22.1A: Classification of Prokaryotes

Prokaryotic organisms were the first living things on earth and still inhabit every environment, no matter how extreme.

Learning Objectives

- Discuss the origins of prokaryotic organisms in terms of the geologic timeline

Key Points

- All living things can be classified into three main groups called domains; these include the Archaea, the Bacteria, and the Eukarya.
- Prokaryotes arose during the Precambrian Period 3.5 to 3.8 billion years ago.
- Prokaryotic organisms can live in every type of environment on Earth, from very hot, to very cold, to super haline, to very acidic.
- The domains Bacteria and Archaea are the ones containing prokaryotic organisms.
- The Archaea are prokaryotes that inhabit extreme environments, such as inside of volcanoes, while Bacteria are more common organisms, such as *E. coli*.

Key Terms

- prokaryote: an organism whose cell (or cells) are characterized by the absence of a nucleus or any other membrane-bound organelles
- domain: in the three-domain system, the highest rank in the classification of organisms, above kingdom: Bacteria, Archaea, and Eukarya
Evolution of Prokaryotes

In the recent past, scientists grouped living things into five kingdoms (animals, plants, fungi, protists, and prokaryotes) based on several criteria such as: the absence or presence of a nucleus and other membrane-bound organelles, the absence or presence of cell walls, multicellularity, etc. In the late 20th century, the pioneering work of Carl Woese and others compared sequences of small-subunit ribosomal RNA (SSU rRNA) which resulted in a more fundamental way to group organisms on earth. Based on differences in the structure of cell membranes and in rRNA, Woese and his colleagues proposed that all life on earth evolved along three lineages, called domains. The domain Bacteria comprises all organisms in the kingdom Bacteria, the domain Archaea comprises the rest of the prokaryotes, and the domain Eukarya comprises all eukaryotes, including organisms in the kingdoms Animalia, Plantae, Fungi, and Protista.

The current model of the evolution of the first, living organisms is that these were some form of prokaryotes, which may have evolved out of protobionts. In general, the eukaryotes are thought to have evolved later in the history of life. However, some authors have questioned this conclusion, arguing that the current set of prokaryotic species may have evolved from more complex eukaryotic ancestors through a process of simplification. Others have argued that the three domains of life arose simultaneously, from a set of varied cells that formed a single gene pool.

Two of the three domains, Bacteria and Archaea, are prokaryotic. Based on fossil evidence, prokaryotes were the first inhabitants on Earth, appearing 3.5 to 3.8 billion years ago during the Precambrian Period. These organisms are abundant and ubiquitous; that is, they are present everywhere. In addition to inhabiting moderate environments, they are found in extreme conditions: from boiling springs to permanently frozen environments in Antarctica; from salty environments like the Dead Sea to environments under tremendous pressure, such as the depths of the ocean; and from areas without oxygen, such as a waste management plant, to radioactively-contaminated regions, such as Chernobyl. Prokaryotes reside in the human digestive system and on the skin, are responsible for certain illnesses, and serve an important role in the preparation of many foods.

Figure 1: Prokaryotes in extreme environments: Certain prokaryotes can live in extreme environments such as the Morning Glory pool, a hot spring in Yellowstone National Park. The spring's vivid blue color is from the prokaryotes that thrive in its very hot waters.