- **CELLS AND THE CELL THEORY**

- All living things are composed of cells and cells are in turn composed of molecules that are made up of atoms.

- Most common and important elements (atoms) that make up living things = CHON SIP CaFe
  Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Sulphur (S), Iodine (I), Phosphorus (P), Calcium (Ca) and Iron (Fe)

- Elements are organized and bonded together to form molecules such as fatty acids, amino acids, carbohydrates, nucleic acids, vitamins, and water. These smaller molecules are bonded together to form the larger macromolecules such as proteins, polysaccharides and lipids that make up the discrete units of life called cells.

- Early in the 17th century, Galileo Galilei (of Astronomy fame) arranged two glass lenses within a cylinder and used it to look at an insect and later described the stunning geometric patterns of its tiny eyes. While Galileo was not a biologist, he was probably the first to record a biological observation made through a microscope.

- In the late 1600s, **Anton van Leeuwenhoek**, a Dutch shopkeeper who had great skill in constructing lenses invents one of the first microscopes and uses it to look at scrapings of tartar from his own teeth, pond water and many other samples. In his studies (using a very primitive microscope by today's standards), he observed "many very small animalcules, the motions of which were very pleasing to behold". He observed diverse protoctistans, sperm and even bacteria – an organism so small it would not be seen again for another two centuries.

- In 1665, the Curator of Instruments for the Royal Society in England, Robert Hooke, was at the forefront of microscopic study. When Hooke first turned a microscope to thinly sliced cork from a mature tree, he observed tiny compartments (formed from the plant cell walls). He gave them the latin name, *cellulae*, meaning small rooms and thus coined the term "cell".

- In 1820, Robert Brown, a botanist, using an improved microscope with better optics noticed an opaque spot in a variety of cells that he called a nucleus.

- By 1839 **Theodor Schwann** (a german zoologist) and **Matthias Schleiden** (a german botanist) formulated the idea that tissues are composed of discrete units or cells which could divide.

- In 1858, Rudolph Virchow, a german pathophysiologist states:

"Every animal appears as a sum of vital units each of which bears in itself the complete characteristics of life"

➢ **The basic tenets of the cell theory are:**

1. **All living things are made of cells.**
2. **Cells only arise from pre-existing cells by division** (spontaneous generation does not occur).
3. **Cells are made of similar compounds with similar characteristics and biochemistries.**

- In single-celled organisms, nutrients, fluids, and other materials simply pass into and out of the cell membrane.
- In order for a multi-cellular organism to communicate with itself and pass nutrients from one cell to another, materials and fluids need to be able to pass from one part of the body to another. Multi-cellular organisms may only take up nutrients, oxygen, and fluids and dispose of carbon dioxide and waste products through certain specialized tissues and organs.
- In multi-cellular organisms, cells are further organized and integrated together to form tissues. In many organisms, tissues are organized into organs and organ systems.
- Humans are multi-cellular and made up of more than 75 trillion cells of over 100 different types.

- **CELL STRUCTURE AND FUNCTION**

Organelle = a compartmentalized structure with a specialized function in a cell.

Note that most of these organelles are only found in **eukaryotic cells**. **Prokaryotic cells** (bacteria) lack a membrane bound cell nucleus and organelles. As noted below, each cell type (plant, animal, fungal, or protist) does not necessarily have every organelle.

ORGANELLE NAME	DESCRIPTION OF ORGANELLE
Cell Membrane	separates cell from other cells and from the environment in which the cells exist; helps regulate what is transported into and out of the cell (all cells)
Cell Wall	maintains cell shape and provides skeletal support for the cell and the entire organism in the case of multicellular organisms such as plants; helps in the binding of the cell to other tissues (plants, fungi, and some protists only)
Cytoplasm	the semifluid medium between the plasma membrane and all of the organelles in a cell
Nucleus	a membrane bound compartment with pores (small holes) where the eukaryotic cell's genetic material (DNA) is stored, copied and used to make RNA
Rough Endoplasmic Reticulum	a network of interconnected membranous sacs in a eukaryotic cell that is studded with ribosomes that make proteins which will become part of the cell membrane, or proteins that will be secreted from the cell
Smooth Endoplasmic Reticulum	a network of interconnected membranous tubules in a eukaryotic cell that contains specific enzymes; the smooth ER lacks ribosomes but it is important for the synthesis of special molecules such as the lipids which make up most of the cell membranes
Golgi Apparatus	stacks of membranous sacs containing special enzymes that modify, store and ship products from the ER to the cell membrane or other parts of eukaryotic cells
Lysosomes	an organelle that contains enzymes that digest food and wastes in eukaryotic cells
Vacuoles	a membrane enclosed sac that has diverse functions in eukaryotic cells, but is often used to store substances inside the cell; the central vacuole in plant cells stores water and has diverse roles in reproduction, growth, and development of the plant
Chloroplasts	an organelle that is enclosed by two membranes (an inner and an outer membrane); chloroplasts absorb sunlight and use it to make food molecules (sugars) by photosynthesis
Mitochondria (plural) Mitochondrion (singular)	an organelle that is enclosed by two membranes (an inner and an outer membrane); a eukaryotic organelle that plays important roles in cellular respiration; mitochondria produce ATP which is the fuel the cell uses for its various activities
Cytoskeleton	a network of small fibers that provides structural support and directs transport and movement of organelles within a eukaryotic cell; the cytoskeleton is formed of three different sized protein fibers: microfilaments, intermediate filaments and microtubules
Microfilaments	the thinnest of the three main kinds of protein fibers that make up the cytoskeleton; microfilaments are solid rods made of the protein called actin; microfilaments help some cells change shape
Intermediate filaments	the middle sized of the three main kinds of protein fibers that make up the cytoskeleton; intermediate filaments are made of fibrous proteins

ORGANELLE NAME	**DESCRIPTION OF ORGANELLE**
Microtubules	the thickest of the three main kinds of protein fibers that make up the cytoskeleton; microtubules are hollow tubes made of proteins called tubulins; flagella, cilia and the spindle fibers used in cell division are made of microtubules
Centriole	a structure in an animal cell, composed of cylinders of microtubule triplets arranged in a 9 + 0 pattern; an animal cell usually has a pair of centrioles which are involved in cell division
Cilia (plural) **Cilium (singular)**	a short cellular appendage that has a 9 + 2 arrangement of microtubules covered by the cell membrane; the cilia beat back and forth in synchrony to propel the cell or to move material outside the cell; not present in all cells
Flagella (plural) **Flagellum (singular)**	a long cellular appendage that has a 9 + 2 arrangement of microtubules covered by the cell membrane; the flagellum moves back and forth to propel the cell forward; sperm, some bacteria and some protists have flagella
Pili	short projections on the surface of bacterial cells that help the bacteria attach to other surfaces or other cells (bacteria only)

Most animal cells (eukaryotes) contain: a nucleus, rough endoplasmic reticulum, ribosomes, smooth endoplasmic reticulum, peroxisomes, mitochondria, a cytoskeleton, a plasma (cell) membrane, Golgi apparatus, lysosomes, centrioles; some animal cells possess a flagella, but many do not possess a flagella.

Most plant cells (eukaryotes) contain: a nucleus, a cell wall, a central vacuole, chloroplasts, peroxisomes, mitochondria, a plasma (cell) membrane, a cytoskeleton, Golgi apparatus, smooth endoplasmic reticulum, ribosomes, & rough endoplasmic reticulum.

Most bacterial cells (prokaryotes) contain: a nucleoid region (where DNA is found), ribosomes, a plasma (cell) membrane, a cell wall, a capsule; some bacteria have pili or flagella, but many do not. Note that the chemical reactions that occur in a bacteria are not compartmentalized in different types of organelles, that is, bacteria (prokaryotes) lack organelles.

<u>Organelles found in animal cells, but not found in most plant cells</u> = lysosomes, flagella, centrioles

<u>Organelles found in plant cells, but not found in most animal cells</u> = cell wall, chloroplast, central vacuole

<u>Etymology of eukaryote and prokaryote</u>
"eu" = true (from Greek)
"pro" = earlier than or before (from Greek)
"kary" = nucleus of a cell (from Greek for nut or kernel)
eukaryote = true nucleus
prokaryote = before nucleus

Eukaryotic cell = a type of cell that has a membrane enclosed nucleus and other membrane enclosed organelles described above. All organisms except bacteria are composed of eukaryotic cells.
All members of the Kingdoms Protoctista, Fungi, Plantae, and Animalia are comprised of eukaryotic cells.

Prokaryotic cell = a bacterial cell; a type of cell lacking a membrane enclosed nucleus and other membrane-enclosed organelles; found only in members of the Kingdom Monera; these types of cells were the first type of cell to evolve 3.5 to 4 billion years ago.