The History of Cells & the Cell Theory

Discovery of Cells
- 1665- English Scientist, Robert Hooke, discovered cells while looking at a thin slice of cork.
- He described the cells as tiny boxes or a honeycomb.
- He thought that cells only existed in plants and fungi.

Anton van Leuwenhoek
- 1673 - Used a handmade microscope to observe pond scum & discovered single-celled organisms.
- He called them "animalcules."
- He also observed blood cells from fish, birds, frogs, dogs, and humans.
- Therefore, it was known that cells are found in animals as well as plants.

150-200 Year Gap???
- Between the Hooke/Leuwenhoek discoveries and the mid 19th century, very few cell theory advancements were made.
- This is probably due to the widely accepted, traditional belief in Spontaneous Generation.
- Examples:
  - Mice from dirty clothes/corn husks
  - Maggots from rotting meat

19th Century Advancement
- Much doubt existed around Spontaneous Generation.
- Conclusively disproved by Louis Pasteur.

Development of Cell Theory
- 1838- English Botanist, Matthias Schleiden, concluded that all plant parts are made of cells.
- 1839- German physiologist, Theodor Schwann, who was a close friend of Schleiden, stated that all animal tissues are composed of cells.
Development of Cell Theory

- 1858: Rudolf Virchow, Russian physician, after extensive study of cellular pathology, concluded that cells must arise from preexisting cells.

3 Basic Components of the Cell Theory

1. All organisms are composed of one or more cells.
   - (Schleiden & Schwann) (1838-39)
2. The cell is the basic unit of life in all living things.
   - (Schleiden & Schwann) (1838-39)
3. All cells are produced by the division of preexisting cells.
   - (Virchow) (1858)

Theory

A set of statements or principles devised to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena.

Modern Cell Theory

- Modern Cell Theory consists of the 3 basic components of cell theory, plus 4 additional statements:
  4. The cell pass information from cell to cell during cell division using DNA.
  5. All cells have basically the same chemical composition and metabolic activities.
  6. All cells have basically the same chemical & physiological functions (movement, digestion, etc)
  7. Cell activity depends on the activities of structures within the cell. (organelles, nucleus, plasma membrane)

How Has The Cell Theory Been Used?

- The previously discovered truths about cells listed in the Cell Theory are the basis for things such as:
  - Disease/Health/Medical Research and Cures (AIDS, Cancer, Vaccines, Cloning, Stem Cell Research, etc.)

Characteristics of Cells

- All Cells have common structures:
  - Cell Membrane
  - Ribosomes
  - Cytoplasm
- Cells contain DNA
- Found in the nucleus
- Cells are independent units of life
Prokaryotic cells

**Components**
- Cytosol
- Ribosomes
- Nucleoid region
- Circular DNA
- Plasmid
- Cell Membrane
- Cell Wall
- Capsule (or slime layer)
- Pili
- Flagellum

**Characteristics of Prokaryotes**
- does not have a nucleus
- single celled organisms
- have few organelles
- perform few functions
- Eat
- Respire
- Reproduce
- smaller than other cells
- Bacteria are the only known prokaryotes

Virus

**Bacteriophage “bacteria eater”**

**Characteristics of Viruses**
- Viruses are not living because they:
  - are not made of cells
  - need a host cell to reproduce
- A virus is very small compared to a cell
- Like cells, viruses contain nucleic acids
Eukaryotic cells

- Cytosol
- Nucleus
- Mitochondria
- Chloroplast
- Ribosomes
- Rough ER
- Smooth ER
- Golgi body
- Vacuoles
- Lysosomes
- Cytoskeleton
- Centriole
- Cilium and Flagellum
- Cell membrane
- Cell Wall

Characteristics of Eukaryotes
- has a nucleus
- can be single or multicellular
- have many organelles, performing complex functions
- specialized to perform specific functions
- larger than prokaryotic cells
- Animals, plants, fungi and protists are made of eukaryotic cells

Summary of Differences

<table>
<thead>
<tr>
<th>Prokaryotic Cells</th>
<th>Eukaryotic cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>small cells (&lt; 5 mm)</td>
<td>larger cells (&gt; 10 mm)</td>
</tr>
<tr>
<td>always unicellular</td>
<td>often multicellular</td>
</tr>
<tr>
<td>no nucleus or any membrane-bound organelles</td>
<td>always have nucleus and other membrane-bound organelles</td>
</tr>
<tr>
<td>DNA is circular, without proteins</td>
<td>DNA is linear and associated with proteins to form chromatin</td>
</tr>
<tr>
<td>ribosomes are small (70S)</td>
<td>ribosomes are large (80S)</td>
</tr>
<tr>
<td>no cytoskeleton</td>
<td>always has a cytoskeleton</td>
</tr>
<tr>
<td>cell division is by binary fission</td>
<td>cell division is by mitosis or meiosis</td>
</tr>
<tr>
<td>reproduction is always asexual</td>
<td>reproduction is asexual or sexual</td>
</tr>
</tbody>
</table>

Animal and Plant Cells
Both Have:
- A nucleus
- Ribosomes that make protein
- Rough and smooth endoplasmic reticulum
- Golgi bodies
- Mitochondria
- Cytoskeleton
- Vacuoles that store food, water and waste products.

Animal Cells
- Can not make their own food
- Have many lysosomes
- Are more round shaped
- Have centrioles
- Use mitochondria to release energy
- Have many Golgi bodies
- Have more extensive cytoskeleton than plant cells

Animal cells cont.
- Do not have a cell wall
- Do not have a large vacuole
- Do not have chloroplasts
Figure 3.2  Structure of the generalized cell.

- **Chromatin**
- **Nucleolus**
- **Smooth endoplasmic reticulum**
- **Cytosol**
- **Mitochondrion**
- **Lysosome**
- **Centrioles**
- **Centrosome matrix**
- **Cytoskeletal elements**
  - **Microtubule**
  - **Intermediate filaments**
- **Nuclear envelope**
- **Nucleus**
- **Plasma membrane**
- **Rough endoplasmic reticulum**
- **Ribosomes**
- **Golgi apparatus**
- **Secretion being released from cell by exocytosis**

### Animal Cell Diversity

#### Animal Cell

- **Cytoplasm**
- **Nucleus**
- **Ribosomes**
- **Cell Membrane**
- **Smooth Endoplasmic Reticulum**
- **Golgi Bodies**

### Eukaryotic Cell Organelles and Function

1. **Nucleus**
   - **Nickname:** "The Control Center"
   - **Function:** holds the DNA
   - **Parts:**
     - **Nucleolus:** dark spot in the middle of the nucleus that helps make ribosomes

**Nucleus** – largest organelle; control center of the cell; consists of:

- **Nuclear envelope** – double membrane structure containing pores
- **Nucleoli** – synthesize ribosomes
- **Chromatin** – threadlike material composed of DNA (genes) & proteins

Note: during cell division, chromatin condenses to form chromosomes
**Cytoplasm**
Consists of:
- Cytosol – liquid portion
- Organelles – specialized cellular compartments
- Inclusions – chemical substances
  - Glycogen (muscle & liver cells)
  - Lipid droplets (fat cells)
  - Melanin granules (skin & hair cells)

**Mitochondria**
- **Nickname:** "The Powerhouse"
- **Function:** Energy formation
  - Breaks down food to make ATP
    - ATP: is the major fuel for all cell activities that require energy
- **Mitochondria** – double membrane structures; site of cellular respiration (ATP synthesis)
  - Contain their own DNA & RNA
  - Able to replicate themselves

**Ribosomes**
- **Function:** makes proteins
- Found in all cells, prokaryotic and eukaryotic

**Ribosomes** – dense particles of rRNA and protein
- **Free ribosomes** – synthesize proteins that function within the cell
- **Attached ribosomes** – synthesize proteins incorporated into cell membranes or exported outside the cell
**Cytoskeleton** – network of rods that support the cell

- **Microtubules** – thick rods composed of tubulin
  - form cilia, flagella & centrioles

- **Microfilaments** – thin filaments composed of actin
  - involved in muscle contraction
  - form **cleavage furrow** during cell division

- **Intermediate filaments** – tough protein fibers attached to desmosomes

- **Centrioles** – paired cylindrical bodies composed of microtubules
  - Organize spindle apparatus (cell division)

**Endoplasmic Reticulum (ER)**

- **Nickname:** “Roads”
- **Function:** The internal delivery system of the cell

**Cellular extensions**

- **Microvilli:** fingerlike projections of the plasma membrane; increase surface area for absorption

- **Cilia:** short hair-like projections; propel substances over surface of cell

- **Flagella:** long hair-like projections; propel the cell

**Endoplasmic Reticulum**

- **2 Types:**
  1. **Rough ER:**
     - Rough appearance because it has ribosomes
     - **Function:** helps make proteins, that’s why it has ribosomes
  2. **Smooth ER:**
     - NO ribosomes
     - **Function:** makes fats or lipids
- **Endoplasmic reticulum (ER)** – extensive membrane system

  Functions
  1. Synthesis of proteins, carbohydrates, and lipids
  2. Storage of synthesized molecules and materials
  3. Transport of materials within the ER
  4. Detoxification of drugs or toxins

**Rough ER** – studded with ribosomes; abundant in secretory cells

**Smooth ER** – free of ribosomes
  - Synthesizes lipids and steroids
  - Detoxifies drugs/poisons (liver cells)
  - Stores calcium ions (muscle cells)

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**Golgi Apparatus**
- AKA Golgi Body or Golgi complex
- **Nickname**: The shippers
- **Function**: packages, modifies, and transports materials to different location inside/outside of the cell
- **Appearance**: stack of pancakes

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**Golgi apparatus** – stack of flattened membranous sacs
- Packages proteins for secretion from the cell (exocytosis)
- Packages proteins for incorporation into plasma membrane
- Forms lysosomes
**Lysosomes** - membranous sacs of hydrolytic enzymes; sites of intracellular digestion

- **Primary lysosome**
  - Formed by Golgi apparatus and inactive enzymes
- **Secondary lysosome**
  - Lysosome fused with damaged organelle
  - Digestive enzymes activated
  - Toxic chemicals isolated

**Peroxisomes** - membranous sacs of oxidase & catalase enzymes; detoxify alcohol & neutralize dangerous free radicals

**Plant Cells**

- Have a cell wall and cell membranes
- Have a large vacuole unlike the animal cell which only has small vacuoles
- Have mitochondria to convert sugar to usable energy for the cell
- Have a few lysosomes
- Are more rectangular in shape
- Have chloroplasts to carry out photosynthesis
- Make sugar to store solar energy

**Plant Cell**

**Vacuoles**

- **Function**: stores water
- This is what makes lettuce crisp
  - When there is no water, the plant wilts
**Chloroplasts**
- **Function:** traps energy from the sun to produce food for the plant cell
- Green in color because of chlorophyll, which is a green pigment

**Cell Wall**
- **Function:** provides support and protection to the cell membrane
- Found outside the cell membrane in plant cells