5.3: Variation in Cells

Bacteria Attack!

Figure \(\PageIndex{1}\) shows a bacterial cell (colored green) attacking human red blood cells. The bacterium causes a disease called relapsing fever. The bacterial and human cells look very different in size and shape. Although all living cells have certain things in common — such as a plasma membrane and cytoplasm — different types of cells, even within the same organism, may have their own unique structures and functions. Cells with different functions generally have different shapes that suit them for their particular job. Cells vary not only in shape but also in size, as this example shows. In most organisms, however, even the largest cells are no bigger than the period at the end of this sentence. Why are cells so small?

Explaining Cell Size

Most organisms, even very large ones, have microscopic cells. Why don't cells get bigger instead of remaining tiny and multiplying? What limits cell size?
The answers to these questions are clear once you know how a cell functions. To carry out life processes, a cell must be able to quickly pass substances into and out of the cell. For example, it must be able to pass nutrients and oxygen into the cell and waste products out of the cell. Anything that enters or leaves a cell must cross its outer surface. It is this need to pass substances across the surface that limits how large a cell can be.

Look at the two cubes in Figure \(\PageIndex{2}\). As this figure shows, a larger cube has less surface area relative to its volume than a smaller cube. This relationship also applies to cells; a larger cell has less surface area relative to its volume than a smaller cell. A cell with a larger volume also needs more nutrients and oxygen and produces more wastes. Because all of these substances must pass through the surface of the cell, a cell with a large volume will not have enough surface area to allow it to meet its needs. The larger the cell is, the smaller its ratio of surface area to volume, and the harder it will be for the cell to get rid of its wastes and take in necessary substances. This is what limits the size of the cell.

![Small Cube: Large Cube:](image)

**Small Cube:**  
Side \((s) = 1 \text{ cm}\)  
SA = 6 \(s^2 = 6 \text{ cm}^2\)  
\(V = s^3 = 1 \text{ cm}^3\)  
\(\text{SA:V} = 6/1 = 6\)

**Large Cube:**  
Side \((s) = 3 \text{ cm}\)  
SA = 6 \(s^2 = 54 \text{ cm}^2\)  
\(V = s^3 = 27 \text{ cm}^3\)  
\(\text{SA:V} = 54/27 = 2\)

Figure \(\PageIndex{2}\): Surface Area to Volume Comparison. A larger cube has a smaller surface area (SA) to volume (V) ratio than a smaller cube. This also holds true for cells and limits how large they can be. (CC BY-NC 3.0; Hana Zavadska via [CK-12 Foundation](https://www.ck12.org/).

**Cell Form and Function**

Cells with different functions often have different shapes. The cells pictured below are just a few examples of the many different shapes that human cells may have. Each type of cell in the figure has characteristics that help it do its job. For example, the job of the nerve cell is to carry messages to other cells. The nerve cell has many long extensions that reach out in all directions, allowing it to pass messages to many other cells at once. Do you see the tail of each tiny sperm cell? Its tail helps a sperm cell "swim" through fluids in the female reproductive tract in order to reach an egg cell. The white blood cell has the job of destroying bacteria and other pathogens. It is a large cell that can engulf foreign invaders.
Cells With and Without a Nucleus

There is a basic cell structure that is present in many but not all living cells: the nucleus. The nucleus of a cell is a...
structure in the cytoplasm that is surrounded by a membrane (the nuclear membrane) and contains DNA. Based on whether or not they have a nucleus, there are two basic types of cells: prokaryotic cells and eukaryotic cells.

### Prokaryotic Cells

**Prokaryotic cells** are cells without a nucleus. The DNA in prokaryotic cells is in the cytoplasm rather than enclosed within a nuclear membrane. Prokaryotic cells are found in single-celled organisms, such as the bacterium represented by the model below. Organisms with prokaryotic cells are called **prokaryotes**. They were the first type of organisms to evolve and are still the most common organisms today.

![Prokaryotic Cell](Public Domain; LadyofHats via Wikicommoms).

### Eukaryotic Cells

**Eukaryotic cells** are cells that contain a nucleus. A typical eukaryotic cell is represented by the model below. Eukaryotic cells are usually larger than prokaryotic cells. They are found in some single-celled and all multicellular organisms. Organisms with eukaryotic cells are called **eukaryotes**, and they range from fungi to people.

Besides a nucleus, eukaryotic cells also contain other organelles. An **organelle** is a structure within the cytoplasm that performs a specific job in the cell. Organelles called mitochondria, for example, provide energy to the cell, and organelles called vacuoles store substances in the cell. Organelles allow eukaryotic cells to carry out more functions than prokaryotic cells can.
Figure \(\PageIndex{7}\): Eukaryotic Cell. Compare and contrast the eukaryotic cell shown here with the prokaryotic cell. What similarities and differences do you see? (Public domain; LadyofHats via Wikimedia).

Summary

- Cells must be very small so they have a large enough surface area-to-volume ratio to maintain normal cell processes.
- Cells with different functions often have different shapes.
- Prokaryotic cells do not have a nucleus. Eukaryotic cells do have a nucleus as well as other organelles.

Review

1. Explain why most cells are very small.
2. Discuss variations in the form and function of cells.
3. Compare and contrast prokaryotic and eukaryotic cells.
4. True or False. Prokaryotic cells do not have mitochondria.
5. True or False. Prokaryotic cells do not have DNA.
6. True or False. All single-celled organisms are prokaryotes.
7. Which was the first type of organisms to evolve – eukaryotes or prokaryotes? Based on their structures, does this make sense to you? Explain your answer.
8. Do human cells have organelles? Explain your answer.
9. Which are usually larger – prokaryotic or eukaryotic cells? What do you think this means for their relative ability to take in needed substances and release wastes? Discuss your answer.
10. DNA in eukaryotes is enclosed within the _______ ________.
11. Name three different types of cells in humans.
12. Which organelle provides energy in eukaryotic cells?
13. What is the function of a vacuole in a cell?
Explore More

https://bio.libretexts.org/link?16741#Explore_More

The video below explains why scientists believe endosymbiosis is the basis for complex cells.

Media, iframe, embed and object tags are not supported inside of a PDF.

There are many different types of cells, with different structures and functions. In this video, a specific type of immune cell, the natural killer cell, is discussed.