2.3: Diversity of Life

So Many Species!

The collage below shows six kingdoms into which all of Earth's living things are commonly classified. How many species are there in each kingdom? In a word, millions. A total of almost 2 million living species have already been identified, and new species are being discovered all the time. Scientists estimate that there may be as many as 30 million different species alive on Earth today! Clearly, there is a tremendous variety of life on Earth.

Figure (PageIndex{1}): Six kingdoms of life: Archaea, Bacteria, Protista, Fungi, Animalia, and Plantae (CC BY-SA 3.0; Maulucioni y Doridi via Wikimedia commons)
What Is Biodiversity?

Biological diversity, or biodiversity, refers to all of the variety of life that exists on Earth. Biodiversity can be described and measured at three different levels: species, genetic, and ecosystem diversity.

- Species diversity refers to the number of different species in an ecosystem or on Earth as a whole. This is the commonest way to measure biodiversity. Current estimates for Earth's total number of living species range from 5 to 30 million species.
- Genetic diversity refers to the variation in genes within all these species.
- Ecosystem diversity refers to the variety of ecosystems on Earth. An ecosystem is a system formed by populations of many different species interacting with each other and their environment.

Defining a Species

Biodiversity is most often measured by counting species, but what is a species? The answer to that question is not as straightforward as you might think. The formal biological definition of species is a group of actually or potentially interbreeding organisms. This means that members of the same species are similar enough to each other to produce fertile offspring together. By this definition of species, all human beings alive today belong to one species, Homo sapiens. All humans can potentially interbreed with each other but not with members of any other species.

In the real world, it isn't always possible to make the observations needed to determine whether different organisms can interbreed. For one thing, many species reproduce asexually, so individuals never interbreed even with members of their own species. When studying extinct species represented by fossils, it is usually impossible to know whether different organisms could interbreed. Therefore, in practice, many biologists and virtually all paleontologists generally define species on the basis of morphology, rather than breeding behavior. Morphology refers to the form and structure of organisms. For classification purposes, it generally refers to relatively obvious physical traits. Typically, the more similar to one another different organisms appear, the greater the chance that they will be classified in the same species.

Classifying Living Things

People have been trying to classify the tremendous diversity of life on Earth for more than two thousand years. 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. It helps make sense of the overwhelming diversity of living things.

Linnaean Classification

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 morphological traits, such as the 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). Figure 2 shows an expanded version of Linnaeus's original classification system. In the original system, taxa range from the kingdom to the species. 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. Ideally, it consists of organisms that are similar enough to interbreed, as discussed above. Similar species are classified together in the same genus (plural, genera), similar genera are classified together in the same family, and so on all the way up to the kingdom.

**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 followed by a specific species identifier. 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 similar to 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 who you mean. In the same way, having two names uniquely identifies a species.

**Revisions in the Linnaean Classification**

Linnaeus published his classification system in the 1700s. Since then, many new species have been discovered. Scientists can also now classify organisms on the basis of their biochemical and genetic similarities and differences.
rather than just their outward morphology. These changes have led to revisions in the original Linnaean system of classification.

A major change to the Linnaean system is the addition of a new taxon called the domain. The domain is a taxon that is larger and more inclusive than the kingdom, as shown in Figure 2. Most biologists agree that there are three domains of life on Earth: Bacteria, Archaea, and Eukarya (Figure 3). Both the Bacteria and the Archaea domains consist of single-celled organisms that lack a nucleus. This means that their genetic material is not enclosed within a membrane inside the cell. The Eukarya domain, in contrast, consists of all organisms whose cells have a nucleus. In other words, their genetic material is enclosed within a membrane inside the cell. The Eukarya domain is made up of both single-celled and multicellular organisms. This domain includes several kingdoms, including the animal, plant, fungus, and protist kingdoms.

![Figure 3: Three domains of life: Bacteria, Archaea, and Eukarya. (CC BY-SA 4.0; Crion via Wikimedia commons)](image)

**Phylogenetic Classification**

Linnaeus classified organisms based on morphology. Basically, organisms were grouped together if they looked alike. After Darwin published his theory of evolution in the 1800s, scientists looked for a way to classify organisms that took into account phylogeny. **Phylogeny** is the evolutionary history of a group of related organisms. It is represented by a phylogenetic tree, or some other tree-like diagram, like the one in Figure 3 for the three domains. A phylogenetic tree shows how closely related different groups of organisms are to one another. Each branching point represents a common ancestor of the branching groups. Figure 3, for example, shows that the Eukarya shared a more recent common ancestor with the Archaea than they did with the Bacteria. This is based on comparisons of important similarities and differences between the three domains.

**Summary**

- Biodiversity refers to the variety of life that exists on Earth. It includes species diversity, genetic diversity within species, and ecosystem diversity.
- The formal biological definition of species is a group of actually or potentially interbreeding organisms. Our own species, *Homo sapiens*, is an example. In reality, organisms are often classified into species on the basis of morphology.
- A system for classifying living things was introduced by Linnaeus in the 1700s. It includes taxa from the species (least inclusive) to the kingdom (most inclusive). Linnaeus also introduced a system of naming species, called binomial nomenclature.
• The domain, a taxon higher than the kingdom, was later added to the Linnaean system. Living things are generally grouped into three domains: Bacteria, Archaea, and Eukarya. The human species and other animal species are placed in the Eukarya domain.

• Modern systems of classification take into account phylogenies, or evolutionary histories of related organisms, rather than just morphological similarities and differences. These relationships are often represented by phylogenetic trees or other tree-like diagrams.

Review

1. What is biodiversity? Identify three ways that biodiversity may be measured.
2. Define biological species. Why is this definition often difficult to apply?
3. Explain why it is important to classify living things and outline the Linnaean system of classification.
4. What is binomial nomenclature? Give an example.
5. Contrast Linnaean and phylogenetic systems of classification.
6. Describe the taxon called the domain, and compare the three widely recognized domains of living things.
7. True or False. Humans have identified all of the species on Earth.
8. True or False. In the binomial nomenclature for humans, Homo is the genus and sapiens refers to the specific species.
9. A kingdom is a:
   A. domain
   B. taxon
   C. genera
   D. phylogeny
10. In Linnaean classification, similar classes together make up a ___________.
11. Based on the phylogenetic tree for the three domains of life above, explain whether you think Bacteria are more closely related to Archaea or Eukarya.
12. A scientist discovers a new single-celled organism. Answer the following questions about this discovery.
   A. If this is all you know, can you place the organism into a particular domain? If so, what is the domain and if not, why not?
   B. What is one type of information that could help the scientist classify the organism?
13. Define morphology. Give an example of a morphological trait in humans.
14. Which type of biodiversity is represented by the differences between humans?
15. Why do you think it is important for the definition of a species that members of a species can produce fertile offspring?

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Watch the video below to learn more about Carolus Linnaeus's life and work.

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