Activity 1-2
Sizing Up Species

AT A GLANCE

Classify organisms using a classification flow chart, play a team game to find out how many species may exist within different groups of organisms, and make a graph to illustrate the relative abundance of living things.

OBJECTIVES

Use a classification flow chart to classify organisms. Name the major groups of organisms and the relative number of species identified worldwide and statewide in each group. Construct bar graphs that compare the number of species, both worldwide and statewide, in different groups of organisms.

SUBJECTS

science

SKILLS

organizing (classifying, estimating, graphing), analyzing (calculating), interpreting (relating)

LINKS TO *ILLINOIS BIODIVERSITY BASICS* CONCEPTUAL FRAMEWORK

species diversity; species

VOCABULARY

abdomen, antennae, appendages, arthropod, bacteria, biosphere, cephalothorax, class, classification, evolution, family, fungi, genus, kingdom, order, organism, phylum, species, taxonomy

TIME

two class periods

MATERIALS

Part I—copies of "Arthropod Pictures" and "Arthropod I.D. Chart" for each student; (optional: scissors and glue)

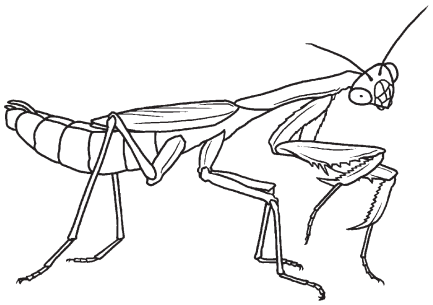
Part II—for each group, a stack of 100 sheets of paper, a ruler, a set of number cards; signs for organism groups; markers; tape or glue; (optional: calculator)

Part III—graph paper (four sheets per student or group); rulers; colored pencils

CORRELATION TO COMMON CORE STANDARDS AND NEXT GENERATION SCIENCE STANDARDS

science: MS-LS2-5

Did you know that a single tree in a rain forest can be home to more than 1,000 different kinds of insects? Or that a coral reef can support as many as 3,000 varieties of fish and other organisms? Or that the deep ocean floor may be home to more than 10,000 species of living things? The sheer number of organisms living on earth is extraordinary. So far, scientists have identified about 1.7 million species worldwide, but there are actually many more. Estimates range from 3 million to more than 100 million.



This activity will help your students understand how scientists classify organisms and how many species have been identified within various groups. They'll discover, for example, that there are nearly 950,000 different species of insects compared to about 4,000 mammal species. And there are still vast numbers of insects that are waiting to be identified—even though about 7,000 new insect species are described every year! Did you know that the state of Illinois has about 17,000 native insect species, but only about 60 species of mammals? And that there are approximately 2,500 species of plants in Illinois? The state of Illinois has more than 54,000 species of organisms. New species are still being discovered in Illinois. For example, in 1999, three spider species were discovered in Lake County. Much work remains to be done in identification of invertebrates and microscopic species.

Part I introduces students to the biological classification system by guiding them through the identification of selected orders within the Phylum Arthropoda. In Part II, students work in teams to estimate the total number of species and the number of species in various organism groups. In Part III, students learn if their estimations were correct and then create graphs that illustrate which organism groups contain the most species that have been identified to date.

Activity 1-2
Sizing Up Species (continued)

BEFORE YOU BEGIN! PART I

Make a copy of the "Arthropod Pictures" and the "Arthropod I.D. Chart" for each student. Depending on your students' choices, you may also need scissors and glue.

WHAT TO DO! PART I

1. **Introduce classification.**
   Begin by explaining to your students that scientists classify living things into various groups. The system they use classifies organisms into ever more closely related groups and gives scientists from all over the world a common way to refer to particular organisms. To give the students a sense of how this classification system works, use the following information to compare the classification of a house cat with a dog (see "Classification Chart"). The students should notice that the cat and the dog share many classification groupings. Cats and dogs are in the same kingdom, phylum, class and order, but they belong to different families. You might also ask the students to name other species that would be in the same family as a house cat (lynx, bobcat, lion, tiger, cougar and other cats) as well as other species that would be in the same family as a dog (wolf, fox, coyote, jackal and so on). You can also have the students name nonmammal chordates (animals with a backbone like fishes, amphibians, reptiles and birds) or noncat and nondog carnivores (bears, raccoons, weasels, mongooses and so on).

Classification Chart

	House Cat	Dog
Kingdom:	Animalia	Animalia
Phylum:	Chordata	Chordata
Class:	Mammalia	Mammalia
Order:	Carnivora	Carnivora
Family:	Felidae	Canidae
Genus:	*Felis*	*Canis*
Species:	*Felis catus*	*Canis familiaris*

2. **Use the "Arthropod I.D. Chart" to introduce the process of classifying organisms.**
   Hand out a copy of the "Arthropod Pictures." (Please note that this is a simplified chart and that all classes and orders in the Phylum Arthropoda are not represented.) Start by writing the names of the six kingdoms on the board or overhead (see page 29). Ask your students if they can describe some of the characteristics of organisms that would be classified in each kingdom. Ask them if they can name which kingdom includes humans. Then ask them which kingdom they think the organisms included in the "Arthropod Pictures" belong to (Animalia). Ask them to look carefully at the drawings and try to determine what characteristics all these organisms share. Students may notice that all the organisms pictured have jointed legs, antennae and other appendages. They may also know that all the organisms have a hard outer shell (exoskeleton). These common characteristics help organize them into a group, or phylum, within the Kingdom Animalia called Arthropoda. Arthropoda means "jointed feet."

   Hand out the "Arthropod I.D. Chart" and explain that the organisms in the Phylum Arthropoda can then be classified into different subgroups including subphyla and classes, which share more specific characteristics. For example, arthropods that are members of the class Insecta have six legs and a body that is divided into three major parts—head, thorax and abdomen. Scientists use keys such as this to identify unknown organisms and relate them to other more familiar species. Write the following vocabulary definitions on the board to help your students when using the chart.

appendage
any body part that extends outward from the main body, or trunk, of an animal, such as a leg, claw or antenna

antenna (singular), **antennae** (plural)
sensory appendage located on the head or cephalothorax of some arthropods

SORTING OUT TAXONOMY

Naming Things

The work of classifying organisms is done by scientists called taxonomists. Taxonomists divide organisms into a hierarchical series of more and more specific groupings. The most general division of life is into six kingdoms: Eubacteria, Archaebacteria, Protista, Fungi, Plantae and Animalia. (See page 29 for a description of each kingdom.) Within each kingdom, there are groups of increasing specificity, each one containing fewer species of increasingly close evolutionary relationships to each other. These groups are phylum, class, order, family, genus and species (see page 21). This hierarchy enables taxonomists to group organisms based on their characteristics and evolutionary relationships. Species in any given order are more closely related to each other than to species in any other order; species in any given family are more closely related to each other than to species in any other family; and so on.

What's in a Name?

Most organisms have more than one common name. For example, what some people call a woodchuck might be called a groundhog by other people. And a tree might be called downy serviceberry, shadbush or downy Juneberry, all for the same species. Or a bird might be called a house sparrow or an English sparrow, depending on who is talking about it. Common names can be very confusing! Taxonomists use Latin words to give scientific names to organisms. Not only does this clear up the confusion over common names in any one language, but it also allows scientists who speak different languages to clearly identify any particular organism or group of organisms.

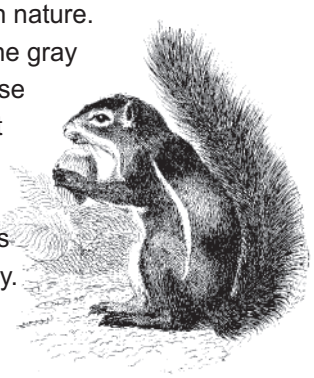
When scientists refer to a particular organism by its scientific name, they are using a combination of the genus (plural: genera) and species (singular and plural) to which the organism belongs. For example, a coyote is referred to as *Canis latrans* (*Canis* is the genus name and *latrans* is the species name). The gray wolf, a closely related species, is *Canis lupus*. The genus and species names are always italicized or underlined. The genus name is capitalized, but the species name is not.

Keeping Relationships Straight

Figuring out just where an organism belongs—how it should be classified—is not always easy. Scientists look for structural and genetic similarities among organisms that they classify together. But differences and similarities among living things are not always clear cut. Taxonomists sometimes disagree about where organisms should be classified, how genera should be arranged within families, and so on. As new information becomes available, taxonomists often revise where an organism is placed within the classification system. For example, giant pandas, which share some characteristics with raccoons and some with bears, have long been classified, along with red pandas, in their own group. However, genetic analysis has confirmed that giant pandas are actually true bears, and taxonomists are revising the species' classification based on those findings.

Defining a Species

A species is a population of organisms that interbreeds and produces fertile offspring in nature. For example, the red fox and the gray fox are different species because they coexist in many areas, but they do not interbreed.

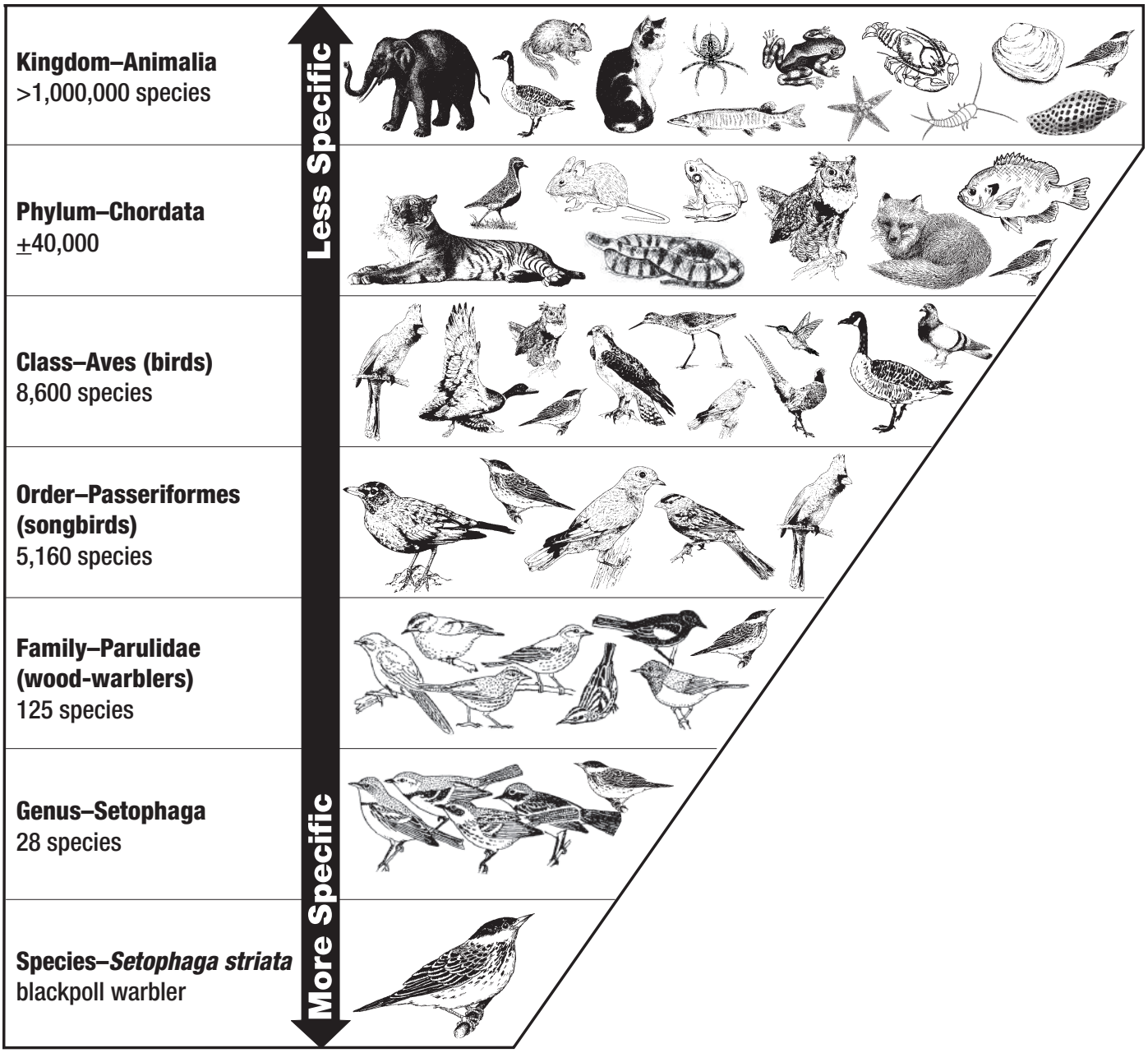


Taxonomy organizes organisms in increasing levels of specificity. A gray squirrel, for example, would be classified like this:

Kingdom: Animalia (animals)
Phylum: Chordata (animals with backbones)
Class: Mammalia (mammals)
Order: Rodentia (rodents)
Family: Sciuridae (squirrels and chipmunks)
Genus: *Sciurus* (squirrels)
Species: *carolinensis*

To refer to a gray squirrel, scientists call the animal by its scientific name: *Sciurus carolinensis*.

Sample Classification: Blackpoll Warbler



This diagram is from *Life: The Science of Biology* by Purves et al. (Sinauer Associates, Inc., 1992).

3. **Use the "Arthropod I.D. Chart" to classify scorpions, spiders, centipedes and other arthropods.** Explain to your students that they will be using the identification chart to identify each of the organisms on the "Arthropod Pictures" page. Remind them that all of the organisms are in the Kingdom Animalia and the Phylum Arthropoda. Their job is to find out which class and order each organism belongs to.

   Go over one example with the whole class to familiarize your students with the key. For example, hold up a picture of organism A, then ask the students to read the descriptions for each of the two subphyla on the I.D. chart and decide which subphylum organism A belongs to (Mandibulata).

   Next have the students read the descriptions of each of the classes beneath Mandibulata and decide which class it belongs to (Insecta). Continue to order (Coleoptera). Once your students figure out an animal's place on the chart, have them write the letter that corresponds to it under the order it belongs to.

   Now have your students work individually or in pairs to classify each of the organisms on the "Arthropod Pictures" page. Remind the students that they need to start at the top of the chart each time. If they'd like, they can cut out the organisms and glue the pictures to the proper places on the bottom of the chart.

   Answers: A = Coleoptera
   B = Cirripedia
   C = Scolopendromorpha
   D = Odonata
   E = Amphipoda
   F = Acari
   G = Decapoda
   H = Xiphosura
   I = Araneae
   J = Scorpionida

BEFORE YOU BEGIN! PART II

Your students will be working in groups of three to five. For the math problem, each group will need a ruler and a stack of 100 sheets of paper. Calculators are optional.

You'll also need to make a set of number cards for each group using a thick marker. To make each set of cards, you'll need six small pieces of paper (about 4 inches x 6 inches). Write the following numbers on separate cards: 4,000; 9,000; 19,000; 72,000; 270,000; 950,000. Make another set of cards with the following numbers: 60; 400; 200; 20,000; 2,500; 17,000. (Make the numbers large enough so they can be seen from a distance.) You may want to make each set of cards a different color. (The first set relates to species worldwide, while the second set is the number of species found in Illinois.)

Next make six signs using poster-sized or butcher paper. Write one of the following words on each sheet of paper: insects; plants; mammals; birds; fungi; and fishes. Hang the signs on the walls in your classroom. Have small pieces of tape or a glue stick handy for attaching the number cards to each large piece of paper.

WHAT TO DO! PART II

1. **Discuss how many organisms there are on earth.** Ask your students to estimate how many different kinds of organisms (species) they think there are in the biosphere, both worldwide and statewide. You may first need to explain that a species is an interbreeding population of organisms that can produce fertile, healthy offspring.

   Discourage students from simply guessing a total number of species. Instead encourage them to reflect on prior knowledge and observations. Allow students to discuss their reasoning. Have each student make an estimate and explain how he or she arrived at that number. If estimates are low, ask students if they considered organisms of all sizes, including microscopic organisms.

Finally, reveal to the students that so far scientists have identified approximately 1.7 million different organisms in the biosphere and about 54,000 species throughout the state of Illinois. But they predict that there may be an additional two to 100 million species that haven't been identified yet worldwide.

Help students gain an appreciation for how many 1.7 million is. Group the students into small teams (three to five students per team). Provide them with a ruler and a stack of 100 sheets of paper. Ask them to work together to solve this problem: If you were to write the name of every known living species (1.7 million) on a different sheet of paper and then stack up all the sheets, how tall would the stack be?

A number of different approaches may be used to solve the problem. One possible solution is to measure the height, in inches, of 100 pages, and use this measurement to calculate the height of 1,700,000 pages. Answers will vary depending on the thickness of the paper. See the "Number Crunching" box for an example.

Compare your answer to a football field, which measures 300 feet long; the Statue of Liberty, which measures 302 feet high; and the Willis Tower in Chicago that is 1,730 feet high to the top of its antenna.

Now that students have a better feel for 1.7 million, challenge them to determine how tall the stack of paper would be if they had a sheet of paper for each species that scientists predict exists but hasn't yet been discovered—1.6 to 100 million. Have the students use the same procedure to arrive at a range representing 1.6 to 100 million. Using the same type of paper, we calculated a height of 333 feet to 20,833 feet (that's more than one to almost 70 football fields tall, or more than one to 69 Statues of Liberty tall or about 0.19 to 12 times the height of the Willis Tower).

In order to help students grasp the concept of 54,000 species in Illinois, repeat the above activity, but substitute 54,000 for 1.7 million (11.25 feet). In addition, have the students calculate what percentage 54,000 is of 1.7 million (3.18 percent).

Number Crunching

Having trouble with the math? Follow these steps to find the height of your tower of paper.

First, measure the height in inches of a stack of 100 sheets of paper. In this example, the height is one-fourth inch. (We'll use the decimal 0.25.) If the height of your 100-page stack is different, substitute the measurement of your stack for the 0.25 used in this example.

Then, use the following ratio to find the height of 1.7 million sheets of paper.

1. 0.25/100 = x/1,700,000
2. 100x = 0.25 (1,700,000)
3. 100x/100 = 425,000/100
4. x = 4,250 inches
5. To calculate feet, divide by 12 inches.
   4,250 inches/12 inches = 354 feet

If you want to find the height of a different number of pages (1.6 million or 100 million), substitute that number of pages for 1,700,000.

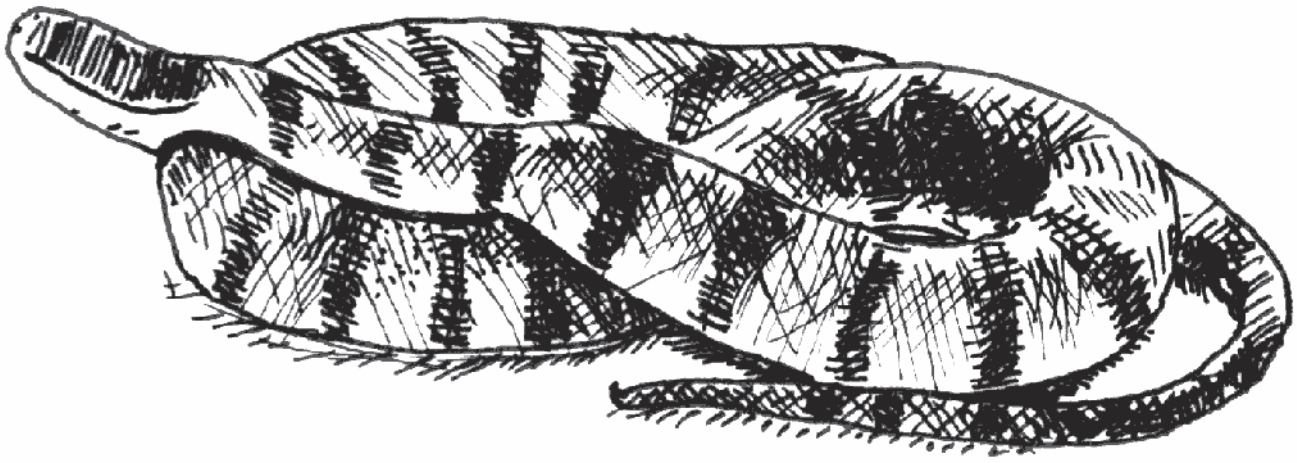
2. **Decide how many species are in each group of organisms.**
   Hand out a set of number cards (representing the worldwide numbers, see "Before You Begin") to each team, and explain that each card represents the number of species worldwide that scientists have identified in a particular group of organisms. Hold up a number card (for example, 19,000) and explain that 19,000 refers to the number of bird, plant, mammal, insect, fish or fungi species that scientists have identified. (Remind your students that this number is not the number of individuals but the number of species—

there may be millions or billions of individuals.) Now explain that each team has to work together to decide which group of organisms listed on the signs posted around the room this number refers to. Once their decisions have been made, the teams should tape their number cards on or below the appropriate signs on the wall. Teams should record their choices so they will remember them. Leave the cards on the signs. Repeat the process for the set of Illinois cards.

3. **Discuss the students' decision-making process.**
Ask your students to share the methods they used for making decisions. Did they guess or reason? Many teams may start with what they believe are the groups with the highest and lowest number of species. Some may start with the number they are most certain about and then use a process of elimination. Other teams may base their guesses on experience and observation.

4. **Reveal the actual numbers.**
Go to each sign and tell your students the correct answers. Then have your students discuss their reactions. Did any of the answers surprise them?

WORLDWIDE:		STATEWIDE:	
Insects	950,000	Insects	17,000
Plants	270,000	Plants	2,500
Fungi	72,000	Fungi	20,000
Fishes	19,000	Fishes	200
Birds	9,000	Birds	400
Mammals	4,000	Mammals	60



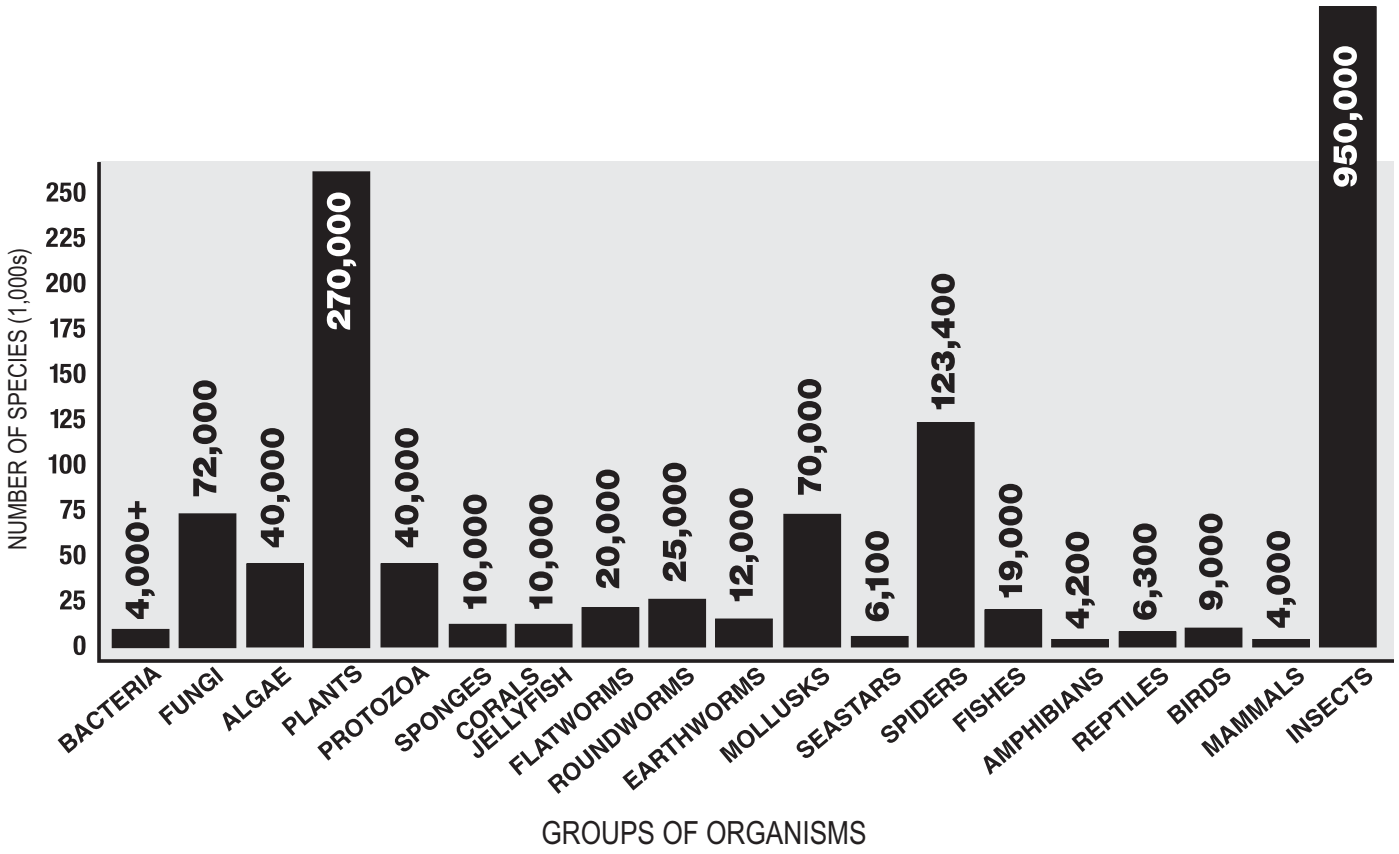
BEFORE YOU BEGIN! PART III

Each student or group will need four sheets of graph paper, rulers and colored pencils.

WHAT TO DO! PART III

1. **Discuss how the data can be presented in a graph.** (See graph below.)
   Ask your students how they would present the species data given in "Sizing Up Species" on a graph. Which format is most appropriate? (A bar graph is probably the easiest to draw, but a pie graph most dramatically illustrates the contrast in numbers of species.) Review how to set up a bar graph on the chalkboard or overhead. Explain that the vertical axis represents the number of different species in each group of organisms. The vertical axis should increase in increments of 5,000 or 10,000. They might also have each number on this axis represent 1,000 different species, so that the number 250 on the graph would actually represent 250,000 species. The horizontal axis represents the different organism groups. You can have your students graph the groups of organisms used in Part II. Next, have them compare the species worldwide with the statewide numbers.

2. **Create bar graphs to illustrate the number of species in different groups of organisms.**
   Hand out graph paper, rulers, and colored pencils, and have your students create their own graphs of the groups of organisms used in Part II. They'll each need about four sheets of graph paper to make room for the bar of 950,000 insect species. You can also have them make graphs using a computer. See the graph below for a sample.



WRAPPING IT UP

Assessment

1. Use both the classification activity and the graphing activity as bases for assessment. Have the students write an explanation of how the "Arthropod I.D. Chart" works. On the graph, have the students write the educated guesses the class discussed and how the data on the graph either do or do not support each guess.

2. Select 10 wild species that live in Illinois. Use species from a variety of taxonomic categories (mammals, birds, reptiles, amphibians, fishes, insects, crustaceans, mollusks, spiders, plants, etc.). Working in groups or as individuals, have the students research the organisms and find their classification information. Have them develop their own identification chart for the organisms.

3. Have students make a collage that includes the different classifications of species or have students choose a classification, such as mammals, and make a collage of just that classification.

4. Write a short magazine article that discusses the amazing diversity of life on earth. Include illustrations and captions.

Portfolio

1. Graphs can be part of the portfolio. The collage could also be added to the portfolio.

Extensions

1. Survey the species diversity of your school grounds or a nearby park or reserve. Your students don't need to identify the species by name; they just need to be able to tell that one species is different from another. Afterward, find out if the ratios of species in different organism groups are similar to the ratios illustrated on the graphs your students made.

2. Have students research a class (or order) of organisms within the Phylum Chordata. Tell them to find out what characteristics the animals within the class share, examples of species within the class, and the approximate number of species that have been identified to date. Have each student write a paragraph to summarize that information. Then pool the data for the group and have each student create a bar graph (on graph paper or using a computer program) that illustrates the relative numbers of species in each group. (Note: Separate the classes and orders when creating the bar graphs.)

   Here are some suggested classes: Osteichthyes (bony fishes); Amphibia; Reptilia; Aves (birds); Mammalia. Here are some suggested orders: within the Class Reptilia, Testudines (turtles), Squamata (snakes, lizards); within the Class Mammalia, Soricomorpha (moles, shrews), Rodentia (rats, mice), Carnivora (cats, dogs, weasels, raccoons), Artiodactyla (even-toed ungulates such as deer, camels, hippos).

Resources

Illinois Department of Natural Resources. 1999. *Biodiversity of Illinois, volume I: aquatic habitats.* Illinois Department of Natural Resources, Springfield, Illinois. CD-ROM.

Illinois Department of Natural Resources. 2000. *Biodiversity of Illinois, volume II: woodland habitats.* Illinois Department of Natural Resources, Springfield, Illinois. CD-ROM.

Illinois Department of Natural Resources. 2001. *Biodiversity of Illinois, volume III: prairie and edge habitats.* Illinois Department of Natural Resources, Springfield, Illinois. CD-ROM.

May, R. M. 1992. How many species inhabit the earth? *Scientific American* (267): 42-48.

Wilson, E. O. 1987. The little things that run the world. *Conservation Biology* 1(4): 344-346.

Wilson, E. O. 1988. *Biodiversity.* National Academy Press, Washington D.C., 538 pp.

World Wildlife Fund. 1994. *WOW!—A biodiversity primer.* Quad/Graphics, Pewaukee, Wisconsin. 67 pp.

Arthropod Pictures

Each of the following creatures represents a general group of arthropods. First identify all 10, then write the letter of each one in the correct place on the Arthropod I.D. Chart.

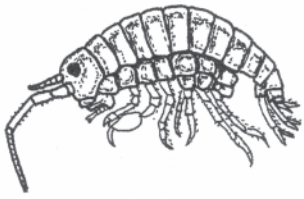
A _____

B _____

C _____

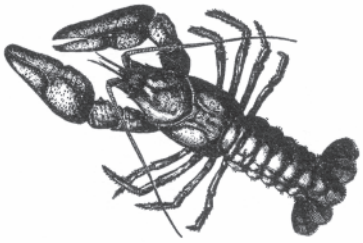
D _____

E _____



F _____

G _____

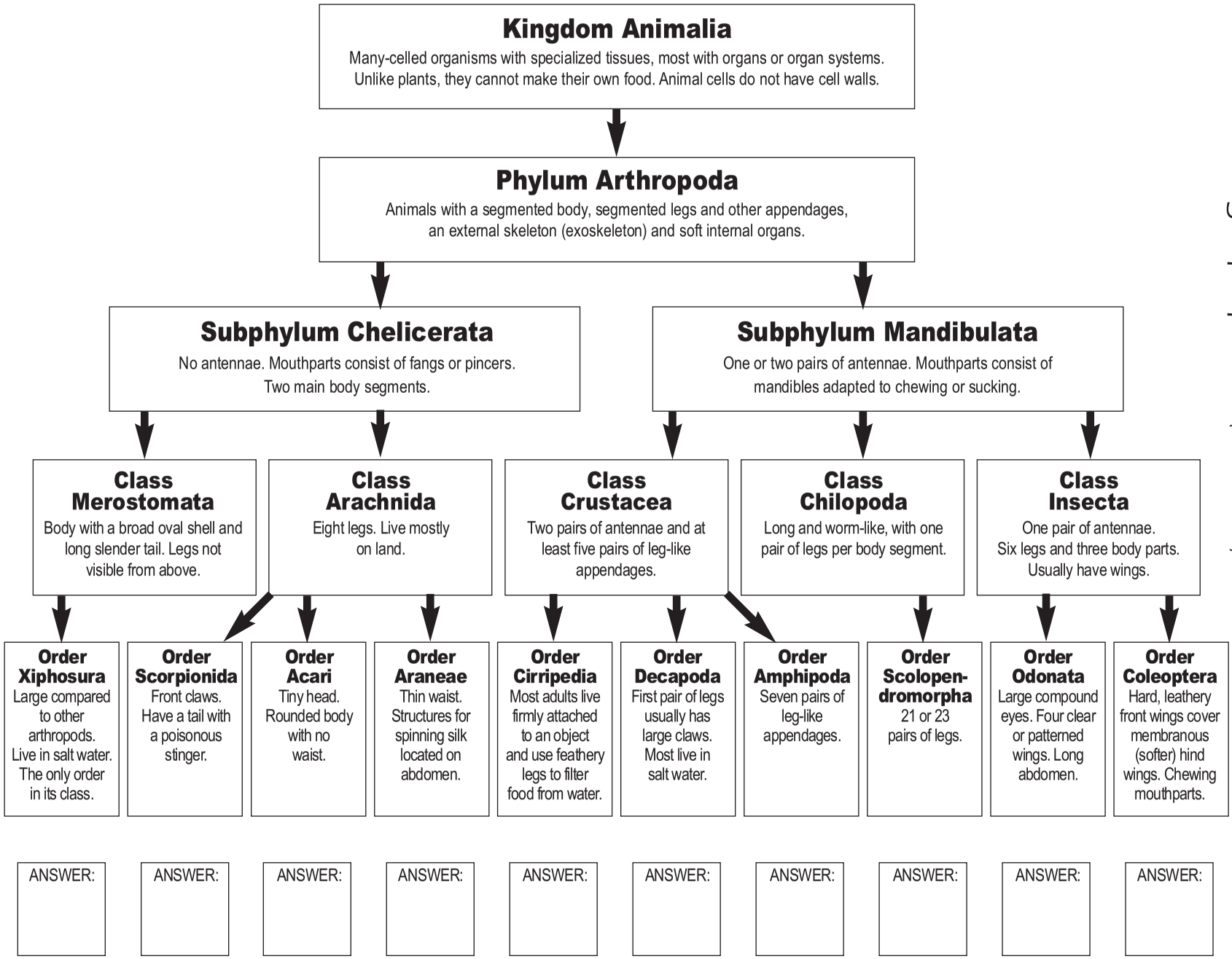


H _____

I _____

J _____

Arthropod I.D. Chart



KINGDOMS

Eubacteria

The eubacteria group contains most of the familiar types of bacteria*. These organisms are single-celled and lack a nucleus and organelles. Some of them obtain nutrients by absorption of materials from living or dead organisms; some make their own food; and some decompose dead organisms for food.

Archaebacteria

Archaebacteria are associated with extreme habitats, such as hot springs and thermal vents on the ocean floor. Like the eubacteria, they do not have a nucleus or organelles, but genetically they are structured like the eukaryotes, those organisms that do have a nucleus. This very ancient group may be the ancestors to multicellular organisms.

Protista (or Protocista)

The kingdom Protista consists of single-celled organisms. Protists have a nucleus as well as other cell structures that perform specific jobs. Protists include certain types of algae, slime molds, amoebas and diatoms.

Fungi

Most fungi are made of many cells. Mushrooms, molds, yeasts and mildews are examples of fungi. They are not able to make their own food. Instead, they get their food energy by digesting the organisms on which they grow (usually plants).

Plantae

As you might guess, this is the kingdom of plants. Most plants produce their own food energy through photosynthesis—a chemical reaction involving sunlight, carbon dioxide and water in the presence of chlorophyll. Flowering plants, mosses, ferns and certain types of algae are members of this kingdom.

Animalia

Most animals are multicellular organisms that have specialized tissues, organs and organ systems. Unlike plants, animals cannot make their own food, and their cells don't have cell walls. Fishes, amphibians, reptiles, birds, mammals and insects and other invertebrates are all part of the Kingdom Animalia.

*The number of kingdoms is often under debate, depending on how scientists interpret current research.