Chapter 2

Living Things

The BIG Idea

Cell structure and function

Q **How does the structure of a cell allow it to carry out the basic processes of life?**

Georgia Performance Standards

S7CS4 Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.

S7CS8 Students will investigate the characteristics of scientific knowledge and how it is achieved.

S7L1 Students will investigate the diversity of living organisms and how they can be compared scientifically.

a. Demonstrate the process for the development of a dichotomous key.

b. Classify organisms based on physical characteristics using a dichotomous key of the six kingdom system (archaebacteria, eubacteria, protists, fungi, plants, and animals).

S7L2 Students will describe the structure and function of cells, tissues, organs, and organ systems.

a. Explain that cells take in nutrients in order to grow and divide and to make needed materials.

b. Relate cell structures (cell membrane, nucleus, cytoplasm, chloroplasts, mitochondria) to basic cell functions.

c. Explain that cells are organized into tissues, tissues into organs, organs into systems, and systems into organisms.

Each transparent ball is a tiny freshwater organism known as a *Volvox*.

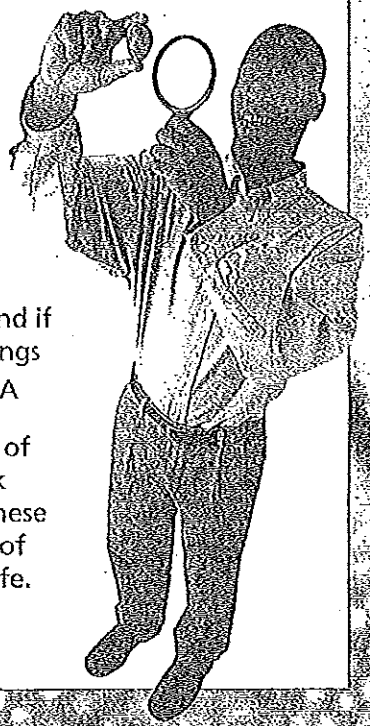
Discovery Channel SCHOOL

Cell Structure and Function
- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ Chapter Project

Mystery Object

It's not always easy to tell whether something is alive. In this chapter, you will learn the characteristics of living things. As you study this chapter, your challenge will be to determine whether or not a mystery object is alive.



Your Goal To study a mystery object for several days to determine whether or not it is alive

To complete the project, you must

- care for your object following your teacher's instructions
- observe your object each day, and record your data
- determine whether your object is alive, and if so, to which domain and kingdom it belongs
- follow the safety guidelines in Appendix A

Plan It! Before you get started, create a list of characteristics that living things share. Think about whether nonliving things also share these characteristics. Also, think about what kind of tests you can carry out to look for signs of life. Create data tables in which to record your observations.

Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

Prefixes

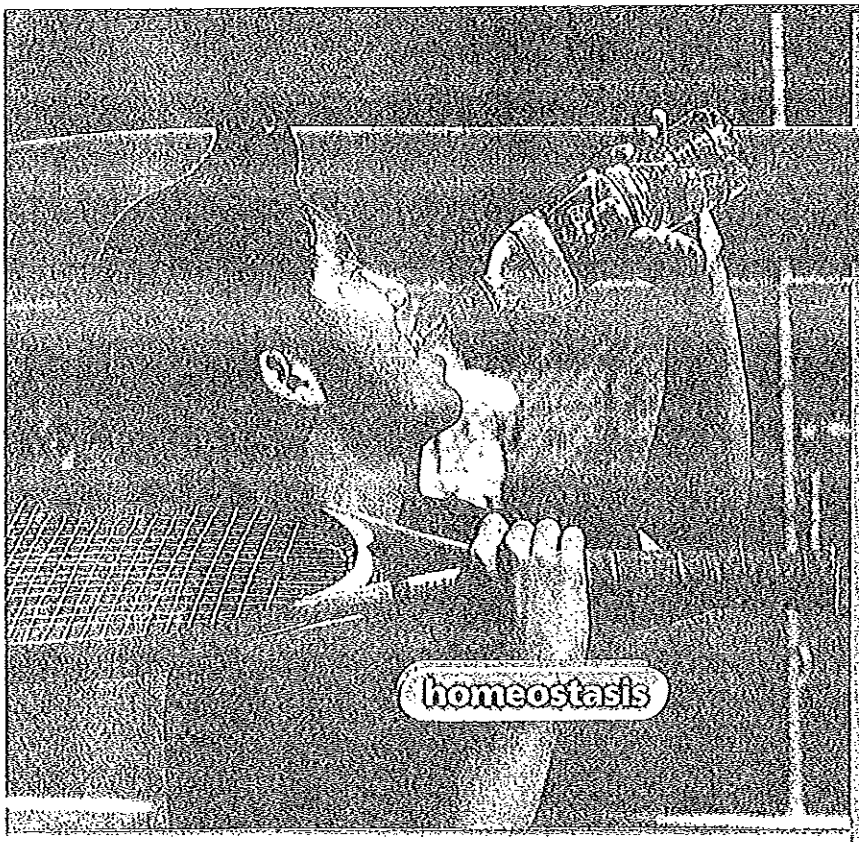
Words can sometimes be divided into parts. A root is the part of the word that carries the basic meaning. A prefix is a word part that is placed in front of the root to change the word's meaning. In the word *multicellular,* for example, *-cellular* is the root and *multi-* is the prefix. The prefix *multi-* means "many." *Multicellular* means "having many cells."

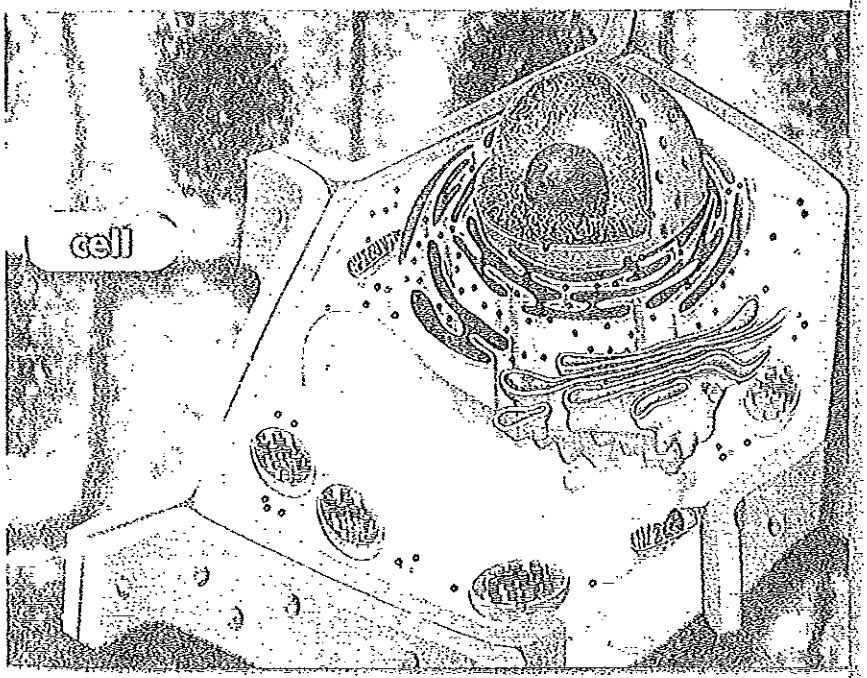
The prefixes below will help you understand some key terms.

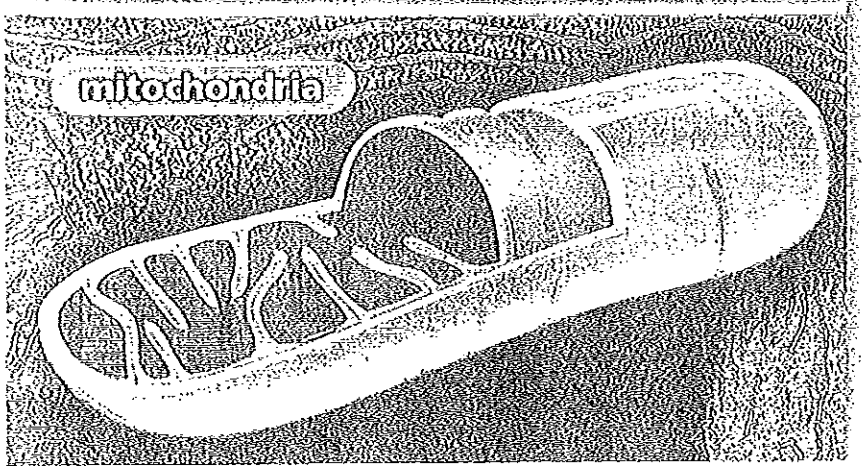
Prefix	Meaning	Example Word
chlor-	green	chloroplast A cellular structure that captures energy from sunlight
cyto-	cell	cytoskeleton The framework inside a cell
multi-	many	multicellular Having many cells
uni-	one	unicellular Having one cell

Apply It!

1. A chloroplast is a structure in plant cells. What color do you think a chloroplast is?
2. What clue within the word cytoplasm lets you know that the word has something to do with cells?







Chapter 2 Vocabulary

Section 1 (page 34)

organism
cell
unicellular
multicellular
stimulus
response
development
spontaneous generation
autotroph
heterotroph
homeostasis

Section 2 (page 42)

classification
taxonomy
binomial nomenclature
genus
species
prokaryote
nucleus
eukaryote

Section 3 (page 52)

cell
microscope
cell theory

Section 4 (page 60)

organelle
cell wall
cell membrane
cytoplasm
mitochondria
endoplasmic reticulum
ribosome
Golgi body
chloroplast
vacuole
lysosome

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Section 1

What Is Life?

Reading Preview

Key Concepts

- What characteristics do all living things share?
- Where do living things come from?
- What do living things need to survive?

Key Terms

- organism
- cell
- unicellular
- multicellular
- stimulus
- response
- development
- spontaneous generation
- autotroph
- heterotroph
- homeostasis

Target Reading Skill

Using Prior Knowledge Look at the section headings and visuals to see what this section is about. Then write what you already know about living things in a graphic organizer like the one below. As you read, write what you learn.

What You Know
1. Living things grow. 2.

What You Learned
1. 2.

Lab zone **Discover Activity**

Is It Living or Nonliving?

1. Your teacher will give you and a partner a wind-up toy.
2. One of you will look for evidence that the toy is alive and the other will look for evidence that the toy is not alive.
3. Observe the toy. List the evidence that supports your position about whether or not the toy is alive.
4. Share your lists with your classmates.

Think It Over

Forming Operational Definitions Based on what you just learned, create a list of characteristics that living things share.

If you were asked to name some living things, or **organisms**, you might name yourself, a pet, and maybe some insects or plants. You would probably not mention a moss growing in a shady spot, the mildew on bathroom tiles, or the slime molds that oozed across lawns. But all of these things are organisms.

The Characteristics of Living Things

Living things share important characteristics. **All living things have a cellular organization, contain similar chemicals, use energy, respond to their surroundings, grow and develop, and reproduce.**

Cellular Organization All organisms are made of small building blocks called cells. A cell is the basic unit of structure and function in an organism. Cells are so small that you need a microscope to see them.

Organisms may be composed of only one cell or of many cells. **Unicellular**, or single-celled organisms, include bacteria (bak TIHR ee uh), the most numerous organisms on Earth. **Multicellular** organisms are composed of many cells that are specialized to do certain tasks. For example, you are made of trillions of cells. Specialized cells in your body, such as muscle and nerve cells, work together to keep you alive.

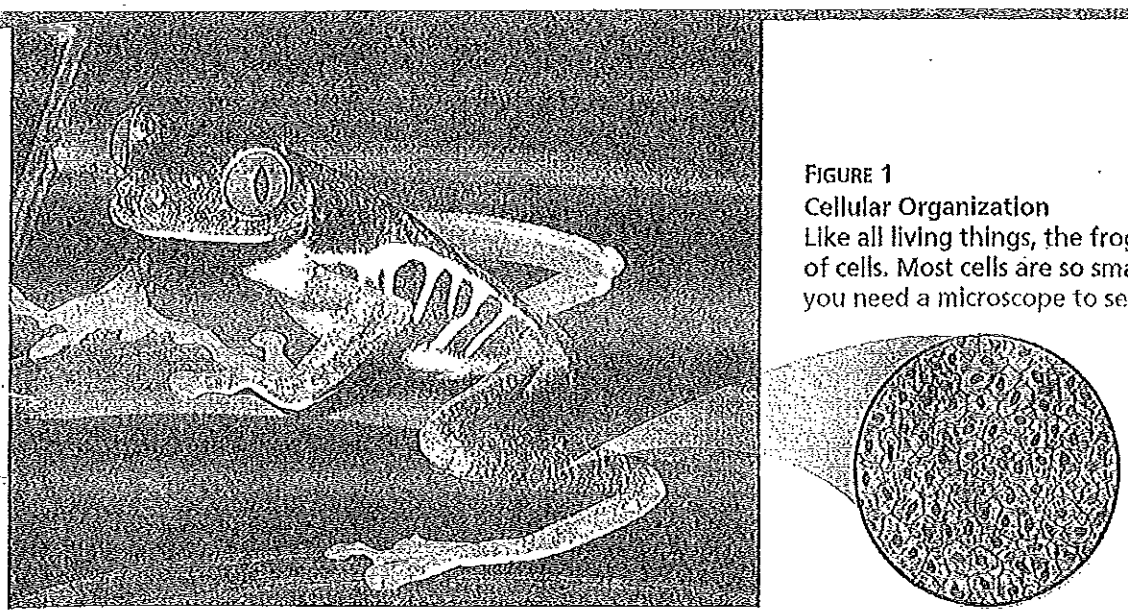


FIGURE 1
Cellular Organization
Like all living things, the frog is made of cells. Most cells are so small that you need a microscope to see them.

The Chemicals of Life The cells of all living things are composed of chemicals. The most abundant chemical in cells is water. Other chemicals, called carbohydrates (kahr boh HY drayts), are a cell's main energy source. Two other chemicals, proteins (PROH teenz) and lipids, are the building materials of cells. Nucleic (noo KLEE ik) acids are the genetic material—the chemical instructions that direct the cell's activities.

Energy Use The cells of organisms use energy to do what living things must do, such as repairing injured parts. An organism's cells are always hard at work. For example, as you read this paragraph, your eye and brain cells are at work. Your blood cells are busy moving chemicals around your body.

Response to Surroundings Have you noticed that plant stems bend toward the light? Plants and all other organisms react to changes in their environment. A change in an organism's surroundings that causes the organism to react is called a **stimulus** (plural *stimuli*). Stimuli include changes in temperature, light, sound, and other factors. An organism reacts to a stimulus with a **response**—an action or change in behavior. For example, has the sound of a car horn ever startled you? The sound was a stimulus that caused your response.

Growth and Development Living things also grow and develop. Growth is the process of becoming larger. Development is the process of change that occurs during an organism's life to produce a more complex organism.

Reproduction Another characteristic of organisms is the ability to reproduce, or produce offspring that are similar to the parents. For example, robins lay eggs that develop into young robins that closely resemble their parents.

Lab zone Try This Activity

React!

1. Have a partner clap his or her hands together about 10 centimeters in front of your face. Describe how you react.
2. Look at one of your eyes in a mirror. Cover the eye with your hand for a minute. While looking in the mirror, remove your hand. Observe how the size of your pupil changes.
3. Bring a slice of lemon close to your nose and mouth. Describe what happens.

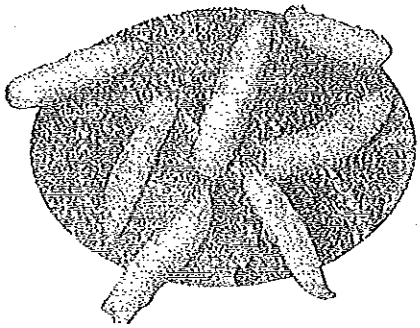
Classifying For each action performed, name the stimulus and the response.

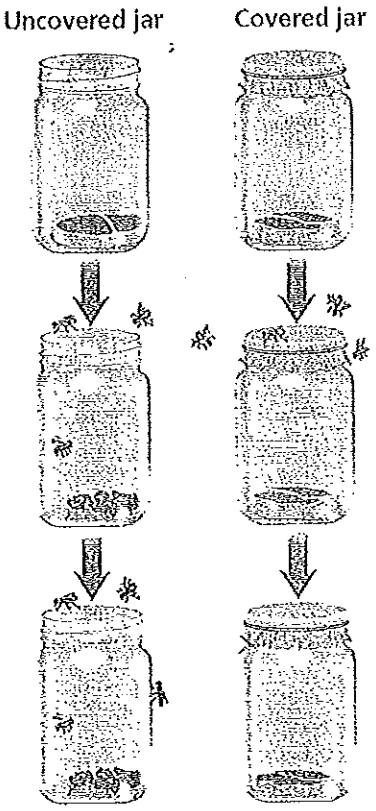
FIGURE 2

Redi's Experiment

Francesco Redi designed one of the first controlled experiments. In his experiment, Redi showed that flies do not spontaneously arise from decaying meat.

Controlling Variables *What is the manipulated variable in this experiment?*





1. Redi placed meat in two identical jars. He left one jar uncovered. He covered the other jar with a cloth that let in air.
2. After a few days, Redi saw maggots (young flies) on the decaying meat in the open jar. There were no maggots on the meat in the covered jar.
3. Redi reasoned that flies had laid eggs on the meat in the open jar. The eggs hatched into maggots. Because flies could not lay eggs on the meat in the covered jar, there were no maggots there. Redi concluded that decaying meat did not produce maggots.

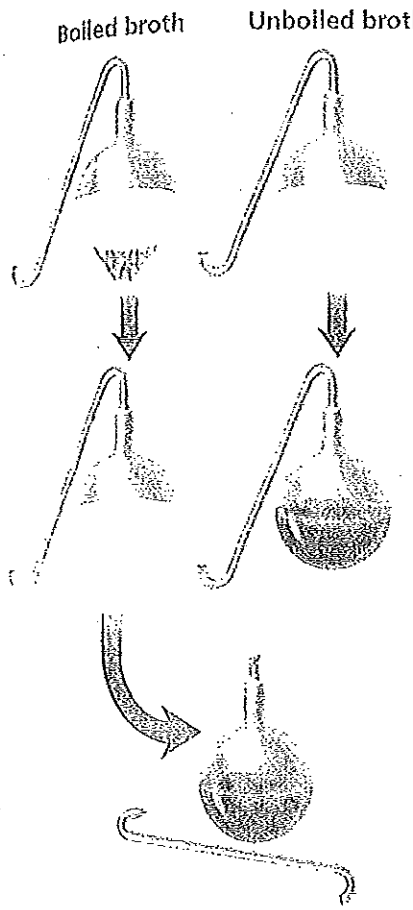
Go Online
active art

For: Redi's and Pasteur's Experiments activity
Visit: PHSchool.com
Web Code: cep-1011

Life Comes From Life

Today, when people see moths fly out of a closet or weeds poking out of cracks in the sidewalk, they know that these organisms are the result of reproduction. Living things arise from **living things through reproduction.** However, four hundred years ago, people believed that life could appear from nonliving material. For example, they thought that flies could arise from rotting meat. The mistaken idea that living things can arise from nonliving sources is called **spontaneous generation.** It took hundreds of years of experiments to convince people that spontaneous generation does not occur.

Redi's Experiment In the 1600s, an Italian doctor named Francesco Redi helped to disprove spontaneous generation. Redi designed a controlled experiment to show that flies do not arise from decaying meat. Recall that in a controlled experiment, a scientist carries out two tests that are identical in every respect except for one factor. The one factor that a scientist changes is called the manipulated variable.



① Pasteur put clear broth into two flasks with curved necks. The necks would let in oxygen but keep out bacteria from the air. Pasteur boiled the broth in one flask to kill any bacteria in the broth. He did not boil the broth in the other flask.

② In a few days, the unboiled broth became cloudy, showing that new bacteria were growing. The boiled broth remained clear. Pasteur concluded that bacteria do not spontaneously arise from the broth. New bacteria appeared only when living bacteria were already present.

Later, Pasteur took the flask with the broth that had remained clear and broke its curved neck. Bacteria from the air could now enter the flask. In a few days, the broth became cloudy. This evidence confirmed that new bacteria arise only from existing bacteria.

FIGURE 3
Pasteur's Experiment
Louis Pasteur's carefully controlled experiment demonstrated that bacteria arise only from existing bacteria.

A Pasteur in his laboratory

In Redi's experiment, shown in Figure 2, the manipulated variable was whether or not the jar was covered. Flies were able to enter the uncovered jar and lay their eggs on the meat inside. These eggs hatched into maggots, which developed into new flies. The flies could not enter the covered jar, however. Therefore, no maggots formed on the meat in the covered jar. Through his experiment, Redi was able to conclude that rotting meat does not produce flies.

Pasteur's Experiment Even after Redi's work, many people continued to believe that spontaneous generation could occur. In the mid-1800s, the French chemist Louis Pasteur designed some controlled experiments that finally rejected spontaneous generation. As shown in Figure 3, he demonstrated that new bacteria appeared in broth only when they were produced by existing bacteria. The experiments of Redi and Pasteur helped to convince people that living things do not arise from nonliving material.

Reading Checkpoint What is a controlled experiment?

Lab zone Skills Activity

Designing Experiments

Your teacher will give you a slice of potato. Predict what percentage of the potato's mass is water. Then come up with a plan to test your prediction. For materials, you will be given a hair dryer and a balance. Obtain your teacher's approval before carrying out your plan. How does your result compare with your prediction?

The Needs of Living Things

Though it may seem surprising, flies, bacteria, and all other organisms have the same basic needs as you. All living things must satisfy their basic needs for water, food, living space, and stable internal conditions.

Water All living things need water to survive. In fact, most organisms can live for only a few days without water. Organisms need water to obtain chemicals from their surroundings, break down food, grow, move substances within their bodies, and reproduce.

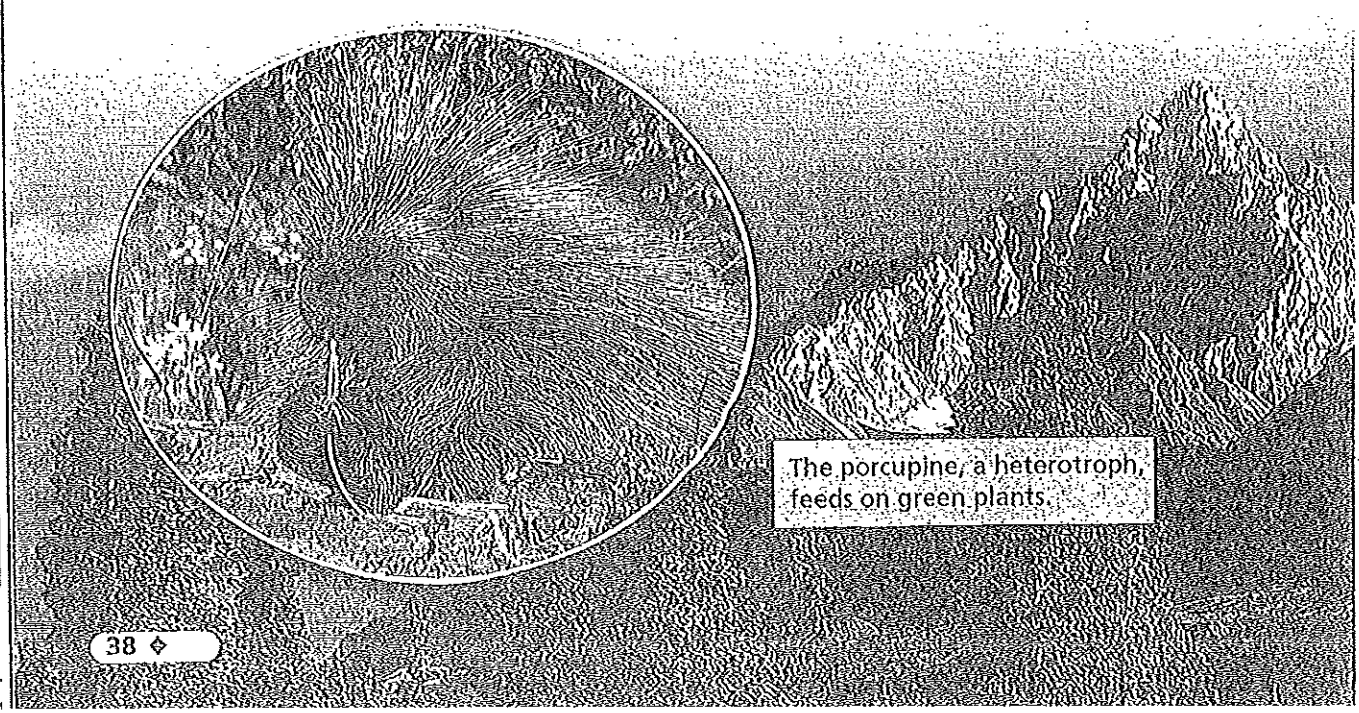
Food Recall that organisms need a source of energy to live. They use food as their energy source. Organisms differ in the ways they obtain energy. Some organisms, such as plants, capture the sun's energy and use it to make food. Organisms that make their own food are called **autotrophs** (AW toh trohfs). *Auto-* means "self" and *-troph* means "feeder." Autotrophs use the food they make to carry out their own life functions.

Organisms that cannot make their own food are called **heterotrophs** (HET uh roh trohfs). *Hetero-* means "other." Heterotrophs obtain their energy by feeding on others. Some heterotrophs eat autotrophs and use the energy in the autotroph's stored food. Other heterotrophs consume heterotrophs that eat autotrophs. Therefore, a heterotroph's energy source is also the sun—but in an indirect way. Animals, mushrooms, and slime molds are examples of heterotrophs.

Reading Checkpoint Why are plants called autotrophs?

FIGURE 4
Water, Food, and Living Space

This environment meets the needs of the many animals that live there. Inferring *How do plants meet their needs for food?*



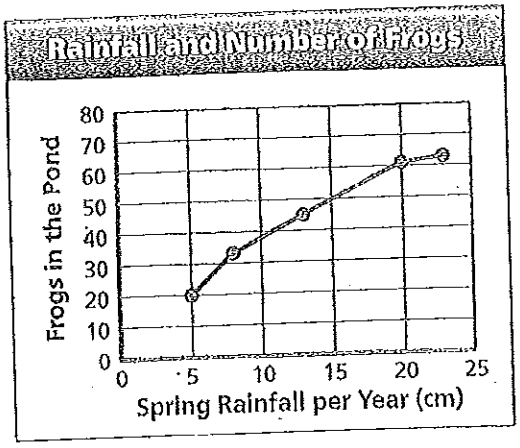
The porcupine, a heterotroph, feeds on green plants.

Math Analyzing Data

Frogs and Rainfall

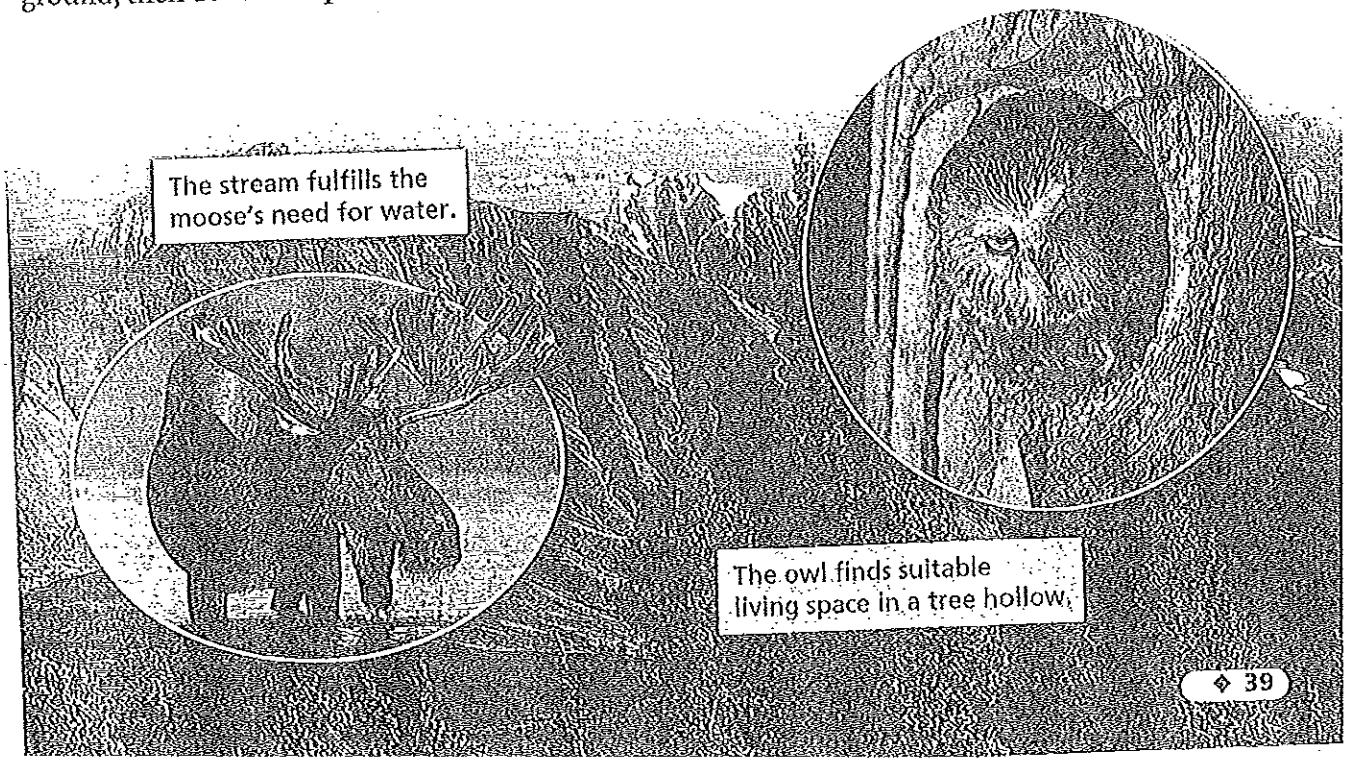
Frogs need a moist environment, such as a pond, to survive. For five years, a scientist counted the frogs in a pond. The scientist also measured the spring rainfall.

1. Reading Graphs What data are plotted on the horizontal axis? What units were used?
2. Interpreting Data What was the greatest number of frogs that the scientist recorded? How much rain fell that spring?
3. Making Generalizations What is the relationship between the number of frogs and the amount of spring rain? What do you know about living things that might help explain that relationship?



Living Space All organisms need a place to live—a place to get food and water and find shelter. Whether an organism lives in the freezing Antarctic or the scorching desert, its surroundings must provide what it needs to survive.

Because there is a limited amount of space on Earth, some organisms must compete for space. Trees in a forest, for example, compete with other trees for sunlight above ground. Below ground, their roots compete for water and minerals.



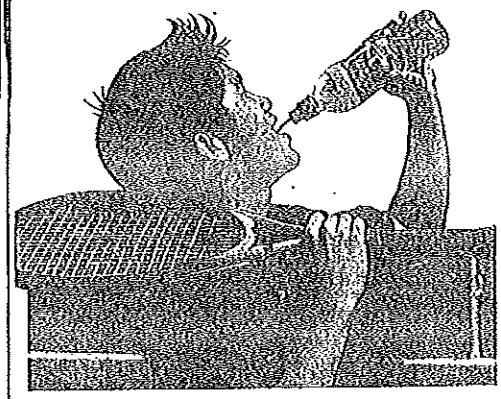


FIGURE 5
Homeostasis
Sweating helps your body maintain a steady body temperature. Your body produces sweat during periods of strenuous activity. As the sweat evaporates, it cools your body down.

Stable Internal Conditions Organisms must be able to keep the conditions inside their bodies stable, even when conditions in their surroundings change significantly. For example, your body temperature stays steady despite changes in the air temperature. The maintenance of stable internal conditions is called **homeostasis** (hoh mee oh STAY sis).

Homeostasis keeps internal conditions just right for cells to function. Think about your need for water after a hard workout. When water levels in your body decrease, chemicals in your body send signals to your brain, causing you to feel thirsty.

Other organisms have different mechanisms for maintaining homeostasis. Consider barnacles, which as adults are attached to rocks at the edge of the ocean. At high tide, they are covered by water. At low tide, however, the watery surroundings disappear, and barnacles are exposed to hours of sun and wind. Without a way to keep water in their cells, they would die. Fortunately, a barnacle can close up its hard outer plates, trapping some water inside. In this way, a barnacle can keep its body moist until the next high tide.

Reading Checkpoint **What is homeostasis?**

Section 1 Assessment

Vocabulary Skill Prefixes Complete the following sentences with key terms.

Because bacteria each have only one cell, bacteria are _____ organisms. Animals have many cells. Therefore, animals are _____ organisms.

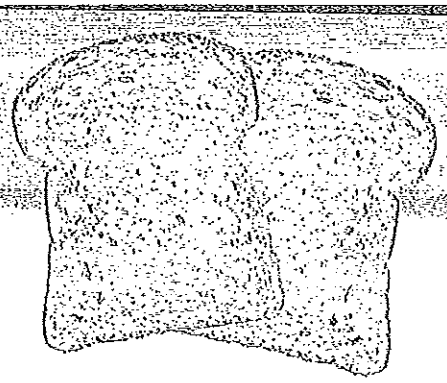
Reviewing Key Concepts

1. a. Reviewing List the six characteristics of living things.
   b. Inferring A bird sitting in a tree flies away as you walk by. Which of the life characteristics explains the bird's behavior?
   c. Applying Concepts Explain why the tree, which does not move away, is also considered a living thing.
2. a. Defining What was meant by the idea of *spontaneous generation*?
   b. Explaining Why is this idea incorrect?
   c. Summarizing How did Pasteur's experiment help show that spontaneous generation does not occur?
3. a. Identifying What four things do all organisms need to survive?
   b. Describing Which need is a fox meeting by feeding on berries?
   c. Applying Concepts The arctic fox has thick, dense fur in the winter and much shorter fur in the summer. How does this help the fox maintain homeostasis?

Lab zone **At-Home Activity**

Observing Life With a family member, observe a living thing, such as a family pet, a houseplant, or a bird outside your window. Record your observations as you study the organism. Prepare a chart that shows how the organism meets the four needs of living things discussed in this section.

Lab zone Skills Lab



Please Pass the Bread!

Problem

What factors are necessary for bread molds to grow?

Skills Focus

observing, controlling variables

Materials

- paper plates
- plastic dropper
- bread without preservatives
- sealable plastic bags
- tap water
- packing tape

Procedure

1. Brainstorm with others to predict which factors might affect the growth of bread mold. Record your ideas.
2. Place two slices of bread of the same size and thickness on separate, clean plates.
3. To test the effect of moisture on bread mold growth, add drops of tap water to one bread slice until the whole slice is moist. Keep the other slice dry. Expose both slices of bread to the air for one hour.
4. Put each slice into its own sealable bag. Press the outside of each bag to remove the air. Seal the bags. Then use packing tape to seal the bags again. Store the bags in a warm, dark place.
5. Copy the data table into your notebook.
6. Every day for at least five days, briefly remove the sealed bags from their storage place. Record whether any mold has grown. Estimate the area of the bread where mold is present. **CAUTION:** *Do not unseal the bags. At the end of the experiment, give the sealed bags to your teacher.*

Analyze and Conclude

1. Observing How did the appearance of the two slices of bread change over the course of the experiment?
2. Inferring How can you explain any differences in appearance between the two slices?
3. Controlling Variables What was the manipulated variable in this experiment? Why was it necessary to control all other variables except this one?
4. Communicating Suppose that you lived in Redi's time. A friend tells you that molds just suddenly appear on bread. How would you explain to your friend about Redi's experiment and how it applies to molds and bread?

Design an Experiment

Choose another factor that may affect mold growth, such as temperature or the amount of light. Set up an experiment to test the factor you choose. Remember to keep all conditions the same except for the one you are testing. *Obtain your teacher's permission before carrying out your investigation.*

Data Table

	Moistened Bread Slice		Unmoistened Bread Slice	
Day	Mold Present?	Area With Mold	Mold Present?	Area With Mold
1				
2				

Section 2

Classifying Organisms

Reading Preview

Key Concepts

- Why do biologists organize living things into groups?
- What do the levels of classification indicate about the relationship between organisms?
- What characteristics are used to classify organisms into domains and kingdoms?

Key Terms

- classification
- taxonomy
- binomial nomenclature
- genus
- species
- prokaryote
- nucleus
- eukaryote

Target Reading Skill

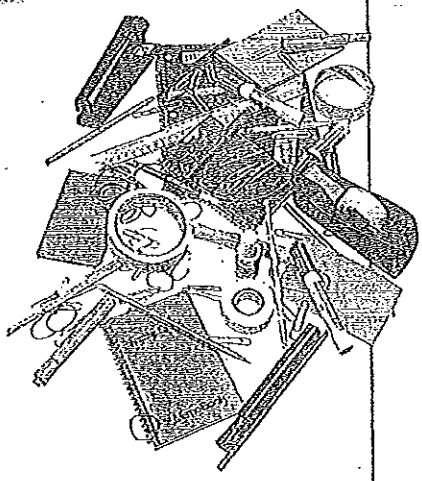
Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what*, *why*, or *how* question for each heading. As you read, write the answers to your questions.

Classifying Organisms

Question	Answer
Why do scientists classify?	Scientists classify because . . .

Lab zone Discover Activity

Can You Organize a Junk Drawer?



1. Your teacher will give you some items that you might find in the junk drawer of a desk. Your job is to organize the items.
2. Examine the objects and decide on three groups into which you can sort them.
3. Place each object into one of the groups, based on how the item's features match the characteristics of the group.
4. Compare your grouping system with those of your classmates.

Think It Over

Classifying Which of your classmates' grouping systems seemed most useful? Why?

Suppose you had only ten minutes to run into a supermarket to get what you needed—milk and tomatoes. Could you do it? In most supermarkets this would be an easy task. You'd probably find out where the dairy and produce sections are, and head straight to those areas. Now imagine if you had to shop for these same items in a market where things were randomly placed throughout the store. Where would you begin? You'd have to search through a lot of things before you found what you needed. You could be there for a long time!

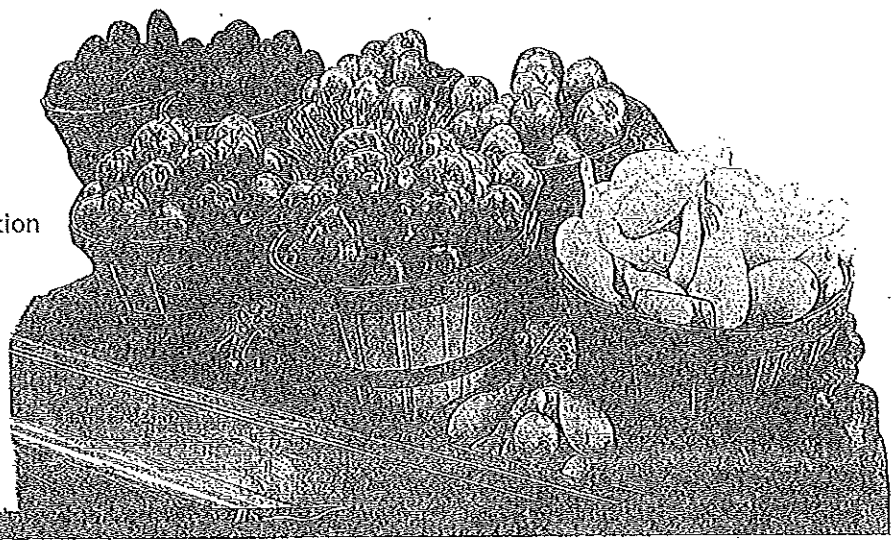


FIGURE 6
Classifying Vegetables
Vegetables in the produce section of a supermarket are neatly organized.

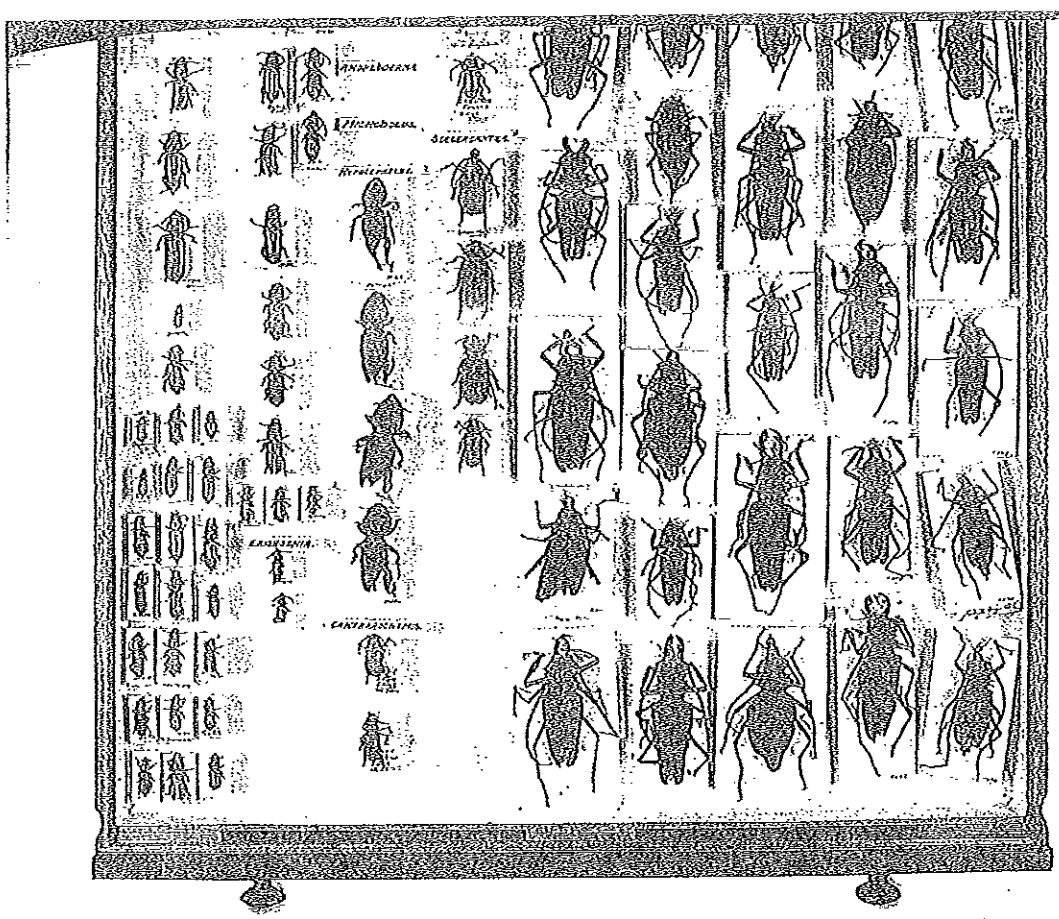


FIGURE 7
Classifying Beetles
These beetles belong to a large insect collection in a natural history museum. They have been classified according to characteristics they share. Observing *What characteristics may have been used to group these beetles?*

Why Do Scientists Classify?

Just as shopping can be a problem in a disorganized store, finding information about a specific organism can also be a problem. So far, scientists have identified more than one million kinds of organisms on Earth. That's a large number, and it is continually growing as scientists discover new organisms. Imagine how difficult it would be to find information about one particular organism if you had no idea even where to begin. It would be a lot easier if similar organisms were placed into groups.

Organizing living things into groups is exactly what biologists have done. Biologists group organisms based on similarities, just as grocers group milk with dairy products and tomatoes with produce. **Classification** is the process of grouping things based on their similarities.

Biologists use classification to organize living things into groups so that the organisms are easier to study. The scientific study of how living things are classified is called **taxonomy** (tak SAHN uh mee). Taxonomy is useful because once an organism is classified, a scientist knows a lot about that organism. For example, if you know that a crow is classified as a bird, then you know that a crow has wings, feathers, and a beak.

Reading Checkpoint **What is the scientific study of how living things are classified called?**

The Naming System of Linnaeus

Taxonomy also involves naming organisms. In the 1750s, the Swedish naturalist Carolus Linnaeus devised a system of naming organisms that is still used today. Linnaeus placed organisms in groups based on their observable features. Based on his observations, Linnaeus gave each organism a unique, two-part scientific name. This naming system Linnaeus used is called **binomial nomenclature** (by NOH mee ul NOH men klay chur). The word *binomial* means "two names."

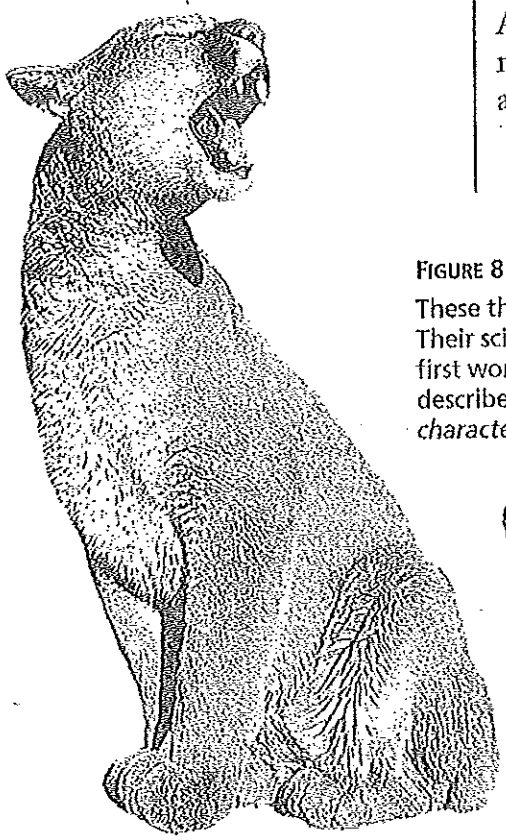
Genus and Species The first word in an organism's scientific name is its genus. A **genus** (JEE nus) (plural *genera*) is a classification grouping that contains similar, closely related organisms. For example, pumas, marbled cats, and house cats are all classified in the genus *Felis*. Organisms that are classified in the genus *Felis* share characteristics such as sharp, retractable claws and behaviors such as hunting other animals.

The second word in a scientific name often describes a distinctive feature of an organism, such as where it lives or its appearance. Together, the two words indicate a unique species. A **species** (SPEE sheez) is a group of similar organisms that can mate with each other and produce offspring that can also mate and reproduce.

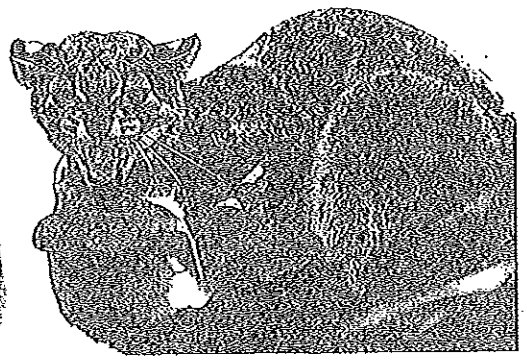
Reading Checkpoint **What kind of name did Linnaeus give each organism?**

FIGURE 8 Binomial Nomenclature

These three species of cats belong to the same genus. Their scientific names, written in Latin, share the same first word, *Felis*. The second word of their names describes a feature of the animal. Classifying *What characteristics do these species share?*



Felis concolor (Puma)
Concolor means "the same color." Notice that this animal's coat is mostly the same color.



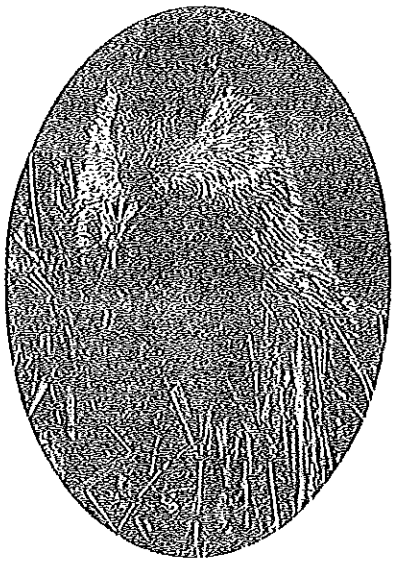
Felis marmorata (Marbled cat)
Notice the marbled pattern of this animal's coat. *Marmorata* means "marble."

Felis domesticus (House cat)
Domesticus means "of the house."

Using Binomial Nomenclature Notice in Figure 8 that a complete scientific name is written in italics. Only the first letter of the first word is capitalized. Notice also that scientific names contain Latin words. Linnaeus used Latin because it was the language that scientists used during that time.

Binomial nomenclature makes it easy for scientists to communicate because everyone uses the same name for the same organism. Using different names can get confusing. For instance, people call the animal in Figure 9 a woodchuck, groundhog, or whistlepig. Fortunately, it has only one scientific name—*Marmota monax*.

FIGURE 9
Marmota monax
Although there are many common names for this animal, it has only one scientific name, *Marmota monax*.



Levels of Classification

The classification system that scientists use today is based on the contributions of Linnaeus. But today's classification system uses a series of many levels to classify organisms.

To help you understand the levels in classification, imagine a room filled with everybody from your state. First, all of the people from your town raise their hands. Then, those from your neighborhood raise their hands. Then, those from your street raise their hands. Finally, those from your house raise their hands. Each time, fewer people raise their hands. But you'd be in all of the groups. The most general group you belong to is the state. The most specific group is the house. The more levels you share with others, the more you have in common with them. Of course, organisms are not grouped by where they live, but rather by their shared characteristics.

The Major Levels of Classification Most biologists today classify organisms into eight levels. First, an organism is placed in a broad group, which in turn is divided into more specific groups. **The more classification levels that two organisms share, the more characteristics they have in common.**

Here are the eight classification levels that biologists commonly use.

- A domain is the highest level of organization.
- Within a domain, there are kingdoms.
- Within kingdoms, there are phyla (FY luh) (singular *phylum*).
- Within phyla are classes.
- Within classes are orders.
- Within orders are families.
- Each family contains one or more genera.
- Each genus contains one or more species.

Go Online
SCILINKS NSTA
For: Links on kingdoms
Visit: www.SciLinks.org
Web Code: scn-0113

Classifying an Owl Look at Figure 10 to see how the grea horned owl is classified. The top row shows a wide variety o organisms that share the owl's domain. Notice that as you move down the levels, there are fewer kinds of organisms in each group. The organisms in each new group have more in common, however. For example, the class Aves includes al birds. The order Strigiformes includes only owls.

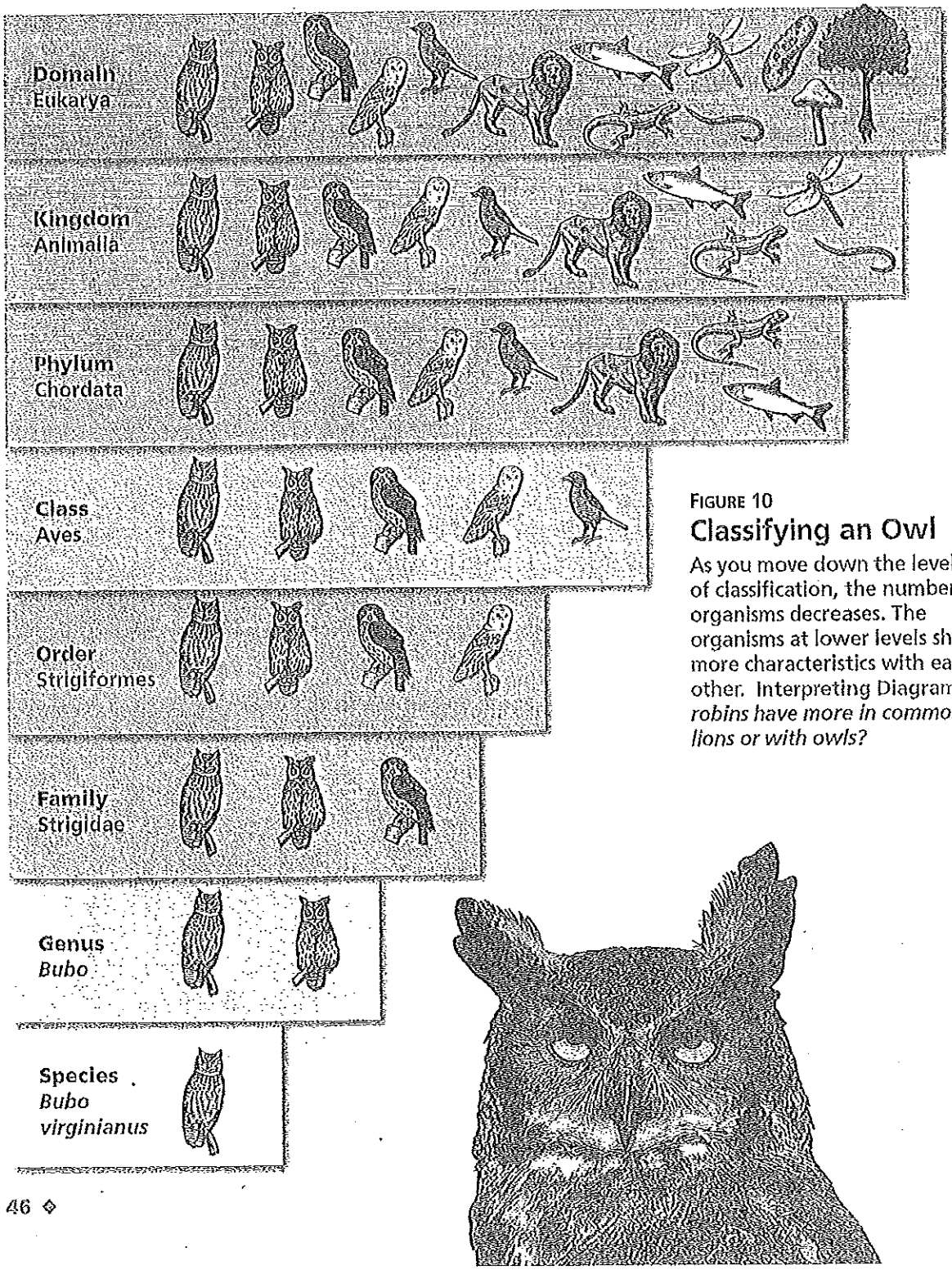


FIGURE 10
Classifying an Owl
As you move down the levels of classification, the number of organisms decreases. The organisms at lower levels share more characteristics with each other. Interpreting Diagrams *Do robins have more in common with lions or with owls?*

Domains and Kingdoms

Today, a three-domain system of classification is commonly used. Shown in Figure 11, the three domains are Bacteria, Archaea, and Eukarya. Within the domains are six kingdoms. Organisms are placed into domains and kingdoms based on their cell type, their ability to make food, and the number of cells in their bodies.

Bacteria Although you may not know it, members of the domain Bacteria (kingdom Eubacteria) are all around you. You can find them in the yogurt you eat, on every surface you touch, and inside your body, both when you are healthy and sick. Some bacteria are autotrophs, while others are heterotrophs.

Members of the domain Bacteria are prokaryotes (proh KA ree ohtz). **Prokaryotes** are organisms whose cells lack a nucleus. A **nucleus** (NOO klee us) (plural *nuclei*) is a dense area in a cell that contains nucleic acids—the chemical instructions that direct the cell's activities. In prokaryotes, nucleic acids are not contained within a nucleus.

Archaea Deep in the Pacific Ocean, hot gases and molten rock spew out from a vent in the ocean floor. Surprisingly, a group of tiny organisms thrives there. They are members of the domain Archaea (kingdom Archaebacteria), whose name comes from the Greek word for "ancient." Archaea can be found in some of the most extreme environments on Earth, including hot springs, very salty water, swamps, and the intestines of cows! Scientists think that the harsh conditions in which archaea live are similar to those of ancient Earth.

Like bacteria, archaea are unicellular prokaryotes. And like bacteria, some archaea are autotrophs while others are heterotrophs. Archaea are classified in their own domain, however, because their structure and chemical makeup differ from that of bacteria.

Reading Checkpoint What is a nucleus?

Lab zone Skills Activity

Classifying

Test your classifying skills using Figure 10. Look carefully at the organisms pictured together at the kingdom level. Make a list of the characteristics that the organisms share. Then make two more lists of shared characteristics—one for the organisms at the class level and the other for those at the genus level. How does the number of shared characteristics on your lists change at each level?

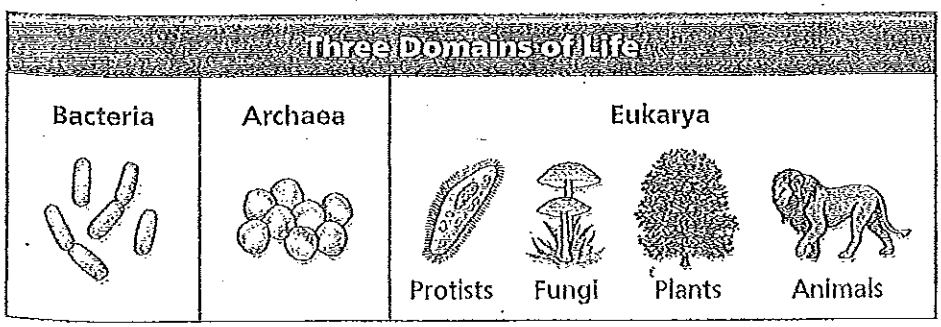
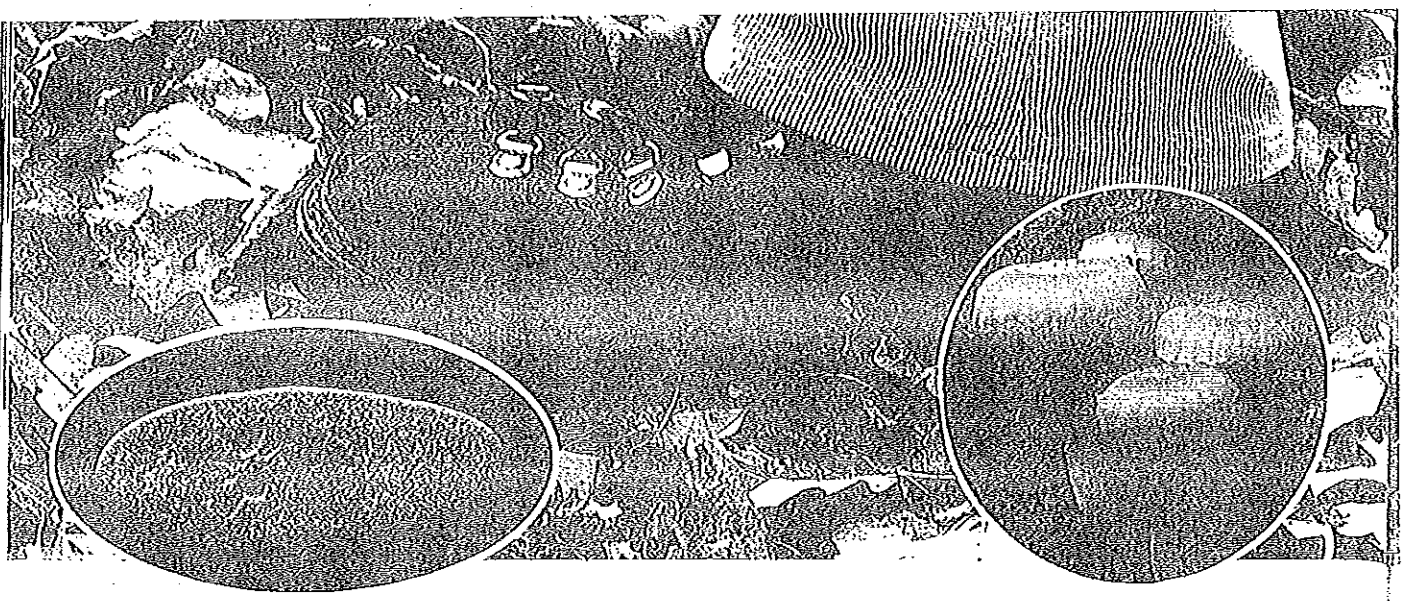


FIGURE 11
Three Domains
In the three-domain system of classification, all known organisms belong to one of three domains—Bacteria, Archaea, or Eukarya.



▲ Protists: Paramecium

▲ Fungi: Mushrooms

FIGURE 12
Domain Eukarya
You can encounter organisms from all four kingdoms of Eukarya on a hike through the woods.
Making Generalizations *What characteristic do all Eukarya share?*

Domain Eukarya

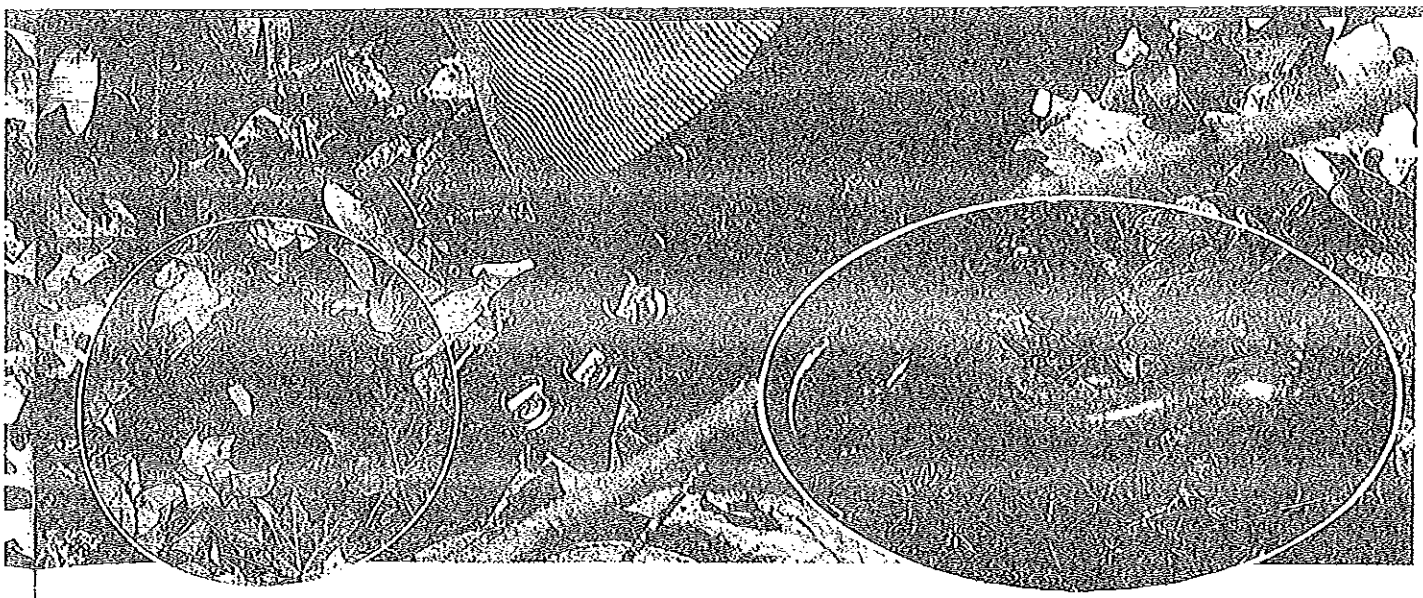
What do seaweeds, mushrooms, tomatoes, and dogs have in common? They are all members of the domain Eukarya. Organisms in this domain are **eukaryotes** (yoo KA ree ohtz)—organisms with cells that contain nuclei. **Scientists classify organisms in the domain Eukarya into one of four kingdoms: protists, fungi, plants, or animals.**

Protists A protist (PROH tist) is any eukaryotic organism that cannot be classified as an animal, plant, or fungus. Because its members are so different from one another, the protist kingdom is sometimes called the "odds and ends" kingdom. For example, some protists are autotrophs, while other protists are heterotrophs. Most protists are unicellular, but some, such as seaweeds, are large multicellular organisms.

Fungi If you have eaten mushrooms, then you have eaten fungi (FUN jy). Mushrooms, molds, and mildew are all fungi. Most fungi are multicellular eukaryotes. A few, such as the yeast you use for baking, are unicellular eukaryotes. Fungi are found almost everywhere on land, but only a few live in fresh water. All fungi are heterotrophs. Most fungi feed by absorbing nutrients from dead or decaying organisms.

Plants Dandelions on a lawn, mosses in a forest, and peas in a garden are familiar members of the plant kingdom. Plants are all multicellular eukaryotes and most live on land. In addition, plants are autotrophs that make their own food. Plants provide food for most of the heterotrophs on land.

The plant kingdom includes a great variety of organisms. Some plants produce flowers, while others do not. Some plants, such as giant redwood trees, can grow very tall. Others, like mosses, never grow taller than a few centimeters.



▲ Plants: Moss

▲ Animals: Salamander

Animals A dog, a flea on the dog's ear, and a cat that the dog chases have much in common because all are animals. All animals are multicellular eukaryotes. In addition, all animals are heterotrophs. Animals have different adaptations that allow them to locate food, capture it, eat it, and digest it. Members of the animal kingdom live in diverse environments throughout Earth. Animals can be found from ocean depths to mountaintops, from hot, scalding deserts to cold, icy landscapes.

Reading Checkpoint Which two kingdoms consist only of heterotrophs?

Section 2 Assessment

Target Reading Skill Asking Questions Use the answers to the questions you wrote about the headings to help you answer the questions below.

Reviewing Key Concepts

1. a. Reviewing Why do biologists classify?
   b. Inferring Suppose someone tells you that a jaguarundi is classified in the same genus as a house cat. What characteristics do you think a jaguarundi might have?
   c. Predicting What genus name would you expect a jaguarundi to have? Explain.
2. a. Listing List in order the levels of classification, beginning with domain.
   b. Applying Concepts Woodchucks are classified in the same family as squirrels, but in a different family than mice. Do woodchucks have more characteristics in common with squirrels or mice? Explain.
3. a. Identifying What are the three domains into which organisms are classified?
   b. Classifying Which two domains include only organisms that are prokaryotes?
   c. Comparing and Contrasting How do the members of the two domains of prokaryotes differ?

Lab zone At-Home Activity

Kitchen Classification With a family member, go on a "classification hunt" in the kitchen. Look in your refrigerator, cabinets, and drawers to discover what classification systems your family uses to organize items. Then explain to your family member the importance of classification in biology.

Lab zone Skills Lab

What's That Organism?

Problem

How can you make and use dichotomous keys to classify living things?

Skills Focus

observing, classifying, inferring

Materials

- group of objects or images for Part 2
- group of objects or images for Part 3

Procedure

PART 1 Examining a Dichotomous Key

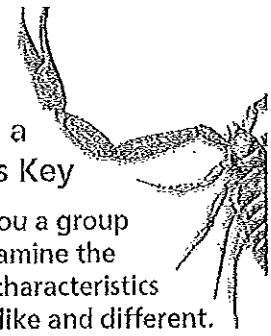
1. Dichotomous keys, also called taxonomic keys, can be used to classify groups of organisms. Use Dichotomous Key 1 to classify the unidentified organism shown at the right. Start by reading statements 1a and 1b. Notice that they describe opposite characteristics. Choose the statement that applies to the unknown organism.
2. Read the direction after the statement you just chose. Since the unidentified organism has two body regions, go to Step 2. Choose either statement 2a or 2b. Continue the process until the key leads you to the organism's identity. Write the name of the organism in your notebook.

PART 2 Classifying Into Kingdoms With a Dichotomous Key

3. Your teacher will give you a group of numbered organisms or images of organisms. Create a data table with four columns: (1) Number of the Organism, (2) Observed Physical Characteristics, (3) Kingdom, and (4) Questions or Problems.
4. Use Dichotomous Key 2 and your data table to classify each organism. Record the characteristics you observe. Classify each organism. If you have any questions or problems, describe them in the last column.

Dichotomous Key 1

Step 1	1a.	Has two body regions	Go to Step 2
	1b.	Does not have two body regions	Go to Step 4
Step 2	2a.	Has clawlike pincers	Go to Step 3
	2b.	Has no clawlike pincers	Spider
Step 3	3a.	Has a long tail with a stinger	Scorpion
	3b.	Has no tail or stinger	Pseudoscorpion



PART 3 Constructing a Dichotomous Key

5. Your teacher will give you a group of objects for Part 3. Examine the objects. List about five characteristics that make the objects alike and different.
6. Use your list to construct a dichotomous key for the objects. Remember that your key must consist of paired statements similar to those in the other keys in this lab. Try out your key to make sure it classifies all the objects.
7. Exchange your objects and key with a partner. If your partner cannot identify all the objects, revise the key as needed.

Dichotomous Key 2

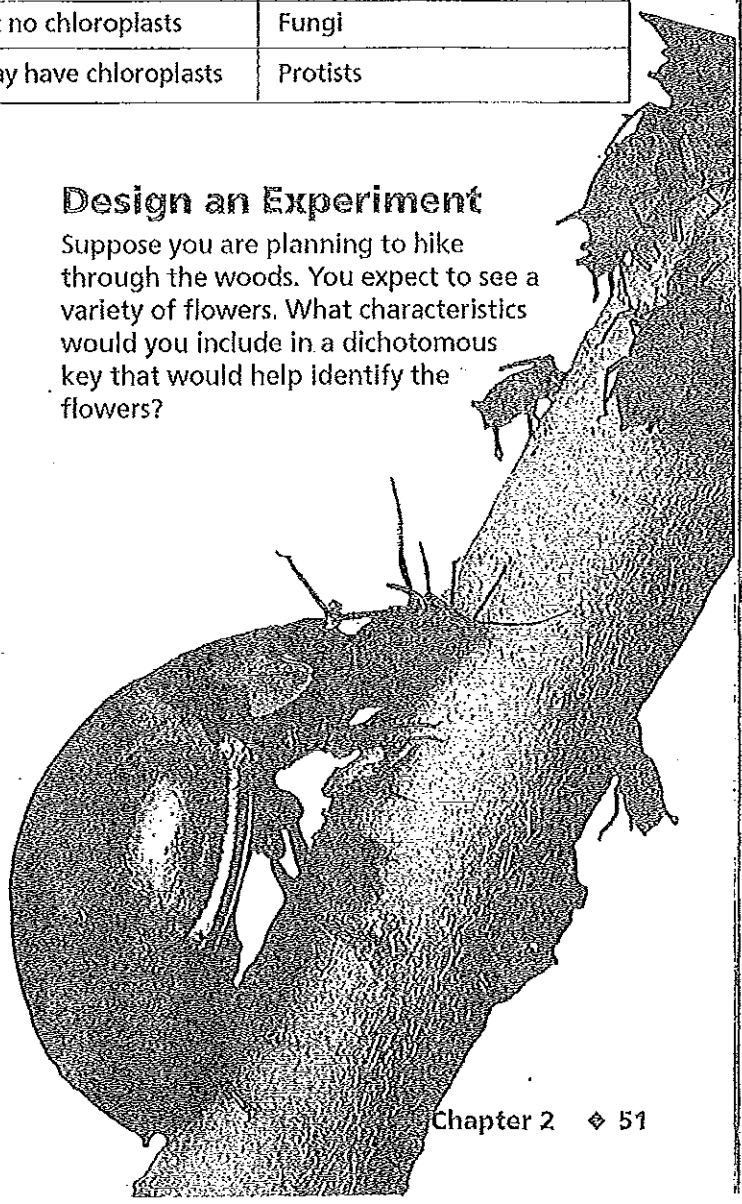
Step 1	1a.	Can be seen without a microscope (multicellular)	Go to Step 2
	1b.	Can be seen only with a microscope (unicellular)	Go to Step 4
Step 2	2a.	Has chloroplasts (green cell parts)	Plants
	2b.	Has no chloroplasts	Go to Step 3
Step 3	3a.	Absorbs food; may be attached to food source	Fungi
	3b.	Captures and eats food; moves or has appendages	Animals
Step 4	4a.	Has no nucleus; cell is very small	Eubacteria or Archaebacteria
	4b.	Has a nucleus and other cell parts	Go to Step 5
Step 5	5a.	Has a cell wall made of chitin, but no chloroplasts	Fungi
	5b.	May or may not have cell wall; may have chloroplasts	Protists

Analyze and Conclude

1. Classifying What is the unidentified organism you examined in Part 1?
2. Classifying To which kingdom does each organism from Part 2 belong?
3. Interpreting Data Did you have any problems classifying any organisms in Part 2? If so, describe those problems.
4. Inferring Explain why the paired statements in a dichotomous key must be opposites.
5. Applying Concepts In Part 3, did your partner have any problems using your key? If so, what revisions did you make?
6. Communicating What advice would you give to someone who has to make up a dichotomous key? Write an explanation of the parts of the task you found easy. What was difficult? How did you overcome your difficulties?

Design an Experiment

Suppose you are planning to hike through the woods. You expect to see a variety of flowers. What characteristics would you include in a dichotomous key that would help identify the flowers?



Section 3 • Tech & Design •

Discovering Cells

Reading Preview

Key Concepts

- What are cells?
- How did the invention of the microscope contribute to knowledge about living things?
- What is the cell theory?
- How do microscopes produce magnified images?

Key Terms

• cell • microscope • cell theory

Target Reading Skill

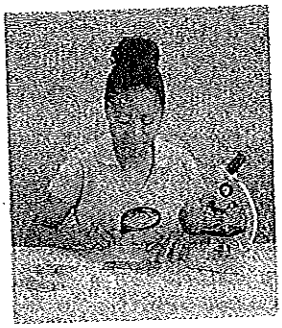
Sequencing A sequence is the order in which a series of events occurs. As you read, construct a flowchart showing how the work of Hooke, Leeuwenhoek, Schleiden, Schwann, and Virchow contributed to scientific understanding of cells.

Discovering Cells

Hooke sees cells in cork.

Lab zone Discover Activity

Is Seeing Believing?



1. Cut a black-and-white photograph out of a page in a newspaper. With only your eyes, closely examine the photo. Record your observations.
2. Examine the same photo with a hand lens. Again, record your observations.
3. Place the photo on the stage of a microscope. Use the clips to hold the photo in place. Shine a light down on the photo. Focus the microscope on part of the photo. (See Appendix B for instructions on using the microscope.) Record your observations.

Think It Over

Observing What did you see in the photo with the hand lens that you could not see with only your eyes? What additional details could you see with the microscope?

A forest is filled with an amazing variety of living things. Some are easy to see, but you have to look closely to find others. If you look carefully at the floor of a forest, you can often find spots of bright color. A beautiful pink coral fungus grows beneath tall trees. Beside the pink fungus, a tiny red newt perches on a fallen leaf.

What do you think a fungus, a tree, and a red newt have in common? They are all living things, or organisms, and, like all organisms, they are made of cells.

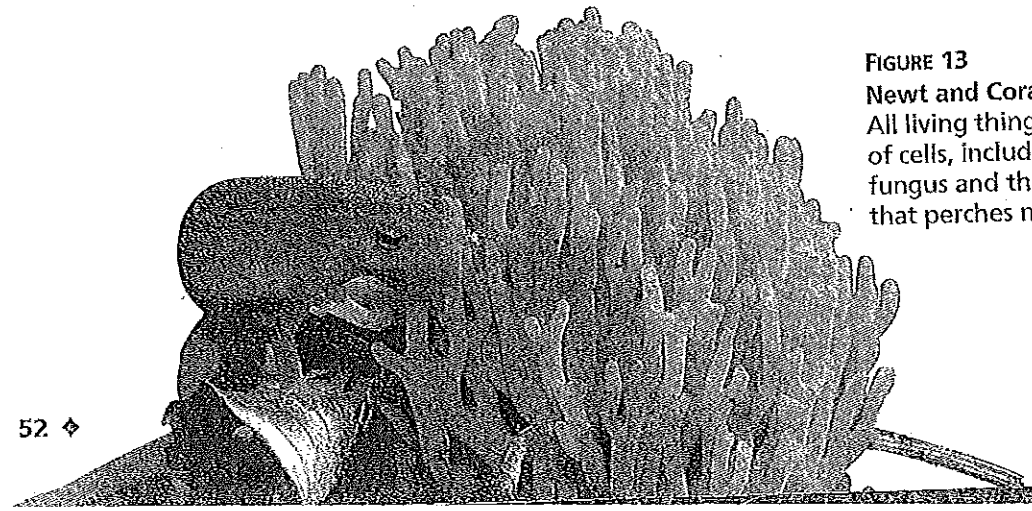


FIGURE 13
Newt and Coral Fungus
All living things are made of cells, including this pink fungus and the red newt that perches next to it.

An Overview of Cells

You are made of cells. **Cells are the basic units of structure and function in living things.** This means that cells form the parts of an organism and carry out all of an organism's processes, or functions.

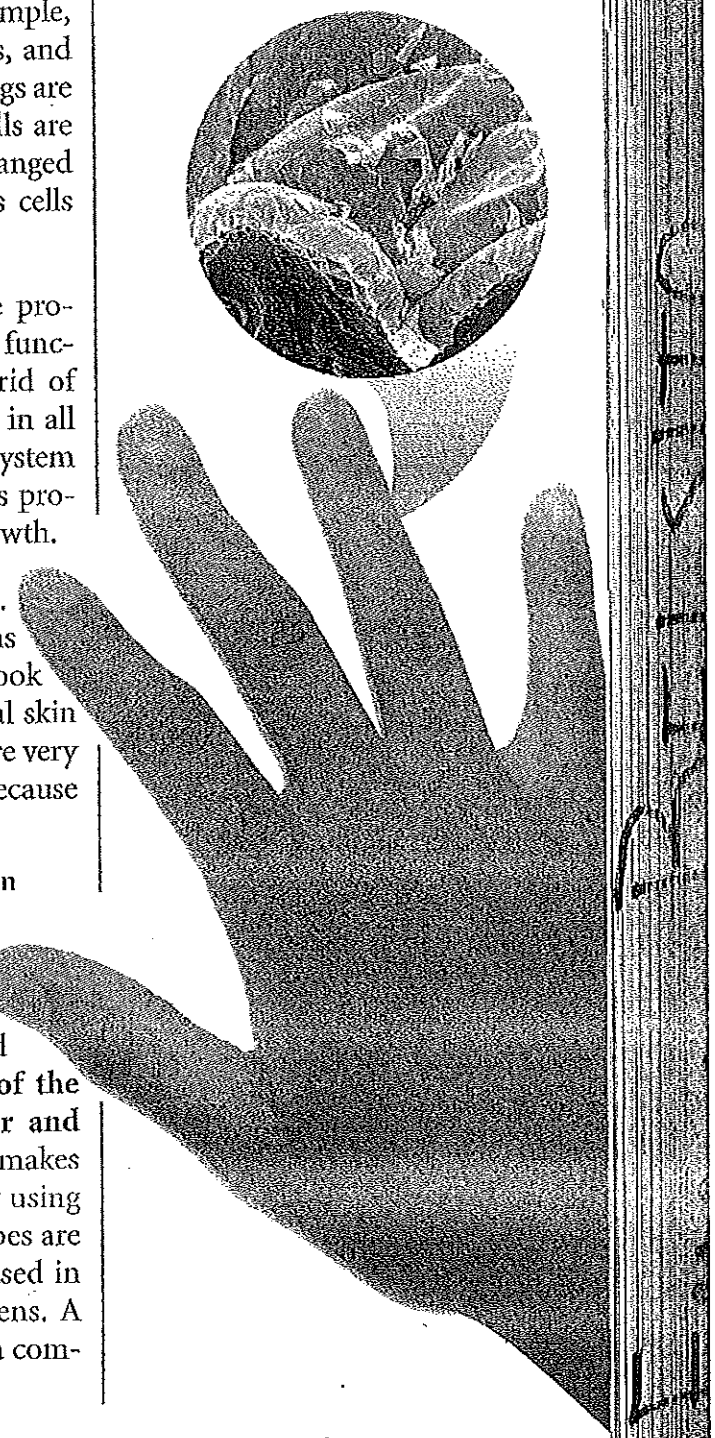
Cells and Structure When you describe the structure of an object, you describe what it is made of and how its parts are put together. The structures of many buildings, for example, are determined by the way in which bricks, steel beams, and other materials are arranged. The structures of living things are determined by the amazing variety of ways in which cells are put together. A tall tree, for example, consists of cells arranged to form a high trunk and leafy branches. A red newt's cells form a body with a head and four legs.

Cells and Function An organism's functions are the processes that enable it to stay alive and reproduce. Some functions in organisms include obtaining oxygen, getting rid of wastes, obtaining food, and growing. Cells are involved in all these functions. For example, cells in your digestive system absorb nutrients, or chemicals from food. The nutrients provide your body with energy and materials needed for growth.

Many and Small Figure 14 shows human skin cells. One square centimeter of your skin's surface contains more than 100,000 cells. But no matter how closely you look with your eyes alone, you won't be able to see individual skin cells. That is because, like most cells, those of your skin are very small. Until the late 1600s, no one knew cells existed because there was no way to see them.

Reading Checkpoint **What are some functions that cells perform in living things?**

FIGURE 14
Skin Cells
Your skin is made of cells such as these. Applying Concepts *What are cells?*



First Observations of Cells

Around 1590, the invention of the microscope enabled people to look at very small objects. **The invention of the microscope made it possible for people to discover and learn about cells.** A **microscope** is an instrument that makes small objects look larger. Some microscopes do this by using lenses to focus light. The lenses used in light microscopes are similar to the clear, curved pieces of glass or plastic used in eyeglasses. A simple microscope contains only one lens. A light microscope that has more than one lens is called a compound microscope.

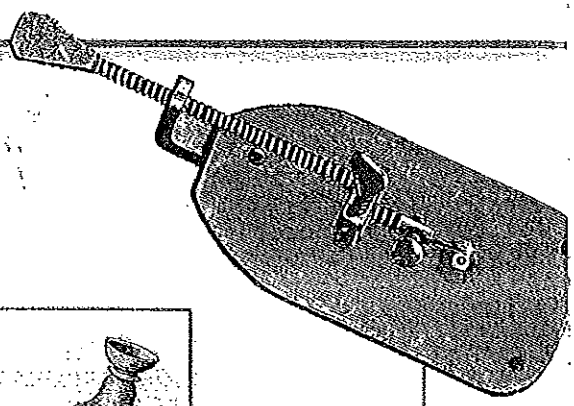
Robert Hooke One of the first people to observe cells was the English scientist and inventor Robert Hooke. Hooke built his own compound microscope, which was one of the best microscopes of his time. In 1663, Hooke used his microscope to observe the structure of a thin slice of cork. Cork, the bark of the cork oak tree, is made up of cells that are no longer alive. To Hooke, the empty spaces in the cork looked like tiny rectangular rooms. Therefore, Hooke called the empty spaces *cells*, which is a word meaning "small rooms."

Hooke described his observations this way: "These pores, or cells, were not very deep, but consisted of a great many little boxes. . . ." What most amazed Hooke was how many cells the cork contained. He calculated that in a cubic inch there were about twelve hundred million cells—a number he described as "almost incredible."

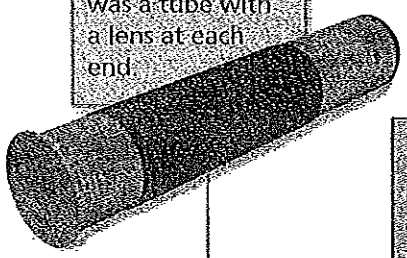
• Tech & Design in History •

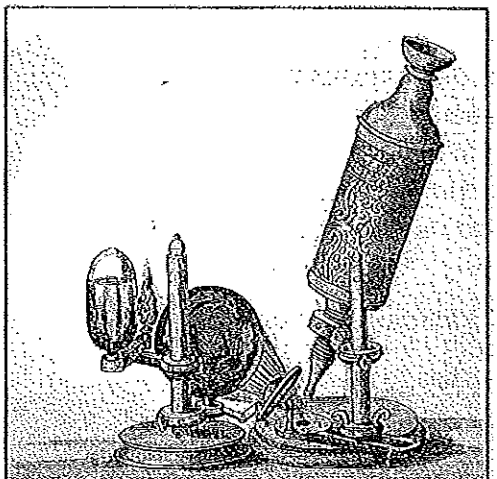
The Microscope: Improvements Over Time

The microscope made the discovery of cells possible. Microscopes have improved in many ways over the last 400 years.



1590 First Compound Microscope Dutch eyeglass makers Zacharias and Hans Janssen made one of the first compound microscopes. It was a tube with a lens at each end.





1660 Hooke's Compound Microscope Robert Hooke's compound microscope included an oil lamp for lighting. A lens focuses light from the flame onto the specimen.

1674 Leeuwenhoek's Simple Microscope Although Anton van Leeuwenhoek's simple microscope used only one tiny lens, it could magnify a specimen up to 266 times.

1500 1600 1700

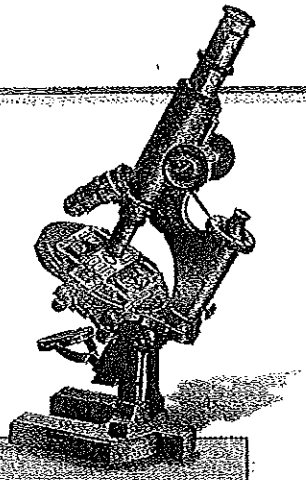
Anton van Leeuwenhoek At about the same time that Robert Hooke made his discovery, Anton van Leeuwenhoek (LAY vun hook) also began to observe tiny objects with microscopes. Leeuwenhoek was a Dutch businessman who sold cloth. In his spare time, he built simple microscopes.

Leeuwenhoek looked at drops of lake water, scrapings from teeth and gums, and water from rain gutters. In many materials, Leeuwenhoek was surprised to find a variety of one-celled organisms. Leeuwenhoek noted that many of these tiny organisms moved. Some whirled, some hopped, and some shot through water like fast fish. He called these moving organisms *animalcules* (an ih MAL kyoolz), meaning "little animals."

Reading Checkpoint **Which type of microscope—simple or compound—did Leeuwenhoek make and use?**

Writing in Science

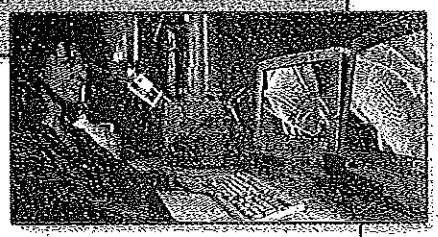
Research and Write Find out more about one of the microscopes. Then write an advertisement for it that might appear in a popular science magazine. Be creative. Emphasize the microscope's usefulness or describe the wonders that can be seen with it.



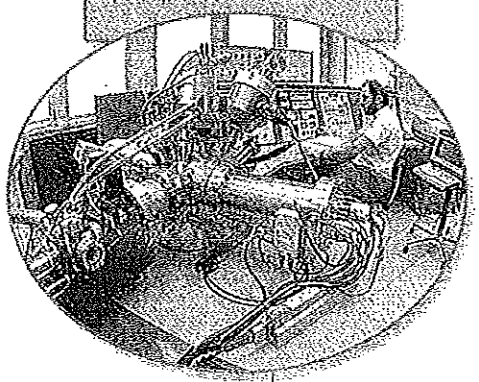
1886 Modern Compound Light Microscope
German scientists Ernst Abbe and Carl Zeiss made a compound light microscope with complex lenses that greatly improved the image. A mirror focuses light up through the specimen. Modern compound microscopes can effectively magnify a specimen up to 1,000 times.

1933 Transmission Electron Microscope (TEM)
German physicist Ernst Ruska created the first electron microscope. TEMs send electrons through a very thinly sliced specimen. TEMs can magnify a specimen up to 500,000 times.

1965 Scanning Electron Microscope (SEM)
An SEM sends electrons over the surface of a specimen, rather than through it. The result is a three-dimensional image of the specimen's surface. SEMs can magnify a specimen up to 150,000 times.



1981 Scanning Tunneling Microscope (STM)
An STM measures electrons that leak, or "tunnel," from the surface of a specimen. STMs can magnify a specimen up to 1,000,000 times.



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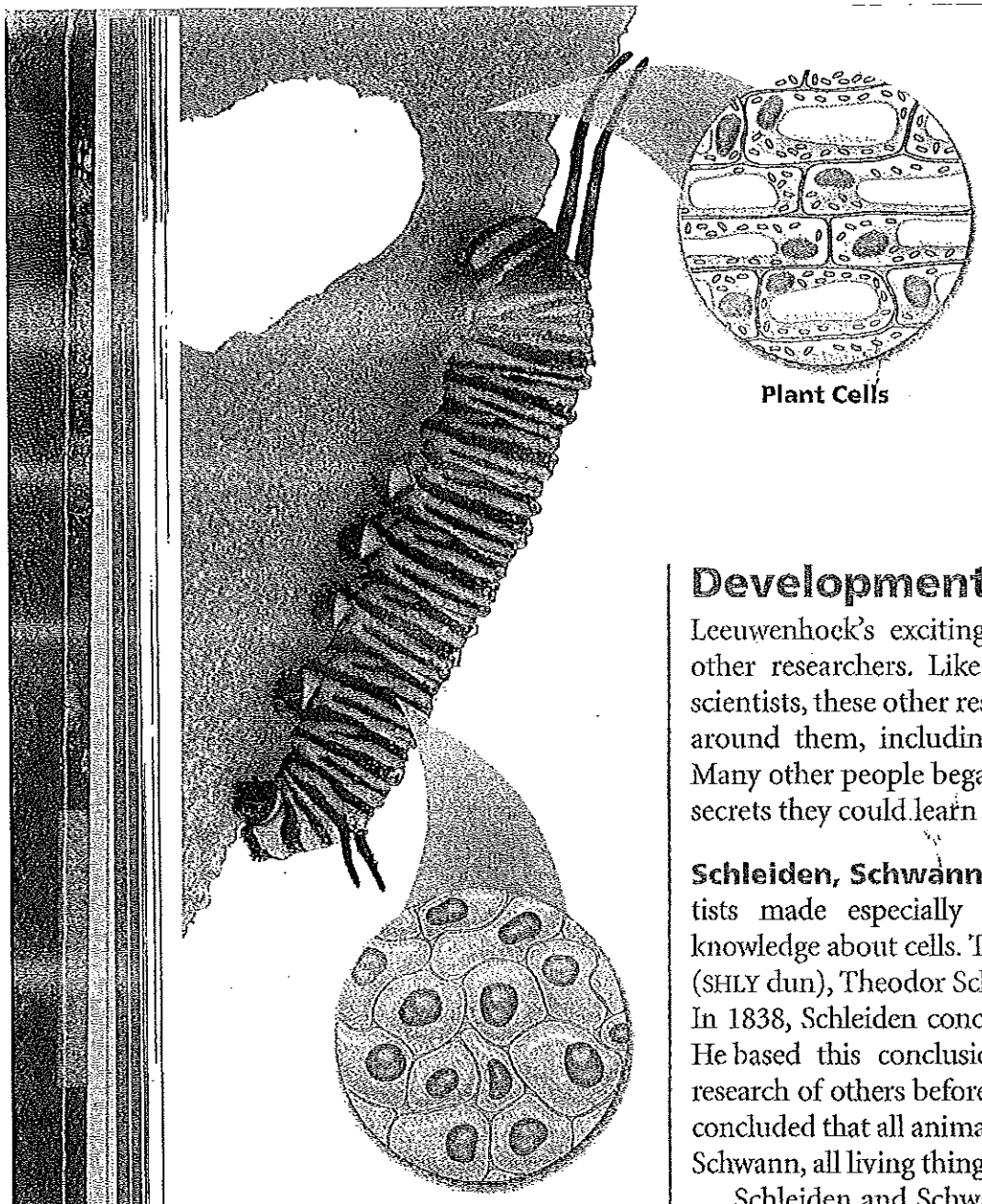

FIGURE 15
Monarch and Milkweed
The monarch butterfly caterpillar and the milkweed leaf that the caterpillar nibbles on are both made of cells.

Development of the Cell Theory

Leeuwenhoek's exciting discoveries caught the attention of other researchers. Like Hooke, Leeuwenhoek, and all good scientists, these other researchers were curious about the world around them, including things they couldn't normally see. Many other people began to use microscopes to discover what secrets they could learn about cells.

Schleiden, Schwann, and Virchow Three German scientists made especially important contributions to people's knowledge about cells. These scientists were Matthias Schleiden (SHLY dun), Theodor Schwann, and Rudolf Virchow (FUR koh). In 1838, Schleiden concluded that all plants are made of cells. He based this conclusion on his own research and on the research of others before him. The next year, Theodor Schwann concluded that all animals are also made up of cells. Thus, stated Schwann, all living things are made up of cells.

Schleiden and Schwann had made an important discovery about living things. However, they didn't explain where cells came from. Until their time, most people thought that living things could come from nonliving matter. In 1855, Virchow proposed that new cells are formed only from cells that already exist. "All cells come from cells," wrote Virchow.

What the Cell Theory Says Schleiden, Schwann, Virchow, and others helped develop the cell theory. The **cell theory** is a widely accepted explanation of the relationship between cells and living things. **The cell theory states the following:**

- **All living things are composed of cells.**
- **Cells are the basic units of structure and function in living things.**
- **All cells are produced from other cells.**

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The cell theory holds true for all living things, no matter how big or how small. Since cells are common to all living things, they can provide information about the functions that living things perform. Because all cells come from other cells, scientists can study cells to learn about growth and reproduction.

Reading Checkpoint **What did Schleiden and Schwann conclude about cells?**

Light and Electron Microscopes

The cell theory could not have been developed without microscopes. For a microscope to be useful, it must combine two important properties—magnification and resolution. Scientists today use two kinds of microscopes: light microscopes and electron microscopes.

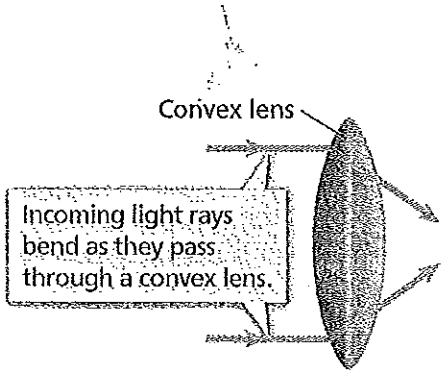
Magnification and Lenses The first property, magnification, is the ability to make things look larger than they are. **The lenses in light microscopes magnify an object by bending the light that passes through them.** If you examine a hand lens, such as the one in Figure 16, you will see that the lens is curved, not flat. The center of the lens is thicker than the edge. A lens with this curved shape is called a convex lens. The light passing through the sides of the lens bends inward. When this light hits the eye, the eye sees the object as larger than it really is.

Lab zone Skills Activity

Observing

1. Read about using the microscope (Appendix B) before beginning this activity.
2. Place a prepared slide of a thin slice of cork on the stage of a microscope.
3. Observe the slide under low power. Draw what you see.
4. Place a few drops of pond water on another slide and cover it with a coverslip.
5. Observe the slide under low power. Draw what you see. Wash your hands after handling pond water.

How does your drawing in Step 3 compare to Hooke's description of cells on page 54? Based on your observations in Step 5, why did Leeuwenhoek call the organisms he saw "little animals"?



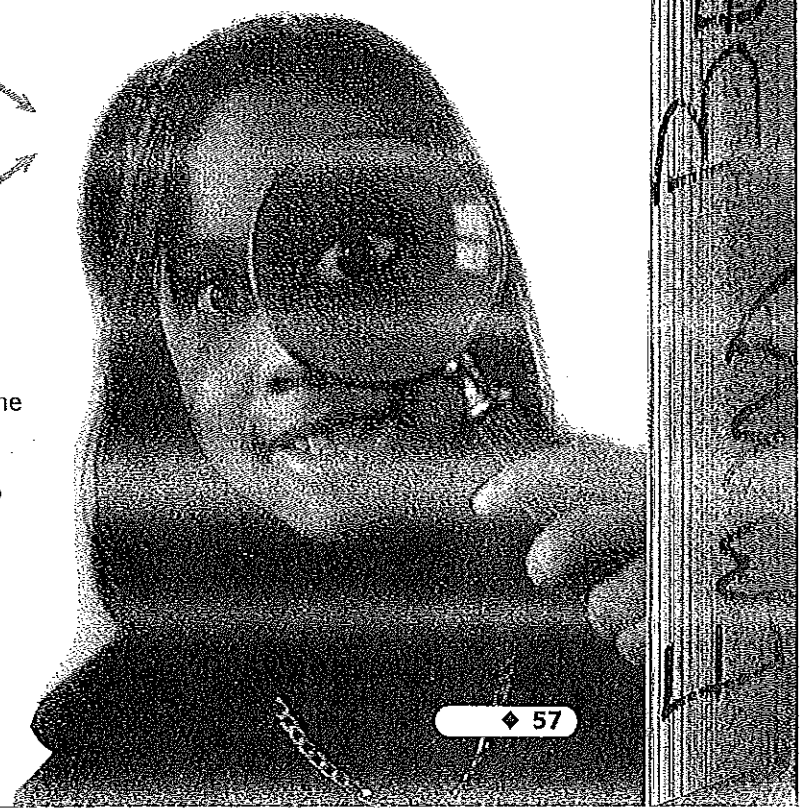


FIGURE 16
A Convex Lens
A magnifying glass is a convex lens. The lines in the diagram represent rays of light, and the arrows show the direction in which the light travels.
Interpreting Diagrams *Describe what happens to light rays as they pass through a convex lens.*

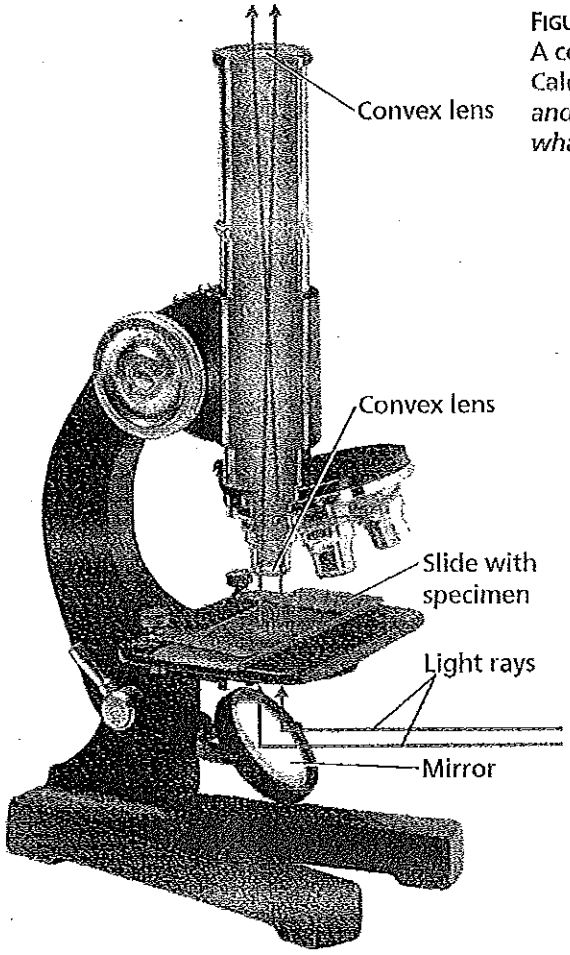


FIGURE 17 A Compound Microscope
A compound microscope has two convex lenses. Calculating *If one lens has a magnification of 10, and the other lens has a magnification of 50, what is the total magnification?*

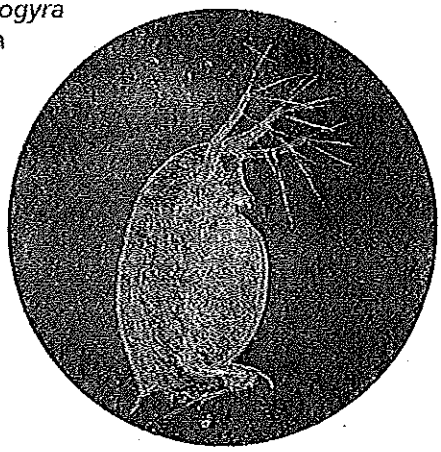
Compound Microscope Magnification

A compound microscope uses more than one lens. As a result, it can magnify an object more than one lens by itself. Light passes through a specimen and then through two lenses, as shown in Figure 17. The first lens, near the specimen, magnifies the object. Then a second lens, near the eye, further magnifies the enlarged image. The total magnification of the microscope is equal to the magnifications of the two lenses multiplied together. For example, suppose the first lens makes an object look 10 times bigger than it actually is, and the second lens makes the object look 40 times bigger than it actually is. The total magnification of the microscope is 10×40, or 400.

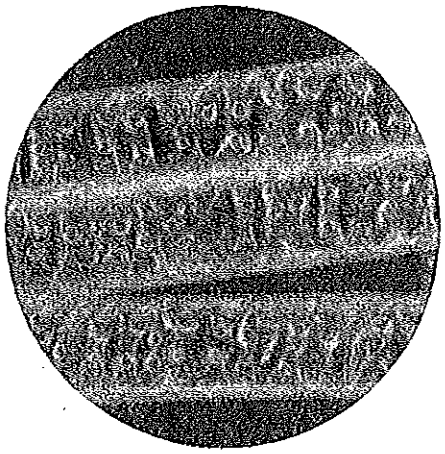
Resolution To create a useful image, a microscope must also help you see individual parts clearly. The ability to clearly distinguish the individual parts of an object is called resolution. Resolution is another term for the sharpness of an image. For example, a photograph in a newspaper is really made up of a collection of small dots. If you put the photo under a microscope, you can see the dots. You see the dots not only because they are magnified but also because the microscope improves resolution. Good resolution is needed when you study cells.

FIGURE 18
Light Microscope Photos
The pictures of the water flea and the threadlike *Spirogyra* were both taken with a light microscope.

Water flea
40 times actual size



Spirogyra
300 times actual size



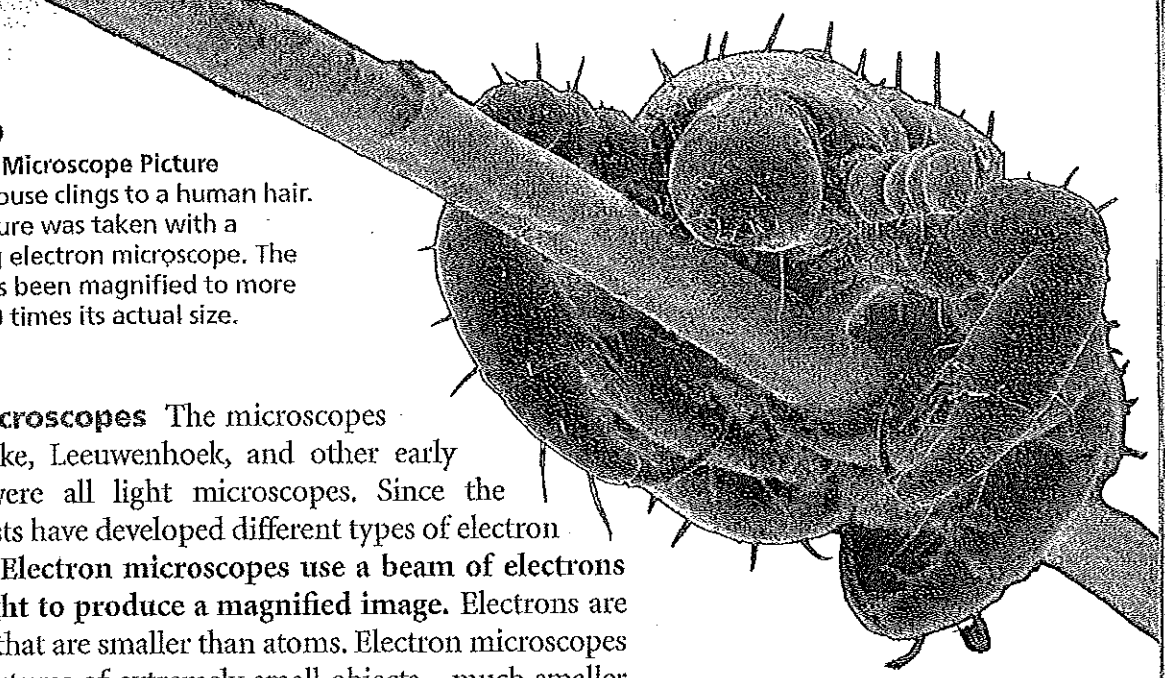


FIGURE 19
Electron Microscope Picture
A head louse clings to a human hair. This picture was taken with a scanning electron microscope. The louse has been magnified to more than 100 times its actual size.

Electron Microscopes The microscopes used by Hooke, Leeuwenhoek, and other early researchers were all light microscopes. Since the 1930s, scientists have developed different types of electron microscopes. **Electron microscopes use a beam of electrons instead of light to produce a magnified image.** Electrons are tiny particles that are smaller than atoms. Electron microscopes can obtain pictures of extremely small objects—much smaller than those that can be seen with light microscopes. The resolution of electron microscopes is much better than the resolution of light microscopes.

Reading Checkpoint **What do electron microscopes use to produce magnified images?**

Section 3 Assessment

Target Reading Skill Sequencing Review your flowchart and use it to answer Questions 2 and 3 below.

Reviewing Key Concepts

1. a. Defining Define *structure* and *function*.
   b. Explaining Explain this statement: Cells are the basic units of structure and function in organisms.
   c. Applying Concepts In what important function are the cells in your eyes involved?
2. a. Reviewing What does a microscope enable people to do?
   b. Summarizing Summarize Hooke's observations of cork under a microscope.
   c. Relating Cause and Effect Why would Hooke's discovery have been impossible without a microscope?
3. a. Reviewing What are the main ideas of the cell theory?
   b. Explaining What did Virchow contribute to the cell theory?
   c. Applying Concepts Use the ideas of Virchow to explain why plastic plants and stuffed animals are not alive.
4. a. Defining What is magnification?
   b. Comparing and Contrasting Contrast the way light microscopes and electron

Writing in Science

Writing an Award Speech Suppose you are a member of a scientific society that is giving an award to one of the early cell scientists. Choose the scientist, and write a speech that you might give at the award ceremony. Your speech should describe the scientist's accomplishments.

Section 4

Looking Inside Cells

Reading Preview

Key Concepts

- What role do the cell wall and cell membrane play in the cell?
- What are the functions of cell organelles?
- How are cells organized in many-celled organisms?

Key Terms

- organelle
- cell wall
- cell membrane
- cytoplasm
- mitochondria
- endoplasmic reticulum
- ribosome
- Golgi body
- chloroplast
- vacuole
- lysosome

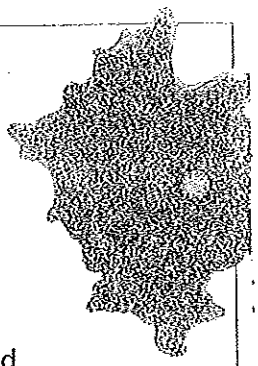
Target Reading Skill

Previewing Visuals Before you read, preview Figure 24. Then write two questions that you have about the illustrations in a graphic organizer like the one below. As you read, answer your questions.

Plant and Animal Cells

Q. How are animal cells different from plant cells?
A.
Q.

Lab zone **Discover Activity**



How Large Are Cells?

1. Look at the organism in the photo. The organism is an amoeba (uh MEE buh), a large single-celled organism. This type of amoeba is about 1 mm long.
2. Multiply your height in meters by 1,000 to get your height in millimeters. How many amoebas would you have to stack end-to-end to equal your height?
3. Many of the cells in your body are about 0.01 mm long—one hundredth the size of an amoeba. How many body cells would you have to stack end-to-end to equal your height?

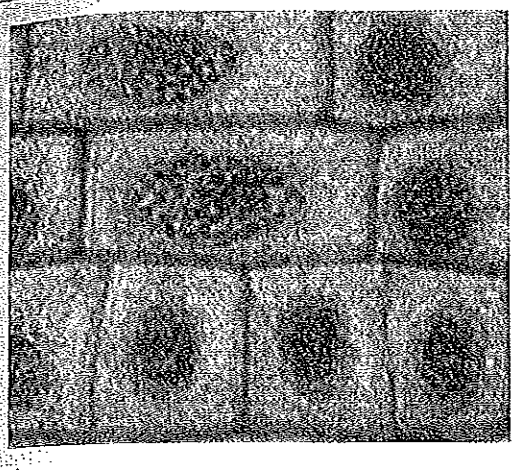
Think It Over

Inferring Look at a metric ruler to see how small 1 mm is. Now imagine a distance one one-hundredth as long, or 0.01 mm. Why can't you see your body's cells without the aid of a microscope?

Nasturtiums brighten up many gardens with green leaves and colorful flowers. How do nasturtiums carry out all the functions necessary to stay alive? To answer this question, you are about to take an imaginary journey. You will travel inside a nasturtium leaf, visiting its tiny cells. You will observe some of the structures found in plant cells. You will also learn some differences between plant and animal cells.

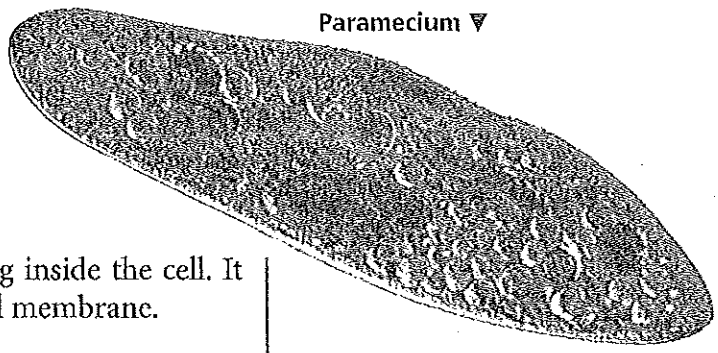
As you will discover on your journey, there are even smaller structures inside a cell. These tiny cell structures, called **organelles,** carry out specific functions within the cell. Just as your stomach, lungs, and heart have different functions in your body, each organelle has a different function within the cell. Now it's time to hop aboard your imaginary ship and sail into a typical plant cell.

Nasturtiums ▶



◀ Onion root cells

Paramecium ▼



Enter the Cell

Your ship doesn't have an easy time getting inside the cell. It has to pass through the cell wall and the cell membrane.

Cell Wall As you travel through the plant cell, refer to Figure 24 in this section. First, you must slip through the cell wall. The **cell wall** is a rigid layer of nonliving material that surrounds the cells of plants and some other organisms. The cells of animals, in contrast, do not have cell walls. **A plant's cell wall helps to protect and support the cell.** The cell wall is made mostly of a strong material called cellulose. Although the cell wall is tough, many materials, including water and oxygen, can pass through easily.

Cell Membrane After you sail through the cell wall, the next barrier you must cross is the **cell membrane.** All cells have cell membranes. In cells with cell walls, the cell membrane is located just inside the cell wall. In other cells, the cell membrane forms the outside boundary that separates the cell from its environment.

The cell membrane controls what substances come into and out of a cell. Everything the cell needs, from food to oxygen, enters the cell through the cell membrane. Fortunately, your ship can slip through, too. Harmful waste products leave the cell through the cell membrane. For a cell to survive, the cell membrane must allow these materials to pass in and out. In addition, the cell membrane prevents harmful materials from entering the cell. In a sense, the cell membrane is like a window screen. The screen allows air to enter and leave a room, but it keeps insects out.

Reading Checkpoint **What is the function of the cell wall?**

FIGURE 20
Cell Wall and Cell Membrane
The onion root cells have both a cell wall and a cell membrane. The single-celled paramecium has only a cell membrane.
Interpreting Photographs *What shape do the cell walls give to the onion root cells?*

Discovery CHANNEL SCHOOL

Cell Structure and Function
Video Preview
▶ Video Field Trip
Video Assessment

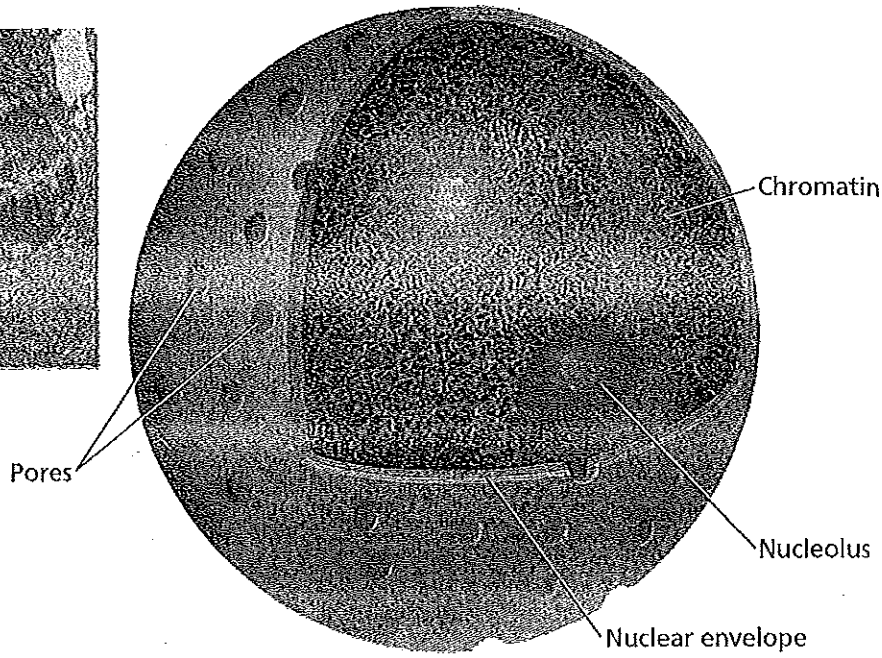


FIGURE 21
The Nucleus
The photo (left) and diagram (right) both show the nucleus, which is the cell's control center. The chromatin in the nucleus contains instructions for carrying out the cell's activities.

Sail On to the Nucleus

As you sail inside the cell, a large, oval structure comes into view. This structure, the nucleus, acts as the "brain" of the cell. **You can think of the nucleus as the cell's control center,** directing all of the cell's activities.

Nuclear Envelope Notice in Figure 21 that the nucleus is surrounded by a membrane called the nuclear envelope. Just as a mailing envelope protects the letter inside it, the nuclear envelope protects the nucleus. Materials pass in and out of the nucleus through pores in the nuclear envelope. So aim for that pore just ahead and carefully glide into the nucleus.

Chromatin You might wonder how the nucleus "knows" how to direct the cell. The answer lies in those thin strands floating directly ahead in the nucleus. These strands, called chromatin, contain genetic material, the instructions for directing the cell's functions. For example, the instructions in the chromatin ensure that leaf cells grow and divide to form more leaf cells.

Nucleolus As you prepare to leave the nucleus, you spot a small object floating by. This structure, a nucleolus, is where ribosomes are made. Ribosomes are the organelles where proteins are produced. Proteins are important chemicals in cells.

Reading Checkpoint **Where in the nucleus is genetic material found?**

Lab zone Try This Activity

Gelatin Cell

Make your own model of a cell.

1. Dissolve a packet of colorless gelatin in warm water. Pour the gelatin into a rectangular pan (for a plant cell) or a round pan (for an animal cell).
2. Choose different materials that resemble each of the cell structures found in the cell you are modeling. Insert these materials into the gelatin before it begins to solidify.

Making Models On a sheet of paper, develop a key that identifies each cell structure in your model. Describe the function of each structure.

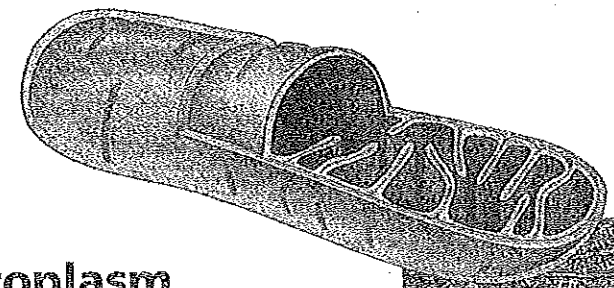


FIGURE 22 Mitochondrion
The mitochondria produce most of the cell's energy. Inferring *In what types of cells would you expect to find a lot of mitochondria?*

Organelles in the Cytoplasm

As you leave the nucleus, you find yourself in the **cytoplasm,** the region between the cell membrane and the nucleus. Your ship floats in a clear, thick, gel-like fluid. The fluid in the cytoplasm is constantly moving, so your ship does not need to propel itself. Many cell organelles are found in the cytoplasm.

Mitochondria Suddenly, rod-shaped structures loom ahead. These organelles are **mitochondria** (my tuh KAHN dree uh) (singular *mitochondrion*). **Mitochondria are known as the "powerhouses" of the cell because they convert energy in food molecules to energy the cell can use to carry out its functions.** Figure 22 shows a mitochondrion up close.

Endoplasmic Reticulum As you sail farther into the cytoplasm, you find yourself in a maze of passageways called the **endoplasmic reticulum** (en duh PLAZ mik rih TIK yuh lum). **The endoplasmic reticulum's passageways carry proteins and other materials from one part of the cell to another.**

Ribosomes Attached to some surfaces of the endoplasmic reticulum are small, grainlike bodies called **ribosomes.** Other ribosomes float in the cytoplasm. **Ribosomes function as factories to produce proteins.** Some newly made proteins are released through the wall of the endoplasmic reticulum. From the interior of the endoplasmic reticulum, the proteins will be transported to the Golgi bodies.

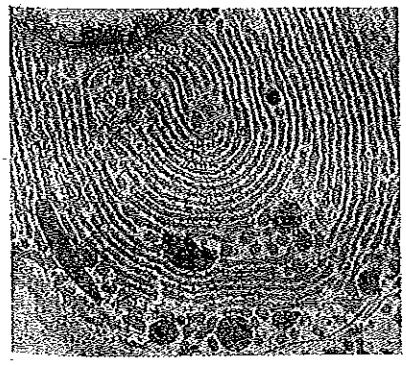


FIGURE 23
Endoplasmic Reticulum
The endoplasmic reticulum is similar to the system of hallways in a building. Proteins and other materials move throughout the cell by way of the endoplasmic reticulum. The spots on this organelle are ribosomes, which produce proteins.

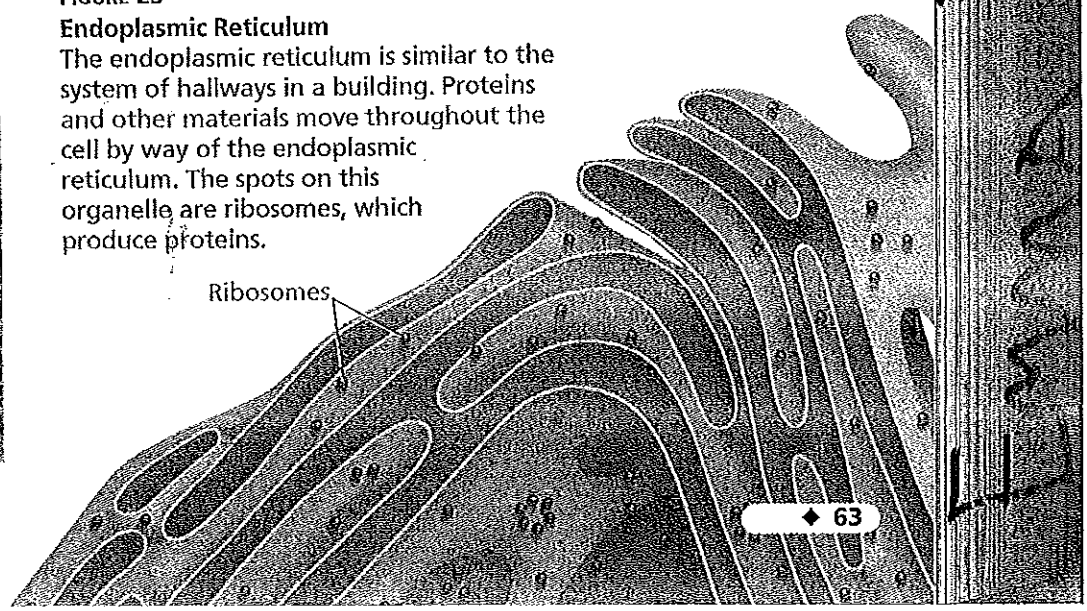
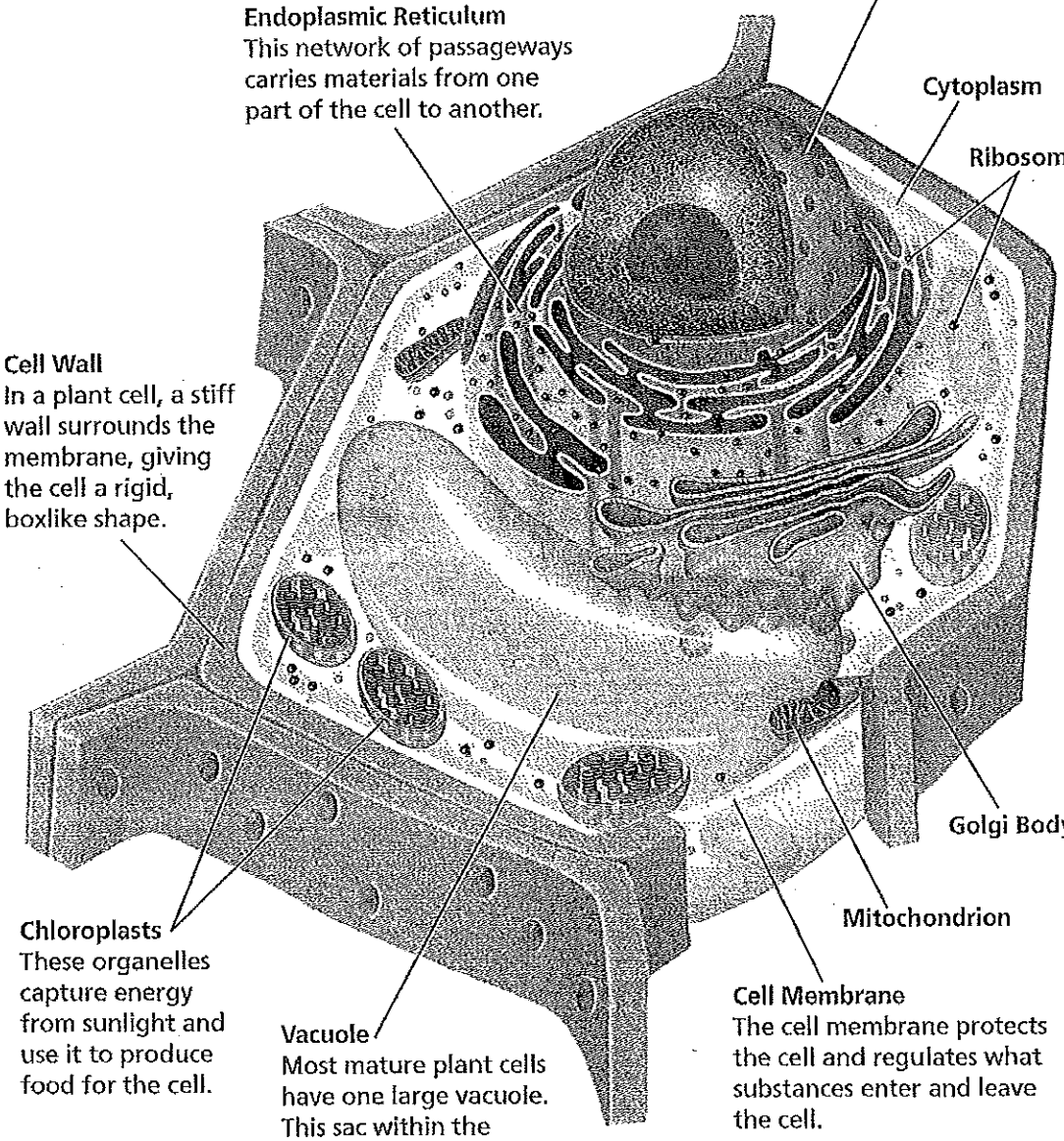


FIGURE 24

Plant and Animal Cells

These illustrations show typical structures found in plant and animal cells. Comparing and Contrasting *Identify one structure found in plant cells but not in animal cells.*



Plant Cell

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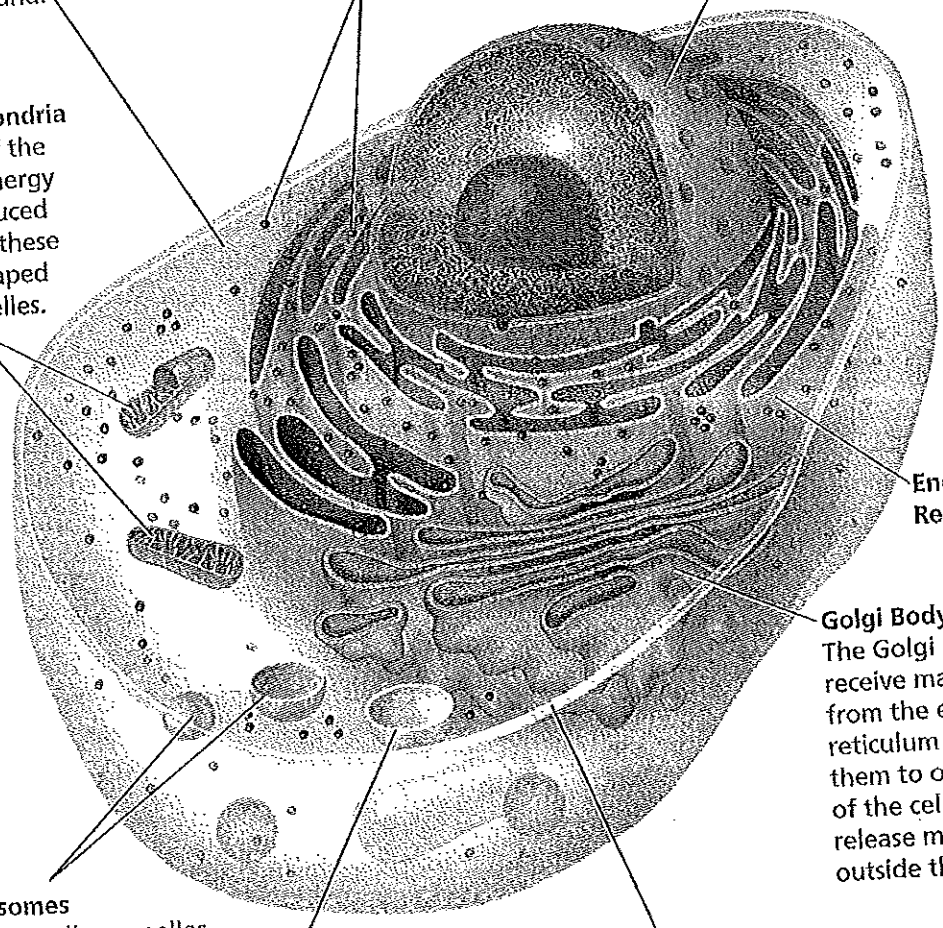


Cytoplasm
The cytoplasm includes a gel-like fluid in which many different organelles are found.

Ribosomes
These small structures function as factories to produce proteins. Ribosomes may be attached to the endoplasmic reticulum, or they may float in the cytoplasm.

Nucleus
The nucleus directs all of the cell's activities, including reproduction.

Mitochondria
Most of the cell's energy is produced within these rod-shaped organelles.

Endoplasmic Reticulum

Golgi Body
The Golgi bodies receive materials from the endoplasmic reticulum and send them to other parts of the cell. They also release materials outside the cell.

Lysosomes
These small organelles contain chemicals that break down food particles and worn-out cell parts.

Vacuole
Some animal cells have vacuoles that store food, water, waste, and other materials.

Cell Membrane
Since an animal cell does not have a cell wall, the cell membrane forms a barrier between the cytoplasm and the environment outside the cell.

Animal Cell

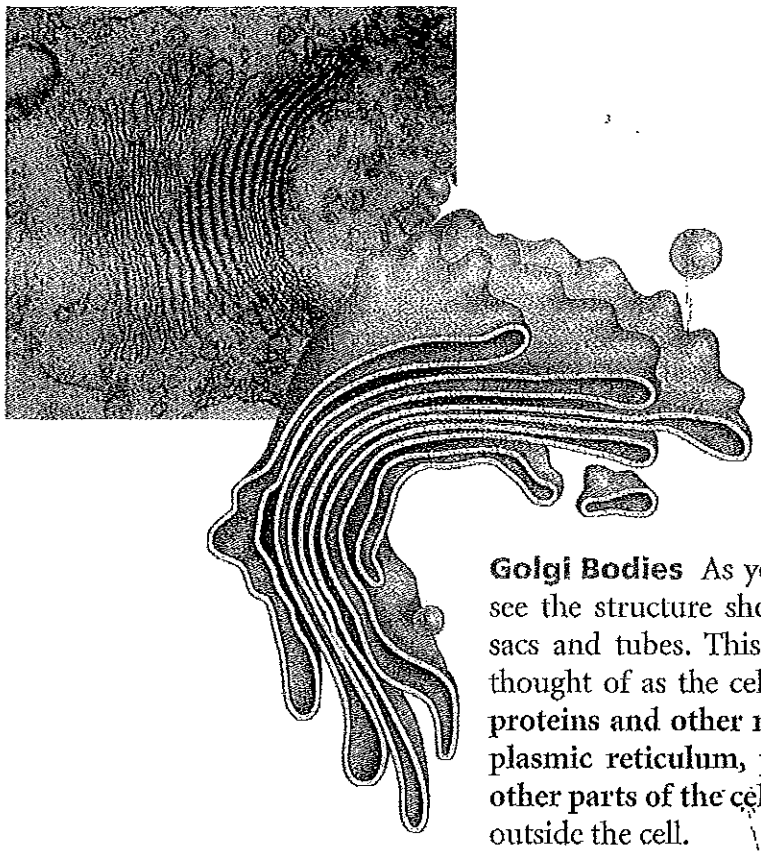


FIGURE 25
A Golgi Body
Golgi bodies are organelles that transport materials.
Applying Concepts *Why can a Golgi body be described as a cell's mail room?*

Golgi Bodies As you leave the endoplasmic reticulum, you see the structure shown in Figure 25. It looks like flattened sacs and tubes. This structure, called a **Golgi body,** can be thought of as the cell's mail room. **The Golgi bodies receive proteins and other newly formed materials from the endoplasmic reticulum, package them, and distribute them to other parts of the cell.** The Golgi bodies also release materials outside the cell.

Chloroplasts Have you noticed the many large green structures floating in the cytoplasm? Only the cells of plants and some other organisms have these green organelles called **chloroplasts. Chloroplasts capture energy from sunlight and use it to produce food for the cell.** Chloroplasts make leaves green.

Vacuoles Steer past the chloroplasts and head for that large, water-filled sac, called a **vacuole** (VAK yoo ohl), floating in the cytoplasm. **Vacuoles are the storage areas of cells.** Most plant cells have one large vacuole. Some animal cells do not have vacuoles; others do. Vacuoles store food and other materials needed by the cell. Vacuoles can also store waste products.

Lysosomes Your journey through the cell is almost over. Before you leave, take another look around you. If you carefully swing your ship around the vacuole, you may be lucky enough to see a **lysosome** (LY suh sohm). **Lysosomes are small, round structures containing chemicals that break down certain materials in the cell.** Some chemicals break down large food particles into smaller ones. Lysosomes also break down old cell parts and release the substances so they can be used again. In this sense, you can think of lysosomes as the cell's cleanup crew.

Reading Checkpoint **What organelle captures the energy of sunlight and uses it to make food for the cell?**

Lab zone **Skills Activity**

Observing

Observe the characteristics of plant and animal cells.

1. Obtain a prepared slide of plant cells from your teacher. Examine these cells under the low-power and high-power lenses of a microscope.
2. Draw a picture of what you see.
3. Repeat Steps 1 and 2 with a prepared slide of animal cells.

How are plant and animal cells alike? How are they different?

Specialized Cells

Plants and animals (including yourself) contain many cells. In a many-celled organism, the cells are often quite different from each other and are specialized to perform specific functions. Contrast, for example, the nerve cell and red blood cells in Figure 26. Nerve cells are specialized to transmit information from one part of your body to another, and red blood cells carry oxygen throughout your body.

In many-celled organisms, cells are often organized into tissues, organs, and organ systems. A tissue is a group of similar cells that work together to perform a specific function. For example, your brain is made mostly of nervous tissue, which consists of nerve cells. An organ, such as your brain, is made of different kinds of tissues that function together. In addition to nervous tissue, the brain contains other kinds of tissue that support and protect it. Your brain is part of your nervous system, which is an organ system that directs body activities and processes. An organ system is a group of organs that work together to perform a major function.

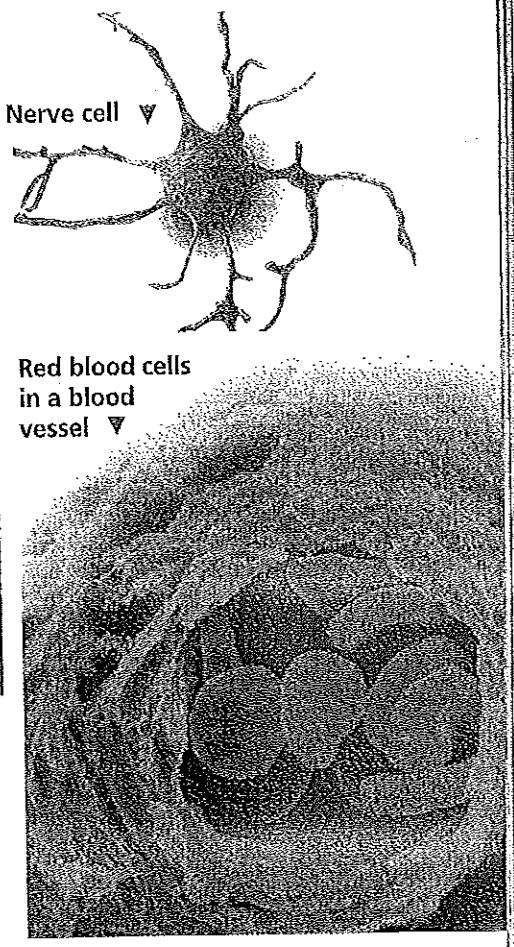


FIGURE 26 **Specialized Cells** Nerve cells carry information throughout the human body. Red blood cells carry oxygen.

Section 4 Assessment

Vocabulary Skill **Prefixes** The key term *endoplasmic reticulum* begins with the prefix *endo-*, which means "in" or "within." Within what part of a cell is the endoplasmic reticulum located?

Reviewing Key Concepts

1. a. Comparing and Contrasting Compare the functions of the cell wall and the cell membrane.
   b. Inferring How does cellulose help with one function of the cell wall?
2. a. Identifying Identify the functions of ribosomes and Golgi bodies.
   b. Describing Describe the characteristics of the endoplasmic reticulum.
   c. Applying Concepts How are the functions of ribosomes, Golgi bodies, and the endoplasmic reticulum related to one another?
3. a. Reviewing What is a tissue? What is an organ?
   b. Explaining What is the relationship among cells, tissues, and organs?
   c. Inferring Would a tissue or an organ have more kinds of specialized cells? Explain.

Writing in Science

Writing a Description Write a paragraph describing a typical animal cell. Your paragraph should include all the structures generally found in animal cells and a brief explanation of the functions of those structures.

Chapter 2 Study Guide

The BIG Idea **Cell structure and function** Cells are the basic building blocks of all living things. All cells have similar structures and carry out similar functions.

1 What Is Life?

Key Concepts

- All living things have a cellular organization, contain similar chemicals, use energy, respond to their surroundings, grow and develop, and reproduce.
- Living things arise from living things through reproduction.
- All living things must satisfy their basic needs for water, food, living space, and stable internal conditions.

Key Terms

organism
cell
unicellular
multicellular
stimulus
response
development
spontaneous generation
autotroph
heterotroph
homeostasis

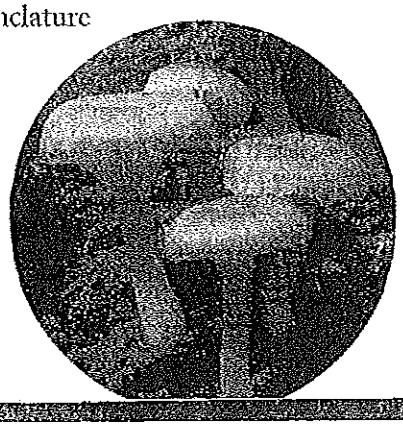
2 Classifying Organisms

Key Concepts

- Biologists use classification to organize living things into groups so that the organisms are easier to study.
- The more classification levels that two organisms share, the more characteristics they have in common.
- Organisms are placed into domains and kingdoms based on their cell type, their ability to make food, and the number of cells in their bodies.

Key Terms

classification
taxonomy
binomial nomenclature
genus
species
prokaryote
nucleus
eukaryote



3 Discovering Cells

Key Concepts

- Cells are the basic units of structure and function in living things.
- The cell theory states the following: All living things are composed of cells. Cells are the basic units of structure and function in living things. All cells are produced from other cells.
- The invention of the microscope enabled people to learn about cells. Light microscopes magnify an object by bending light. Electron microscopes use electrons instead of light.

Key Terms

cell
microscope
cell theory

4 Looking Inside Cells

Key Concepts

- A plant's cell wall protects and supports the cell. The cell membrane controls what substances come into and out of a cell.
- The nucleus directs the cell's activities.
- Mitochondria convert energy in food molecules to energy the cell can use.
- The endoplasmic reticulum carries materials throughout the cell.
- Ribosomes produce proteins.
- The Golgi bodies receive materials, package them, and distribute them.
- Chloroplasts capture energy from sunlight and use it to produce food for the cell.
- Vacuoles are the storage areas of cells.
- Lysosomes contain chemicals that break down certain materials in the cell.
- In many-celled organisms, cells are often organized into tissues, organs, and organ systems.

Key Terms

• organelle • cell wall • cell membrane
• cytoplasm • mitochondria
• endoplasmic reticulum • ribosome
• Golgi body • chloroplast • vacuole
• lysosome

Review and Assessment

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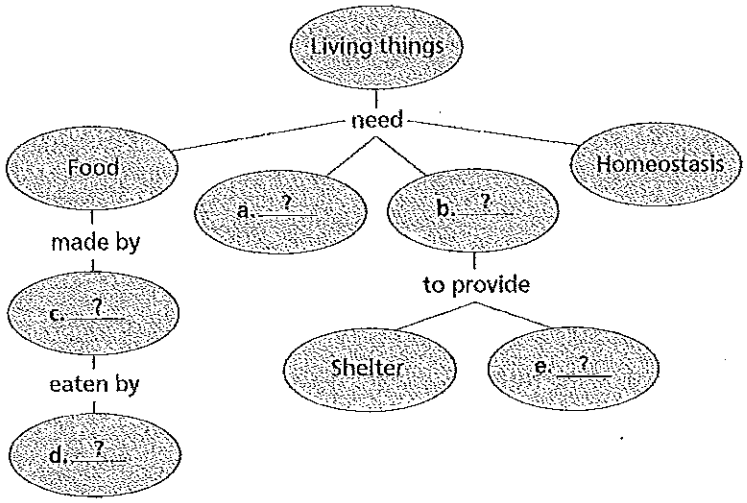
Organizing Information

Concept Mapping Copy the concept map about the needs of organisms onto a separate sheet of paper. Then complete it and add a title. (For more on Concept Mapping, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

1. The idea that life could spring from nonliving matter is called
   a. development.
   b. spontaneous generation.
   c. homeostasis.
   d. evolution.
2. The scientific study of how living things are classified is called
   a. development.
   b. biology.
   c. taxonomy.
   d. evolution.
3. A genus is divided into
   a. species. b. phyla.
   c. families. d. classes.
4. The basic units of structure in all living things are
   a. nuclei. b. organelles.
   c. tissues. d. cells.
5. In plant and animal cells, the control center of the cell is the
   a. chloroplast.
   b. cytoplasm.
   c. nucleus.
   d. Golgi body.

If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.

6. Bacteria are <u>unicellular</u> organisms.
7. Linnaeus devised a system of naming organisms called <u>binomial nomenclature</u>.
8. The gray wolf, *Canis lupus*, and the red wolf, *Canis rufus*, belong to the same <u>species</u>.
9. Cells were discovered using <u>electron</u> microscopes.
10. <u>Ribosomes</u> produce proteins.

Writing in Science

Dialogue A dialogue is a conversation. Write a dialogue that might have taken place between Schleiden and Schwann. The scientists should discuss their observations and conclusions.

Discovery SCHOOL

Cell Structure and Function
Video Preview
Video Field Trip
▶ Video Assessment

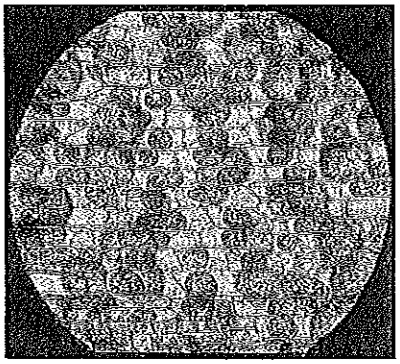
Review and Assessment

Checking Concepts

11. Your friend thinks that plants are not alive because they do not move. How would you respond to your friend?
12. Describe how your pet, or a friend's pet, meets its needs as a living thing.
13. What are the advantages of identifying an organism by its scientific name?
14. What role did the microscope play in the development of the cell theory?
15. Describe the function of the cell wall.
16. Which organelles are called the "powerhouses" of the cell? Why are they given that name?
17. How are cells usually organized in large multicellular organisms?

Thinking Critically

18. **Applying Concepts** How do you know that a robot is not alive?
19. **Inferring** Which two of the following organisms are most closely related: *Entamoeba histolytica, Escherichia coli, Entamoeba coli*? Explain your answer.
20. **Applying Concepts** The photograph below has not been artificially colored. Do the cells in the photo come from a plant or an animal? Explain your answer.

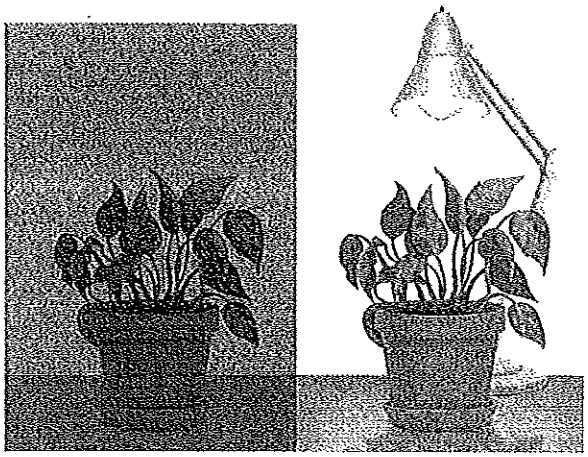


21. **Classifying** If you were trying to classify an unfamiliar organism by looking at its cells, what could the cells tell you?

Applying Skills

Refer to the illustrations below to answer Questions 22–25.

A student designed the experiment pictured below to test how light affects the growth of plants.



22. **Controlling Variables** Is this a controlled experiment? If so, identify the manipulated variable. If not, why not?
23. **Developing Hypotheses** What hypothesis might this experiment be testing?
24. **Predicting** Based on what you know about plants, predict how each plant will change in two weeks.
25. **Designing Experiments** Design a controlled experiment to determine whether the amount of water that a plant receives affects its growth.

Lab zone Chapter Project

Performance Assessment Prepare a display presenting your conclusion about your mystery object. Describe the observations that helped you to reach your conclusion. Compare your ideas with those of other students. If necessary, defend your work.