Cells are an organism's basic unit of structure and function

- The cell is the lowest level of structure that is capable of performing *all* the activities of life.
  - Structural and functional units of life
  - Many types, but all share common features
- The first cells were observed and named by Robert Hooke in 1665 from a slice of cork
- In 1838, Matthais Schleiden concluded that cells are the basic unit of life for all ***plants***
- In 1839,Theodor Schwann concluded cells are the basic unit of life for all ***animals***
- In 1858, Rudolf Virchow concluded that all cells come from other living cells, or pre-existing cells
- Cell Theory
  1. All living organisms are composed of cells
  2. Cells are ***fundamental units*** of all organisms and chemical reactions of life occur within cells
  3. All cells come from pre-existing cells.

Microscopes provide windows to the world of the cell

- The discovery and early study of cells progressed with the invention and improvement of microscopes in the 17th century.
- In a **light microscope (LMs)** visible light passes through the specimen and then through glass lenses.
  - The lenses refract light so that the image is magnified into the eye or a video screen.
- Microscopes vary in magnification and resolving power.
- **Magnification** is the *ratio* of an object's image to its real size.
- **Resolving power** is a measure of image *clarity*.
  - minimum distance two objects can be separated and still viewed as two separate objects.
  - limited by the ***shortest wavelength*** of the source, in this case light.
- The minimum resolution of a light microscope is about 2 microns, the size of a small bacterium
- Light microscopes can magnify effectively to about 1,000 times the size of the actual specimen.
  - At higher magnifications, the image blurs.

- Techniques developed in the 20th century have enhanced contrast and enabled particular cell components to be labeled so that they stand out.
- While a light microscope can resolve individual cells, it cannot resolve much of the internal anatomy, especially the **organelles**.
- To resolve smaller structures we use an **electron microscope** (**EM**), which focuses a beam of electrons through the specimen or onto its surface.
  - Because resolution is inversely related to wavelength used, electron microscopes with shorter wavelengths than visible light have finer resolution.
  - Theoretically, the resolution of a modern EM could reach 0.1 nanometer (nm), but the practical limit is closer to about 2 nm.

- **Transmission electron microscopes** (**TEM**) are used mainly to study the ***internal ultrastructure*** of cells.
  - A TEM aims an electron beam through a thin section of the specimen.
  - The image is focused and magnified by electromagnets.
  - To enhance contrast, the thin sections are stained with atoms of heavy metals.

Cell biologists can isolate organelles to study their functions

- Electron microscopes reveal organelles, but they can only be used on *dead cells* and they may introduce some ***artifacts***. ***(What is an artifact?)***
- Light microscopes do not have as high a resolution, but they can be used to study *live cells*.
- Microscopes are a major tool in *cytology*, the study of cell structures.
- Cytology coupled with *biochemistry*, the study of molecules and chemical processes in metabolism, developed modern cell biology.

- This process is driven by an **ultracentrifuge,** a machine that can spin at up to 130,000 revolutions per minute and apply forces more than 1 million times gravity (1,000,000 *g*).
- Fractionation begins with *homogenization*, gently disrupting the cell.

- Then, the homogenate is spun in a centrifuge to separate heavier pieces into the pellet while lighter particles remain in the supernatant.
  - As the process is repeated at higher speeds and longer durations, smaller and smaller organelles can be collected in subsequent pellets.
- Cell fractionation prepares quantities of specific cell components.
- This enables the functions of these organelles to be isolated, especially by the reactions or processes catalyzed by their proteins.
  - For example, one cellular fraction is enriched in enzymes that function in cellular respiration.
  - Electron microscopy reveals that this fraction is rich in the organelles called mitochondria.
- Cytology and biochemistry complement each other in connecting cellular structure and function.