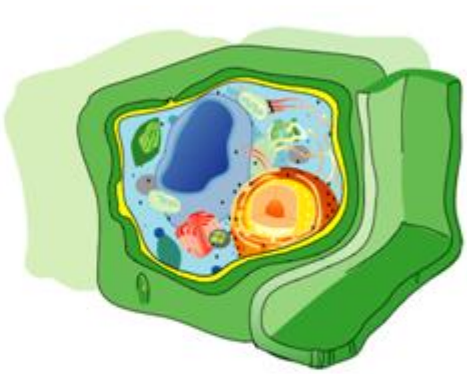
Name: ______________________________________ Date: ________________________

Guided Learning: Different Types of Cells

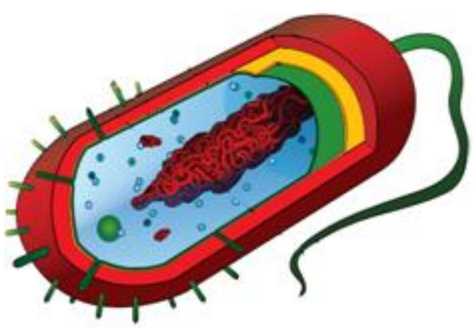
Learning goals
After completing this activity, you will be able to …
- Compare prokaryotic and eukaryotic cells.
- Differentiate between structure and function in plant and animal cell organelles.
- Compare the functions of a cell to the functions of organisms.
- Describe the Margulies theory on evolution of eukaryotic cells.
- Compare the structure of viruses to cells.

Vocabulary: cell membrane, cell wall, chloroplast, cytoplasm, endosymbiotic theory, eukaryotic cell, organelle, mitochondrion, nucleus, prokaryotic cell, vacuole, virus

Warm-up questions:
The two diagrams below are of two different kinds of cells.



Cell A



Cell B

1. What are some similarities between the two cells? ___________________________________

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2. What are some differences between the two cells? __________________________________

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3. Which cell do you think is a bacterial cell? Explain your choice. _______________________

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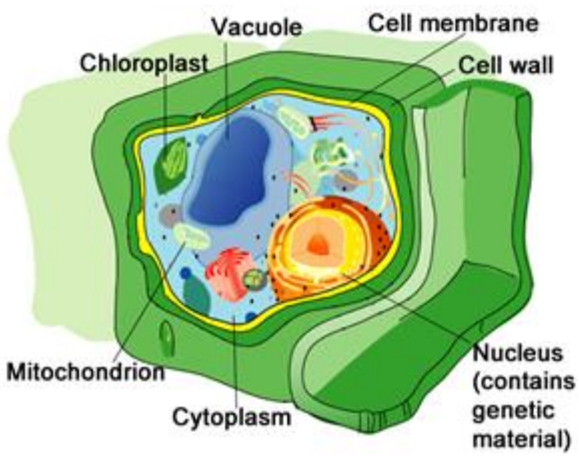
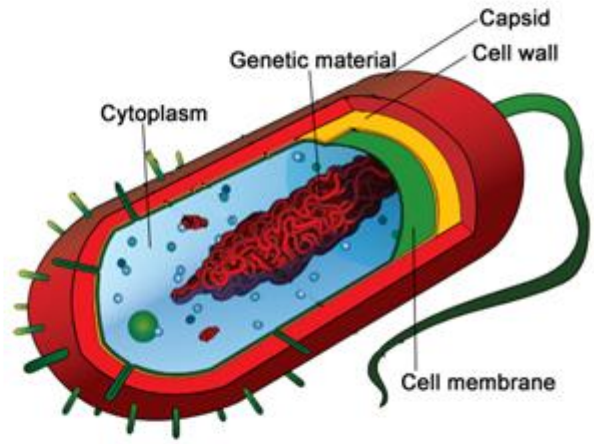
Activity A: Prokaryotes and eukaryotes

Every organism is made up of at least one cell, but as you saw on the previous page, not all cells are the same. In fact, all cells can be categorized into one of two kinds: **prokaryotic** or **eukaryotic**. You can see examples of these two kinds of cells below.



Eukaryotic cell



Prokaryotic cell

The main difference between prokaryotic and eukaryotic cells is the presence or absence of a **nucleus**. A nucleus is a membrane-bound cell structure that contains the cell's genetic material. Eukaryotic cells have nuclei. But the genetic material of prokaryotes floats freely in the cell's **cytoplasm**, or the fluid portion of the cell. So, which type of cells do you think are found in your body? As it turns out, all of your cells are eukaryotic cells. But your cells don't look quite like the eukaryotic cell shown here. The cell shown here is a plant cell. Plants are also eukaryotes, as are all animals, fungi, and protists. Bacteria are prokaryotes.

Prokaryotic cells are generally much smaller and simpler than eukaryotic cells. Despite this, unicellular prokaryotes are able to carry out the same major biological functions as a multicellular eukaryote. Think about some of the main biological functions of an animal, such as a cat. A cat eats to take in energy, gets rid of waste products by excreting them, and maintains water levels. Likewise, individual cells are able to take in energy, excrete waste products, and maintain water levels.

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1. How do eukaryotic cells differ from prokaryotic cells? ________________________________

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2. How are eukaryotic cells similar to prokaryotic cells? ________________________________

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3. You observe a large cell that has a nucleus. Is this cell prokaryotic or eukaryotic? Explain.

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4. Cats are able to reproduce to create offspring (kittens). Do you think individual prokaryotic cells are able to reproduce? Explain. ____

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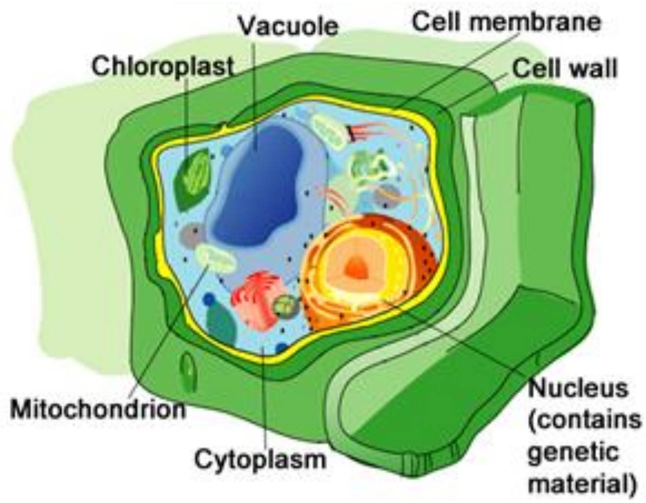
Activity B: Cell structures

You've already learned that eukaryotic cells have a nucleus, while prokaryotic cells do not. A nucleus is a membrane-bound **organelle**. Organelles are structures that act like specialized organs within cells. In fact, the term *organelle* actually means "little organ." Only eukaryotic cells have membrane-bound organelles.



Different types of eukaryotic cells have different organelles. For example, plant cells have several organelles not found in animal cells. Look at the plant cell shown at right. As you read about each cell part, locate the part on the diagram.

- **Chloroplasts:** This cell contains organelles called **chloroplasts**. You can think of chloroplasts as tiny solar panels. They contain stacks of tiny discs that capture the Sun's energy and turn it into sugars. Pigments in the chloroplasts are what give most plants their green color.

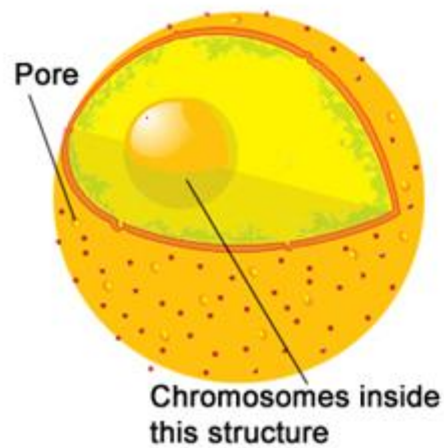
- **Plant vacuoles:** Many plant cells also contain a single large **vacuole**. This sac-like structure stores materials like water, salts, and sugars. A plant cell's vacuole helps make the plant cell rigid, giving it strength. This allows plants to support heavy structures, such as leaves and flowers.

- **Animal vacuoles:** Other types of cells, including some animal cells, have vacuoles, but they are usually smaller and more abundant than plant cell vacuoles. Animal cell vacuoles help transport materials into and out of the cell, but because they are so small they do little to give an animal cell structure.

- **Mitochondria:** Some organelles are found in both plant and animal cells. For example, **mitochondria** (singular, *mitochondrion*) are in all animal cells and almost all plant cells. These organelles convert sugars into energy that cells can use to carry out life functions. Mitochondria have two separate membranes. The outer membrane is permeable to nutrient molecules, such as sugars, as well as oxygen, carbon dioxide, and water. The inner membrane is only permeable to oxygen, carbon dioxide, and water. Oxygen is used to break down sugar molecules and release energy. Carbon dioxide and water are the waste products of this reaction. Thus, the outer membrane lets in water and sugar and lets out waste products, while the inner membrane "traps" the sugar, allowing the sugar to be broken down and energy released.

- **Nucleus:** Both plant and animal cells also have nuclei. The nucleus of a cell, shown at right, is surrounded by an envelope that has pores, which allows materials to move into and out of the nucleus. Inside the nucleus are bundles of genetic material. These bundles are called *chromosomes*. The genes that encode an organism's traits are found on chromosomes in the nucleus.

Cell nucleus



- **Cytoplasm:** Like prokaryotic cells, plant and animal cells are filled with cytoplasm. The cytoplasm contains dissolved substances, such as the sugar that is used by the cell for energy. Cytoplasm also contains water, salt, and other materials needed by the cell to perform its functions.

- **Cell membrane:** A cell's cytoplasm and organelles are surrounded and protected by a **cell membrane**. The cell membranes for both plants and animals have tiny channels that selectively allow needed materials to enter the cell and waste products to exit the cell. In plants, the cell membrane has fibers to give it added support. Animal cells lack these fibers, which makes the cell membrane of animal cells more flexible.

- **Cell wall:** In addition to a strong cell membrane, plants also have a **cell wall**. The cell wall keeps the plant from shrinking too much when it loses water and bursting when it gains water. Like a plant cell's membrane, the cell wall is very fibrous. It gives the cell a great deal of strength, allowing the cell to maintain its shape even when placed under a great deal of force.

- **Ribosomes:** Ribosomes are small structures that are found in all cells, including prokaryotic cells. Ribosomes are sites where proteins are manufactured. Proteins form essential components of all cells.

You might be wondering why plant cells have so many structures that animal cells lack to help strengthen the cell. Most animals have internal or external skeletons to give them support. Plants don't have this. Thus, their cells must provide the strength needed for the plant to stand up against the force of gravity.

1. What structures contain a cell's genetic information, and where are these structures located? ____

2. Complete the chart to describe the structure and function of plant and animal cell organelles. Contrast plant and animal cell structures and functions when there is a difference.

Organelle	Found in plants?	Found in animals?	Structure	Function
Cell membrane				
Cell wall				
Chloroplast				
Cytoplasm				
Mitochondrion				
Nucleus				
Animal vacuole				
Plant vacuole				
Ribosome				

Activity C: Origin of eukaryotic cells

Scientists have found fossils of prokaryotic cells that are over three billion years old. Eukaryotic cells don’t appear in the fossil record until about one billion years later. Where did these early eukaryotic cells come from?

In 1967, Dr. Lynn Margulis of the University of Massachusetts published a paper that proposed an intriguing explanation for the origin of organelles in eukaryotic cells. According to her theory, small prokaryotic cells were engulfed (eaten) by larger prokaryotic cells, but were not digested right away. Instead, the smaller prokaryotic cells began to live inside larger prokaryotic cells.

The relationship benefited them both. The small prokaryotic cells were protected inside the larger cells. In exchange, the small cells provided nutrients and energy to the larger cells. Eventually, these small prokaryotic cells evolved into membrane-bound organelles such as mitochondria and chloroplasts. This theory is called the **endosymbiotic theory**.

Margulis and other biologists have amassed a large amount of evidence to support the endosymbiotic theory. Margulis discovered that both mitochondria and chloroplasts contain their own DNA, just as a prokaryotic cell would. Furthermore, this DNA is very similar to bacterial DNA. Finally, both mitochondria and chloroplasts reproduce in the same way that prokaryotic cells reproduce. While the endosymbiotic theory is relatively new, there is enough evidence in its favor that it has become widely accepted among biologists.

While endosymbiotic theory has been very successful in explaining the origin of the mitochondria and chloroplasts, the origin of the nucleus remains mysterious. Several hypotheses have been proposed to explain the nucleus. One states that the nucleus originated when an archaebacteria was engulfed by a larger eubacteria. Another hypothesis states that the nucleus was actually viral in origin. Other ideas posit that the nucleus evolved without any external invaders. These theories are hotly debated and remain an active area of research.

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1. What is the Margulis theory on evolution of complex eukaryotic cells? ___________________

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2. What evidence supports this theory? ____

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3. What theories have been proposed to explain the origin of the nucleus? _________________

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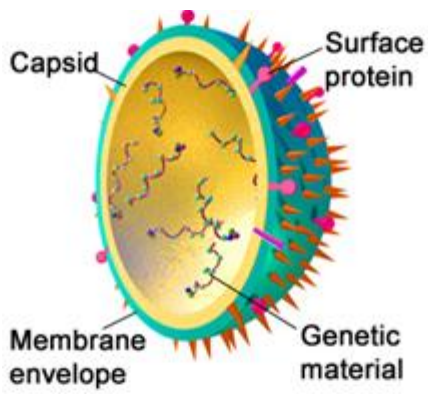
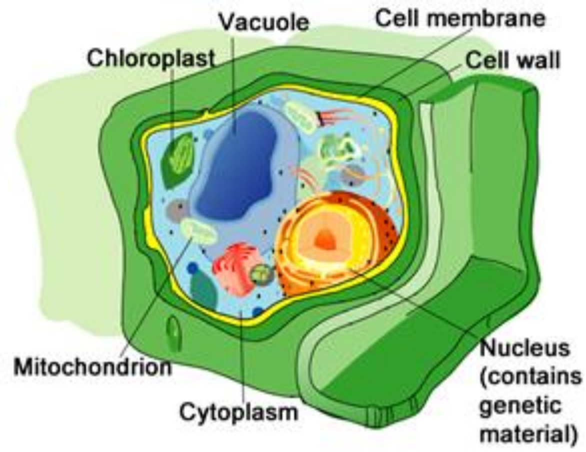
Activity D: Viruses

Have you ever gotten a cold or the flu? Both of these illnesses occur when tiny particles called **viruses** infect your cells. Viruses use cells to produce more viruses, destroying the cells in the process. Compare the virus with the cell shown below.

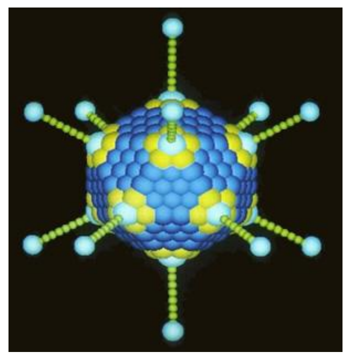


Virus



Eukaryotic cell

As you can see, viruses and eukaryotic cell have some of the same structures, including genetic material and a membrane. However, there are many more differences than similarities. A cell also has structures to take in and use energy, maintain water levels, and carry out other life processes. A virus has none of these structures. For this reason, a virus is not considered to be a living thing.



The structure of a virus consists of genetic material (DNA or RNA) surrounded and protected by a protein coat, called a capsid. The shape of a virus might be roughly spherical, icosahedral, helical, elongated, or complex. The adenovirus shown at right has an icosahedral shape.

A virus infects a cell by attaching to the cell wall or cell membrane. Proteins on the capsid bond to specific molecules on the cell membrane or cell wall, allowing the virus to attach. Most viruses only attach to a limited range of *target cells*, determined by their proteins. For example, the HIV virus that causes AIDS only infects certain types of white blood cells called T-cells. After it is attached, the virus may be engulfed by the cell, absorbed by the cell, or it may inject its genetic material directly into the cell. This is called *penetration*.

Once inside the cell, the capsid dissolves and the viral genetic material floats freely within the cell. The viral genes start to replicate and synthesize new viral proteins, utilizing the cell's own genetic replication and protein synthesis mechanisms to do this. The viral proteins and replicating viral DNA (or RNA) then begin to self-assemble into hundreds of new viruses. Eventually, the host cell *lyses*, or bursts. This kills the host cell and releases the new viruses into the world to infect new host cells. Viral diseases occur when the viruses begin to kill large numbers of cells. For example, the AIDS virus can decimate the body's T-cells, making the body vulnerable to infection from other diseases.

Not all viruses kill host cells immediately. Some viruses, such as the herpes virus, can lie dormant in a cell for months or years, and then suddenly become active. In viruses called proviruses, the viral DNA is embedded in a host cell's chromosome, replicating along with the host cell's DNA when the host cell divides. Proviruses can remain dormant for long periods of time before becoming active and killing host cells.

1. What is the basic structure of a virus? ____

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2. How are viruses similar to cells? ____

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3. How are viruses different from cells? ____

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4. Why are viruses not considered to be living organisms? ______________________________

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5. Describe the "life cycle" of a typical virus. ____

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6. How do viruses cause diseases? ____

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