

18.1 Finding Order in Diversity

Lesson Objectives

-  Describe the goals of binomial nomenclature and systematics.
-  Identify the taxa in the classification system devised by Linnaeus.

Lesson Summary

Assigning Scientific Names To study Earth's great diversity of organisms, biologists must give each organism a name. Biologists also must organize living things into groups in a logical way. Therefore, biologists need a classification system. The science of naming and grouping organisms is called **systematics**.

In the 1730s, Carolus Linnaeus developed a naming system, called **binomial nomenclature**. In binomial nomenclature, each species is assigned a two-part scientific name:

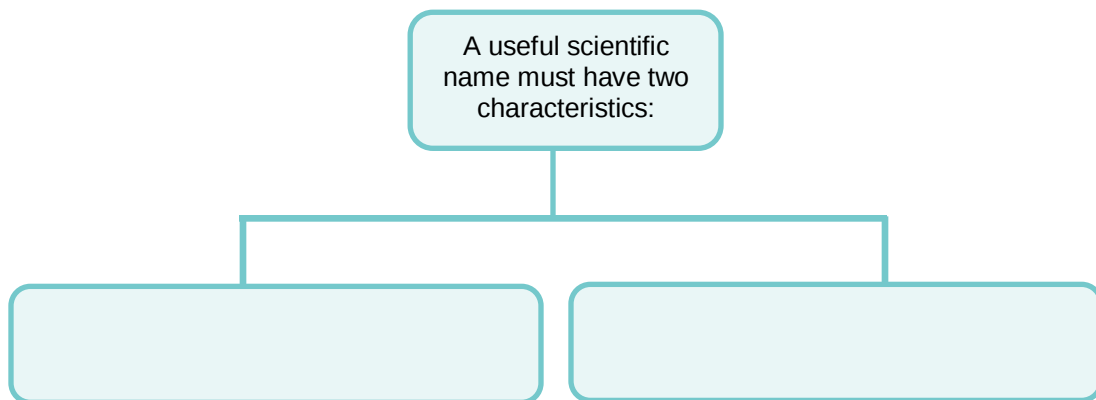
- ▶ The first part of the name refers to the **genus**, or a group of similar species.
- ▶ The second part of the name is unique to each species.

Linnaean Classification System Linnaeus's system of classification has seven different levels. From smallest to largest, the levels are species, genus, family, order, class, phylum, and kingdom. Each of the ranking levels is called a **taxon**.

- ▶ Just as a genus is a group of similar species, a **family** is a group of similar genera.
- ▶ An **order** is a group of similar families.
- ▶ A **class** is a group of similar orders.
- ▶ A **phylum** is a group of similar classes.
- ▶ A **kingdom** is a group of similar phyla.

Assigning Scientific Names

1. Complete the graphic organizer.



For Questions 2–3, write the letter of the correct answer on the line at the left.

_____ 2. What is the science of naming and grouping organisms called?

- A. genetics
- B. speciation
- C. systematics
- D. linnaeanology

_____ 3. Modern systematists try to group organisms based on

- A. size.
- B. evolutionary relationships.
- C. ecological niche.
- D. physical appearance.

4. Why is it confusing to refer to organisms by common names?

5. What is binomial nomenclature?

6. What genus does the grizzly bear, *Ursus arctos*, belong to?

7. What is the correct way to write scientific names in the binomial nomenclature system?

Linnaean Classification System

For Questions 8–10, complete each statement by writing the correct word or words.

- 8. The goal of systematics is to organize living things into groups, called _____, that have biological meaning.
- 9. The largest taxonomic category in the Linnaean system of classification is the _____, while the smallest is the _____.
- 10. Similar classes are grouped into a(n) _____, and similar orders are grouped into a(n) _____.

11. **THINK VISUALLY** Fill in the name of each missing taxonomic category in the chart below.

							KINGDOM Animalia
							Chordata
							Mammalia
							Carnivora
							Ursidae
							Ursus
							SPECIES <i>Ursus arctos</i>
							
							

Apply the Big idea

12. How does Linnaeus's system of classification help establish the unity of life?

18.2 Modern Evolutionary Classification

Lesson Objectives

-  Explain the difference between evolutionary classification and Linnaean classification.
-  Describe how to make and interpret a cladogram.
-  Explain the use of DNA sequences in classification.

Lesson Summary

Evolutionary Classification The study of evolutionary relationships among organisms is called **phylogeny**. Classification based on evolutionary relationships is called phylogenetic systematics, or evolutionary classification.

- ▶ Evolutionary classification places organisms into higher taxa whose members are more closely related to one another than they are to members of any other group. The larger the taxon, the further back in time all of its members shared a common ancestor.
- ▶ In this system, organisms are placed into groups called clades. A **clade** is a group of species that includes a single common ancestor and all descendants of that ancestor. A clade must be a monophyletic group. A **monophyletic group** must include all species that are descended from a common ancestor, and cannot include any species that are not descended from that common ancestor.

Cladograms A **cladogram** is a diagram that shows how species and higher taxa are related to each other. A cladogram shows how evolutionary lines, or lineages, branched off from common ancestors.

- ▶ In a cladogram, the place where the ancestral lineage splits is called a fork, or a node. Nodes represent the point where new lineages last shared a common ancestor.
- ▶ The bottom of the diagram, or the root, represents the ancestor shared by all of the organisms on the cladogram.
- ▶ Cladistic analysis relies on specific shared traits, or characters. A **derived character** is a trait that arose in the most recent common ancestor of a particular lineage and was passed to all of its descendants.

DNA in Classification All organisms have DNA. Because DNA is so similar across all forms of life, this molecule can be compared in different species. In general, the more derived genetic characters two species share, the more recently the species shared a common ancestor and the more closely related they are.

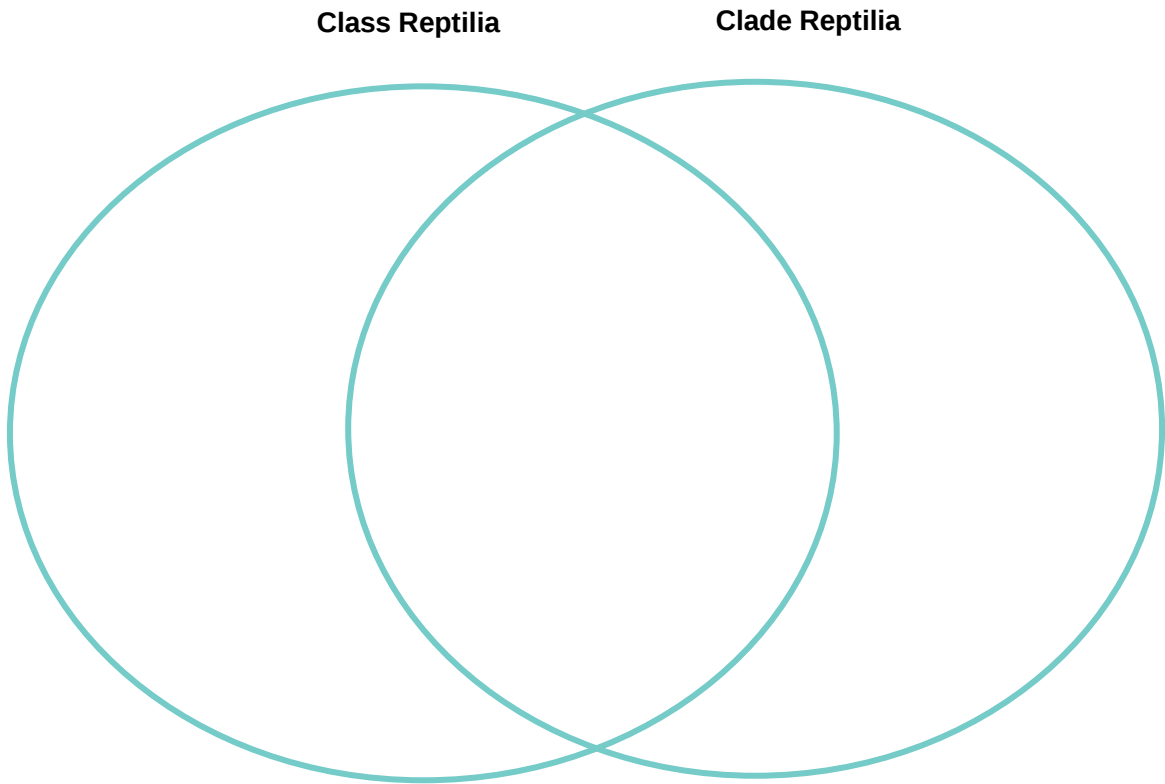
Evolutionary Classification

1. How did Darwin's theory of evolution change the way biologists thought about classification categories?

2. Describe the goal of phylogenetic systematics (evolutionary classification).

3. Which group of organisms would have the most recent common ancestor: the members of a clade corresponding to a genus or the members of a clade corresponding to an order? Explain your answer.

4. Use the Venn diagram to compare and contrast the definitions of the Linnaean class Reptilia and the clade Reptilia.



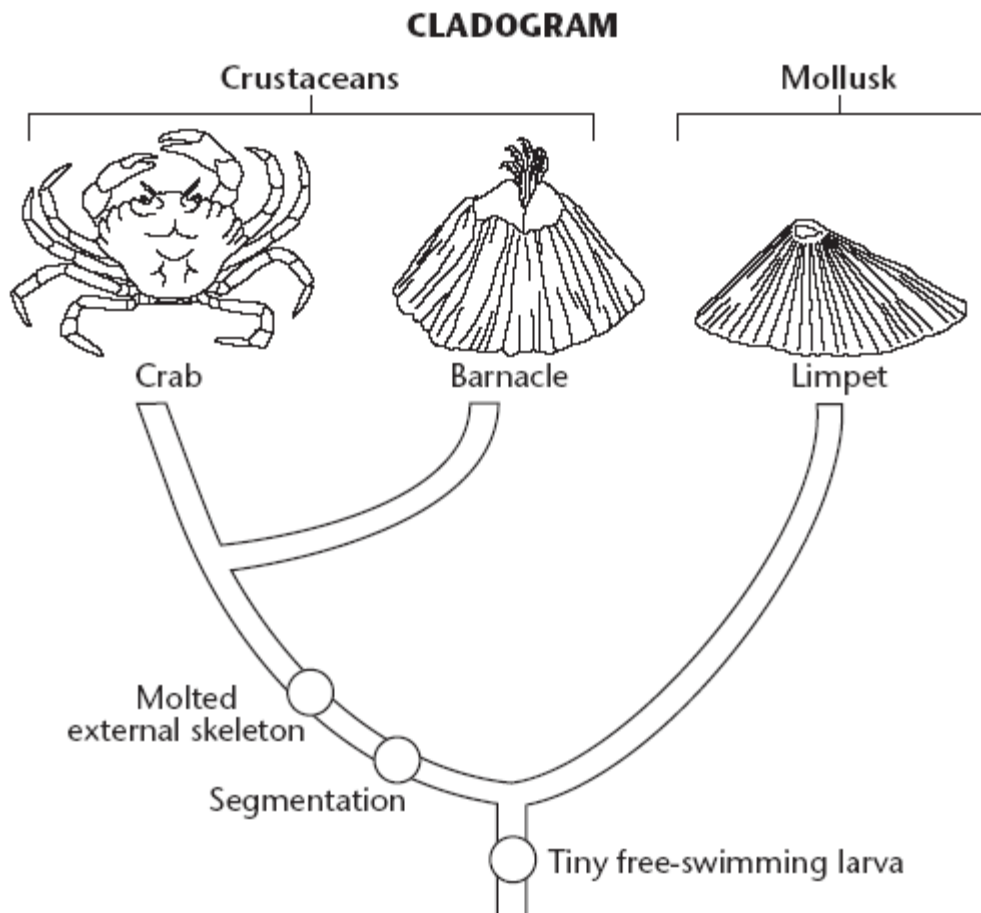
For Questions 5–7, complete each statement by writing the correct word or words.

5. All species descended from a(n) _____ are part of a monophyletic group.
6. _____ is the study of how living and extinct organisms are related to one another.
7. A clade includes a common ancestor and all its descendants, living or _____.

Cladograms

For Questions 8–10, complete each statement by writing the correct word or words.

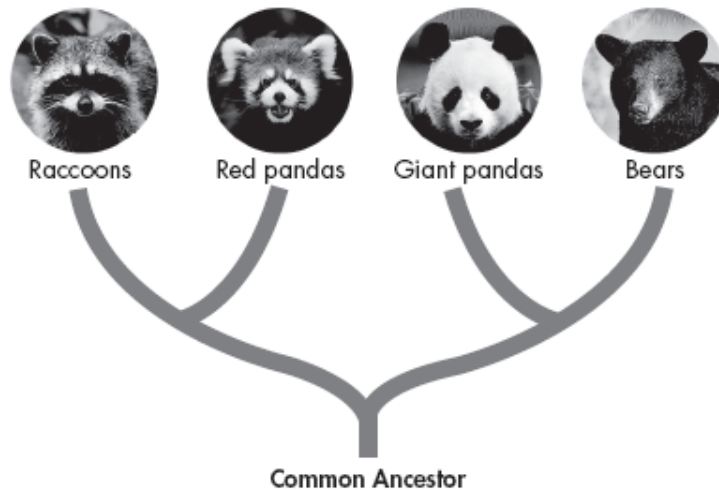
8. A diagram that shows the evolutionary relationships among a group of organisms is called a(n) _____.
9. The place where the ancestral lineage splits on a cladogram is called a fork, or a(n) _____.
10. Characteristics shared by members of a clade and only by members of that clade are called _____.
11. **THINK VISUALLY** Examine the cladogram below:
 - Shade in the two organisms that belong to a clade that does not include the third organism. Cross-hatch the organism that does not belong to the clade.
 - Circle the point on the cladogram that shows the most recent common ancestor of the crab and the barnacle.
 - Mark an X on the point on the cladogram that shows the most recent common ancestor of mollusks and crustaceans.
 - Underline the characteristic that all three organisms have in common.



DNA in Classification

12. Why can genes be considered derived characters?

Use the figure below to answer Questions 13–15.



13. According to the figure, which species is most closely related to red pandas?

14. Although giant pandas and raccoons share some distinct anatomical similarities, they are in different clades. What type of evidence do you think was used to construct this diagram?

15. Biologists had previously classified giant pandas together with raccoons and red pandas. What did DNA analysis reveal about giant pandas and bears?

Apply the Big idea

16. Both humans and yeasts have a gene that codes for a myosin protein. What does this indicate about their ancestry?

18.3 Building the Tree of Life

Lesson Objectives

-  Name the six kingdoms of life as they are currently identified.
-  Explain what the tree of life represents.

Lesson Summary

Changing Ideas About Kingdoms As biologists learned more about the natural world, they realized that Linnaeus's two kingdoms, Animalia and Plantae, did not represent all life.

- ▶ Researchers found that microorganisms were very different from plants and animals. They were placed in their own kingdom, called Protista.
- ▶ Then, yeast, molds, and mushrooms were separated from plants and placed in their own kingdom, called Fungi.
- ▶ Because bacteria lack nuclei, mitochondria, and chloroplasts, they were separated from Protista and placed in another new kingdom, called Monera.
- ▶ In the 1990s, kingdom Monera was divided into two kingdoms: Eubacteria and Archaeobacteria. The six-kingdom system of classification includes the kingdoms Eubacteria, Archaeobacteria, Protista, Fungi, Plantae, and Animalia.
- ▶ Genetic analysis revealed that two prokaryotic groups are even more different from each other, and from Eukaryotes, than previously thought. This discovery led to the creation of a new taxon, called the domain. The **domain** is a larger, more inclusive category than a kingdom. The three domain system consists of: Bacteria, Archaea, and Eukarya.
- ▶ Domain Bacteria corresponds to the kingdom Eubacteria. Domain Archaea corresponds to the kingdom Archaeobacteria. Domain Eukarya corresponds to kingdoms Fungi, Plantae, Animalia, and "Protista."
- ▶ Quotations are used for the old kingdom Protista to signify that it is not a valid clade.

The Tree of All Life The tree of life shows current hypotheses regarding evolutionary relationships among taxa within the three domains of life.

- ▶ The domain **Bacteria** includes unicellular organisms without a nucleus. They have cell walls containing a substance called peptidoglycan.
- ▶ The domain **Archaea** also includes unicellular organisms without a nucleus. These organisms have cell walls that do not contain peptidoglycan.
- ▶ The domain **Eukarya** includes the four remaining kingdoms: "Protista," Fungi, Plantae, and Animalia. All members of the domain Eukarya have cells with a nucleus.
 - Most members of the kingdom "Protista," are unicellular organisms. Some Protista are photosynthetic; others are heterotrophs.
 - Most members of the kingdom Fungi are multicellular, and all members of this kingdom are heterotrophs with cell walls containing chitin.
 - All members of the kingdom Plantae are multicellular and photosynthetic. Most plants cannot move about, and their cells have cell walls.
 - All members of the kingdom Animalia are multicellular heterotrophs. Most animals can move about, and their cells lack cell walls.

Changing Ideas About Kingdoms

1. What fundamental traits did Linnaeus use to separate plants from animals?

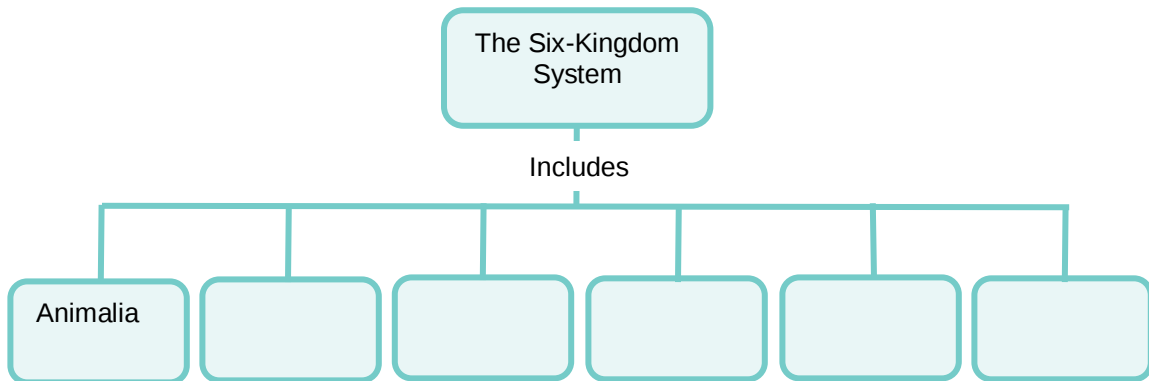
2. What types of organisms were first placed in the kingdom Protista?

3. What types of organisms were placed into the kingdom Fungi?

4. Why did scientists place bacteria in their own kingdom, the Monera?

5. What two kingdoms was kingdom Monera separated into?

6. Complete the concept map.



7. What is a domain?

8. What did genomic analysis reveal about the two prokaryotic groups?

The Tree of All Life

9. Complete the chart below.

Classification of Living Things		
Domain	Kingdom	Examples
	Eubacteria	<i>Salmonella typhimurium</i>
Archaea		<i>Sulfolobus archaea</i>
	"Protista"	
		mushrooms, yeasts
	Plantae	
		Sponges, worms, insects, fishes, mammals

Match the kingdom with the description that applies to members of that kingdom.

Kingdom

- _____ 10. "Protista"
- _____ 11. Fungi
- _____ 12. Plantae
- _____ 13. Animalia

Description

- A. They feed on dead or decaying organic matter.
- B. They have no cell walls and they move about.
- C. They are a "catchall" group of eukaryotes.
- D. They include mosses and ferns.

Apply the Big idea

14. What characteristics led camels to be classified in the same domain, kingdom, phylum, and class as dogs?

Chapter Vocabulary Review

Match the term with its definition.

Term

- _____ 1. phylogeny
- _____ 2. Bacteria
- _____ 3. order
- _____ 4. phylum
- _____ 5. clade
- _____ 6. class
- _____ 7. Eukarya
- _____ 8. domain

Definition

- A.** The domain containing all organisms that have a nucleus
- B.** The domain containing organisms that are prokaryotic and unicellular
- C.** A group of classes
- D.** A group of orders
- E.** A group of families
- F.** A group of species that includes a single common ancestor and all descendents of that ancestor
- G.** A larger, more inclusive category than a kingdom
- H.** The study of how living and extinct organisms are related to one another

For Questions 9–18, complete each statement by writing the correct word or words.

- 9. Members of the domain _____ live in some of the most extreme environments on Earth.
- 10. A(n) _____ is a trait that arose in the most recent common ancestor of a particular lineage, and was passed along to its descendants.
- 11. Multicellular organisms that move about are placed in the _____ Animalia.
- 12. Under Linnaeus' classification system, similar genera were placed into a larger category called a(n) _____.
- 13. Families, Orders, Classes, and Phyla are all _____.
- 14. The science of naming and grouping organisms is called _____.
- 15. A(n) _____ shows relative degrees of relatedness among lineages.
- 16. The name *Ursus arctos* is an example of the two-part scientific name given in the _____ system.
- 17. A(n) _____ is a group of similar species.
- 18. A clade is made up of a(n) _____.

