Chapter 4
Cell Biology
What is Cell Biology?
Cell Biology or Cytology is the study of cells.

Why do we study Cell?
Because the cell is the fundamental unit of life.
We use microscopes to study cells.

Light Microscopes: Use different techniques to enhance contrast and selectively highlight cellular components.
Electron microscopes: These allows greater magnification and reveals cellular details.
Cells are ruled by the Cell Theory

The cell theory comprises two main statements:

1. All living things are composed of cells. Schleiden and Schwann, 1838
2. Cells come from other cells. Virchow 1858
What Features Are Shared by All Cells?

- All Cells Are Enclosed by a Plasma Membrane
- All Cells Use DNA As a Hereditary Blueprint
- All Cells Contain Cytoplasm
- All Cells Obtain Energy and Nutrients from Their Environment
What is the average size of a cell?

- Most cells measure between 1-100 μm

- Prokaryote cells (bacteria) range between 1-10 μm.

- Eukaryote cells size ranges between 10-100 μm.
Human height

Length of some nerve and muscle cells

Chicken egg

Frog egg

Unaided eye

Light microscope

Electron microscope

10 m

1 m

100 mm

(10 cm)

10 mm

(1 cm)

1 mm

100 μm

10 μm

1 μm

100 nm

10 nm

1 nm

0.1 nm

Atoms

Proteins

Small molecules

Lipids

Viruses

Ribosome

Nucleus

Most plant and animal cells

Mitochondrion

Most bacteria

Mycoplasmas (smallest bacteria)

Most plant and animal cells

Figure 4.2A
Natural laws limit cell size

- At minimum, a cell must be large enough to house the parts it needs to survive and reproduce.
- The maximum size of a cell is limited by the amount of surface needed to obtain nutrients from the environment and dispose of wastes.
A small cell has a greater ratio of surface area to volume than a large cell of the same shape.

- **Figure 4.3**
  - Surface area of one large cube: 5,400 µm²
  - Total surface area of 27 small cubes: 16,200 µm²
Two types of cells.

- There are two kinds of cells: prokaryotic and eukaryotic.

- Prokaryotic cells are small, relatively simple cells and they do not have a nucleus surrounded by a nuclear envelope. Bacteria, cyanobacteria and other type of monerans have prokaryote cells.
Eukaryotic cells

- All other life forms are made up of one or more eukaryotic cells. These forms include protistans, fungi, plantae and animalia.

- These are larger and more complex than prokaryotic cells and they are partitioned into functional compartments

- Eukaryotes are distinguished by the presence of a true nucleus
Two main types of eukaryote cells.

- Eukaryote cells can be distinguished into two main types of cells.
  - Animal type cells
  - Plant type cells
What Are the Main Features of Eukaryotic Cells?

- Let’s start by studying a generalized animal cell and later we will look at the differences between these cells and plant cells.
An animal cell

- Plasma membrane
- Golgi apparatus
- Ribosomes
- Nucleus
- Smooth endoplasmic reticulum
- Rough endoplasmic reticulum
- Mitochondrion
- Cytoskeleton
- Flagellum
- Lysosome
- Centriole
- Peroxisome
- Microtubule
- Intermedidate filament
- Microfilament
- Not in most plant cells
- Ribosomes
- Golgi apparatus
- Plasma membrane
- Mitochondrion
- The plasma membrane controls the cell’s interaction with the environment
- The cytoplasm contains organelles
- Many organelles have membranes as boundaries
  - These compartmentalize the interior of the cell
  - This allows the cell to carry out a variety of activities simultaneously
Organelles

The different organelles of an eukaryote cell can be grouped as:

- **Protein Production**: Ribosomes

- **Energy organelles**: Mitochondria

- **Endomembrane system**:
  - Rough Endoplasmic reticulum
  - Smooth Endoplasmic reticulum
  - Golgi apparatus
- Vacuoles and vesicles
- **Digesting Organelles:** Lysosomes and Peroxisomes.
- **Cytoskeleton**
  - Microtubules
  - Microfilaments
  - Cilia
  - Flagella
- The nucleus
Ribosomes

- Ribosomes contain rRNA and protein.
- A ribosome is composed of two subunits
- Ribosomes: are the site for protein synthesis
- Not membrane bound.
The mitochondria

Not in most plant cells
(d) Scanning electron microscope

mitochondria

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Mitochondria harvest chemical energy from food

- Mitochondria carry out cellular respiration
  
  This process uses the chemical energy in food (from glucose) to make ATP for cellular work
Endomembrane system:

Rough Endoplasmic reticulum
Smooth Endoplasmic reticulum
Golgi apparatus
The endomembrane system

- Plasma membrane
- Golgi apparatus
- Rough endoplasmic reticulum
- Smooth endoplasmic reticulum
- Nucleus
- Flagellum
- Lysosome
- Peroxisome
- Mitochondrion

Not in most plant cells
- Rough endoplasmic reticulum makes membrane and proteins.

- Smooth ER synthesizes lipids. In some cells, it regulates carbohydrate metabolism and breaks down toxins and drugs.
vesicles from ER
Golgi complex
vesicles leaving Golgi complex
The Golgi Complex (apparatus)

- The Golgi Complex Sorts, Chemically Alters, and Packages Important Molecules.
Lysosomes digest the cell’s food and wastes

- Lysosomes are sacs of digestive enzymes
The cytoskeleton

- Nucleus
- Flagellum
- Centriole
- Microtubule
- Intermediate filament
- Microfilament
A network of protein fibers makes up the cytoskeleton
- **Microfilaments** of actin enable cells to change shape and move

- **Intermediate filaments** reinforce the cell and anchor certain organelles

- **Microtubules**
  - Made of the protein tubulin
  - give the cell rigidity
  - provide anchors for organelles
  - act as tracks for organelle movement
Cilia and flagella move when microtubules bend

- Eukaryotic cilia and flagella are locomotor appendages that protrude from certain cells
- A cilia or flagellum is composed of a core of microtubules wrapped in an extension of the plasma membrane
propulsion of fluid

cilia lining trachea

Cilium

propulsion of fluid

return stroke

Figure 4.17A

Figure 4.17B
The Nucleus

(a) Diagram showing the nucleus, nucleolus, nuclear envelope, and nuclear pores.

(b) Micrograph of a nucleus with visible nuclear pores.

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What Role Does the Nucleus Play?

- The Nuclear Envelope (with its nuclear pores) controls Passage of Materials
- The Nucleus Contains Chromosomes
- Ribosome Components Are Made at the Nucleolus
Chromatin

- Eukaryotic chromosomes are made of chromatin, a combination of DNA and proteins.
- The chromatin consists and DNA that wraps around the proteins forming a “beads-on-a-string” structure.

- Its levels of condensation varies during the different stages of the cell life cycle. When the cell is going to divide, the chromatin (DNA + proteins) forms the chromosomes.
<table>
<thead>
<tr>
<th>General Function: Manufacturing</th>
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<tbody>
<tr>
<td><strong>Nucleus</strong></td>
<td>DNA synthesis; RNA synthesis; assembly of ribosomal subunits (in nucleoli)</td>
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<tr>
<td><strong>Ribosomes</strong></td>
<td>Polypeptide (protein) synthesis</td>
</tr>
<tr>
<td><strong>Rough ER</strong></td>
<td>Synthesis of membrane proteins, secretory proteins, and hydrolytic enzymes; formation of transport vesicles</td>
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<tr>
<td><strong>Smooth ER</strong></td>
<td>Lipid synthesis; carbohydrate metabolism in liver cells; detoxification in liver cells; calcium ion storage</td>
</tr>
<tr>
<td><strong>Golgi apparatus</strong></td>
<td>Modification, temporary storage, and transport of macromolecules; formation of lysosomes and transport vesicles</td>
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<thead>
<tr>
<th>General Function: Breakdown</th>
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<tbody>
<tr>
<td><strong>Lysosomes (in animal cells and some protists)</strong></td>
<td>Digestion of nutrients, bacteria, and damaged organelles; destruction of certain cells during embryonic development</td>
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<tr>
<td><strong>Peroxisomes</strong></td>
<td>Diverse metabolic processes, with breakdown of H$_2$O$_2$ by-product</td>
</tr>
<tr>
<td><strong>Vacuoles</strong></td>
<td>Digestion (like lysosomes); storage of chemicals; cell enlargement; water balance</td>
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</tbody>
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<th>General Function: Energy Processing</th>
<th></th>
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<tr>
<td><strong>Chloroplasts (in plants and some protists)</strong></td>
<td>Conversion of light energy to chemical energy of sugars</td>
</tr>
<tr>
<td><strong>Mitochondria</strong></td>
<td>Conversion of chemical energy of food to chemical energy of ATP</td>
</tr>
</tbody>
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<th>General Functions: Support, Movement, and Communication Between Cells</th>
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<td><strong>Cytoskeleton (including cilia, flagella, and centrioles in animal cells)</strong></td>
<td>Maintenance of cell shape; anchorage for organelles; movement of organelles within cells; cell movement; mechanical transmission of signals from exterior of cell to interior</td>
</tr>
<tr>
<td><strong>Cell walls (in plants, fungi, and some protists)</strong></td>
<td>Maintenance of cell shape and skeletal support; surface protection; binding of cells in tissues</td>
</tr>
<tr>
<td><strong>Extracellular matrix (in animals)</strong></td>
<td>Binding of cells in tissues; surface protection; regulation of cellular activities</td>
</tr>
<tr>
<td><strong>Cell junctions</strong></td>
<td>Communication between cells; binding of cells in tissues</td>
</tr>
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What Are the Features of Plant Cells?

Plant Cells have:

- Cell Wall
- Plastids:
  - Amyloplasts
  - Chromoplasts
  - Chloroplasts
- Central Vacuole.
Nucleus
Golgi apparatus
Not in animal cells
Central vacuole
Chloroplast
Cell wall
Mitochondrion
Peroxisome
Plasma membrane
Rough endoplasmic reticulum
Ribosomes
Smooth endoplasmic reticulum
Microtubule
Intermediate filament
Microfilament
Cytoskeleton

Figure 4.5B
The Outside: The cell wall

- Cell wall protects and supports cell
- Is made of CELLULOSE
- Allows water and other molecules to pass through (like a cardboard box)
The Plastids

- **Organelles with two external membranes:** The outer membrane and the inner membrane
- **Amyloplasts:** Filled with starch
- **Chromoplasts:** Filled with color pigments
- **Chloroplasts:** Very complex. Used in photosynthesis.
Amyloplasts found in potato cells stained with IKI
Chloroplasts convert solar energy to chemical energy

- Chloroplasts are found in plants and some protists
- Chloroplasts convert solar energy to chemical energy in sugars
PERCENT LOADED
**Vacuole**

- Makes up to 90% of plant cell volume
- Has its own membrane, called **tonoplast**
- **Vacuole:** Stores a watery solution of sugars, salts, acids, proteins.

![Diagram of a plant cell with a central vacuole and tonoplast](image-url)
Vacuole

- Often acidic content (sap), it’s what makes lemons and limes taste tart!
A prokaryotic cell is enclosed by a plasma membrane and is usually encased in a rigid cell wall.

- The cell wall may be covered by a sticky capsule.

- Inside the cell are its DNA and other parts.
Prokaryotes have inhabited Earth for billions of years

- Prokaryotes are the oldest life-forms
- They remain the most numerous and widespread organisms on Earth today

Figure 16.7
Archaea and bacteria are the two main branches of prokaryotic evolution

- Prokaryotes are cells that lack nuclei and other membrane-enclosed organelles
Prokaryotes come in a variety of shapes

- Spheres (coccì) are the most common
- Rods (bacillì)
- Curves or spirals