

Z00-302 CR: CELL AND MOLECULAR BIOLOGY

(1.1) Cellular diversity: Structural features of Prokaryotic and Eukaryotic Cells

The cell. 1. Cell diversity. Atlas of Plant and Animal Histology
mmegias.webs.uvigo.es/02-english/5-celulas/1-diversidad.php

1. INTRODUCTION

Cell: anatomical and functional unit of living organisms.

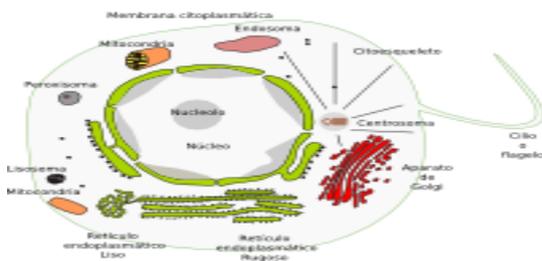
Compartment: set of molecules dealing with a function, usually they are confined to a defined space of the cell.

Organelles: membrane-bound compartments.

Main eukaryotic cell compartments: nucleus, cell membrane, cytoplasm.

Cytoplasm: cytosol + organelles.

Cytology (generally known as cell biology) is the topic of this part of the Atlas, and mainly focused on the organization of the cell. But, what is a cell? The following may be a good definition: **cells are the anatomical and functional unit of living organisms**. Cells may be alone or grouped to form multicellular organisms. A cell is the simplest molecular organization that it is considered alive. Three cell lineages are known to be present on Earth: **archaea and bacteria**, which are unicellular prokaryotes, and **eukaryotes**, which can be unicellular or form multicellular organisms. Prokaryotes (anterior to the nucleus) do not usually have internal compartments surrounded by membranes, while eukaryotes (true nucleus) always contain internal membranous organelles. The nucleus is a characteristic compartment of eukaryotes.



Main compartments of an animal cell.



Main compartments of a plant cell.

Cells, either prokaryote or eukaryote, are highly organized sets of molecules. In fact, cells have many internal compartments with specific functions. Let's say a cellular compartment is a space, delimited or not by membrane, where a necessary or important function for the cell is performed. One of the compartments present in every cell is the **cell membrane**, also known as plasmalemma or plasma membrane, which encloses all the other cellular compartments, and is a semipermeable barrier that separates the inner cell space from the outer cell space.

Eukaryotic cells have internal compartments delimited by membranes. The **nucleus** is one of them. It is bounded by a double membrane and contains the genetic material known as DNA. DNA contains the necessary information for the cell to carry out tasks that allow survival and reproduction. The space between the nucleus and the plasma membrane is filled with the **cytosol**, an aqueous gel containing a variety of molecules involved in structural and metabolic functions, in homeostasis, in signaling, and many others. For example, the ribosomes for protein synthesis, the cytoskeleton for the internal organization of the cell and mobility, many enzymes and co-factors for metabolism. Between the cell membrane and the nucleus there are also many **organelles**, membrane bounded compartments, that accomplish functions such as digestion, respiration, photosynthesis, metabolism, intracellular transport, secretion, energy production, storage, etcetera. Mitochondria, chloroplasts, peroxisomes, lysosomes, endoplasmic reticulum, and vacuoles are some of these organelles. The **cytoplasm** is the cytosol plus all the organelles,

excluding the nucleus.

In the following pages we will take a tour through the different parts of the eukaryotic cell, and also by its surroundings. Some aspects of the cell function will not be dealt deeply, such as gene expression or cellular metabolism. It would need a huge amount of space which would undermine the idea we want to give about the cell. Furthermore, there are many Internet sites dedicated to these areas. The different "places" of the cell that we are going to "visit" are indicated on the right side panel.

CELL DIVERSITY

Cells show a diversity in size, morphology and functions.

Micrometer or micron (μm): 10^{-3} mm.

Average cell size: 10 to 30 μm .

Cell morphology: rounded, filiform, star-like shapes

Cellular function: digestion, movement, support, protection,

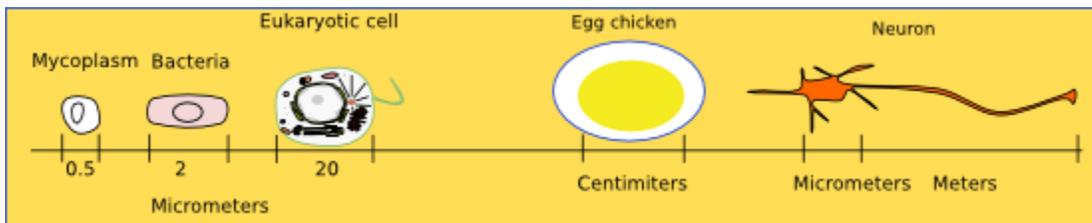
Cells show a **great diversity** in form and functions, and it was not easy to realize that all living organisms are made up of units, known as cells, having a common basic structure. The other major difficulty was the very small size of cells.

Cell size

Cell size is measured in micrometers (μm). One micrometer, or micron, is one thousandth of a millimeter (10^{-3} millimeters), and one millionth of a meter (10^{-6} meters). **A typical eukaryotic cell is around 10 and 30 μm** in size. This is true for cells of a worm and for those of an elephant, there are many more cells in the elephant. To get an idea of how small the cells are we can imagine that a person is 1.70 meters tall, and is stretched to the height of Everest, which is about 8500 meters. The stretched giant cells of this person would measure 1.3 centimeters, smaller than one euro cent coin (we would have a giant formed by a huge amount of euro cent coins).

However, there are eukaryotic cells that escape from the most common

dimensions and can be very small, like sperm, whose head can be **less than 4 μm** in diameter, while others like the eggs of some birds and reptiles can be **more than 10 centimeters** (thousands of microns) in their larger axis. An extreme example is the egg of ostrich, but only the yolk, since the egg white is not part of the cell. Some cells may have cytoplasmic extensions being **several meters in length**, such as the brain neurons of a giraffe that innervate the more caudal part of the spinal cord. Smaller than eukaryotic cells are prokaryotic cells which typically are around 1 to 2 μm in diameter, being *Mycoplasma* the smallest with 0.5 μm .



Some examples of cell dimensions.

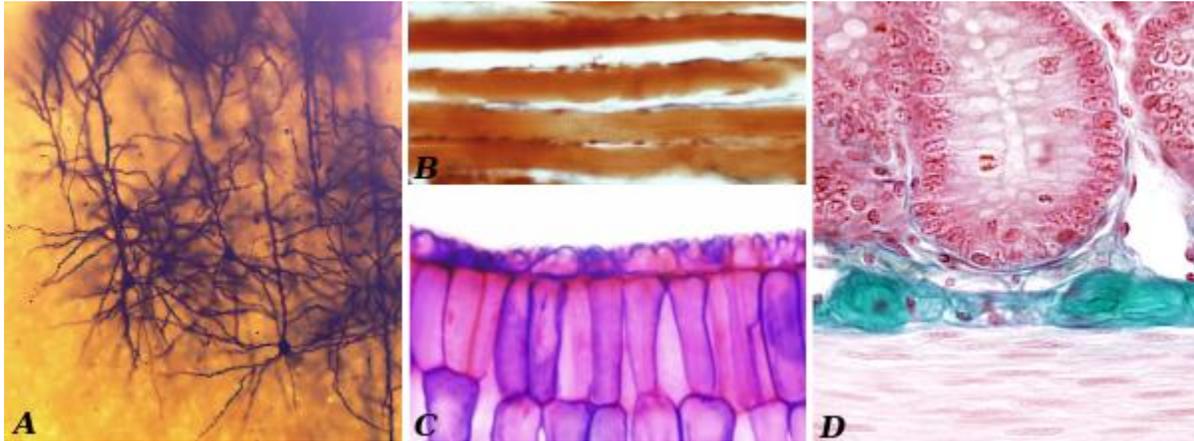
Number

Most living organisms are unicellular, they are a single cell. Among these, prokaryotes (bacteria and archaea) are the most abundant. Unicellular eukaryotic species are abundant too. Organisms that can be seen without microscopes are mostly multicellular, i.e. they are made up of many cells. They are animals, plants, fungi and some algae. In general, larger multicellular organisms contain higher number of cells, since the average cell size is similar for mostly all of the organisms. Estimates of the total number of cells of an organism with similar size to humans may range from 10^{13} (one followed by 13 zeros) to 10^{14} (one followed by 14 zeros). To get an idea of these numbers, the estimation of the total number of cells of the human brain is about 86×10^9 neurons and of a mouse brain is about 15×10^9 . The most abundant cells of the human body are red blood cells and glial cells of the nervous system.

Morphology

The cells are typically sketched as rounded but this is probably the most

uncommon shape (except blood cells). The morphology of cells in animal tissues is diverse, **enormously diverse!** It can range from rounded to star-like, from multi lobed to filiform. Plant cells also show a wide diversity of forms, which are determined by cell wall, being cuboidal and columnar shapes the most common morphology. See the following examples:



Cell shapes. A) Neurons of the cerebral cortex. B) Skeletal muscle cells in longitudinal view. C) Cells of a leaf. It can be observed the different morphology between parenchyma, large and elongated cells, and epidermis, small and irregular cells located in the upper part. D) Different cell types of the small intestine. The violet upper cells are epithelial cells, the pale elongated cells at the bottom are smooth muscle, and the greenish cells are connective tissue cells.

Function

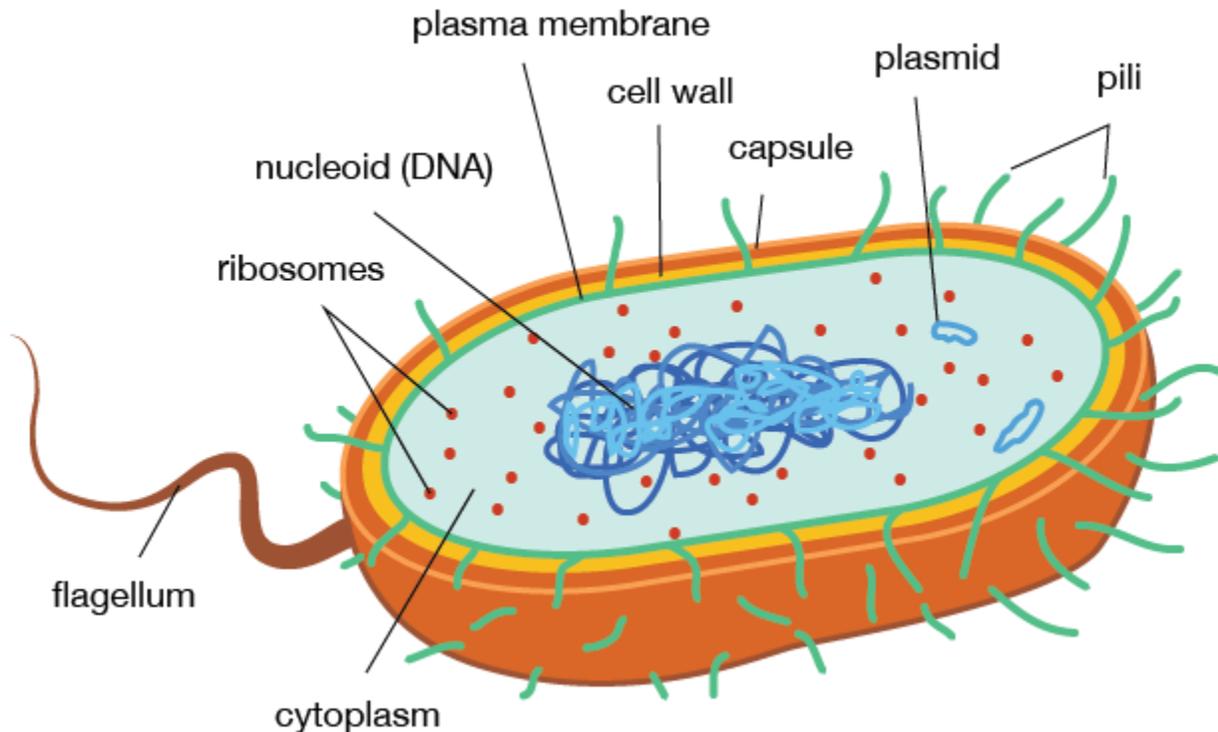
Every living organism needs to perform many functions to maintain its integrity, grow and reproduce, which are carried out by many different cell types working in concert. These functions are extremely complex and diverse, going from those related to food digestion, detoxification, movement, reproduction, support, defense against pathogens, those related to thinking, emotions or consciousness. All these functions are carried out by specialized cells, such as those of the gastrointestinal epithelium, liver, muscle, germ cells, bone, lymphocytes and neurons, respectively. Cells need particular molecular framework, mainly based in proteins, to carry out their functions. Some functions in an organism can be carried out by cells belonging to one type, but **commonly the cooperation of several cell types acting in a coordinated way**

is needed.

PROKARYOTIC CELL STRUCTURE AND FUNCTION

<http://www.shmoop.com/biology-cells/prokaryotic-cells.html>

The vast majority of cells on Earth are actually **prokaryotic**, so we are in the minority.



There are two major kinds of prokaryotes:

- **Bacteria**
- **Archaea (single-celled organisms)**

Biologists now estimate that each human being carries nearly **20 times** more bacterial, or prokaryotic, cells in his or her body than human, or eukaryotic, cells. If that statistic overwhelms you, rest assured that most of these bacteria are trying to help, and not hurt, you. Numerically, at minimum, there are 20 times more prokaryotic cells on Earth than there are eukaryotic cells. This is only a minimum estimate because there are trillions of trillions of bacterial cells that are not associated with eukaryotic organisms. In addition, all Archaea are also prokaryotic. As is the case for

bacteria, it is unknown how many Archaeal cells are on Earth, but the number is sure to be astronomical. In all, eukaryotic cells make up only a very small fraction of the total number of cells on Earth.

There are four main structures shared by all prokaryotic cells, bacterial or Archaeal:

1. **The plasma membrane**
2. **Cytoplasm**
3. **Ribosomes**
4. **Genetic material (DNA and RNA)**

Some prokaryotic cells also have other structures like the **cell wall**, **pili** (singular pillus), and **flagella** (singular flagellum). Each of these structures and cellular components plays a critical role in the growth, survival, and reproduction of prokaryotic cells.

Prokaryotic Plasma Membrane

Prokaryotic cells can have multiple **plasma membranes**. Prokaryotes known as "**gram-negative bacteria**," for example, often have two **plasma membranes** with a space between them known as the **periplasm**. As in all cells, the plasma membrane in prokaryotic cells is responsible for controlling what gets into and out of the cell. A series of proteins stuck in the membrane (poor fellas) also aid prokaryotic cells in communicating with the surrounding environment. Among other things, this communication can include sending and receiving chemical signals from other bacteria and interacting with the cells of eukaryotic organisms during the process of **infection**. The plasma membrane is universal to *all* cells, prokaryotic and eukaryotic. Because this cellular component is so important and so common, it is addressed in great detail in its own [In Depth](#) subsection.

Prokaryotic Cytoplasm

The **cytoplasm** in prokaryotic cells is a gel-like, yet fluid, substance in which all of the other cellular components are suspended. It is very similar to the **eukaryotic cytoplasm**, except that it does *not* contain organelles. Recently, biologists have discovered that prokaryotic cells have a complex and

functional **cytoskeleton** similar to that seen in eukaryotic cells². The cytoskeleton helps prokaryotic cells divide and helps the cell maintain its plump, round shape. As is the case in eukaryotic cells, the cytoskeleton is the framework along which particles in the cell, including proteins, ribosomes, and small rings of DNA called plasmids, move around. It's the cell's "highway system" [suspended in Jello](#).

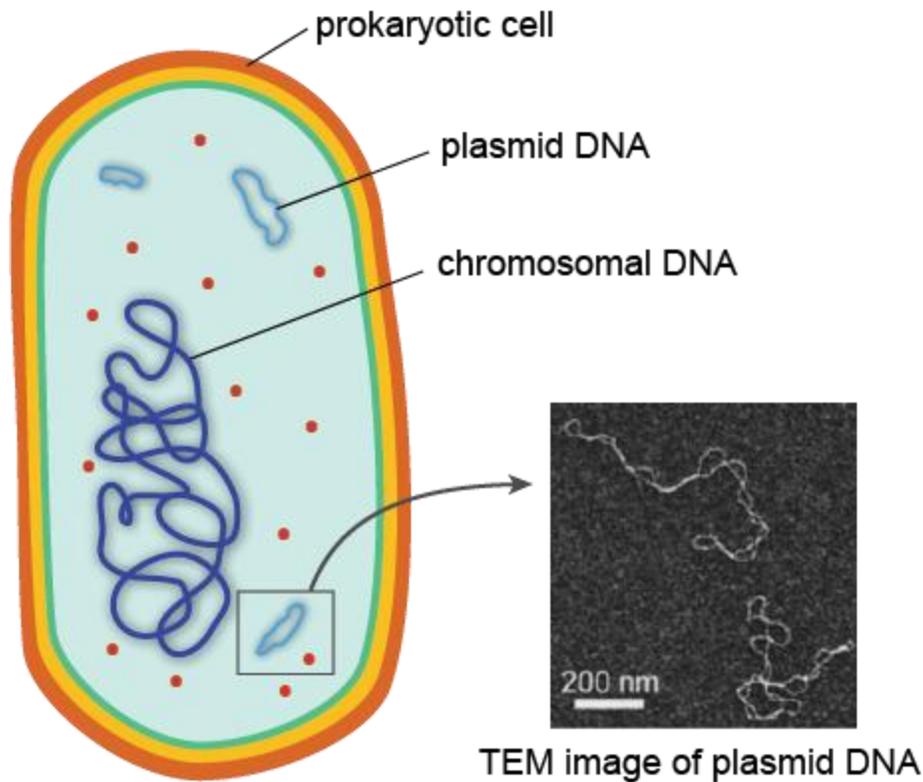
Prokaryotic Ribosomes

Prokaryotic ribosomes are smaller and have a slightly different shape and composition than those found in eukaryotic cells. Bacterial ribosomes, for instance, have about half of the amount of **ribosomal RNA (rRNA)** and one third fewer **ribosomal proteins** (53 vs. ~83) than eukaryotic ribosomes have³. Despite these differences, the function of the prokaryotic ribosome is virtually identical to the eukaryotic version. Just like in eukaryotic cells, prokaryotic ribosomes build proteins by translating messages sent from DNA.

Prokaryotic Genetic Material

All prokaryotic cells contain large quantities of **genetic material** in the form of **DNA** and **RNA**. Because prokaryotic cells, by definition, do *not* have a nucleus, the single large circular strand of DNA containing most of the genes needed for cell growth, survival, and reproduction is found in the cytoplasm.

The DNA tends to look like a mess of string in the middle of the cell:



Transmission electron micrograph image [source](#)

Usually, the DNA is spread throughout the entire cell, where it is readily accessible to be transcribed into **messenger RNA (mRNA)** that is immediately translated by **ribosomes** into protein. Sometimes, when biologists prepare prokaryotic cells for viewing under a microscope, the DNA will condense in one part of the cell producing a darkened area called a **nucleoid**. As in eukaryotic cells, the **prokaryotic chromosome** is intimately associated with special proteins involved in maintaining the **chromosomal structure** and **regulating gene expression**. In addition to a single large piece of **chromosomal DNA**, many prokaryotic cells also contain small pieces of DNA called **plasmids**. These circular rings of DNA are replicated independently of the **chromosome** and can be transferred from one prokaryotic cell to another through **pili**, which are small projections of the cell membrane that can form physical channels with the pili of adjacent cells.

The transfer of plasmids between one cell and another is often referred to as "bacterial sex." The genes for **antibiotic resistance**, or the gradual ineffectiveness of antibiotics in populations, are often carried on plasmids. If these plasmids get transferred from resistant cells to nonresistant cells, **bacterial infection** in populations can become much harder to control. For example, it was recently learned that the **superbug MRSA**, or multidrug-resistant *Staphylococcus aureus*, received some of its drug-resistance genes on plasmids.

Prokaryotic cells are often viewed as "simpler" or "less complex" than eukaryotic cells. In some ways, this is true: prokaryotic cells usually have fewer visible structures, and the structures they do have are smaller than those seen in eukaryotic cells. Don't be fooled, however, into thinking that just because prokaryotic cells seem "simple" that they are somehow inferior to or lower than eukaryotic cells and organisms. Making this assumption can get you into some serious trouble.

Biologists are now learning that bacteria are able to communicate and collaborate with one another on a level of complexity that rivals any communication system ever developed by humans. In addition, some Archaeal cells are able to thrive in environments so hostile that no eukaryotic cell or organism would survive for more than a few seconds⁶. Try *living* in a hot spring, saltlake, deepEarth, or volcano!

Prokaryotic cells are also able to pull off stuff that eukaryotic cells could only dream of, in part *because* of their increased simplicity. Being bigger and more complex is not always better. These cells and organisms are just as adapted to their local conditions as any eukaryote, and in that sense, are just as "evolved" as any other living organism on Earth.

STRUCTURES IN ALL EUKARYOTIC CELLS

<http://www.shmoop.com/biology-cells/all-eukaryotic-cells.html>

Eukaryotic Cell Structure and Function

A cell is defined as **eukaryotic** if it has a **membrane-bound nucleus**. Any organism composed of eukaryotic cells is also considered a **eukaryotic organism**.

Biologists do not know of any single organism on Earth that is composed of both eukaryotic and prokaryotic cells. However, many different types of prokaryotic cells, usually bacteria, can *live inside* larger eukaryotic organisms. We humans, for example, have trillions of bacteria living in our colons, not to mention in our mouths and stomachs and small intestines and...you get the picture. Despite the fact that we have gobs of prokaryotic cells living inside and on us, humans are still categorically eukaryotic organisms. This means that all human cells, including those found in the brain, the heart, the muscles, and so on, are also eukaryotic.

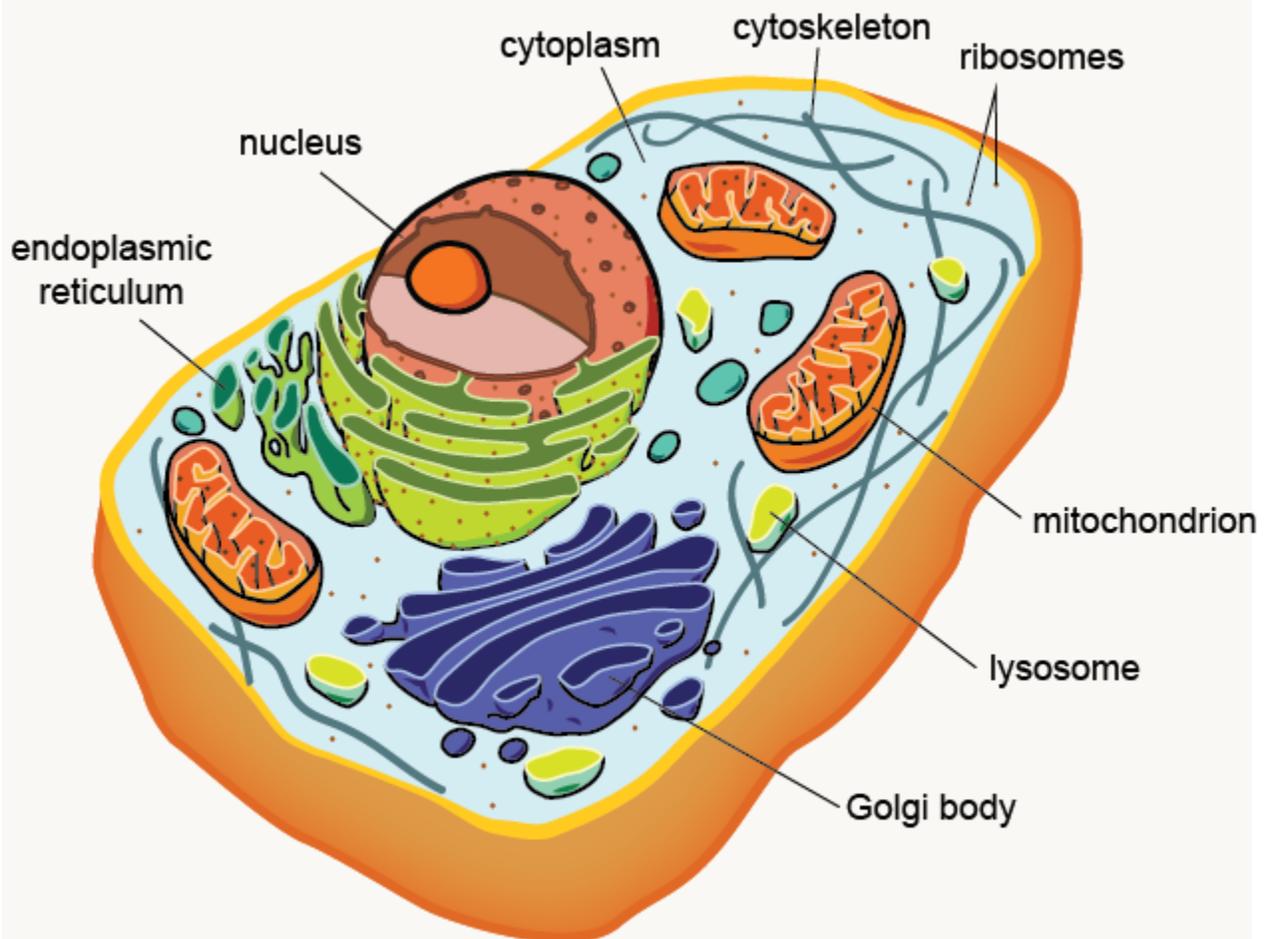


Figure of cell showing internal details

All of the organisms we *can* see with the naked eye are composed of one or more eukaryotic cells, with most having many more than one. This means that most of the organisms we are familiar with are eukaryotic. However, most of the organisms on Earth, by number, are actually prokaryotic.

Here are some examples of eukaryotes:

- Animals
- Plants
- Fungi (mushrooms, etc.)
- Protists (algae, plankton, etc.)

Most plants, animals, and fungi are composed of many cells and are, for that reason, aptly classified as **multicellular**, while most protists consist of a single cell and are classified as **unicellular**.

All eukaryotic cells have: A **nucleus**, Genetic material, A **plasma membrane**, **Ribosomes**, **Cytoplasm**, including the **cytoskeleton**

Most eukaryotic cells also have other membrane-bound internal structures called **organelles**.

Organelles include: **Mitochondria**, **Golgi bodies**, **Lysosomes**, **Endoplasmic reticulum**, **Vesicles**

There are a few major differences between animal, plant, fungal, and protistan cells.:

All plant cells have:

1. A **cell wall** made of cellulose
2. A large central **vacuole**
3. **Chloroplasts**

Some animal and protistan cells have:

1. **Flagella**
2. **Cilia**

All animal cells have:

1. **Centrioles**

All fungal cells have:

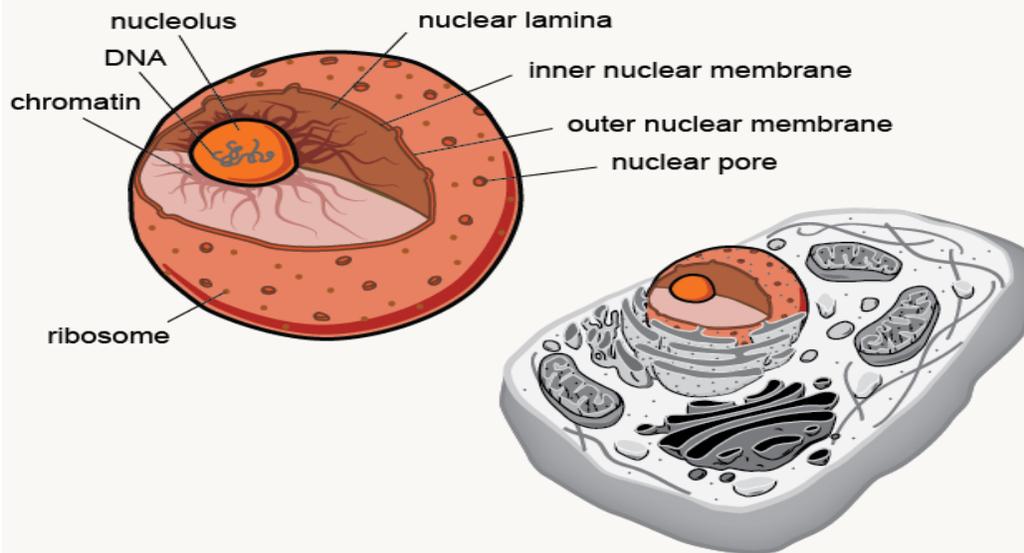
1. A **cell wall** made of chitin.

Structures Found in All Eukaryotic Cells

The Nucleus and Eukaryotic Genetic Material

The nucleus in the cell is analogous to the brain in the body. It is a control center for a cell.

Presenting, the nucleus:



The nucleus stores all the information the cell needs to grow, reproduce, and function. This information is contained in long but thin molecules of deoxyribonucleic acid, or DNA. One of the functions of the nucleus is to protect the cell's DNA from damage. The nucleus is basically a large membranous sac.

The nucleus also contains a small round body called a nucleolus that holds nucleic acids and proteins. The nuclear membrane has pores through which the contents of the nucleus communicate with the rest of the cell. The nuclear membrane tightly controls what gets into the nucleus and what gets out. This regulation of communication by the nuclear membrane has a great effect on what a cell looks like and what it does.

Chromosomes are also located in the nucleus and are basically organized structures of DNA and proteins. In eukaryotes, the chromosomal DNA is packaged and

organized into a condensed structure called chromatin. Chromosomes are single pieces of DNA along with genes, proteins, and nucleotides, and chromatin is a condensed package of chromosomes that basically allows all the necessary DNA to fit inside the nucleus.

Both eukaryotic and prokaryotic cells each have genomes, which is what we call the entire set of an organism's genetic and hereditary information. Genomes are entirely encoded in either the DNA or the RNA. In the case of eukaryotes, multiple linear pieces of DNA comprise its genome.

In eukaryotic organisms, the DNA inside the nucleus is also closely associated with large protein complexes called histones. Along with the nuclear membrane, histones help control which messages get sent from the DNA to the rest of the cell. The information stored in DNA gets transferred to the rest of the cell by a very elegant process—a process so common and so important to life on Earth that it is called the central dogma of biology.

In eukaryotic cells, the first stage of this process takes place in the nucleus and consists of specific portions of the DNA, called genes, being copied, or transcribed, into small strands of ribonucleic acid, or RNA. RNA containing a copy, or transcript, of DNA is called messenger RNA, or mRNA. These mRNA molecules are then physically transported out of the nucleus through the pores (holes) in the nuclear membrane and into the cytoplasm where they are eventually translated into proteins by ribosomes.

Therefore, the central dogma of biology is simply:

DNA → RNA → Protein

and it all starts in the nucleus of eukaryotes.

Most eukaryotic cells have a nucleus throughout their entire life cycles, but there are a few notable exceptions. Human red blood cells (RBCs), for example, get rid of their nuclei as they mature. With their nuclei removed, red blood cells have more space to carry oxygen throughout the body.

[Eukaryotic Plasma Membrane](#)

The plasma membrane in eukaryotic cells is responsible for controlling what gets into and out of the cell. A series of proteins stuck in the membrane help the cell communicate with the surrounding environment. Among other things, this communication can include

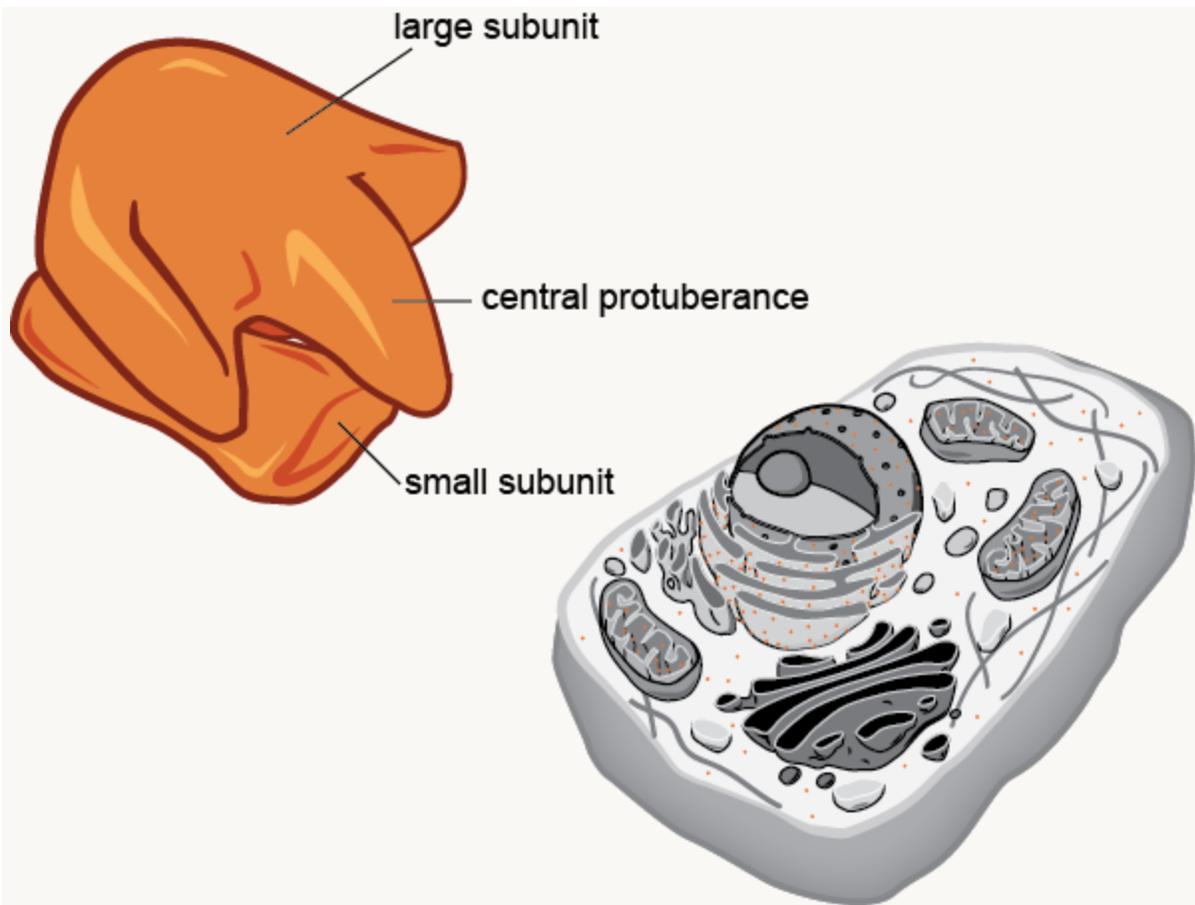
- Sending and receiving chemical signals from other eukaryotic cells
- Interacting with the cells of prokaryotic organisms during the process of infection.

Keep in mind that the plasma membrane is universal to all cells, prokaryotic and eukaryotic.

Eukaryotic Ribosomes

Ribosomes are small cellular machines made of proteins and ribosomal RNA. All cells, both eukaryotic and prokaryotic, have ribosomes.

Presenting, the ribosome:



Eukaryotic ribosomes are larger and have a slightly different shape and composition than those found in prokaryotic cells. Eukaryotic ribosomes, for instance, have about twice the amount of ribosomal RNA (rRNA) and one third more ribosomal proteins (~83 vs. 53) than prokaryotic ribosomes have.³ Despite these differences, the function of the eukaryotic ribosome is virtually identical to the prokaryotic version. This is a remarkable example of what we call evolutionary unity. Ribosomes translate mRNA into protein, or the last step in the central dogma of biology described earlier.

Eukaryotic Cytoplasm and Cytoskeleton

The cytoplasm in eukaryotic cells is a gel-like, yet fluid, substance in which all of the other cellular components are suspended, including all of the organelles. The underlying structure and function of the cytoplasm, and of the cell itself, is largely determined by the cytoskeleton, a protein framework along which particles in the cell, including proteins, ribosomes, and organelles, move around.

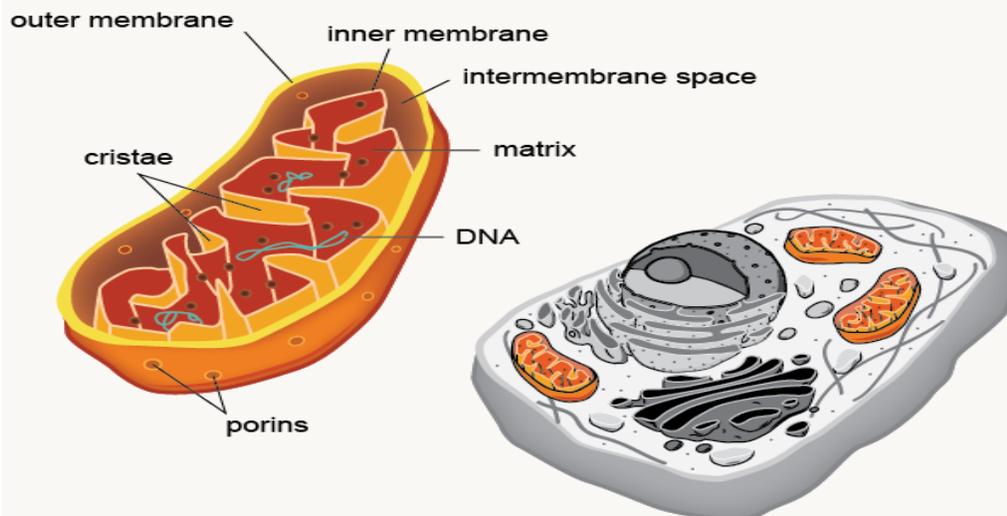
You can think of the cytoskeleton as a type of 3D "highway system" with roads running in every direction, including up and down. The cytoplasm is the thick fluid in which the "highway system" is suspended and through which cellular materials are transported.

STRUCTURES IN MOST EUKARYOTIC CELLS

Most eukaryotes have these, but some don't.

Mitochondria

All cells need energy to grow, reproduce, and function. Like the organisms they comprise, cells must "eat" in order to get the energy they need. One of the most important types of cellular food is a molecule called **glucose**, which is a type of sugar and a carbohydrate. Eukaryotic cells take in glucose through proteins that cross the **plasma membrane** and then transport it through the **cytoskeleton** to the **mitochondria** (mitochondria is plural; the singular is **mitochondrion**) in the cytoplasm. The mitochondrion is often called the cell's powerhouse.



In the **cytoplasm** just outside the mitochondria, glucose is broken down into smaller molecules through a process called **glycolysis** (literally "sugar breaking"), which releases chemical energy. This energy is temporarily captured by specialized molecules and transported through the **mitochondrial membranes** into the mitochondria. There it is used to make an important molecule called **adenosine**

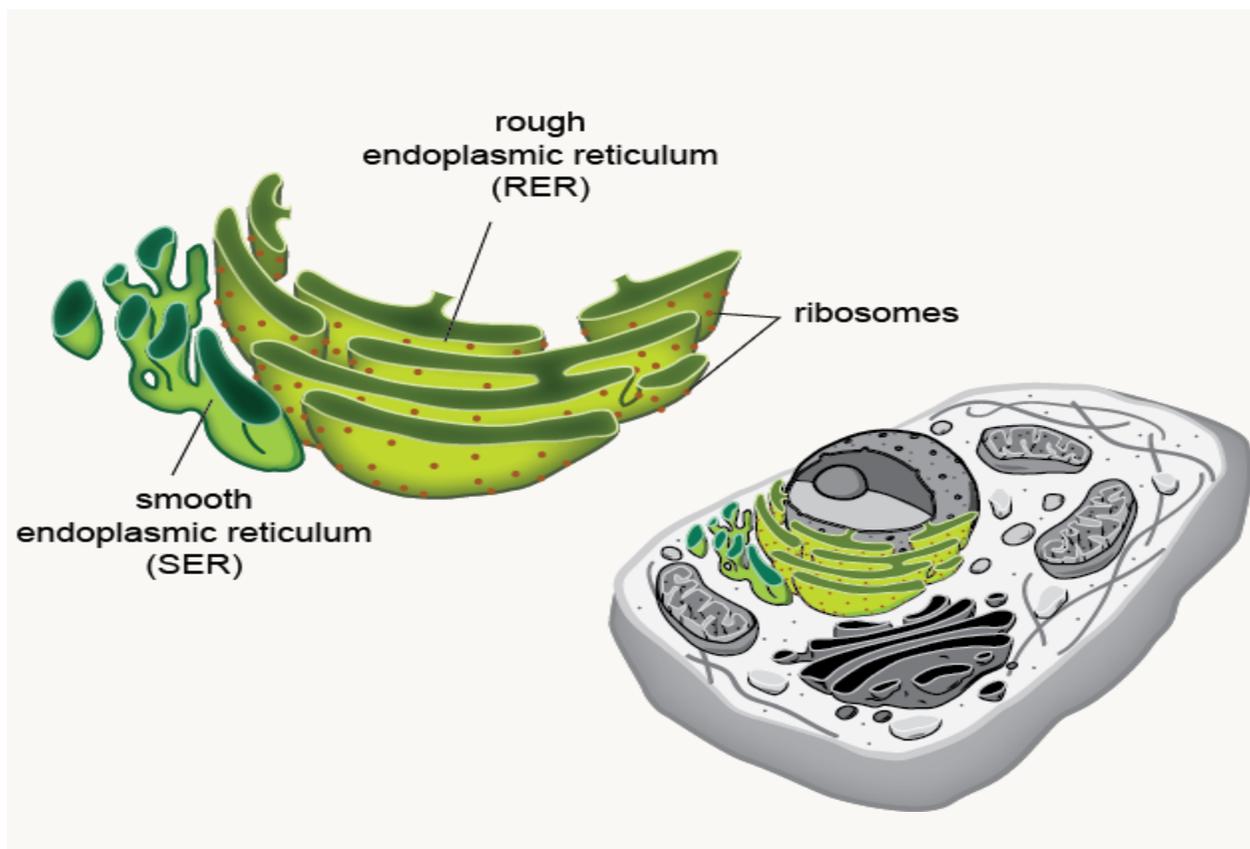
triphosphate (ATP) through a process known as **cellular respiration**. Mitochondria can convert a single molecule of glucose into ~38 molecules of ATP! Mitochondria do not mess around with energy storage; they mean business. You can think of each ATP molecule as a unit of stored energy ready to be used by the cell whenever needed.

The main function of all mitochondria, then, is to make ATP, which is the energy source for nearly all cellular functions and processes. You can read more about the details of how mitochondria are involved in cellular respiration in a later unit.

Endoplasmic Reticulum

Endoplasmic reticulum has got to be on a "top ten best term" list somewhere. There are two types of endoplasmic reticulum (ER) in eukaryotic cells:

- **Smooth ER (SER)**
- **Rough ER (RER)**



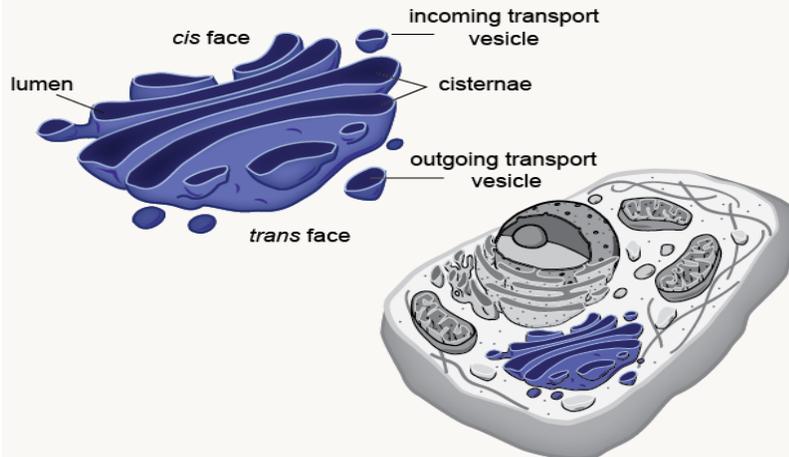
Both ER types are involved in making important cellular components. The **rough**

endoplasmic reticulum (RER) is mainly responsible for the synthesis and processing of proteins that are either secreted from the cell or that end up stuck in the plasma membrane. Proteins marked for secretion are sent from the RER to the **Golgi body** (he's next in line for explanation, so hang tight) for further processing. Insulin is an example of a secreted protein processed by the RER. This very large protein is secreted in huge quantities from the pancreas cells in mammals and aids in the uptake and digestion of glucose.

The smooth endoplasmic reticulum (SER) is primarily involved in the synthesis of lipids (fatty fat fats) and steroids, both very important components of **cell membranes**. The lipids made in the SER are combined with phosphorous to make **phospholipids**, the most abundant component of cell membranes. The steroids, including cholesterol, made in the SER are also important components of cell membranes because they provide the rigidity and structure needed for the membrane to keep its general shape.

Golgi Bodies

The Golgi body is simply a flattened stack of membrane disks.



In these membranous stacks, called **cisternae**, proteins that have been marked for secretion in the RER are packaged into vesicles that transport them to the **plasma membrane** where they are secreted from the cell. The Golgi body also packages the lipids and steroids made in the SER into vesicles. Packaged lipids and steroids are transported to the edge of the cell, as well as to all organelles within the cell, where they are used to build or repair the cell and organelle membranes. Lastly, small portions of the Golgi body cisternae often bud off into small spheres to create **lysosomes**. Just in case you're wondering, the incessant capitalization of

the "G" in "Golgi" is not a word processor error, but a result of the fact that this interesting organelle was named after its discoverer, the preeminent Italian physician Dr. Camillo Golgi.

Lysosomes

Lysosomes are small spheres of **phospholipids** made by the **Golgi bodies** and are responsible for breaking down cellular debris and material taken into the cell through the process of **phagocytosis** (the cell's swallowing up of things). The interior of a lysosome contains many enzymes and is slightly acidic so that material can be digested without harming the rest of the cell. Lysosomes maintain their acidity by pumping protons (hydrogen ions, or H^+ ions) across their membranes through **integral channel proteins**.

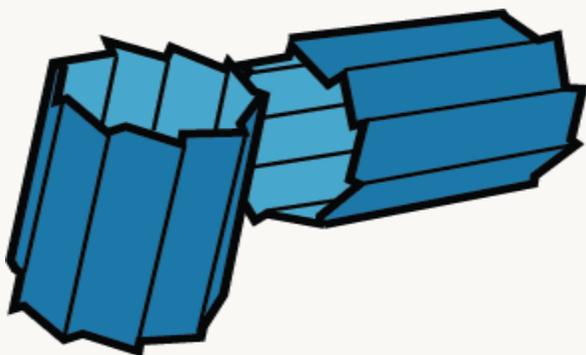
Vesicles

Vesicles are small spheres of phospholipids made by the **Golgi bodies** and are responsible for transporting proteins, lipids, and steroids to various places throughout the cell, especially to the **plasma membrane**. The interior conditions of a vesicle are similar to the conditions of the surrounding **cytosol** so that transported proteins and lipids are not damaged en route to their destinations.

STRUCTURES ONLY IN ANIMAL CELLS

Centrioles

The **centriole** is a small, barrel-shaped tube composed of protein located in the cytoplasm.

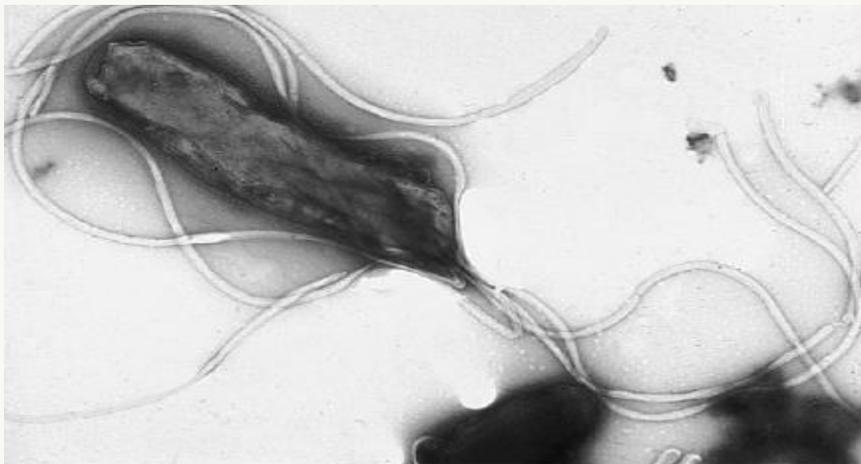


The centriole's main function is to aid in **cell division** and in the spatial arrangement of structures within the cell. Less is known about the function of centrioles than many of the other organelles discussed in this section, but biologists are learning that these little protein tubes play a critical role in **cellular reproduction** and even **cell growth**. What's more, centrioles are now known to be essential for the development of **flagella** and **cilia**. Cells with damaged or missing centrioles cannot form properly functioning flagella and cilia, a condition that can lead to disease and even death of the organism in which cells containing flagella and cilia are found.

Flagella and Cilia

Flagella and **cilia** are extensions of the cell membrane that are lined with **cytoskeleton** and, in the case of flagella, **mitochondria**. Flagella are generally much longer than cilia, like whips, but there are often hundreds more cilia than flagella on a given cell. Flagella are primarily responsible for cell movement.

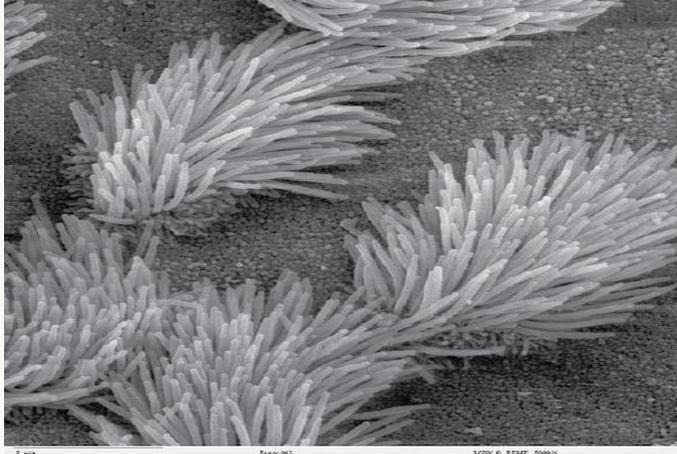
Here are some real-life flagella:



Electron micrograph image [source](#)

They function by spinning like a whip, allowing a cell to move through the environment. Sperm cells are an excellent example of animal cells that have flagella. In these cells, flagella spin rapidly to allow the sperm to move up the vaginal canal, into the uterus and into the egg.

Cilia, on the other hand, act more like short hairs moving back and forth across the outside of the cell. A picture under the sea? just some cilia:



Scanning electron micrograph image source: [Wikimedia Commons](#)

Cilia generally move matter past a cell. The most common examples of ciliated cells are those that line the trachea, or wind pipe, of animals. Here, the cilia move mucus containing dirt and other inhaled particles up the windpipe and into the esophagus where they can be coughed up or swallowed.