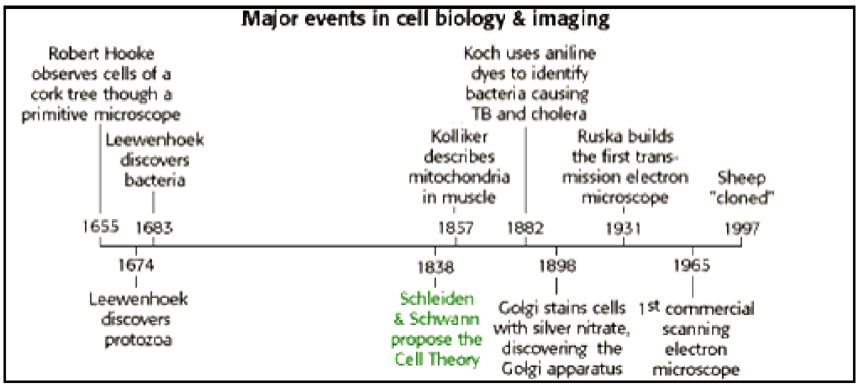
PDF File

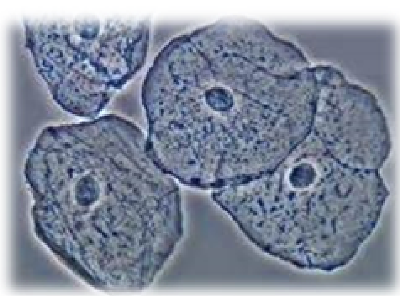
CELLS

History of Studying Cells

Because of the limitations of the human eye, much of the early biological research concentrated on developing tools to help us see very small things. As imaging technology became more sophisticated, biological discoveries abounded. Below is a timeline detailing some of those major events in biology.



The Cell Theory



In 1838, Matthias Schleiden, a German botanist, discovered and stated that plants are made of cells. In 1839, Theodor Schwann, a German zoologist, discovered and stated that animals are made of cells. In 1858, Rudolph Virchow, a German physician, stated that cells only come from the division of previous existing cells. This idea was important to recognize and state because of the popular belief, at the time, of spontaneous generation. Spontaneous generation dealt with the idea that living things could possibly come from non-living things. If you recall, we mentioned in a previous lesson how Louis Pasteur was the scientist that finally disproved spontaneous generation. The “cell theory”, developed by Schleiden, Schwann, and Virchow, changed biology and cell biology research forever.

The cell theory states that:

- Living things (organisms) are made of one or more cells.

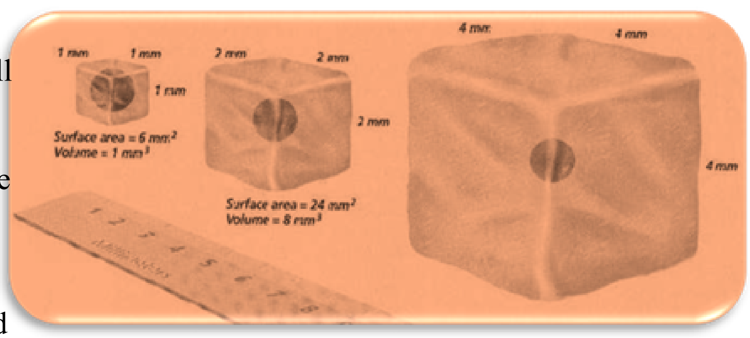
- Cells are the basic unit of structure and function in organisms.
- All cells arise from existing cells.

The cell theory also provides us with an operational definition of "life" as it is one of the characteristics of life mentioned in a previous lesson.

Cell

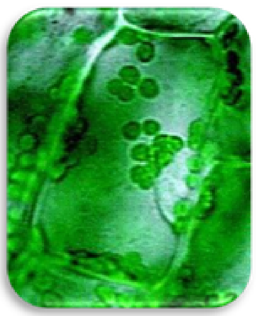
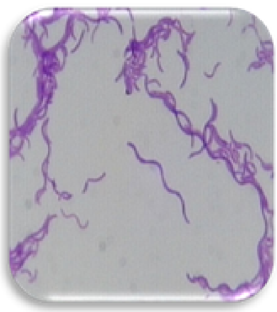
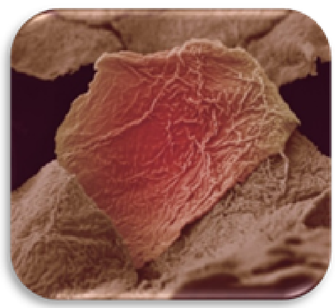
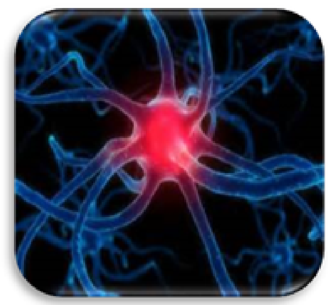
In biology, the basic unit of which all living things are composed is called a cell. As the smallest units retaining the fundamental properties of life, cells are the “atoms” of the living world. A single cell is often a complete organism in itself, such as a bacterium or yeast. Other cells, by differentiating in order to acquire specialized functions and cooperating with other specialized cells, become the building blocks of large multicellular organisms as complex as the human being. Although they are much larger than atoms, these building blocks are still very small. The smallest known cells are a group of tiny bacteria called mycoplasmas; some of these single-celled organisms are spheres about 0.3 micrometers in diameter, with a total mass of 10^{-14} gram—equal to that of 8,000,000,000 hydrogen atoms. Human cells typically have a mass 400,000 times larger, but even they are only about 20 micrometers across. It would require a sheet of about 10,000 human cells to cover the head of a pin, and each human being is composed of more than 75,000,000,000,000 cells.

Cell Size and Shape



Cells vary greatly in size and shape. Cell size is greatly influenced by the surface of the cell (cell membrane). All substances that enter or leave a cell must pass through the surface of the cell. The larger the cell becomes the more nutrients it needs to move in and the more waste there is to move out. In larger cells the nutrients and waste must move greater distances to pass through the surface of the cell. So, it is said that cell size is limited by a cell’s surface area to volume ratio. Cells with a greater surface are to volume ratio can exchange nutrients and waste more efficiently. So, when comparing smaller and larger cells, it can be found that the smaller the cell the greater the surface area to volume ratio. Therefore, it would benefit the cell to remain smaller in size for survival.

Not all cells need to stay small, some cells can survive larger when compared to others. Larger cells need to have shapes that increase the surface area so that enough exchange in and out of the cell can occur. A cell can only grow large in one dimension and still survive. Some large cells are long and skinny or broad and flat. We tend to always see models of cells, in pictures and hand-held models, as circular objects, when in reality all cells differ in size and shape. Below are some pictures of different types of real living cells and how they differ in shape.

Cell Structure

All cells, regardless of type, have the same five features in common. Those five features are *cell membrane, cytoplasm, cytoskeleton, ribosomes, and DNA*.

Cell Membrane is the cell's outer boundary that acts as a barrier between the outside and inside of a cell. We will discuss more about the cell membrane's structure and function in a future unit.

The **cytoplasm** is the material from the nucleus to the cell membrane or, if no nucleus is present, everything within the cell membrane solid and liquid. The cytoplasm consists of the fluid, which is known as cytosol, with all of the dissolved particles in it, and all of the structures suspended in it. Cytoplasm contains molecules, ions, water, and every cell organelle, except the nucleus. The liquid of the cytoplasm acts like a buffer, maintain a pH that promotes life, helps chemical reactions to work optimally.

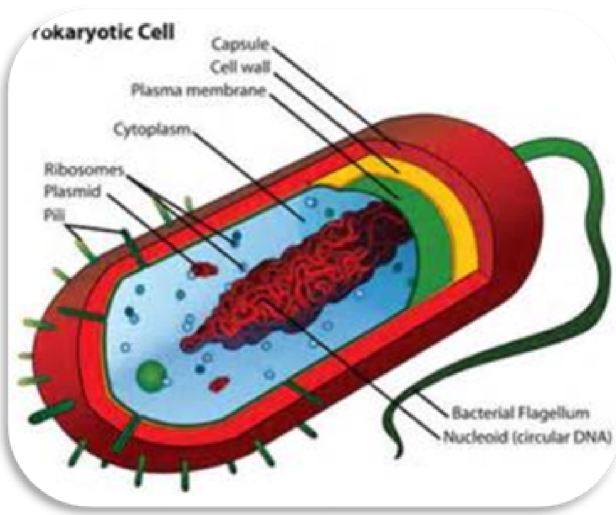
The **cytoskeleton** is what enables the cell to have a particular shape, organize the parts within, and move either as a whole cell or the parts within. The cytoskeleton is primarily mentioned as a feature of a cell which has a nucleus (eukaryote), but similar structures have also been found in cells without a nucleus (prokaryotes). When one looks at one single-cell organism, the ameba, you see a blob that can alter its shape to suite its needs of movement, eating, and disposing of waste. But many cells have specific shapes. Cytoskeletons are networks of proteins the helps the cell maintain its shape without the need of extra energy to contract the cell membrane. The cytoskeleton is composed microtubules, microfilaments, and intermediate fibers. Microtubules are hollow, protein tubes that act as "tracks" along which organelles can move through a cell. Microfilaments are long, thin protein fibers that help cells move, change shape, and/or provide some shape and structure to the cell. Microfilaments are much thinner than microtubules, 7nm and 25nm respectively. Intermediate fibers are moderately thick (size is between microtubules and microfilaments) and mainly anchor organelles and enzymes to certain regions of the cell.

All cells have **ribosomes** which are responsible for producing the proteins of a cell. Ribosomes may have one of the most important jobs within cells. Ribosomes carries out the job of assembling proteins, based upon the blueprint found in the DNA molecule, by linking together amino acids. Ribosome uses both mRNA, and tRNA to make proteins. Ribosomes are found on sections of an organelle called the endoplasmic reticulum or floating independently in the cytosol. When the ribosome make proteins, the proteins directly enter the endoplasmic reticulum (if present).

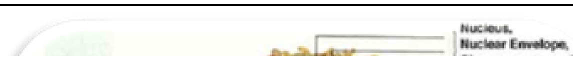
Lastly, all cells have **DNA (deoxyribonucleic acid)** which is the genetic material responsible for providing the instructions for making proteins, regulating cellular activities, and enabling the cell to reproduce.

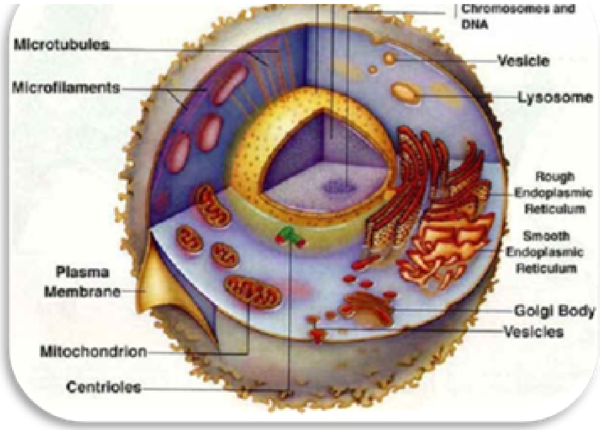
Prokaryote and Eukaryote Cells

There are two basic types of cells that exist, **prokaryote and eukaryote**. A *prokaryote* is a cell which does not have a nucleus or membrane-bound organelles. A *eukaryote* is a cell which has a nucleus and membrane-bound organelles. The only prokaryotes that exist are the single-celled (unicellular) organisms known as bacteria. All other organisms, whether it be a protist, fungus, plant, or animal and unicellular or multicellular, are eukaryotes.

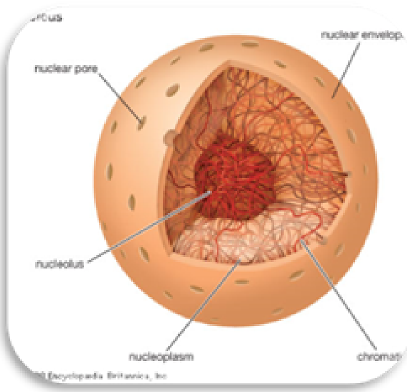


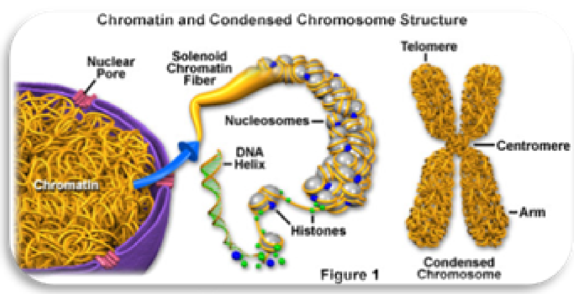
A **PROKARYOTE** is a very simple type of cell. The genetic material (DNA) is a single tangled loop found in a region known as a **nucleoid** There are other smaller rings of DNA known as **plasmids**. Cytoplasm completely fills the cell with ribosomes, enzymes, the nucleoid, and plasmids suspended throughout it. Surrounding the cytoplasm is a **cell membrane**. Outside of the cell membrane is a **cell wall** made primarily of peptidoglycan. Peptidoglycan is a molecule consisting of a carbohydrates and amino acids. The cell wall, with its peptidoglycan, provide structure and support for the cell. Some prokaryotic cells may also have another layer surrounding the cell wall called the **capsule**. The capsule provides another layer of protection in addition to a surface that enables the prokaryotic cell to attach or cling to living and nonliving surfaces. Prokaryotes (and some eukaryotes) may also have a **flagellum** to provide a means of locomotion (movement) for the cell. Pili may also be present. **Pili** are protein tube extensions of the cell membrane used for attachment to another cell or for the exchange of genetic material with another cell.





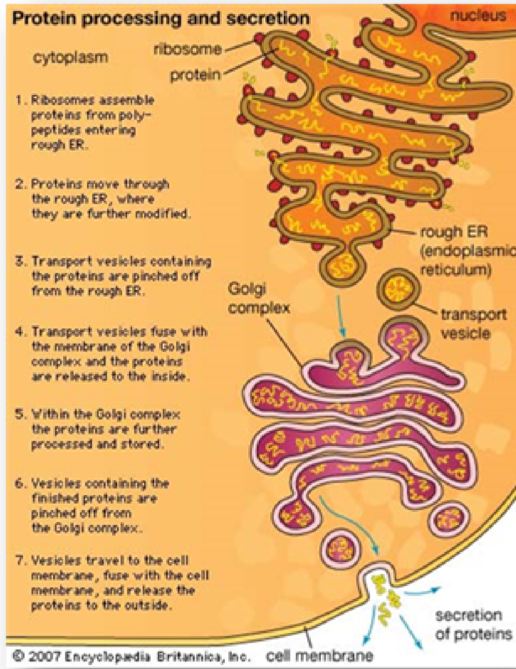
A **EUKARYOTE** is a more complex type of cell. A eukaryotic organism may be made up of one cell (unicellular) or many cells (multicellular). Scientists believe the first prokaryotic cells may have lived 2.5 billion years ago or more, while the first eukaryotes may have first appeared 1.5 billion years ago. In addition to the common features all cells have, they also have an internal compartment which houses the cell's DNA. This compartment is known as the **nucleus** and is sometimes nicknamed the *control center* of the cell. There is a membrane surrounding the nucleus known as the nuclear membrane or nuclear envelope. The nuclear envelope contains thousands of tiny holes known as nuclear pores, through which RNA may leave the nucleus. The nucleus also has a small spherical structure within it called a **nucleolus** which is responsible for making ribosomes. The DNA within the nucleus may be arranged as chromatin or chromosome. Chromatin is when the DNA and proteins associated with it are scattered throughout the nucleoplasm (cytoplasm of the nucleus). Chromosomes are observed when the cell is preparing to divide or is in the process of dividing. Chromosomes are visible when the DNA wraps or coils around the proteins associated with them and forms a visible microscopic rod-shaped structure. Along with having all of the common cell features and a nucleus, a eukaryote also has membrane-bound organelles that carry out specific functions within the cell. Next, we will take a look at each of these organelles.





Endoplasmic Reticulum

The **endoplasmic reticulum** is a long internal system of continuous membranes, running throughout a cell and usually attached to the nuclear envelope. The section of the endoplasmic reticulum that has ribosomes is called the rough endoplasmic reticulum (rough ER). It is called rough because of the rough, bumpy look that the ribosomes give the surface of the endoplasmic reticulum. Where you do not have ribosomes, the endoplasmic reticulum is called the smooth endoplasmic reticulum (smooth ER). Within this section of the endoplasmic reticulum, specialized enzymes can be found, making things like lipids and breaking down toxins. The polypeptides (beginning of a protein) that are made in a ribosome found on the rough endoplasmic reticulum are then transported to the end of the rough ER membranous channel and pinched off by the ER membrane into a vesicle (transport vesicle). The vesicle transports the newly made substance just as an envelope transports a letter through the mail. These vesicle-enclosed polypeptides are then transported to the Golgi apparatus.



Golgi Apparatus

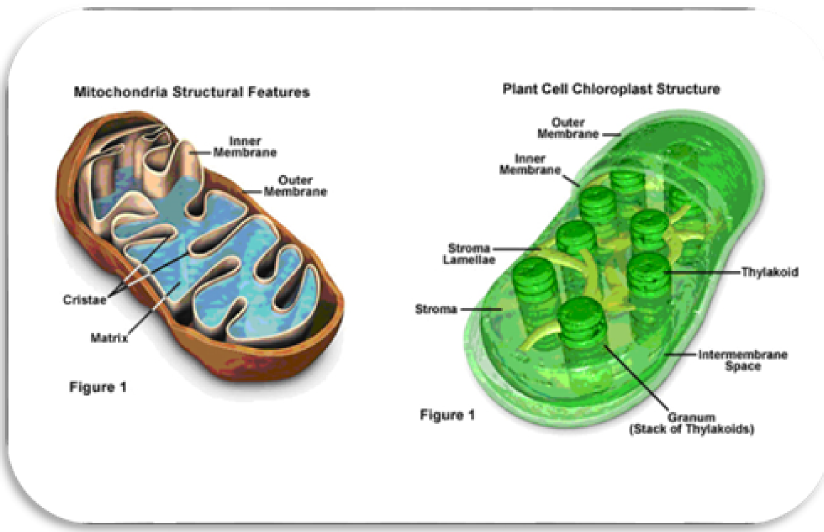
The Golgi apparatus (complex) finishes the proteins, by modifying the polypeptide (adding carbohydrates and lipids to the protein). From the Golgi apparatus, proteins are finally sent on their way through the endoplasmic reticulum, to the outside of the cell by way of another vesicle which again is just the membrane of the now Golgi apparatus pinched off. **This process of making a polypeptide by way of the Ribosome to the Endoplasmic Reticulum to the Golgi Apparatus is sometimes referred to as "protein processing" and/or "protein transport".**

Vacuoles

An advantage of eukaryotes over prokaryotes is the membrane bound organelles. This is particularly the case when the cell makes too many proteins, like digestive enzymes. Vacuoles are the storage organelles of the cell. Vacuoles hold water, salts, proteins, carbohydrates, and sugars. Specialized vacuoles may contain very strong digestive enzymes. In this case, we call the organelle lysosomes. **Lysosomes** contain powerful enzymes the can rapidly breakdown proteins, nucleic acids, lipids, and carbohydrates, so the lysosome acts as the stomach of the cell. By breaking down these biomolecules, the remaining materials can now be recycled by the cell. Those organelles that hold enzymes that can convert fats into carbohydrates, or can convert hydrogen peroxide into water are called **peroxisomes**. Some protists have specialized vacuoles known as **contractile vacuoles** which pump excess water out of their cell. By pumping out excess water, these cells can now balance the concentration of salt and other molecules in an effort to maintain homeostasis.

Energy Producing Organelles

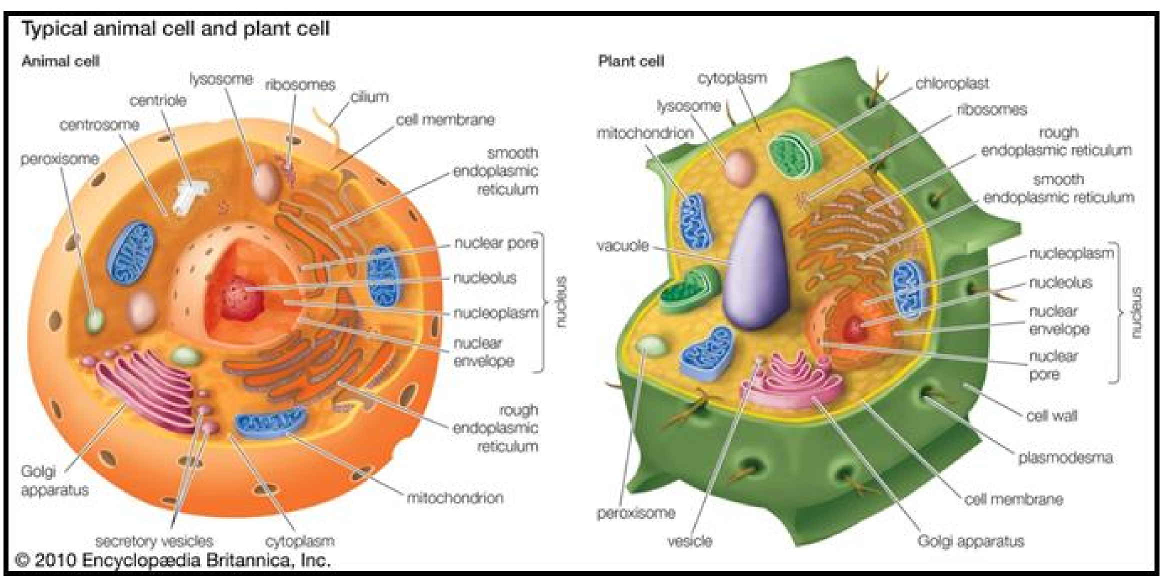
Two important organelles involved in converting energy into a usable form are chloroplast and mitochondrion. **Chloroplasts** contain molecules and carry out a process (photosynthesis) that converts the energy from sunlight into sugars. **Mitochondria** (nicknamed the "powerhouse" of the cell) contain enzymes that can convert the energy in sugars and other high-energy molecules to ATP (the cells fuel) which is the cell's only usable form of chemical energy. Once the energy stored in sugar has been converted to ATP, the cell has the extra energy that it needs to run complex processes. More details about the reactions and processes that take place in the mitochondrion and chloroplast will be discussed later.

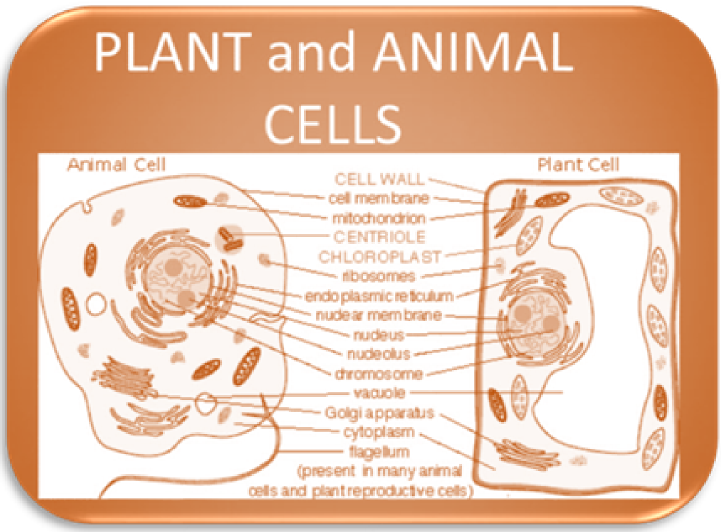


The following video profiles the structure of a eukaryotic cell, describing the form and function of each part of a cell. The program covers the phospholipid bilayer, cytoskeleton, cytoplasm, mitochondria, lysosome, nucleus, and the rough and smooth endoplasmic reticulums.

Animal Cell vs Plant Cell

Plant cells have three structures that animal cells do not. Plant cells have a central vacuole, chloroplasts, and cell wall. We have already discussed vacuoles. A central vacuole is the same as a vacuole, however, it is much larger in a plant cell as it may take up as much as 90% of the volume of the plant cell's center. We also already mentioned chloroplasts as providing a means of chemical energy. The cell wall in a plant cell is located outside of the cell membrane and is only found in a plant cell and not an animal cell. The plant's cell wall provides structure, support, and protection for the plant cell. The primary component for the plant's cell wall is a complex carbohydrate named cellulose.





Additional practice: Print out the following worksheets to see if you can correctly label all the parts of the cell. This is practice only!

Printable Animal Cell Worksheet

Printable Plant Cell Worksheet

Plant and Animal Cell Worksheet

UNIT VOCABULARY REVIEW

membrane or, if no nucleus is present,

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