

The Cell Interior and Function

5



5.0 CHAPTER PREVIEW

In this chapter we will:

- Investigate and understand the organization and function of the cell interior.
- Define the differences between eukaryotic and prokaryotic cell structure.
- Discuss the structure and function of the following eukaryotic organelles and structures:
 - Protoplasm
 - Cytoplasm
 - Nucleoplasm
 - Cytoskeleton
 - Nucleus
 - Ribosome
 - Endoplasmic reticulum
 - Golgi apparatus
 - Lysosomes and peroxisomes
 - Mitochondria
 - Plastids
 - Vacuoles
 - Middle lamella
 - Extracellular matrix

5.1 OVERVIEW

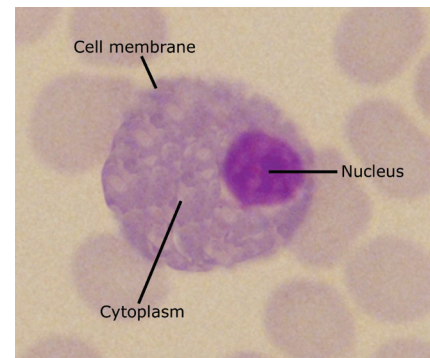
Once again, the focus of this chapter will be the cell, but now we will learn about the interior structures - organelles - and their functions in eukaryotic cells. We will cover the prokaryotic cells later in the course. Eukaryotes are more complex cell structures than the already complex prokaryotes. Eukaryotic cells contain a membrane-bound nucleus. They also have complicated, membrane-bound organelles. Prokaryotic cells do not have membrane-bound organelles.

The cell's structural plan calls for the interior to be surrounded by the cell membrane. Within the boundaries of the membrane, the cell is filled with a jelly-like substance, called the cytoplasm. Organelles are found in the cytoplasm. The cytoplasm is jelly-like so molecules and organelles can move through it effectively. There are many things transported through the cytoplasm every minute.

Figure 5.1.1

Basic cell structure

This is a light micrograph of an animal cell. The basic structures of the cell are labeled. All eukaryotic cells have this general structure of a cell nucleus surrounded by cytoplasm. The structure we learned about last chapter—the cell membrane—holds everything inside the cell and protects the cell from the environment.



5.2 ORGANELLES – GENERAL

Organelles are the individual functional units of all cells. Because any given cell has complicated functions that must be performed, the different functions of the cell are divided and spread out among the various structures inside the cell. For example, the protein-making organelle is called a ribosome. Vesicles function as storage and transport organelles. The nucleus is the organelle that houses and protects DNA in eukaryotic cells.

The organelles that are found in all eukaryotic cells are: protoplasm, cytoplasm, nucleoplasm, cytoskeleton, nucleus, nucleolus, ribosome, endoplasmic reticulum, Golgi apparatus, mitochondrion (plural mitochondria), lysosome/peroxisome and vacuoles. Structures that are found only in animal cells are centrioles. Structures that are found only in plant cells are plastids. Prokaryotic cells only contain one true organelle – ribosomes.

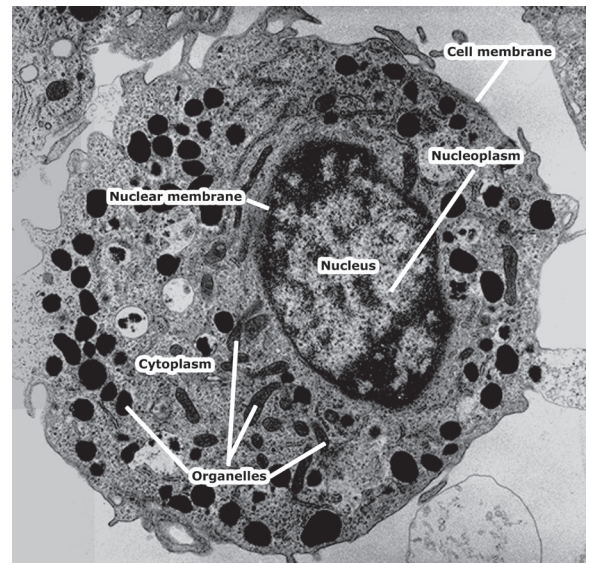
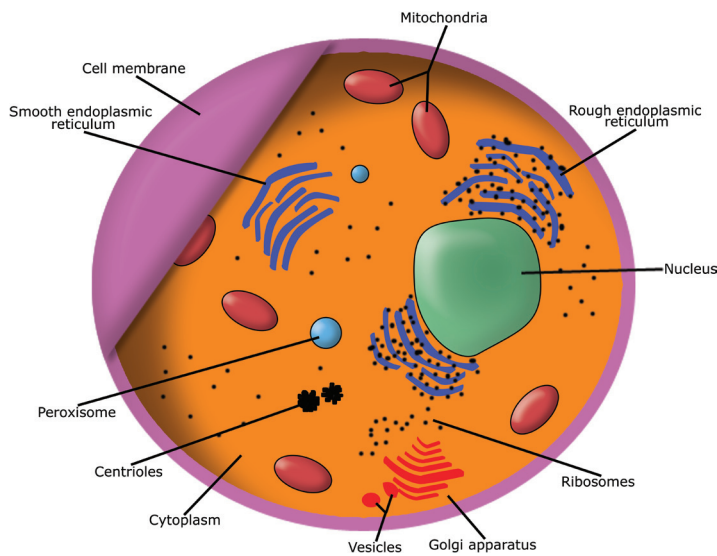


Figure 5.2.1

General structure and organelles of eukaryotic cells

Above is an updated version of the animal cell graphic we saw last chapter. All of the organelles are labeled. The right electron micrograph is a human blood cell. The resolution is not good enough to make out many of the organelles, though. The nucleus is easily visible. It is filled with a jelly-like inside called nucleoplasm. Everything outside of the nucleus is called cytoplasm. Cytoplasm is a mixture of water, organelles, molecules and ions. The larger “sausage-shaped” organelles are mitochondria. Mitochondria manufacture almost all of the energy molecules for the cell. The large circular organelles with the light interior are vesicles. The very small black dots in the cytoplasm are ribosomes. They are all over the cytoplasm of most cells. As we proceed through this chapter, we will learn the function of all of the organelles shown.

5.3 PROTOPLASM

Technically, the **protoplasm** refers to all substances and objects contained inside the cell membrane. The protoplasm, therefore, includes the organelles, nucleus, and fluid inside the cell. The protoplasm is basically all the “stuff” within the boundaries of the cell membrane. The easiest way to remember what the protoplasm includes is that it consists of the cytoplasm and nucleus.

Technically, the breakdown of the protoplasm is as follows:

- The **cytoplasm** refers to all the structures outside the nucleus but inside the cell membrane.
- The cytoplasm contains the **cytosol**, which is the aqueous component of the cytoplasm.
- The cytosol contains about 70% water. The remaining 30% consists of ions and various soluble molecules such as proteins, enzymes, carbohydrates, and lipids.
- The cytoplasm includes all of the organelles except the nucleus. The nucleus is not considered to be part of the cytoplasm; it is part of the protoplasm.
- The cytoplasm also contains the skeletal structure of the cell called the cytoskeleton.

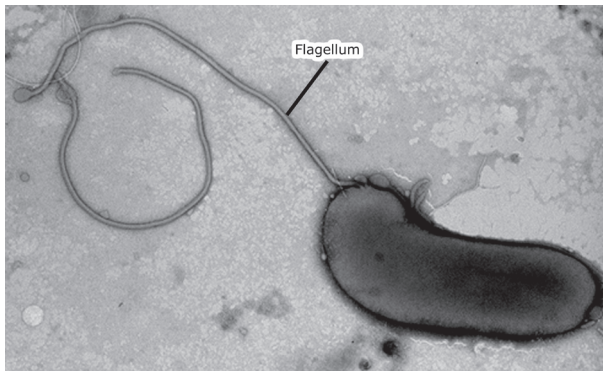
This mixture of the cytosol, the organelles, and the cytoskeleton give the cytoplasm the overall consistency of jelly.

5.4 NUCLEOPLASM

The nucleus is a large, membrane-bound organelle. Like the cell, the nucleus also has a fluid interior. This “plasm” of the nucleus is not called cytoplasm, though. It is called **nucleoplasm**. Like the cytoplasm, the nucleoplasm is mainly composed of water, ions and soluble molecules. In addition, eukaryotic DNA (deoxyribonucleic acid) is stored within the nucleoplasm. Recall that prokaryotic DNA is free within the cytoplasm.

Microtubules also make up the structure of eukaryotic **flagella** and **cilia**. A flagellum is a long, thin projection from the cell surface that propels some eukaryotic cells by whipping back and forth. Cilia are shorter and more numerous cell projections that also move rhythmically back and forth. Some ciliated organisms use the cilia to move their bodies. This is true of many unicellular, ciliated organisms. Multicellular organisms use cilia to move substances past the cells. One example of this is the use of cilia in the respiratory tract (breathing tract) of animals. The cells that line the respiratory tract are covered with cilia. These beat back and forth in order to keep the areas clean from foreign substances such as dust particles and bacteria.

Figure 5.6.2

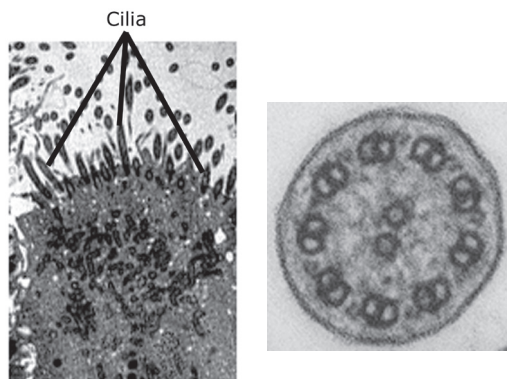


Flagella

An electron micrograph of an organism with a flagellum is shown here. One cannot usually tell the difference between a eukaryotic and prokaryotic flagellum just by looking at it, though. This picture happens to be of a prokaryotic flagellum from a bacterium. No matter what the species, though, flagella function by whipping back and forth, propelling the organism. The difference between eukaryotic and prokaryotic flagella is great. All eukaryotic flagella are made up of multiple molecules of the protein tubulin. Prokaryotic flagella are made of a single molecule of the protein flagellin. In addition, eukaryotic flagella are actually extensions of the cytoplasm and are covered by the cell membrane. Prokaryotic flagella simply are molecules that extend out from the surface of the cell membrane.

Microtubules are also important in moving genetic material during cell division. Microtubules make up the main structure of **centrioles**. Centrioles are found only in animal cells, and some fungi and algae. There are no centrioles in plants. Centrioles are important in cell division, where they help to pull the chromosomes (DNA) apart. We will discuss this later in the course. Centrioles are formed from nine sets of three microtubules arranged in a circle.

Figure 5.6.3



Cilia

Both of these pictures are from an electron microscope. The picture on the left is of a cell with cilia extending from the surface. Cilia and eukaryotic flagella are both composed of microtubules, as well as other proteins. When cilia and flagella are viewed in cross section with an electron microscope, they have what is called the "**9 + 2 structure**." This means there are nine pairs of microtubules surrounding a central core of two tubules, as can be seen in the cross section of a cilium on the right. Here, the dark line is the boundary of the cilia. Since cilia and flagella are extensions of the cytoplasm, this corresponds to the cell membrane. On the inside of the dark line, which is within the cytoplasm, are nine outer rings of paired microtubules. In the center are two more microtubules. This is the 9 + 2 structure. Cilia are not found in prokaryotic cells and are shorter than flagella. Also, normally organisms with cilia have more than 10 - sometimes even hundreds - of cilia. Usually eukaryotes with flagella have one or two flagella per cell.

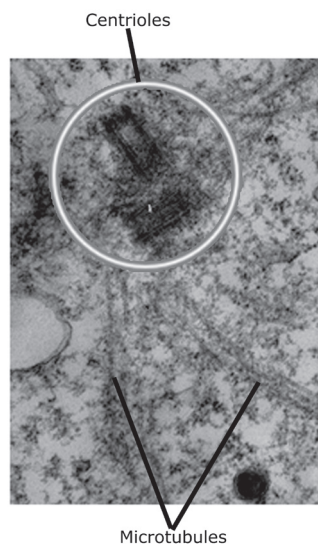
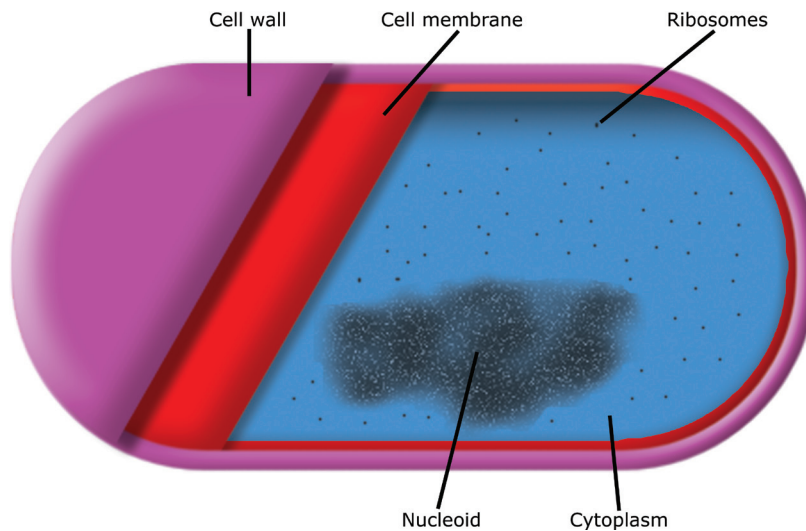


Figure 5.6.4

Centrioles

Here is an electron micrograph of part of the cytoplasm of an animal cell. Centrioles usually are seen paired together. Both centrioles are seen on their sides. Centrioles are made up of microtubules. They are made up of nine triplets of microtubules, rather than the 9 + 2 structure of cilia and flagella.

**Figure 5.18.1****Typical prokaryotic cell**

This is the same graphic we saw in Chapter 4. However, now it will help us pull everything together. As mentioned previously, prokaryotes are considered structurally “simple” to many scientists. In a way, this is correct, especially when comparing them to eukaryotes. However, even the simplest prokaryote is extremely complex. No matter how smart scientists think they are, no one has been able to make a fully functional cell in a laboratory. All prokaryotes have a cell wall and a cell membrane. The cell wall is outside the cell membrane and provides an added layer of protection for the organism. As mentioned earlier, the cell wall of bacteria is made up of different carbohydrates than the cell walls of organisms, from Fungi and Plantae. In addition, some prokaryotes have another layer surrounding the cell wall called the capsule. (We will learn much more about bacterial capsules in the future chapter on bacteria.) Inside the cell membrane is the jelly-like substance of the cytoplasm. The cytoplasm contains many ribosomes to make proteins. Also, there is an area within the cytoplasm where the single piece of circular DNA is contained. This area is called the nucleoid.

Figure 5.18.2**Summary of Cell Structures/Organelles and Their Function**

The prokaryotes are the organisms in the Kingdoms Archaea (**Ar**) and Bacteria (**E**), and the eukaryotes are the organisms from the Kingdoms Protista (**Pr**), Fungi (**F**), Plantae (**Pl**), and Animalia (**A**).

Structure/Organelle	Type of Cell	Function
cell wall	Ar, E, F, most Pl	Protection; support
cell membrane	all organisms	boundary/gatekeeper; protection
cytoplasm	all organisms	site of most metabolism; jelly-like environment for substance transport
nucleoplasm	Pr, Pl, F, A	jelly-like environment for transport of substances in/out of nucleus
centriole	Pr, A, F, algae	cell reproduction (mitosis and meiosis)
chloroplast	Pl	photosynthesis
endoplasmic reticulum	all organisms	intracellular transport; molecule packaging
Golgi apparatus	all organisms	Storage; secretion of substances
lysosome	mainly A	intracellular digestion
microfilaments	all organisms	intracellular transport
microtubules	all organisms	intracellular transport
mitochondria	all organisms	energy production/cellular respiration
nucleolus	Pr, Pl, F, A	manufacture ribosome parts
nucleus	Pr, Pl, F, A	houses genetic material
ribosome	all organisms	manufacture proteins
vacuole	Pl, some Pr, F and A	storage of molecules

5.19 PEOPLE OF SCIENCE

Robert Brown (1773-1858) was born in Scotland and studied to be a doctor. He was a surgeon in the army. He became interested mainly in botany and traveled to Australia in 1801. As a result of his observations there, he was known as the leading authority on Australian botany of the early 19th century. While he was viewing preparations of an orchid through a microscope, he saw a large organelle which was the nucleus.

5.20 KEY CHAPTER POINTS

- Organelles are special structures inside of cells that perform specific, specialized functions.
- The inside of a cell is filled with a jelly-like substance called cytoplasm, and the inside of the nucleus contains nucleoplasm.
- The cytoskeleton holds the cell together.
- The nucleus is surrounded by a double lipid bilayer with holes in it, called pores. The nucleus contains the DNA and nucleolus.
- Mitochondria, ribosomes, endoplasmic reticulum, Golgi apparatus, vesicles, vacuoles, peroxisomes, and lysosomes are organelles found in all eukaryotic cells. All of them are bound by a membrane except ribosomes.
- Plants have plastids, a type of organelle not found in animal cells.
- Animal cells have centrioles, a type of organelle not found in plant cells.
- Almost all plant cells are also surrounded by a cell wall. No animal cells have cell walls.
- Animal cells are held to one another by the extracellular matrix.
- Plant cells are held to one another by the middle lamella.
- Prokaryotic cells contain cytoplasm, DNA free in the cytoplasm (not protected by a membrane), and ribosomes.

5.21 DEFINITIONS

9 + 2 Structure

The microtubule structure of cilia and flagella; nine pairs of microtubules surrounding a central core of two tubules.

actin

The protein which makes up microfilaments.

centriole

Microtubules that help pull the DNA apart during cell division. They are composed of 9 triplets of microtubules.

chloroplast

A type of plastid that performs photosynthesis.

chromatin

The collection of DNA and various proteins which are contained in the nucleus.

cilia

Short, numerous cell projections that move rhythmically back and forth.

collagen

One of the glycoproteins that make up the extracellular matrix of animal cells.

cristae

Folds of the inner mitochondrial membrane.

plastids

Organelles that either perform photosynthesis, or store material such as starch. They are found only in plants and algae.

polyribosomes

A grouping of many ribosomes.

polysomes

Same as polyribosome.

proteoglycans

One of the glycoproteins that makes up the extracellular matrix of animal cells.

protoplasm

All of the substances inside the cell membrane.

ribosomes

Organelles that manufacture proteins.

rough ER

ER that has many ribosomes attached to it.

signal group

A short segment of amino acids that are attached onto a protein by the Golgi apparatus, signaling the cell where the protein should be taken.

smooth ER

ER that does not have any ribosomes attached to it.

tubulin

Long, thin, hollow tubes found just inside the cell membrane.

vacuoles

A storage structure in the cytoplasm that may hold food or wastes.

vesicle

A membrane bound organelle which stores substances.

STUDY QUESTIONS

1. Describe the difference between eukaryotic and prokaryotic cells.
2. What is an organelle?
3. What components make up the protoplasm?
4. True or False? The cytosol is mainly made up of soluble molecules and ions.
5. If you are inside the nucleus of a eukaryotic cell and travel from the interior of the nucleus to the interior of the cell, what two jelly-like substances do you travel through?
6. What is the function of the cytoskeleton? What three types of proteins make up the cytoskeleton?
7. Besides the cytoskeleton and nuclear matrix, what three eukaryotic cell structures are composed of microtubules?
8. The nucleus contains one very important molecule and one structure. What are they? What is the function of this structure found in the nucleus?
9. How do substances move in and out of the nucleus?

10. Describe the pathway that a protein takes once it is made by the ribosome.
11. List three double membrane-bound organelles.
12. If you are standing in a cell and you see a membrane bound structure that has starch granules, what type of organelle are you looking at and are you in a plant or animal cell?
13. List at least two ways lysosomes and peroxisomes are similar.
14. What is the middle lamella?
15. How are animal cells held to one another?
16. If you are standing in a cell and you see a nucleoid, in what type of cell are you standing?

PLEASE TAKE TEST #2 IN TEST BOOKLET
