Unit 2

LS.2 Investigating Cells
The student will investigate and understand that all living things are composed of cells. Key concepts include
a) cell structure and organelles;
b) similarities and differences between plant and animal cells;
c) development of cell theory; and
d) cell division.

LS.3 Cellular Organization
The student will investigate and understand that living things show patterns of cellular organization. Key concepts include
a) cells, tissues, organs, and systems; and
b) patterns of cellular organization and their relationship to life processes in living things.
Up until now, at least in the state of Virginia, your science education has been a broad look at the various categories of science: physical science, earth science, and life science. You’ve studied a little bit in each of these categories each year. This year, as a 7th grader, you will exclusively study life science, otherwise known as the study of organisms or living things. Life science is helpful in improving the quality and standard of life. It applies to health, agriculture, and medicine, among many other areas. Life science is a very important part of our daily life: we take medicine and/or vitamins to stay healthy, we eat food raised by farmers, we learn lots of things every day (neuroscience is a branch of life science that examines the brain and how we learn).

If we are studying living things, we probably need to know what defines a “living” thing. So if you are looking for life, what do you look for? Living organisms share six important characteristics with all other living things. All living things are composed of cells and they have a cellular organization. They all contain similar chemicals. They use energy. They grow and develop. They respond to their surroundings. All living things reproduce. These characteristics actually form the basis for our whole year’s material.

The first characteristic of living things is that they are composed of cells. Before we can explore that, it would be helpful to know how we came to know that. Over 400 years ago a simple scientific tool called a microscope was developed. This scientific tool magnified small objects, making them appear larger. Much like Galileo’s telescope has been improved, the first microscopes have also been improved. There are many different types of microscopes. The first (and most common) microscopes were light microscopes (also called optical microscopes). Light microscopes use visible light and a system of lenses to magnify objects. Modern scientists still use light microscopes but they are much improved over the years. Modern scientists also now use electron microscopes. Electron microscopes use a beam of accelerated electrons as a source of illumination. Because electrons are so much smaller than light rays, electron microscopes can magnify objects up to 10,000,000 times whereas light microscopes are limited to magnifications below 2000 times.

The original inventor of the microscope is hard to identify. The first compound microscope is thought to have been developed by Zacharias and Hans Janssen, eyeglass makers in the Netherlands around 1595. A compound microscope uses two convex or curved lenses contained within a tube. With a sufficient amount of light, an enlarged image of an object can be seen. Following their invention, a Dutch draper and scientist named Antone van Leeuwenhoek perfected his own method for polishing glass lenses. With his method, van Leeuwenhoek’s microscopes were able to magnify things over 200 times their size. He is known for making hundreds of microscopes in his lifetime.
In the mid-1600s, Robert Hooke, an English scientist, became the first researcher to use a microscope to observe the cellular structure of plants. While observing a piece of cork under a microscope, he noticed a number of tiny, empty compartments that looked like rooms or cells. As a result, Hooke would be the first to give the cell its name.

About 10 years later, van Leeuwenhoek turned the considerable power of his microscopes toward the yet unexplored microscopic world, eventually earning himself the unofficial title of Father of Microbiology (although this title is sometimes also used to refer to Louis Pasteur). Van Leeuwenhoek became the first person to use a microscope to observe living cells such as bacteria, protists, and blood cells. The invention of the microscope combined with the work of a number of important scientists would lead to the discovery of the cell and the development of the cell theory.

In the 1800s, discoveries made by three German scientists lead to the development of the cell theory. In 1838, Matthias Schleiden discovered that plants were made up of cells. Then in 1839, Theodor Schwann discovered that animals were made up of cells. Approximately 20 years later, Rudolph Virchow concluded that living cells come from other living cells. These major scientific discoveries and improvements in the microscope led to the development of the original cell theory. The original cell theory includes 3 components:

1. All living things are composed or made of cells.
2. Cells are the smallest unit or structure that can carry out the processes or functions necessary for life.
3. Cells can only come from other living cells.

Now that we have learned that all living organisms are made up of cells, we also need to know that they are incredibly organized! Whether the organism is unicellular (made up of a single cell) like bacteria or multicellular (made up of lots of cells) like you, organisms have a number of basic life functions that are necessary for them to survive. Cells in both unicellular and multicellular organisms are organized in a way that allows them to carry out the basic life functions: respiration, growth and repair, waste removal, reproduction, and stimulus response.

In a unicellular organism, a number of specialized parts called organelles (tiny cell structures that carry out specific functions in a cell) work together to perform the life functions that keep the organism alive. Organelles called mitochondria perform the life function of cellular respiration. During this process, sugar molecules are broken down to produce energy, carbon dioxide, and water.
Unicellular organisms also carry out the life functions of growth and repair. Although unicellular organisms do not grow as large as other kinds of organisms, they still need to replace worn-out cell parts and create new cell parts. To do this they consume, or take in, materials from their environment, change these materials into energy, and use this energy to grow or create new cell parts.

Waste removal is another life function carried out in unicellular organisms. Organelles called vacuoles work with the cell membrane to move materials into and out of the cell. Vacuoles can also store food and other materials needed by the organism.

Like all living organisms, unicellular organisms produce other organisms like themselves. This life function is called reproduction. Most single cell organisms reproduce themselves by simply dividing. Reproduction is controlled by genetic material that is usually contained in the nucleus of the unicellular organism.

Today, when we look at baby ducklings, we know these organisms are the result of reproduction. Four hundred years ago, however, people believed that life could appear suddenly from nonliving material. An excellent example was when people saw a swarm of flies on and about some decaying meat. They concluded that flies could arise from rotting meat. When frogs appeared in muddy puddles after heavy rains, people concluded that frogs could sprout from the mud in ponds. This mistaken idea of living things arising from non-living things is called spontaneous generation.

It took hundreds of years of experiments to convince people that spontaneous generation does not occur. One famous experiment was performed by an Italian doctor named Francesco Redi in the mid-1600’s. He took two identical jars and placed meat inside them. He left one jar uncovered. He covered the other jar with cloth that let air in. After a few days, Redi saw maggots (young flies) on the decaying meat in the open jar but not on the meat in the covered jar. Many people did not believe Redi’s results! In was not until the mid-1800’s when a French chemist named Louis Pasteur designed some controlled experiments using flasks with curved necks and broth that spontaneous generation was finally disproved.

Unicellular organisms also sense and respond to their environment. This life function is called stimulus response. Stimulus response allows unicellular organisms to respond to stimuli such as light, touch, and temperature. This life function takes place in the cytoplasm or fluids of the cell or by external cell parts.
Multicellular organisms also perform basic life functions. Instead of organelles performing the life functions separately however, multicellular organisms have specialized cells (organized into tissues, organs, and organ systems). Plants and animals are multicellular organisms. You are a good example of a multicellular organism with specialized cells: you have muscle cells and nerve cells (just to name a few) that work together to keep you alive. Nerve cells carry messages to your messages from your surroundings to your brain. Other nerve cells then carry message to your muscle cells, making your body move. By using this specialization, multicellular organisms can grow bigger and more complex.

The cells that make up multicellular organisms have organelles just like unicellular organisms. Some organelles, like the cell membrane, nucleus, cytoplasm, vacuoles, endoplasmic reticulum, mitochondria, ribosomes, and Golgi bodies can be found in both plant and animal cells. Lysosomes are only found in animal cells. Other organelles, like the cell wall and chloroplasts, are found only in plant cells. Let’s investigate some of these cell organelles and their functions in animal cells.

1. **Cell Membrane** – The *cell membrane* is a very thin layer of protein and fat that forms a border around an animal cell. It has pores that allow the movement of certain things into and out of the cell (food, water, oxygen, wastes). The cell membrane also protects the cell by blocking unwanted substances from entering the cell.

2. **Nucleus** – Near the center of the animal cell is an oval organelle called the *nucleus*. The nucleus is the cell’s command center. It contains genetic material which directs all of the cell’s activities. Some of these activities, or life processes, include growing, reproducing, taking in nutrients, and giving off wastes. Because an animal cell has a nucleus, it is called a *eukaryote*.

3. **Cytoplasm** – Filling the space between the nucleus and the cell membrane is a thick, jelly-like material called *cytoplasm* which contains and supports the remainder of the cell’s organelles. Although it is made up mostly of water, it also contains other important substances like proteins, fats, and sugars that the cell needs.

4. **Vacuoles** – Located in the cytoplasm are small, round organelles called *vacuoles*. Vacuoles are like storage bubbles in the cytoplasm. They hold food that needs to be digested and wastes that will be released from the cell.

5. **Endoplasmic Reticulum** – Connected to the outside of the nucleus is a ribbon-like organelle called the *endoplasmic reticulum*. As it stretches outward from the nucleus to the cell membrane, this network of tubes acts like a pipeline as it makes, stores, and transports materials throughout the cell.
7. **Mitochondria** – The *mitochondrion* (singular form of mitochondrdia) is a bean-shaped organelle that helps produce the energy a cell needs. It breaks down sugars for fuel and releases energy for use by the cell. The mitochondria are like the power plants or engines of the cell.

8. **Ribosomes** – These small structures function as factories to produce proteins. Ribosomes may be attached to the outer surfaces of the endoplasmic reticulum, or they may float free in the cytoplasm.

9. **Golgi bodies** – The Golgi bodies receive materials from the endoplasmic reticulum and send them out to other parts of the cells. They also release materials outside the cell.

10. **Lysosomes** – These small organelles found in many animal cells contain chemicals that break down food particles and worn-out cell parts.

As you can see, animal cells are made up of a number of specialized organelles. Each organelle performs a specific job for the cell. This division of labor within the animal cell is necessary to ensure the successful function and survival of the entire cell.

The cells of living things are not visible to the human eye. They are so tiny, or minute, many of these organelles can only be seen with the help of a compound light microscope. The microscope has allowed scientists to observe and study the similarities and differences in plants and animals at the cellular level. As a result, we now have a better understanding of cell organelles and their functions.

We know that the cell membrane, nucleus, cytoplasm, vacuoles, endoplasmic reticulum, mitochondria, and Golgi bodies can be found in both plant and animal cells. Other organelles, like the cell wall and chloroplasts, are found only in plant cells. Let’s investigate some of these cell organelles and their jobs in plant cells.

1. **Cell Wall** – In plants, a thick, rigid *cell wall* surrounds each cell. This tough outer covering is made out of specialized sugars called cellulose. It supports the cell and helps the plant keep its shape and structure by bonding with other cell walls. The cell wall also protects the delicate contents of the cell while allowing nutrients and waste to pass through.

2. **Cell Membrane** – Just inside the cell wall is an organelle called the *cell membrane*. It is a very thin layer of protein and fat. This membrane is semi-permeable, which means it has pores that allow certain things to move into and out of the cell (food, water, oxygen, wastes). The cell membrane also protects the cell by blocking unwanted substances from entering the cell.

3. **Nucleus** – The *nucleus* is a spherical organelle that controls the functions of the plant cell. It is the cell’s command center. It contains genetic material which directs all of the cell’s activities. Some of these activities, or life processes, include growing, reproducing, taking in nutrients, and giving off wastes. Because a plant cell has a nucleus, it is called a eukaryote.
4. **Cytoplasm** – Filling the space between the nucleus and the cell membrane is a thick, jelly-like material called *cytoplasm* which contains and supports the remainder of the cell’s organelles. Although it is made up mostly of water, it also contains other important substances like proteins, fats, and sugars that the cell needs.

5. **Vacuoles** – Most plant cells have one or more large *vacuoles* located in their cytoplasm. These vacuoles are filled with fluid and help keep the shape and structure of the plant cell and plant. When plants are given enough water, the water collects in the vacuoles and gives the plant rigidity. Without sufficient water the amount of liquid in the vacuoles decreases and the plant wilts, or bends. Vacuoles also hold food that needs to be digested and wastes that will be released from the cell.

6. **Endoplasmic Reticulum** – Connected to the outside of the nucleus is a ribbon-like organelle called the *endoplasmic reticulum*. As it stretches outward from the nucleus into the cytoplasm, this network of tubes acts like a pipeline as it makes, stores, and transports materials throughout the cell and between the cells in plants.

7. **Mitochondria** – The *mitochondrion* (singular form of mitochondria) is a bean-shaped organelle that helps produce the energy a cell needs. It breaks down the sugars produced through photosynthesis for fuel and releases energy for use by the cell. The mitochondria are like the power plants or engines of the cell.

8. **Chloroplasts** – *Chloroplasts* are specialized organelles that use the Sun’s energy to produce food in the form of sugar. Plants use this sugar to carry out the functions of the cell. Chloroplasts contain a green substance called chlorophyll that absorbs sunlight. This light energy is then changed into chemical energy through a process called photosynthesis.

Just like animal cells, plant cells are also made up of a number of specialized organelles. Each organelle performs a specific job, or function, for the cell. This division of labor within the plant cell is necessary to ensure the successful function and survival of the entire cell.

Plant and animal cells have many similarities but plants and animals are not the only organisms on Earth. You may remember classifying living things in 5th grade. There were plants and animals but there were also fungus, protists, and bacteria. While both plant and animal cells have a nucleus, some other organisms do not. A bacterial cell is an example. A bacteria does have a cell wall and a cell membrane but it does not have a nucleus! Organisms whose cells lack a nucleus are called **prokaryotes**.
The cells of all living things are composed of similar chemicals. The most abundant chemical in cells is water. Other chemicals like carbohydrates, lipids, and proteins also make up cells. Carbohydrates are a cell’s energy source. Proteins and lipids are the building blocks of cells. Lastly, nucleic acids are the genetic material or instructions that direct the cell’s activities.

Living things have four basic needs: energy, water, living space, and stable internal conditions. Since we know that living things use energy, they must get it from somewhere. They use food as their energy source. Organisms differ in the ways they obtain their energy. Some organisms, such as plants, directly capture the sun’s energy and use it along with carbon dioxide and water to make their own food. Organisms that make their own food are called autotrophs. Autotrophs use the food they make as an energy source to carry out their life functions. Organisms that cannot make their own food are called heterotrophs. A heterotroph’s energy source is the sun too, just indirectly. Heterotrophs either eat autotrophs and obtain energy from them or they consume other heterotrophs that eat autotrophs.

Water is a basic necessity for living things. They use it to perform such tasks as obtaining chemicals from their surroundings, breaking down food, growing, moving substances within their bodies, and reproducing. Because water is the universal solvent (remember that from 6th grade?), lots of nutrients and chemicals are dissolved in it. Organisms need those nutrients to survive and can dispose of their waste using water too.

All organisms need a place to live (to get their food & water and to find shelter). Many organisms compete for space because of the limited amount of living space on Earth. Because conditions in their surroundings may change significantly, organisms must be able to keep the conditions inside their bodies constant. The maintenance of stable internal conditions despite changes in the surroundings is called homeostasis. A good example of homeostasis is how your body temperature stays around 98°F even though the temperature outside changes dramatically!