** use a magnetic field to focus a beam of electrons through an object or onto an object's surface. An electron microscope can magnify an image up to 100,000 times or more. The resolution of an electron microscope can be as small as 0.2 nanometers (nm), or two-billionths of a meter. This resolution is up to 1,000 times greater than a light microscope. The two main types of electron microscopes are transmission electron microscopes (TEMs) and scanning electron microscopes (SEMs).

TEMs are usually used to study extremely small things such as cell structures. Because objects must be mounted in plastic and then very thinly sliced, only dead organisms can be viewed with a TEM. In a TEM, electrons pass through the object and a computer produces an image of the object. A TEM image of a white blood cell is shown in **Figure 13**.

SEMs are usually used to study an object's surface. In an SEM, electrons bounce off the object and a computer produces a three-dimensional image of the object. An image of a white blood cell from an SEM is shown in **Figure 13**. Note the difference in detail in this image compared to the image in **Figure 12** of a white blood cell from a light microscope.

 **Key Concept Check** What are the types of microscopes, and how do they compare?

REVIEW VOCABULARY

atom

the building block of matter that is composed of protons, neutrons, and electrons

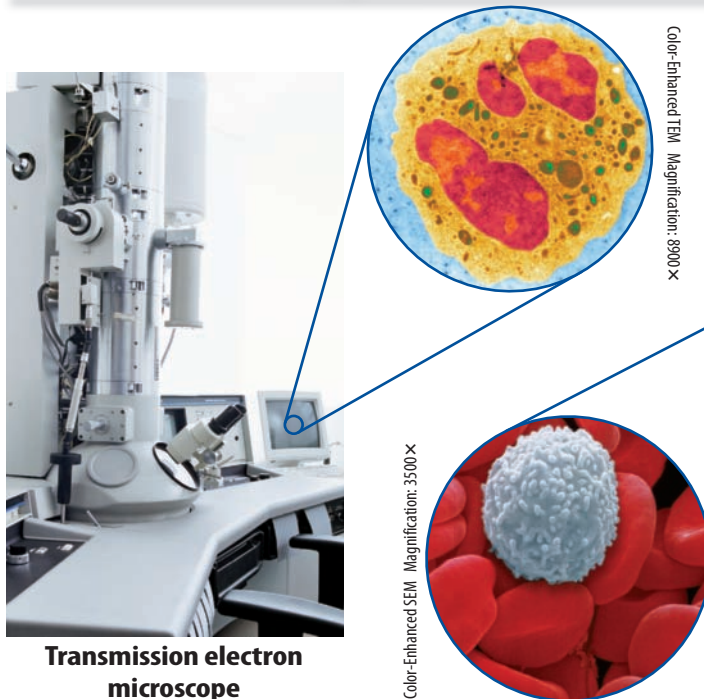
FOLDABLES®

Make a two-column folded chart. Label the front *Types of Microscopes*, and label the inside as shown. Use it to organize your notes about microscopes.



Figure 13 A TEM greatly magnifies thin slices of an object. An SEM is used to view a three-dimensional image of an object.

Electron Microscopes



Transmission electron microscope

Color-Enhanced SEM Magnification: 3500x

Color-Enhanced TEM Magnification: 8900x

Concepts in Motion Animation



Scanning electron microscope

How do microscopes help us compare living things?



A microscope enables scientists to study objects in greater detail than is possible with the unaided eye. Compare what objects look like with the unaided eye to those same objects observed using a microscope.



- 1 Read and complete a lab safety form.
- 2 Examine a **sea sponge**, a **leaf**, and **salt crystals**. Draw each object in your Science Journal.
- 3 Observe **microscope slides of each object** using a **microscope** on low power.
- 4 Draw each object as it appears under low power.

Analyze and Conclude

1. **Compare** your sketches of the objects observed with your unaided eye and observed with a microscope.
2. **Key Concept** Explain how studying an object under a microscope might help you understand it better.

WORD ORIGIN

microscope

from Latin *microscopium*, means “an instrument for viewing what is small”

ACADEMIC VOCABULARY

identify

(*verb*) to determine the characteristics of a person or a thing

Using Microscopes

The **microscopes** used today are more advanced than the microscopes used by Leeuwenhoek and Hooke. The quality of today's light microscopes and the invention of electron microscopes have made the microscope a useful tool in many fields.

Health Care

People in health-care fields, such as doctors and laboratory technicians, often use microscopes. Microscopes are used in surgeries, such as cataract surgery and brain surgery. They enable doctors to view the surgical area in greater detail. The area being viewed under the microscope can also be displayed on a TV monitor so that other people can watch the procedure. Laboratory technicians use microscopes to analyze body fluids, such as blood and urine. They also use microscopes to determine whether tissue samples are healthy or diseased.

Other Uses

Health care is not the only field that uses microscopes. Have you ever wondered how police determine how and where a crime happened? Forensic scientists use microscopes to study evidence from crime scenes. The presence of different insects can help identify when and where a homicide happened. Microscopes might be used to **identify** the type and age of the insects.

People who study fossils might use microscopes. They might examine a fossil and other materials from where the fossil was found.

Some industries also use microscopes. The steel industry uses microscopes to examine steel for impurities. Microscopes are used to study jewels and identify stones. Stones have some markings and impurities that can be seen only by using a microscope.



Reading Check List some uses of microscopes.

Lesson 3 Review



Assessment

Online Quiz

Visual Summary



Living organisms can be viewed with light microscopes.



A compound microscope is a type of light microscope that has more than one lens.



Living organisms cannot be viewed with a transmission electron microscope.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think **NOW?**

You first read the statements below at the beginning of the chapter.

5. Most cells are too small to be seen with the unaided eye.
6. Only scientists use microscopes.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

- 1 **Define** the term *light microscope* in your own words.
- 2 A(n) _____ focuses a beam of electrons through an object or onto an object's surface.

Understand Key Concepts

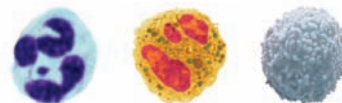
- 3 **Explain** how the discovery of microscopes has changed what we know about living things.
- 4 Which microscope would you use if you wanted to study the surface of an object?
 - A. compound microscope
 - B. light microscope
 - C. scanning electron microscope
 - D. transmission electron microscope

Interpret Graphics

- 5 **Identify** Copy and fill in the graphic organizer below to identify four uses of microscopes.



- 6 **Compare** the images of the white blood cells below. How do they differ?



Critical Thinking

- 7 **Develop** a list of guidelines for choosing a microscope to use.

Math Skills



Review

Math Practice

- 8 A student observes a blood sample with a compound microscope that has a 10× ocular lens and a 40× objective lens. How much larger do the blood cells appear under the microscope?

Materials



a collection of objects

Constructing a Dichotomous Key

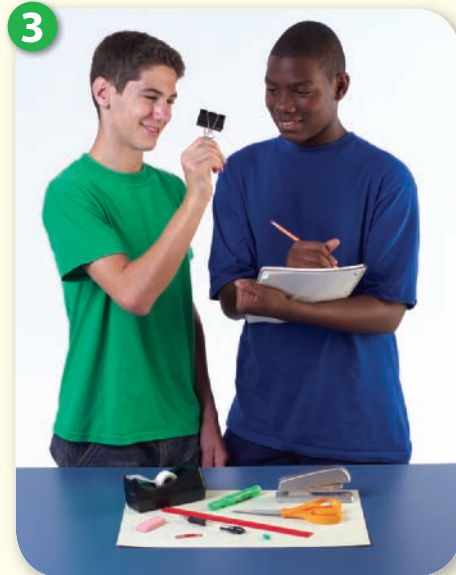
A dichotomous key is a series of descriptions arranged in pairs. Each description leads you to the name of the object or to another set of choices until you have identified the organism. In this lab, you will create a dichotomous key to classify objects.

Question

How can you create a dichotomous key to identify objects?

Procedure

- 1 Read and complete a lab safety form.
- 2 Obtain a container of objects from your teacher.
- 3 Examine the objects, and then brainstorm a list of possible characteristics. You might look at each object's size, shape, color, odor, texture, or function.
- 4 Choose a characteristic that would separate the objects into two groups. Separate the objects based on whether or not they have this characteristic. This characteristic will be used to begin a dichotomous key, like the example below.



Dichotomous Key to Identify Office Supplies

The object is made of wood. Go to 1.
The object is not made of wood. Go to 2.
1. The object is longer than 20 cm. Go to 5.
3. The object is not longer than 20 cm. Go to 9.
2. The object is made of metal. Go to 6.
4. The object is not made of metal. Go to 10.

- 5 Write a sentence to describe the characteristic in step 4, and then write "Go to 1." Write another sentence that has the word "not" in front of the characteristic. Then write "Go to 2."
- 6 Repeat steps 4 and 5 for the two new groups. Give sentences for new groups formed from the first group consecutive odd numbers. Give sentences for groups formed from the second group consecutive even numbers. Remember to add the appropriate "Go to" directions.
- 7 Repeat steps 4–6 until there is one object in each group. Give each object an appropriate two-word name.
- 8 Give your collection of objects and your dichotomous key to another group. Have them identify each object using your dichotomous key. Have them record their answers.

Analyze and Conclude

- 9 **Evaluate** Was the other team able to correctly identify the collection of objects using your dichotomous key? Why or why not?
- 10 **The Big Idea** Summarize how dichotomous keys are useful in identifying unknown objects.

Communicate Your Results

Create a poster using drawings or photos of each object you identified. Include your two-word names for the objects.

Inquiry Extension

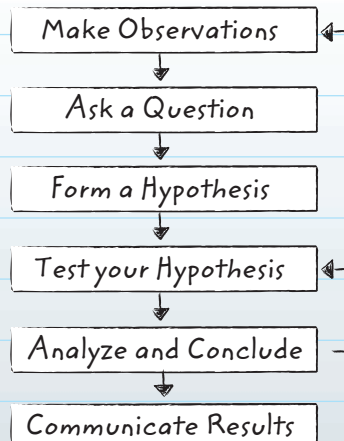
Teach a peer how to use a dichotomous key. Let the peer use your collection to have a first-hand experience with how a key works.



Lab Tips

- ✓ Base the questions in your key on observable, measurable, or countable characteristics. Avoid questions that refer to how something is used or how you think or feel about an item.
- ✓ Remember to start with general questions and then get more and more specific.

Remember to use scientific methods.



Chapter 14 Study Guide



All living things have certain characteristics in common and can be classified using several methods. The invention of the microscope has enabled us to explore life further, which has led to changes in classification.

Key Concepts Summary

Lesson 1: Characteristics of Life

- An **organism** is classified as a living thing because it has all the characteristics of life.
- All living things are organized, grow and develop, reproduce, respond to stimuli, maintain **homeostasis**, and use energy.



Vocabulary

organism p. 421
cell p. 422
unicellular p. 422
multicellular p. 422
homeostasis p. 425

Lesson 2: Classifying Organisms



- Living things are classified into different groups based on physical or molecular similarities.
- Some **species** are known by many different common names. To avoid confusion, every species has a scientific name based on a system called **binomial nomenclature**.

binomial nomenclature p. 433
species p. 433
genus p. 433
dichotomous key p. 434
cladogram p. 435

Lesson 3: Exploring Life

- The invention of microscopes allowed scientists to view cells, which enabled them to further explore and classify life.
- A **light microscope** uses light and has one or more lenses to enlarge an image up to about 1,500 times its original size. An **electron microscope** uses a magnetic field to direct beams of electrons, and it enlarges an image 100,000 times or more.



light microscope p. 440
compound microscope p. 440
electron microscope p. 441

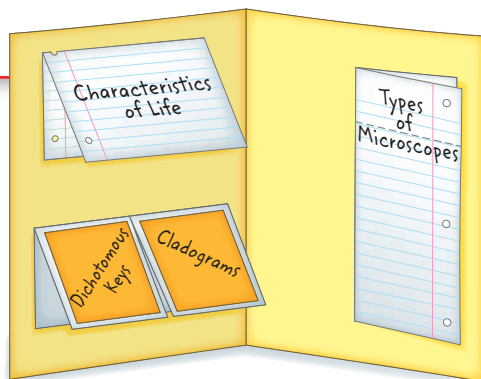


- Personal Tutor
- Vocabulary eGames
- Vocabulary eFlashcards

FOLDABLES®

Chapter Project

Assemble your lesson Foldables as shown to make a Chapter Project. Use the project to review what you have learned in this chapter.



Use Vocabulary

- 1 A(n) _____ organism is made of only one cell.
- 2 Something with all the characteristics of life is a(n) _____.
- 3 A(n) _____ shows the relationships among species.
- 4 A group of similar species is a(n) _____.
- 5 A(n) _____ has a resolution up to 1,000 times greater than a light microscope.
- 6 A(n) _____ is a light microscope that uses more than one lens to magnify an image.

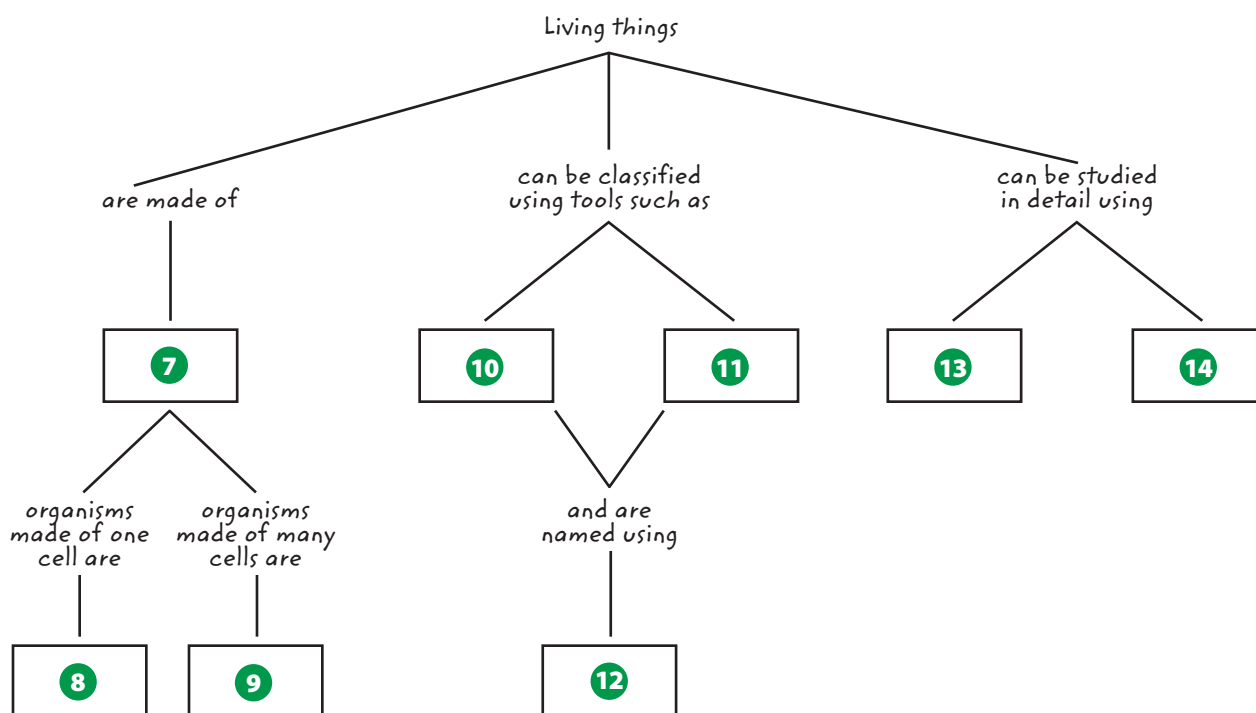
Link Vocabulary and Key Concepts

Copy this concept map, and then use vocabulary terms from the previous page to complete the concept map.



Concepts in Motion

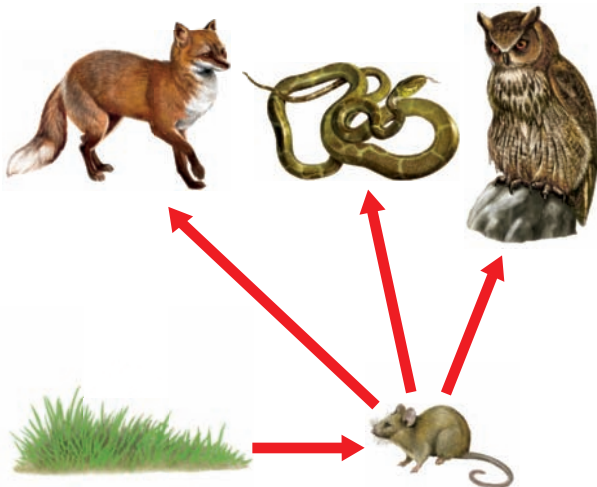
Interactive Concept Map



Chapter 14 Review

Understand Key Concepts

- 1 Which is an internal stimulus?
- A. an increase in moisture
 - B. feelings of hunger
 - C. number of hours of daylight
 - D. the temperature at night
- 2 Which is an example of growth and development?
- A. a caterpillar becoming a butterfly
 - B. a chicken laying eggs
 - C. a dog panting
 - D. a rabbit eating carrots
- 3 Based on the food web below, what is an energy source for the mouse?



- A. fox
 - B. grass
 - C. owl
 - D. snake
- 4 Which shows the correct order for the classification of species?
- A. domain, kingdom, class, order, phylum, family, genus, species
 - B. domain, kingdom, phylum, class, order, family, genus, species
 - C. domain, kingdom, phylum, class, order, family, species, genus
 - D. domain, kingdom, phylum, order, class, family, genus, species
- 5 The organism shown below belongs in which kingdom?



- A. Animalia
 - B. Archaea
 - C. Bacteria
 - D. Plantae
- 6 Which was discovered using a microscope?
- A. blood
 - B. bones
 - C. cells
 - D. hair
- 7 What type of microscope would most likely be used to obtain an image of a live roundworm?
- A. compound light microscope
 - B. scanning electron microscope
 - C. simple light microscope
 - D. transmission electron microscope
- 8 Which best describes a compound microscope?
- A. uses electrons to magnify the image of an object
 - B. uses multiple lenses to magnify the image of an object
 - C. uses one lens to magnify the image of an object
 - D. uses sound waves to magnify the image of an object

Critical Thinking

- 9 **Distinguish** between a unicellular organism and a multicellular organism.
- 10 **Critique** the following statement: An organism that is made of only one cell does not need organization.
- 11 **Infer** In the figure below, which plant is responding to a lack of water in its environment? Explain your answer.



- 12 **Explain** how using a dichotomous key can help you identify an organism.
- 13 **Describe** how the branches on a cladogram show the relationships among organisms.
- 14 **Assess** the effect of molecular evidence on the classification of organisms.
- 15 **Compare** light microscopes and electron microscopes.
- 16 **State** how microscopes have changed the way living things are classified.
- 17 **Compare** magnification and resolution.
- 18 **Evaluate** the impact microscopes have on our daily lives.

Writing in Science

- 19 **Write** a five-sentence paragraph explaining the importance of scientific names. Be sure to include a topic sentence and a concluding sentence in your paragraph.

REVIEW



- 20 Define the characteristics that all living things share.
- 21 The photo below shows living and nonliving things. How would you classify the living things by domain and kingdom?



Math Skills



Math Practice

Use Multiplication

- 22 A microscope has an ocular lens with a power of $5\times$ and an objective lens with a power of $50\times$. What is the total magnification of the microscope?
- 23 A student observes a unicellular organism with a microscope that has a $10\times$ ocular lens and a $100\times$ objective lens. How much larger does the organism look through this microscope?
- 24 The ocular lens on a microscope has a power of $10\times$. The microscope makes objects appear 500 times larger. What is the power of the objective lens?

Standardized Test Practice

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

Multiple Choice

- 1 What feature of living things do the terms *unicellular* and *multicellular* describe?
- A how they are organized
 - B how they reproduce
 - C how they maintain temperature
 - D how they produce macromolecules

Use the diagram below to answer question 2.

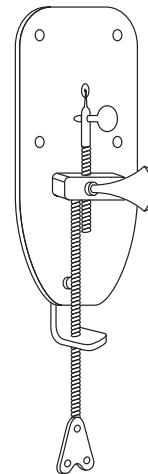


- 2 Which characteristic of life does the diagram show?
- A homeostasis
 - B organization
 - C growth and development
 - D response to stimuli
- 3 A newly discovered organism is 1 m tall, multicellular, green, and it grows on land and performs photosynthesis. To which kingdom does it most likely belong?
- A Animalia
 - B Fungi
 - C Plantae
 - D Protista
- 4 Unicellular organisms are members of which kingdoms?
- A Animalia, Archaea, Plantae
 - B Archaea, Bacteria, Protista
 - C Bacteria, Fungi, Plantae
 - D Fungi, Plantae, Protista

- 5 Which microscope would best magnify the outer surface of a cell?

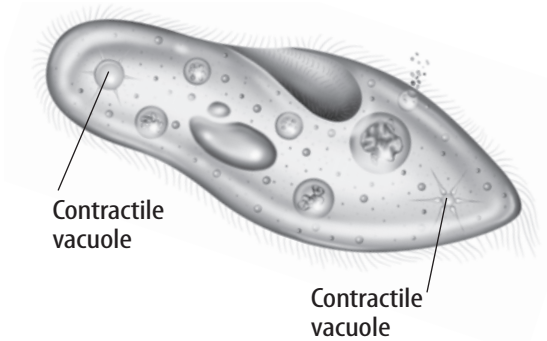
- A compound light
- B scanning electron
- C simple dissecting
- D transmission electron

Use the diagram below to answer question 6.



- 6 Which discovery was NOT made with the instrument above?
- A Bacterial cells have thick walls.
 - B Blood is a mixture of components.
 - C Insects have small body parts.
 - D Tiny organisms live in pond water.
- 7 Which statement is false?
- A Binomial names are given to all known organisms.
 - B Binomial names are less precise than common names.
 - C Binomial names differ from common names.
 - D Binomial names enable scientists to communicate accurately.

Use the diagram below to answer question 8.



- 8 Which is the function of the structures in this paramecium?
- A growth
 - B homeostasis
 - C locomotion
 - D reproduction
- 9 Which sequence is from the smallest group of organisms to the largest group of organisms?
- A genus → family → species
 - B genus → species → family
 - C species → family → genus
 - D species → genus → family
- 10 Which information about organisms is excluded in the study of systematics?
- A calendar age
 - B molecular analysis
 - C energy source
 - D normal habitat

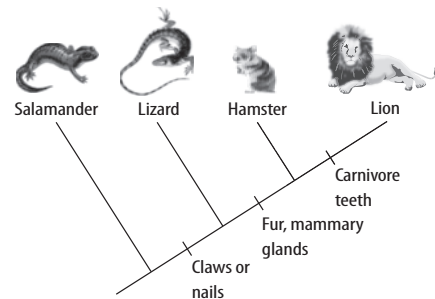
Constructed Response

- 11 Copy and complete the table below about the six characteristics of life.

Characteristic	Explanation

- 12 Choose one characteristic of living things and explain how it affects everyday human life. From your own knowledge, give a specific example.

Use the diagram below to answer question 13.



- 13 Explain why the lion is more closely related to the hamster than the hamster is related to the salamander.

NEED EXTRA HELP?													
If You Missed Question...	1	2	3	4	5	6	7	8	9	10	11	12	13
Go to Lesson...	1	1	2	2	3	3	2	1	2	2	1	1	2