

2.3

KEY CONCEPT

Classification systems change as scientists learn more.

BEFORE, you learned

- Scientists give each species a unique scientific name
- There are seven levels of classification
- Dichotomous keys help us identify organisms

NOW, you will learn

- About the connection between new discoveries and taxonomy
- About three domains
- About six kingdoms

VOCABULARY

- domain p. 61
- Plantae p. 63
- Animalia p. 63
- Protista p. 63
- Fungi p. 63
- Archaea p. 63
- Bacteria p. 63

THINK ABOUT

How do scientists define kingdoms?

Look at this photograph of a sea urchin. It lives its life buried in or slowly moving across the ocean floor. The sea urchin's mouth is located on its underside. It feeds on food particles that settle on or are buried in the ocean floor. The sea urchin doesn't appear to have much in common with a tiger, an alligator, even a human. Yet all of these organisms belong in the same kingdom, called Animalia. Why do you think scientists would group these organisms together?



Taxonomy changes as scientists make discoveries.

The list of species continues to grow as scientists discover new species. In addition, taxonomists are learning more about the evolutionary history of species. As you read in Section 1, new knowledge resulted in the reclassification of species such as the giant panda. Both the names of species and the groups into which they are arranged may change as a result of discoveries about the evolution of these species.

Early scientists described two large groups of organisms—plants and animals. Plants were described as green and nonmoving. Animals moved. Most scientists today use a system that includes six kingdoms. In addition, taxonomists have added a level of organization above the kingdom level.

Three Domains

Microscopes and other advances in technology have allowed scientists to observe that there are three fundamentally different types of cells. Based on this observation scientists have arranged kingdoms into larger groups called **domains**. For example, the domain Eukarya contains the protists, fungi, plants, and animals.

The table below summarizes the relationships among the six kingdoms and the three domains. You will learn more about kingdoms in the rest of this section.

Domains and Kingdoms						
Domain	Bacteria	Archaea	Eukarya			
Kingdom	Bacteria	Archaea	Protista	Fungi	Plantae	Animalia
Cell type	No nucleus	No nucleus	With nucleus	With nucleus	With nucleus	With nucleus
Cell number	Unicellular	Unicellular	Unicellular	Mostly multicellular	Multicellular	Multicellular
How organisms get energy	Varies	Varies	Varies	Absorbs materials	Uses sunlight	Consumes food

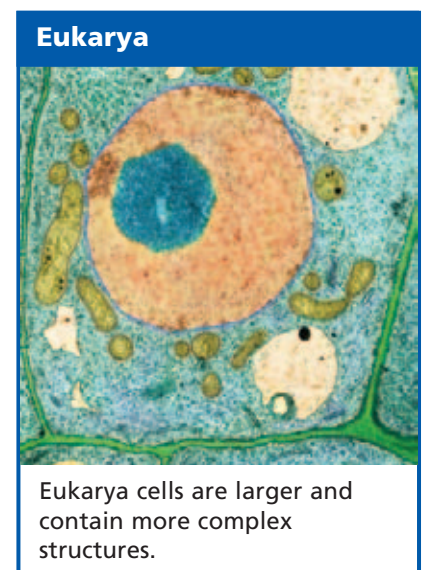
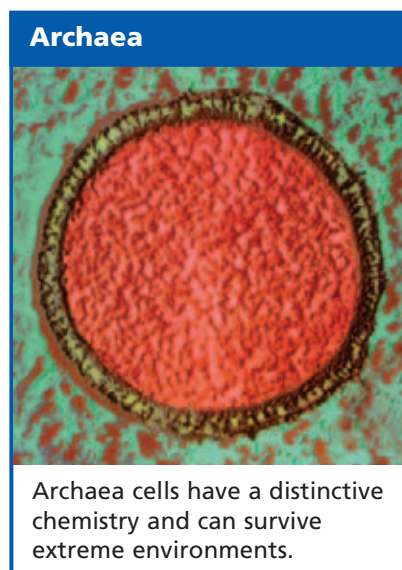
The photographs below show examples of cells from each domain. One of the traits that distinguishes cells of Eukarya from cells of Bacteria and Archaea is the presence of a nucleus. Cells that contain a nucleus are called eukaryotic cells, and cells that do not contain a nucleus are called prokaryotic cells. The domains Bacteria and Archaea include prokaryotic cells. Organisms in the domain Eukarya include those having eukaryotic cells.



How are prokaryotic cells different from eukaryotic cells?



Find out more about modern classification.



Six Kingdoms

All living things on Earth can be classified in six kingdoms.



Plantae

- Plants are multicellular and live on land.
- Plants obtain energy from sunlight.
- A plant cell has a nucleus, a cell wall, and chloroplasts.



Animalia

- Animals are multicellular and able to move.
- Animals obtain energy by eating food.
- An animal cell has a nucleus but no cell wall or chloroplasts.



Protista

- Most protists are single-celled.
- Multicellular protists lack complex structure.
- A protist cell has a nucleus.



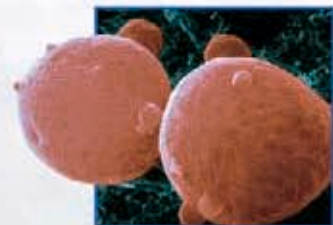
Fungi

- All fungi except yeasts are multicellular.
- Fungi obtain energy by absorbing materials.
- A fungus cell has a nucleus and a cell wall, but no chloroplasts.



Archaea

- Archaea are unicellular organisms without nuclei.
- Archaea cells have different chemicals than bacteria.
- Archaea can live in extreme conditions.



Bacteria

- Bacteria are unicellular organisms.
- A bacterial cell has no nucleus.
- Bacteria reproduce by dividing in two.



Six Kingdoms

The classification system that many scientists use today has six kingdoms. Every known species on Earth is included in one of these six kingdoms.

- Kingdom **Plantae** (PLAN-TEE) includes plants such as trees, grass, and moss.
- Kingdom **Animalia** (AN-uh-MAL-yuh) includes animals, from lions and tigers and bears to bugs and multicellular microbes.
- Kingdom **Protista** (pruh-TIHS-tuh) includes organisms that don't fit easily into animals, plants, or fungi. They are either unicellular organisms or have a simple multicellular structure.
- Kingdom **Fungi** (FUHN-jy) includes mushrooms, molds, and yeasts.
- Kingdom **Archaea** (AHR-kee-uh) contains organisms that are similar to bacteria, but have a cell structure that is so different that scientists separate them into their own kingdom.
- Kingdom **Bacteria** (bak-TIHR-ee-uh) are unicellular organisms with no nucleus.

This system may change as scientists learn more about the species in each kingdom. Before 1990, most scientists preferred a five-kingdom system that combined Archaea and Bacteria into a single kingdom. However, as scientists learned of chemical differences between the cells of the species, they arranged them into two kingdoms. Today, some scientists suggest that the kingdom Protista should be arranged into smaller kingdoms because of the many differences among its species. Many scientists agree on a system similar to the one summarized on page 62.

CHECK YOUR READING

Which of the six kingdoms include unicellular organisms?

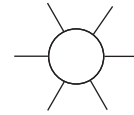
The two most familiar kingdoms are plants and animals.

Carolus Linnaeus divided all of the species he identified into two large groups: plants and animals. People still use these groups to describe most living things today. But these two kingdoms also include unfamiliar organisms.

It might seem odd that living things that are so different from each other—humans, elephants, termites, ducks, fish, worms—are all part of the same group. However, all of these organisms share some general traits, just as all plants share another set of general traits.

VOCABULARY

Add description wheels for *Plantae*, *Animalia*, *Protista*, *Fungi*, *Archaea*, and *Bacteria* to your notebook. You may want to add to your diagrams as you read the section.





Plantae

About 250,000 plant species live on Earth. They range from tiny mosses to the largest organisms on the planet, giant sequoia trees. The oldest living organism on our planet is a plant called the bristlecone pine. Some living bristlecone pines were growing when the Egyptians built the pyramids, about 4000 years ago.

All plants are multicellular and are eukaryotes, which means their DNA is stored in the nucleus of their cells. All plants are able to make sugars using the Sun's energy. Plants cannot move from place to place, but they can grow around objects, turn toward light, and grow upward. Plant cells are different from animal cells, because plant cells have tough walls outside their cell membranes.

Clematis viticella
(Italian clematis)



Animalia

Scientists have already named a million species in the kingdom Animalia. Many different types of animals inhabit the planet, but more than 90 percent of the named species are insects. The animal kingdom also includes familiar animals such as whales, sharks, humans, bears, dogs, and fish.

All animals get their energy by eating other organisms or by eating food made by other organisms. Animals have the ability to move around for at least part of their life. Most animals have mouths and some type of nervous system. Plant and animal cells are both eukaryotic, but animal cells have no cell walls.



What is the most abundant type of species in the animal kingdom?



Abracadabrella birdsville
(jumping spider)



Giraffa camelopardalis
(giraffe)



Octopus cyanea
(day octopus)

Other organisms make up four more kingdoms.

Carolus Linnaeus's classification systems included the organisms he knew about in the late 1700s. Some of the organisms Linnaeus called plants—the mushrooms, molds, and their relatives—turned out to have some characteristics very different from those of plants. Biologists now put fungi in a kingdom of their own.

Three other kingdoms consist mainly of microscopic organisms. These are Protista, Archaea, and Bacteria. Most organisms on Earth are classified as bacterial or archaea. These are prokaryotic organisms, which have small, simple cells and no nuclei.

CHECK YOUR READING

What are the four kingdoms besides Plantae and Animalia?

Protista

The kingdom Protista includes a wide variety of organisms. Most protists are unicellular. Protists that are multicellular have structures that are too simple to be classified as animals, plants, or fungi. All protists have large, complex cells with a true nucleus (eukaryotes). Some eat other organisms as animals do, some get energy from sunlight as plants do. Some protists resemble fungi. However, protists that are multicellular do not have as many specialized cells or structures as plants, animals, and fungi.

Many protists live in pond water or sea water. The largest of these unicellular species are barely visible without a microscope. However, large organisms such as seaweeds are also classified as Protista. Some seaweeds can grow hundreds of feet in a single year.

Different groups of protists evolved from different ancestors. Scientists still debate whether kingdom Protista should be classified as one kingdom or should be split into several kingdoms.



Macrocystis pyrifera
(giant kelp)



Fungi

Every time a loaf of bread is baked, a fungus is responsible for the rising dough. One group of fungi called yeasts makes it possible for us to make bread and many other food products. Another type of fungi that people eat includes some mushrooms. A mushroom grows in thin threads underground, and only the small cap breaks above the ground.

READING TIP

Fungi is the plural form of *fungus*.

Fungi are usually divided into three categories: mushrooms, molds, and yeasts. The trait that separates fungi from other organisms is that fungi take in nutrients from their surroundings instead of eating other organisms or using sunlight. Both plants and fungi remain rooted in one place. Most fungi have cell walls similar to the cell walls of plants. Unlike plants, however, many fungi act as decomposers, breaking down dead or decaying material into simpler parts that can be absorbed or recycled by other organisms.



Penicillium
(bread mold)



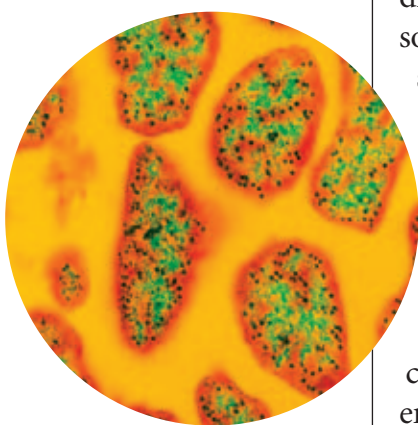
Lepiota procera
(parasol mushroom)



Archaea

In the mid-1990s a researcher studying the genes of some bacteria discovered that although they resembled bacteria in size and cell type, some species had very specific genetic differences. After more study, scientists decided to call these organisms archaea. They differ so much that scientists now classify archaea in the separate kingdom of Archaea.

Archaea appear to be more related to eukaryotes—organisms with complex cells containing nuclei—than to bacteria. Archaea do not have nuclei, but their cell structure is different from that of bacteria. Like bacteria, archaeans live in many environments, especially in the ocean. But they also live in some very extreme environments, such as boiling mud near geysers, hot vents at the bottom of the ocean, salty ponds, and deep under the sand.



Methanococcoides burtonii



Which traits classify an organism as part of the kingdom Archaea?



Bacteria

Bacteria live nearly everywhere on Earth. This kingdom includes organisms that cause human disease and spoil food, but most of these organisms are helpful members of biological communities.

All bacteria are unicellular organisms. They have small, simple cells without a nucleus. Most bacteria have a cell wall outside the cell membrane, but this wall is not the same as the cell wall of plants. Bacteria reproduce by dividing in two, which allows them to increase their numbers quickly.



Escherichia coli
(*E. coli*)

Species and environments change.

In the last chapter you have read about the ways species change over time. You have also read how the evolutionary history of species helps scientists classify living things.

Scientists have named over a million species and placed them into six kingdoms. In addition, scientists estimate that there are millions—maybe tens of millions—more species that haven't been discovered. Scientists have also discovered forms of life preserved in the fossil record. Some of those organisms are the ancestors of organisms that live today.

Species evolve over time as individual organisms and environments change. Individual organisms are faced with many other pressures that affect daily lives. These pressures may come from changes in their living space, in the availability of food or other resources, or from other organisms. In the next chapter, you will read about how groups of species are affected by changes in their surroundings.

2.3 Review

KEY CONCEPTS

1. What are the names of the six kingdoms used in the classification system?
2. How are species sorted into the various kingdoms?

CRITICAL THINKING

3. **Communicate** Make a table with columns headed Characteristics, Animalia, and Plantae. Using as many rows as needed, list characteristics that differ between these two kingdoms.
4. **Analyze** Explain how fungi differ from plants.

CHALLENGE

5. **Analyze** One bacterium has a membrane surrounding its DNA. Should this organism be classified with the eukaryotes? Why or why not?