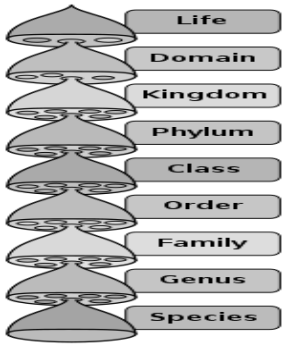
Explaining Classification:
Read the following and complete your graphic organizer as you read.

Organization helps us make sense of our surroundings. Some people organize their sock drawers by color. Books in a library are often organized by topic, the activity you did at the beginning of this sequence, "What is That Mess", and arrangement of food in grocery stores is organized so we know just where to find something.

For scientists, organization is an essential tool. The organization of similar organisms into groups helps scientists understand how living things are related. It also allows scientists to communicate about all forms of life. For example, suppose a scientist in the United States writes about a specific group of animals. Other scientists around the world will know exactly what group of animals to which the writer is referring. But how do scientists decide which organisms to group together? Do they use a particular process?
Scientists classify organisms in different ways.

Scientists organize the living world using a process called **taxonomy**, which is the science of classifying organisms based on shared structures, functions, and relationships to other organisms. For example, organisms can be classified based on their cellular structure. Organisms that have nuclei are eukaryotes. Eukaryotes also have organelles, or specialized structures bound in a membrane. They are in a different group than prokaryotes, which are organisms that do not have **nuclei** (Plural for nucleus; Part of the cell that holds structures that control cell activities). Also, many **unicellular** (made up of one cell) organisms are in a different group than are **multicellular** (made up of more than one cell) organisms. For example, bacteria are unicellular organisms. They are in a different group than animals, which are multicellular.



Living things also can be classified according to the way in which they obtain food. Think about the differences between plants and animals. Plants make their own food and are called *autotrophs*. Animals must consume other organisms and are called *heterotrophs*. This difference classifies plants and animals into two separate groups.

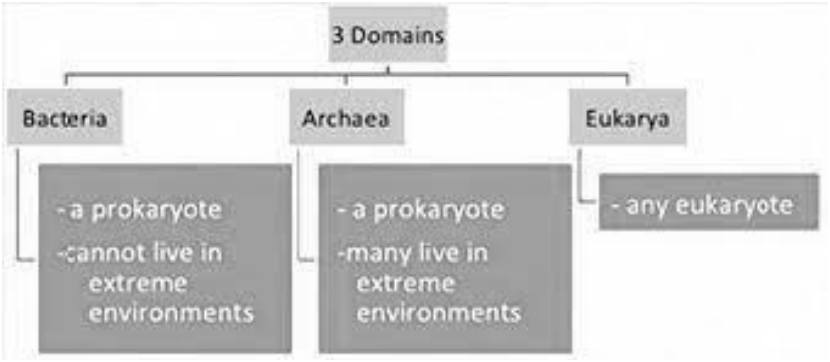
Method of reproduction can be used to classify organisms into even smaller groups. The two main reproductive methods are asexual and sexual reproduction. In asexual reproduction, only one parent is involved in producing offspring. In sexual reproduction, two parents are involved: a male and a female.

Look at the images below. Which organisms would you group together? Why? What additional information would you need to know about the organisms to improve how you classified them?






Scientists classify organisms into three domains.
Scientists use a branching system of classification. The broadest group is the domain. Each domain is subdivided into kingdoms, followed by phyla, classes, orders, families, genera, and species. We will focus on domains and kingdoms.



All living organisms are classified into one of three domains: Bacteria, Archaea, and Eukarya. The domain Bacteria includes organisms commonly referred to as bacteria, which are unicellular prokaryotes. They are tiny organisms that reproduce asexually. Some bacteria are autotrophs (make their own food), but most of them are heterotrophs (consume their food).

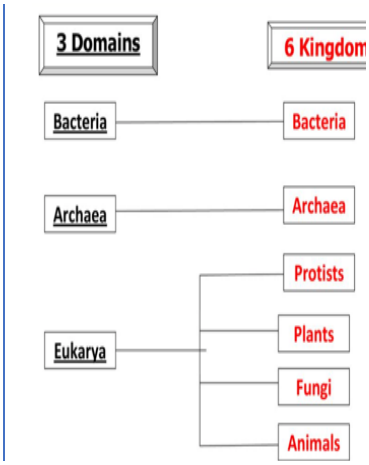
The organisms in the domain Archaea are a specialized group of unicellular prokaryotes. Scientists discovered these unique organisms living in areas with extreme conditions. Some archaea are found in hot springs and are called thermophiles (heat loving). Other archaea are found in very salty conditions and are called halophiles (salt loving). Similar to bacteria, archaea reproduce asexually. Some archaea are autotrophs, and others are heterotrophs. You might

wonder why archaea and bacteria are divided into separate domains. After all, they are both unicellular prokaryotes.

In the 1970s, a study revealed that the cellular structures of archaea are so different from bacteria that they deserve their own domain. For example, archaea have a unique plasmid membrane structure not found in any other organisms.

Some of the first archaea were discovered in Hot Springs like this one. Hot Springs are natural pools of extremely hot water.

Scientists classify organisms into six kingdoms.
The three domains are further divided into six kingdoms. See diagram below.



The first two kingdoms are easy to remember. The domain Bacteria has just one kingdom: Bacteria. The domain Archaea also has just one kingdom: Archaea. Classification gets more complicated when identifying the organisms in the domain Eukarya.

The Domain Eukarya has four kingdoms: Animalia, Plantae, Fungi, and Protista. They are classified based on the complexity of their cellular organization, their ability to obtain nutrients, and their mode of reproduction.

Organisms in the kingdom Animalia are the most complex and are commonly referred to as animals. They are multicellular heterotrophs. Most reproduction in this kingdom is sexual, although a few animals can reproduce asexually. For example, if you divide a flatworm in half, each of the two halves will grow into a new flatworm.

In the kingdom Plantae, the organisms are referred to as plants and are also very complex. Plants are autotrophs since they make their own food. They are multicellular and can reproduce sexually or asexually.

The kingdom Fungi includes organisms such as mushrooms and molds. Most fungi are multicellular and can reproduce sexually or asexually. All fungi are heterotrophs. However, the way in which they obtain food is unique. Fungi absorb nutrients from the environment.

Think about a piece of moldy bread. The mold is a fungus that releases chemicals to break down the bread into smaller substances. The mold can then absorb these smaller substances, using them as nutrients. This characteristic makes fungi different from animals.

The kingdom Protista includes organisms with simple structures compared to other eukaryotes. There is great diversity among the protists. Most of them are unicellular. However, some protists are multicellular. Some are autotrophs, in which case they resemble plants. Other protists are heterotrophs, more closely resembling animals. Most Protists can reproduce asexual, but a few such as green algae and slime mold can reproduce sexually. They swim through water and consume nutrients from their environment. Their simple organization keeps them in a kingdom separate from plants and animals.

The simple organization of Euglena places them in the kingdom Protista.

Protists have been the most difficult group of organisms for scientists to classify. Some protists, such as green algae, have the photosynthetic pigment chlorophyll, which gives them a green color like that of plants. Other protists behave more like animals, with whiplike structures that allow them to zoom around in the water. You can think of protists as the *other* category. They are single-celled organisms with a nucleus, but their structures are too simple to qualify them as plants or animals.

Linnaean Classification

The evolution of life on Earth over the past 4 billion years has resulted in a vast variety of **species**. For more than 2,000 years, humans have been trying to classify the great diversity of life. The science of classifying organisms is called **taxonomy.** Classification is an important step in understanding the present diversity and past evolutionary history of life on Earth.

All modern classification systems have their roots in the **Linnaean classification** system. It was developed by Swedish botanist Carolus Linnaeus in the 1700s. He tried to classify all living things that were known at his time. He grouped together organisms that shared obvious physical traits, such as number of legs or shape of leaves. For his contribution, Linnaeus is known as the "father of taxonomy."

The Linnaean system of classification consists of a hierarchy of groupings, called **taxa** (singular, taxon). Taxa range from the **kingdom** to the species (see the **Figure** below). The **kingdom** is the largest and most inclusive grouping. It consists of organisms that share just a few basic similarities. Examples are the plant and animal kingdoms. The **species** is the smallest and most exclusive grouping. It consists of organisms that are similar enough to produce fertile offspring together. Closely related species are grouped together in a **genus.** As organisms become less closely related, they are successively grouped into families, orders, classes, phyla, and finally Kingdoms and Domains.

Taxon ↓				
Species	*sapiens*	*troglodytes*	*musculus*	*naja*
Genus	*Homo*	*Pan*	*Balaenoptera*	*Naja*
Family	Hominidae	Hominidae	Balaenopteridae	Elapidae
Order	Primates	Primates	Artiodactyla	Squamata
Class	Mammalia	Mammalia	Mammalia	Reptilia
Phylum	Chordata	Chordata	Chordata	Chordata
Kingdom	Animalia	Animalia	Animalia	Animalia

[Figure 2]

Linnaean Classification System: This chart shows the taxa of the Linnaean classification system. Each taxon is a subdivision of the taxon below it in the chart. For example, a species is a subdivision of a genus.

Binomial Nomenclature

Perhaps the single greatest contribution Linnaeus made to science was his method of naming species. This method, called **binomial nomenclature**, gives each species a unique, two-word Latin name consisting of the genus name and the species name. An example is *Homo sapiens*,

the two-word Latin name for humans. It literally means “wise human.” This is a reference to our big brains.

Why is having two names so important? It is like people having a first and a last name. You may know several people with the first name Michael but adding Michael’s last name usually pins down exactly whom you mean. In the same way, having two names uniquely identifies a species.

Discover Science: A Changing Classification System

The classification system we use today has changed many times over the years as new information has been discovered. Swedish scientist Carl Linnaeus is known for creating the first version of the modern taxonomy system in the 1700s. He classified organisms into two kingdoms: Animalia and Plantae. Years later, as scientists were able to use better microscopes and observe organisms more closely, they added three more kingdoms to the system: Monera (unicellular prokaryotes), Protista, and Fungi. In recent years, the classification shifted again, and it is now the three-domain system about which you have just learned. The new system is based on information from cell studies and the recent discovery of archaea. Do you think the system will change again in the future? If you answered yes, you are probably right! Scientists are always making new discoveries. Some of these discoveries will encourage them to rethink the current three-domain system.