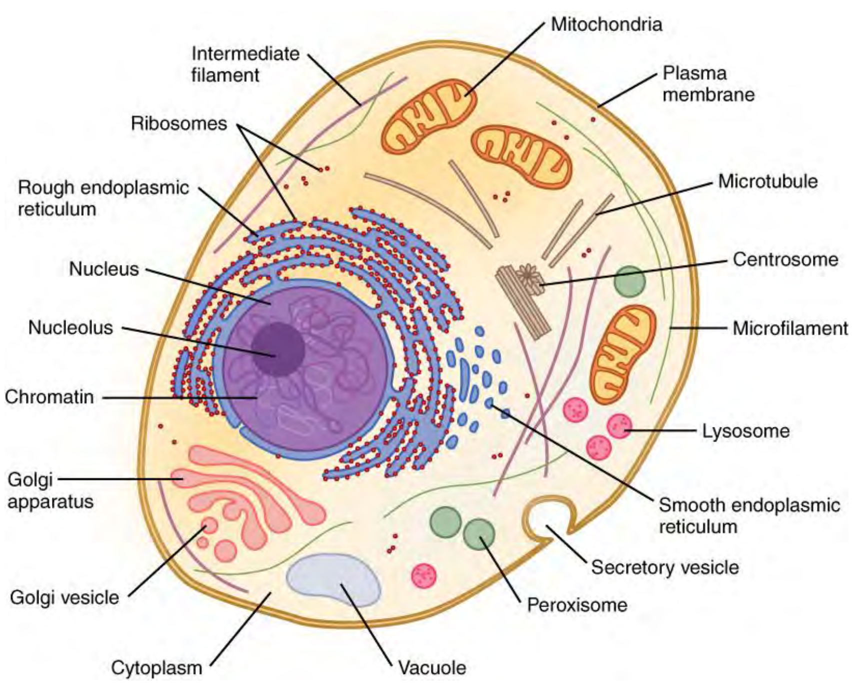
The domains of Bacteria and Archaea are both classified as prokaryotic cells, however there are significant differences between them. Unlike Archaea, bacteria have a cell wall made of peptidoglycan, and many have a polysaccharide capsule (Figure 4.6). The cell wall acts as an extra layer of protection, helps the cell maintain its shape, and prevents dehydration. The capsule enables the cell to attach to surfaces in its environment. Some prokaryotes have flagella or pili. Flagella are used for locomotion, while most pili are used to exchange genetic material during a process called conjugation.

Unlike most bacteria, archaeal cell walls do not contain peptidoglycan, but their cell walls are often composed of a similar substance called pseudopeptidoglycan. Like bacteria, archaea are found in nearly every habitat on earth, even extreme environments that are very cold, very hot, very basic, or very acidic (Figure 4.7). Some archaea live in the human body, but none have been shown to be human pathogens.

Figure 4.7 Some archaea live in extreme environments, such as the Morning Glory Pool, a hot spring in Yellowstone National Park. The color differences in the pool result from the different communities of microbes that can thrive at various water temperatures. (credit: Parker et al. / Microbiology OpenStax)

Eukaryotic Cells



Eukaryotic cells are cells that contain a membrane-bound nucleus and other membrane-bound compartments or sacs, called organelles (Figure 4.8). **Organelles** are cell structures with specialized functions that will be discussed in section 4.4.

Figure 4.8 Eukaryotic animal cell with many membrane-bound organelles visible. (credit: Betts et al. / Anatomy and Physiology OpenStax)

Unlike prokaryotic cells, eukaryotic cells possess a nucleus. The nucleus is a membrane-bound organelle that houses the DNA. The nucleus, because it contains the DNA, ultimately controls all activities of the cell and also serves an essential role in reproduction and heredity. Eukaryotic cells typically have their DNA organized into multiple linear chromosomes. The DNA within the nucleus is highly organized and condensed to fit inside the nucleus.

Cell Size

At 0.1–5.0 µm in diameter, prokaryotic cells are significantly smaller than eukaryotic cells, which have diameters ranging from 10–100 µm (Figure 4.9). The small size of prokaryotes allows ions and organic molecules to enter and spread to other parts of the cell quickly. Similarly, any wastes produced within a prokaryotic cell can quickly move out.

Larger eukaryotic cells have evolved different structural adaptations to enhance cellular transport. The large size of these cells would not be possible without these adaptations. Cell size is limited because volume increases quicker than cell surface area. As a cell becomes larger, it becomes more and more difficult for the cell to acquire sufficient materials to support the metabolic processes occurring inside the cell. This can be explained by looking at a cell's surface-area-to-volume ratio.

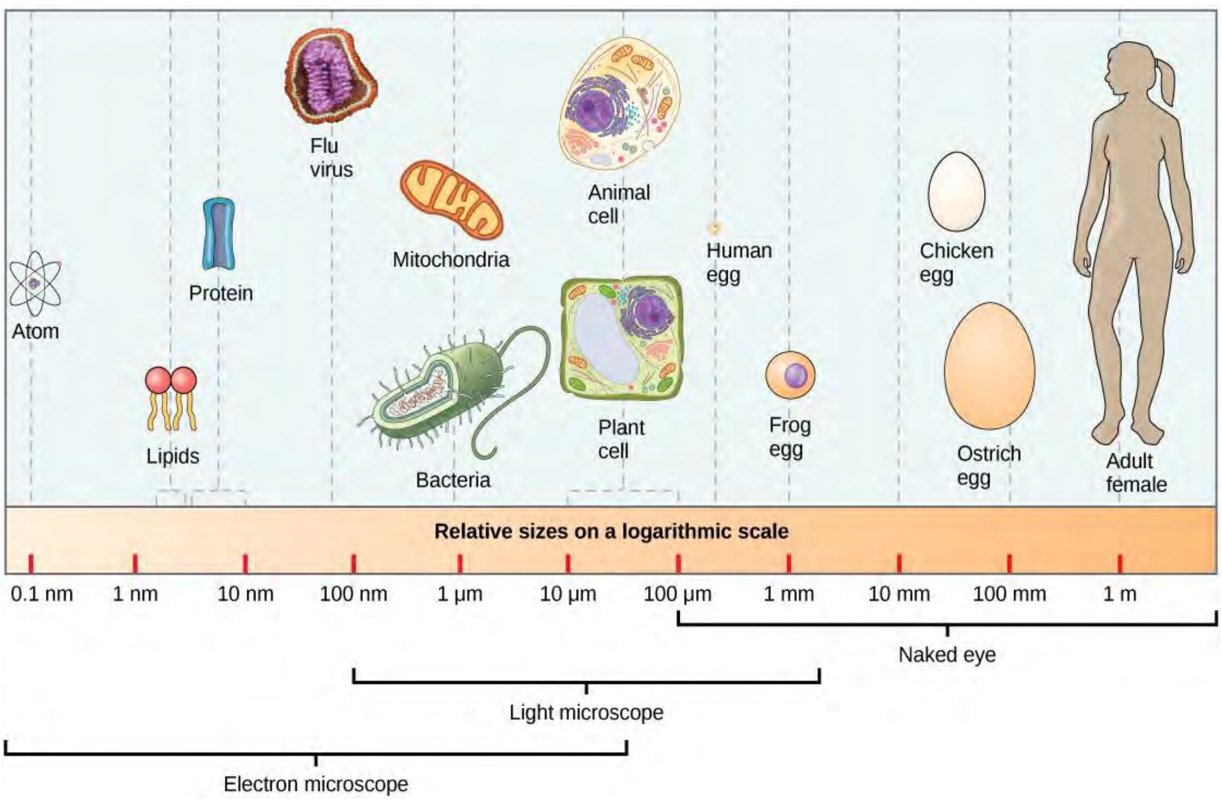


Figure 4.9 This figure shows the relative sizes of different kinds of cells and cellular components. An adult human is shown for comparison. (credit: Clark et al. / [Biology 2E OpenStax])

VISUAL CONNECTION

Notice that as a cell increases in size, its surface area-to-volume ratio decreases. When there is insufficient surface area to support a cell's increasing volume, a cell will either divide or die. In Figure 4.10, the cell on the left has a volume of 1 mm^3 and a surface area of 6 mm^2. Therefore, the cell on the left has a surface area-to-volume ratio of 6 to 1. The cell on the right has a volume of 8 mm^3 and a surface area of 24 mm^2, with a surface area-to-volume ratio of 3 to 1. The cell on the right has a smaller surface-area-to-volume ratio. As a result, it would be more difficult for the cell on the right to acquire sufficient materials to support processes inside the cell compared to the cell on the left.

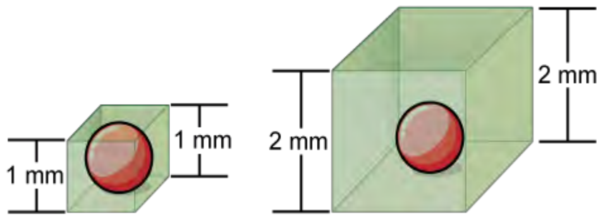


Figure 4.10 Surface area comparison of two different size cubes. (credit: Clark et al./ Biology 2E OpenStax)

CAREER CONNECTION - Microbiologist

The most effective action anyone can take to prevent the spread of contagious illnesses is to wash his or her hands. Why? Because microbes are ubiquitous. They live on doorknobs, money, your hands, and many other surfaces. If someone sneezes into his hand and touches a doorknob, and afterward you touch that same doorknob, the microbes from their mucus are now on your hands. If you touch your hands to your mouth, nose, or eyes, those microbes can enter your body and can make you sick.

However, not all microorganisms cause disease. Many microbes are beneficial. You have microbes in your gut that make vitamin K, which is required when making blood-clotting proteins. Other microorganisms are used to ferment beer and wine.

Microbiologists are scientists who study microorganisms (Figure 4.11). Microbiologists can pursue several careers. They can work in the food industry, be employed in veterinary and medical fields, and work for environmental organizations, just to mention a few.

Environmental microbiologists may look for new ways to use specially selected or genetically engineered microbes to remove pollutants from soil or groundwater. We call using these microbes bioremediation technologies. Microbiologists can also work in the bioinformatics field, providing specialized knowledge and insight for designing and developing computer models.

Figure 4.11 A microbiologist works to extract DNA to be analyzed. (credit: Sukulya/ Wikimedia)